A COMPARATIVE STUDY IN THE CONSUMPTION OF UTILITIES AND MAINTENANCE COSTS BETWEEN GREEN BUILDING INDEX (GBI) AND NON-GREEN BUILDING INDEX (NON-GBI) RATED BUILDINGS

By

LEE ZHENG PING

A thesis submitted to the Department of Engineering Science,
Faculty of Engineering, Green and Technology (FEGT),
Universiti Tunku Abdul Rahman,
in partial fulfilment of the requirements for the degree of
Master of Engineering Science
July 2018

DECLARATION

I LEE ZHENG PING hereby declare that the thesis/dissertation is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UTAR or other institutions.

(LEE ZHENG PING)

Date 1st July 2018

ABSTRACT

A COMPARATIVE STUDY IN THE CONSUMPTION OF UTILITIES AND MAINTENANCE COSTS BETWEEN GREEN BUILDING INDEX (GBI) AND NON-GREEN BUILDING INDEX (NON-GBI) RATED BUILIDINGS

Lee Zheng Ping

Green buildings have much been popularized since year 2009 in Malaysia. There had been multiple schemes in rating green building throughout the world. Malaysia has its own rating scheme too which is Green Building Index (GBI) created by the members from Building Industry Presidents Council (BIPC) (PAM, 2009). This study was conducted to identify the types of maintenance in term of replacement frequency of service and cost involved within a consistent period of 12 months operation, record the cost implication on key saving drivers on "Electricity" and "Water" utility consumption and to compare both operation and maintenance actual cost distribution in green and non-green rated building. From many of the published articles, conventional building are still lack of many green elements such as the basic element of building's orientation, natural lighting, green planting and landscaping. As such, lack of publication and marketing on GBI products may act as an obstruction for the developers to opt for sustainable green buildings. Methodology of this study requires collection of qualitative data on utilities consumption for a continuous period of 12 months whereby the maintenance costs rendered by occupied buildings for more than 2 years. The analysis of the collected data via t-test formula which extract from

the differences obtained from the collected data either it was statistically significant or vice versa. Two categories of buildings are studied, namely high-rise residential building and high-rise non-residential building. The annual collected maintenance costs of RM123, 061.54 and RM123, 191.00 for residential and non-residential respectively of non-green rated building (Non-GBI) whereby green rated building (GBI) recorded lower maintenance cost at RM76, 595.40 and RM73, 432.50 for residential and non-residential respectively. Both categories of GBI and Non-GBI rated building are marked at 37.7% and 40.4% of excess utilities and maintenance spending per year. Besides that, the residential type of building was recorded at RM0.88 and RM1.46 per meter square rate for GBI to Non-GBI residential building. For non-residential type of building, RM1.83 and RM2.88 per meter square rate resulted between GBI and Non-GBI non-residential building. Thus, the findings of this study may assists the building and home owners to pre-estimate the rental rate for the building leasable spaces. On utilities, electricity consumption cost saving recorded for GBI to Non-GBI rated buildings at 26.4% and 6.6% whereas water consumption recorded at 39.8% and 46.3% for minimum 90% of building occupancy rate recorded during the survey. This study have developed significant on higher actual cost saving analysis for residential building in term of building maintenance, electricity and water consumption whereby non-residential building shown better cost saving on building maintenance and water consumption only.

ACKNOWLEDGEMENT

This research study was supported by the assistantship of the Main-Supervisor, Ms. Chu Hui Chen and Co-Supervisor, Mr. Lee Lim Tat. I sincerely would like to thank for their constant encouragement and guidance during pre-consultation and progress of this research study. Without their consistent and illuminating instruction, this research study could not complete successfully. I also would like to express my gratitude and greatly indebted to the examiners of this research study for their valuable comments and efforts to ensure the quality on this research writing is achieved.

APPROVAL SHEET

This dissertation/thesis entitled "**A COMPARATIVE STUDY IN THE CONSUMPTION OF UTILITIES AND MAINTENANCE COSTS BETWEEN GREEN BUILDING INDEX (GBI) AND NON-GREEN BUILDING INDEX (NON-GBI) RATED BUILIDINGS"** was prepared by LEE ZHENG PING and submitted as partial fulfillment of the requirements for the degree of Master of Engineering Science at Universiti Tunku Abdul Rahman.

Approved by:

_____
(Ms. Chu Hui Chen)
Date: ……
Supervisor
Department of Construction Management
Faculty of Engineering and Green Technology
Universiti Tunku Abdul Rahman

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVATIONS

GBI	Green Building Index
PAM	Pertubuhan Akitek Malaysia
ACEM	Association of Consulting Engineers Malaysia
LEED	Leadership in Energy and Environmental Design
BREEAM	Building Research Establishment Environmental Assessment Method
BEPAC	Building Environmental Performance Assessment Criteria
EEWH	Green Building Evaluation System
WGBC	World Green Building Council
GDP	Gross Domestic Product
AIA	American Institute of Architects
CO2	Carbon Dioxide
TNB	Tenaga Nasional Berhad
NRNC	Non-Residential New Construction
RNC	Residential New Construction
INC	Industrial New Construction
NREB	Non-Residential Existing Building
IEB	Industrial Existing Building
T	Township
MOF	Ministry of Finance
JKR	Jabatan Kerja Raya
SPAN	Suruhanjaya Perkhidmatan Air Negara
WSIA	Water Service Industry Act 2006
VOC	Volatile Organic Compounds
CFC	Chlorofluorocarbons
MGBC	Malaysia Green Building Confederation
AAC	Autoclaved Aerated Concrete
BMT	Base Metal Thickness
SRI	Solar Reflectance Index
BQ	Bills of Quantities
MSC	Multimedia Super Corridor

NLA	Net Let-table Area
HVAC	Heating and Ventilation Air Conditioning
M&E	Mechanical and Electrical
IAQ	Indoor Air Quality

CHAPTER 1

INTRODUCTION

1.1 Overview

In Malaysia, driven by the rapid climate change and as a thrust for Malaysia's construction industry to be more responsible, Pertubuhan Akitek Malaysia (PAM) in collaboration with the Association of Consulting Engineers Malaysia (ACEM) created the Green Building Index (GBI). This rating tool was officially launched in April 2009 (GBI, 2009) and has been used as a platform to assess green rated building in Malaysia by different categories. In today's world, the pursuit of having sustainable green rated buildings has become much more relevant and significant to the property owners and end-users globally. Meanwhile, the implementation of the green rating tool in Malaysia will promote sustainable development and escalate the awareness among building property owners or developers, architects, engineers, surveyors, town planners, landscape designers, contractors, and eventually by the public in relation to environmental issues. Indeed, it is the responsibility of the entire team including the end-users to ensure our next generation will be able to enjoy a better environment (Kassim et al., 2013). Around the globe, there are plenty of green building assessment tools with certification to suit environmental differential aspects such as internationally recognized certifications of Leadership in Energy and Environmental Design (LEED) in the United States of America, Building Research Establishment Environmental Assessment Method (BREEAM) in the United Kingdom, Canada's Building Environmental Performance Assessment Criteria (BEPAC), Japan's Comprehensive Assessment System for Built Environment Efficiency (CASBEE), Hong Kong's Building Environment Assessment Method (HK-BEAM), Taiwan's Green Building Evaluation System (EEWH), Vietnam Green Building Council (VGBC), Singapore's Green Mark, Australia's Green Star, and Green Building Index (GBI) in Malaysia. The aforementioned certifying green buildings agencies are certified by the World Green Building Council (WGBC). Indeed, GBI was not the only assessment tool being promoted in Malaysia in today's competitive industry. Figure 1.1 illustrates the Malaysian sustainability rating tools that includes GreenRE, MyCrest, Metereai Hijau Melaka, pH JKR, Comprehensive Assessment System for Built

Environment Efficiency (CASBEE), SUSDEX, and MyGHI besides GBI. It is important for the type of development to be identified at the pre-planning stage in order to adopt the suitable rating tool for building, township, or infrastructure development. According to Fuad (2012), GBI is highly focused on sustainable development as well as people-oriented in building design as well as practicability among the other assessment tools that are available in Malaysia. Furthermore, it was the earliest rating tool being adopted by various building industry professionals such as the Architects and Engineers. Six key elements that comprised of Energy Efficiency (EE), Indoor Environment Quality (EQ), Sustainable Site Planning & Management (SM), Material and Resources (MR), Water Efficiency (WE), and Innovation (IN) were used as the main assessment criteria emphasized in this study.

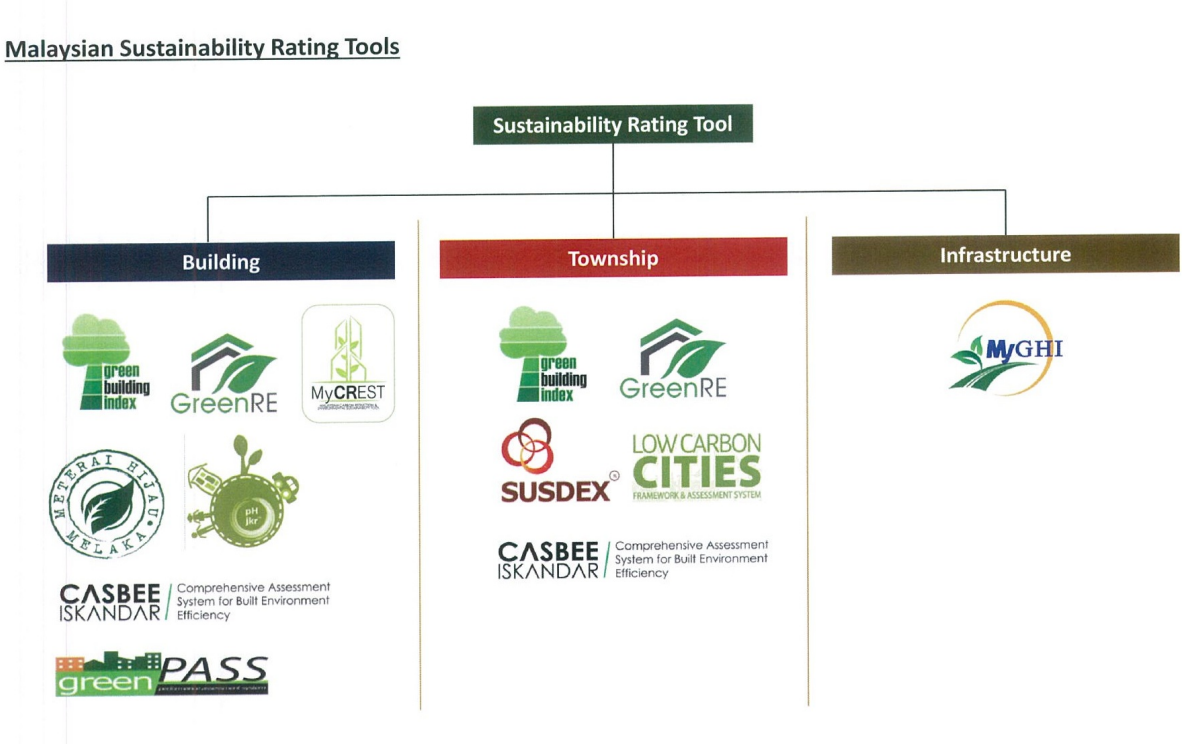


Figure 1.1 Malaysian Sustainability Rating Tools

In today's development, Malaysia's construction industry has grown competitively and more advanced in order to meet the people's needs. It is essential to carry out sustainable green building study in order to determine the actual cost savings in terms of the building's operation and maintenance factors (Kassim et al., 2013) as higher cost savings on a building's operation and maintenance at certain construction or development is possible as reported by Abu Bakar et al. (2010). However, the actual cost and percentage of saving has not been ventured by any researchers on the categories involving residential and non-residential buildings in Malaysia. However, a study from the University of Massachusetts reported that a comparative case study on the analysis and assessment of green building have been carried out in order to bring the attention of the government to impose the concept of 'green development', such as the practice of using the building's resources as well as materials to be more efficient while creating healthier and more energy-efficient buildings (Haidee, 2009). The concept of green development has become more prevalent in recent years and many state governments in Malaysia have begun to promote various levels of green building practices especially in Selangor, Pulau Pinang, and Johor in order to reduce the negative environmental impacts from the construction activities.

GBI has been used to evaluate the sustainable design concepts being implemented by the building owners, developers, consultants, and designers to achieve the category of green certification of certified, silver, gold, and platinum ratings. The capital invested in fixed assets and life-cycle cost connection to attain several ratings on green building either for residential or non-residential buildings are the predetermined points for most of the industrial practitioners, whereby the conversion from certified to silver, gold, or platinum rating will lead to a certain cost range such as the Rafflesia Hill project in Johor Bahru, Johor for residential building and the MBSA Banquet Commercial Hall in Shah Alam, Selangor for non-residential building (Neapoli, 2013). However, it will result in greater demands for green rated buildings from the potential purchasers, tenants, and investors whereby their interest in these properties increases the expectations of the property market. A study by the World Green Building Councils (WGBC) have found that green buildings are able to reduce the building's operating and maintenance costs as much as 9%,

increase the asset's values by 7.5%, and 6.6% increment for return on investment annually (Stuart, 2012). Sustainable green development, either new or refurbished aged building, can be build and developed in various ways; with the key savings drivers on 'Electricity' and 'Water' utilities being favoured in the quest for the highest green building 'Platinum' rating solution (Tan, 2008). As such, green rated building does not only possess ecological and environmental benefits, but it is economical too.

Ultimately, this study will create awareness on the actual differences between the two building categories, which are residential and non-residential building by specifically analysing the building's operation and maintenance frequency service costs calculation. For industry practitioners, this study may be applied into their project's feasibility study at the pre-planning stage as well as post-construction costing to the handing over of the units to the homebuyers. It can be applied as cost projection on maintenance fees to be paid-off. Furthermore, in year 2017 under the Strata Management Act 2013, the Department of Lands and Mines Malaysia in collaboration with local councils have implemented the compulsory requirement to include the building maintenance costs, category of buildings as well as detailed elements of the building in the Certificate of Share Unit Formula or its acronym SIFUS application prior to the issuance of Certificate of Completion and Compliance (CCC) by the project architect. Eventually, this study will create the awareness of the importance of GBI implementation by the use of collected actual data supported by potential outcomes.

1.2 Problem Statement

The rapid and continuous development in the construction and property development activities across the globe are generating constraint on natural and environmental resources. It is frequently mentioned that the property and construction industry is a significant and prime contributor to the global warming issue due to extensive emissions of greenhouse gases from the energy usages in buildings (Tan, 2008). Relatively, this industry indeed has grown tremendously for the past decades and yet will continue to expand. The industry itself is responsible for approximately 4%–5% of the global particulate emission, which make them one of the main agenda in polluting the air and water (John & Kirk, 1998). Various agencies such as the Professional Architect Malaysia (PAM), Real Estate and Housing Developers' Association (REHDA), Institute of Engineer Malaysia (IEM) and many more have introduced the practicability and awareness of the advantages of GBI to the public. The execution of GBI in Malaysia by the industrial practitioners especially the property developers are still at the infancy level. A search through related literature revealed that very few studies had been done on the comparison of residential and non-residential buildings; most of it merely concerned on theoretical study point of view such as elaboration of cost saving materials on GBI rated buildings. Furthermore, it was difficult to gain access and opportunities to the actual analysis data involving the building's operation and maintenance costs from most of the property developers in Malaysia compared to general estimation that have been practiced by building management team (Anthony, 2011).

As such, industry professionals constantly create and invent many ways to ensure the construction industry practitioners play their part and contribute to save Mother Nature. Furthermore, a report by the American Institute of Architects (AIA) information published in the year 2000 stated that the biggest source of emissions and energy consumption both in the United States and around the globe is from the construction industry. In a statement presented to the International Investors Group on climate change, Kruse (2004) explained that the, the cement sector alone accounted for 5% of global man-made carbon dioxide emissions.

Developing nation like Malaysia acknowledged the construction industry to contribute essential role to the nation's financial capability. There are few weaknesses and challenges that are required to be improved in this industry in terms of productivity, quality, safety, technology, and management. The book of "Malaysia's Vision 2020" published in the year 1993 described the nation's ambitions and future opportunities to be explored. One of the fundamental principal to achieve the vision and goal is to lead the nation to be more ecologically sustainable. This vision has become a motivation towards the nation's sustainability agenda. Recently, more property developers are continuously taking initiatives and unites with the green movement by promoting sustainable development or commonly known as GBI buildings. For instance, established and prominent local developers like SP Setia Berhad, Sunway Berhad, IJM Land Berhad, Ken Holdings Berhad, and Sime Darby Property Berhad have moved toward this direction. However, there are still plenty of property developers in Malaysia who have not emphasized the prime concept of "GBI Building". By adopting the sustainable approach into the property development business point of view, the developers do not only satisfy their own corporate responsibilities services, but will entice the increasing numbers of environmentally conscious consumers and likely to encourage the long-term economic benefits of going green (Lee, 2010). Nevertheless, this still remains a challenge for the developers to promote, operate, and maintain their building after completion. For end-users, the main problem is not the lack of information and awareness of green buildings. Ironically, they often find themselves bombarded with too much information and too much technical jargon in regard to green rated building.

To date, property developers understand that certified green rated projects incur additional construction budget from 1%–5% greater than the budget for conventional and affordable property projects, while, "Platinum" rating building had budget that were 10%–12% greater than conventional building (Geoff et al., 2003). These developments are essential in teaching about new possibilities and technologies by bringing green rated building to the attention of new and established developers and eventually to the potential buyers or public. From many of the published articles, conventional buildings still lack in many

green elements such as the basic element of the building's orientation, natural lighting, green planting, and landscaping. As such, the lack of publication and marketing on these products may act as an obstruction for the developers to opt for sustainable green buildings. According to James Chua the Executive Director of Malaysia Green Real Estate, although some of the developers generate huge income on the building's operation and management, some does not; this is due to the lack of building management knowledge and high level of difficulties in managing and executing the building's operation and maintenance works. However, once all these add up, people will see the worth and significance of the green buildings in terms of cash saving value. Today's construction industry practices still lack of study considered for green rated building's operation and maintenance actual costs incurred compared to conventional buildings (Mashitoh, 2012). This study will provide selected case study information that will ultimately create the awareness on the actual differences between residential and non-residential building specifically on the building's operation and maintenance frequency service costs calculation.

1.3 Aim of Research

The prime aim of this study is to compare the operation and maintenance actual cost for a green and non-green rated building category.

1.4 Objective of Research

There are three research objectives to be achieved in this study:

(i) To identify the types of maintenance in terms of replacement frequency of service and cost involved within a consistent period of 12 months operation for green and non-green rated building;

(ii) To record the cost implication of key saving drivers on 'Electricity' and 'Water' utility consumption for green and non-green rated building and;

(iii) To compare both operation and maintenance actual cost distribution in green and non-green rated building.

1.5 Scope of Research

Sustainable green building is a broad subject to explore with plenty of scopes that have yet to be discussed by researchers. There are various assessment tools available in Malaysia since the year 2009. This study involves the study of Green Building Index (GBI) as the pioneer among other assessment tools implemented in Malaysia. It focuses on the elements of residential and non-residential building and the identification process of the selected building in terms of the building's operation and maintenance services cost such as the building's materials replacement frequency due to wear and tear after certain period of usage, depletion of natural resources, and increment of actual operation costs for electricity and water utilities consumption.

The selection of the building's operation and maintenance cost implication is based on six key elements from GBI which are Energy Efficiency (EE), Indoor Environment Quality (EQ), Sustainable Site Planning & Management (SM), Material and Resources (MR), Water Efficiency (WE), and Innovation (IN). Each of the elements from the selected buildings was identified and analysed, whereby the selection criteria must fulfil the six elements stated above. Any criteria that did not adhere to the above-mentioned elements will be excluded from this study. The recent unavoidable price hike for electricity tariff and huge energy losses each year along with insufficient water supply have created the interest and demand for understanding to prove the acceptance and cost savings of GBI rated buildings in states like Selangor and Penang. It is important to understand that the cost of living in relation to the building's maintenance costs is equally important as tenants or end-users to ensure the amount or sum of money they pay for the maintenance fee is sufficient to maintain their property. In this study, maintenance elements are focused on the green building products that will be elaborated in Chapter 2 (Literature Review) for each of the selected green materials. From the selection of green materials, similar items found on the selected non-GBI rated building were used to compare the replacement works cost throughout 12 months of full building operations. The analysis of replacement frequency and costs are discussed in Chapter 4.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Sustainable green building construction has been rapidly growing since the introduction of sustainable process in the year 2009. The development of sustainable green building has driven more affirmative action, proactive, and improved economic benefits as a prove and evident on the prominent development especially on residential and commercial building in Malaysia (Nazirah, 2009). Furthermore, most of the people in the industry and investors are likely to relate the green rated buildings to higher investment in terms of the building's selling price (Nazirah, 2009). This belief on higher initial cost of a building's price has proven to be false assumptions when building professionals together with green building materials manufacturers and suppliers have found various ways to achieve better savings in upfront costs which meant pre and post construction period (Means, 2011). Furthermore, this chapter focuses and introduces the benefits of sustainable development, the significance of the green rated buildings, and brief introduction and concept of the Green Building Index (GBI) besides the main objective and aim to focus on the building's operation and maintenance frequency services in terms of actual cost implications. From the GBI annual report, about 318 units have applied for the residential category of green building, while 483 units have applied for the non-residential category of green building (GBI, 2018). Before delving deeper into the research, it is essential to understand the fundamental classifications of GBI in Malaysia.

2.2 Green Building Development in Malaysia

The GBI in Malaysia was founded in January 2009 and started at the Green Design Forum that was organized by the Architectural Association of Malaysia or Pertubuhan Akitek Malaysia (PAM). It was deemed necessary for Malaysia's construction industry to come up with a green rating tool created to allow adaptation to the tropical climate in order to preserve the environment and create the awareness on norm construction practices.

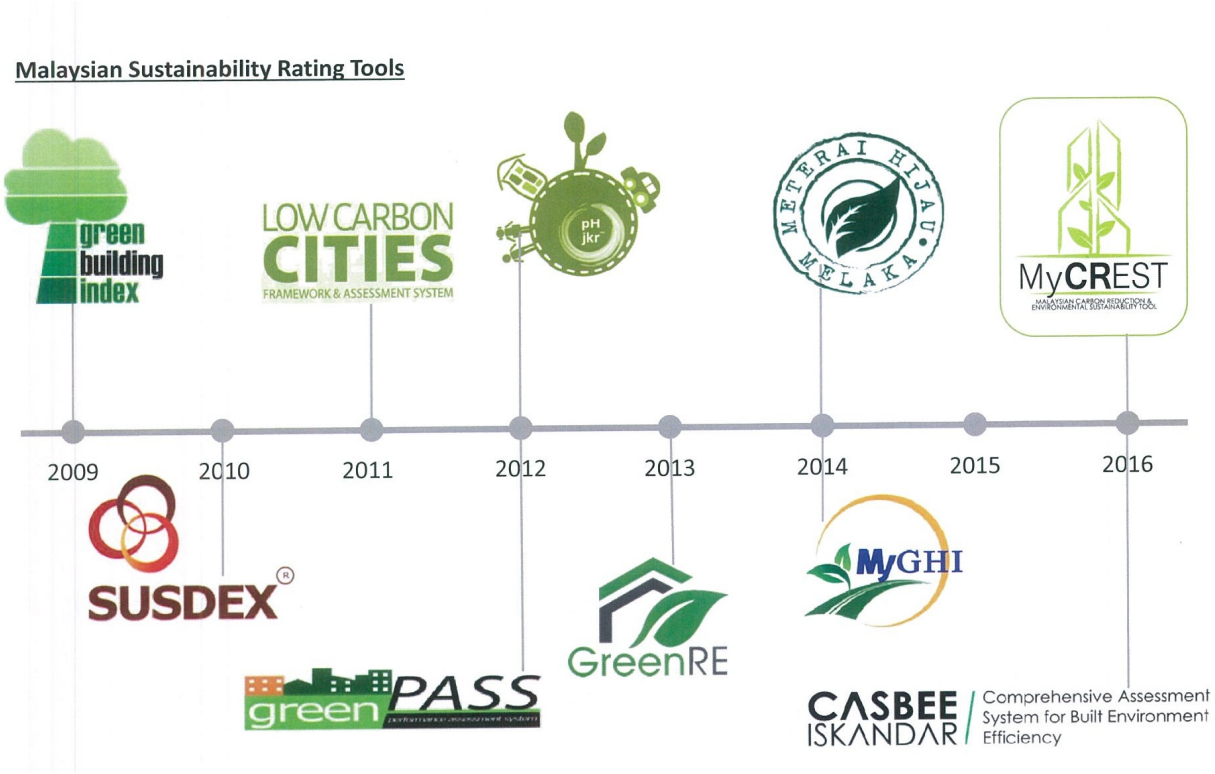


Figure 2.1 Malaysian Sustainability Rating Tools History

A few international standards and rating systems has been monitored and evaluated as a guideline to the GBI rating system such the United Kingdom's BREEAM (Building Research Establishment Environmental Assessment Method) and the United States of America's LEED (Leadership in Energy and Environmental Design). Many researchers believed that the federal and state government has been promoting the sustainable green building effectively (Atsusaka, 2003; Samari, 2012). Plenty of efforts were applied to ensure the effectiveness of the green buildings such as enforcing supporting additional

rules and regulations as well as instruments prior to the sustainable development. However, most of the researchers argued on the most effective instrument for the selection and analysis of GBI in Malaysia. More assessment tools have introduced since year 2010 as illustrate in figure 2.1 above. For instance, Shafiie and Othman (2005) pointed out there are many impediments to promote sustainable green development in Asia. These are due to lack of awareness especially towards the end-users, lack of training and mode of education about sustainable design, green building set-up cost, special green materials, effective rules and regulation, lack of green technology, and eventually discouraging market demand. Moreover, three important barriers to green building development existed as explained by Handan (2012):

(i) Builder Incentives: Energy saving and worker productivity are popular benefits of green rated buildings. These benefits have positive effects on the end-users, but imposed extra cost for the builders. Hence, cost efficiency is the main obstacle in green building development.

(ii) Product Information and Sourcing: The common obstacle to green building development in developing countries is the lack of green product information and knowledge for high-performance and greener building systems. This obstacle leads the developers to hire specialized consultants.

(iii) Client Awareness: The effective ways to remove this barrier are to introduce a credible evidence of the advantages of green rated building and long-term studies to prove the benefits of green rated building.

Green rated building referred to a building's structure with environmental friendly design framework and utilizes effective resources on the building's life cycle from the aspects of building's orientation and architectural façade design specifically to receive more natural ventilation and lighting, construction management, operation and maintenance, interior design, and perhaps refurbishment works (Han and Daan, 2012). Although impromptu creation in regard to building technologies are rapidly developing in order to improve the present practices by generating greener building with advanced construction

technologies, the primary objective still emphasized on the building's orientation design in order to minimize the severe impact from the built environment towards surrounding people and natural resources (Jones, 2008).

The followings are the outlines of the benefits of green rated buildings according to Jones (2008):

(i) Green buildings are designed to save energy and resources, recycle materials, and minimize the emission of toxic substances throughout its life cycle.

(ii) Green buildings harmonize with the local climate, traditions, culture, and the surrounding environment.

(iii) Green buildings are able to sustain and improve the quality of human life whilst maintaining the capacity of the ecosystem at local and global levels.

(iv) Green buildings make efficient use of resources; have significant operational savings and increases workplace productivity.

(v) Green building also sends the right message about a company or organization that is well run, responsible, and committed to the future also known as recognition to the company.

The perspective of GBI on sustainability is a general term for the community and society to enjoy long term viability of better environment. In order to achieve GBI certification, the core classification for creating sustainable development for building, infrastructures, and townships; particularly in Malaysia may need to be conducted. It comprises of well-planned and designed development concept, safe and secure living compound, and improving natural environment or greener products. Since it was first introduced in 2009, the reliability and criteria for building assessment is more geared towards the GBI. Thus, this study adopts the GBI concept as the building assessment tool.

The core categories for the sustainable development in Malaysia are as follows (Jones, 2008):

(i) Climate, Energy, and Water

Sustainable townships are balanced in their on-going production and consumption of energy and water. They aim for zero net carbon emissions by maximizing passive design principles, minimizing the impact of heat island effect, minimizing energy consumption, adopting on-site energy generation, and utilizing renewable energy technologies such as co-generation and micro-generation. They adopt the water neutral concept through the reduction of main water consumption, rainwater harvesting, and grey water recycling.

(ii) Ecology and Environment

Sustainable townships respect their surrounding environment and native ecological systems. They are sensitive to the needs of the local ecology and biodiversity with the aim to preserve and enhance the ecological value of the natural environment. They assist in stabilizing land and subsidence by reducing the impact of flooding and erosion.

(iii) Community Planning and Design

Sustainable townships are planned and designed for the benefit of the community. They are created using an integrated approach to master planning and best practiced urban design principles emphasizing people's priority and green spaces. Such goals help create a strong sense of place for communities resulting in more liveable and diverse neighbourhoods.

(iv) Transportation and Connectivity

Sustainable townships are well-connected places that have a broad range of transportation options. They have excellent accessibility, connectivity, and are well-linked to surrounding districts. They make good use of existing transport links and make priority and provision for future services such as transit rail, bus, and cycling networks.

(v) Building and Resources

Sustainable townships have low impact resources by applying the 'more from less' principle. They emphasize the need to minimize the use of highly resource-intensive materials by using a life cycle approach. They make effective use of local materials and resources for the construction of new communities.

(vi) Business and Innovation

Sustainable townships are tailored to respond to local needs in creating business and employment whilst incorporating innovative solutions. They provide employment opportunities for its residents to work closer to their homes and schools. They provide avenues for businesses to form and flourish. They demonstrate best practices through the implementation of innovative technologies and solutions at many different levels of the township.

There are no significant differences between GBI and non-GBI rated building in terms of the building's façade, appearances or other general aspects like building height, number of units, building orientation, etc. Specifically, GBI rated building have improved indoor environment and provides more operational savings compares to Non-GBI. Moreover, GBI rated buildings have been identified by the previous researchers to have tangible and intangible benefits (Rosenfeld, 2012). Tangible benefits on the economic advantages are not immediately visible. Lifetime payback is much higher compared to that of conventional building as non-GBI building, which mainly accrue from operational and maintenance cost savings, reduced carbon emission credits and potentially higher rental or high building's capital values (Fisk, 2013). The intangible benefits such as social advantages are due to the positive impact of green rated building in the neighbourhood's environment (Rosenfeld, 2012).

2.3 GBI Rating System

GBI rating on each of the evaluated building are based on the six key elements as stated in the GBI Township Tool Framework (dated 4th December 2010) as shown below. These key elements would be the main criteria and application tools to apply on this research study:-

(i) Energy Efficiency (EE)

Improve energy consumption by optimizing building orientation, minimizing solar heat gain through the building envelope, harvesting natural lighting, adopting the best practices in building services including use of renewable energy and ensuring proper testing, commissioning and regular maintenance.

(ii) Indoor Environment Quality (EQ)

Achieve good quality performance in indoor air quality, acoustics, visual and thermal comfort. These will involve the use of low volatile organic compound materials, application of quality air filtration as well as proper control of air temperature, movement and humidity.

(iii) Sustainable Site Planning and Management (SM)

The selection of appropriate sites with planned access to public transportation, community services, open spaces, and landscaping. Avoidance and conservation of environmentally sensitive areas through the redevelopment of the existing sites and brown-fields and in the same time implementation of proper construction management, storm water management, and reducing the strain on existing infrastructure capacity.

(iv) Material and Resources (MR)

Promotion of the use of environment-friendly materials sourced from sustainable recycled sources and implementation of proper construction waste management with storage, collection, and re-use of recyclables and construction formwork and waste.

(v) Water Efficiency (WE)

Rainwater harvesting, water recycling, and water-saving fittings such as sensor wash tap.

(vi) Innovation (IN)

Innovation design and initiatives that meet the objectives of the GBI

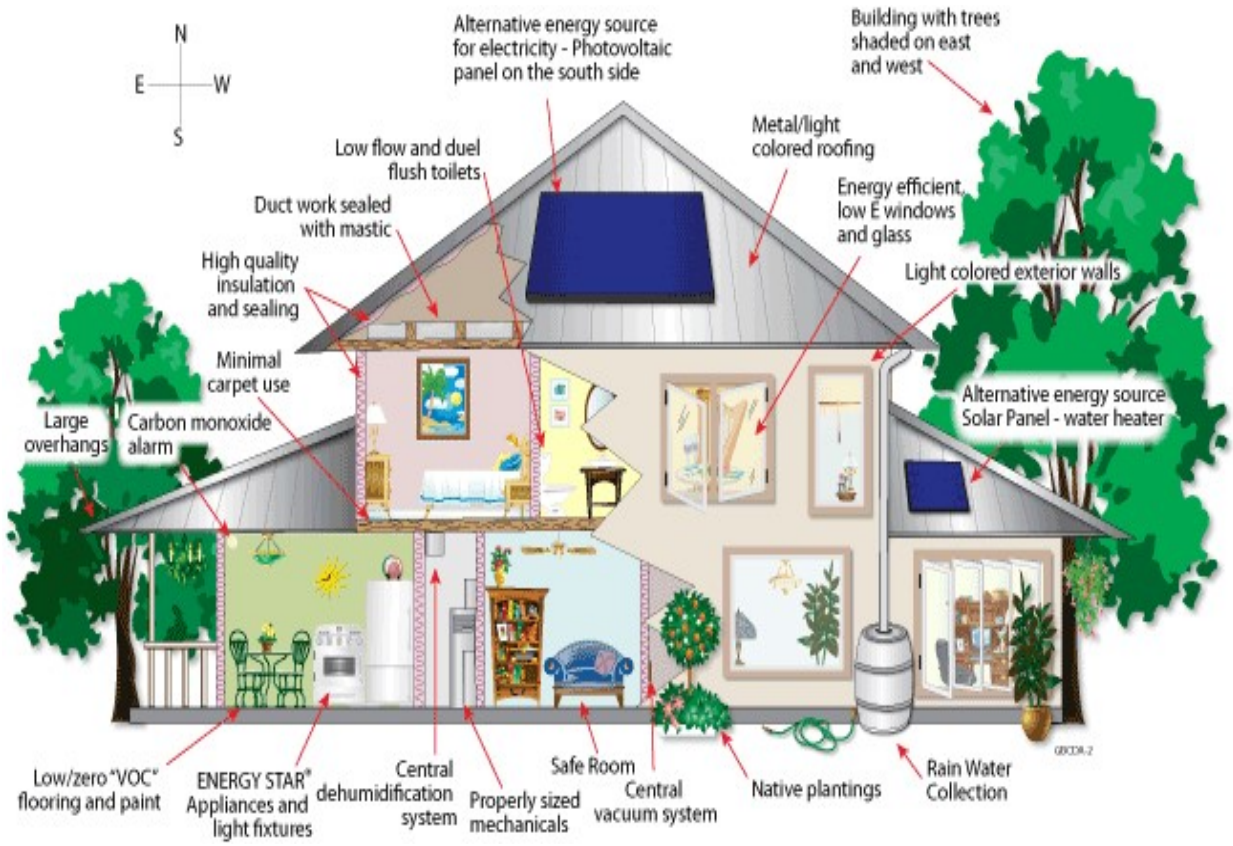
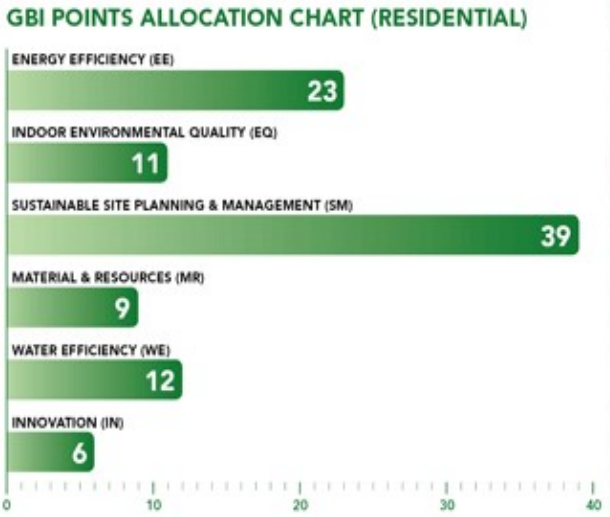


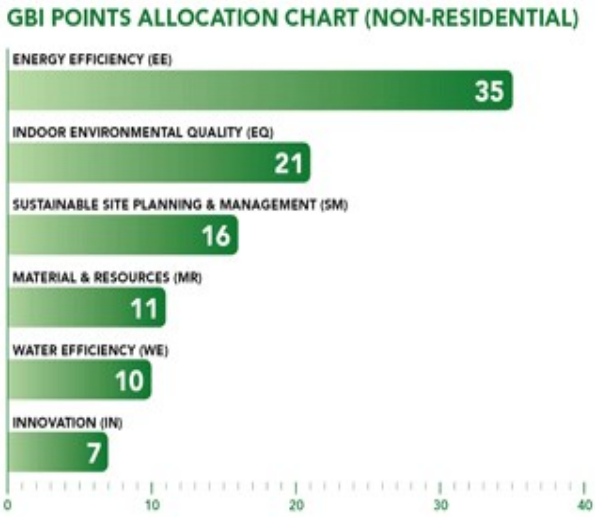
Figure 2.2: Cross Section of Green Building

Source: Energy Efficiency and Renewable Energy, US Department of Energy

The rating system is comprised of two main categories; residential and non-residential buildings in Malaysia. Residential category of building consists of linked terrace houses, condominiums, apartments, townhouses, semi-detached houses, and bungalows. The full implementation of the six key elements in the green building residential category is illustrated in Figure 2.2 and it was used as a guideline for the selection of buildings in this study. This category of GBI rating analyses highly emphasized sustainable site planning and management as illustrated in Table 2.1 below. This to ensure and encourage the building owners, developers, and tenants or end-users to take into consideration the environmental quality of their buildings and homes with provision to public transport access, infrastructures' connectivity, and community services. Out of the six key criteria shown above, the GBI points allocation chart for "Residential" and "Non-Residential" category are as shown below:-

Table 2.1: GBI Points Allocated Chart





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

PART	ITEM	MAXIMUM POINTS
1	Energy Efficiency	35
2	Indoor Environmental Quality	21
3	Sustainable Site Planning & Management	16
4	Material & Resources	11
5	Water Efficiency	10
6	Innovation	7
	TOTAL SCORE	100

Source: GBI Township Tool Framework (GBI, 2010)

The GBI Points Allocation Charts (Table 2.1) was endorsed and approved by the PAM council in year 2008 via the accreditation panel of Green Building Index Sdn. Bhd. The highest point of differences rating recorded between residential to non-residential building is the sustainable site planning and management, which are recorded at maximum points of 39 and 16 respectively. It is due to the development of the residential township that is much more concerned on the environmental achievement. Whereas, the highest point differences rating between non-residential to residential building is on the energy efficiency recorded at 12 points variance. This is due to non-residential development tended to be on a large scale of development. For instance, the efficiency of the mechanical and electrical systems of shopping malls and factory buildings are of top priority in order to be categorized as green building.

Eventually, the GBI classification that is required by the examined buildings should exceed a minimum total of 50 points from the abovementioned six key criteria in order to be certified as green rated building.

Table 2.2: GBI Classification

Points	GBI Rating
86+ points	Platinum
76 to 85 points	Gold
66 to 75 points	Silver
50 to 65 points	Certified

Source: GBI Township Tool Framework (GBI, 2010)

Below are the projects reference for GBI accredited as "Green Building" status in Malaysia:-

(i) Setia City Mall, Setia Alam, Selangor Darul Ehsan

GBI Rating	Silver
Certificate No.	GBI-NRNC-0007
Certification Date	10 July 2013
Building Category	Non-Residential New Construction (NRNC)

Figure 2.3: Setia City Mall, Setia Alam Shah Alam Selangor Darul Ehsan

Setia City Mall has achieved Singapore's Building and Construction Authority (BCA) Green Mark Gold Award and is also a candidate of the Malaysian GBI pilot accreditation scheme. High efficiency motor, chiller performance, water pumps and fans (80% better efficiency than local building code requirement) with cooling tower working at 50% improved efficiency, 24% efficiency improvement for air distribution, 50% less energy saving lights with daylight sensor, and escalators slowing down and lifts goes on sleep mode when not in use are the green utility consumption features available in this shopping mall. Low emission glazing and low wall to window ratio created an efficient building envelop. Other features include manual push door to outside park, natural ventilation on car park floors and acoustic insulations, indoor temperature fixed at 26 °C, relative humidity of less than 70% for the entire indoor vicinity, heat insulation on the atrium roof, and rainwater harvesting and drip irrigation to all planter boxes. Bio waste composting to produce organic fertiliser for the surrounding mall landscape and symphonic drainage system created better irrigation system while utilizing the natural resource. Building smoke spill to flush in fresh air, educational environment clips on LCD boards and electric car charging stations are also available. Water saving fittings for toilet flush and hand basins and water leak detection system with 16% saving of water daily by recycling condensed water from air conditioners are the best options to minimize the usage of water utility. Rainwater collection for daily construction work with special storage for harmful chemicals and paints, lightweight block system for external walls inclusive of sustainable materials for toilet cubicle partitions, ceiling boards and internal partitions, ozone friendly refrigerants as well as sustainability project management team and low Volatile Organic Compounds (VOC) paints are all applicable in this shopping mall in order to achieve the Green Building status.

(ii) G Tower, Jalan Tun Razak, Kuala Lumpur

GBI Rating	Certified
Certificate No.	GBI-NRNC-0012(P)
Certification Date	03 March 2011
Building Category	Non-Residential New Construction (NRNC)

Figure 2.4: G Tower, Jalan Tun Razak, Kuala Lumpur

The hotel operator of the GTower Hotel, Kuala Lumpur took their commitment to living green and reducing carbon footprint seriously. Strong environment-friendly credentials allow them to be placed in Malaysia's first internationally green-rated building (Singapore's BCA Green Mark Gold) along with their commitment to uphold the four tenets of environmental sustainability, which are Rethink, Reduce, Reuse, and Recycle. The professional project team of this building decided to challenge conventional building norms by constructing a building that would be more than just four walls, a window and a roof. They wanted GTower Hotel to be a construct of intelligence, integrity, ingenuity, and sensitivity. By rethinking key elements from site orientation to harnessing the latest sustainable green building technologies and systems available, GTower Hotel functions on energy more efficiently than a building of similar size. The professionals worked to reduce energy consumption by using double glazed low e-glass, allowing for maximum entry of natural light while minimizing the amount of heat transmission. They also

invested in a state-of-the-art chilled water centralized air-con chillers that circulate cool air through the rooms at lower energy consumption than traditional air-conditioning systems.

Light fixtures in the hotel utilize low energy LED lighting, energy saving PLC and T5 lighting providing ambient lux level, whilst minimizing energy consumption. Green food for thought, an LED light bulb can reduce energy consumption by 80%–90% and lasts around 100,000 hours. Day to day hotel operations often use a vast quantity of chemical cleansers and cleaning agents. The hotel also utilizes environmentally friendly cleaning agents that are good not only for the environment, but for their guests as well. The infinity pool, with the KL skyline as a backdrop is a showcase eco-friendly pool. To reduce the use of chemicals, salt is used to condition the water. The pool is heated from waste energy from the air conditioning units. The waste heat generated from the air conditioners is harvested using a sophisticated heat exchanger, providing warm water for the pool. All sanitary and tap fittings are green rated for water efficiency by reducing the usage of water, without affecting comfort levels.

The hotel operator is committed in reusing as many resources as possible, with the sophisticated building management system of GTower. They have created key water catchment areas to harvest rainwater that irrigates the building's green roofs and green walls throughout the building. These inbuilt green walls play an essential role as natural air purifiers, absorbing CO_2 and releasing oxygen in return to help maintain air quality. They just do not stop at conserving water, even waste heat from the air-con units are recovered and reused to generate hot water for the bathrooms.

Apart from that, in terms of management, an active recycling policy were maintained where housekeeping staff are educated on the proper methods of separating waste and disposing it into the recycle bins, while the interiors of room feature furnishings that have been made of recyclable materials or are recycled. Even the paint used on the room walls feature a low volatile organic compound (VOC), reducing toxicity,

and improving on indoor environmental quality. Hotel amenities and paper used are made from green or recycled materials.

(iii) The Haven Lakeside Residences, Ipoh Perak Darul Ridzuan

GBI Rating	Silver
Certificate No.	GBI-RNC-0032(P)
Certification Date	20 September 2012
Building Category	Residential New Construction (RNC)

Figure 2.5: The Haven Lakeside Residences, Ipoh Town, Perak Darul Ridzuan

Acclaimed as the "World's Best Value Condominium" and dubbed the "Haven on Earth", The Haven has long adopted green initiatives beyond the property's green nature and the Titiwangsa range as its backdrop. One has to spend at least a couple of days at The Haven to enjoy its serenity and fresh air in order to appreciate the intention behind the development of this property. According to Mr. Peter Chan, Chairman of The Haven Sdn. Bhd., most of the urban green criteria are not relevant in the valuation of the "greenness" of The Haven as it is not an urban project. Though it is situated on the outskirts of the city, it is a self-contained community where it caters to the convenience of a city life.

Although this development was not awarded maximum GBI points for being sited away from the bus terminal and railway station, a responsible and common sense approach was taken in preserving the project in its entirety, without over-emphasizing on the urban green initiatives. For instance, no trees were felled or rock formation blasted at the site to keep nature intact and pristine throughout and after the construction of buildings has been completed. In fact, to further enhance the environment, hundreds of trees and flora that are native to the area have been planted. In terms of ecology of the area, maximum windows and sliding doors are put in place to reduce the need for air conditioning, saving the use of excessive energy in Malaysia's tropical heat.

At The Haven, fans are preferred over air-conditioners. Buildings in The Haven are designed with maximum ventilation, lighting, and views for every unit. Buildings are designed to be split for unobstructed ventilation and look out to either the lake or hills. To serve this purpose, two low-level multi storey car parks are intentionally placed between and behind the three blocks of buildings. This is part of the building's orientation that emphasized the GBI key elements. Other green initiatives taken by the developer included the use of metal form-works in its construction, which are reusable, also the use of durable and high quality of building formworks. In other words, up to 10 times of recyclable building formworks if compare to conventional type of building formworks. Moreover, Shell Flintkote waterproofing paint for the exterior is applied to all condominium blocks, which could last up to 10 years.

In addition, rain-harvesting system is implemented in The Haven to ensure that water level in the lake remains constant. Additionally, special pits are created within the grounds of The Haven to decompose waste matter for use as organic fertilizers in the garden. This eliminates the need for chemical fertilizers to maintain the lush garden of the property. Meanwhile, for the disposal of household garbage, different coloured bins are provided for the separation of paper, plastic, bottles, and others for recycling purposes. These bins are available on all floors of the three blocks of buildings.

(iv) Sunway Resort City, Petaling Jaya, Selangor Darul Ehsan

GBI Rating	Silver
Certificate No.	GBI-T-0001(P)
Certification Date	29 June 2012
Building Category	Township (T)

Figure 2.6: Sunway Resort City, Petaling Jaya, Selangor Darul Ehsan

Sunway Resort City in Petaling Jaya, Selangor was awarded the Prestigious Silver Rating by Malaysia's GBI for being recognized as the First Green Township in Malaysia. The criteria set up by GBI for a sustainable township is for the township to have a minimum of 15% greenery. GBI is an industry-recognised green rating tool designed specifically for the tropical climate (hot and humid) and Malaysia's current social, infrastructure and economic development. GBI is a profession driven initiative developed by PAM and the Association of Consulting Engineers Malaysia (ACEM). It has the support of all the professional institutes, relevant government agencies, and the building or property industry. Sunway Resort City has been evaluated in six broad categories comprising of Climate, Energy & Water, Environmental & Ecology, Community Planning & Design, Transportation & Connectivity, Building and Resources, and Business & Innovation. Among the comprehensive green features of Sunway Resort City are lower ambient temperature to surrounding environment, minimized water usage, reduced need for

travel by car to essential facilities within reasonable walking distance, handicap-friendly infrastructure, secure design, health design, recycling facilities, community trust, reduction of travel by car, encouraged use of public transportation system, buildings, and resource and innovation.

To elaborate the green features stated above, development of the township have reduced 50% of public spaces while footpath are shaded with the provision of shaded green space to more than 20% of the development footprint. In terms of water utilization, more than 20% of potable water consumption was reduced and recycled for irrigation and general usage. Furthermore, the township was transformed from a barren ex-tin mining land to a bio-diversified secondary jungle in the Sunway Lagoon Theme Park with 22 bird species sighted. In terms of distance, a reduction in travel distance to essential amenities provided such as bank, convenient or grocery shop, police station, laundry, library, medical or dental, pharmacy, post office, restaurant, school, supermarket, and theatre is observed as all of them are within reasonable pedestrian network. Linkages and open spaces to the amenities are provided with universal accessibility. The streets are designed in such a way for it to have no dark corners, ill lighted streets, or dead-end streets to avoid any unforeseen safety issues. The secure design is emphasized in terms of regular security officer patrol and CCTV provision on the streets. The absence of any polluting industry in the vicinity contributed to the health being of the township. Wastewater from restaurants and hospital is properly treated before being discharged to the public drainage system. Recycling program is practised in all business units such as hospitals, Menara Sunway, Pyramid Mall, and universities and colleges. Sunway Group conducts annual recycling program with recycling facilities such as recycling bins placed in strategic areas, recycling centre with bin accessible by truck, and compactor station. Sunway Group continuously engages active dialog with existing community within the vicinity in order to address issues affecting the community to ensure the green rating township is well maintained. For connectivity within one place to another, walkway connection to all essential amenities located within walking distance and pedestrian network links to all transitory hubs with shaded and covered walkway was set up. Building materials used in the development of the township comprised of 70% construction materials extracted and

manufactured within 500 km radius to reduce the impact of carbon emission from transportation and quality construction as proposed by the Qlassic score. Future construction is to adopt construction waste management plan such as the future plan to recycle lake water to serve toilets and general usage for the Pyramid Shopping Mall that target to save 30% of water usages in this township throughout a year.

Table 2.3: GBI Certified Projects by Rating Categories

GBI CERTIFIED PROJECTS BY RATING CATEGORIES							
RATING	**Total as of 15 October 2014**	**NRNC**	**RNC**	**NREB**	**INC**	**IEB**	**T**
Platinum 86 to 100 points	12 (5%)	6	4	-	1	-	1
Gold 74 to 85 points	60 (24%)	38	21	1	-	-	-
Silver 66 to 75 points	32 (13%)	17	12	-	1	-	2
Certified 50 to 65 points	144 (56%)	56	75	4	5	1	3
Total Certified	**248**	**114**	**112**	**5**	**7**	**1**	**6**

Note: NRNC= Non Residential New Construction, RNC= Residential New Construction,

INC= Industrial New Construction, NREB= Non Residential Existing Building,

IEB= Industrial Existing Building, T= Township

Source: Green Building Index Monthly Report, Executive Summary as of 15 October 2014

Table 2.3 above lists the six categories of projects categorized under the GBI in Malaysia, which are Non-Residential New Construction (NRNC), Residential New Construction (RNC), Industrial New Construction (INC), Non-Residential Existing Building (NREB), Industrial Existing Building (IEB), and Township (T). Throughout the green building certification process, the highest certification was recorded on the NRNC and RNC that were considered to be more significant and have higher impacts compared to other categories. As a result, this study focuses on these categories of buildings, which are non-residential and residential buildings in Malaysia.

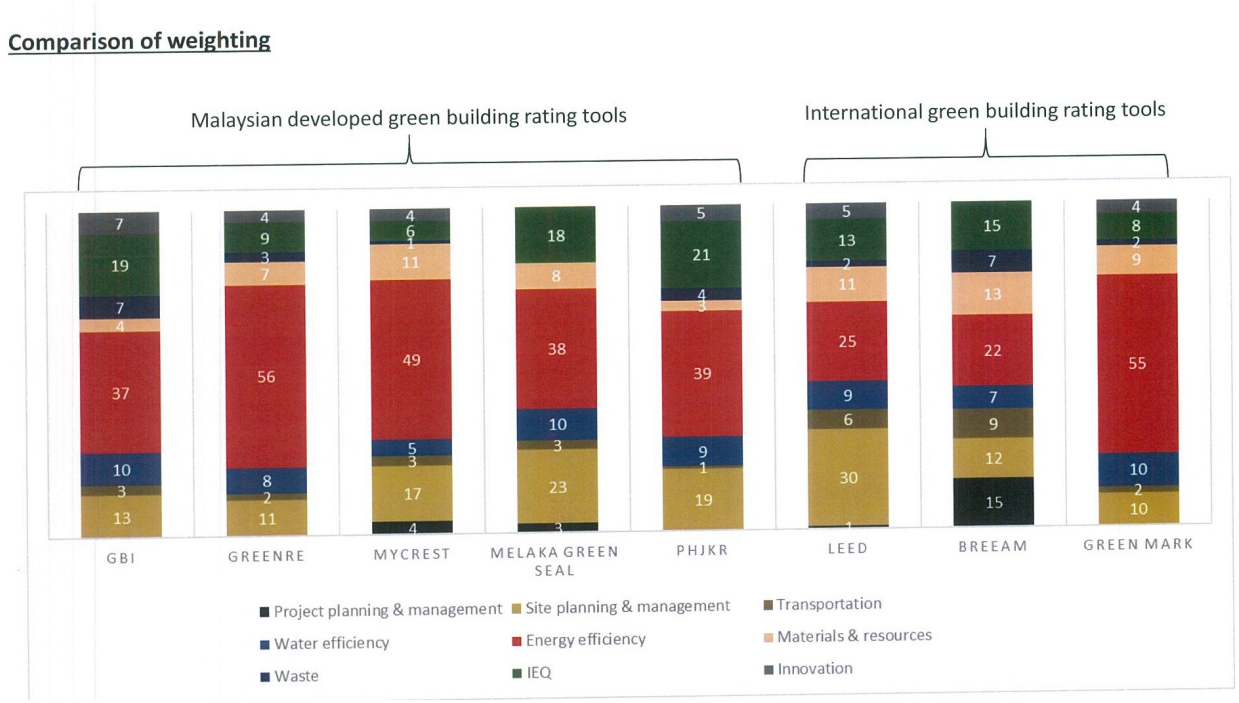


Figure 2.7 Comparison of Weighting in GBI

From Figure 2.7, the GBI is more consistent in terms of the six key elements upon comparison of weighting among all eight other green building assessment tools applied locally and internationally. GBI is more suitable and specifically meant for the tropical climate (hot and humid) and Malaysia's current social, infrastructure, and economic development. The summary for the assessment tools in Malaysia via the collected data and analysis of the assessment on comprehensive & effectiveness (Figure 2.9).

Table 2.4 Assessment tools in Malaysia on Comprehensiveness & Effectiveness

Rating Tool	Comprehensiveness			Effectiveness		
	Applicability	**Technical Content**	**Sustainability Coverage**	**Usability**	**Communicability**	**System Maturity**
GBI	Very Good	Very Good	Good	Good	Very Good	Very Good
GrenRE	Very Good	Very Good	Good	Good	Very Good	Very Good
MyCREST	Very Good	Very Good	Good	Good	Good	Good
CASBEE Iskandar	Very Good	Very Good	Good	Good	Good	Good
PHJKR	Fair	Good	Good	Good	Fair	Fair
Melaka Green Seal	Fair	Fair	Good	Good	Fair	Fair

The correlation analysis was carried out on collective data from surveys that have been conducted by GBI Malaysia in the year 2016 for five main assessment tools applicable in Malaysia (Figure 2.8). The data are compared in the weighting chart as shown in Figure 2.9 where the comprehensiveness and effectiveness of each of the assessment tools are identified. The modes of comparison are based on applicability, technical content, sustainability coverage, usability, communicability, and system maturity.

2.4 Building Operation and Maintenance Cost Saving

Buildings categorized as green rated operate and utilize lesser electricity, water, and natural resources; where it will indirectly reduce the material waste, but conversely will generate better and healthier living environment lifestyle for the occupants (Jones, 2008). The features of the GBI rated buildings consist of several sustainable features such as electricity and water utility efficiency, renewable energy and recyclable building materials and eco-friendly environment, perfect match on landscapes not only to beautify the spaces but to provide the savings on electricity consumption such as natural lighting, effective building management and control systems, and high comfortable level for indoor general spaces.

The building's operation and maintenance cost saving is the main agenda to be discussed by most of the building owners, developers, investors, and even end-users for both GBI and non-GBI rated building as explained in Figure 2.08. The interrelated factors between higher initial set-up or initial cost of construction with low operation and maintenance cost for the green rated building through the capability of tenants' to pay higher rental and maintenance fees are the key of understanding to pursue sustainable green development. In typical conventional buildings, electricity efficiency itself represents 20%–30% of the total building's operation expenses that is categorized as the largest expenditure on the building's utilities cost or also known as manageable building's expenditure (Eichholtz, Richard, and Anita, 2009). In the United States, Kats (2003) reported that the financial benefits of green design buildings are between $50 and $70 per square foot in a LEED building, which is over 10 times the additional cost associated with green rated building. The financial benefits are lower energy and electricity saving, lower water costs with less waste, lesser environmental and emissions costs, lower operational and maintenance costs, and increased productivity and health of the people. The study by Kats (2003) also demonstrated that green rated buildings are cost-effective buildings, which can be practiced and applied during the commencement of the building construction stage or pre-construction or planning stage for a better development in terms of costs and expenditures monitoring process. Gottfried (2006) also agreed that green rated buildings operating costs decreased by 8%–9% in the United States property market.

Conversely, the scenario in Malaysia is similar although the market for green rated buildings are still in the emerging phase. The Ministry of Finance (MOF), Malaysia highlighted that the impact on the operation and maintenance cost for green rated building specifically in non-residential category of commercial office building have already shown an advantage in terms of total cost saving around RM1.75 per square meter compared to the conventional office building in the first year of operation (Mashitoh, 2012).

Referring to the global opinion survey conducted by the World Business Council for sustainable green, green rated buildings are deemed to have 17% higher cost than conventional buildings (Turner and Frankel, 2008). Besides that, standard code-complaint buildings such as certified GBI rating building in Malaysia only cost 0%–4% more than conventional or non-GBI building (Wong et al., 2010). Zero cost on green rated buildings can be proven on the passive green design such as the building's design orientation, natural ventilation, natural lighting, cost of paint, and composited products (Herman, 2013). However, most of the researchers agreed that the figure generated was rather reasonable if one factor for the long-term cost savings and investment was replaced (Wong et al., 2010). Furthermore, referring to Farizan d'Avezac De Moran, Senior Partner at Green A Consultants Pte. Ltd. in Singapore, buildings going for green status will definitely involve cost impacts, but the savings and benefits will overtake and outweigh the initial cost in no time basis. The financial payback period for the property's owner typically exceeds greening costs by 4–6 times in a period of more than 10 years operation.

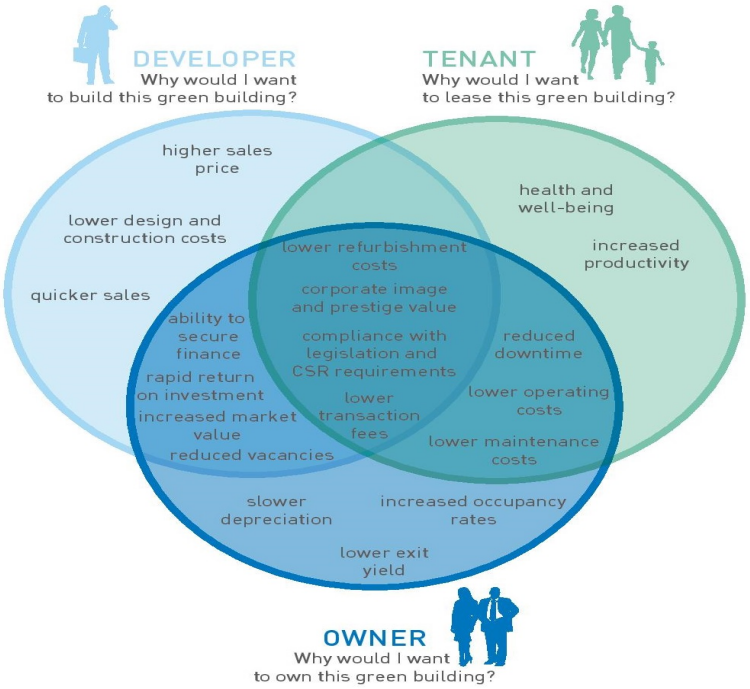


Figure 2.08 Life Cycle Wheel - Owner, Developer & Tenant

Source: World Green Building Council (WGBC) (2013)

In other developed countries, the obsolescence of non-green rated buildings are becoming more prominent by the great awareness on green rated building. Major super funds as well as trust and listed property are realizing that meeting corporate sustainability objectives, for themselves or their tenants, is a long term 'value added' on their asset (Chegut et al., 2012). The key players of the market struggled to calculate the value of green rated buildings because its benefits in terms of longer lifespan, reduced replacement, and lower operating cost are not easily expressed when accounting methods were used on depreciation factor only (Sayce et al., 2010). The move away from financial modelling that focuses on payback and capital cost reduction towards life-cycle costing on utility efficiency, resources and materials usage, and employees' productivity revealed a more accurate picture according to Sayce et al. (2010).

2.4.1 Electricity Savings

Property developers are highly encouraged to introduce greener building concept that deemed to be higher in construction cost, but yet higher return on investment and cost saving in terms of the building's operation and maintenance services in long term perspectives.

Table 2.5 Electricity Usages in Malaysia from Year 2000 to Year 2011

Year	Maximum Demand (MW)	Installed Capacity (MW)	Excess Capacity %
2000	950	2,518	62%
2001	1,012	2,828	64%
2002	1,049	2,666	61%
2003	1,085	2,788	61%
2004	1,108	2,795	60%
2005	1,121	2,957	62%
2006	1,202	3,254	63%
2007	1,284	3,294	61%
2008	1,361	3,294	59%
2009	1,437	3,267	56%
2010	1,529	3,267	53%
2011	1,601	3,213	50%

Note: Excluding demand of 132kV customers supplied via direct 132kV connection.

Source: Tenaga Nasional Berhad (TNB)

Referring to Table 2.5 above, electrical utility consumption recorded each year increase gradually on the total usage of electricity consumption, which is expected to continue to rise over the time. From the above data, there is more than 50% excess of consumption each year recorded by Tenaga Nasional Berhad (TNB) on the consumer's consumption and usage.

Building efficiency on electricity caused significant impact on the total building operation running costs, as a result of energy prices increase, operational electricity utility will become an utmost important driver to keep the buildings in cost saving mode (Geoff et al., 2003). According to a study by LEED in the United States for certified category of green rated building, an estimation of about 25%–30% reduction of green building electricity consumption was reported compared to a conventional code-compliant building (Cottrelle, 2010). Moreover, a study by Kats (2003) stated that higher level certification of green rated buildings often contributes to higher level percentages of electricity savings as shown in Figure 2.11 below. Besides that, in a similar study by Kats (2010), the 39% electricity consumption reduction was estimated compared to conventional building by the usage of renewable solar energy and other efficient green elements and fixtures.

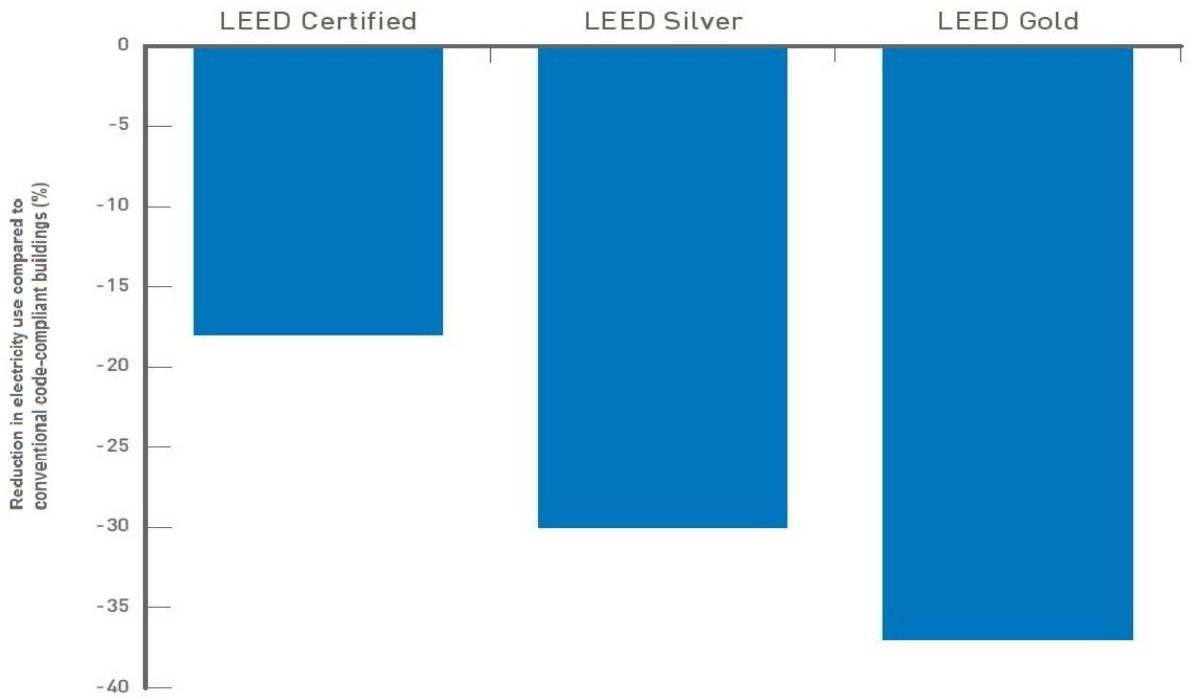


Figure 2.09 Relationship between Certification Levels with Electricity Usage

Source: World Green Building Council (WGBC, 2013)

Referring to Figure 2.091, the momentum of the green rated buildings retrofit or newly emerging market for electricity efficiency keeps increasing. Most of the developed countries are increasingly aware of the improper and inefficient usage of electricity toward the existing buildings aligned with the global energy reducing goals (WGBC, 2013). For instance, a study of buildings in Singapore revealed that the resulting electricity savings of a sample of building is 17% post retrofit (Yu et al., 2011). A case study by Transwestern, a private real estate firm from the United States, reported typical savings of 3%–15% on the utility bills on its managed properties that have undergone electricity performance upgrades (Bernstein et al., 2003). The prices of energy continue to rise from time to time beyond individual capability, therefore the outcome of electricity efficiency becomes essential and relevant in today's scenario. The highest electricity usage for commercial building and housing property is on the air-conditioning system (James, 2010). He believed that cost of savings from green rated buildings that used

less air conditioning alone would be enough to tempt most of the investors and owners to opt for such buildings.

Green building is one that focuses on reducing the impact of building towards the environment. A well-known designer and architect, KenYeang explained in his book *The Green Skyscraper*, that green rated buildings are designed, implemented, and managed in a manner that places the environment first (KenYeang, 2011). One of the key goals of the green rated building movement is to reduce the material, constructional and operational costs of buildings, and also to reduce the excessive depletion of natural resources. The new electricity tariffs are highlighted in table 2.5 and table 2.6 below.

(i) For Domestic Customers (Residential Category of Building)

The tariff will remain unchanged at RM0.218 cent/kWh for the first 200 kWh consumption per month – this constitutes nearly 50.4% (3.25 million) of all domestic users who pay RM43.60 or less monthly. About 20.3% or 1.3 million customers who fall within the consumption band from 201–300 kWh will not experience any increase at 33.40 cent/kWh. As an average calculation, the domestic customers will experience an increase of 10.6% of RM3.03 cent/kWh monthly.

Table 2.6: TNB Domestic Rate

TARIFF CATEGORY	CURRENT RATES (1 JUNE 2011)	NEW RATES (1 JANUARY 2014)
Tariff A - Domestic Tariff		
For the first 200 kWh (1 - 200 kWh) per month	21.80 sen/kWh	21.80 sen/kWh
For the next 100 kWh (201 - 300 kWh) per month	33.40 sen/kWh	33.40 sen/kWh
For the next 100 kWh (301 - 400 kWh) per month	40.00 sen/kWh	51.60 sen/kWh
For the first 100kWh (401 - 500 kWh) per month	40.20 sen/kWh	
For the next 100 kWh (501 - 600 kWh) per month	41.60 sen/kWh	
For the next 100 kWh (601 - 700 kWh) per month	42.60 sen/kWh	54.60 sen/kWh
For the next 100 kWh (701 - 800 kWh) per month	43.70 sen/kWh	
For the next 100 kWh (801 - 900 kWh) per month	45.30 sen/kWh	
For the next kWh (901 kWh onwards) per month	45.40 sen/kWh	57.10 sen/kWh
The minimum monthly charge is RM3.00		

Source TNB, http://www.tnb.com.my/residential/pricing-and-tariff.html, dated 23rd May 2015

(ii) For Commercial Customers (Non-Residential Category of Building)

The change in average tariff will be at RM0.691 cent/kWh. However, 10% discount for welfare homes, government schools, government institutions of higher learning, and places of worship is maintained. University teaching hospitals that are fully funded by the government under the Ministry of Education (USM, UKM, & UM) will also enjoy a 10% discount. These are the special rates implemented and gazetted by the federal government of Malaysia. Apart from that, there are different rates in terms of electricity charges between domestic and commercial type of buildings, which will be further analysed in this study.

Table 2.7: TNB Commercial Rate

	Tariff Category	Current Rates (1st June 2011)	New Rates (1st January 2014)
1.	**Tariff B - Low Voltage Commercial Tariff**		
	For Overall Monthly Consumption Between 0-200 kWh/month		
	For all kWh	39.3 sen/kWh	
	The minimum monthly charge is RM7.20		
	For Overall Monthly Consumption More Than 200 kWh/month		
	For all kWh (From 1kWh onwards)	43.0 sen/kWh	
	The minimum monthly charge is RM7.20		
	New Structure Effective 1 January 2014		
	For the first 200 kWh (1 -200 kWh) per month		43.5 sen/kWh
	For the next kWh (201 kWh onwards) per month		50.9 sen/kWh
	The minimum monthly charge is RM7.20		
2.	**Tariff C1 - Medium Voltage General Commercial Tariff**		
	For each kilowatt of maximum demand per month	RM25.90/kW	RM30.30/kW
	For all kWh	31.2 sen/kWh	36.5 sen/kWh
	The minimum monthly charge is RM600.00		
3.	**Tariff C2 - Medium Voltage Peak/Off-Peak Commercial Tariff**		
	For each kilowatt of maximum demand per month during the peak period	RM38.60/kW	RM45.10/kW
	For all kWh during the peak period	31.2 sen/kWh	36.5 sen/kWh
	For all kWh during the off-peak period	19.2 sen/kWh	22.4 sen/kWh

	The minimum monthly charge is RM600.00

Source TNB, http://www.tnb.com.my/residential/pricing-and-tariff.html, dated 23rd May 2015

2.4.2 Water Savings

Water, as we know is an essential element for life. Reducing water consumption and protecting water quality are key objectives in sustainable building. Critical issue of water consumption is the demands of the supplying aquifer exceeding its ability to replenish itself (Yoshida, 2011). To maximise the extent of feasibility, the facilities should increase their dependence on water being collected, used, purified, and reused on-site (Sugiura, 2011). The protection and conservation of water throughout the life of a building may be accomplished by designing dual plumbing that recycles water in toilet flushing or by using water for washing of the cars (Miller et al., 2009). In today's scenario, rainwater harvesting has been typically recognized as one of the innovative solution for sustainable green building development. Malaysia is moving towards achieving a developed nation status by the year 2020 following the rapid socioeconomic growth in the last two decades. With a present estimated total of 21 million people, Malaysian population is expected to increase and escalate approximate 30 million in year 2020, and cities and towns may achieve 55%–60% of the total population growth (Abu Bakar et al., 2010). Malaysia is blessed with plentiful water resources with an average annual rainfall of 3000 mm or 990 billion cubic meters over the Malaysian land mass amounts, which 566 billion cubic meters becomes surface runoff, 64 billion cubic meters recharges the aquifers, and 360 billion cubic meters returns to the atmosphere. A total of 97% of the raw water supply originates from surface water sources (Abu Bakar et al., 2010). However, conservation of this natural resource is equally important to avoid any shortfall, natural disasters or calamities, and any other unwanted circumstances. Thus, rainwater harvesting is not a new technique to collect and store water for later general use. It has been adopted thousands of years ago by our ancestors when the piped water system is not in existence. It is still in practice for certain areas where water supplies are low, insufficient, and expensive or of poor water quality in certain countries. Although the

water supply system has been improved, the demands keep increasing due to population growth and development as emphasized earlier. However, the prolonged dry period phenomena due to global weather change can be considered as another factor affecting water supply for the nation. The harvesting of rainwater involves the collection of rainwater from catchment area by conveying the water to storage tanks and subsequent delivery to the building. This will be another alternative for those end-users as potable and non-potable usages. The potable uses include drinking, cooking, bathing, and washing dishes. However, it was highly advisable that rainwater used for this purpose must be treated to remove the contaminants. Non-potable uses are ideal and match the needs of rainwater that include flushing toilets, watering garden, washing floor, and other domestic household usage. Green rated buildings use 20%–30% less water compared to similar conventional buildings and indirectly will reduce the operational water expenses (Jitender, 2015). Aforementioned, 70%–90% of used water is treated and reused for landscaping and air conditioning system especially for shopping complexes, government office building, cooperates buildings, convention hall, and much more (Jitender, 2015). This may reduce the load on the final discharge to the sewage system. Through the water conservation and the reuse of rainwater, green rated buildings save the operational costs and simultaneously promote sustainability. Water volume savings throughout the usage in every single household or other usage can be determined by using the simple formula below (Thamer et al., 2007):

Annual water saving = V1 – V2

Where V1 is the volume of water before construction of rainwater harvesting system and V2 is volume of water after construction of rainwater harvesting system.

According to Thamer et al. (2007), the use of rainwater technology can help to reduce the direct source of water supply on external works such as landscaping and external daily cleaning works. Besides landscaping works, this system can help to reduce flooding, control erosion, and improve water quality by holding on-site storm runoff as detention pond. It was proven to be easily operated and maintained, and indeed cost saving too.

The benefits of rainwater harvesting system towards the end-users, environment, and local government are described below (Jitender, 2015):-

(i) Independent and ample supply of water in the dwelling buildings.

(ii) Water received is free of any costs. Use of this water significantly reduces water bills for purchased water from local service provider or state government.

(iii) Costs incurred for purifying the water for potable usages are nominal.

(iv) For users located in the rural areas, an independent supply of water avoids the cost of installing a public water supply system.

(v) Harvesting rainwater is not only water conserving, it is also energy conserving since the energy input required to operate a centralized water system designed to treat and pump water over a vast service area is by-passed.

(vi) Reduce the burden for new investment to build, operate, and maintain additional water supply systems such as reservoirs, water treatment plants, and distribution systems necessary to meet the ever-increasing demands for water.

By adopting the water preservation system, huge savings can be generated, as the sole dependent supply from the direct water supply source will be diminished. The Jabatan Kerja Raya (JKR), Johor State Department drafted actual estimation for their own JKR's office that used to support the proposal of rainwater harvesting system as listed below:-

(i) Rainwater Harvesting System Costs Breakdown

Estimate of Cost for Installing a Rainwater Harvesting System = RM3, 000.00

C	= Initial Capital Cost	N	= Expected system life
C	= RM3, 000.00	N	= 20 Years
C/N	= RM150.00		
Operating Cost	= RM50.00		
Total Annual Cost	**= RM200.00**		

Rainwater Yield & Utilized = 252 meter cubic

* (JKR Johor Data, Year 2012)
* Tank capacity 1,000 L (Usage 30%)
* Balance 700 L per day × 30 days × 12 months

Unit Cost of Rainwater = Annual Cost/ Yield= **RM0.79/cubic meter**

(ii) Conventional Water Supply Costs Breakdown

Syarikat Air Johor (SAJ Holdings Sdn. Bhd.) Water Tariff Rate per meter as stated below:-

First Block 0–23 m^3 = RM0.60/m^3

Second Block 23–40 m^3 = RM1.65/m^3

Subsequence Block = RM2.96/m^3

Average Residential Usage for consumption more than **35 m^3 per month**

First Block 0–23m3 = RM0.60 × 23 m^3 = RM13.80

Second Block 23–40m3 = RM1.65 × 12 m^3 = RM19.80

Total Cost = RM33.60/35 m^3 = **RM0.96/cubic meter**

Can save up to 21% of water supply monthly with unit cost RM0.79 per cubic meter!

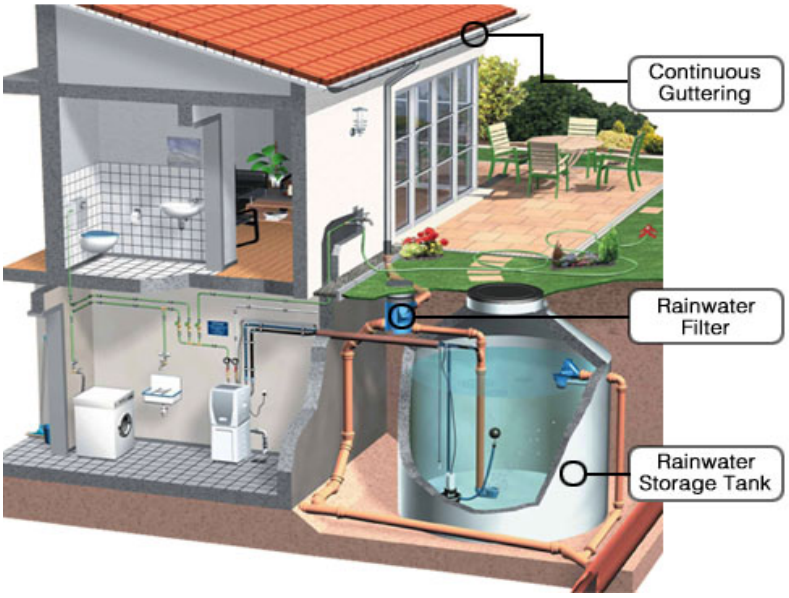


Figure 2.10: Rainwater Harvesting System

Source: Jabatan Kerja Raya (JKR) via http://www.jkrjohor.gov.my/

The calculation shown earlier is regarding the simple installation of rainwater harvesting system as illustrated in Figure 2.12 adopted by JKR Malaysia for the preliminary study of rainwater harvesting system implementation for all the JKR offices in Malaysia. From the findings, there is a high initial set-up costs for rainwater harvesting system compared to main water source without any new installation of water system apart from ready internal plumbing system for every residential or commercial unit. However, for the first year itself, about 20% of the cost saving was observed if the rainwater harvesting system was adopted in the area. Furthermore, it is expected to be more than 50% of cost saving if this system was maintained within 5 years with less maintenance and at an acceptable efficiency level.

Table 2.8 Water Usages in Pulau Pinang, Malaysia from Year 1999 to Year 2011

Year	Consumption (‘000 000 Cubic Metres)	% Increase
1999	195.8	-
2000	208.1	6.3
2001	216.4	4.0
2002	224.6	3.7
2003	223.4	-0.5
2004	233.1	4.3
2005	241.0	3.4
2006	249.4	3.5
2007	262.5	5.2
2008	272.4	3.8
2009	269.8	-1.0
2010	285.6	5.9
2011	283.2	-0.8

Source: Perbadanan Bekalan Air Pulau Pinang Sdn Bhd. (Selected State of Pulau Pinang)

Table 2.9: Water Usages in Selangor Darul Ehsan, Malaysia

Year	Average Scheduled Tariff (RM)	Rate of Increase (%)	Targeted NRW Reduction (%)	SYABAS's Actual NRW Reduction (%)
2005	1.21	-	-	-
2006	1.39	14.8	37.78	37.78
2009	1.90	36.6	27.98	35.45
2012	2.38	25.2	19.98	32.77
2015	2.86	20.1	15.48	-
2018	3.15	10.2	15.00	-
2021	3.31	5.0	15.00	-
2024	3.48	5.0	15.00	-
2027	3.65	4.9	15.00	-
2030	3.83	4.9	15.00	-

Source: Selangor Times Issue 118, Published 22nd February 2013.

(Selected State Government of Selangor Darul Ehsan)

Tables 2.8 and 2.9 shown above are the records of actual and projected usage of water utility for the state of Pulau Pinang and Selangor Darul Ehsan respectively. In Pulau Pinang, the consumers' consumption of water utility each year increases consistently except for the years 2003, 2009, and 2011, where it recorded minimal decrement on the total annual water usage. Whereas the state of Selangor Darul Ehsan is initiating the effort to minimize the usage of water consumption by generating 3 years state's target water consumption reduction plan. From the recorded data, the water supply from the year 2006–2012 kept increasing from 14.8%, 36.6%, and 25.2% for the years 2006, 2009 and 2012 respectively. The base of monitoring and controlling set by the state government is via increase of consumption and revision of water tariff rate every 3 years. The above data showed that the consumption of utilities increases from

year to year. Thus, the actual records particularly for electricity and water consumption is essential for further analysis in terms of utilities consumption if we were to adopt GBI building compared to non-GBI building.

In Malaysia, several water supply agencies are monitored under the supervision of Suruhanjaya Perkhidmatan Air Negara (SPAN) or also known as National Water Services Commission. It was gazetted under the Water Service Industry Act 2006 (WSIA) that has been enforced since January 1, 2008. Below are the water tariffs used and applied for each of the states in Malaysia. There are two main categories of water tariff in Malaysia namely domestic (residential) and commercial (non-residential) supplies. Domestic supplies cater towards residential homes, religious and public centre, and government buildings other than for commercial purposes. The premises involved under the commercial water supplies category are the industries, shop offices or shop houses, and other related commercial usage. All the water service charges are referred to the state's service provider as described in table 2.10 below. Each water service provider agency will impose their standard calculation water rate with the approval from the respective state government.

Table 2.10: Water Service Provider in Peninsular and East Malaysia

No	State	Abbreviation	Company Name
1	Johor Darul Takzim	SAJ	SAJ Holdings Sdn Bhd
2	Negeri Sembilan	SAINS	Syarikat Air Negeri Sembilan Sdn Bhd
3	Selangor Darul Ehsan / Wilayah Persekutuan Kuala Lumpur / Wilayah Persekutuan Putrajaya	SYABAS	Syarikat Bekalan Air Selangor Sdn Bhd
4	Pulau Pinang	PBA	Perbadanan Bekalan Air Pulau Pinang
5	Kedah Darul Aman	SADA	Syarikat Air Darul Aman Sdn Bhd
6	Pahang Darul Makmur	PULAPEL	Pengurusan Air Pahang Bhd
7	Perlis Indera Kayangan	PAAB	Pengurusan Asset Air Bhd
8	Kalantan Darul Naim	AKSA	Air Kelantan Sdn Bhd
9	Wilayah Persekutuan Labuan	JBA	Jabatan Bekalan Air
10	Melaka Darul Azim	SAMB	Syarikat Air Melaka Bhd
11	Terengganu Darul Takzim	SATU	Syarikat Air Terengganu Sdn Bhd
12	Perak Darul Ridzuan	LAP	Lembaga Air Perak
13	Kuching, Sarawak	KWB	Kuching Water Board
14	Sibu, Sarawak	SWB	Sibu Water Board
15	Sri Aman, Sarikei, Miri, Umbang, Kapit (All Sarawak)	LAKU	LAKU Management Sdn Bhd
16	Bintulu, Sarawak	LAKU	LAKU Management Sdn Bhd
17	Sabah	JANS	Jabatan Air Negeri Sabah

Source: Suruhanjaya Perkhidmatan Air Negara (SPAN), 2012

Table 2.11: Water Tariff in Malaysia

TYPE OF CHARGE	JOHOR	NEGERI SEMBILAN	SELANGOR / F. T. KUALA LUMPUR / F.T. PUTRAJAYA
DOMESTIC SUPPLIES **Residential Home**	0 - 20 m³ @ RM 0.60/m³ >20-35m³ @ RM 1.65/m³ > 35 m³ @ RM 2.96/m³ *Min Charge - RM 5.00*	0-20m³ @ RM 0.55/m³ >20-35m³ @ RM 0.85/m³ > 35m³@ RM 1.40/m³ *Min Charge - RM 5.00*	0-20m³ @ RM 0.57/m³ >20-35m³ @ RM 1.03/m³ >35m³ @ RM 2.00/m³ (Including government quarters with individual meter/account - private swimming pool) *Min Charge - RM 6.00*
Religious Institutions(Mosque/Surau/Madrasah/ Religious school) Management and surveillance under government)	- ditto -	RM 0.20/m³ in excess of free supply	RM 0.46/m³ *Min Charge - RM 6.00*
Charitable Organisations Management and surveillance under government)	- ditto -	*Min Charge - RM 3.00*	RM 0.58/m³ *Min Charge - RM 6.00*
Government Buildings, institution and Statutory Bodies	RM 2.80/m³ *Min Charge - RM 25.00* (Include Govt Hospital, Army camps, Prison Complex)	RM 0.80/m³ *Min Charge - RM 10.00*	RM 1.61/m³ *Min Charge - RM 17.00* (Inclusive of Schools - Gov Institution)
COMMERCIAL SUPPLIES **Industrial/commercial**	0-35 m3 @ RM 2.60/m³ > 35m3 @ RM 2.96/m³ Min Charge - RM 25.00/m³	0-35m³ @ RM 1.50/m³ >35m³ @ RM 1.60/m³ *Min Charge - RM 15.00*	0-35 m³ @ RM 2.07/m³ >35m³ @ RM 2.28/m³ (Inc.Public swimming pool, service apartments and ship houses) *Min Charge - RM 36.00*
Construction	- ditto -	- ditto -	- ditto -
Swimming Pool	- ditto -	RM 1.30/m³ *Min Charge - RM 15.00*	Private : As for residential Homes Public : As for Industrial/Commercial

TYPE OF CHARGE	PULAU PINANG	KEDAH	PAHANG
DOMESTIC SUPPLIES **Residential Home**	**Individual Meter** 0-20m³- RM 0.22/m³ >20-40m³ - RM 0.42/m³ >40-60m³ - RM 0.52/m³ >60-200m³ - RM 0.90/m³ >200m³ - RM 1.00/m³ Water conservation surcharge for water consumption exceeding 35m³ a month at residential premise - RM 0.24/m³ *Min Charge : RM 2.50* **Domestic (Bulk Rate)** 0-90 m³ · *Min Charge : RM 26.00* > 90 m³ - RM 0.35/m³	0-20 m³ - RM 0.50/m³ >20-35 m³ - RM 0.90/m³ > 35 m³ - RM 1.30/m³ *Min Charge : RM 6.00*	0-18 m³ @ RM 0.37/m³ 18-45m³ @ RM 0.79/m³ >45m³ @RM 0.99/m³ *Min Charges - RM 3.00* # Supply to residential from temporary treatment plants @ RM 0.33/m³
Religious Institutions **Management and surveillance under government)**	as per Domestic (Individual Meter)	0-20 m³- RM 0.40/m³ >20-40 m3 - RM 0.70/m³ >40-60 m³ - RM 0.90/m³ >60 m³ - RM 1.10/m³ *Min Charge : RM 6.00*	RM 0.44/m³
Charitable Organizations **Management and surveillance under government)**	as per Domestic (Individual Meter)	- ditto -	RM 0.44/m³
Government Buildings, institution and Statutory Bodies	**Government Institution** - as Per Domestic (Individual Meter) **Government Building / Statutory Bodies** - as for Trade (Normal) expect Quarters and barrack	as per Residential Home (Domestic Supplies)	- ditto -

TYPE OF CHARGE	PERLIS	KELANTAN	FT LABUAN
DOMESTIC SUPPLIES Residential Home	0-15m³ @ RM 0.40/m³ 15.1-40m³ @ RM 0.70/m³ >40.1 m³ @ RM 1.10/m³ *Min Charge - RM 4.00*	0-20m³ @ RM 0.40/m³ 21-40m³ @ RM 0.75/m³ >41m³ @ RM 1.05/m³	@ RM0.90/m³ *Min Charge - RM 4.00*
Religious Institutions(Mosque/Surau/Madrasah/ Religious school) Management and surveillance under government)	- ditto -	Free for the 1st 35m³ >36m³ @ for RM 0.70/m³	Free
Charitable Organisations Management and surveillance under government)	- ditto -	as for commercial	@ RM 0.90/m³
Government Buildings, institution and Statutory Bodies	- ditto -	as for commercial	- ditto -
Schools	-	as for commercial	@ RM 0.45/m³
COMMERCIAL SUPPLIES Industrial/commercial	Part – Trade RM 1.10/m³ *Min Charge - RM 5.00* Trade RM 1.30/m³ *Min Charge - RM 8.00*	RM 1.25/m³ *Min Charge - RM 12.50*	@ RM 0.90/m³ *Min. Charge RM 4.00*
Construction	as for trade	- ditto -	- ditto -
Swimming Pool	as for trade	- ditto -	as for commercial

TYPE OF CHARGE	MELAKA	TERENGGANU	PERAK
DOMESTIC SUPPLIES **Residential Home**	0-20m³ @ RM 0.60/m³ >20-35m³ @ RM 0.95/m³ >35m³ @ RM 1.45/m³ *Min Charge – RM 6.00*	0-20m³ @ RM 0.42/m³ >20-40m³ @ RM 0.65/m³ >40-60m³ @ RM 0.90/m³ >60m³ @ RM 1.00/m³ *Min Charge - RM 4.00*	0-10 m³ @ RM 0.30/m³ 11-20m³ @ RM 0.70/m³ >20m³ @ RM 1.00/m³ *Min Charge - RM 3.00*
Religious Institutions(Mosque/Surau/ Madrasah/ Religious school) Management and surveillance under government)	RM 0.55/m³ *Min Charge - RM 20.00*	<50m³- Free5 0-70m³ @ RM 0.95/m³ >70m³ @ RM 1.15/m³ No charge if erection of building Has been Granted permission In writing by the commissioner of Religious Affairs Terengganu	0-20m³ @ RM 0.30/ m³ >20m³ @ RM 0.34/ m³ Min Charge - RM 3.00
Charitable Organisations Management and surveillance under government)	- ditto -	as per residential	- ditto -
Government Buildings, institution and Statutory Bodies	RM 1.30/m³ *Min Charge - RM 20.00*	<70m³ @ RM 0.95/m³ >70m³ @ RM 1.15/m³ *Min Charge - RM 15.00*	as for residential
Schools	As above for Government/ As below for private	do as for state/federal schools private schools as for commercial	as for residential
COMMERCIAL SUPPLIES **Industrial/commercial**	0-50m³ @ RM 1.65/m³ *>50-100m³ @ 1.70/ m³* >100m³ *@ 1.80/ m³* *Min Charge - RM 20.00*	Industrial RM 1.15/m³ *Min Charge - RM 50.00* Commercial <70m³ @ RM 0.95/m³ > 70m³ @ RM 1.15/m³ *Min Charge - RM 15.00*	Industrial / Commercial 0-10m³ @ RM 1.20/m³ 11-20m³ @ RM 1.40/m³ >20m³ @ RM 1.61/m³ *Min Charge - RM 12.00*
Construction	as for industrial/commercial	house 1 no - as for commercial house > 2 nos. as for industrial	- ditto -
Swimming Pool	as for industrial/commercial	as for industrial/residential / ²	Condominium : Bulk Rate Public : As Gov.Rate

TYPE OF CHARGE	SARAWAK[1]		
	KUCHING	SIBU	SRI AMAN,MIRI,LIMBANG, SARIKEI, KAPIT
DOMESTIC SUPPLIES Residential Home	1-15m³ @ RM 0.48/m³ 15-50m³ @ RM 0.72/m³ > 50m³ @ RM 0.76/m³ *Min Charge - RM 4.40*	1-15m³ @ RM 0.48/m³ 15-50m³ @ RM 0.72/m³ > 50m³ @ RM 0.76/m³ *Min Charge - RM 4.40*	1-15m³ @ RM 0.48/m³ 15-50m³ @ RM 0.72/m³ > 50m³ @ RM 0.76/m³ *Min Charge - RM4.40*
Religious Institutions (Mosque /Surau/Mardrasah)	- ditto -	- ditto -	- ditto -
Charitable Organisations	- ditto -	- ditto -	- ditto -
Government Buildings, institution and Statutory Bodies	as for commercial	as for commercial	as for commercial
Schools	as for commercial	as for commercial	@ RM 0.66/m³
COMMERCIAL SUPPLIES Industrial/commercial	Commercial *Min. Charge RM 22.00* 1-25m³ @ RM 0.97/m³ > 25m³ @ RM 1.06/m³ Domestic/Commercial *Min. Charge RM 18.70* 1-25m³ @ RM 0.83/m³ > 25m³ @ RM 0.95/m³	Commercial *Min Charge RM 22.00* 1-25m³ @ RM 0.97/m³ > 25m³ @ RM 1.06/m³ Domestic/Commercial *Min. Charge RM 18.70* 1-25m³ @ RM 0.83/m³ > 25m³ @ RM 0.95/m³	Commercial *Min. Charge RM 22.00* 1-25m³ @ RM 0.97/m³ > 25m³ @ RM 1.06/m³ Domestic/Commercial *Min. Charge RM 18.70* 1-25m³ @ RM 0.83/m³ > 25m³ @ RM 0.95/m³ Industrial *Min. Charge RM 24.20* 1-25m³ @ RM 1.05/m³ > 25m³ @ RM 1.32/m³

TYPE OF CHARGE	SARAWAK[2]	SARAWAK[3]	SABAH / [1]
	Bintulu	Other Parts of Sarawak	
DOMESTIC SUPPLIES Residential Home	0-14m³ @ *Min. Charge RM 6.60* 14-45m³ @ RM 0.61/m³ > 45m³ @ RM 0.66/m³ *Min. Charge - RM 6.60*	0-15m³ @ RM 0.44/m³ 15-50m³ @ RM 0.65/m³ > 50m³ @ RM 0.69/m³ *Min. Charge - RM 4.00*	@ RM0.90/m³ *Min Charge - RM 4.00*
Religious Institutions	- ditto –	- ditto -	Free
Charitable Organisations	- ditto -	- ditto -	@ RM 0.90/m³
Government Buildings, institution and Statutory Bodies	as for commercial	- ditto -	- ditto -
Schools	@ RM 0.66/m³	@ RM 0.60/m³	@ RM 0.45/m³
COMMERCIAL SUPPLIES Industrial/commercial	Commercial 0-23m³ @ *Min. Charge RM 20.90* > 23m³ @ RM 0.99/m³ Domestic/Commercial Rates 0 - 25m³ @ RM 0.83/m³ > 25m³ @ RM 0.95/m³ *Min. Charge - RM 18.70* Industrial 0-23m³@ *Min. Charge RM 24.20* > 23m³ @ RM 1.21/m³	Commercial 0-25m³ @ RM 0.88/m³ > 25m³ @ RM 0.96/m³ *Min. Charge - RM 20.00* Domestic/Commercial Rates 0-25m³ @ RM 0.75/m³ > 25m³ @ RM 0.86/m³ *Min. Charge - RM 17.00* Industrial 0-25m³ @ RM 0.95/m³ > 25m³ @ RM 1.20/m³ *Min. Charge - RM 22.00*	Commercial @ RM 0.90/m³ *Min. Charge RM 4.00*

Source: Suruhanjaya Perkhidmatan Air Negara (SPAN), 2012

From the table 2.11 above, in Malaysia there are various water tariff that applicable at each of the states in Malaysia. It was due to state government policy that under the supervision of the related water service agency. However, there are few stages of the reading such as first 25m3 was the minimal rate or tariff that imposed into the water consumption charges; second and third captioned reading to be apply into the water consumption. Meaning, the more we use, the more we need to pay. In term of minimum usage, there is a minimum charges for water consumption that imposed at different rate throughout the states in Malaysia if we referred to the data above.

Table 2.10 and Table 2.11 listed various water tariffs applicable at each of the states in Malaysia. It is due to the state government's policy under the supervision of the related water service agency. However, there are a few stages of the reading such as the first 25 m^3 is the minimal rate or tariff imposed into the water consumption charges, with the second and third captioned reading to be applied into the water consumption. Meaning, the more we use, the more we need to pay. In terms of minimum usage, there is a minimum charge for water consumption imposed at different rates throughout the states in Malaysia.

2.5 Green Building Materials

Sustainability is not restricted to electricity and water preservation only, but expanded to resources used for building and conservation of living habitat and surroundings (Jones, 2008). Green rated building emphasized on waste reduction as well. For instance, construction wastes and demolition debris are the main wastes produced during the construction process, and these wastes degrade the quality of the surrounding environment. Green rated building will ensure waste reduction by reusing and minimization of construction wastes and debris by diverting them into recycling units. Furthermore, the use of existing building structure as refurbishment development, reclamation land development, and reclaimed building materials in the core and shell of a project will increase the usage of recycled content in construction materials by designing the structure to produce less scrap and execute it according to the plan (Jones, 2008). Green rated building reduces construction waste by approximately 50% compared to that of similar conventional buildings, hence accruing all the aforementioned benefits (Jones, 2008). Thus, such building materials are those that use the earth's resources in a responsible way. Green building materials respect the limitations of non-renewable resources such as coal and metal ores and work within the pattern of nature's cycles and the interrelationships of ecosystems (Rose, 2010). Green building materials are non-toxic besides being electricity and water efficient. They are made from recycled materials and therefore recyclable themselves. In detail, materials are green in the way they are manufactured, the way they are used, and the way they are reclaimed after use. Referring to Table 2.1, green building materials are those that produce high marks for resource building management, impact on indoor environment

quality (EQ) with good building operation, and maintenance performance. While people may recognize that the term green means “environmental friendly”, most have several misperceptions about how environmentally friendly products perform relatively on the quality and standard itself than other standard of construction products (Edmund, 2011). Paradoxically, it is equally acceptable to express apprehension at implementing green approaches rather than conventional approaches.

The proposed environmental related materials and criteria applied on the green rated building products as well as the assessment of the materials are as follows (Spigel and Meadows, 2010):

(a) Low Toxicity

Manufactured materials demonstrate reduced toxicity or are non-toxic and lacking in carcinogenic compounds and ingredients.

(b) Minimal Emissions

Products that have minimal chemical emissions with low emission or VOC and avoided the use of chlorofluorocarbons (CFC).

(c) Low-VOC Assembly

Materials installed with minimal VOC produce compounds or non-VOC mechanically attached methods and minimal hazards.

(d) Recycled Content

Recyclable product material contents that is inclusive of post-industrial content.

(e) Resource Efficient

Products manufactured with resource-efficient processes including reducing energy consumption, minimizing waste, and reducing greenhouse gases.

(f) Recyclable

Materials that are recyclable at the end of it useable period.

(g) Reusable

Building components that can be reused or salvaged.

(h) Sustainable

Renewable natural materials harvested from sustainably managed sources preferably that have an independent certification.

(i) Durable

Materials are either longer lasting or comparable to conventional products with long life expectancies.

(j) Moisture

Products and systems that are moisture resistant or able to inhibit the growth of biological contaminants in buildings.

(k) Energy Efficient

Building material, component, and system that are able to minimize energy wastages and consumptions.

(l) Water Conserving

Products and systems that help reduce water consumption in buildings and conserve water in general areas.

(m) Improves Indoor Air Quality (IAQ)

System and equipment that promote healthy IAQ by identifying indoor air pollutants and enhancing the air quality index.

(n) Local Product

Building material, component, and system found either locally or internationally on energy savings and resources inclusive of transportation to the project site.

(o) Affordable

Building product life cycle costs comparable to conventional materials and within a project defined percentage of the overall budget.

Aside from resource efficiency, another typical feature for green rated building is focused on the durability and longevity of the systems and materials. A material is usually considered in terms of its entire life cycle, as well as its attributes at the time of installation, utilizing a cradle-to-cradle or perfect match approach that takes into consideration the embodied energy, toxicity and emissions, replacement cycles, frequency of service required, and disposal to ensure that a material is 'green' in all aspects (Ding, 2007). A proper specification of sustainable material and building systems would provide financial benefit in the long term through less replacement cost involved, reduces the cleaning and maintenance requirements process, as well as benefits linked to healthier indoor environments with low toxicity and emissions (Rose, 2010). According to Spiegel and Meadows (2010), the range of green building materials that are available has grown exponentially in response to the development growth on green rated building

for all levels. Green building materials also offer wide range of aesthetical needs, good performance, and cost-competitiveness with exceptional quality.

2.5.1 Cellulose Fibre Cement Boards (PRIMA)

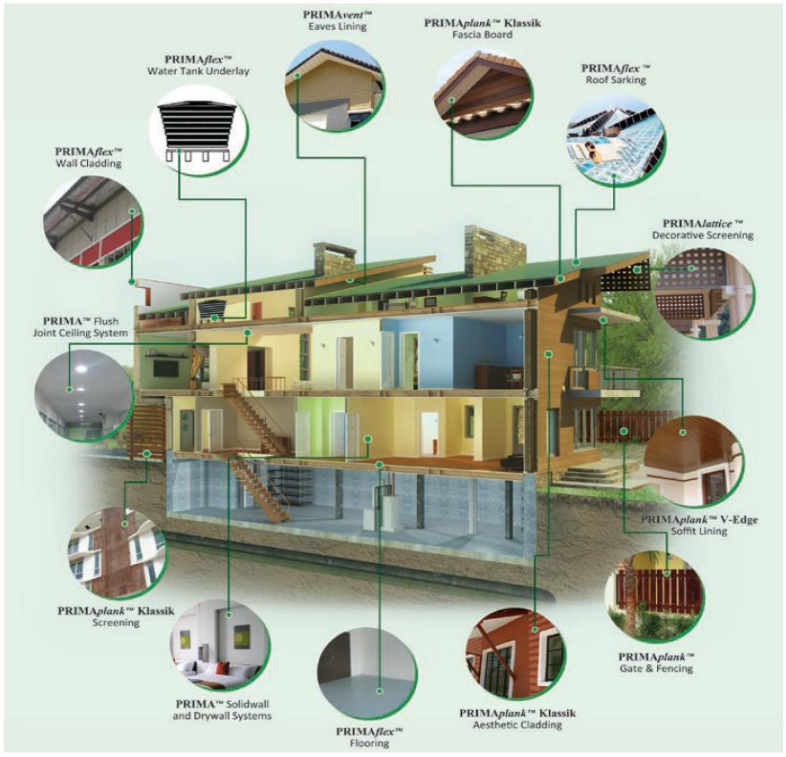


Figure 2.11 PRIMA Cellulose Fibre Cement Boards

Source: Green Pages Malaysia of Hume Cemboard Industries (MGBC, 2010)

This green product was extracted and produced from renewable resources such as pulp fibre from plantations and the minerals are from local resources with up to 20% recycled content. The green manufacturing process is in accordance with ISO 14001 Standard and aligned with the concept of Reduce, Reuse, & Recycle of raw materials. It is non-hazardous, low VOC, durable, and has no formaldehyde contents and certified as Green Building Material by Global Eco-Label Certification Bodies such as Singapore Environmental Council, Good Environmental Choice Australia, and Korea Environmental Industry & Technology Institution.

2.5.2 Autoclaved Aerated Concrete (AAC) Blocks

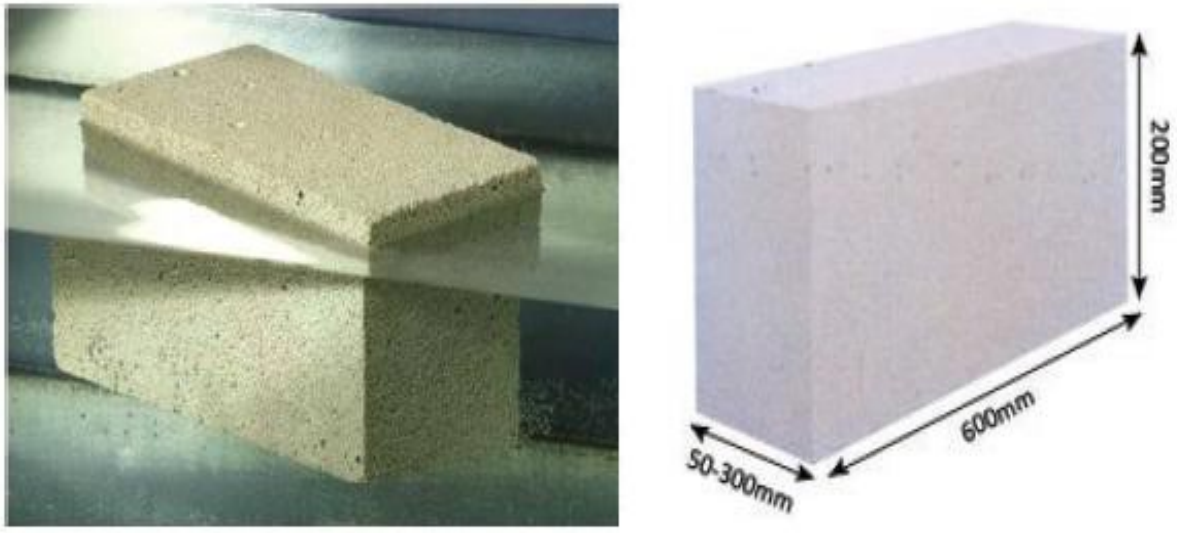


Figure 2.12 Autoclaved Aerated Concrete (AAC) Blocks

Source: “Henner” Sustainable Walling Solutions by Saint-Gobain AAC Sdn. Bhd.

Autoclaved Aerated Concrete (AAC) blocks contain pore content of approximately 45%, with the consumption of raw materials and total energy consumed during the production 2–3 times lower than other building materials such as burnt bricks. The emissions of gasses such as CO_2, CO, and NOx are also relatively low. By-products of AAC production such as condensate from the autoclaving process, hardened AAC waste, and unhardened AAC mixture can be recycled back into the production of AAC. Besides that, other industrial waste like fly ash and slag can be utilized as main raw materials too. It possesses one of the excellent thermal insulation properties, with less energy is required to cool a building. It is breathable and effective in moderating the moisture levels and maintaining the correct relative humidity.

2.5.3 Ceiling Board (Queen Energy)

PRODUCT SPECIFICATIONS	Suspended Ceiling	Plaster Ceiling
Thickness in mm	5.5mm	8.8mm
Length x Width in mm	600mm x 1,200mm	900mm x 1,800mm
Average Weight in kg/m² at EMC	6.7 kg/m²	7.9 kg/m²

Figure 2.13 Ceiling Queen Energy Board

Source: Green Pages Malaysia of Ceiling Queen, (MGBC, 2010)

Ceiling Queen Energy Board used biotechnology procedures from Japan and Korea that can generate and emit negative ions and far infrared rays using natural radiation materials i.e. tourmaline, radium, thorium, and potassium. Its low thermal conductivity and excellent insulation properties can help to reduce heat generation and energy consumption of the air conditioning system. The microfibre or fiberglass can also be installed to be in contact with the ceiling to further enhance its thermal qualities and provide additional heat penetration control.

2.5.4 Jotashield Extreme (JOTUN) / Safe Coat Zero VOC Paint (NIPPON)

Figure 2.14 JOTUN Jotashield Extreme / NIPPON Safe Coat Zero VOC Paint

Source: Jotun Malaysia Sdn Bhd and Buidling System by Diagnostics Pte Ltd

This paint consists of twice UV protected colours and up to 8 years performance and allows less repainting cycles, which reduces the impact on the environment. Jotashield Extreme with its unique two times heat reflective technology reflects heat absorbed by walls, therefore improving indoor temperature. Definitely, this paint will increase the comfort level and decrease the energy loaded to cool homes in the heat, ultimately reducing energy consumption. It was 100% free from harmful chemicals such as APEO, formaldehyde, and heavy metals. The most popular indication in today's sustainable green building always emphasized on none or low VOC compounds that will reduce the vapour pressure at ordinary room temperature that is harmful when inhaled. By reducing the vapour content, the paint is less toxic, but more hygienic.

2.5.5 Steel (Clean Colorbond)

Figure 2.15 Clean Colorbond Steel

Source: Zincalume and Colorbond by NS BlueScope Malaysia Sdn Bhd

Aluminum steel is commonly used because it is lightweight and able to reduce the need for heavy lifting equipment, construction time, and transport cost. For example, 1 kg of steel would likely clad almost 9 times the area of 1 kg of roof tiles. In terms of capability, this product is strong and durable, and requires low maintenance and replacement. Thus, it can be reused and recycled by reducing raw material consumption and Green House Gas (GHG) emissions. It generates high strength to weight ratio with the high efficiency material without sacrificing its functionality. For example, it uses base metal thickness (BMT) of 0.42 mm steel roofing instead 0.55 mm (24% less) than other equivalent products. Colorbond steel has low thermal mass, thus lowering the demand for cooling in the building. Furthermore, it generates high solar reflectance index (SRI) and reduce Urban Heat Island (UHI) intensity. Similar to paint product, it may help to emit less VOCs and formaldehyde.

2.5.6 PVC Membranes (Sika Sarnafil)

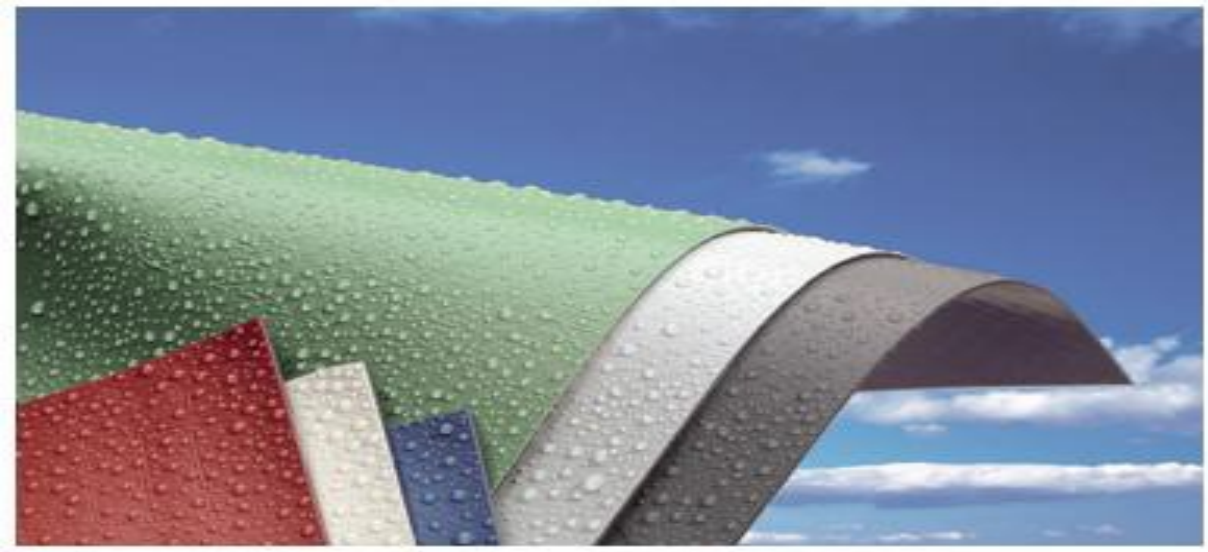


Figure 2.16 Sika Sarnafil PVC Membranes

Source: Sika Malaysia of World Class Roofing

Sika Sarnafil PVC membranes for roof waterproofing (including green roofs) is a sustainable roof cladding system that creates the roof membranes for cool roofs especially for hot climates or urban climates. Green roofing is one of the most exciting developments in sustainable building design. The environmental benefits for which green roofs have obtained the most attention are improvements in air quality, storm water runoff management, reduction of urban heat island effect, and energy efficiency. During warm weather, green roofs are cooler than conventional roof surfaces. Sika membranes meet the most stringent test standards for root resistance and have a proven history of durability. It allows owners of buildings to create high performance structures that are acknowledged under the GBI certification program in Malaysia and LEED certification program in the United States of America. This product includes a highly reflective, lacquer-coated surface that decreases heat flow through the building envelope and has been proven to reduce the amount of energy required to maintain comfort in an air-conditioned building.

Any decisions made in regards to the maintenance works of all the selected green products explained have implications on cost, quality, duration, and resource allocation of the buildings (Ali et al., 2008). To produce good decisions, the quality and the amount of information available are critical. Since the decisions made during this process commit a large percentage of project funds, adequate and accurate information are needed in a timely manner. The quality of decision-making depends on the accuracy and completeness of information. Fischer (2014) noted good decision making required informative formulation, clear evaluation, and quick re-formulation of alternatives. Without a sufficient amount of data, it is impossible for the maintenance stakeholders to make good decisions, especially during the inception stage of design when the quantity of data available is very limited. Moreover, the maintenance stakeholders need to explore differences such as perception, expectation, languages, and work activities to avoid inaccuracies and mistakes in the decision-making process (Ali et al., 2008). According to Ramly (2012), the lack of maintenance knowledge on the part of building managers and inadequate building inspections could result in problems with the implementation of maintenance works, which could cause deficiencies in decision-making of maintenance cost. Besides, criteria that need to be considered in the decision-making of maintenance cost also need to be established explicitly. Therefore, the identification of criteria in the decision-making of maintenance cost is paramount to ensure the quality of the decision outcome. Six dominant variables have been identified that are associated with the decision-making of building cost from previous studies. The variables are existing building condition, building age, complaint received regarding building performance, client's request, availability of funding, and safety and health requirements.

The condition of existing buildings is assessed through several ways. One of the easiest methods is by using visual survey. The exterior of each building structure was viewed from the ground level and all important information would be documented and some areas of deterioration are noted through annotated sketches and plans. However, with recent new technology, detecting building defects would be more effective by implementing non-destructive test (Pitt, 1997; Lee and Scott, 2009). For instance, detecting a

rusty steel bar is by using a scanning instrument. However, by implementing visual inspection only, not many things about the condition of building can be discovered (Yiu, 2008). Ali (2008) argues that any allocation of maintenance cost must consider existing conditions of a building. This is because decision on the maintenance is complex and the best solution is by referring to the existing conditions of the building. Hence, the factor of existing building condition needs to be considered during the decision-making process of maintenance cost.

The age of a building provides important indication on the level of maintenance service required. Lateef (2008) argues that one of the important elements that need to be considered in the allocation of maintenance resources is the building's age. In order to know the future image of a building, building manager needs to offer the right service so that the building has competitive advantage. Services given must meet expectation in response to time, delivery schedules, and within the agreed performance indicator. In general, the older the building, the more attention and focus to special maintenance works need to be carried out. Based on the consideration of life cycle management and facility management that are connected to each other, maintenance works such as a major refurbishment and retrofitting of building equipment need to take place when a building has reach its economic life span. To implement this, large allocation of money is required from the building owner. Therefore, the building stakeholders need to consider this factor during their decision-making process of the maintenance cost of a building.

Inefficient maintenance works could invite complaints by the building users. Users are normally looking for a comfortable space in a building. This includes well functioning building equipment, clean environment, and safety. If the building does not fulfil the user's needs, the users would make complaints with regards to the maintenance performance. Therefore, in formulating decision with regards to the maintenance cost, element of users satisfaction is vital and need to be taken into consideration (Lateef, 2008. This data is considered important in which the building manager would investigate and try to figure out the reason for the complaints. If the complaint is due to non-performance of building equipment or

other services, more attention is required to maintain the problem. To do that, more allocation is needed to perfectly maintain the system. Hence, this factor is vital to be considered in the decision making of maintenance cost.

Client refers to the owner of a building. The client is the one who provides maintenance finance and a project brief in the early stage of maintenance works. The quality of a client's brief would influence the building performance. Boyle (2003) notes that the key success of design rests much with the clients besides other factors such as a good budget. Poor briefing and communication breakdown always occur when the client is not committed in the maintenance works. Some of the clients have set organization strategies, corporate image, and identity. In order to keep up with the good reputation, a part of the maintenance allocation usually was put aside to fulfil those requirements (Ali, 2008). This becomes the dilemma of a building manager in decision making when the budget allocation for maintenance work is limited and there are other important factors that need to be taken into account.

The most prominent constraint for the building design and selection of materials is highly rely on the budget allocation allocated by the building owner or client. Boyle (2003) noted that the most important factor contributing to successful maintenance work is sufficient budget allocated for a project. The project fund must be sufficient to ensure the maintenance works could run smoothly. One of the reasons clients initiated changes in maintenance planning is due to limited allocation of budget. Moreover, Tilley and McFallen (2000) claimed that insufficiency in a maintenance fund could affect the maintenance performance. The maintenance brief prepared by the clients should reflect the amount of funds allocated for buildings. A limited project fund could result in low-quality parts being used for buildings, which was incompatible with existing equipment parts. Hence, the clients must be committed in providing resources such as financial and management supports. A committed client would ensure project resources such as financial allocations are sufficient for a project. This is important towards the success of maintenance works. The clients should be certain of their financing cash flow requirement when the maintenance

works started. The lack of ability of the clients to provide faster decision often creates problem in the maintenance works.

Safety and health requirements are command factors influencing the decision-making of maintenance works (Lee and Scott, 2009). This is because building maintenance works pose risk to the maintenance personnel and building users. It is the responsibility of the building stakeholders, particularly the manager to ensure that health and safety assessments and safety work procedure are documented. This is as a guideline to the maintenance personnel who perform maintenance works in the buildings. In addition, control measures need to be available and implemented when undertaking the maintenance activities (Ali, 2008; Hashim, 2004). However, the implementation, safety control, and the well-being of workers in the maintenance works demand monetary support. Safety equipment such as harness, gloves, shoes, etc. need to be available upon request. This is to prevent accidents and work-related health and safety. Hence, some portion of the maintenance budget needs to be put aside in order to cater to safety and health needs.

2.6 Maintenance for GBI and non-GBI Building

Maintenance performance is the measurement of performance in providing an indicator of the level of success and for improving the quality of work. Salter and Torbett (2011) mentioned that the measurement of performance could lead to innovation and comparativeness. Without an indicator to measure products, it is difficult for the individual or organization to improve their maintenance works wisely. With the performance measurement, participants especially the building manager could tell their client whether the building maintenance was running well, was profitable, and when the necessary action could be taken to improve the maintenance performance before the end of the year. In measuring performance, some of the indicators that are normally used are time and cost. Johnson (2015) found that most practitioners agree that performance is typically categorized in terms of schedule, cost, and functionality. Meanwhile, Sidewell (2010) maintained that variables with regard to money and effort hours were suitable in measuring the performance. Therefore, the element of cost is used in measuring maintenance performance

of buildings. The maintenance performance is calculated using the variance from actual and planned cost for building maintenance works.

The Government has also given instructions to all their agencies to carry out maintenances of all their building at the very early stage so as to reduce the cost of maintenances and to avoid risk of higher maintenance cost due to negligence through time. A few researches have been carried out focusing on the scope and the element of building maintenance. By the way, very less attention has been given to the building maintenance budget and it is very rare to see research carried out on the subject of maintenance expenditure, funding, or financial budget of maintenance work (Mohd Noor et al., 2013). There is no standard format or guideline to be called standard operating procedure to be followed as a guide to the entire public client in terms of building maintenance. Worsening the scenario, it is always a problem and it is usually a very hard task to determine the exact cost of maintenance works such as repairs, replacement, or internal maintenance works and the estimated cost usually go uncertain and far from the actual cost. Unfortunately, there is no uniformity in the procurement procedure or standard contract regulation being used. For non-GBI building, it is widely known that among the biggest obstacle is the 'resistance to change' by the building or property manager. Traditionally, the management often consider the budget as the primary planning document and will then be implemented in the budget preparation. So it is a significant loophole in asset management in Malaysia (Kasmin, 2013). For GBI type of building, identification of building maintenance works method can be divided into four sections. The first method is 'key figure-oriented budgeting', the second method is 'value-oriented budgeting', and the third is 'the analytical calculation of maintenance measures', and the fourth method is budgeting by condition description

2.7 Conclusion

This chapter presented precise study from the introduction particularly on sustainable development of green rated buildings in Malaysia. Literature search of previous studies are reflected in the objectives of the current study. Brief history and introduction of GBI as an assessment tool for green rated buildings in Malaysia was discussed and selected in this study due to it reliability and mature assessment tools that have been introduced since the year 2009. Detailed elaboration and explanation of building operation and maintenance specifically on the key drivers of 'Electricity' and 'Water' utilities is presented in this chapter, along with cost saving calculations and elements, characteristics and the significance of green building materials available in our nation. Various cost saving analyses in terms of yearly recorded usage for both electricity and water consumption in Malaysia were used as a reference on the significance this study. Furthermore, as the type of green products or materials varies widely, this study focuses on the materials selected based on similar items found in Malaysia. The growing trend of sustainable development in Malaysia for building operation and maintenance costs are equally important to work out either pre- or post-construction stage costing on green and non-green rated buildings and to create the awareness by cultivating this practice as an essential routine for both the building owners and consultants. The final outcome in this chapter shall assist as a part of the feasibility study, cost estimation, budgeting, and material selection especially on pre-construction and planning stage. Apart from that, how GBI and non-GBI building operates the respective maintenance works and what factors influence the method of maintenance for each of the building category is explained in this chapter.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

The research methodology defines what the activity of research is, how to proceed, how to measure progress, and what constitutes success. It provides us an advancement of wealth of human knowledge, develops a critical and scientific attitude, disciplined thinking to observe objectively, and skills of research particularly in the 'age of information' (Noel, 2008). In general, research methodology is how to structure a study with the meaning of logical arrangement on the organization, meaning from a systematic approach, activity and progress flow. Research methodology is an essential part of research activity, to be transformed into an object of reality, result orientated, learning, and reasonable elements by conducting a mode of the study such as an interview, survey, and case study or by using questionnaires (Noel, 2008). In research, writing is essential to assure the productiveness and smooth progress for the entire research stages. As such, the selection on the mode of methodology to apply for this study are site survey approach to identify the actual cost implications by comparing two different categories of building, which are green and non-green rated building. The research study data were primarily obtained from direct interviews, feedback, actual and price quotation or invoices, and an analysis study on previous findings inclusive of books, construction journals, academic conference papers, articles, daily newspapers, and webpage search as secondary data. All the collective data in this study adapt the qualitative data collection method via criterion sampling, meaning a sample that has been selected to meet some criteria, such as for this case study are storey of the building or building height, occupancy rate, total units, usable land area, mode of the building, years of operation, and type of building. Instruments for collecting data can be done by observations, site survey, and questionnaires or by personal construct. Consideration on the size of sampling does not affect the result of the study (Abdulllah et al., 2004). For instance, many interviews can be conducted for the same research study, but after certain interview with repetitive questions being asked, it might turn out that no new concept emerged from the interviews. As mentioned earlier, sustainable

building project is still in its infancy stage in this country and there are still limited stakeholders who are familiar with such projects. Thus, judgment sampling and case study are useful tools to be used to select the respondents who are expected to have expert knowledge by virtue of having gone through the experiences and processes themselves and might perhaps be able to provide good data and information to the researcher (Gifford, 2015).

Actual domestic tariffs for electricity and water utility was collected via the respective service providers; which are Tenaga Nasional Berhad (TNB) for electricity, and Perbadanan Bekalan Air Pulau Pinang (PBA) and Syarikat Bekalan Air Selangor Sdn. Bhd. (SYABAS) for water utility in the state of Penang and Selangor respectively. As mentioned, a total of 12 months consistent utility statement was recorded to ensure accurate data. From the collected utilities data, total annual usages were accumulated and multiplied with the service provider rates for each of the selected building in this study.

For the building's maintenance works, the case study of buildings to be analysed were obtained to ensure similarity of the comparison elements. For instance, maintenance work that adopted six key elements for green rated building might be different compared to non-green rated building. The flooring works for green building involves replacement of imported materials such as encaustic cement patterned flooring which might be damaged, discontinued production, and wear and tear of the product that are mostly lacking in the non-green rated buildings. Therefore, each of the comparable building maintenance works in this study was selected based on the similarity between green and non-green rated buildings in order to achieve comparable data analysis and discussion. Eventually all these collected visual inspection building’s data and information were analysed and illustrated via standard basic calculation using Microsoft Excel and justification of the outcome to be further analysed via the t-test analysis.

3.2 Research Design

3.2.1 Primary Data

It was categorized as raw and original data that can be collected via methodologies such as questionnaire surveys, experimental studies, and case studies (Tan, 2007). Mode of collection for primary data can either be obtained directly at selected case study site survey or by conducting direct interview to obtain clear and accurate information from related parties on a variety of expertise such as from development consultant and construction profession. Although the information and results obtained are regarded as high in accuracy and reliability of the collected data, the cost to conduct and time spent during the site survey are at the higher side of output. In brief, this primary data methodology is higher in cost and time consuming.

3.2.2 Secondary Data

Apart from that, secondary data is the information obtained from third parties or any other external parties, but not originally from the author him/herself. The conventional sources of secondary data in the category of social science include collected data through qualitative methodologies, censuses, society, or association records (Charm, 2012). The advantage of secondary data analysis is it saves the researcher's time. It will provide broad quality database that might be impractical for any individual researcher to collect individually.

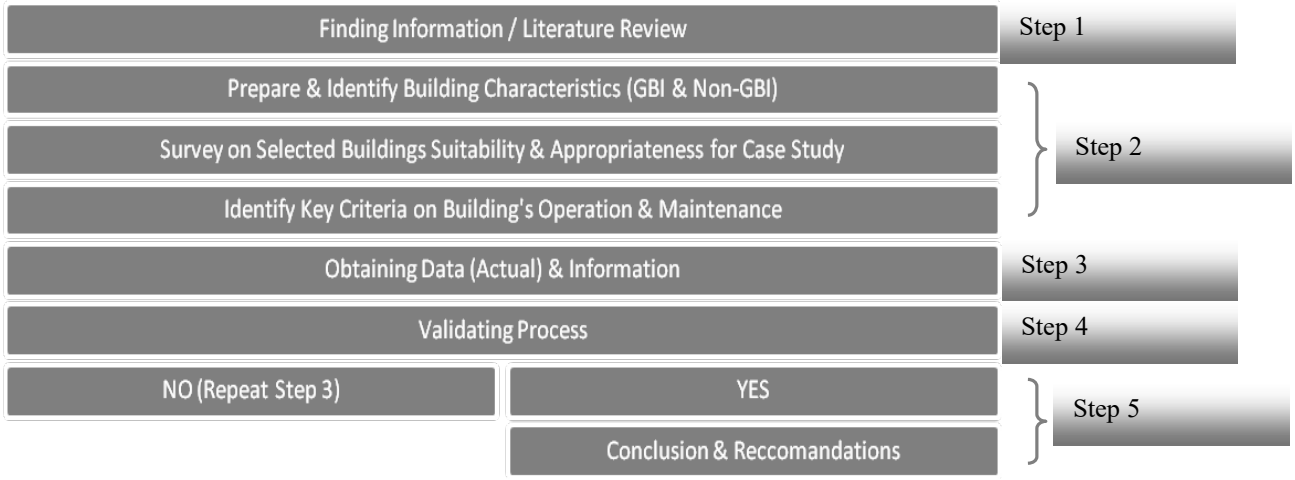
3.3 Research Process & Structure

The first step was a preliminary exploration of the basic principle of green rated building development in Malaysia that may influence the sustainable development and a building's performance in terms of operation and maintenance. This involves a comprehensive study on assessment and indicative tools for green buildings in Malaysia, which is the GBI. As mentioned in the problem statements, the lack of awareness in terms of green building implication existed in today's construction industry. Indeed, everyone either the academics or industry professionals agreed that it brings more benefits in today's construction and property development. Thus, this study creates potential demand on the comprehensive review by creating awareness towards all level of people on sustainable green buildings by adopting the reference from actual building operations and maintenance.

Actual site survey was conducted between selected GBI and non-GBI rated building by identifying the building's operation and maintenance frequency replacement service costs factors. Face-to-face interviews with property building manager was conducted to identify frequent building maintenance works, key savings elements as well as any solutions to be proposed for improvement on certain inconsistent data received during the analysis stage and eventually to provide guidelines and method to tempt those potential investors, end-users, and tenants to go for green buildings.

The purpose of this research project is to record the operation and maintenance on selected GBI and non-GBI building characteristics. It involves the formulation and calculation on maintenance works and identification of utilities consumption, which is classified under the total usage as the building's operation and maintenance actual cost within a 12-month period. Apart from that, the formulation and calculation must be validated to be significant of the collected data and proven effective by the use of t-test analysis and by the industry professional via the Likert scale method. The overall research process is highlighted below:-

3.3.1. Outline Research Process



3.4 Data Collection Method

3.4.1 Semi-structured Interview

This structure can be very flexible in terms of questioning and answering the discussed topics. For instance, interview is a direct confrontation conversation where the interviewer will query a person being interviewed, which is also known as the respondent, while the questions are formulated and designed to obtain information in regard to the discussed topics of this study. Semi-structured interview is categorized as a neutral between the formal planned and structured interview where to a certain extend depends on the researcher to make decision on upholding the discussion points and control the interview process. However, the functionality and quantity of a person's involvement in the interview is important to ensure the smooth flow of the interview. In brief, this type of interview is flexible; any related additional questions are highlighted at the process of the interview. As such, this interview seems to go more like a conversation.

3.4.2 Site Survey

The term ‘survey’ is commonly applied to a research methodology designed to collect data from a specific population, or a sample from that population, and typically utilizes a questionnaire or an interview as the survey instrument (Ponto, 2015). For this study, site surveys were used as a data collection method by allowing identification of the building’s characteristics and differences between green and non-green rated buildings, whereas the conditions of these two types of buildings in terms of operation and maintenance cost saving elements were monitored meticulously. Findings from the site survey helps to generate and prove green buildings operation and maintenance to be more economical in long term perspective. Most of the researchers agreed that sample surveys are an important tool for collecting and analysing information from selected individuals. Outcomes of the site survey and the characteristics of the green and non-green buildings are presented in Chapter 4.

3.5 Research Framework

An easy to perceive research framework should be thoroughly generated and designed in order to forecast a proper and systematic methodology for the research. Thus, to achieve the research aim and objective, a proper research framework is essential and should highlight the key steps to be executed and performed. The research flow and output are the main components in the research design as illustrated below:-

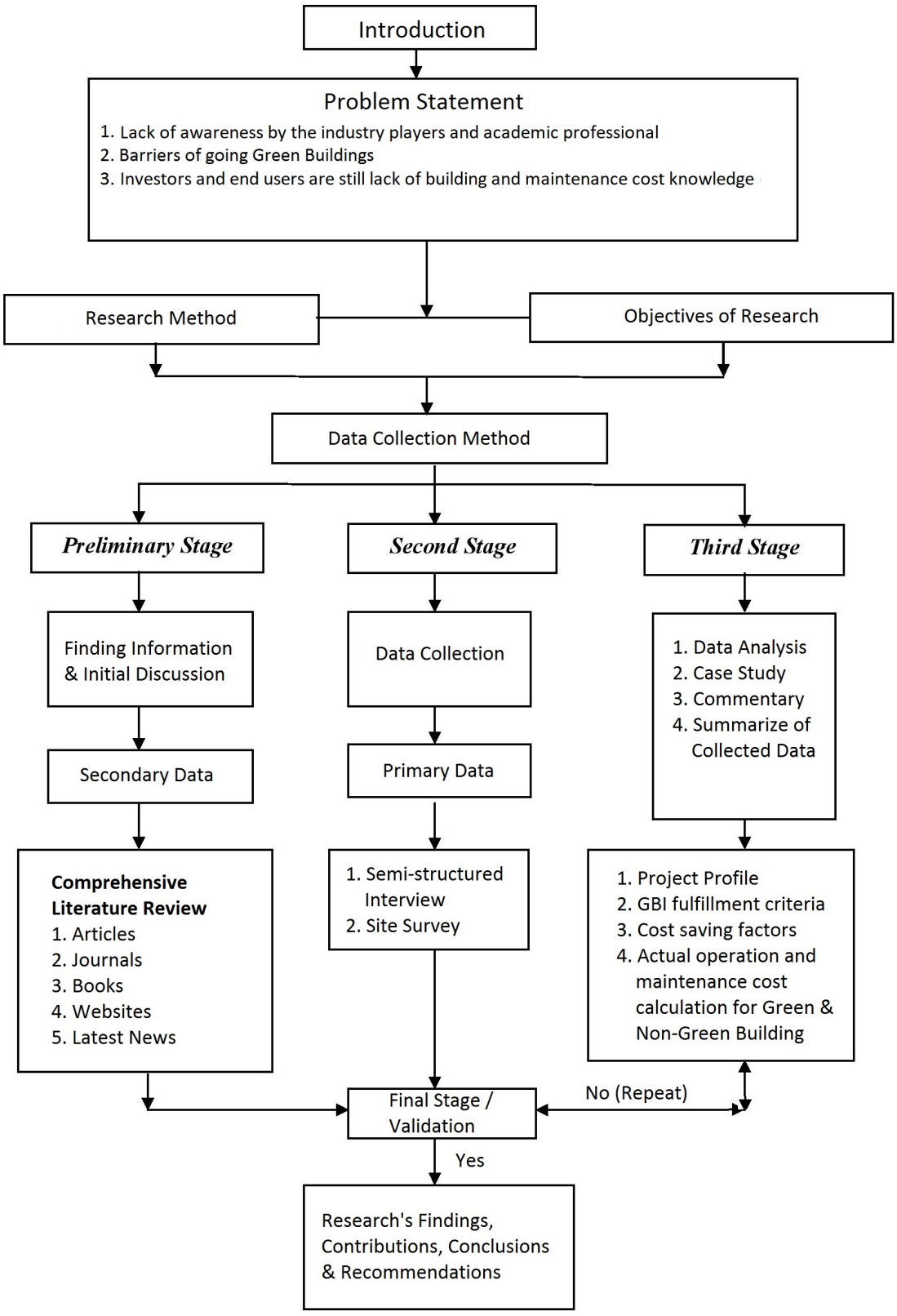


Figure 3.1: Flowchart of Research Methodology

3.5.1 Preliminary Stage

(a) Finding Information and Initial Discussion

The discussion in this stage relates to the overview of the problem statement and issues related to the research whether it is significant to the industry. It is essential to conduct this discussion with the supervisors as he or she can provide a full overview of the limitation and challenges on pursuing this topic and to guide in completing this research without any impediment.

(b) Comprehensive Literature Review

The purpose of the literature review conducted in chapter 2 is to strengthen, verify, and review the critical points of this research study. It is to provide evidence that the selected relevant literature is able to create some awareness of the current state of knowledge on the research objectives (Bell, 2013). The literature review presents the consequences of other related research and studies being undertaken (Creswell, 2009). With the objectives and scope of research properly defined in Chapter 1, this part of the research allows the researcher to perform a proper structure on the literature review to suit the flow of the entire research and benefited to achieve the aim of the research study. References taken from books, articles, journals, websites, latest local and global news sources are widely referred to in this chapter. Furthermore, it helps to identify current and relevant issues on research topic or any other limitations found by other researchers, which can support the basis for knowledge to conduct this research. According to Hart (2001), a critical review of the literature generally helps to understand complicated and complex situations by synthesizing previously unconnected ideas, and gain appropriate research methods and possible solutions proved in similar situations. Eventually, the information gathered in this literature review was then studied, analysed, and summarized to develop the research findings.

3.5.2 Second Stage

(a) Data Collection – Semi-structured Interview and Site Survey

Interview is a common method used by many researchers to collect information as well as opinions in the research study. The data collected will usually be more reliable, flexible, and contains more contextual information while providing an opportunity for the interviewee to give a more detailed response. Apart from that, new questions to be brought up by the researcher impromptu interview as a response to what the interviewee said. The researcher prepared discussion questions on fundamental understanding of green rated buildings criteria, project profiles and references undertaken by the interviewee, and actual costs on operation and maintenance between green and non-green rated buildings to be explored during the interviews. Thus, initial preparation for interviews by grouping topics and questions gives the researcher the ability to ask questions in different ways. Also prepared interview guides help researcher to focus an interview on the topics at hand without constraining them to a particular format. This freedom can help interviewers to tailor their questions to the interview situation and to the people they are interviewing (Lindlof & Taylor, 2002). The focused group would be the professional architects as well as the building and property manager. The interviews with the end-users or owners of the GBI building is deemed to be essential regarding the benefits and the reason they choose such building as to give a broader understanding and to prove how green rated buildings operation and maintenance are made affordable to the people compare to non-GBI building.

3.5.3 Third Stage

(a) Data Analysis, Commentary, Case Study, and Summary of Data

The data or information collected from stage two was compiled and a summary of the research findings was done at this stage. The collected items and figures from the quotations and invoices were analysed and abstracted into the results and analyses chapter. The rates for the total annual building operation and maintenance used to complete this study need to be competitive and accurate rates obtained by the researcher from the industrial building data collection, submission of actual quotations by the vendors,

contractors, suppliers and nominated sub-contractors, and cost advice from specialist consultants for the building maintenance process. The data analysis is based on statistics or other measurable empirical data. Conclusions were drawn from the analysis of the physical or tangible actual measurement.

3.5.4 Final Stage and Validation Process

(a) Validation

Before entering the final step of the collected data via data analysis, case study, commentary and summarization of collected data; a validation and improvement of the statistical results or other measurable empirical data collection were carried out. The validation process also facilitated the identification of other potential issues, which have not been found through the earlier stages of data collection method. There are various validation methods used to validate research and these methods can vary depending on examining the aspects of research. For example, the validation processes can be divided into conceptual and operational groups (Rao et al., 1998). Operational validation is mostly used for products testing, and checking operational tasks and procedures. This study adopted a conceptual design for the validation and conducted validation using a survey of experts. In order to conclude the data collection process, the researcher conducted a validation process on survey via the Likert scale in order to validate those findings and data. The selected parties involved in the validation process are property developers and active construction professionals.

The survey used to validate the collected data involved a questionnaire containing items with responses made on Likert scales and open-ended questions. The Likert scale is the most used and broadly applies to all types of survey research (Likert, 1932). Likert scales allow respondents to express the respondents' either degree of agreement or disagreement to a statement that is highlighted in the study. In the validation questionnaire, respondents could indicate the extent of their agreement and disagreement on the developed framework according to a five-point Likert scale ranging from 'strongly disagree' to 'strongly

agree'. Two open-ended questions were included to get the respondents' opinion on significant issues and to make comments on the measurable collected data.

The purpose of the validation process was to confirm that the collected data are suitable for its intended use. To confirm framework suitability, the researcher conducted a survey of experts, which had the following specific purposes:-

(i) To identify the so-called experts are involved in building operation and maintenance costing analysis;
(ii) To explore any hidden issues and factors associated with green building criteria procedures;
(iii) To identify experts and industry practitioners' knowledge on the green buildings criteria.

(b) Validation of t-Test Analysis

A t-test is most commonly applied when the test statistic would follow a normal distribution if the value of a scaling term in the test statistics were known. T-test is a statistical test, which is widely used to compare the mean of two groups of samples. It is therefore used to evaluate whether the means of the two sets of data are statistically significantly different from each other. In other words, the t-test (also called Student's T-Test) compares two averages (means) and tells you if they are different from each other. The t-test also tells you how significant the differences are. In other words, it lets you know if those differences could have happened by chance. When the scaling term is unknown and is replaced by an estimate based on the data, the test statistics (under certain conditions) follow a *t* data distribution. The t-test can be used, for example, to determine if two sets of data are significantly different from each other. In each case, the formula for a test statistic that either exactly follows or closely approximates a t-distribution under the null hypothesis is given. Once the *t* value and degrees of freedom are determined, a t-value can be found using a table of values from collected data distribution. If the calculated t-value is below the threshold chosen for statistical significance (usually the value of 0.05 below level), then the

null hypothesis is rejected in favour of the alternative hypothesis. Every test comes with a few assumptions, for t-test assumptions; the first assumption made is concerning the scale of measurement. The assumption for a t-test is that the scale of measurement applied to the data collected follows a continuous or ordinal scale, such as the collected monthly utilities consumption in this study. The second assumption made is that of a simple random sample, meaning that the data is collected from a representative, randomly selected portion of the total population. The third assumption is the data, when plotted, resulted in a reasonably large sample size. A larger sample size means the distribution of results should approach or nearer to the variance data when the standard deviations of samples are approximately equal.

Two kinds of hypotheses exist for a one sample t-test, the null hypothesis and the alternative hypothesis. The alternative hypothesis assumes that some difference exists between the true mean (μ) and the comparison value (m0), whereas the null hypothesis assumes that no difference exists. The purpose of the one sample t-test is to determine if the null hypothesis should be rejected, given the sample data. The alternative hypothesis can assume one of the three forms depending on the question being asked. If the goal is to measure any differences, regardless of direction, a two-tailed hypothesis is used. If the direction of the difference between the sample mean and the comparison value matters, either an upper-tailed or lower-tailed hypothesis is used. The null hypothesis remains the same for each type of one sample t-test.

The procedure for a one sample t-test can be summed up according to the formula below. The symbols to be used are as follows:

t = The *t*-statistic (*t*-test statistic) for a one sample *t*-test

D = Random sample

N = The sample size

$$t = \frac{(\sum D)/N}{\sqrt{\frac{\sum D^2 - \left(\frac{(\sum D)^2}{N}\right)}{(N-1)(N)}}}$$

Other calculation for mean and standard deviation are listed below:

Formula calculation for the sample mean (μ).

$\mu = y1 + y2 + \cdots + ynn$

Formula calculation for the sample standard deviation (σ^).

$\sigma\hat{} = (y1 - y)2 + (y2 - y)2 + \cdots + (yn - y)2n - 1$

Once the assumptions have been verified and the calculations are complete, all that remains is to determine whether the results provide sufficient evidence to reject the null hypothesis by obtaining the t-test value below 0.05 in favour of the alternative hypothesis.

3.5.5 Research Findings and Conclusion

The utmost critical scope is the final stage to conclude the findings by compiling the entire final research writing via the collected data and information. In this study, a sample of table that summarizes the collected data according to specified categories regarding the total operation and maintenance cost differences between green and non-green rated building is set up to determine which building are cost effective and it's essential to meet the overall specified objectives.

CHAPTER 4

RESULTS

4.1 Introduction

This chapter explains in detail the characteristics and profile of the selected GBI and non-GBI buildings to enable a better understanding of the sustainable green buildings concept. Two types of building have been selected in this research. The selected buildings are similar in terms of the type, category, location, and age of the building for comparison purposes in order to compare with the similar object at different range of building category. The age of all selected case study building operation were observed and maintained at a minimal of 2 years fully operated. The annual differences in terms of maintenance and operation costs were recorded. The outcomes obtained from site surveys and interviews with the property building manager on selected building to ensure accurate raw data is collected. The project's Bills of Quantities (BQ) on the selected building was used to be verified on-site during the survey to ensure the selected green rated criteria are fulfilled hence to justify the selection of category and type of building. Besides that, operation and maintenance cost calculation are included in this chapter, which were obtained from various maintenance work quotations and invoices as a proven documentation on maintenance works are either frequently or periodically executed. Furthermore, operation and maintenance cost monitoring and calculation from selected building were calculated and compared in this study specifically the key drivers on 'Electricity' and 'Water' focused solutions by using total usage multiple with the utility service provider standard rate. Thus, total operation and maintenance cost between green and non-green rated buildings will be able to be compared clearly. Those characteristics described above are important to be applied on non-residential buildings as tabulated below in order to achieve similarity as well as accuracy of the collected data.

4.2 Survey Study Areas

The study areas were focused on prominent and developed town in Malaysia located in the northern and central region in Peninsular Malaysia. The selected case study of the buildings were based on the population density of the selected area, type of building, building value, numbers of rooms or units, building's storey height, location, mode of operation, years of operation, occupancy rate, occupant's lifestyle, average monthly operation, and maintenance cost. In this study, the category of building that select were based on Residential New Construction (RNC) and Non-Residential New Construction (NRNC) for GBI and non-GBI rated categories of building.

4.2.1 Residential Buildings

RNC for condominium type of building, the Light Point Condominium is located in the state of Penang specifically at the heart of Penang Island as shown in Figure 4.1 below. It is in a historical location with middle-to-high-income residents in comparison with most districts township in Penang. The main six criteria emphasized in GBI were fulfilled especially on electrical and water utilities as well as operational and maintenance work scopes of selected green building materials.

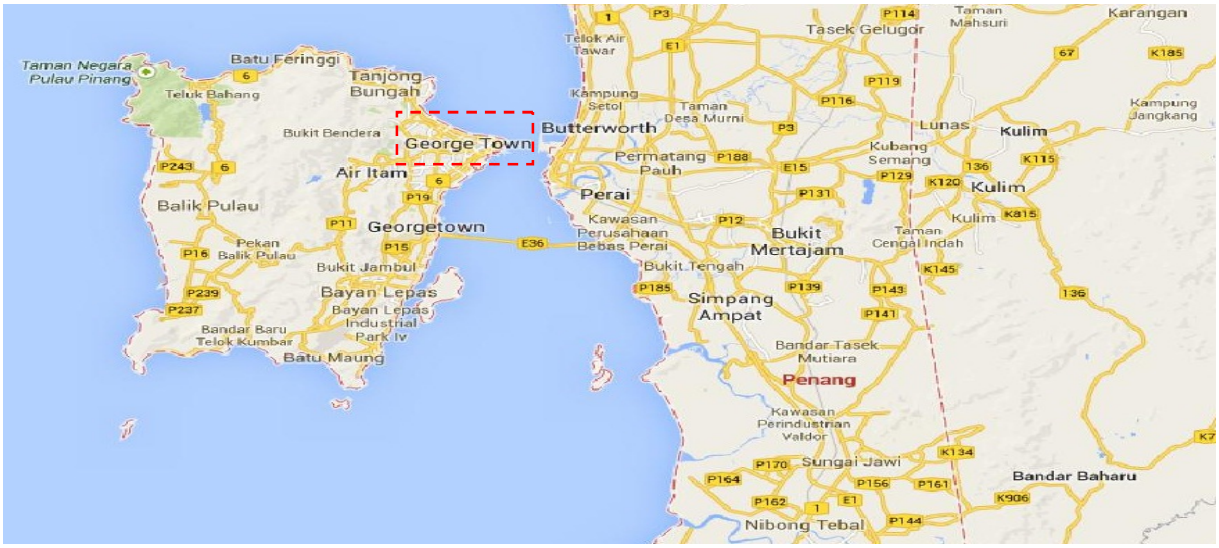


Figure 4.1: George Town, Penang Map

(Source: Google Map Online via https://www.google.com/maps, accessed on 30th August 2014)

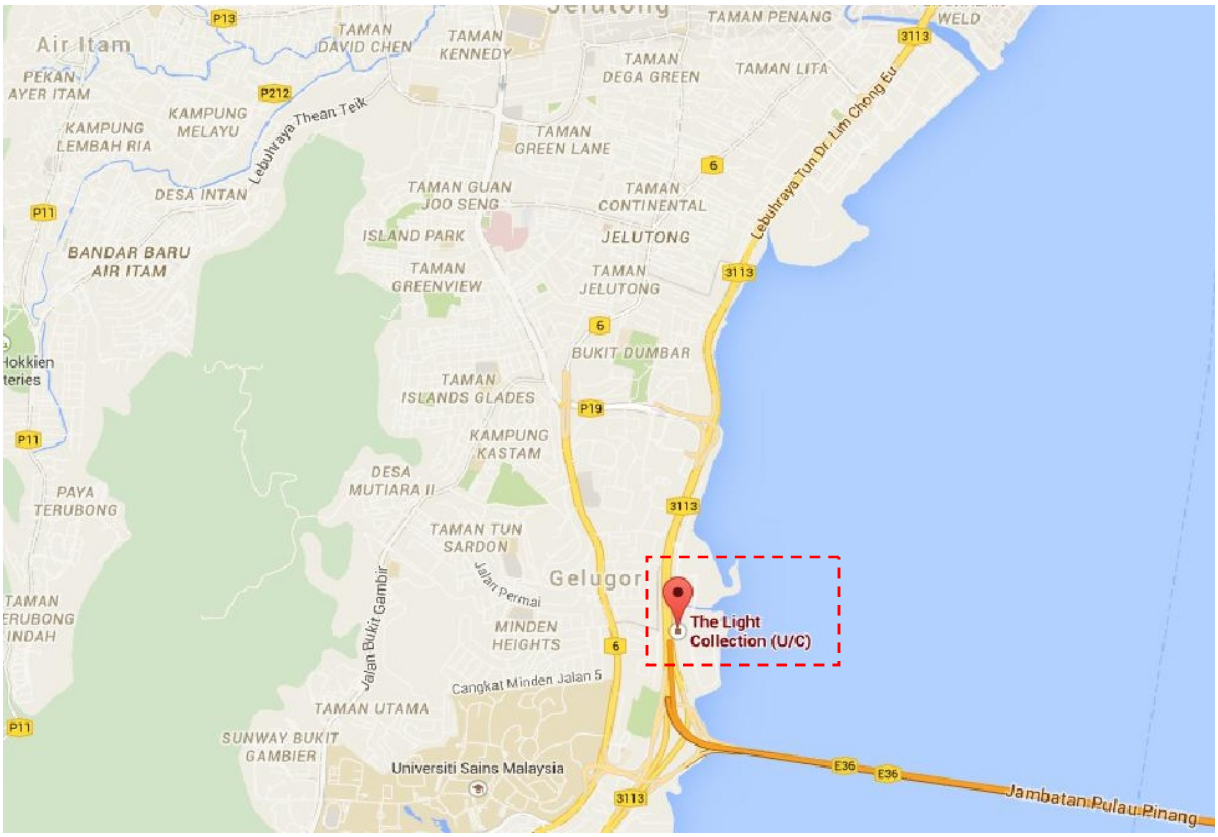


Figure 4.2: The Light Point Condominium, Penang Map

(Source: Google Map Online via https://www.google.com/maps, accessed on 30th August 2014)

For same type of building but different category of Non-Green Building Index (Non-GBI) rated building to compare with The Light Point Condominium, Penang will be the Palm Palladium Condominium, located in Jalan Minden 1, Gelugor Penang that officially operated in July 2011 that illustrates in figure 4.2 and figure 4.3 respectively. The distance between these two buildings is approximately 5.4km as shown in figure 4.4 below. In term of building's façade, both buildings are well maintained and occupancy rate is recorded more than 90%.

Figure 4.3: Palm Palladium Condominium, Penang Map

(Source: Google Map Online via https://www.google.com/maps, accessed on 30th August 2014)

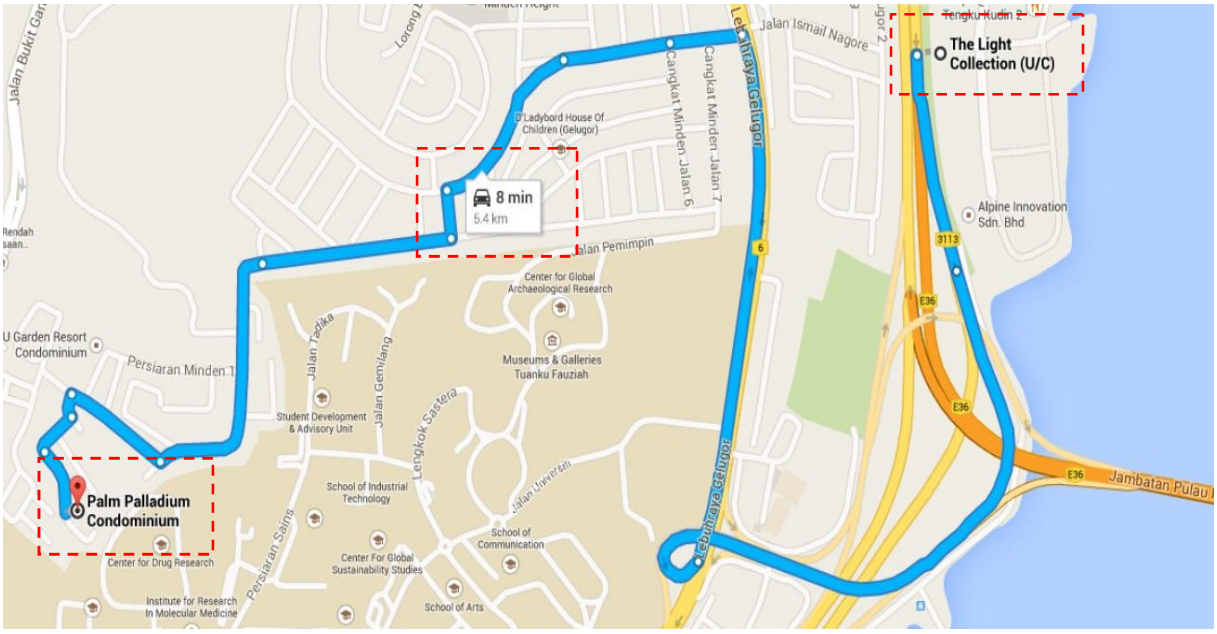


Figure 4.4: Distance between 2 Buildings Map

(Source: Google Map Online via https://www.google.com/maps, accessed on 30th August 2014)

4.2.2 Non-Residential Buildings

On the third comparison, Green Building Index (GBI) category of Non-Residential New Construction (NRNC) is an office type of building, the selected building is Point 92 or also known as Menara OBYU, which is located in the developed and dynamic township of Damansara Perdana, Petaling Jaya Selangor Darul Ehsan. The geographical map as shown on figure 4.5 and figure 4.6 below. The main 6 criteria that emphasized and categorized by GBI are fulfilled in terms of building materials, landscaping, electrical and water utilities as well as grade "A" green office building.

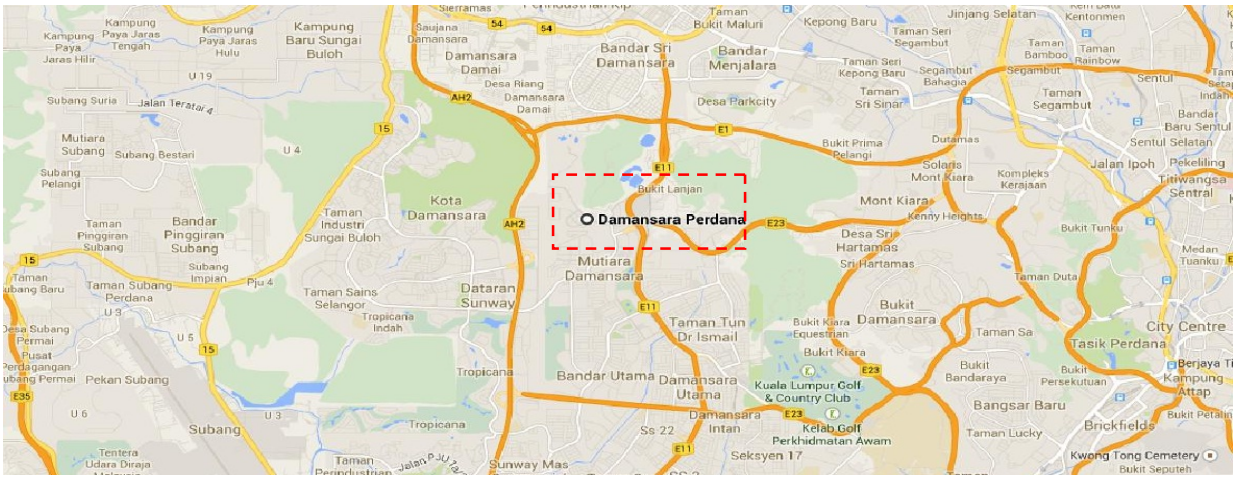


Figure 4.5: Damansara Perdana, Petaling Jaya, Selangor Darul Ehsan Map

(Source: Google Map Online via https://www.google.com/maps, accessed on 30th August 2014)

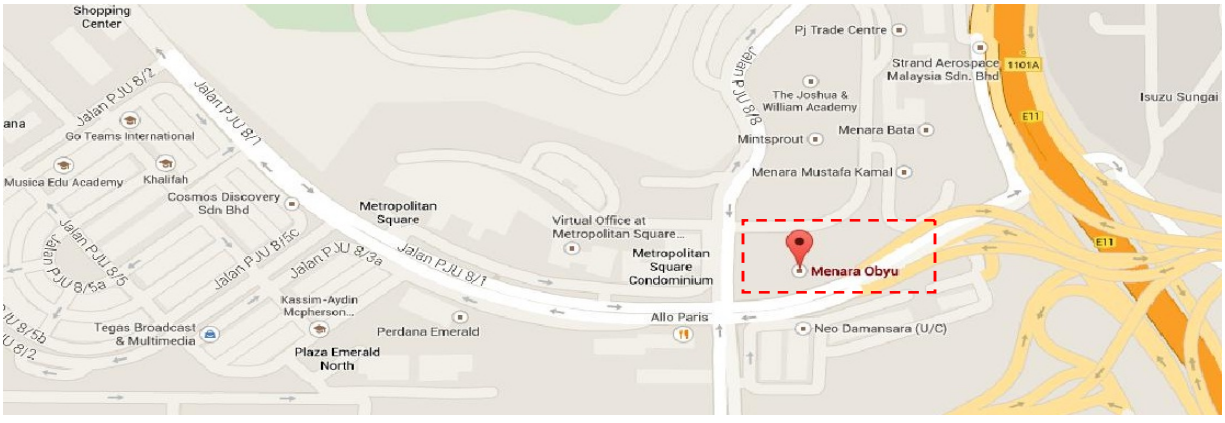


Figure 4.6: Menara OBYU, Damansara Perdana, Petaling Jaya, Selangor Darul Ehsan Map

(Source: Google Map Online via https://www.google.com/maps, accessed on 30th August 2014)

For the similar type of grade "A" office building but categorized as non-green rated building which to be compare under the same usage of building is Menara Mudajaya. Referring to figure 4.7; this building located within the same township of Damansara Perdana, Petaling Jaya, Selangor Darul Ehsan that officially operated in September 2012. The distance between these two buildings is less than a kilometre as shown in figure 4.8 below. The basic building's characteristic and criteria to compare between these two buildings are still remain unchanged as explained earlier in order to provide similar comparison especially on the building's operation and maintenance cost differences between the building. Both selected office buildings are recorded 95% of occupancy rate on December 2014.

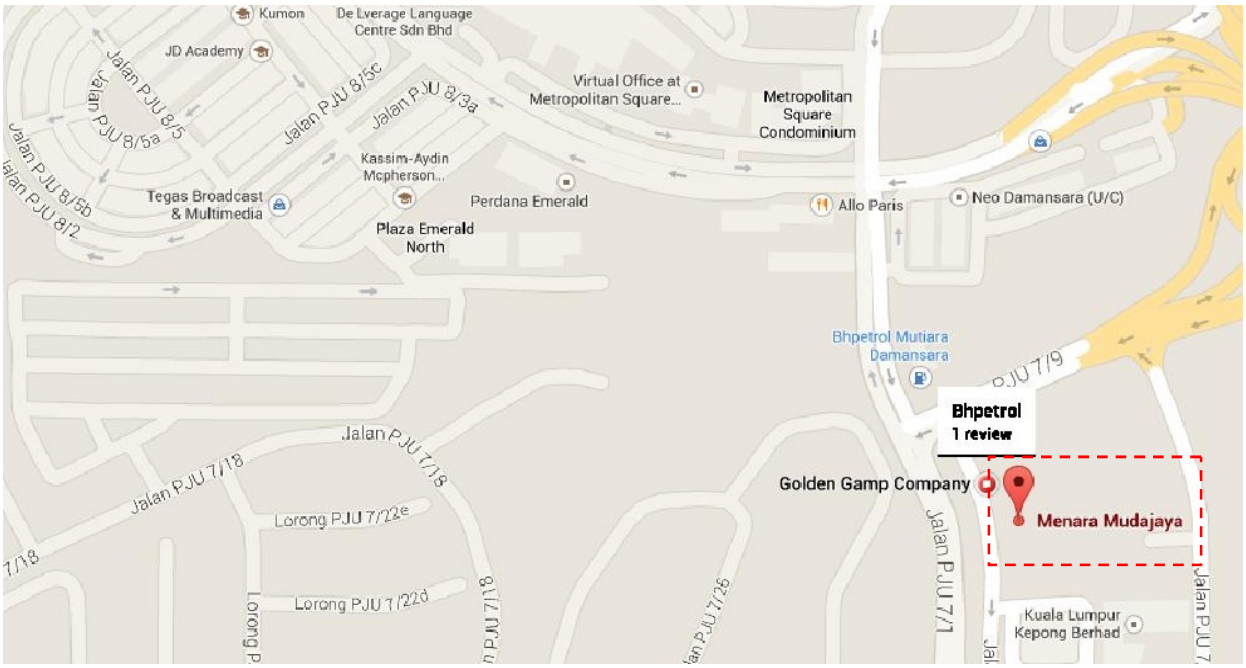


Figure 4.7: Menara Mudajaya, Damansara Perdana, Petaling Jaya, Selangor Darul Ehsan Map

(Source: Google Map Online via https://www.google.com/maps, accessed on 30th August 2014)

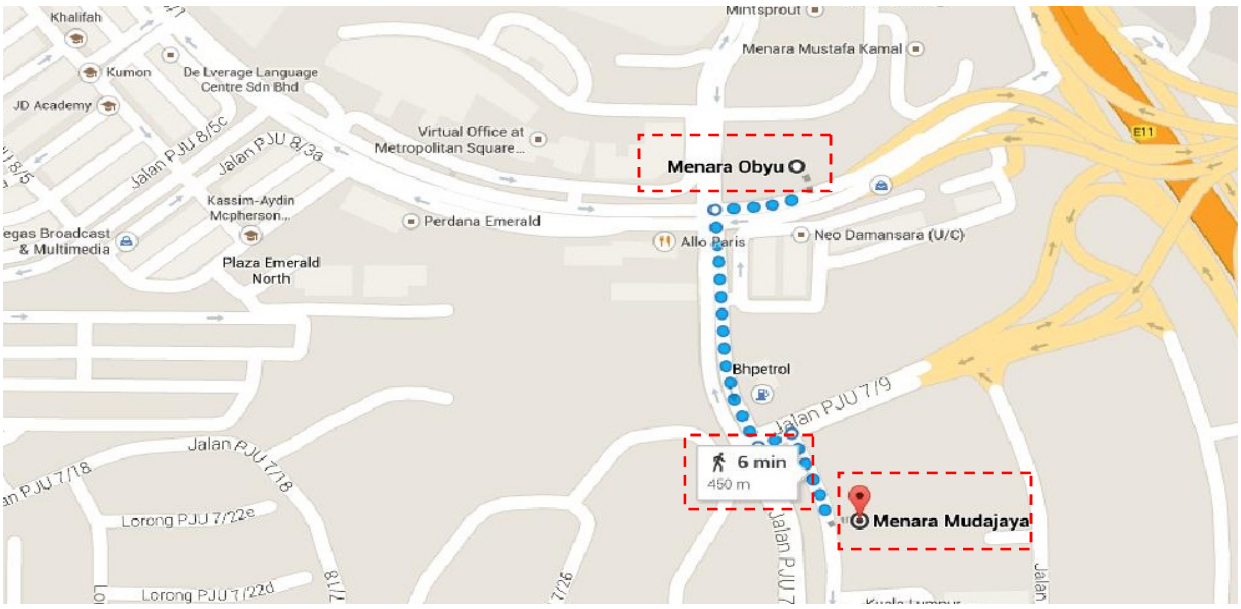


Figure 4.8: Distance between 2 Buildings Map

(Source: Google Map Online via https://www.google.com/maps, accessed on 30th August 2014)

4.3 Survey Structure

The following sections present the findings of the survey. The analyses are based on site survey or inspections and characteristics of the green and non-green rated buildings.

This study conduct a visual survey of the building's conditions of the selected building. However, this survey did not involve any inspection on overall features on the building, but confined itself to the exteriors specifically on the painting works, roofing membrane or cladding, internal lighting, internal ceiling board or panel, water saving features such as rainwater harvesting system or equivalent technology, solar system or any other related sustainable building features and any other miscellaneous and general features such as compositing recyclable bins, landscaping, windows, tinted film and other green related materials and fittings.

4.4 Case Study: The Light Point Condominium, Penang

The Light Point Condominium, Penang consists of 28-storey of residential building. This building was constructed in early year of 2010.

Figure 4.9: The Light Point Condominium, Penang construction site earthworks in progress

(Source: Chartered Quantity Surveyor of Kuantibina Sdn Bhd website via http://kuantibina.com.my/, accessed on 18th December 2014)

Figure 4.10: The Light Point Condominium, Penang location map on air view

(Source: Chartered Quantity Surveyor of Kuantibina Sdn Bhd website via http://kuantibina.com.my/, accessed on 18th December 2014)

Figure 4.11: The Light Point Condominium, Penang construction of building structure at roof level

(Source: Chartered Quantity Surveyor of Kuantibina Sdn Bhd website via http://kuantibina.com.my/, accessed on 18th December 2014)

The Light Point Condominium is Phase 1 of The Light Waterfront mixed development project which is being handled by one of Malaysia's best developer of IJM Land Berhad. Built along the beach of Northern Penang and this development is built on freehold land, a factor that adds to its appeal and high demand property in the Penang Island as shown on figure 4.9 and 4.10 above. The completed condominium has only limited units or low density residential concept due to the huge built-up area and spaces for the each of the individual home and to provide a lavish dwellings. The Light Point is a single storey that rises elegantly to 28-storeys high. It is a highly exclusive low density resort home with only 112 units available in the entire development with approximately 4 units each floor. With 7 different layouts available to choose from, the residents is able to choose the one that suits those most. The exact building design was shown on figure 4.11 above.

The Light Point is a development that gives its residents in return of every cent that is paid for in term of the smart home system that has home automation is well as lights and fans automation controllable via the use of central command interfaces, which are the keys features for electricity cost saving element. With wide and spacious balconies designed for this home, residents will be able to enjoy the sea air without ever leaving the comforts of their home as the perfect orientation of the building to achieve maximum level of natural lighting and cool air ventilation for every single day. Furthermore, the centralized vacuum system will assist in keeping homes dust-free and the air-conditioning units provided additional cooling mechanism to cool down the temperature mechanically to the residents during warm weather.

Each unit of the Light Point comes with 3 parking bays so residents need never worry about the lack of parking space. Lobbies and lifts are monitored by Closed Circuit Television (CCTV) which is in turn monitored by the 24-hour security team, letting the residents a peace of mind and wander around the ground safely. Building facilities that operates and available on this building are the 50-metres swimming pool, the children's pool, barbecue and community area, the Jacuzzi, gymnasium, games room, reading rooms, outdoor reading area and multi-purpose hall. All these facilities will determine the similarity of the services and utilities usage as a comparison to another non-green rated building.

Location wide, strategically close to Georgetown, the Light Point is well provided for. The overall master plan of The Light Waterfront Penang development was illustrate on figure 4.12 below which consists of few schools in the vicinity, and E-Gate and Tesco Penang hypermarket are within the walking distance toward the condominium. Apart from that, being set close to the Penang Bridge it is also well connected to highly travelled roads such as the Jalan Tunku Kudin, the Jelutong Highway and Jalan Sultan Azlan Shah. With all these features describe above, The Light Point Condomium was awarded and recognized as Green Rated Building by Green Building Index Sdn Bhd Malaysia in Year 2012. Various actual site photos are illustrates on figure 4.13 such as main building entrance, landscaping design, location of TNB sub-station, solar energy lighting and many more.

Figure 4.12: Master Plan of The Light Waterfront Penang

(Source: IJM Land Berhad Website via http://www.ijm.com.my/, accessed on 25th December 2014)

Figure 4.13: The Light Point Condominium, Penang Main Entrance

Figure 4.14: The Light Point Condominium, Penang Main Entrance

Figure 4.15: The Light Point Condominium, Penang TNB Sub-Station (Electricity Source)

Figure 4.16: The Light Point Condominium, Penang TNB Sub-Station (Electricity Source)

Figure 4.17: The Light Point Condominium, Penang Water Pump Room (Water Source)

Figure 4.18: The Light Point Condominium, Penang External Landscape (Green Area)

Figure 4.19: The Light Point Condominium, Penang External Solar Lighting (Re-chargeable)

With most condos offering delightful, panoramic views of the ocean, city centre and landscaped gardens that dot the vicinity to eco-centric environment. Plant life in and around the property is watered by an rain water harvesting system, while part of the construction is made of green building materials such as autoclaved aerated concrete (AAC) blocks, cellulose fibre cement boards (PRIMA), safe coat zero (VOC) paint, ceiling energy board and other recyclable materials.

Figure 4.20: The Light Point Condominium, Periodically Maintenance Works, Painting Works & Façade Cleaning

Figure 4.21: The Light Point Condominium, External Drainage Works for Drainage Construction

This building periodically maintenance works will be carry out twice a year especially on the building façade and to improve the existing ventilation and natural lighting opening building design. Apart from that, drainage system is the main infrastructure works for such building as a mitigation reaction toward the flood issue. For this building, the façade is equally important to preserve and maintain in order to receive recognition from Green Building Index (GBI) agency on the renewal of the Green Building Certification every year. All the maintenance works for this building is performed by skilled workers with the supervision of qualified and competent supervisor such as experienced and GBI's registered supervisor as to comply the GBI 6 Keys Elements. Others maintenance works involved for this building are includes electrical works on led lighting checking and replacement works if require, water harvesting system, landscaping, roofing cladding inspection, maintenance and replacement if require as well as general facilities equipment such as disposal bin, walkway floor and wall tiles, door accessories and fittings, carpark pavement and road lining. Above on figure 4.20 is to illustrate the actual situation of building maintenance works being carry out for The Light Point Condominium.

4.5 Case Study: Palm Palladium Condominium, Penang

As a comparison to The Light Point Condominium, Palm Palladium Condominium which also consist of 28-storey building (Figure 4.22 and Figure 4.23) located at the district of Gelugor, Penang. Palm Palladium is a condominium block in the Minden Heights neighborhood of Gelugor, Penang. Developed by Harta Intan Ventures Sdn Bhd, comprise of 28-storey block that was built on freehold tenure and completed in year 2011. The units come in different configurations, with built-up area ranging from 1,150 square feet to 2,400 square feet. There are only three units on each floor, which is served by two lifts. Palm Palladium has a total of 134 residential units. Facilities at Palm Palladium include 24-hour security, covered parking lots, swimming pool, gymnasium, multi-purpose hall, children's playground and barbecue area, among others. Geographically; Palm Palladium Condominium is 11.9 km from Magazine Circus, making it quite a distance from the city centre. With 3 units on each floor, Palm Palladium offers

the best privacy and low density living lifestyle with 2 lifts serving only 3 units per floor for this 28-storey condominium.

Physically appears for this building does not reflect any special feature apart of conventional and standard high-rise condominium. Pure reinforced concrete structure with painted finish appearance, north-south building orientation, and conventional window glazing as well as well equipped conventional type of condominium facilities as described early was available. The main utilities usage on water and electricity are operate up to 24 hours per day. Entire building will undergoes minor maintenance works annually as recorded by the building management since year 2011.

Figure 4.22: Palm Palladium Condominium structural works in progress

Figure 4.23: Palm Palladium Condominium, completed building (Taken Date: 16th April

(Source: Malaysia's Skyscaper City website via http://www.skyscrapercity.com, Accessed on 10th April 2014)

Figure 4.25: Palm Palladium Condominium, Resident's Walkway (General Area)

Figure 4.26: Palm Palladium Condominium Lift by Sigma Elevator (M) Sdn Bhd

Figure 4.27: Palm Palladium Condominium Water Supply Perbadanan Bekalan Air Pulau Pinang (PBA) Pocket Meter.

Figure 4.28: Palm Palladium Condominium Resident's Services Room for Water, Electricity, PABX System and Pump Room.

Figure 4.29: Palm Palladium Condominium,

Hose Reel, Bell and Fire Extinguisher

(Bomba Fire Fighting Services & Equipments)

Figure 4.30: Palm Palladium Condominium

T8 Fluorescents Tube Lighting

(General Area)

Figure 4.31: Palm Palladium Condominium, Penang, TNB Sub-Station (Electricity Source)

Figure 4.32: Palm Palladium Condominium, Penang Periodically Maintenance Works (Painting & Building Façade Cleaning Works in Progress)

Figure 4.33: Palm Palladium Condominium, Paint Weather-bond

Figure 4.34: Palm Palladium Condominium Improved Rubbish Bin

Figure 4.35: Palm Palladium Condominium, Exit Driveway

Figure 4.36: Palm Palladium Condominium Pump Room (Hydraulic Pump System)

Figure 4.37: Palm Palladium Condominium, Penang, Vehicle's Washing Bays

Figure 4.38: Palm Palladium Condominium,

Penang, Main Entrance

For the above actual photos on figure 4.25 to 4.38 are illustrates the selected maintenance products that found in the non-GBI rated building criteria to match the GBI 6 keys elements as explained in Chapter 2 of literature review such as water and electricity relevant items like passengers lift and common lighting, selected external paints, green materials dustbin and others.

4.6 Case Study: Point 92 a.k.a Menara OBYU, Damansara Perdana, Petaling Jaya Selangor

On third category of selected case study building, Point 92 also known as Menara OBYU located at Damansara Perdana, Petaling Jaya which consists of a single 19-storey tower with 20,000 square meters of office space. It sits on a small site of 0.92 acres, hence the name Point 92. The building was completed in year 2012. Point 92, a new Grade "A" green-rated office building which is fast becoming a landmark in Damansara Perdana in Petaling Jaya with its eye-catching design, officially completed in September 2012. The Malaysian Green Building Index-(GBI) certified 19-storey tower as Multimedia Super Corridor (MSC) Malaysia recognition status building with a "Net Let-table Area" (NLA) of 15, 500 square meters. It has six levels of basement car park and outdoor decks on the 7th, 8th and 9th floor with the landscaping by "Seksan Design", a landscape architecture planning specialist. The building is located at the entrance to Damansara Perdana via the Damansara Puchong Highway. Tujuan Gemilang Sdn Bhd, the developer of Petaling Jaya (PJ) Trade Centre in Damansara Perdana, sold the office tower late last year to Sarawak-based OBYU Holdings Sdn Bhd. OBYU is a company involved in property development, construction and engineering, power and telecommunications, plantations, services and trading. Despite the small site, about 500 trees were planted, creating the feel of dense vegetation around the main lobby floor. Cut-out zones were created at the upper floors of the building to create break out areas and connection with nature. The white concrete façade was cast in-situ in a simple and economical way, despite the elaborate design. The distinctive form and elegant façade has made the building a well-known landmark in the area, fondly referred to as "the Fendi Italian bag" design as shown on figure 4.39 to figure 4.44 on architectural design.

Figure 4.39: Point 92, Damansara Perdana, Petaling Jaya Selangor Darul Ehsan

Source: ZLG Design Sdn Bhd, http://www.zlgdesign.com/ access on 21st July 2014.

Marine plywood with "Meranti" veneer was used on the walls and ceilings of the lobby level, as well as at the outdoor breakout areas. Concrete in various finishes such as polished, washed, bush-hammered and broomed were used on the floors and walls. These simple local materials, carefully designed and crafted, combine to give a feel that is natural and pleasing. The building has received very positive comments generally and was featured on the cover of d+a magazine, one of the established magazines in the region. Point 92 is a certified green building by the Green Building Index (GBI) of Malaysia. A key green feature is the white concrete façade, which comprises of 150mm thick walls with only 38% openings for windows, minimizing heat gain while maintaining optimum natural light in the office spaces. Point 92 is

also a certified MSC Cyber-centre Status building; with specifications that fulfill the stringent requirements of MSC status companies.

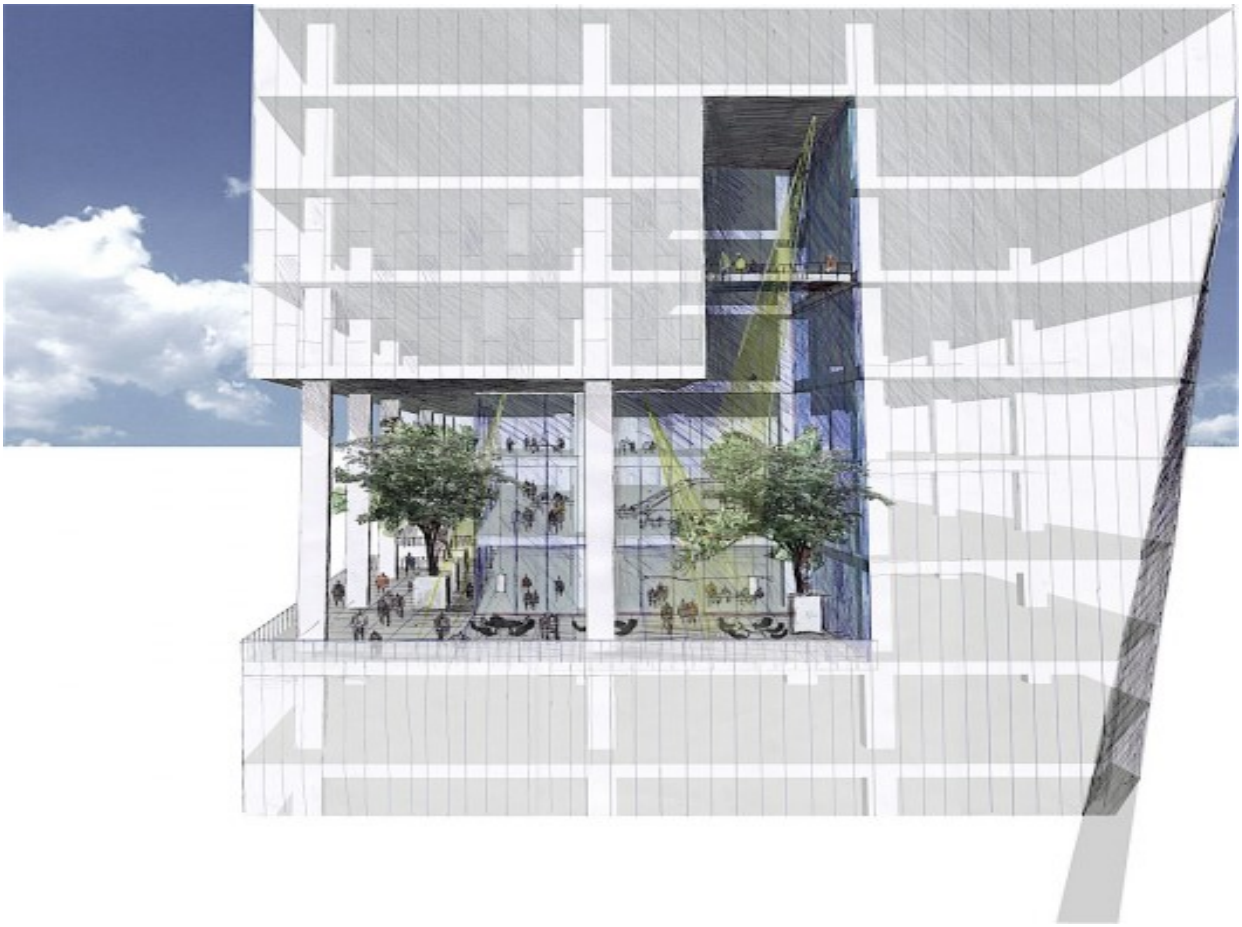


Figure 4.40: Point 92 Conceptual Architectual Design

Source: ZLG Design Sdn Bhd, http://www.zlgdesign.com/ access on 21st July 2014.

As an office plan, the generating feature of the floor plate is in fact a cut-out space which comprises of several levels of voids connected through gardens and meshes of vertical planting. The centre support column is braced to either side with different thickness of beams each corresponding to different floor forces framing the vertical space that is the garden. The terrace is specially lit and designed grandly to give the viewers from outside a taste of the garden.

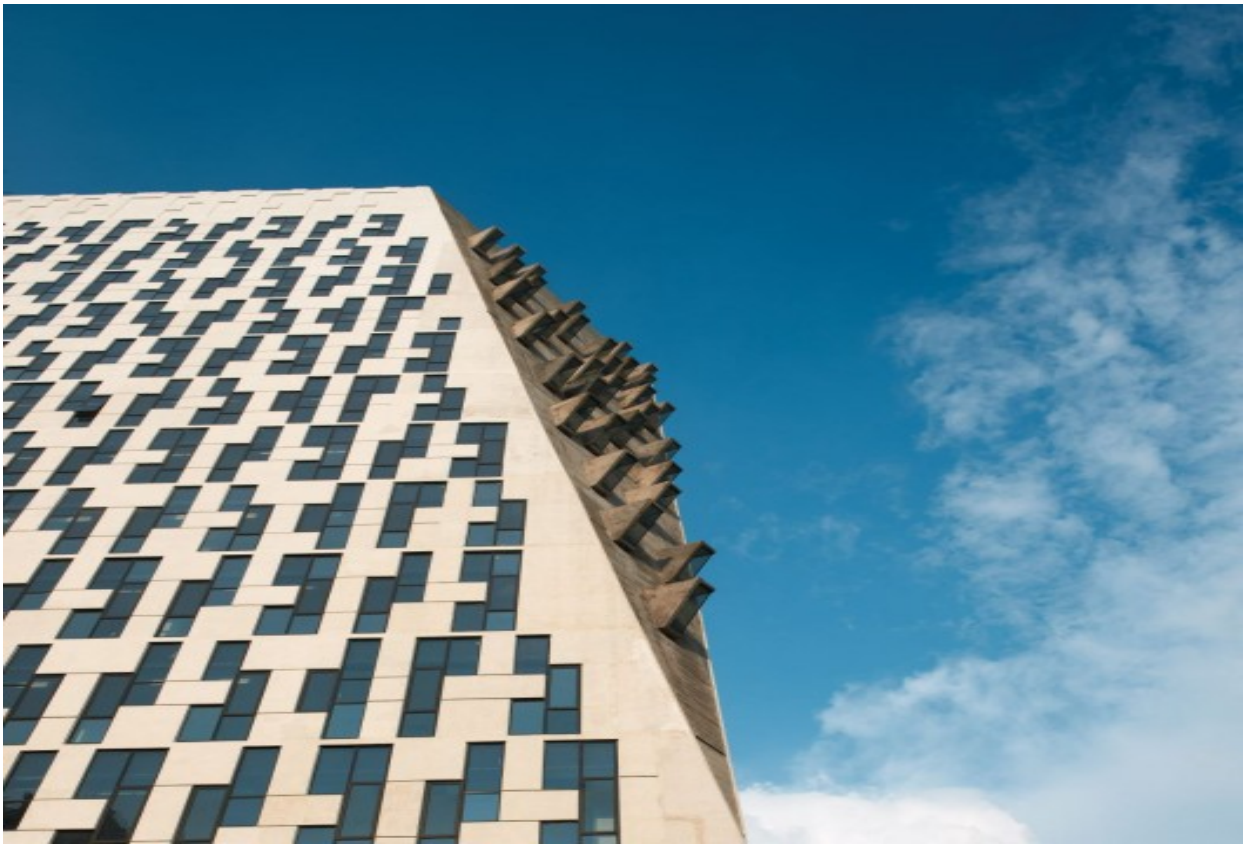


Figure 4.41: Point 92 ‘Fendi Bag’ Design

Source: ZLG Design Sdn Bhd, http://www.zlgdesign.com/ access on 21st July 2014.

To show that simple local materials can be crafted to create a building that is appealing and distinctive, local materials were carefully design and crafted, combine to give a feel that is natural and pleasing. Off-form white concrete and local marine plywood were chosen as the main materials. To overcome the problem of building on a slope, the design opted for in-situ concrete wall instead of the usual precast concrete solutions. Not only was it necessary to use metal formwork in sets to meet with a target schedule, it is also informed of the uniformity issues if the façade was casted in regular sequences. Hence the randomly casted sequence. Elegantly rising from the slopes, the slanting walls in the façade continues the natural geometry of the site while the rectangular punctuations complement the ever developing built environment in Damansara Perdana.

Figure 4.42: Point 92 Material Design

Source: ZLG Design Sdn Bhd, http://www.zlgdesign.com/ access on 21st July 2014.

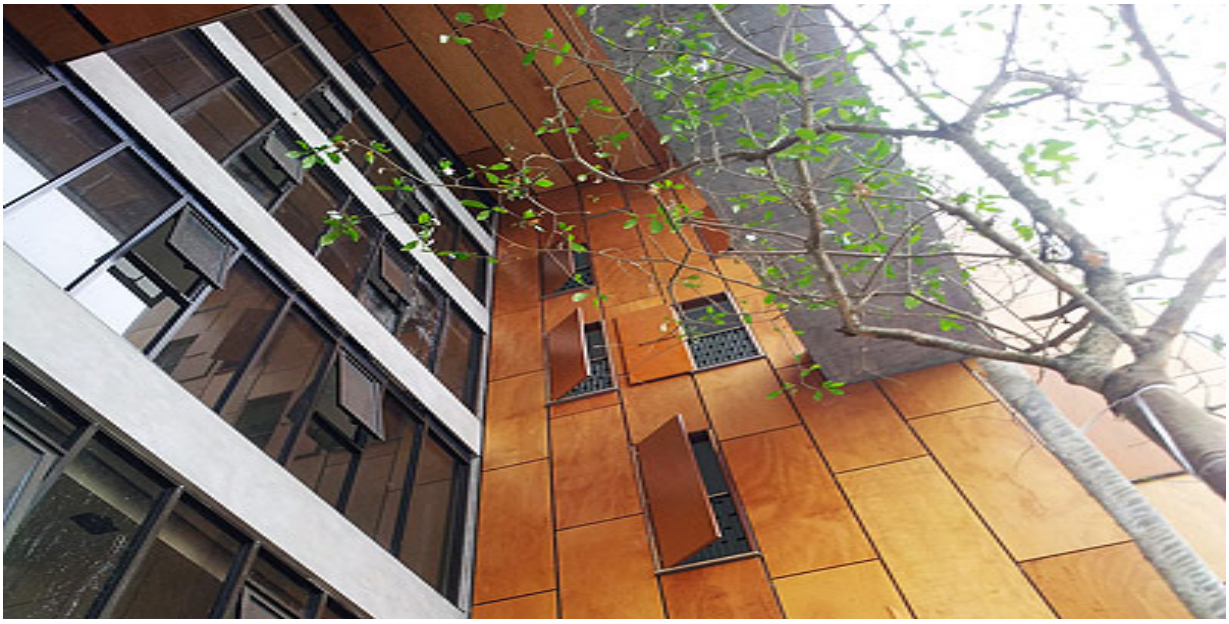


Figure 4.43: Point 92 Material Design

Source: ZLG Design Sdn Bhd, http://www.zlgdesign.com/ access on 21st July 2014.

A key green feature is the in-situ placed white concrete façade, which comprises of 150mm thick walls with only 38% openings for windows, minimizing heat gain while maintaining optimum natural light in the office spaces.

Figure 4.44: Point 92 Landscaping Design

Source: ZLG Design Sdn Bhd, http://www.zlgdesign.com/ access on 21st July 2014.

Figure 4.45: Point 92 Office Spaces

Figure 4.46: Point 92 Office Spaces

Figure 4.47: Point 92 Office Spaces with Tenant

Figure 4.48: Point 92 Office Spaces with Tenant

Figure 4.49: Point 92 Office Spaces with Tenant

The internal office spaces are shown on figure 4.45 and 4.46 for unoccupied office unit as a comparison to figure 4.47 and figure 4.48 for office spaces with tenants. The differences to illustrate the utilities consumption and type of green and non-green fixtures that could be found on the office spaces. From unoccupied office spaces, indeed it was fully bare units with cement render, open ceiling and bare wall with emulsion paint finish. This unit categorized as non-maintenance unit for the building manager. However, for tenanted office unit; most of the spaces are utilities with floor carpets and with plenty of ceiling LED lighting that less maintenance services needed if compare to conventional lighting.

4.7 Case Study: Menara Mudajaya, Damansara Perdana, Petaling Jaya Selangor Darul Ehsan

Figure 4.50: Menara Mudajaya Office Building

Menara Mudajaya as shown on figure 4.50 above, fully owned by Mudajaya Group of Companies which consist of 19-storey modern and grade "A" office building located nearby The Curve, Mutiara Damansara, Petaling Jaya, Selangor Darul Ehsan. It has been completed in September 2012 and was a headquarters for public listed conglomerate Mudajaya Group Berhad. It was situated in the upwardly mobile and trendy township of Mutiara Damansara, Petaling Jaya North or Golden Triangle for Petaling Jaya for the state of Selangor Darul Ehsan. Menara Mudajaya is the newest modern office tower situated majestically among other older corporate office buildings such as Surian Tower, Menara UAC, Menara KLK, PJ Trade Centre, amongst others within less than 1km radius.

Menara Mudajaya offers freehold, low density luxurious corporate office suites for the privileged few in the heart of Mutiara Damansara, the most prestigious corporate office in Petaling Jaya. Whichever way you look at it, Menara Mudajaya is a prime spot to anchor your place to do business. Few of the building concept and surrounding areas are shown on figure 4.51 onwards.

Figure 4.51: Menara Mudajaya artist's impression of lobby and reception

(Source: Mudajaya's Official Website via http://www.mudajaya.com/home

accessed on 09th February 2015)

Figure 4.52: Menara Mudajaya, artist's impression on façade of the building

(Source: Mudajaya's Official Website via http://www.mudajaya.com/home

accessed on 09th February 2015)

Figure 4.53: Menara Mudajaya, artist's impression of lift lobby

(Source: Mudajaya's Official Website via http://www.mudajaya.com/home

accessed on 09th February 2015)

Figure 4.54: Menara Mudajaya, Petaling Jaya. Main Entrance.

Figure 4.55: Menara Mudajaya, Petaling Jaya. Office Lobby.

Figure 4.56: Menara Mudajaya, Petaling Jaya. Drop-off Area.

Figure 4.57: Menara Mudajaya, Petaling Jaya. Access road using paver concrete blocks and tar premix road.

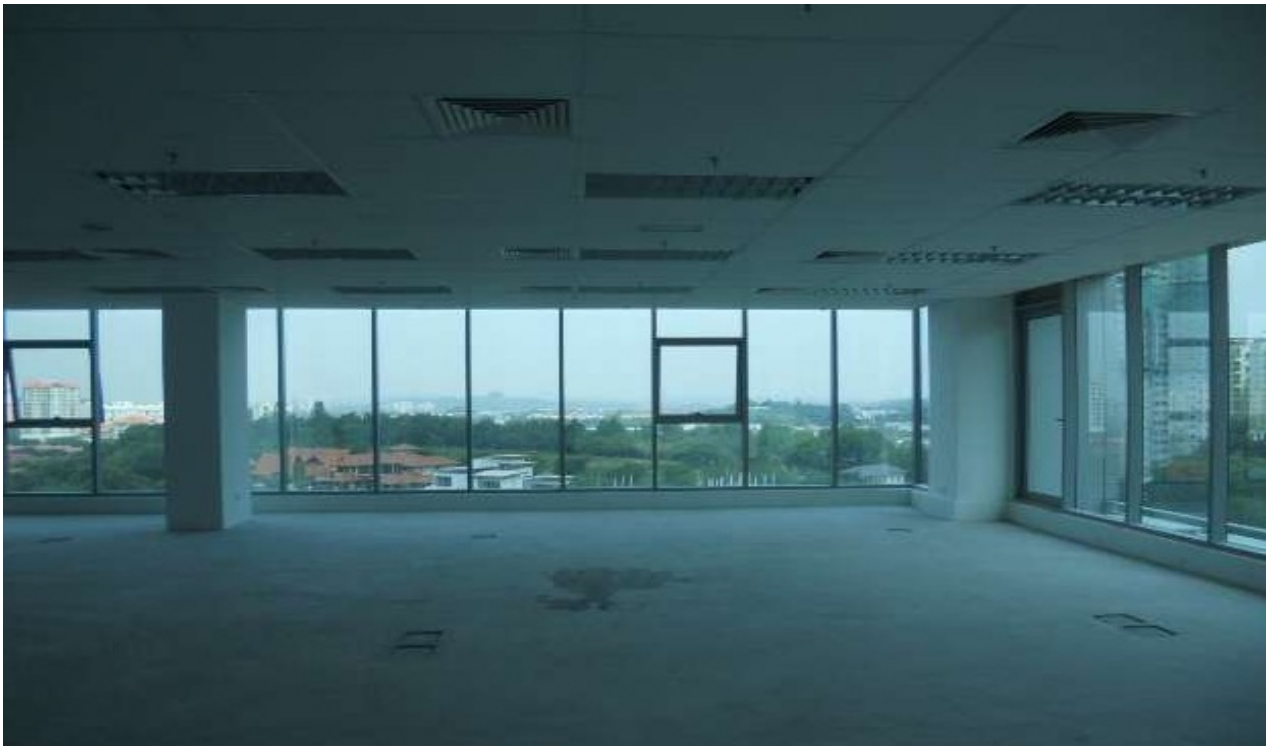


Figure 4.58: Menara Mudajaya, Petaling Jaya. Internal Leasable Office Space.

Figure 4.59: Menara Mudajaya, Petaling Jaya. Fixed Aluminium Frame Window Panel.

High frequency office maintenance works are carried out during the site visit as informed by the building manager mainly due to the quality of materials that selected by the project Architect's during the construction and planning stage. The frequent maintenance works are shown on figure 4.64 to figure 4.64 for painting works, leaking piping and even replacement of existing light weight blocks to Autoclaved Aerated Concrete (AAC) Blocks which considered to be light in weight, reduce the emissions of gasses such as CO2, CO and NOx. By-products of AAC Production such as condensate from the autoclaving, hardened AAC waste and unhardened AAC mixture can be recycled back into the production of AAC. Apart from that, this blocks may act as thermal insulation properties, less energy is required to cool a building and effective in moderating the moisture levels and maintaining the correct relative humidity.

Figure 4.60: Menara Mudajaya, Painting & Electrical Works in Progress.

Figure 4.61: Menara Mudajaya, Painting Works in Progress.

Figure 4.62: Menara Mudajaya,

Change leaking sprinkler piping

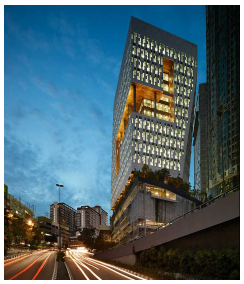
Figure 4.63: Menara Mudajaya,

Periodically checking by M&E Supervisor.

Figure 4.64: Menara Mudajaya, Petaling Jaya. Autoclaved Aerated Concrete (AAC) Blocks

4.8 Project Profile and Characteristics

Table 4.1: Summary of Selected Building's Observations, Results and Discussions

Building Category	**Residential**		**Non-Residential**	
Descriptions	The Light Point Condominium	Palm Palladium Condominium	Point 92 a.k.a. Menara OBYU	Menara Mudajaya
Illustration of Actual Building's Photo				
Type of Building	Condominium	Condominium	Office Commercial	Office Commercial
Category of Building	Green Rated Building	Non-Green Rated Building	Green Rated Building	Non-Green Rated Building
Total Built-up Area (m2)	8,091.08	7,782.28	3,724.46	3,967.36
Building Height / Floor	98.0m / 28-Storey Building	98.5m / 28-Storey Building	95.8m / 19-Storey Office Building	95.0m / 19-Storey Office Building
Completion Date	01st December 2012	01st July 2011	01st October 2012	01st September 2012
Construction Cost (RM)	RM68,750,000.00	RM53,150,000.00	RM46,150,000.00	RM35,210,000.00
Average Annual Maintenance Cost (January 2014 to December 2014)	RM38, 297.70	RM121, 565.12	RM36, 716.25	RM69, 308.50

Above table 4.1 indicates 2 types of residential building, which are The Light Point Condominium and Palm Palladium Condominium whereby both located in the state of Penang. Age of all selected case study building operation are observed and maintained at minimal of 2 years fully operated. The main differences are on the construction cost as well as the annual recorded building's operation and maintenance cost. Furthermore on residential buildings, it was recorded the total construction cost between green to non-green rated buildings are at 22.6% higher. However, there is a lower building's operation and maintenance cost recorded at 37.7% saving on green rated building to non-green rated building. Similar principle apply for non-residential buildings, the result recorded at 23.7% higher in construction cost but the cost saving percentage recorded at 40.4%. From the results, it's shown that good return on investment factor for green rated buildings that minimum operation of 24 months. Below table 4.2 and table 4.3 are the indication of selected case study building for residential type of building between GBI and Non-GBI building. Whereas, table 4.4 and table 4.5 are the indication of selected case study building for non-residential building type of building between GBI and Non-GBI building.

4.8.1 Residential Category

(A) Case Study: The Light Point Condominium, Penang

Table 4.2: Characteristics of The Light Point Condominium, Penang

No.	Category	Descriptions
1.	**Project Name**	Cadangan untuk membina pemajuan perumahan di atas air (Shore Front Development Fasa 1), 1 Blok Kondominium 28-Tingkat di atas sebahagian tapak pembangunan tanah tebusguna lot 27201, Seksyen 8, Bandar Georgetown, Daerah Timur Laut, Pulau Pinang untuk Tetuan Jelutong Development Sdn Bhd.
	Project Profile	The Light Point Condominium 3
	Type of Project	High-Rise Building
	Category of Building	Green Rated Building Category
	Total Built-up Area	8,091.08m2
	Building Height / Floor	98.0m / 28-Storey Building
	Mode of Operation	Residential
	Building Criteria	Operation In Progress
	Completion Date	01st December 2012
	Location	Georgetown, Pulau Pinang
	Construction Cost (RM)	RM68,750,000.00
	Average Annual Operation and Maintenance Cost (RM)	RM38, 297.70

(B) Case Study: Palm Palladium Condominium, Penang

Table 4.3: Characteristics of Palm Palladium Condominium, Penang

No.	Category	Descriptions
1.	**Project Name**	Cadangan Pembangunan 134 Unit Pangsapuri 28-Tingkat yang mengandungi 5-Tingkat Podium Letak Kenderaan Di Atas PT. 1357 DAN PT. 1358, Lebuh Minden 1, Daerah Timur Laut, Pulau Pinang untuk Tetuan Harta Intan Ventures Sdn Bhd
	Project Profile	Palm Palladium Condominium
	Type of Project	High-Rise Building
	Category of Building	Non-Green Rated Building Category
	Total Built-up Area	7,782.28m2
	Building Height / Floor	98.5m / 28-Storey Building
	Mode of Operation	Residential
	Building Criteria	Operation In Progress
	Completion Date	01st July 2011
	Location	Gelugor, Pulau Pinang
	Construction Cost (RM)	RM53,150,000.00
	Average Annual Operation and Maintenance Cost (RM)	RM121, 565.12

4.8.2 Non-Residential Category

(A) Case Study: Point 92 a.k.a. Menara OBYU, Damansara Perdana, Selangor Darul Ehsan.

Table 4.4: Characteristics of Point 92 a.k.a. Menara OBYU, Damansara Perdana, Selangor Darul Ehsan

No.	Category	Descriptions
1.	**Project Name**	Pembangunan 1 Blok Bangunan Pejabat 19 Tingkat Yang Mangandungi 1 Tingkat Lobi Pejabat, 7 Tingkat Tempat Letak Kereta Di Atas Lot PT 47369, Jalan PJU8/8, Damansara Perdana, Mukim Sungai Buloh, Daerah Petaling, Selangor Darul Ehsan.
	Project Profile	Point 92 a.k.a Menara OBYU
	Type of Project	Corporate Office Suites
	Category of Building	Green Rated Building Category
	Total Built-up Area	3,724.46m2
	Building Height / Floor	95.8m / 19-Storey Office Building
	Mode of Operation	Non-Residential / Commercial
	Building Criteria	Operation In Progress
	Completion Date	01st October 2012
	Location	Damansara Perdana, Petaling Jaya Selangor Darul Ehsan.
	Construction Cost (RM)	RM46,150,000.00
	Average Operation and Maintenance Cost (RM)	RM36, 716.25

(B) Case Study: Menara Mudajaya, Damansara Perdana, Selangor Darul Ehsan.

Table 4.5: Characteristics of Menara Mudajaya, Damansara Perdana, Selangor Darul Ehsan

No.	Category	Descriptions
1.	**Project Name**	Pembangunan 1 Blok Bangunan Pejabat 19 Tingkat Yang Mangandungi Lobi Pejabat, 3 Tingkat Besmen Dan 4 Tingkat Tempat Letak Kereta Di Atas Lot PT 49905, Jalan PJU7/3, Damansara Perdana, Mukim Sungai Buloh, Daerah Petaling, Selangor Darul Ehsan.
	Project Profile	Menara Mudajaya
	Type of Project	Corporate Office Suites
	Category of Building	Non-Green Rated Building Category
	Total Built-up Area	3,967.36m2
	Building Height / Floor	95.0m / 19-Storey Office Building
	Mode of Operation	Non-Residential / Commercial
	Building Criteria	Operation In Progress
	Completion Date	01st September 2012
	Location	No. 12A, Jalan PJU 7/3, Mutiara Damansara, Petaling Jaya.
	Construction Cost (RM)	RM35,210,000.00
	Average Operation and Maintenance Cost (RM)	RM69, 308.50

CHAPTER 5

DISCUSSION

5.1 Assessment Criteria Score with Cost Implication

The selected green and non-green rated building assessment scoring criteria are tabulated below with the operation and maintenance cost computation column indicating whether there will be any additional cost between 2 different types and category of building as to be highlighted by the Building's Manager on technical issues with operation and maintenance actual cost. The frequency and cost involved are elaborated in detail under sub-topic 4.4.1, 4.4.2 and 4.4.3. Operation and Maintenance Cost Implication. The operation and maintenance assessment criteria will still reflects the GBI's 6 key elements which are Energy Efficiency (EE), Indoor Environment Quality (EQ), Sustainable Site Planning & Management (SM), Material and Resources (MR), Water Efficiency (WE) and Innovation (IN). However, not all elements shall be fully comply and examine but the assessment will based on the significant level of the building's operation and maintenance tasks' listing on frequency and cost involved.

5.2 Maintenance Cost Implication

For a closer and selective examination of all 6 elements, the tables below show the cost implications in comparing the conventional building as non-green rated building (Non-GBI) items with the aforesaid green building items. In the tables below, the non-green rated building's maintenance cost expenditure for the elements of Internal and External Finishes (Painting), Electrical Works, Internal Ceiling Paneling, Roof Covering or Sheets, Sanitary Fittings, and Mechanical Works such as on Rainwater Harvesting System abstracted from the contract agreement of maintenance services on selected building whereby to compared against the costs of the alternative green items. Eventually, a summary of the total cost implications and the differential cost percentage for all the aforesaid elements are presented as tables below.

Table 5.1: Internal and External Finishes (Painting Works) Cost Comparison Table

Category	Type of Building	Item Description	Cost (RM)	Durability / Warranty	GBI Element
Residential Building					
Green Building	The Light Point Condominium, Penang	Low Volatile Organic Compound (VOC) / Weather Bond Paint *(After 2 Years on House's Rule Policy)*	42,000.00	2 Years	EQ 5
Non-Green Building	Palm Palladium Condominium, Penang	Basic Emulsion Paint – *Repaint Entire Building (After 3 Years on House's Rule Policy)*	213, 422.00	3 Years	-
Non-Residential Building					
Green Building	Point 92 a.k.a. Menara OBYU, Damansara Perdana, Selangor Darul Ehsan.	Low Volatile Organic Compound (VOC) / Weather Bond Paint *(After 2 Years on House's Rule Policy)*	51, 000.00	2 Years	EQ 5

Non-Green Building	Menara Mudajaya, Damansara Perdana, Selangor Darul Ehsan	Basic Emulsion Paint *(After 2 Years on House's Rule Policy)*	67, 305.00	2 Years	-

The type of painting used plays an important role in making the habitable space free from substances that could harm the health of the occupants apart from cost-effective point of views. As such, instead of using the normal emulsion paint, low VOC paint is used which the GBI recognizes and rewards under the area of assessment: "Volatile Organic Compounds". Attached in Appendix B is the competitive quotation from Nippon/ICI/Jotun paint. In term of durability and warranty period that given by the same manufacturer but for different type of paints are as stated above. From the calculation, the maintenance expense for Internal and External Painting Works identify as below:-

Residential Building

(i) Low Volatile Organic Compound (VOC) Paint

Total Costing = RM42, 000.00 / 2 Years

Per Year Maintenance Cost = RM21, 000.00

(ii) Basic Emulsion Paint

Total Costing = RM213, 422.00 / 3 Years

Per Year Maintenance Cost = RM 71, 140.70

Differential Maintenance Cost Saving (i) – (ii) = RM50, 140.70 / Year

Differential in Percentage = 70.4%

Non-Residential Building

(i) Low Volatile Organic Compound (VOC) Paint

Total Costing = RM51, 000.00 / 2 Years

Per Year Maintenance Cost = RM25, 500.00

(ii) Basic Emulsion Paint

Total Costing = RM67, 305.00/ 2 Years

Per Year Maintenance Cost = RM33, 652.50

Differential Maintenance Cost Saving (i) – (ii) = RM8, 152.50 / Year

Differential in Percentage = 24.2%

Table 5.2: Electrical Services Works Cost Comparison Table

Category	**Type of Building**	**Item Description**	**Cost (RM)**	**Durability / Warranty**	**GBI Element**
Residential Building					
Green Building	The Light Point Condominium, Penang	Energy Saving Fluorescent Lights (T5)	7, 200.00	2 Years	IN 1 & WE3
Non-Green Building	Palm Palladium Condominium, Penang	Normal Fluorescent Lights (T8) – *Upgrade to LED Lighting*	93, 010.00	3 Years	
Non-Residential Building					
Green Building	Point 92 a.k.a. Menara OBYU, Damansara Perdana, Selangor Darul Ehsan.	Energy Saving Fluorescent Lights (T5)	4, 704.00	2 Years	IN 1 & WE3
Non-Green Building	Menara Mudajaya, Damansara Perdana, Selangor Darul Ehsan	Normal Fluorescent Lights (T8)	14, 700.00	2 Years	

During the survey and interview with the Building Manager, the latter highlighted type of electrical lighting equipment which vastly used in the high-rise building especially at the general working areas can contribute to the GBI rating such as using T5 Energy Saving Fluorescent Lights. The T5 Fluorescent lights save up to 25% more energy than the conventional T8 fluorescent lights. Point is given under IN1 Innovation in Design & Environmental Design Initiatives for using energy efficient fluorescent light. Both collected data and costing are received from lighting specialist, which is Pascal Engineering Sdn Bhd from Penang lighting specialist.

Residential Building

(i) Energy Saving Fluorescent Lights (T5)

Total Costing = RM7, 200.00 / 2 Years

Per Year Maintenance Cost = RM 3, 600.00

(ii) Normal Fluorescent Lights (T8) – Upgrading to LED Lighting

Total Costing = RM93, 010.00 / 3 Years

Per Year Maintenance Cost = RM31, 003.30

Differential Maintenance Cost Saving = RM27, 403.30 / Year

Differential in Percentage = 88.3%

Non-Residential Building

(i) Energy Saving Fluorescent Lights (T5)

Total Costing = RM4, 704.00 / 2 Years

Per Year Maintenance Cost = RM 2, 352.00

(ii) Normal Fluorescent Lights (T8)

Total Costing = RM14, 700.00 / 2 Years

Per Year Maintenance Cost = RM7, 350.00

Differential Maintenance Cost Saving (i) – (ii) = RM4, 998.00 / Year

Differential in Percentage = 68.0%

Table 5.3: Internal Ceiling Panels Cost Comparison Table

Category	**Type of Building**	**Item Description**	**Cost (RM)**	**Durability / Warranty**	**GBI Element**
Residential Building					
Green Building	The Light Point Condominium, Penang	Ceiling Queen Energy	12, 315. 40	2 Years	
Non-Green Building	Palm Palladium Condominium, Penang	Plaster Ceiling Board	3, 600.00	3 Years	
Non-Residential Building					
Green Building	Point 92 a.k.a. Menara OBYU, Damansara Perdana, Selangor Darul Ehsan.	Ceiling Queen Energy / Fibrous Ceiling	7, 728.50	2 Years	
Non-Green Building	Menara Mudajaya, Damansara Perdana, Selangor Darul Ehsan	Plaster Ceiling Board	4, 680.00	2 Years	

Residential Building

(i) Ceiling Queen Energy

Total Costing = RM12, 315. 40 / 2 Years

Per Year Maintenance Cost = RM 6, 157.70

(ii) Plaster Ceiling Board

Total Costing = RM3, 600.00/ 3 Years

Per Year Maintenance Cost = RM1, 200.00

Differential Maintenance Cost Saving (i) – (ii) = RM4, 957.70 / Year

Differential in Percentage = 80.5% *(Ceiling Queen Energy > Plaster Ceiling Board)*

Non-Residential Building

(i) Ceiling Queen Energy

Total Costing = RM7, 728.50 / 2 Years

Per Year Maintenance Cost = RM 3, 864.25

(ii) Plaster Ceiling Board

Total Costing = RM4, 680.00 / 2 Years

Per Year Maintenance Cost = RM2, 340.00

Differential Maintenance Cost Saving (i) – (ii) = RM1, 524.25 / Year

Differential in Percentage = 39.4% *(Ceiling Queen Energy > Plaster Ceiling Board)*

Table 5.4: Roofing Sheets Cost Comparison Table

Category	**Type of Building**	**Item Description**	**Cost (RM)**	**Durability / Warranty**	**GBI Element**
Residential Building					
Green Building	The Light Point Condominium, Penang	Steel Roofing (Clean Colorbond / Aluocarbon Panel Sheet)	15, 080.00	2 Years	
Non-Green Building	Palm Palladium Condominium, Penang	Clay Roofing / Metal Decking Roofing	51, 998.39	3 Years	
Non-Residential Building					
Green Building	Point 92 a.k.a. Menara OBYU, Damansara Perdana, Selangor Darul Ehsan.	Steel Roofing (Clean Colorbond / Aluocarbon Panel Sheet)	10, 000.00	2 Years	
Non-Green Building	Menara Mudajaya, Damansara Perdana, Selangor Darul Ehsan	Clay Roofing / Metal Decking Roofing	21, 080.00	2 Years	

Residential Building

(i) Steel Roofing (Clean Colorbond / Aluocarbon Panel Sheet)

Total Costing = RM15, 080.00 / 2 Years

Per Year Maintenance Cost = RM 7, 540.00

(ii) Clay Roofing / Metal Decking Roofing

Total Costing = RM51, 998.39 / 3 Years

Per Year Maintenance Cost = RM17, 332.79

Differential Maintenance Cost Saving (i) – (ii) = RM9, 792.79 / Year

Differential in Percentage = 56.4%

Non-Residential Building

(i) Steel Roofing (Clean Colorbond / Aluocarbon Panel Sheet)

Total Costing = RM10, 000.00 / 2 Years

Per Year Maintenance Cost = RM5, 000.00

(ii) Clay Roofing / Metal Decking Roofing

Total Costing = RM21, 080.00 / 2 Years

Per Year Maintenance Cost = RM10, 540.00

Differential Maintenance Cost Saving (i) – (ii) = RM5, 540.00 / Year

Differential in Percentage = 52.5%

Table 5.5: Mechanical Services and Works Cost Comparison Table

Category	**Type of Building**	**Item Description**	**Cost (RM)**	**Durability / Warranty**	**GBI Element**
Residential Building					
Green Building	The Light Point Condominium, Penang	Rainwater Harvesting System	0.00	2 Years	IN 1 & WE3
Non-Green Building	Palm Palladium Condominium, Penang	Conventional Direct Water Tank Supply (Inclusive of Water Usage of RM45.00/35m3 per Month) – PBA's Rate	2, 665.00	3 Years	-
Non-Residential Building					
Green Building	Point 92 a.k.a. Menara OBYU, Damansara Perdana, Selangor Darul Ehsan.	Rainwater Harvesting System	0.00	2 Years	IN 1 & WE3
Non-Green Building	Menara Mudajaya,	Conventional Direct Cold	15, 426.00	2 Years	-

	Damansara Perdana, Selangor Darul Ehsan	Water Supply (Inclusive of Tariff of RM45.00/35m3 per Month)			

Residential Building

(i) Rainwater Harvesting System

Total Costing = RM0.00 / 2 Years

Per Year Maintenance Cost = RM 0.00

(ii) Conventional Direct Water Tank Supply

Total Costing = RM2, 665.00 / 3 Year

Per Year Maintenance Cost = RM888.33

Differential Maintenance Cost Saving (i) – (ii) = RM888.33 / Year

Differential in Percentage = 100.0%

Note: Source of water usage calculation for both buildings is for non-drinking usage only

Non-Residential Building

(i) Rainwater Harvesting System

Total Costing = RM0.00 / 2 Years

Per Year Maintenance Cost = RM 0.00

(ii) Conventional Direct Water Tank Supply

Total Costing = RM15, 426.00 / 2 Years

Per Year Maintenance Cost = RM15, 426.00

Differential Maintenance Cost Saving (i) – (ii) = RM15, 426.00 / Year

Differential in Percentage = 100.0%

Note: Source of water usage calculation for both buildings is for non-drinking usage only

For rainwater harvesting system entails the collection and storage of rainwater for reuse before it reaches the aquifer. It is used to provide water for irrigation as well as other similar uses. Although some rooftop materials may contaminate the rainwater collected and could be harmful to human health as drinking water, it can be useful for watering the garden and washing cars; these uses alone may amount to 50% or more water used in a typical home of 4 person occupancy. The mechanical technician had graciously advised the researcher on this system could be able to withstand without any major maintenance involved for period of 10 years usage. Furthermore, with the incorporation of a rainwater harvesting system into the building's design, 1 point can be obtained under WE1 Rainwater Harvesting and another 1 point under WE3 Water Efficient Landscaping.

Table 5.6: Summary Maintenance Cost Implication

Building Category / Function	**Residential**		**Non-Residential**	
Description on Building's Maintenance Works	The Light Point Condominium	Palm Palladium Condominium	Point 92 a.k.a. Menara OBYU	Menara Mudajaya
Internal and External Painting Works (Periodically Maintain)	42,000.00	213, 422.00	51, 000.00	67, 305.00
Electrical Works (Replacement on Spoiled/Damaged Items Only)	7, 200.00	93, 010.00	4, 704.00	14, 700.00
Internal Ceiling Panels (Replacement on Wear & Tear Items Only)	12, 315. 40	3, 600.00	7, 728.50	4, 680.00
Roofing Sheets (Replacement on Wear & Tear Items Only)	15, 080.00	51, 998.39	10, 000.00	21, 080.00
Mechanical Works (Study Focused On Water Tank System)	0.00	2, 665.00	0.00	15, 426.00

The collected maintenance costs involved annually tabulation on table 5.6 shown above a total cost implication of RM76, 595.40 and RM364, 695.39 for residential and non-residential respectively of non-green rated building (Non-GBI) whereby green rated building (GBI) recorded lower maintenance cost at RM73, 432.50 and RM123, 191.00 for residential and non-residential respectively; both based on total annual collected amount generated throughout the building's maintenance period. The cost differences in percentage between both categories of green rated building are marked at 78.9% and 40.4% of excess spending against non-green rated building. In another words, the building's owner will need to fork out more than 40% additional sum of monies if they did not adopt green building criteria with selected key elements on maintenance works as stated on table 5.6. There are 3 main major maintenance works been executed by Palm Palladium Condominium that cost the highest maintenance costs spending which includes painting works at RM328, 422.00, electrical fittings and works at RM143, 010.00 and roofing sheets replacement at RM51, 998.39 in Year 2014. The main reason for painting works with huge amount spent due to local council requested the building's owner to re-paint entire building (exterior and partially interior) due to poor appearances as stipulated under state government's residential rules and regulations with the approval from Joint Member Committee (JMC) in Year 2014. All the expenditures are contributed from building's maintenance fees and sinking fund. Secondly, electrical fittings, JMC's with unanimous decision to make a huge change on conventional T8 fluorescent light to LED lighting for entire general areas for those categorized under strata title common areas. The pre-installation works was tested and conducted by Pascal Engineering Lighting Specialist from Penang showing huge saving on electricity by additional perk of providing 8 years maintenance free period. Next, roofing sheets replacement works to be carry out due to major leakage and rusty finishes discovered at the roof top level on roofing sheets cladding and its sub-structures, need immediate replace to avoid any calamities. Ideally, going for green rated building will generates higher positive result in longer period of time. The data above showed the building's operation range between 2 to 3 years for the case study. The lowest percentage saving on maintenance works recorded is non-residential category building. It was due to low office building operation usage with slightly controlled operation hours with fixed usage period

throughout the day as a result in reducing the cost of maintenance. However, from the 6 key elements; non-residential category of building still recorded the highest reading as mentioned at residential building category, which are painting works, electrical fittings and works, roofing sheets replacement and mechanical works specifically on water tank system.

5.3 Operation Cost Implication

Operation cost effective or cost saving to compare would be the key element to consider from the selection of the building by the end-users. A total of 12 months utilities consumption mainly on electricity and water will analyze and recorded to compare the 2 similar function of building from the 2 main categories of building which are residential and non-residential of buildings. The recorded data below are collected from 1st January 2014 to 31st December 2014, which is total of 12 months utility consumption records. For electricity, the tariff will refer to Tenaga Nasional Berhad (TNB) standard tariff based on the type and category of building via total electricity usage. Whereby, water consumption will base on the service provider in specified state such as in Selangor Darul Ehsan will refer to Syarikat Bekalan Air Selangor (SYABAS) whereas in Pulau Pinang will refer to Perbadanan Bekalan Air Pulau Pinang (PBA). For all the recording on water consumption will recorded at the main water meter supply connection reading which is the main water inlet to the building or also known as domestic bulk meter. Each state in Malaysia will serve by different water tariff according to the total water usage. Below are the summary of the total utilities consumption and differential cost percentage throughout the year of 2014 for all selected building as tables below.

Table 5.7: Summary of Building's Operation Works

Building Category	**Residential**		**Non-Residential**	
Descriptions	The Light Point Condominium	Palm Palladium Condominium	Point 92 a.k.a. Menara OBYU	Menara Mudajaya
Built-Up Space	8,091.08m2	7,782.28m2	3,724.46m2	3,967.36m2
Number of Total Units	112	134	118	116
Occupancy Rate	90%	90%	95%	95%
Operation Hours	24 Hours (06:00-02:00)	24 Hours (06:00-02:00)	18 Hours (06:00-00:00)	18 Hours (06:00-00:00)
Usable During Weekend / Public Holiday	Yes	Yes	No	No
Electricity Consumption (Kwh)	95,912	125,936	87,125	93,045
Water Consumption (m3)	24,860	38,789	19,461	34,762

Simple calculation applicable for electricity usage, the tariff to be referred to Tenaga Nasional Berhad (TNB) which it based on the type of building as shown below:

Electricity Utility Cost Implication and Calculation

(i) The Light Point Condominium

The Total Annual Usage = 95,912Kwh

TNB Calculated Tariff for Residential (Average Annual Rate) = RM0.55/Kwh

Total Annual Cost for Electricity Consumption = RM52, 752.00

(ii) Palm Palladium Condominium

The Total Annual Usage = 125,936Kwh

TNB Calculated Tariff for Residential (Average Annual Rate) = RM0.55/Kwh

Total Annual Cost for Electricity Consumption = RM69, 264.80

(iii) Point 92 a.k.a. Menara OBYU

The Total Annual Usage = 87,125Kwh

TNB Calculated Tariff for Residential (Average Annual Rate) = RM0.42/Kwh

Total Annual Cost for Electricity Consumption = RM36, 592.50

(iv) Menara Mudajaya

The Total Annual Usage = 93,045Kwh

TNB Calculated Tariff for Residential (Average Annual Rate) = RM0.42/Kwh

Total Annual Cost for Electricity Consumption = RM39, 078.90

Table 5.8: Electricity Consumption for Residential and Non-Residential Building

Building Category / Function	**Residential**		**Non-Residential**	
Description on Building's Maintenance Works	The Light Point Condominium	Palm Palladium Condominium	Point 92 a.k.a. Menara OBYU	Menara Mudajaya
The Total Annual Usage (Electricity)	95,912Kwh	125,936Kwh	87,125Kwh	93,045Kwh
TNB Calculated Tariff for Residential/Non-Residential (Average Annual Rate)	RM0.55/Kwh	RM0.55/Kwh	RM0.42/Kwh	RM0.42/Kwh
Total Annual Cost for Electricity Consumption	RM52, 752.00	RM69, 264.80	RM36, 592.50	RM39, 078.9
Electricity consumption saving for GBI rated buildings to Non-GBI rated buildings in Percentage (%)	23.8%		6.3%	

Table 5.8 shows the highest differences in terms of percentage for the same category of building i.e. residential building recorded at 23.8% cost implication with annual difference between The Light Point Condominium and Palm Palladium Condominium utility cost rate at RM52, 752.00 and RM69, 264.80 respectively. Both buildings are located in Penang Island. Besides that, non-residential building data obtained were compared between Point 92 a.k.a. Menara OBYU and Menara Mudajaya, both office commercial buildings situated at Damansara Perdana, Petaling Jaya, Selangor Darul Ehsan. The recorded

data showed the electricity usage for Point 92 a.k.a. Menara OBYU and Menara Mudajaya marked at RM36, 592.50 and RM39, 078.90 respectively. As described above, the highest collected data were recorded on residential buildings due to the 24 hours daily operation period inclusive of weekend and public holiday compared to non-residential buildings, which operates at an average of 18 hours daily, excluding weekend and public holidays.

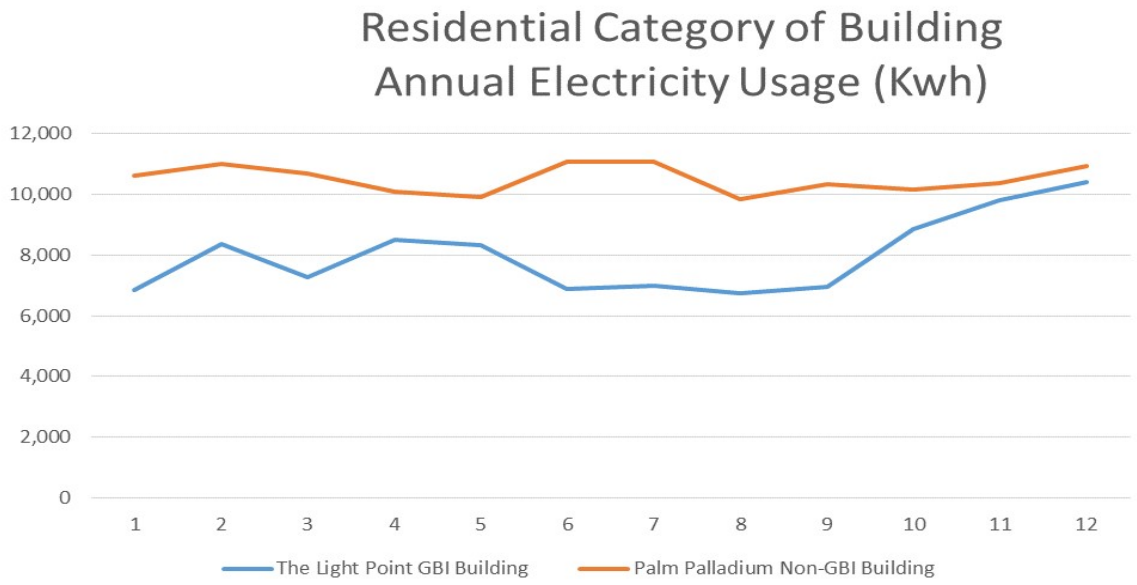


Figure 5.1 Residential Category of Building for Annual Electricity Usage

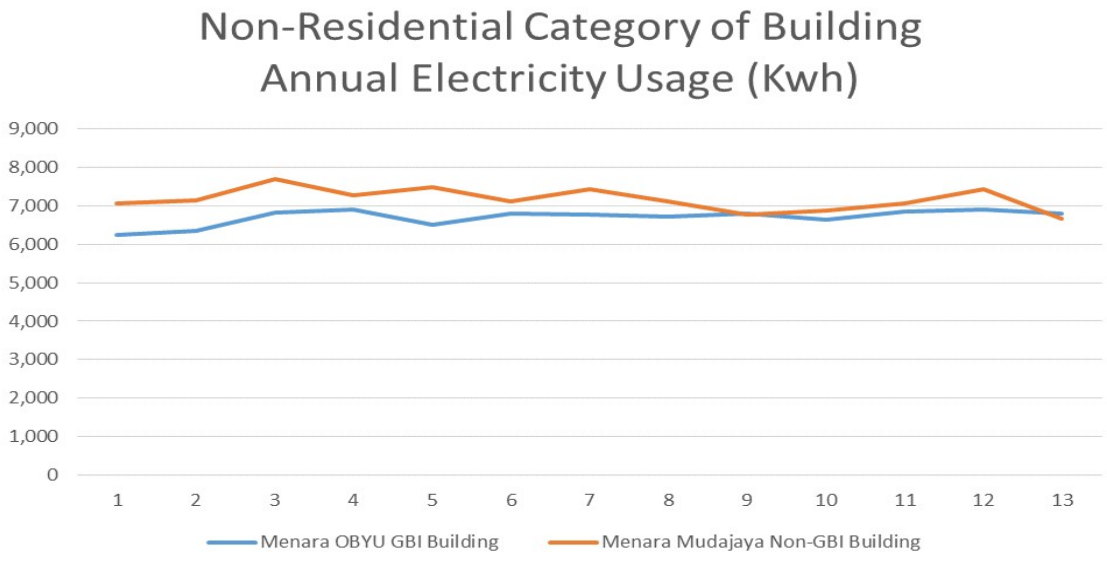


Figure 5.2 Non-Residential Category of Building for Annual Electricity Usage

TNB electricity tariff rate shown on the calculation above was derived on average cumulative reading collected on monthly electricity TNB statement. Electricity consumption for residential buildings in a year was recorded at RM0.55/Kwh, whereby non-residential buildings at RM0.42/Kwh. There are no significant saving criteria provided by the electricity service provider of TNB. All savings elements are based on the building's total electrical usage and saving criteria emphasized on Sustainable Green Building such as zero cost construction. This was achieved by utilizing the building's orientation for natural lighting and ventilation causing the building to be less heated by the direct sun and indirectly reduces the usage of mechanical cooling system such as air-conditioning system especially on the general areas and spaces considered insignificant and a waste of energy, which was highly emphasized by the Point 92 a.k.a. Menara OBYU office building. Apart from that, LED lighting would be the main factor contributing to huge saving on the building's electricity usage as confirmed by lighting specialist.

Similar calculation applicable for water usage, the tariff to be referred to respective water service provider that varies by different states in Malaysia. All final water reading to be based on domestic bulk meter which obtained from each of the building.

Table 5.9: Water Consumption for Residential and Non-Residential Building

Building Category / Function	**Residential**		**Non-Residential**	
Description on Building's Maintenance Works	The Light Point Condominium	Palm Palladium Condominium	Point 92 a.k.a. Menara OBYU	Menara Mudajaya
The Total Annual Usage (Water Services)	24,860m3	38,789m3	19,461m3	34,762m3
PBA/SYABAS Calculated Tariff for Residential/Non-Residential (Average Annual Rate)	RM0.35/m3	RM0.35/m3	RM2.28/m3	RM2.28/m3
Total Annual Cost for Water Consumption	RM8, 701.00	RM13, 576.15	RM44, 371.00	RM79, 257.36
Water consumption saving for GBI rated buildings to Non-GBI rated buildings in Percentage (%)	35.9%		44.0%	

Water Utility Cost Implication and Calculation

(i) The Light Point Condominium

The Total Annual Usage = 24,860m3

PBA Calculated Tariff for Residential (Average Annual Rate) = RM0.35/m3

Total Annual Cost for Water Consumption = RM8, 701.00

(ii) Palm Palladium Condominium

The Total Annual Usage = 38,789m3

PBA Calculated Tariff for Residential (Average Annual Rate) = RM0.35/m3

Total Annual Cost for Water Consumption = RM13, 576.15

(iii) Point 92 a.k.a. Menara OBYU

The Total Annual Usage = 19,461m3

SYABAS Calculated Tariff for Residential (Average Annual Rate) = RM2.28/m3

Total Annual Cost for Water Consumption = RM44, 371.00

(iv) Menara Mudajaya

The Total Annual Usage = 34,762m3

SYABAS Calculated Tariff for Residential (Average Annual Rate) = RM2.28/m3

Total Annual Cost for Water Consumption = RM79, 257.36

Referring to calculation above, water consumption with cost implication for year 2014 recorded from the selected buildings as a case study shown that both residential and non-residential buildings consumes average consumption within the range of 19,461m3 to 38,789m3. Specifically for residential building recorded at 24,860m3 and 38,789m3 for The Light Point Condominium and Palm Palladium Condominium water consumption respectively. Whereby for non-residential buildings recorded at

19,461m3 and 34,762m3 for Point 92 a.k.a. Menara OBYU and Menara Mudajaya respectively. From the site survey, the highest saving area was evaluated and monitored at the rain water harvesting system and recyclable water system that fully utilize by the building for non-drinking purposes. Estimated more than 50% daily usage for external cleaning, landscape and building cooling system by splashing the harvesting water at the roof top to reduce the building temperature are all applied on this green rated building, which is The Light Point Condominium. Residential building recorded the lowest cost implication rate at 35.9% differential sum between The Light Point Condominium and Palm Palladium Condominium. This due to residential buildings covered 3 main areas on each building mainly are management office, condominium general facilities such as swimming pool, washing bay, landscape and external general areas includes periodically external façade and building cleaning services. As mentioned, cost saving factor for residential building is on the recyclable water system such as rainwater harvesting system and ground water pumping system. The Light Point Condominium is located at the reclamation land and therefore obtaining from the natural source such as recyclable sea water is obtainable for legal policy usage and both residential case study buildings are applying the state water control policy which final water outlet is recorded at state water service provider bulk meter at flat rate of RM0.35 per m3 water usage. Whereby, non-residential buildings which are Point 92 a.k.a. Menara OBYU and Menara Mudajaya the rate was fixed by the Joint Member Corporation (JMC) also known as the building management board decided to fix the ceiling rate at RM2.28 per m3 of water usage. As a result those total costs on water consumption are slightly higher level as a comparison to residential type of buildings.

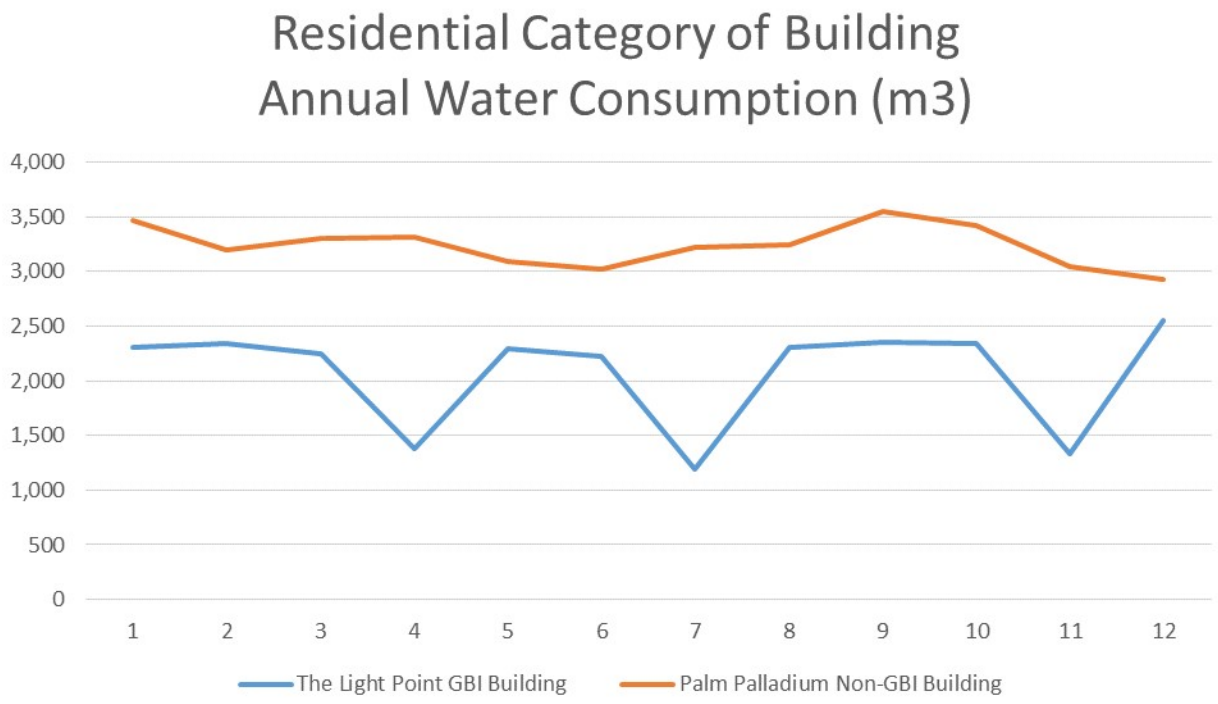


Figure 5.3 Residential Category of Building for Annual Water Usage

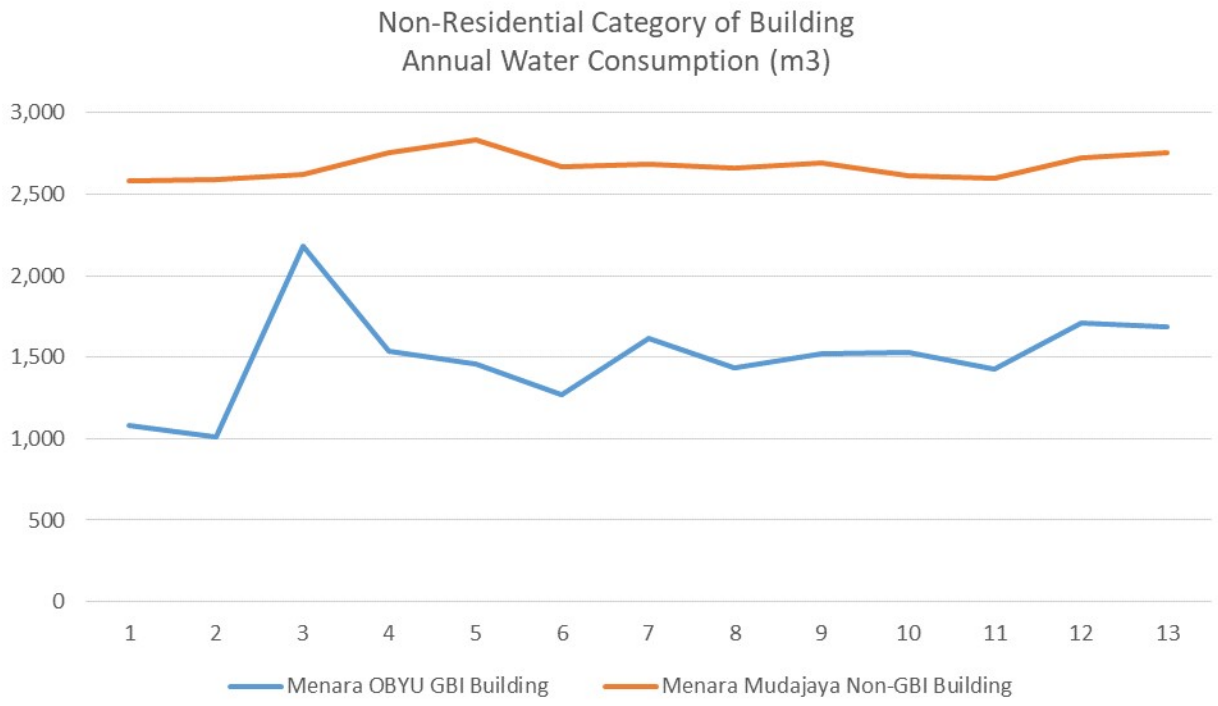


Figure 5.4 Non-Residential Category of Building for Annual Water Usage

By referring to the site survey and inspection on selected case study buildings, the 6 keys elements that used on the GBI are the main consideration for this research mainly for non-green buildings are low energy efficiency by huge waste on electricity usages especially on the lighting compared to green building that encourage the usage of natural light source such as effective building's orientation and design as an innovation efforts. The main problem existed by non-green buildings are due to the pre-construction planning that lack of awareness on sustainable planning and management to make it as priority on building construction and planning requirements. As such, the indoor environment quality is more rely on mechanical system of ventilation instead of natural ventilation system. With the lack of pre-construction planning for non-green buildings, building technology are out of the development planning for instance the used of the water efficiency system such as rain water harvesting technology and solar system which widely apply on green rated buildings. Most of the non-green building's management did not practice regular maintenance that causes the entire building produce losses in operating and maintaining the building. Outcome on this study will create awareness to the building's owner and people in the industry to apply green buildings elements especially at the pre-construction planning stage. It was not merely for reputation of the company but will indirectly create long term benefits to the home buyers or tenants.

5.4 Validation Methodology

Following the findings from the selected building's operation and maintenance cost implication study, data collection and site survey in an area requiring in-depth analyses of the collected data, the next step of the study is to ensure the authenticity and accuracy for the operation and maintenance costs between green and non-green rated buildings. With the findings obtained in this study, the literature study and survey findings were integrated and responded in the conceptual validation process via the views from the people in the relevant industry. Questionnaires' by utilizing "Likert" scale method will be structured and distributed to the interviewees and property development and construction industry experts for validation on collected secondary data. The purpose of the validation process was to confirm that the collection data

is suitable to compare between two selected buildings on the same type of building usage. To confirm data collection suitability the researcher conducted a survey of experts, which had following specific purposes:

(i) To validate the accuracy and reliability of the collected data

(ii) To explore hidden issues and factors associated with building's operation and maintenance costs;

(iii) To identify experts perception for the building's operation and maintenance costs.

In T-test analysis describe with the final analysis generate below 0.05 reading, meaning the data consist of high null hypothesis and with high absolute value. Thus, we reject the Null Hypothesis (<0.05). The t-test (also called Student's T-test) compares two averages (means) and tells you if they are different from each other. The T-test also tells you how significant the differences are; In other words it lets you know if those differences could have happened by chance (James, 2016).

Source from Statistic Solutions for Engineering Science 2016, Advancement through Clarity.

Formula Application, T-test Analysis:-

$$t = \frac{(\sum D)/N}{\sqrt{\frac{\sum D^2 - \left(\frac{(\sum D)^2}{N}\right)}{(N-1)(N)}}}$$

Table 5.10 Collected Annual Data for Electricity and Water Consumption for Residential and Non-Residential Building

Elect. Cons.	Type of Building	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Electricity Usage (Kwh)
The Light Point	GBI	6,831	8,346	7,283	8,509	8,323	6,872	7,001	6,752	6,943	8,864	9,804	10,384	95,912
Palm Palladium	Non-GBI	10,596	10,982	10,672	10,082	9,900	11,060	11,051	9,845	10,320	10,156	10,355	10,917	125,936
Diff. (D)	-	3,765	2,636	3,389	1,573	1,577	4,188	4,050	3,093	3,377	1,292	551	533	30,024
Menara OBYU	GBI	6,345	6,827	6,890	6,516	6,793	6,769	6,725	6,806	6,630	6,855	6,913	6,802	87,125
Menara Mudajaya	Non-GBI	7,147	7,681	7,266	7,470	7,115	7,416	7,119	6,762	6,872	7,062	7,425	6,656	93,045
Diff. (D)	-	802	854	376	954	322	647	394	44	242	207	512	146	5,500

Water Cons.	Type of Building	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Water Usage (m^3)
The Light Point	GBI	2,309	2,343	2,248	1,378	2,292	2,219	1,190	2,308	2,352	2,337	1,333	2,551	24,860
Palm Palladium	Non-GBI	3,470	3,190	3,299	3,311	3,096	3,025	3,217	3,243	3,545	3,413	3,049	2,931	38,789
Diff. (D)	-	1,161	847	1,051	1,933	804	806	2,027	935	1,193	1,076	1,716	380	13,929
Menara OBYU	GBI	1,014	2,181	1,537	1,460	1,271	1,614	1,435	1,518	1,528	1,426	1,708	1,689	19,461
Menara Mudajaya	Non-GBI	2,586	2,619	2,752	2,834	2,665	2,687	2,659	2,691	2,613	2,596	2,721	2,755	34,762
Diff. (D)	-	1,572	438	1,215	1,374	1,394	1,073	1,224	1,173	1,085	1,170	1,013	1,066	13,797

(a) Electricity Element (Residential - The Light Point vs Palm Palladium)

t= 2520 = 0.00399 (Reject Null Hypothesis but Accept Alternative Hypothesis)

6260004

Answer: There is a different cost saving between GBI & Non-GBI rated building due to the data is rejected the Null Hypothesis (<0.05). By adopting GBI rated building element such as above significant data for Electricity is giving positive saving on building in term of building's operation works.

(b) Electricity Element (Non-Residential - OBYU vs Mudajaya)

t= 458 = 0.31412 (Accept Null Hypothesis)

1458

Answer: There is no different cost saving between GBI & Non-GBI building for non-residential category due to the significant of data obtained is accept the Null Hypothesis (>0.05). Thus, there is less significant for electricity element on this category of building.

(c) Water Element (Residential - The Light Point vs Palm Palladium)

t= 1160 = 0.000861 (Reject Null Hypothesis but Accept Alternative Hypothesis)

1347340

Answer: There is a different cost saving between GBI & Non-GBI rated building due to the data is rejected the Null Hypothesis (<0.05). By adopting GBI rated building element such as above significant data for Electricity is giving positive saving on building in term of building's operation works.

(d) Water Element (Non-Residential - OBYU vs Mudajaya)

t= 1160 = 0.000869 (Reject Null Hypothesis but Accept Alternative Hypothesis)

1347340

Answer: There is a different cost saving between GBI & Non-GBI rated building due to the data is rejected the Null Hypothesis (<0.05). By adopting GBI rated building element such as above significant data for Electricity is giving positive saving on building in term of building's operation works.

5.5 Conclusion of Validation Methodology

The first objective of this research paper is to identify monitor and record the cost implication on key saving drivers as "Energy" and "Water" utility consumption of green office buildings in Malaysia. The issue on how much do green building cost to be build or percentage of incremental cost can be identified by using the certified calculation on green cost sum that can be collected from the owner of the building or organization who certified the building. This research also concludes that the incremental construction cost varies according to the type of building. Thus, the comparison with other different type of building might not be the best approach to get the differential on green cost due to the usage and operation capacity, occupancy rate, age of the building, total volume and area of the building and much more. The best way was actually based on the cost of the buildings itself in the same type of building in order to obtained the consistency of the data and cost implication differential. The incremental construction cost was difference according to the certification level itself which is from 5% to 15% maximum by the professional facilitator. There are also other cost involved in special green materials involved which hardly obtain in Malaysia, specialist involved such as green materials sub-contractor, high maintenance costs, commissioning and testing by the specialist and application, appeal and renewal fees and etc. The payback period for the construction cost was less than 3 years in this study.

While, in term of operating cost saving when compare with conventional and green buildings usually are around RM0.164 per square feet in first year of operation (Mashitoh, 2012). This was the result of the first year analysis since green office buildings in Malaysia were just completed in year 2010 (Mashitoh, 2012). The result for this research is only on preliminary stage, since green building is an emerging market in Malaysia, further and much more research need to be done to review and to get better result.

CHAPTER 6

CONCLUSIONS

6.1 Objective 1: To record the cost implication on key saving drivers as "Electricity" and "Water" utility consumption for a green and non-green rated building. Identification of the key saving drivers of electricity and water utility is essential as it was used all the time since the first day of operation and to ensure the developers made correct decisions, proper planning, and achieve sustainability for their building operation system. The study included site visits and a survey of the selected buildings, which consists of GBI and non-GBI rated building that have been operating for more than 2 years since the date of first vacant possession obtained. Those site survey and activities helped to explore and obtain the actual annual meter reading as summarized by the building management on total water and electricity consumption and eventually total cost implication and savings for green and non-green building was identified. Technical and costing knowledge about the key elements and criteria assessed by the GBI on residential and commercial buildings has been identified and helped during the site visit investigation and survey to assess whether these residential buildings were over-spending or vice versa.

6.2 Objective 2: To identify the types of maintenance in terms of replacement frequency of service and cost involved within a consistent period of 12 months operation for a green and non-green rated building. Exploration of issues and problems on today's buildings enhance the efficiency in identifying the types of maintenance involving high frequency and cost. The research identified many types of building maintenance problems within various aspects of the proposed selected case study buildings such as limitation of green products available in the markets, limitation of the GBI professionals and expertise, and much more. However, the selection were based on the similar occurrence of the same type of buildings as well as GBI-related criteria assessment such as on the painting, ceiling, electrical, plumbing, and roofing. Many building maintenance issues and problems were identified in the literature review and via survey. The issues identified for every phase and stages of the maintenance varied in terms of the size

and area to be maintained. Identification of the building maintenance issues and problems in this research created a chance for further analysis to seek possible solutions to minimize those issues and to improve the present maintenance works in the utmost efficiency level.

6.3 Objective 3: The third objective of this research was to compare the total operation and maintenance cost implication for a green and non-green rated building. Site visits and surveys were conducted to obtain and identify the operation and maintenance factors for selected buildings, hence allowing the types of maintenance and issues on cost implication on selected case study buildings to be assessed. The identified issues along with the collective data and readings on utilities were used to compare the possible cost implication differences between the same type of building yet of different category of building i.e. green and non-green buildings. For instance, total annual spending on each building was presented with differential percentage obtained based on simple calculation formula as described earlier. From this data, the developer or building owners are able to estimate the total spending or output for selected criteria deemed frequent and involved cost. In terms of building sustainability, the cost differential obtained can assist the developer or building owner to adopt cost saving methods such as the replacement of conventional T8 lighting tube to LED lighting tube, replacement of conventional paint to low volatile organic compound (VOC) / Weather Bond paint, which gave long lasting finishes, more storage on additional natural water or rainwater via rainwater harvesting system and much more. Finding sustainable solutions from the summarized results on each type of buildings based on site survey and collected data will help to make right decisions to deal with issues and achieve sustainable and greener building in long period of time.

6.4 Contributions to the Academic Knowledge Basis

To date, not much research has been done to compare the green and non-green rated building in terms of building operation and maintenance as well as the frequency of material replacement on a periodical basis. This study has been conducted and achieved substantial contribution to improve the knowledge and awareness especially on the advantages and benefits of sustainable green buildings. Furthermore, this research has successfully identified the existing problems specifically confronted by the construction industry on global warming and potential problems associated with the building owners or developers to the existing and prospective end-user or home buyers on the selection of their residential or non-residential commercial buildings in Malaysia. A clear cost comparison chart has been included in Chapter 4 Data Analysis and Discussion reflecting the main elements of GBI in Malaysia. The outcome has been shown in the same chapter, as well as to prove the building best suited the building owners, end-users, and tenants in specific period of time. As such, this study provides an essential new contribution to understanding the actual cost involved on both analysed buildings, which are green, and non-green rated buildings in Malaysia.

6.5 Study Limitation

The main study limitation was that only two established or well developed township was involved in the research and mainly focused in Malaysia. GBI in Malaysia is still at its infancy stage as it was firstly initiated in 2009; therefore less opportunity were available to explore more certified buildings in Malaysia. To date, for residential category of building, GBI have certified less than 500 building as GBI rated building throughout thousands of residential buildings in Malaysia, which is also applicable to non-residential building. The average reading recorded by GBI is still below 100 certified GBI building per annum. The research included a survey of two GBI and non-GBI rated buildings in Malaysia particularly in the cities of Damansara Perdana, Petaling Jaya, Selangor Darul Ehsan and Georgetown, Pulau Pinang. These selected buildings are significant in today's construction industry, which include residential, hotel, and commercial office buildings. However, other types of buildings with high usage on operation and

maintenance factors can be studied such as shopping mall complexes or buildings, as well as mixed development condominium buildings. These types of buildings will allow more criteria to be observed and identified in terms of complicated advanced building construction such as adopted by fast track development and building services on exhaust mechanical with other energy saving electrical system. Data collection was within the year of this study being carried out, which is 2014. Various information is maintained within the time frame of maximum 5–6 years subject to the research objectives in this study.

In addition, the selection of either green or non-green buildings as the candidate to be studied to be within the range of 2–5 years may need to be slightly improved as new buildings does not achieve the maturity of the buildings in terms of the building's operation system and services. It was proven from the data that the longer period of time a building being examined, the higher saving rate would be obtained for green rated buildings. Whereas higher building operation and maintenance cost implication and spending with inefficient building will occur if does not adopt cost saving evaluation study at the beginning stage of building efficient and cost saving rate.

This research was mostly based on responses from single group of participants, which are the people in the construction industry or so called the professionals, experts, and industry stakeholders. It is known that professionals might raise up various opinions of their own that might lead to more financial compensation prior to achieving highly efficient or green building. In comparison, the general public idea and opinion will creates more incentives to generate more general building requirements apart from technical knowledge and details by the building professionals. Combination of both parties from the professional and publics or potential house owner will lead to greater opinion and survey data.

6.6 Recommendations for Continuation of Research

The differences of operation and maintenance cost implications between green and non-green rated building will be continuously studied. For a better understanding on the comprehensive cost implications of operating and maintaining a building, the following recommendations have been proposed and the possible areas for future research that may also be beneficial to the industry:

(i) Architects to provide integrated green design approach.

The architect or designer will control the design, planning, and materials to meet time and budgetary constraints. At the pre-contract stage, the building construction cost inclusive of green design, operation, and maintenance factors as total actual costs will be known. With this comprehensive approach, the developer will have initial view on all aspect from pre-contract to post-contract stage. Therefore, it is proposed that a research be continued in that area to find out the actual cost implication that includes construction of the structures and architectural works, selection of materials usage, building's operation and maintenance cost factors, and whether the cost implication will be higher or lower if the design and materials are decided in the early stage.

(ii) Education and training programs on benefits of incorporating sustainable development concept.

Professional bodies should take up the responsibility in educating the construction players through conducting conferences, training sessions, seminars, and workshops. A study is proposed whether those education and training programs do help in increasing the awareness and usage of green products or materials and reducing the total operation and maintenance cost of a building.

(iii) Cost Implication

If it is proven that green buildings are more economical in terms of building's operation and maintenance costs, the additional cost implication to convert the existing non-green or conventional buildings can be explored and determined. This definitely benefits the industrial players or investors to invest in refurbishment of aged buildings and to turn them into green rated building status.

6.7 Closure

In Malaysia, the sustainable building and township development involves complex activities as green rated buildings are still at the infancy level of awareness. As a result, the aim of this study was to find out the operation and maintenance cost implication for a green building and non-green building category in the nation. This study achieved its aim by generating a better understanding on the issues towards the global impact and supported by the actual cost comparison between these two buildings on similar selected building elements within the same period of analytical time frame.

REFERENCES / BIBIOGRAPHY

Abdulllah, F. M., Chiet, V. C., Anuar, K., & Shen, T. T. (2004). An Overview on the Growth and Development of the Malaysian Construction Industry. Workshop on Construction Contract Management, University Teknologi, Malaysia.

Abu Bakar, A.H., Abd Razak, A., Abdullahi, S., Awang, A., Parumal, V. (2010). Critical Success Factor For Sustainable Housing: A Framework From The Project Management View. Asian Journal of Management Research. ISSN 2229-3795. Pp 66-80.

Ahmad Fuad (2012). Building Information Modeling, Construction Research Institute of Malaysia (CREAM), First Issue.

American Institute of Architects (AIA) (2000). Environmental Resource Guide Subscription. Washington: American Institute of Architects (AIA)

A.M. Kassim, M.S. Jamri, M. N. Othman, M.Z.A. Rashid, S.J.S. Ismail (2013). "Design and Development of Low Cost Certified Green Building for Non Residential Existing Building (NREB)", Advanced Materials Research, Vol. 748, pp. 1125-1129, Aug. 2013

Autoclaved Aerated Concrete (AAC) Blocks. "Henner" Sustainable Walling Solutions, Saint-Gobain AAC Sdn Bhd Retrieved January 11, 2015, from www.henner.com.my

Association Consulting Engineers Malaysia (ACEM) Directory (2012). Retrieved from http://www.acem.com.my/index.php?option=com_content&task=view&id=58&Itemid=1

Atsusaka, N. (2003). Growing the Green Building Industry in Lane County - A report for the lane county sustainable business and job project, report prepared from the program for Watershed and Community Health, Institute for a Sustainable Environment, University of Oregon, USA.

BCA Green Mark (2013). BCA homepage. Retrieved February 8, 2013, from http://www.bca.gov.sg/GreenMark/green_mark_buildings.html

Bell, H. R. (1993). Social Research Methods: Qualitative and Quantitative Approaches. London: Sage Publishing Ltd.

Bernstein, H.M. and Russo, M.A. (2003). Business Case for Energy Efficient Building Retrofit and Renovation. McGraw Hill Construction Smart Market Reports.

Building Sector Energy Efficiency Project (2011). Building Sector Energy Efficiency Project-BSEEP [Internet], Kuala Lumpur, Available from http://www.undp.org.my/uploads/Procurement/IC/110603_IC%20Procurement%20Notice_DBD_AK.pdf

Cellulose Fibre Cement Boards (Prima). Retrieved January 11, 2015, from www.greenpagesmalaysia.com/.../prima-cellulose-fibre-cement-boards/

Charmaz K (2006). Constructing Grounded Theory: A Practical Guide through Qualitative Analysis. London: Sage Publications.

Chegut, A., Eichholtz, P. & Kok, N. (2012). Supply, Demand, and the Value of Green Buildings. RICS Research.

Cottrelle, M. (2010). Guide to The LEED Green Associate Exam. John Wiley & Sons.

Creswell, J. W. (2007). Qualitative Inquiry & Research Design: Choosing Among Five Approaches, Sage Publication.

Davis. A. (2001). Barriers to Building Green. Retrieved from http://www.greenbiz.com/blog/2001/11/01/barriers-building-green

Davis Langdon (2007). The Cost and Benefits of Achieving Green Buildings, Second Series.

Dennis, K. (2006). The Compatibility of Economic Theory and Proactive Energy Efficiency Policy. The Electricity Journal, 19(7), 58-73. http://dx.doi.org/10.1016/j.tej.2006.07.006

Ding K.C. (2007). Sustainable construction-The role of environmental assessment tools. Journal of Environmental Management .Volume 86, Issue 3, Pages 451-464.

Edmund (2011). CalRecycle. Green Building Materials. Retrieved 01st May, 2014, from http://www.calrecycle.ca.gov/greenbuilding/materials/

Eichholtz (2009). Doing Well by Doing Good? Green Office Buildings, Center for the Study Energy Markets.

Fisk, W., & Rosenfeld, A. (1998). Potential nationwide improvements in productivity and health from better indoor environments.

Florence & Gunawansa (2011). Strategies for Potential Owners in Singapore to Own Environmentally Sustainable Homes. pp. 579-594. Emerald Group Publishing Limited.

Geoff Syphers, Baum, M., Bouton, D & Sullens, W. (2003). Managing the Cost of Green Buildings. Kema.

Gottfried David (2006). "A Blueprint for Green Building Economics" from "Environmental Design + Construction"

Government of Malaysia (2011). Malaysian 10th Plan Economic Planning Unit, Malaysia 10th Plan, Available from: http://www.epu.gov.my/rmk10 [Accessed 28 Jun 2014]

Green Building Index (2009). The GBI Rating System. Retrieved July 20, 2012, from http://www.greenbuildingindex.org/how-GBI-works2.html#RatingTools

GreenbuildingIndex Sdn Bhd (2011). GBI Criteria, Available from http://www.greenbuildingindex.org/index.html [Accessed 29 Jun 2011]

Han Meyer & Daan Zandbelt (2012). High-Rise and the Sustainable City, July 2012. First Edition.

Hart, C (2001). Doing a literature search: a comprehensive guide for the social sciences, Sage Publications Ltd.

Henry Waxman, (2012). Inclusive Green Growth: The Pathway to Sustainable Development, pp. 88. The World Bank Publications.

Herman Miller, (2013). Churn in the Workplace Understanding and Managing Its Impact," Available at: http://www.hmeurope.com/WhitePapers/wp_Churn_in_Workpl.pdf. Retrieved January 23, 2014.

Jabatan Kerja Raya (JKR). National Hydraulics Research Institute of Malaysia, Retrieved March 3, 2014, from http://www.jkrjohor.gov.my/

Jabatan Kerja Raya (JKR). Rainwater Harvesting Model Calculation via Retrieved February 25, 2014, from http://www.jkrjohor.gov.my/

John P. McCracken and Kirk R. Smith (1998). Emission and Efficiency of Improved Woodburning Cookstoves, Environment of Health Sciences, Vol. 24, University of California, CA USA pp. 739-747

Jones Lang and Lasalle Mehgaj (2008). Greenomics: Cost Efficiency of Green Buildings, First Edition, pp. 51.

Jotun Malaysia, Retrieved January 11, 2015, from www.jotun.com/my/en/b2c

Jitender Dev Sehgal (2005), A Guide to Rainwater Harvesting in Malaysia, Rotary Club of Johor bahru Publications.

Kats (2003), Green Building Costs and Financial Benefits, Massachusetts Technology Collaborative, USA

Ken Yeang (2011). The Green Skyscraper: The basis for designing sustainable intensive buildings, First Edition pp. 206

Kruse (2004), Green Buildings And The Law, CIB Publication, pp. 201

Lee, W. L. (2010). Benchmarking energy use assessment of HK-BEAM, BREEAM and LEED, Building and Environment, 43(11), 1882–1891.

Likert, R (1932). 'A technique for the measurement of attitudes', Archives of Psychology, Vol 22 no. No. 140, p. pp. 55.

Lindlof, TR & Taylor, BC (2002). Qualitative communication research methods, 2nd edition, Sage Publications, Thousands Oaks, CA

Lindsay, E. (2012). Construction industry a significant contributor to the nation's GDP. Borneo Post online. Retrieved July 20, 2012, from http://www.theborneopost.com/2012/05/30/construction-industry-a-significant-contributor-to-the-nations-gdp/

Malaysia Green Building Confederation (MGBC) (2010). GreenPagesMalaysia. Architectual Building Materials. Retrieved 24 June, 2011, from http://www.greenpagesmalaysia.com/product/index.php

Mashitoh Binti Halim (2012). Economic Issues on Green Office Buildings in Malaysia, Ministry of Finance Malaysia.

Miller, N., Pogue, D., Gough, Q.D. & David, S.M. (2009). Green Buildings and Productivity. Journal of Sustainable Real Estate. Vol 1 No 1, pp.65-89.

Moore, P. (2000). What Does Green Really Cost?. PREA Quarterly, Summer. Retrieved August 2, 2012, from http://www.davislangdon.com/upload/images/publications/USA/Morris%20Article.pdf.

Nazirah Zainul Abidin, (2009). Sustainable Construction in Malaysia – Developers' Awareness. Retrieved July 20, 2012, from http://www.waset.org/journals/waset/v53/v53-131.pdf.

New Straits Times (NST) (2012). Green Technology: Enticements to go green. Retrieved January 15, 2013, from http://www.nst.com.my/opinion/letters-to-the-editor/green-technology-enticements-to-go-green-1.63378

Noel Perez (2008). Research Methodology: An Example In A Real Project

Pertubuhan Akitek Malaysia (PAM) (2008). PAM homepage. Retrieved April 18, 2014, from http://www.pam.org.my

Philip McKeen and Alan S. Fung (2014). The Effect of Building Aspect Ratio on Energy Efficiency, Open Access, ISSN 2075-5309, www.mdpi.com/journal/buildings/article

PVC Membranes (Sika Sarnafil). Sarnafil®: PVC membranes for roof waterproofing (including green roofs), Retrieved January 11, 2015, from www.pamdirectory.my/profile_supplier.aspx

Queen Ceiling Energy Board. Victory Plaster Ceiling Sdn Bhd webpage, Retrieved January 11, 2015, from www.ceilingqueen.com.my/

Rahmawati, Y., Anwar, N., & Utomo, C. (2013). A Concept of Successful Collaborative Design towards Sustainability of Project Development. International Journal of Social, Human Science and Engineering,7(4), pp. 219-225.

Rao, L, Owen, L & Goldsman, D (1998). 'Development and application of a validation framework for traffic simulation models', paper presented to Winter Simulation Conference, Washington, D.C.

Richard Fellow and Anita Liu (2009). Research Method for Construction, Third Edition, pp. 53-75.

Robson, C. (2002). Real World Research 2nd Edition, Oxford: Blackwell Publishers

Rose B, (2010). Green Building – Sustainable materials for home construction. Retrieved 25th February, 2014, from http://ezinearticles.com/?Green-Building---Sustainable-Materials-For-Home-Construction&id.

Ross Spiegel & Dru Meadows (2010). In A Guide to Product Selection and Specifications Green Building Materials Third Edition. Canada: John Wiley & Sons, Inc., Hoboken, New Jersey

Peter H. Rossi, James D. Wright, and Andy B. Anderson (1983). Handbook of Survey Research.
American Journal of Sociology Vol. 90, No. 3 (Nov., 1984), pp. 667-669.
Published by: The University of Chicago Press

RS Means. (2011). Green Building, Project Planning & Cost Estimating Third Edition. Canada: John Wiley & Sons, Inc., Hoboken, New Jersey.

Samari, M., Ghodrati, N., & Shafiei, M. V. M. (2012). Implementation of Sustainable Development in Construction Industry in Penang Island, International Conference on Civil Engineering AICCE 2012.

Sayce, S., Sundberg, A. & Clements, B. (2010). Is Sustainability Reflected in Commercial Property Prices: an analysis of the evidence base. Kingston University; London.

Sekaran and Bougie (2009). Research Method for Business, 5th Edition

Shafiie, F., & Othman, M. Z. (2005). Sustainable Building and Construction in South-East Asia, Proceedings of The Conference on Sustainable Building South-East Asia, Malaysia, pp. 111-113.

Suruhanjaya Perkhidmatan Air Negara (SPAN) (2012). Retrieved February 8, 2014, from www.span.gov.my

Steel (Clean Colorbond). Retrieved January 11, 2015, from www.bluescope.com.my/product/clean-colorbond-ultra/

Tan, Y.J. (2008). City & Country: Moving in the green direction. The Edge Daily.

Thamer, A.M; Megat-Johari, M.M; Noor, A.H.G. (2007). Study on Potential Uses of Rainwater havesting in Urban Areas. Conference Paper presented at Rainwater Utilization Colloquium on 19 & 20 April 2007 at NAHRIM Mini Auditorium.

The Edge (2014). Malaysia Green Building Index. Retrieved March 02, 2014 , from http://www.theedgemalaysia.com/greenbuildingindex

The Edge (2013). The Cost of Going Green. Retrieved March 20, 2014 , from http://www.theedgemalaysia.com/252825-special-focus-the-cost-of-going-green.html

Tony Arnel (2012). Green Building Council. (2009). US Green Building Council, Green Building Council. Retrieved July 23, 2012, from http://www.usgbc.org/displaypage.aspx?CMSPageID=1449

Turner, C. & Frankel, M (2008). Energy performance of LEED for new Construction Building, Final report.

Wong, N., Chang, Y. C., & Nunn, C. (2010). Life-cycle assessment for sustainable design options of a commercial building in Shanghai. Journal of Building and Environment, 45, 1415-1421. http://dx.doi.org/10.1016/j.buildenv.2009.12.004

World Green Building Council (WGBC) (2013). The Business Case for Green Building, pp. 52-63.

Yu, S., Yong, T., & Chenxi, L. (2011). "Green Retrofitting Costs and Benefits: A New Research Agenda." IRES Working Paper Series. Singapore: National University of Singapore, Institute of Real Estate Studies.

Yoshida, J. & Sugiura, A. (2011). Which 'greenness' is valued? Evidence from green condominiums in Tokyo. Presentation.

APPENDICES

Appendix 1.

Survey questions for Building/Property Manager (Selected Green/Non-Green Building)

No	Questions	Answer (Comments)
1	Building's name & address	
2	Building's management name & address	
3	Years of experience in building/property management	
4	Building's description in property management	
5	Building's special feature and materials	
6	Building's key operation and maintenance factors	
7	Any special building's supervision tools implemented?	
8	Building's operation and maintenance team capacity?	
9	Contract to manage the building	
10	Occupancy rate (Present / To date)	
11	Operation criteria and level	
12	Present building's condition / Any issue to highlight?	
13	Total utility usage per month (Water)	
	Total utility usage per month (Electricity)	
14	Total maintenance replacement works involve per month (Please specify the works)	
15	Any special operation and maintenance works to carry out for this building?	
16	Any specialists require assisting to operate and maintain this building?	
17	Key saving drivers – Water and Electricity consumption, any cost effective medium in this building?	
18	Are present residents/visitors/tenants satisfied with the building operation and maintenance?	
19	Others improvement can be made after completion of building's works	
20	Any pros and cons in management green buildings compare to non-green buildings in Malaysia?	

Appendix 2.

This is a "Likert" scale questions for the survey. For each question below, please indicate the extent of your agreement and disagreement by placing tick in the appropriate box.

The response rate scale is as follows:

1. Strongly Agree

2. Agree

3. Slightly Agree

4. Neither Agree nor Disagree

5. Slightly Disagree

6. Disagree

7. Strongly Disagree

No	Question	Respondents						
1	Are the study identified present development issues and impacts are important?	Strongly Agree	Agree	Slight Agree	Neither Agree nor Disagree	Slightly Disagree	Disagree	Strongly Disagree
2	Are the building's operation and maintenance factors are important?	Strongly Agree	Agree	Slight Agree	Neither Agree nor Disagree	Slightly Disagree	Disagree	Strongly Disagree
3	Is the cost comparison chart designed is easy to understand and able to fulfill the needs to compare the buildings?	Strongly Agree	Agree	Slight Agree	Neither Agree nor Disagree	Slightly Disagree	Disagree	Strongly Disagree
4	Can the cost comparison chart able to create awareness and thrust the people to opt for green buildings?	Strongly Agree	Agree	Slight Agree	Neither Agree nor Disagree	Slightly Disagree	Disagree	Strongly Disagree

Appendix 3.

Collected data on electricity and water utility consumption per year.

Appendix 4.

Collected data on building's maintenance works cost implication quotation and invoices.

Appendix 5.

Invitation to Participate on This Research Study for Interviewee (Selected Buildings)

UNIVERSITI TUNKU ABDUL RAHMAN
Wholly Owned by UTAR Education Foundation (Company No. 578227-M)

13 March 2015

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

LETTER OF CONFIRMATION

This serves to confirm that the following candidate is a registered part-time candidate at Faculty of Engineering and Green Technology, Universiti Tunku Abdul Rahman.

His details are as follows:

Name:	Lee Zheng Ping
I.C Number	850713-08-5755
Student Registration Number:	14AGM01301
Programme Enrolled:	Master of Engineering Science
Dissertation Title:	A STUDY TO COMPARE THE COST OF OPERATION AND MAINTENANCE IN GREEN BUILDING INDEX (GBI) AND NON-GREEN BUILDING INDEX (NON-GBI) RATED BUILDING IN MALAYSIA
Medium of Instruction:	English
Date of Commencement:	14 February 2014
Duration of Programme:	2 years (Minimum); 6 years (Maximum)

He had passed both Compulsory Subjects of **MGGG10203 Research Methods in Engineering and Science and MGGG10303 Directed Readings in Engineering and Science.** While Research Writing for the core unit "**MGGA10100 – Dissertation**" is in progress, and he will be meeting his Supervisor(s) from time to time based on appointment to discuss its progress.

Should you have any queries, please do not hesitate to contact our staff-in-charge Ms. Loo Jun Yi at 05-4688888, Ext. 2229 or email her at loojy@utar.edu.my.

Thank you.

Yours faithfully,

Dr. Chong Yee Lee
Deputy Director
Institute of Postgraduate Studies and Research
Universiti Tunku Abdul Rahman

Address: 9, Jalan Bersatu 13/4, 46200 Petaling Jaya, Selangor Darul Ehsan, Malaysia **Postal Address:** P O Box 11384, 50744 Kuala Lumpur, Malaysia
Tel: (603)7958 2628 **Fax:** (603) 7956 1923 **Homepage:** http://www.utar.edu.my

Appendix 6.

Research Publication Certification for this research title from 4th International Buildling Control Conference (IBCC), Main Organizer of University of Malaya.

UNIVERSITI MALAYA

Certificate of Award

FACULTY OF BUILT ENVIRONMENT

This certificate is awarded to

LEE ZHENG PING

in recognition of the contribution made as

Presenter

for

4th International Building Control Conference (IBCC) 2016
'Intelligence, Sustainable & Resilience in the Built Environment'

held on

7th – 8th March 2016
at **Pullman Bangsar Hotel, Kuala Lumpur, Malaysia**

Associate Professor Dr Sr Syahrul Nizam Kamaruzzaman
Conference Chairman
4th International Building Control Conference