A STUDY OF ENERGY EFFICIENCY OPPORTUNITIES IN PUTRAJAYA MARITIME CENTRE TOWARDS GREEN BUILDING

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ABSTRACT

Nowadays, people are more concerned about energy efficiency, energy consumption and conservations in buildings. With this in view, a project to investigate the potential of energy saving in selected building in Putrajaya Maritime Centre was carried out. The scope of the study includes identifying energy consumption in a selected building, to study energy saving opportunities, and to analyse cost investment in term of economic. As a public building and a recreation centre, these building should take the initiative to protect the environment towards green building. According to the research and analysis, several solutions are proposed to help reduce energy consumption and energy cost in the Maritime Centre. First, by improving physical properties of building components. Second, by changing the air condition temperature control setting. This paper also discuss about the improvement of lighting system efficient. From the data analysis, it has been found that huge amount of energy can be saved for a better green environment.

ABSTRAK

Dewasa kini, wujud kesedaran mengenai penggunaan tenaga, kecekapan penggunaan tenaga dan penjimatan tenaga di dalam bangunan di kalangan pengguna. Menyedari hakikat ini satu projek untuk mengkaji potensi penjimatan tenaga dijalankan pada bangunan terpilih iaitu di Pusat Maritim, Putrajaya. Liputan kajian ini termasuklah mengenalpasti pengunaan tenaga di dalam bangunan terpilih, mengkaji peluang penjimatan tenaga dan menganalisa kos pelaburan. Sebagai sebuah bangunan rekreasi yang dibuka kepada orang awam, bangunan ini harus mengambil inisiatif untuk melindungi alam sekitar ke arah bangunan hijau. Berdasarkan kajian dan analisis yang dijalankan, beberapa langkah telah dicadangkan bagi membantu mengurangkan penggunaan dan kos tenaga di Pusat Maritim, Putrajaya. Pertama, dengan memperbaiki komponen fizikal dalam bangunan. Kedua, dengan mengubah kawalan suhu bagi penghawa dingin dalam bangunan. Selain itu, kajian ini juga membincangkan tentang pembaharuan sistem pencahayaan yang lebih efisien. Hasil daripada data yang dianalisis, kajian mendapati sejumlah besar tenaga dapat dijimatkan bagi membentuk persekitaran hijau.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Building is one of the biggest energy consumers in the world, accounting for one-quarter to one-third of all energy use and a similar amount of greenhouse gas emissions [1]. Surprisingly less attention has been paid to ensure energy efficiency (EE) in buildings even though it has tremendous impact on costs and environment. The McKinsey Global Institute estimates that four of the five most cost-effective measures taken to reduce greenhouse-gas emissions involve building efficiency [1]. The measures are building insulation, lighting systems, air conditioning and water heating.

In Malaysia, the National Energy Policy (NEP) was introduced in 1979 which line up three main objectives that is supply objective, utilization objective and environmental objective [2]. The aim of this utilization objective is to promote efficient utilization of energy, discourages wasteful and non-productive patterns of energy consumption. NEP can be considered as proactive mitigation to arrest rapid energy demand and consumption in developing country like Malaysia. Later in 2009, National Green Technology Policy specifies the guideline of green technology development [2]. This policy emphasize four major elements that is strong promotion and public awareness of Green Technology, promotion of Green Building Index (GBI), intensification of Green Technology research and innovation towards commercialization, and promotion of application of renewable energy in commercial and residential buildings such as rainwater harvesting, phasing out of incandescent lights and photovoltaic. The latest National Policy on Climate Change launched in 2009 also highlights the EE in the supply and demand sector; these include promotion of EE for power producer, establishment of EE targets and standards.

The government of Malaysia continues promoting EE through the demonstration of Low Energy Office (LEO) building of the Ministry of Energy, Green Technology and Water in 2004 and also the Green Energy Office (GEO) of Malaysia Green Technology Corporation (MGTC) formerly known as Pusat Tenaga Nasional (PTM) in 2008. These demonstration buildings become a true role model to encourage more private building to be constructed with low energy design and adapt the GBI as green building rating tool.

1.2 Problem Statements

Rising cost in producing energy will directly impact the energy consumption cost by the end user thus the world may left with few choices but to make a concerted effort to use energy in buildings more efficiently. Globally, McKinsey says that overall energy demand will accelerate from 1.6 percent a year in the past decade to 2.2 percent annually over the next 15 years unless wide-ranging efficiency measures are taken [1]. Commercial and residential demand is expected to grow at similar rates as these overall figures.

Unlike cars or electrical equipments, buildings last for decades, therefore the way buildings are designed and constructed today will not only have an impact on their operating costs, but will affect the world's energy consumption patterns and environmental conditions for many years to come. Today, commercial and residential buildings account for about one-third of the world's final energy consumption [3].

New technologies are the key to substantial improvements in energy intensity. Greater efficiency means consumers can enjoy the same level of comfort but use less energy. When it comes to efficiency, improvements in buildings offer the most cost-effective way to reduce energy use and greenhouse gas emissions.

The other big impact which leads to EE is environmental concerns i.e World Climate Change. Climate change will have wide-ranging effects on the environment, and on socio-economic and related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity. Changes in rainfall pattern are likely to lead to severe water shortages and/or flooding. From 2004 to 2030 the world’s CO2 emissions are projected to increase around 50 percent, absent any global agreement to limit emissions [1]. More than 57 percent of that projected increase will come from Asia, with China alone accounting for 30 percent, putting great pressure on environmental sustainability in Asia and the world.

Above concerns will not be addressed without having a pool of resources especially human resources and proper execution plan. Eventually know-how aspects and depth experience will become a pre-requisite to enter the EE industry in ensuring deliverables are met. There is a lot of public interest towards the research in EE for green building.

The basic ideology of building energy efficiency is to use less energy for heating, cooling, and lighting, without affecting the comfort of those who use the building. High-performance buildings not only save energy costs and natural resources, but also mean a higher-quality indoor environment. The benefits of building energy efficiency include: Reduced Resource Consumption, Minimized Life-cycle Costs, Reduced Environmental Impact, Healthier Indoor Environment, and Increased Employee Productivity. This research also will create a public awareness for Malaysian to participate in EE industry.

1.3 Project Objectives

The aim of this research is to study the performance of energy efficient for a building in Malaysia.

Its measurable objectives are as follows:

a) To identify energy consumption in a selected building.
b) To study energy saving opportunities in the selected buildings.
c) To analyse cost investment in term of economic

1.4 Project Scopes

This project is primarily concerned with the energy efficiency for green environment. The scopes of this project are:

a) There are many technical measures that can be used for energy efficiency improvements. In this study, only several measurements have been considered.
b) The analysis is dependent on what the data given by the building. The Building Energy Intensity (BEI) usually expressed as kWh/m2/year which measure the total energy used in a building for one year in kilowatts hours divided by the gross floor area of the building in square meters.
c) The limitation of study is only involving the communities who have involved in the building development and also those who have building related expert.

CHAPTER 2

LITERATURE REVIEW

2.1 Theories

This chapter will explain the literature study that is related to energy efficiency, green building, and energy efficiency in green building.

2.1.1 What is Energy Efficiency (EE)?

In simple words, energy efficiency means using less energy to provide the same service. For an example, when you replace an appliance, such as a refrigerator or washing machine, or office equipment, such as a computer or printer, with a more energy-efficient model, the new equipment provides the same service, but uses less energy. This action will not only saves money on the energy bill, but also reduces the amount of greenhouse gases going into the atmosphere. There is one common misunderstanding on EE; turning off a light is energy conservation. Replacing an incandescent lamp with a compact fluorescent lamp (which uses much less energy to produce the same amount of light) is energy efficiency. Thus EE is not energy conservation but both efficiency and conservation can reduce greenhouse gas emissions and saves money.

Energy performance of a building is the amount of energy actually consumed or estimated to meet the different needs associated with a standardized use of the building. These may include heating, water heating, cooling, ventilation and lighting.

The amount of energy used in buildings depends firstly on what it is used for. Thus the initial and most important step in isolating the factors affecting energy use is to determine its end-use.

2.1.2 Green Building

A Green building focuses on increasing the efficiency of resource use – energy, water, and materials – while reducing building impact on human health and the environment during the building's lifecycle, through better sitting, design, construction, operation, maintenance, and removal. Green Buildings should be designed and operated to reduce the overall impact of the built environment on its surroundings. These include reduced fossil fuel use for electricity and heat, minimal site disruption, lower water consumption, and fewer pollutants used and released during construction and occupation. The term "energy-efficient building" or "high-performance building" is often used when referring specifically to the energy efficiency and productivity benefits of a building, whereas "green building" refers to the broader environmental considerations of a building, including energy-efficient aspects.

2.1.3 Green Building in Malaysia

The government of Malaysia has taken several pro-active actions in promoting energy efficiency through the demonstration of Low Energy Office (LEO) building of the Ministry of Energy, Green Technology and Water in 2004 and also the Green Energy Office (GEO) of Malaysia Green Technology Corporation (MGTC) formerly known as Pusat Tenaga Nasional (PTM) in 2008. These demonstration buildings will hope to encourage private building to also construct and design low energy buildings The Code of Practice on the Use of Renewable Energy and Energy Efficiency in

Non-Residential Buildings under MS 1525:2001 will be incorporated in the amendments to the Uniform Building By-Laws (UBBL) for all building in Malaysia.

Figure 2.1: Green Energy Office (GEO) Building, MTGC, Bangi formerly known as PTM Malaysia's first GBI certified rating building.

2.1.4 Green Building Rating Tools

Green Building Rating Systems (GBRS) is a design checklist and credit rating calculators developed to assist designers in identifying design criteria and documenting proposed design performance.Worldwide, there is already a push towards building more energy efficient buildings. The Building Research Establishment (BRE) in the UK introduced the first scheme in 1990, the Building Research Establishment Environmental Assessment Method (BREEAM) for office buildings. Later, Leadership in Energy and Environmental Design (LEED) from U.S came into the mainstream in the late 1990s. The green building ratings was introduced so that there is a sense of realization that buildings and the built environment contributes significantly to green house gas emission. This is to help people who involve with construction field to know that their building needs to be re-designed to reduce their negative impact to the environment.

2.1.5 Green Building Index (GBI)

Green Building Index (GBI) Malaysia was introduced on 3rd January 2009 by Pertubuhan Akitek Malaysia (PAM) and the Association of Consulting Engineers Malaysia (ACEM) and officially launched on 21st May 2009. Green rating tools is very dependent upon location and environment due to the difference in temperature climate zones. Each country has their own green rating tools to meet the country special needs. GBI Malaysia was introduced to promote sustainability in the built environment and raises awareness among developers, architects, engineers, planners, designers, contractors and the public about environmental issues and our responsibility to the future generations. Moreover, increases of the environment education knowledge of Malaysian will promote the effective ways to benefits the green responsive building and green responsive awareness. The Malaysian government is supporting the drive towards green buildings and green technology and its Budget 2010 was the first one ever to give priority to promote public interest. The budget contained a fund of no less than RM1.5 billion to be given as soft loans to the companies and also granted tax breaks and stamp duty exemptions. In addition, a number of building in Malaysia have been LEED or Green Mark (Singapore) certified as well.

According to first edition of GBI assessment criteria for non-residential new construction (NRNC) Version 1.0 dated April 2009 [4], there are SIX main criteria's of evaluating the environmental design and performance of Malaysian buildings. Figure 2.2 illustrates the six elements which accumulates overall point score 100 point. Refer to Appendix A to see the detail evaluation for EE categories.

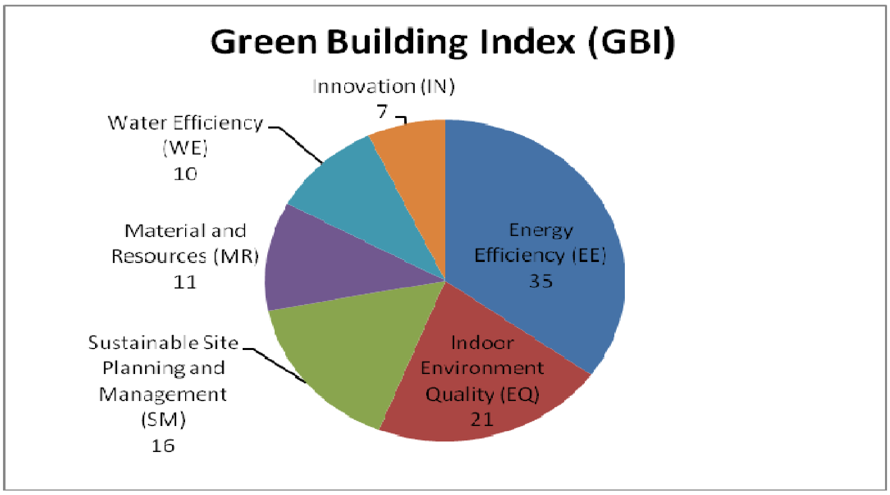

Figure 2.2: The assessment criteria for green building.

As mention earlier, the GBI is developed specifically for the Malaysian tropical weather, environmental and developmental context, cultural and social needs. The buildings will be awarded based on four types of ratings namely certified, silver, gold and platinum depending on the scores achieved. The logo of GBI is as illustrates in figure 2.3.

Table 1.1: Green Index Building Classification.

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

Figure 2.3: The logo for the Green Building Index (GBI) Malaysia.

2.1.6 Factors Influencing Energy Use In Buildings

According to Chan [5], the factors affecting the building's energy consumption can be divided into two category, they are, non design factors and passive design factors. Figure 2.4 illustrates the two categories in detail.

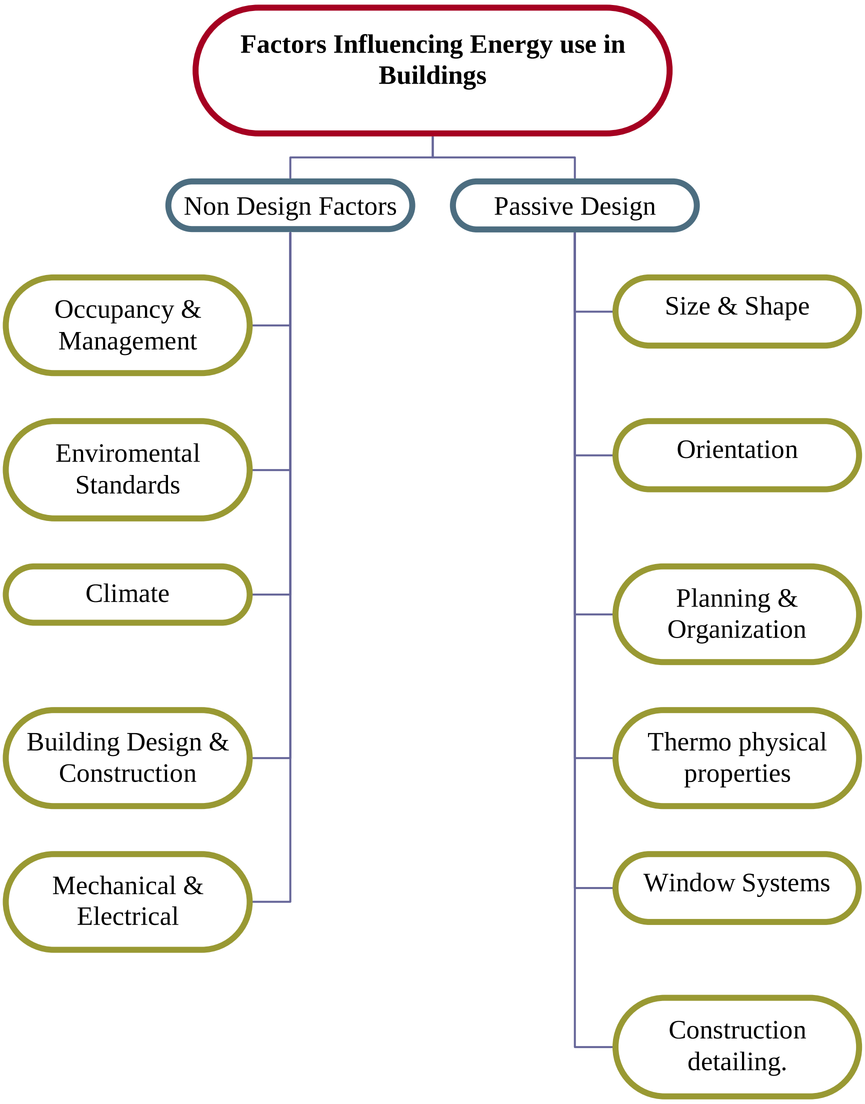

Figure 2.4: Factors that influencing energy use in building.

A typical Malaysia Office Building consumes about 250 kWh/m2/year of energy of which about 64% is for air conditioning, 12% lighting and 24% general equipment [5]. The most commonly used index for comparing energy use in buildings is expressed as kWh/m2/year which measure the total energy used in a building for one year in kilowatts hours divided by the gross floor area of the building in square meters. Energy efficient design can be divided into two part, they are [6]:

a) Passive Design

Passive design has two major aspects, the use of the building's location and site to reduce the building's energy profile and the design of the building itself such as its orientation, aspect ratio, massing, day lighting, ventilation paths, solar thermal collector, and plug load reduction.

b) Active System

Active system involves the mechanical and electrical approaches in order to improve energy efficiency of the building. Heat, Ventilation, and Air Conditioning (HVAC) are the mechanical system, where as light and electrical motor are the electrical system.

c) Renewable Energy Technology

Renewable energy can be generated on-site by three different techniques, photovoltaic, wind energy, and biomass.

2.1.7 Cooling Loads

Cooling load is the amount of heat that must be removed from a building to maintain a comfortable temperature for its occupants. The total cooling load on any building consists of both sensible as well as latent load components. The sensible load affects the dry bulb temperature, while the latent load affects the moisture content of the conditioned space. Factors that influence to the sensible cooling load are as follows:

a) Glass windows or doors
b) Sunlight striking windows, skylights, or glass doors and heating the room
c) Exterior walls
d) Partitions (that separate spaces of different temperatures)
e) Ceilings under an attic
f) Roofs
g) Floors over an open crawl space
h) Air infiltration through cracks in the building, doors, and windows
i) People in the building
j) Equipment and appliances operated in the summer
k) Lights

While, factors that influence to the latent cooling load when moisture is introduced into a structure through:

a) People
b) Equipment and appliances
c) Air infiltration through cracks in the building, doors, and windows

Obviously from energy efficiency and economics points of view, the system design strategy for an externally loaded building should be different from an internally loaded building. Hence, there is a need for prior knowledge of whether the building is externally loaded or internally loaded for effective system design. Figure 2.5 shown illusion factor which influence to cooling load estimation.

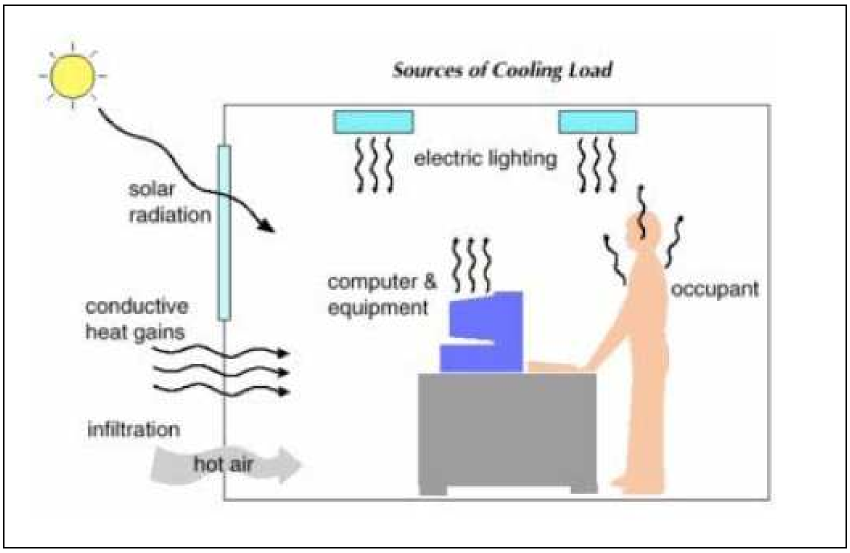

Figure 2.5: Factors of cooling loads in building.

2.1.8 Window Performance

Window glazing is the actual glass part of a window. Glazing is mounted in the window with the assistance of glazing putty and a frame which supports the glass and hold it in place. Nowadays, there are a number of options for window glazing. Double or triple glazed windows create more insulation, making a structure more energy efficiency by reducing heat loss through the windows. Glass can also be tinted to keep out sunlight, coated in a clear film which increases energy efficiency, and otherwise treated to make windows more efficient.

Common types of glazing that are used in architectural applications include clear and tinted float glass, tempered glass, and laminated glass as well as a variety of coated glasses, all of which can be glazed singly or as double, or even triple, glazing units. Ordinary clear glass has a slight green tinge but special clear glasses are offered by several manufacturers.

Window performance are rated using several performance parameters that allow designers to select a glazing option that satisfies a project’s aesthetic, comfort, day lighting and energy efficiency criteria. Several important window performance ratings are discussed below:

a) U-Value

The rate of heat flow through a window assembly due to the temperature difference between the two sides of the window. The lower the U-value, the greater the insulating value of the window.

b) Shading Coefficient (SC)

The shading coefficient measures a window’s effectiveness at blocking solar heat. Solar heat is the single largest contributor to the workload on home’s cooling system. When considering various types of windows or shading devices, the shading coefficient is the most important factor to consider. The lower the SC, the lower the solar heat gain through the window.

c) Solar Heat Gain Coefficient (SHGC)

The SHGC is the fraction of incident solar radiation admitted through a window, both directly transmitted and absorbed and subsequently released inward. SHGC is expressed as a number between 0 and 1. The lower a window's solar heat gain coefficient, the less solar heat it transmits.

d) Visible Light Transmittance (VLT)

The percentage of visible light that passes through the window assembly. A high VLT indicates a greater fraction of incident natural light passing through the window. While VT theoretically varies between 0 and 1, most values among double- and triple-pane windows are between 0.30 and 0.70. The higher the VT, the more light is transmitted. A high VT is desirable to maximize daylight. Reducing cooling loads by specifying lower SC and

SHGC ratings needs to be considered in conjunction with the visible light transmittance of the glazing choice to achieve a balance between cooling load reduction and the desired natural light environment. Select windows with a higher VT to maximize daylight and view.

e) Ultraviolet Transmittance

An indication of the percentage of ultraviolet radiation striking the glazing that passes through it. Many energy-efficient glazings also reduce ultraviolet (UV) transmission. Fading of interior furnishings is often attributed to UV radiation from the sun passing through windows onto interior surfaces.

f) Sound Transmission

Sound transmission properties are expressed as the "outdoor-to-indoor-transmission class (OITC)." The higher the OITC, the better its sound insulation properties.

2.1.9 Lighting Efficiency

Lighting is an essential service in all the industries. The power consumption by the industrial lighting varies between 2 to 30% of the total power depending on the type of industry. A lighting scheme is called efficient over the other when for the same visual comfort and usage pattern it will consume lesser amount of electrical energy. The efficiency in a lighting scheme is guided by the following three factors:

a) Lighting Power Density

Lighting power density of a lighting scheme is the ratio of installed lighting power in a space (includes power of lamp, ballast, current regulators and control devices) to the floor area of that space.

b) Integration of artificial lighting scheme with daylight

Whenever the orientation of a building permits, day lighting can be used in combination with electric lighting. Utilization of daylight can reduce the dependency on artificial lighting during daytime and can help in saving significant amount of energy which would have been otherwise wasted to provide similar visual comforts.

c) Lighting controls

Lighting controls in a lighting scheme are directly related to the operations. Controls like dimming, step-down, on-off, occupancy; photocells, timers etc are widely used now a day in lighting schemes. Modern advances on occupant sensing and daylighting add additional cost-effective options for managing lighting systems.

The most commonly used lamps are described briefly as follows:

a) Incandescent

Incandescent lamps produce light by means of a filament heated to incandescence by the flow of electric current through it. Incandescent lamps have relatively short lives and are the least efficient of common light sources. In fact, only about 15 percent of the energy they use comes out as light – the rest becomes heat. However, they produce a pleasant color that is similar to natural sunlight. Incandescent lamps are the least expensive to buy but the most expensive to operate. Reduced-wattage incandescents produce about the same light output but consume less energy than standard bulbs.

b) Compact Fluorescent Lamps(CFLs)

CFLs are about four times as efficient as incandescents and last up to 10 times longer. Lamp ballast combinations that replace incandescents in standard fixtures are substantially more expensive than their incandescent counterparts.

c) Tubular fluorescent fixtures

Tubular fluorescent lamps are one of the most common sources of commercial lighting and also are among the most efficient. The new generation of small diameter lamps (T-8 and T-10) is particularly efficient. It is important to understand that lamps and ballasts work as a system and the overall efficiency of a lighting fixture is dependent on the lamp/ballast combination.

d) Tungsten-halogen

Halogen lamps are a type of incandescent lamp that has become increasingly popular in recent years. They produce a whiter, more intense light than standard incandescents and are typically used for decorative, display or accent lighting. They are about twice as efficient as regular incandescent lamps and last two to four times longer than most incandescent lamps.

e) High-intensity discharge (HID)

As with fluorescent lights, HID lights require ballast for proper lamp operation. The efficiency of HID sources varies widely from mercury vapor – with efficiency almost as low as incandescent to low-pressure sodium which is among the most efficient light sources. Color rendering varies widely from the bluish cast of mercury vapor lamps to the distinctly yellow light of low-pressure sodium.

f) Light emitting diodes (LEDs)

LEDs are small in size but can be grouped together for higher intensity. The efficacy of a typical residential application LED is approximately 20 lumens per watt though 100 lumens per watt have been created in laboratory conditions. LEDs are better at placing lighting in a single direction than incandescent or fluorescent bulbs.

The performance characteristics and efficiencies of common light sources are shown in Table 1.2.

Table 1.2: Luminous Performance Characteristics of Commonly Used Luminaries.

Type of Lamp	**Lumens / Watt**		**Color Rendering Index**	**Typical Application**	**Typical Life (hours)**
	Range	**Avg.**			
Incandescent	8-18	14	Excellent	Homes, restaurants, general lighting, emergency lighting	1000
Fluorescent Lamps	46-60	50	Good w.r.t. coating	Offices, shops, hospitals, homes	5000
Compact fluorescent lamps (CFL)	40-70	60	Very good	Hotels, shops, homes, offices	8000-10000
High pressure mercury (HPMV)	44-57	50	Fair	General lighting in factories, garages, car parking, flood lighting	5000
Halogen lamps	18-24	20	Excellent	Display, flood lighting, stadium exhibition grounds, construction areas	2000-4000
High pressure sodium (HPSV) SON	67-121	90	Fair	General lighting in factories, ware houses, street lighting	6000-12000
Low pressure sodium (LPSV) SOX	101-175	150	Poor	Roadways, tunnels, canals, street lighting	6000-12000

2.2 Description of Previous Methods

In the previous studies, some indicators were proposed to measure the change of energy use efficiency performance across countries or regions, such as energy intensity, the energy/output ratio and traditional energy efficiency index. Energy efficiency is difficult to conceptualise and there is no single commonly accepted definition that will lead to various kind of indicators to measure the efficiency [7].

Data envelopment analysis (DEA) has recently been widely applied to analyze energy use efficiency. DEA is a non-parametric model that does not need to specify either the production functional form or weights on different input and outputs. In DEA model, each evaluation unit is considered as a decision making unit (DMU), the efficiency of input and output system is evaluated by using observed sample data. Based on Xian Ming conference paper [8], this study used three methods; firstly the super efficiency data envelopment analysis (DEA), malmquist index analysis and Torbit model analysis. The super efficiency DEA analysis was used to analyse the efficiency of every province and benchmark of energy efficiency was found, then the malamquist index analysis were used to decompose energy efficiency, and finally Torbit model analysis was used to achieve the influencing factors of energy efficiency.

Innovative direction of energy efficiency is the use of information and computer software for monitoring and energy efficiency analysis. One of the examples is Energyplan software. Energyplan provides tracking energy consumption and costs, allowing to identify savings opportunities and determine the efficiency of energy use. Using this program allows to set up monitoring of energy consumption, estimate the effectiveness of energy usage, check the correctness of energy bills, monitor compliance with energy limits, check comfort conditions in buildings.

CHAPTER 3

METHODOLOGY

3.1 Project Methodology

Methodology procedure needs to be arranged systematically in order to achieve the aim of this research. This chapter will explain about the detail of the project. Its also includes the project progress that have block diagram, flow chart and also the brief explanation about the project. The project explanation will be explained phase by phase that refer to the block diagram. The procedure is started from topic selection, followed by identifying issues, objectives, scopes, data, data collection, data analysis, conclusion and recommendation and finally the report write up.

3.2 Stages of Methodology

In order to achieve the objectives of the study, essential stages of methodology were conducted from phase 1 to 3. The project will be conducted as in basis flow chart in figure 3.1.

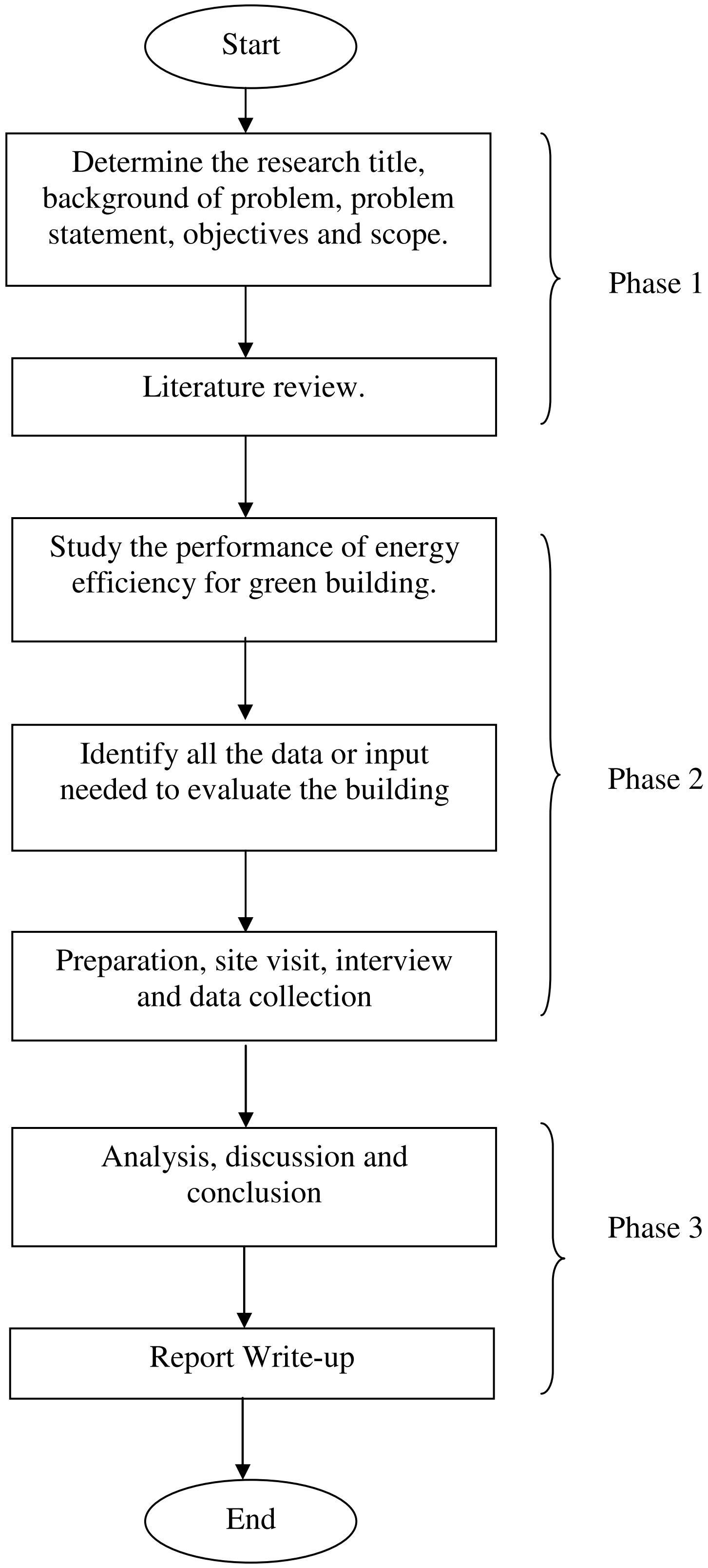

Figure 3.1: Process flow of methodology of study.

3.2.1 Phase 1

In this preliminary stage, this research will be started by identifying problem statement which covered objective and scope of research and followed by exploratory research of the literature. In the literature review, the information on EE in green building is gather as much as possible from textbook, journal papers, conference paper, internet, and database browser.

3.2.2 Phase 2

This research will continue to identify the problem and point out the scope of data collection. To achieve the objectives of this research, the following steps will be carried out:

- A preliminary research on the factors that affect the performance of energy-efficient design for the energy-efficient in green building (primary data).
- Site visit to the selected building, interview and discussion session with the EE building design team to understand the energy efficient design of the building (secondary data).
- Data collection is the most important part in this phase. The primary data is collected from the reading materials and the secondary data is from the validation survey and interview.

3.2.3 Phase 3

In the final stage, after all the data were analysing, a conclusion and suggestions were presented as the outcome of this research. The project's Gantt chart is given in Appendix B.

3.3 Project Block Diagram

In order to achieve this project, several techniques and measures have been selected and describe in process flow shown as figure 3.2.

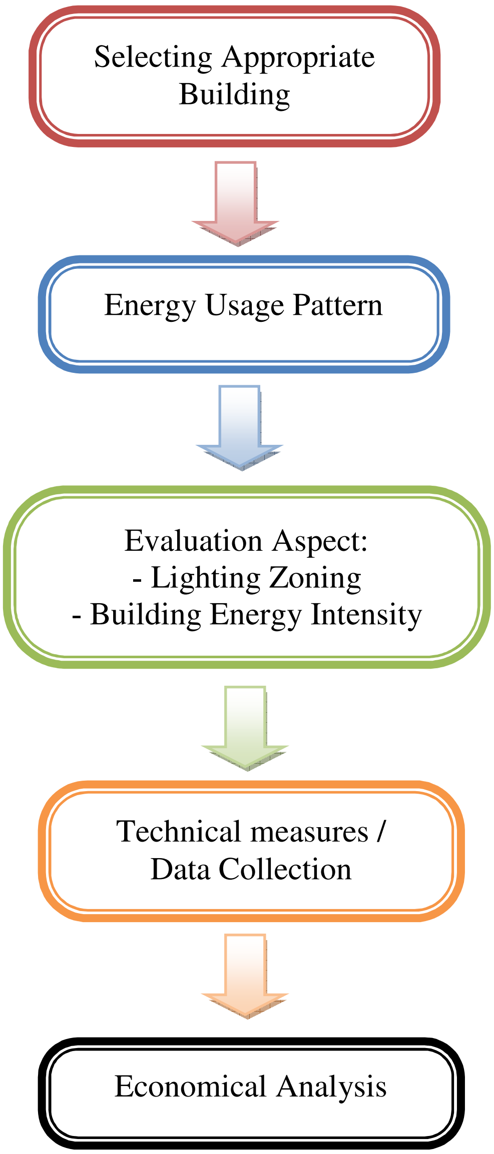

Figure 3.2: Operation flow of the research.

3.3.1 The Selected Building

Putrajaya Maritime Centre at Precinct 5 has been selected for this project. This is a recreational building open to public 7 days a week and the operating hours starts from 9.00 am and ends at 10.00 pm. The building selected occupies a strategic and landmark waterfront location within Precinct 5 which is part of the core area of Putrajaya. The waterfront edge of the site forms part of the bay where most of the intensive water sport activities will be taking place. The overall site is irregular in shape and the total site area is 7.05 acres. The Maritime Centre is composed of two 'mirrored' superstructure blocks of 3 storey high from Plaza Level. The building is designed as an integrated complex with common plaza level, basement level and waterfront level. The Maritime Centre has three main components, which are Public Amenities Area (West Wing), a boat club and Exhibition Hall (East Wing) and a cruise/tour/ Ferry Terminal. Figure 3.3 shows the picture of the selected building and figure 3.4 illustrates the perspective view of Putrajaya Maritime Centre. The building consists of 5 levels, they are:

Figure 3.3: Putrajaya Maritime Centre.

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