# FRAMEWORK FOR COST SAVING ESTIMATION OF COMMERCIAL BUILDING IN ENERGY EFFICIENCY

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**DEDICATION**

Specially dedicated to *Mak* and *Abah*

I really miss both of you.

*Al-Fatihah*

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# ABSTRACT

Commercial buildings are identified as one of the largest developments that utilize the highest amount of electricity in Malaysia. While it is a huge challenge for a commercial building owner to take necessary energy saving measures, by practicing energy efficiency activities, the building owner could save on operating costs and indirectly promoting environmental conservation. The main purpose of this study is to develop a framework for the purpose of achieving energy efficiency of commercial buildings. To identify the major barriers in implementing energy efficiency in buildings, Angsana Mall Johor Bahru was selected as the case study. A questionnaire survey session involving selected building energy management staff members and business space tenants of the building was conducted. In addition, the energy saving measurement (ESM) before and after the energy-saving program and estimation of energy cost savings were also taken. The analysis of the questionnaire survey shows that the importance of each barrier to the implementation of energy efficiency varies between the management and building tenants. Statistically, two main types of barriers in the category of *capital constraints* and *investment priorities* have been identified. These two barriers are *business capital-deficit factors for the purchasing of energy-saving equipment* and *the need of capital investment in energy efficiency to compete with other business investment priorities*. ESM results show that the highest contributor to energy saving and operating costs is from the replacement of old chillers for the centralised air-conditioning system of the building. A total of 160,575.15kWh or 15.48% energy savings with an approximate value of RM58, 609.93 per month can be achieved. This study has proven that energy saving for existing commercial buildings can be implemented but it requires high capital investment. A framework to enable building owners to continuously carry out ESM program has been developed and later validated through a focus group session conducted with the top management of UDA Holding Berhad as representative of Angsana Mall Johor Bahru building owner.

# ABSTRAK

Bangunan komersial dikenal pasti sebagai salah satu pembangunan terbesar yang menggunakan jumlah tenaga elektrik tertinggi di Malaysia. Walaupun ia menjadi satu cabaran yang amat besar bagi pemilik bangunan komersial untuk mengambil langkah-langkah penjimatan tenaga yang diperlukan dengan mengamalkan aktiviti kecekapan tenaga, pemilik bangunan boleh menjimatkan kos operasi dan secara tidak langsung mempromosikan pemuliharaan alam sekitar. Tujuan utama kajian ini adalah untuk membangunkan rangka kerja kecekapan tenaga bangunan komersial. Untuk mengenal pasti halangan utama dalam melaksanakan usaha penjimatan dan kecekapan tenaga dalam bangunan, Angsana Mall Johor Bahru dipilih sebagai kajian kes. Satu sesi kajian soal selidik yang melibatkan staf pengurusan tenaga bangunan dan penyewa-penyewa ruang perniagaan yang terpilih telah dijalankan. Di samping itu, pengukuran penjimatan tenaga (ESM) sebelum dan selepas program dan anggaran penjimatan kos juga dilakukan. Analisis kajian soal selidik menunjukkan bahawa tahap kepentingan setiap halangan terhadap perlaksanaan kecekapan tenaga adalah berbeza-beza antara pihak pengurusan dan penyewa bangunan. Secara statistik, dua jenis halangan utama dalam kategori kekangan modal dan keutamaan pelaburan telah dikenal pasti. Kedua-dua halangan tersebut termasuklah faktor perniagaan kekurangan modal untuk pembelian peralatan sistem jimat tenaga dan keperluan pelaburan modal dalam kecekapan tenaga untuk bersaing dengan keutamaan pelaburan lain. Hasil ESM menunjukkan bahawa penyumbang tertinggi kepada penjimatan tenaga dan kos operasi adalah dari aktiviti penggantian alat penyejuk untuk sistem pendingin hawa berpusat. Sejumlah 160,575.15kWh atau 15.48% penjimatan tenaga dengan nilai anggaran sebanyak RM58,609.93 sebulan boleh dicapai. Kajian ini telah membuktikan bahawa penjimatan tenaga untuk bangunan komersial sedia ada boleh dilaksanakan tetapi memerlukan pelaburan modal yang tinggi. Rangka kerja bagi membolehkan pemilik bangunan melaksanakan program ESM secara berterusan telah dibangunkan dan pengesahan kebolehlaksanaan telah di buat melalui satu sesi kumpulan fokus yang dijalankan dengan pengurusan tertinggi UDA Holding Berhad yang mewakili pemilik bangunan Angsana Mall Johor Bahru.

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# LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| AFUE | - | Annual fuel utilization efficiency |
| ANSI | - | American National Standards Institute |
| ARI | - | Air-Conditioning and Refrigeration Institute |
| ASHRAE | - | American Society of Heating, Refrigerating and Air-Conditioning Engineers |
| ASTM | - | American Society for Testing and Materials |
| BECP | - | Building Energy Codes Program |
| Btu | - | British thermal units |
| CAV | - | constant air volume |
| cfm | - | cubic feet per minute |
| CBECS | - | Commercial Building Energy Consumption Survey |
| DOE | - | U.S. Department of Energy |
| ECB | - | Energy Cost Budget |
| ECI | - | Energy Cost Intensity |
| EIA | - | Energy Information Administration |
| EPCA | - | Energy Policy and Conservation Act |
| EPACT | - | Energy Policy Act (of 1992) |
| EUI | - | energy use intensity |
| FCU | - | Fan Coil Unit |
| $ft^2$ | - | square feet |
| hp | - | Horsepower |
| h | - | hour(s) |
| in. wc | - | inches water column |
| HVAC | - | Heating, Ventilating, and Air Conditioning |
| IESNA | - | Illuminating Engineering Society of North America |
| kBtu kilo | - | British thermal unit |

| | | |
|---|---|---|
| kW | - | kilowatt(s) |
| kWh | - | kilowatt hour(s) |
| LPD | - | Lighting Power Density |
| PBA | - | Principal Building Activity |
| SHGC | - | Solar Heat Gain Coefficient |
| SRI | - | Solar Reflectance Index |
| SSPC | - | Standing Standards Product Committee |
| TQM | - | Total Quality Management |
| TMY | - | Typical Meteorological Year |
| U.S. | - | United States |
| VAV | - | Variable Air Volume |
| W | - | Watt(s) |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

Commercial building sector using approximately up to 50% of all electrical energy consumption in Malaysia, saving energy in the commercial building represents an important challenge for both the environment and the energy consumer. The concern on energy efficiency refers to the use of energy, prudence and wise. By definition, energy efficiency simply means to conserve the use of energy; to use less to accomplish the same task. It is something that affects every single individual, from purchasing energy-saving household appliances to the use of more efficient industrial equipment, both of which will help the end user save energy, reduce the cost of operations and in the process still be able to produce the same desired results or even better. Apart from that. promoting energy efficiency improvements is considered to play an important role in achieving energy savings because it reduces energy consumption of curtailing social welfare (Kenichi, Keigo, Fuminori, Junichiro, & Takashi, 2012). It is therefore important that these industries become more energy efficient in the interests of competitiveness and the global environment (Vikhorev et al. 2013). Considering to this, there are areas of study such as energy efficiency, seeking ways to optimize the use of energy within the environment it is being used. Several authors study this area and look for different ways to propose application models. Çengel (2011) stated that energy efficiency is to reduce energy use to the minimum level, but to do so without reducing the standard of living, the production quality, and the profitability.

In Malaysia at present, there are three (3) buildings specifically designed with energy efficient features such as Ministry of Energy, Communications, and Multimedia office building or well known as Low Energy Office (LEO), Green Energy Office (GEO) which houses the office building for Malaysia Green Technology Corporations and the Energy Commission office building also known as ST Diamond. (United Nations Environment Programme, 2011). Energy efficiency is a universal method and is recognized as the most effective method of cost control, especially for improving energy security, addressing climate change and encouraging competitiveness in the commercial buildings industry. Besides, energy efficiency is viewed as a key strategy in creating a global energy system more economically and environmentally friendly. The energy efficiency method has great potential and is needed for improvement in terms of economic growth in all sectors of housing, factories, office buildings, airports, shopping centres and power plants. According to the Annual Review of Energy and the Environment through Energy Efficiency Policy and Market Failure by Levine *et al.,* (2007); Levine, MD, Koomey, Jonathan G., McMahon, James, Enstad, Alan H., Hirst, Eric, (1995); 40% of global energy consumption and nearly a third of global $CO_2$ production is from commercial buildings. Additionally, according to Heyzer, N., (2008) energy demand in Asia and the Pacific region is expected to grow by 2.75% per year up to 2030, accounting for half of global demand at the time.

## 1.2 Problem Background

The energy demand in Malaysia has been increasing and requires a large electricity generation. An alternative to increase availability of energy is to make commercial buildings more energy efficient. Understanding energy consumption in buildings requires insight into the total energy and the different types of fuel used. Buildings that make use of renewable energy can reduce energy demand and thus reduce the amount of carbon dioxide ($CO_2$) generated. The global energy consumption is expected to increase by 1.6% per year or 45% over a period of 15 years starting from 2015 to 2030. Electricity demand in Malaysia is expected to reach 18,947 MW by 2020 and 23,092 MW by 2030 (Solangi et.al, 2013). According to the study, the Malaysian government plans to introduce energy efficiency as an important element in the framework of a national energy policy. This is to reduce the depletion of natural resources, lessen climate change and grow the economy. Currently, the Malaysian government provides a variety of incentives and fully supports those who wish to improve energy efficiency voluntarily. The fact that commercial owners can choose whether or not to implement energy efficient systems is one of the reasons energy efficient systems is not so widely used.

According to reports from the National Energy Balance (2008), The Ministry of Energy, Green Technology and Water expect that the total electricity demand in Malaysia will grow consistently at between 7 to 8 percent per year until 2020. In addition, a study conducted by Saidur (2009) on the use of energy saving emission analysis show that basic energy consumption of office buildings of commercial sectors use 8% to 50% of total energy consumption for selected countries. Saidur (2009) found that the commercial sector accounts for about 32% of total energy consumption in Malaysia in his study of the energy consumption of energy saving emission analysis as basic energy in office building. A study conducted by Luis Perez-Lombard, 2008 (2008) shows that the energy usage in commercial and residential buildings has grown between 20% and 40% in developed countries in the last decade.

There is insufficient data available about the Energy Performance or actual annual energy consumption of buildings in Malaysia at present. However, according to Kristensen, (2003) the index of energy which the amount of energy used in a building during a year divided by the gross floor area of the building in a regular office building is between 250-300 kWh / $m^2$ / year, depending on the type and function of the building. For a breakdown of the public attention the average energy consumption of office buildings was 52% for air conditioning and lighting, and 20% to 28%. The commercial buildings sector is known as the biggest consumer of energy for selected countries with the consumption approximately eight to 50 percent (Saidur and Masjuki, 2008). Commercial buildings are responsible for the steady increase of energy consumption by between twenty and forty percent in developed countries for the last decade (Luis Perez-Lombard, 2008).

Rapid development of commercial buildings due to high demands of spaces from other sectors caused the escalation of energy usage. For commercial buildings, approximately 80 to 90 percent of the energy consumed in the building's lifecycle is used in the operation phase while the remaining channelled to the construction, material manufacturing and demolition phase (Ashwin *et al.*, 2010; Keoleian *et al.*, 2000; Scheuer *et al.*, 2003; Utama and Gheewala, 2008). Besides that, the energy consumption of the building is expected to grow gradually over the next 30 years due to its long life cycle. (Levine *et al.*, 2007). Therefore, energy saving measures need to be taken on the operations phase.

Building owners face the problem of high operation costs due to escalating electricity tariffs which increase as a result of the depletion of energy resources. Because of the long life cycle of the buildings, the equipment or systems such as lifts, escalators, HVAC, lighting etc. become inefficient and outdated from the technological aspect, hence, they result in high consumption. Therefore, many initiatives have been introduced to reduce the consumption of energy without compromising the comfort of the people in the building. As a result of this situation, the energy efficiency concept was introduced to energy management of commercial buildings globally. Green buildings is the most familiar approach in moving towards energy efficiency and has been implemented in several countries, but it is preferably suitable for the development of new commercial building. However, the construction cost for such new buildings equipped with the energy efficiency program is fifteen percent higher than conventional designs (Al-Mofleh *et al.*, 2009). Significant planning, preliminary design and assessment tasks must be conducted prior to retrofitting the relevant energy conserving systems in existing commercial buildings. (Shaurette, 2010). Energy retrofitting is a way of improving the existing system through replacement of inefficient components with energy efficient ones (Al-Mofleh *et al.*, 2009).

The indicator of energy efficiency is often used to represent the energy consumption level of a particular energy-consuming system. Building owners are keen to enhance energy efficiency as it has a direct effect on operation costs. Building Energy Intensity (BEI) or another term such as Energy Usage Intensity (EUI) is usually used to indicate energy consumption for a particular building. Benchmarking has been demonstrated as an effective tool for energy efficiency improvement with diverse types of buildings and equipment. The use of benchmarks is important because energy efficiency of a building can be compared to a standard. In addition, it is important to identify the energy distribution spread across the building to identify opportunities to improve energy performance in. For example, the comparison of BEI to the benchmark will enable the building owner to compute the amount of energy consumed and identify where improvements can be made to minimize the consumption within that specific area. These opportunities for improvement, once taken action upon, lead to energy conservation.

These improvement measures require an upfront capital investment which depends on the type of initiative selected. There are different opportunities available at different times throughout the life cycle of the building. Basically, energy efficient buildings do not necessarily cost more to build than conventional buildings. If they are well maintained and manage energy effectively, they are set to be very reliable, comfortable and as productive as a normal building. The cost benefits analysis shows that the energy saving initiative can pay back the added cost that was invested to make the building energy efficient. The incurred cost of investment for an energy conserving design is identified by analysing its benefit to cost ratio. The payback period yield leads the building owner to make the decision to use an energy conserving program and design. Studies claim that there are a number of barriers that inhibit the adoption of cost effective energy efficiency measures (Sardianou, 2008). Although there is a need for industrial energy efficiency, studies indicate that the measurements for efficient energy conservation in relation to costs are not always implemented, which indicates the existence of an energy efficiency gap. This gap is explained by the existence of barriers to energy efficiency (Hirst and Brown, 1990). An commercial building energy program aims to reduce barriers that prevent energy efficiency. For this reason, it is extremely important to detect obstacles that restrict markets for energy efficient technologies in order to effectively reduce these barriers (Thollander and Dotzauer, 2010).

Several study propose frameworks on how energy efficiency must be implemented in commercial building, and how to make these applications easier. Considering this, the present study seeks to compile several models on energy efficiency that were applied in different industrial areas that were found through a systematic literature review. This study therefore compliments existing study in energy efficiency by reporting the develop framework model for implementing cost saving estimated objective of commercial building from a life cycle perspective. The framework will allow building owner have an appropriate balance between economic, social and environment issue, this also changing the way owner and practitioners think about the information they use when assessing commercial building, thereby facilitating of building industry. The framework developed is useful for commercial building performance assessments. This manual aims to assist commercial buildings to obtain certification compliance because they will eventually be judged on these criteria. Therefore, it is an assessment framework and not an implementation framework. The framework of literature that can be attributed to the new building is a multi-faceted aspect, but the majority are mostly devoted to energy.

Ma et al. (2012) present a framework for the selection and identification of energy retrofit options for existing buildings, which addresses the project phases and aspects that influence the success of the project in a holistic manner. Volvaciovas et al. (2013) developed nine feasible multi attribute selection strategies to determine the best scheduling and associated scheduling cost approach for retrofitting a small public building in Lithuania that served as a kindergarten. McArthur (2015) developed a building information management (BIM) framework for existing building maintenance, operations and sustainability. The framework was tested on a complex university building. Menassa and Baer (2014) developed a House of Quality (HOQ) model that integrates the competing objectives of stakeholders and was tested on an existing US Navy building. The selection process of retrofit technologies for existing buildings was addressed by Si et al. (2016). Lee et al. (2015) evaluated 18 energy retrofit toolkits developed to analyse retrofit options in terms of cost and energy performance. These toolkits come from different contexts in terms of climate and building type. Styles et al. (2015) provided general water management guidelines for the hospitality industry in Europe through best practice, benchmarking and key performance indicators. Tsai et al. (2014) used mathematical programming to create an integrated decision model that can be used in the construction industry to select green building projects without sacrificing profit margins. A broad-spectrum risk management system that provides recommendations for energy retrofitting was developed by Wei et al. (2014) and can be applied to various building categories.

## 1.3 Problem Statement

In general, energy cost is one of the highest operation cost components of commercial buildings, office buildings, hotels and hospitals (Jim, 2006; Hassan, 2006). Building owners are confronted with a vast array of systems when designing heating, ventilating and air conditioning (HVAC), lifts and escalator systems. The selection of the best system for a building's particular needs is a complex task because of the variety of options and lack of empirical data to guide selection. Currently, there is very little breakthrough in possible approaches for building energy efficiency studies throughout the world (Radhi, 2008). Comparative analysis method may be able to indicate which system is the most energy saving by using available empirical formulae such as in the research conducted by Saidur et al. (2007). To perform effective selection analysis, the availability of reliable cost data is vital (Barringer, 2003). However, there is no data bank of historical cost and energy consumption patterns, which results in difficulty in computing the total life cost of buildings. Besides that, extracting such data from files or other sources would be too time consuming.

Understanding even a single building energy usage is an analytical challenge. A building energy consumption depends on its physical structure and design components, but it is significantly influenced by inconsistent factors such as occupant use, equipment operation and maintenance, and climate variation. One of the challenges toward energy efficiency in commercial buildings is the inconsistency of the behaviours among the tenant and occupant as they can influence the energy usage. Chakraborty (2011) revealed between 2 to 20% of the 40% of buildings energy consumed thru electricity leakage ineffective appliances misused. Without the aid of detailed monitoring equipment it may be difficult to determine how much energy is used by the building operations such as heating, cooling, ventilation, lighting, the tenant's usage of computers, refrigerators, stoves and how these activities influence each other. While efficient light bulbs, refrigerators, and cars undergo prototype testing before they are mass-produced, buildings are custom-built. Testing procedures for buildings are typically limited to computer simulations or scale models.

Like an appliance or an automobile, a building's performance will vary over its life cycle, which is on the order of about 50 years. Technological development and ongoing changes in building practice further compound the complications in characterizing building energy use. Uncertainties about energy use in buildings arise due to the lack of adequate data for the building sector. Compared to industry and transportation, the other two major energy consuming sectors, international and country sources for energy statistics give little detailed information about buildings. Buildings often fall into the other category which lumps together the residential, commercial, public service, and agricultural sectors. The International Energy Association publishes separate figures for residential and commercial use, but the differences between these sub-sectors are more significant than a single pair of numbers can convey. Based on records and personal experience working with commercial building property, it can be seen that there are numbers of apparent barriers preventing widespread adoption of energy saving in commercial building. Those problems include lack of awareness of applying sustainable practice amongst building owners, lack of training, materials use and methods, data issues and high additional capital costs. Others barriers such as the decision making process, energy prices, lack of information as well as lack of confidence in the information also hinder the process of adoption of energy saving practice (Worrell and Price, 2001). Many times these problems can be linked with poor understanding and lack of clarity. In addition, it may be contributed by personal and human factors in administration, hidden agendas in contract administration and poor understanding of energy conservation problems.

Limited capital availability makes energy efficiency investments compete with other investment priorities, hence, many building owners tend to put less priority on energy saving investments. In addition, the high upfront cost of hiring energy consultants and a lack of trust between contractors and vendors available to guide and implement energy saving systems often results in building owners taking no action (Shaurette, 2010). In other cases, cost effectiveness and benefits of a particular system are not justified satisfactorily even though a consultant has been appointed to propose a solution for this obstacle. Because of that, building owners make evaluations using procurement costs and energy efficiency features comparisons which are widely used as the primary and sometimes only criteria for equipment or system selection (Dhillon, 2009). Thus, the results show that they tend to choose an equipment without taking into account its future energy consumption, which could possibly transfer to high energy costs in the operational stage.

Information collection and processing consumes time and resources which would be especially difficult for building owners (Gruber and Brand, 1991; Velthuijsen, 1995; Worrell and Price, 2001). Without cost and energy consumption data, decisions would be made on numerous assumptions with no evaluation process or mathematical justification. Lack of data has consequently made equipment suppliers unable to trace the ways to access, evaluate, or distribute such data. Thus, the supplier fails to convince the end user of the capability of their products in terms of energy efficiency. Recently, an abundance of energy efficient products have been released into market. Besides that, there is a focus on market and production expansion, which may be more effective than efficiency improvements to generate cost effective maximization (Worrell and Price, 2001). In summary, significant analytical assessments must be conducted prior to utilizing an energy conservation system in a commercial building (Shaurette, 2010). However, lack of adequate management tools, techniques and procedures to account for economic benefits of efficiency improvements prove to be an obstacle in the undertaking of such an initiative..

A random study found that energy efficiency in commercial buildings still did not focus on the major aspects of energy efficiency such as:

i. No provision of policies pertaining to energy use
ii. Management on energy is not merged into the organization
iii. There is no motivation on the whole body of energy usage
iv. There is no effective information system that can help increase energy efficiency
v. Effective introduction and promotion of energy use across the entire organization is not implemented
vi. There is no investment in the effort to improve the efficient use

There are some building owners who do not care or do not directly practice indoor energy management. This is because most organizations today say energy management is in addition to technical activities and letting the technical division handle all the problems that occur in energy use and not getting enough help from others in the organization. This is because the owners of a building are unaware of the importance of effective energy management in helping them reduce costs and negatively impact the environment.

## 1.4 Research Aim and Objectives

The aim of this study is to develop a Framework for Cost Savings Estimated of Commercial Building in Energy Efficiency. The main purpose of the framework is to enable management to make and prioritize decisions on energy management of existing commercial buildings. The following objectives have been identified to achieve the above aim:

i. To identify the barriers of implementing energy efficient in existing commercial buildings,
ii. To estimate the energy savings measures of the building,
iii. To evaluate cost savings as a result of energy efficiency initiatives in commercial buildings,
iv. To develop a framework improving commercial building in energy efficiency; and
v. To validate the framework using triangulation

## 1.5 Scope of Study

UDA Holdings Berhad is a Malaysian company engaged in property development, property management and the leisure industry. The company's property development division is involved in the redevelopment of new townships, public housing, recreation, hotels, commercial buildings and industrial premises. UDA is a developer under the Ministry of Finance and is also a part of the statutory body of the Agency, currently UDA is developing a number of joint initiatives with Bumiputera owners, Local Authority and the State Islamic Religious Council.

The case study for this study is only focuses on commercial buildings for UDA Holdings Berhad in Johor Bahru. The main objectives of this study are to develop a framework the cost savings estimate of energy efficiency in commercial buildings to aid in system selection such as heating, ventilating and air conditioning (HVAC), lifts and escalators. Another objective is to identify the barriers of implementing energy efficient systems and optimizing energy saving in existing commercial buildings. As energy efficiency for commercial buildings is still new in Malaysia, the research done and data available are still insufficient. Furthermore, there is still a lack of awareness of the need for energy efficiency amongst owners, building operators, designers and the end users. A number of professional articles and studies on energy efficiency emphasize the importance of life cycle cost analysis to explain the cost benefits for commercial buildings.

## 1.6 Significance of The Study

Energy efficient systems are much needed because energy requirements will increase as year 2020 draws closer. The building sector is a major energy consumer where it uses up 48% of the total electrical energy. According to the MS1525 standard, the recommended building energy index in Malaysia is 135kWh/m$^2$/yr. but most of the commercial buildings exceed this level. A substantial amount of energy is used in operating commercial buildings and that has significantly contributed to the amount of carbon dioxide ($CO_2$) in the atmosphere. There are a number of commercial buildings that are environmentally unfriendly and contribute to the already excessive demands for scarce resources like fossil fuels.

The findings of this study will make building owners more aware of the importance of energy efficiency in commercial buildings that would eventually help in reducing energy consumption. Commercial buildings will receive many direct and indirect benefits of using an energy efficient system such as saving on operation costs long term and reducing the amount of $CO_2$ released into the atmosphere. Energy efficiency is explicitly addressed in the Ninth Malaysia Plan. Energy efficiency programmes in this plan will focus on energy saving features in the industrial and commercial as well as the domestic sectors. Efficient Management of Electrical Energy Regulations are to be introduced and Uniform Building By Laws to be amended to incorporate energy efficiency features and specifications for accurate and informative electrical appliance labelling.

It is hoped that the finding of this present study will contribute to the body of knowledge in energy efficiency particularly in identifying the criteria of energy efficiency for commercial building. Additionally it is hoped that the finding of this present research has fill the gap in the body of literature related to the energy saving, and consumption issues which gives impact to the energy efficiency for Malaysia commercial buildings. Similarly, this study will give valuable contribution to commercial building, administrators, policy makers, developers and other related authorities in helping them dealing with energy consumption and saving.

## 1.7 Methodology of Study

The methodology of study is a guideline for the study to be completed in a systematic way to achieve the study objectives. In this study, the study process consisted of four stages: Stage 1: initial study and confirmation of study area, Stage 2: creating the study proposal, Stage 3: data collection and analysis, and Stage 4: write-up and conclusions.

The following shows the outline of the study:

i. Stage 1 involves initial studies and determining the research area. Three approaches were used in the initial studies such as literature review and critical review on several documents . These approaches aimed to narrow down the research area. At the end of this stage, a rough idea of the research topic was obtained. The objectives and scope of the research were determined. A research outline was prepared in order to determine the type of data needed for this research. Also, data sources and gathering techniques were identified as well. After that, a research proposal was drafted and confirmed.

ii. Stage 2 is the main phase of the study involves in depth interviews with several key player of the building in order to address an appropriate measures to be implemented. A meta-analysis on literature review, and document analysis also were conducted to strengthen and verify the research area such as zone load and factors and barriers that could affect energy efficiency on the identified building. In this stage the appropriate measures for energy efficiency were identified

iii. In stage 3, all data gather in stage 2 will be incorporated to form a energy saving proposal. Measures identified would be represent the operating measures as well as the general energy management measures. All the suggested measures will be implement a those identified measures would be implemented. The calculation of energy consumption between before and after implementation would be recorded

iv. In stage 4, is the conclusion stage. In this stage, the feasibility of the proposed measures was validated by comparing the energy consumption recorded (before and after measures) with the real data of the building. The real data would derived from the independent party report as well as the building current utility bills

## 1.8 Summary

Discussions of this study were divided into five chapters, Chapter 1: Introduction, Chapter 2: Literature Review, Chapter 3: Research Methodology, Chapter 4: Findings and Discussion and Chapter 5: Discussions and Conclusions.

Chapter 1 was the introductory chapter which discussed definition of topic, background of study, problem statement, and objectives of the study, scope of study, justification of the study, significant contribution to new knowledge and organization of the chapters.

Chapter 2 presented extensive literature review regarding Energy efficiency, Energy consumption, energy efficiency option, building retrofitting, Utilization of Energy Efficient, Formulating Energy Efficiency Guidelines, Energy Performance, Energy Management, Energy Audit, Automated Costing System, Building Automation and Control Systems (BACS), Barriers To Energy Efficiency, Factors To Energy Efficiency, Validating the energy efficiency, The energy efficiency gap and framework

Chapter 3 presented the overall research process. It describes and justifies research methodologies that covered research philosophy, and research design including research problem, purpose of research, theoretical framework, research questions and hypothesis, operational definition, methodology used, assumptions, limitations and expected outcomes.

Chapter 4 discussed on finding analysis and discussion which focused on five important objectives; identify the barriers of implementing energy efficient systems and optimizing energy saving in existing commercial buildings, determine zone load of existing building from the study location, estimate the energy savings measures of the building, evaluate cost savings as a result of energy efficiency initiatives in commercial buildings, develop a framework improving commercial building in energy efficiency; and validate the framework. All the discussion in this chapter was divided into three sections; preliminary stage, assessing energy saving measures for saving initiatives stage, and validating energy saving stage.

In Chapter 5, discussions and conclusions of the research findings with some recommendations were made. Assumptions, limitations, practical implementation and expectations were made in this chapter.

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