



A LESSON IN LOW ENERGY DESIGN ON THE
UTILIZATION OF ELECTRICITY – A CASE STUDY ON
THE FACULTY OF DESIGN AND ARCHITECTURE
BUILDING IN UNIVERSITY PUTRA MALAYSIA

BY

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A dissertation submitted in fulfilment of the requirement for
the degree of Master of Science in Building Services
Engineering

Kulliyyah of Architecture and Environmental Design
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ABSTRACT

Several researchers have investigated the energy consumption of office buildings in Malaysia. In this study, energy consumption of low energy buildings, strategies, an overview of electricity usage in buildings, and performance evaluation of green buildings in Malaysia, will be conducted. The Faculty of Design and Architecture (FRSB), University Putra Malaysia (UPM) was selected as a case study for this research. The results of this study will become a reference for UPM, as the owner of the FRSB building, to become a pioneer of energy efficiency programs. These results will be compared with the Malaysian Code of Practice Standard for Energy Efficiency and Use of Renewable Energy for Non-Residential Building (MS 1525:2007); in order to identify compliance with that standard. This study will also identify the factors that contribute towards energy consumption for the FRSB building and provide recommendations for minimizing energy usage for education buildings; particularly in Kuala Lumpur, Malaysia, and create awareness for building designers and occupants alike. The findings will show that the FRSB building complied with MS 1525:2007, in terms of Overall Thermal Transfer Value (OTTV) and overall energy usage. The results presented in this study will confirm that this building's electricity usage comes mostly from air conditioning and lighting systems. This study will provide suggestions for using a Building Management System (BMS) to control overall energy usage and for the installation of photovoltaic panels; which may help to provide energy by itself. The recommendations provided will attempt to overcome the problems caused by occupant's behaviour towards energy use.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Science in Building Services Engineering.

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole of any other degrees at IIUM or other institutions.

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**A LESSON IN LOW ENERGY DESIGN ON THE UTILIZATION OF
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ARCHITECTURE BUILDING IN UNIVERSITY PUTRA MALAYSIA**

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Dedicated to

My beloved father, mother, brothers, sisters and my love

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LIST OF ABBREVIATION

ACEM	Association of Consulting Engineers Malaysia
ASEAN	Association of Southeast Asian Nations
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BEI	Building Energy Index
BIPV	Building Integrated Photovoltaic
BMS	Building Management System
CCC	Certification of Completion and Compliance
CIDB	Construction
CO ₂	Carbon Dioxide
EB3	Enterprise Building 3
EE	Energy Efficiency
EIA	Energy Information Administration
EPA	U.S Environmental Protection Agency
EPU	Economic Planning Unit
FRSB	<i>Fakulti Rekabentuk dan Senibina</i> (Faculty of Design and Architecture)
GBI	Green Building Index
GHG	Green House Gases
HVAC	Heating, Ventilation and Air Conditioning
IEQ	Indoor Environment Quality
IPTA	<i>Institut Pengajian Tinggi Awam</i> (Public Higher Education Institution)
IPTS	<i>Institut Pengajian Tinggi Swasta</i> (Private Higher Education Institution)
KeTTHA	<i>Kementerian Tenaga, Teknologi Hijau dan Air</i> (Ministry of Energy, Green Technology and Water)
KPKT	<i>Kementerian Perumahan dan Kerajaan Tempatan</i> (Ministry of Housing and Local Government)
kWh	kiloWatt/hour
kWp	kiloWatt-peak
LEED	Leadership in Energy and Environmental Design
LEO	Low Energy Office
MEWC	Ministry of Energy, Water and Communication
MS1525	Malaysia Standard 1525
MSB	Main Switch Board
OTTV	Overall Thermal Transfer Value
PAM	<i>Pertubuhan Arkitek Malaysia</i>
PPPA	<i>Pejabat Pengurusan Pembangunan dan Aset</i>
PTM	<i>Pusat Tenaga Malaysia</i>
RH	Relative Humidity
RTTV	Roof Thermal Transfer Value
TWh	Terra Watt/hour
UBBL	Uniform Building By-Law
UNFCCC	United Nations Framework Convention on Climate Change
UPM	University Putra Malaysia
Wh	Watt/hour
ZEO	Zero Energy Office

CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

This chapter was designed to present an overall introduction to this study. Section 1.2 describes the problem that our environment is facing regarding the impact of the operational energy used of buildings. Section 1.3 and 1.4 respectively clarifies the problem statement and the research aims and objectives of this study. Section 1.5 clarifies the research questions while section 1.6 is the elaboration of research methodology. Consequently, the significance of this study will be discussed in section 1.7 and subsequently, section 1.8 discussed the limitations of this study. Finally, section 1.9 presents the overall outline of this study.

1.2 BACKGROUND OF STUDY

Global warming is a serious problem facing the world today as well as the world in the future. In order to stop or reverse this problem, society must change, learn to be less harmful to the environment. Making buildings “green” would greatly impact this problem. There are many ways for this to be done and more ways are being developed rapidly. New developments are made every day in the field of engineering that are meant to save energy and protect the environment. This is a very important time to be conscious of energy consumption, due to global warming.

Reducing energy use in buildings is a critical component of meeting carbon reduction commitments. There are several ways of accomplishing this goal, each of which emphasizes actions by a different set of stakeholders. In this scenario,

architects, engineers and efficiency advocates are the major players, making technical improvements to existing buildings and designing new ones to higher standards. Reducing the operational energy use and increasing durability should be the main concerns of architect who wish to design and build “green” buildings. It has been suggested (Lstiburek, 2008) that 80% of a green architect’s concern should be directed towards reducing energy consumption during operation.

The solution to the problem begins with awareness of the importance of operational energy consumption to environmental damage, resource depletion, habitat destruction, and hence, to green buildings. Solutions will take many forms, but all will involve prediction of energy consumption and confirmation that the low energy building is actually built and operated as one (Straube, 2009).

Energy consumption should be measured in terms of environmental damage, such as carbon emissions, resource depletion, or habitat destruction. None of these are easily measured. However, every month, a uniformed people (meter readers) are deployed around the country to measure the energy used in buildings and this energy use data is remarkably precise, summarize into easy-to-read formats and send to the building owners.

The operational energy use of buildings is giving the biggest environmental impact. Green buildings, which must be low-energy buildings, need to be designed to respond to this reality. Despite the massive amount of evidence pointing to the importance of energy consumption to green design, designer and even rating program like LEED still seem fixated on material choices, not energy reduction (Straube, 2009). Perhaps the lack of attention to this critical issue is a result of the fact that architects are trained in the arrangement of spaces, massing, cultural influences and the selection of finishes.

Designing buildings that consume little operational energy is not a normal skillset but it requires much more quantitative understanding of heat transfer and radiation physics, weather and sun and mechanical equipment operational details than architects normally possess. Nevertheless, it is the architects that make most of the significant choices that impact energy consumption. The real savings from improved window technology, more efficient equipment, and better design tools have disguised the fact that we are wasting more energy because of over-ventilated, over-glazed and under-insulated buildings.

If a building's orientation, massing, window area or shading, insulation arrangements, and airtightness are not properly optimized, no amount of mechanical engineering, chilled slabs, natural ventilation or green materials can make the building a 'low-energy' building.

1.3 PROBLEM STATEMENT

Climate change is one of the results of global warming phenomenon. Buildings and the built environment contribute significantly to green house gas (GHG) emissions and hence the needs for better designs that reduce the overall contributions of the sector to climate change.

According to the Climate Change Performance Index 2013 (Appendix 1) prepared by Germanwatch and Climate Action Network in Europe, Malaysia ranked 55 in the 2013, compare to ranked 52 in 2009. Climate Change Performance Index is an instrument that evaluates and compares the climate protection performances of the 57 countries that are responsible for more than 90 percent of global energy-related CO₂ emissions. In terms of energy use per capita, Malaysia out surpasses other

ASEAN countries such as Vietnams, Philippines, Indonesia and Thailand (Dixon, 2009).

In order to reduce the emissions of GHG from the buildings, there are significant potential energy savings that can be achieved by building more energy efficient buildings in Malaysia. This is clearly seen through energy audit conducted by Pusat Tenaga Malaysia (PTM) to government buildings. Besides that, the implementation of Energy Management (EM) in order to optimize the use of energy by avoiding was or recovering unused energy in processes or facilities. This indicates the need for Malaysia to establish a roadmap for national energy saving. Although awareness of energy efficiency within building has to a certain extent been generated among Malaysian builders, architects and consultants, nevertheless the implementations aspect is still very weak.

The new buildings in Malaysia are somehow designed towards low energy building, but the main challenge is to turn an existing building to a low energy building. Although the implementation needs more cost to adapt the passive design to the building, the occupant themselves need to have an awareness on the importance of energy saving as well as to educate people on how to save the energy. There are many research that confirms that the occupant of the building itself is one of the factors that contributing the energy consumption level.

The current situations in Malaysia where the cost of energy; electricity is increasing due to the cost of production and supply of the energy are both getting higher year by year. Indirectly, it will affect the operational cost of the building. In order to sustain the overall cost, there should be a way to reduce the energy consumption of the building itself.

1.4 RESEARCH AIMS AND OBJECTIVES

The aim of this study is to find the average usage of energy consumption for an existing education building as a case study and to compare the result with the Standard that has been stated in the Malaysian Standard MS 1525 : Code of Practice on Energy Efficiency and Use of Renewable Energy for Non Residential Buildings. Furthermore, the findings will be used as the basis of recommendation towards low-energy building. In order to achieve these aims, the following objectives are listed :

- i. To identify the source and the pattern of energy usage in the building,
- ii. To verify the result from the case study whether it comply with MS 1525 or not, and
- iii. To provide recommendation/s on how to integrate low energy concept to the case study building so that it can comply with MS 1525.

1.5 RESEARCH QUESTION

In order to conduct this study and to achieve all the objectives listed, there are few research questions that must be answered to get better understanding and conclusion of the energy consumption of education buildings and to get the recommendation on how to minimize the usage of electricity. The research questions are :

- i. What is a low energy building?
 - a. What are the characteristics of low energy building?
 - b. What are the trend and the future of low energy building in Malaysia?
 - c. What is Malaysia Government saying about low energy building?

- d. How can we integrate the low energy concept to existing building?
 - e. What buildings in Malaysia are certified as low energy building? What are the characteristic of it?
 - ii. What is the electrical consumption pattern for an education building?
 - a. What are the sources of energy consumption for education building?
 - b. What is the average energy consumption of the building?
 - iii. What is Malaysia Standard MS 1525 : Code of Practice on Energy Efficiency and Use of Renewable Energy for Non Residential Buildings?
 - a. What are the characteristics of MS 1525?
 - b. What are the standards to be fulfilled in order to comply with it?

1.6 RESEARCH METHODOLOGY

This research essentially focuses on energy consumption for an academic building that must comply with MS 1525. Due to this matter, this author used the quantitative method, which the analysis will be from all the data collected from the case study building. In order to identify how this method will assist the researcher in achieving the research objectives, the main research framework, are briefly illustrated and explained in the following.

1.6.1 Research Process

The chart showing the research flow of the research explained below. The working conceptual model of this thesis is shown in Figure 1.1.

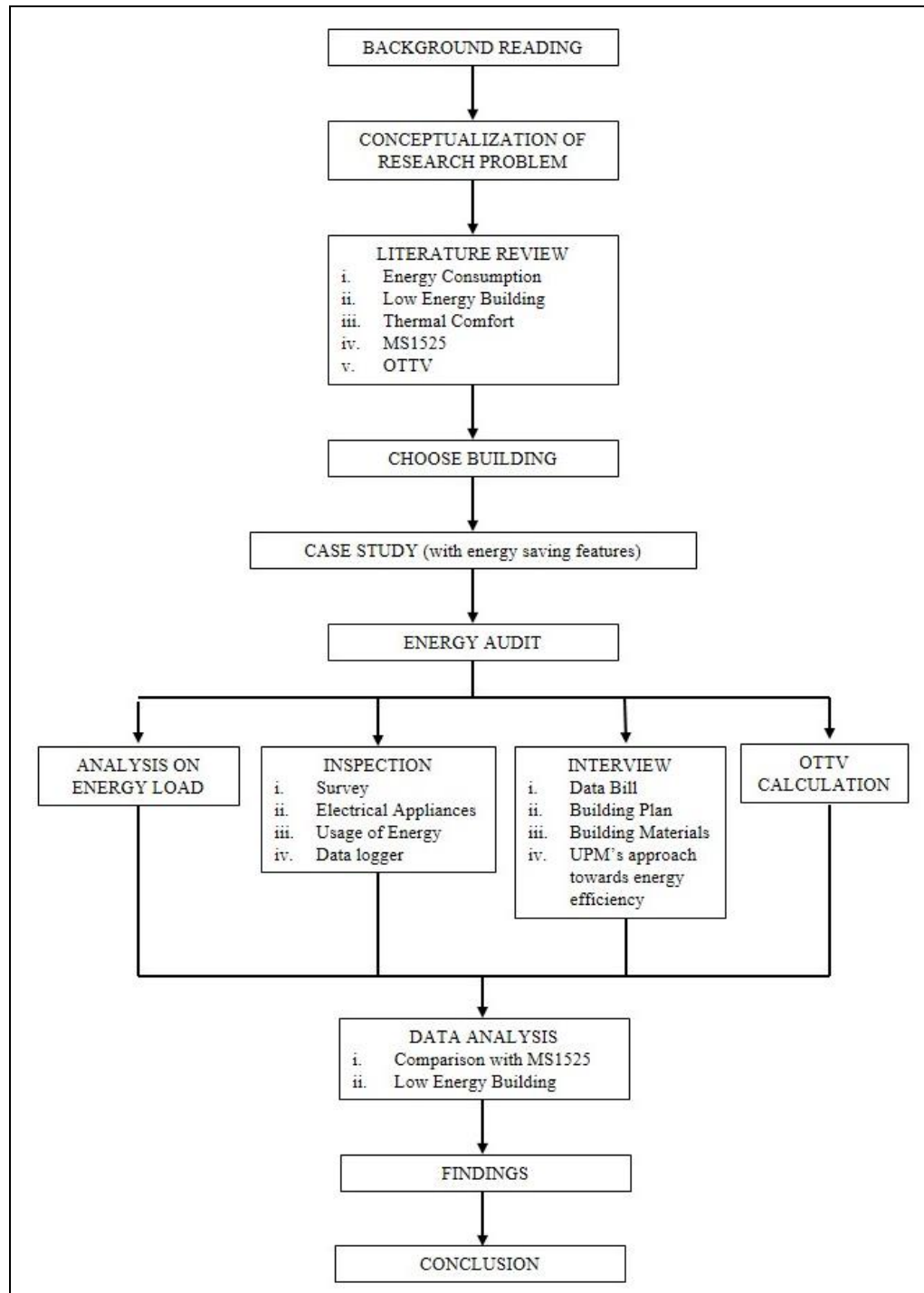


Figure 1.1 : Research Process of this research

1.7 SIGNIFICANCE OF STUDY

This study is to give general view on the use of electricity of academic buildings and the advantages of the low energy building, including the Malaysia Government views on this matter. Furthermore, the study may help to promote integrate the low energy concept to the existing building as this will assist the nation in achieving the aims in reducing energy consumption and the emissions of GHG to sustain the environment. The findings of the research are expected to make recommendation for better design strategies to the stakeholders and it will be beneficial to the owner particularly and to the whole environment generally as explained further below.

1.7.1 Significance Towards the Building Design Team

Studying the effectiveness of the low energy building design by providing the data that supporting the fact, is a satisfaction of achieving the goal in designing a low energy building. This information is useful for the design team as it provides the overview of effectiveness of the green design so that the design team can be implemented from the very beginning, which is at the planning stage.

1.7.2 Significance Towards the Building Stakeholders

The study shows the cost of energy usage for the building which can give an overview on how much they need to spend to run the building to run. This information hopefully will create awareness to the owner of the building in minimizing the energy consumption, and by doing so, it can minimize the effect to the environments as well by reducing the emissions of GHG to the atmosphere.

1.8 SCOPE AND LIMITATION OF THE STUDY

The study was concentrated and limited only to an existing education building that is partly glazed and fully air conditioned (split unit system). The building chosen is the Faculty of Design and Architecture, Universiti Putra Malaysia (UPM).

1.9 OUTLINE OF THESIS

The thesis is organized into five chapters. These are summarized as below :

Chapter One : Introduction

The first chapter introduces the thesis with the background of the research, problem statements, aim and objectives of the research, research questions posed, its significance and limitations, as well as the methodologies undertaken.

Chapter Two : Literature Review

The second chapter is a collection of reviews and current information related to this thesis. It gives information on the electricity, low energy building, the characteristic of low energy building, achieving low energy building for existing building, Green Building performance evaluation and thermal comfort. This chapter also provides an overview of MS 1525, as well as an overview regarding Overall Thermal Transfer Value (OTTV).

Chapter Three : Research Methodology

Chapter three describes the methodology used in this research which included the checklist, energy audit and the field work measurement.

Chapter Four : Data Finding and Analysis

This chapter is the analytical chapter where all the data collected from the checklist, energy audit and the field work measurement will be analyzed and discuss in order to