UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Mechanical Engineering

ANALYSIS OF ENERGY USAGE OF THE LIBRARY BUILDING IN UTeM MAIN CAMPUS

Malik Raihan Rshieh

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(Energy Engineering)

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MALIK RAIHAN RSHIEH

A thesis submitted
in fulfillment of the requirements for the degree of Master of Mechanical Engineering
(Energy Engineering)

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DECLARATION

I declare that this project entitled "Analysis of Energy Usage of the Library Building in UTeM Main Campus" is the result of my own research except as cited in the references. The project has not been accepted for any degree and it is not concurrently submitted in candidature of any other degree.

Signature	:	....
Name	:	MALIK RAIHAN RSHIEH
Date	:	....

APPROVAL

I hereby declare that I have read this report and in my opinion, this thesis is sufficient in terms of scope and quality for the award of Master of Engineering in Mechanical Engineering (Energy Engineering).

Signature	:	....
Supervisor Name	:	DR. SHAMSUL ANUAR BIN SHAMSUDIN.
Date	:	....

DEDICATION

I would like to present my work to those who did not stop their daily support since I was born, my dearest father, and my kindest mother, who never hesitate to provide me all the facilities to push me foreword as much as they can. This work is a simple and humble reply to their much goodness I have received all this while. I thank them for giving me many chances and I love them so much.

I also dedicate this project to my wife and brothers who have supported me through my life. I always miss and I cherish the memories that we had. I love all of you.

ABSTRACT

Air-conditioning and mechanical ventilation system (ACMV) is one of the main contributors to the total building energy consumption. According to previous works, buildings use about 60% on air-conditioning of the total energy consumption. At the same time, the most economical way was to determine the most efficient system for air conditioning system. Temperature, humidity, pressure and air motion are some of the important variables that refrigeration and air conditioning deals with the techniques to control the environment and provide comforts to enable the better living. Factors that affect human comfort were determined by using Indoor Air Quality Meters and also by calculating the building energy index for 2016 and 2017. From the study, measurement and evaluation of the existing indoor comfort parameters of the *Laman Hikmah* Library building located in the *Universiti Teknikal Malaysia Melaka* (UTeM) main campus were conducted. The area of the library building is 10,063.68 square meters that covers of four floors. The physical parameters such as air velocity, average flow, average operating temperature, average relative humidity, lighting, and CO_2 readings were recorded, analysed and then compared to the current ASHRAE-55 and MS1525:2014 standards. Based on the collected data and information, the total building cooling load is then being estimated. In addition, the Building Energy Index could also be determined, where it was found that the results were 94.4252 kWh/m²/year and 117.8952 kWh/m²/year for the years 2016 and 2017 respectively. All of these values were less than the MS 1525:2014 Standard of 135 kWh/m²/year. The current energy consumption for all floors that the air conditioning recorded the highest rate consumption was 67.75% of electricity usage in building, followed by the consumption of lighting was found to be 17% and others equipment 15.25%. Finally, economic analysis is included with potential alternative measures to achieve optimum building energy usage.

ABSTRAK

Pendinginan Hawa dan Pengudaraan Mekanikal (ACMV) adalah penyumbang besar dalam pengunaan tenaga untuk sesebuah bangunan. Kajian seblum ini menunjukkan sekitar 60% penggunaan tenaga adalah untuk pendingin hawa. Pada masa yang sama, cara paling ekonomik ditentukan melalui sistem yang paling cekap untuk operasi sistem pendingin hawa. Suhu, kelembapan, tekanan dan pergerakan udara adalah beberapa pembolehubah penting untuk penyejukan dan pendingin hawa menangani teknik-teknik untuk mengawal persekitaran dan memberikan keselesaan bagi membolehkan kehidupan yang lebih baik. Faktor-faktor yang mempengaruhi keselesaan manusia ditentukan melalui bacaan menggunakan Meter Kualiti Udara Dalaman dan juga mengira indeks tenaga binaan untuk tahun 2016 dan 2017. Dari kajian ini, pengukuran dan penilaian parameter keselesaan dalaman memberikan tumpuan kepada bangunan perpustakaan Laman Hikmah yang terletak di kampus induk UTeM. Perpustakaan ini mempunyai keluasan 10,063.68 meter persegi, merangkumi empat aras. Parameter fizikal seperti halaju udara, aliran purata, operasi purata suhu, kelembapan relatif purata, pencahayaan, dan kanduangan gas CO_2 *direkodkan, dianalisis dan kemudian dibandingkan dengan piawaian ASHRAE-55 dan MS1525:2014 serta Indeks Tenaga Bangunan. Hasilnya, untuk tahun 2016 dan 2017 bacaan indeks adalah 94.4252 kW* /m^2/*tahun dan 117.8952 kWh*/m^2/*tahun. Semua nilai ini adalah kurang daripada daripada yang dicadangkan dalam Standard MS 1525: 2014 iaitu sebanyak 135 kWh*/m^2/*tahun. Keputusan untuk projek ini memberikan corak ilustrasi dalam turun naik dalaman dan parameter keselesaan. Penggunaan tenaga semasa ketika itu adalah 67.75% digunakan untuk pendingin hawa, diikuti oleh pencahayaan sebanyak 17% dan peralatan lain 15.25%. Akhirnya, analisis ekonomi turut disertakan dengan langkah-langkah alternatif yang berpotensi untuk mencapai penggunaan tenaga bangunan yang optimum.*

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF SYMBOLS

M/s	-	Meter per second
°C	-	Degrees Celsius
hr	-	Hour
BTU	-	British thermal unit
M	-	Meter
KW	-	kilowatt
Ib	-	Pound
W/ m^2	-	Watt per meter square
%	-	Percentage
TR	-	Tones Refrigerant
CO_2	-	Carbon Dioxide
Ft	-	Feet
Cfm	-	Cubic feet per minute
ppm	-	Parts-per Million

LIST OF ABBREVIATION

ABBREVIATIONS	DESCRIPTION
PMV	Predicted Mean Vote
PPD	Predicted Percentage Dissatisfied
ACMV	Air-conditioning & Mechanical Ventilation
IEQ	Indoor Environmental Quality
BEI	Building Energy Index
TNB	Tenaga National Berhad
GMT	Greenwich Mean Time
GW	Giga Watts
GDP	Gross Domestic Product
USGBC	Building Council of the United States of America
BRE	Building Research Establishment
BREEAM	BRE Environmental Assessment Method
MRT	Mean Radiant Temperature
UTCI	Universal Thermal Climate Index
IAQ	Indoor Air Quality
LEO	Low Energy Office
CO	Carbon Monoxide
CO_2	Carbon Dioxide
Rn	Radon

VOC	Volatile Organic Compounds
RAC™	Room Acoustic Comfort™
HVAC	Heating, Ventilation and Air-Conditioning
GHG	Greenhouse Gas
SET	Standard Effective Temperature
TAC	Task/Ambient Conditioning Systems
RH	Relative Humidity
NO2	Nitrogen Dioxide
VOC	Volatile Organic Compound
AHU	Air Handling Unit
UTeM	Universiti Teknikal Malaysia Melaka
UTHM	Universiti Tun Hussein Onn Malaysia
MS	Malaysian Standard
ISO	International Organization for Standardization
EN	European Standard
CONS	Consumption

CHAPTER 1

INTRODUCTION

1.1 Research Background

These days, the demand for electricity has increased because of the population growth and the improvement of living standards all over the world. Most power plants are using fossil fuels to produce the energy of electric, leading to the increase of the prices for energy and the increase of the pollution. In terms of the renewable energy sources such as solar energy, wind energy, geothermal energy and ocean energy they play an effective role in the production of energy and most effectively to deal with the problems of energy conservation.

The increasing levels of global warming, depleting sources of fossil fuels and increasing energy costs are all having a large detrimental effect on today's society. Many efforts are being made to try and increase energy efficiency all over the world (Lau et al., 2009). One of the most difficult problems to achieve energy efficiency is to reduce energy costs for a building when the energy costs are accounted as part of the general overhead. Therefore, building energy audit is one approach that is being studied and implemented to reduce energy costs. The energy audit serves to identify and evaluate how much the building facility uses energy and identifies energy conservation opportunities. It also serves to establish an energy consumption pattern, monitoring of how the energy used in the building, how the system elements interrelate and study the external environment affecting the building (Ahmed et al, 2014).

The buildings in which human live, play and work are protecting them from nature's extreme. But people have to remember that buildings also affect their health and environment in countless way. Building have significant impact on the environment. It was harmful to our living environment and brewing an unsecure environment for our next generation (Muzar, 2011). In this research, an attempt is made to determine the indoor environmental quality (IEQ) for a library building of its respective data, and recommend the effective ways to thermal comfort in the non-residential buildings. In the partitioning scenario, without conditioned space interior design should pose a threat is great not only for the comfort of the occupants but also to energy use in the building. Therefore, it is important to study qualitatively impact restrictions in place of interaction of the air-conditioned comfort of heat, and energy consumption when restrictions are installed in or removed from the air conditioned space (Azar et al.,2014, Li,z et al., 2014).

According to previous studies, the energy used to run the fans and pumps which operate in the chiller system, heat transfers and cooling from central heating and cooling plants to conditioned spaces, can represent a significant portion of this energy from 20% to 60% of electricity usage in a building (Sarbu et al.,2014). Air conditioning is the control of the humidity of air by either increasing or decreasing its moisture content. In addition to the control of the humidity is the control of temperature by either heating or cooling the air, the purification of the air by washing or filtering the air and the control of the air motion and ventilation. Ventilation refers to the process of supplying and removing air by natural or mechanical means to and from any space; such air may or may not be conditioned (Jazizadeh and Ghahramani, 2014).

A new and existing building must comply with Malaysia Standard policies that are stated in MS 1525:2014 while undergoing the design, construction, operation and maintenance. Hence, it is clear that energy is utilised in sizeable quantities to provide comfort air conditioning in offices, educational institutions, commercial buildings and homes. Therefore, Department of Standards Malaysia (DSM) published code of practice for energy efficiency and the use of renewable energy for non-residential building. This provides the criteria and minimum energy-efficient design standards for air conditioning installations, reducing the use of energy without constraining creativity in design, building function and the comfort or productivity of the building occupants (Malaysian Standard, 2014).

Referring to Malaysia Standard, MS1525:2014, it was recommended that the commercial building energy index (BEI) in Malaysia is 135kWh/m²/yr (Noranai and Yusof, 2011). For this wok, the electricity bills for the years 2016 and 2017 are enclosed in Chapter Four. In a related development, starting January 2017, cost of energy has also increased, which contributes to an increase in energy charge. Therefore, regarding on matters mentioned above, it is important to seek for efficient ways for building operation at optimum stage and meet the best energy conservation level. Hence, the research is interested to investigate in detail the energy consumption, evaluation of ACMV system and building energy index (BEI) for the whole building up to four floors for the library building UTeM located on main campus. This project aims to reduce energy consumption and recommend the effective ways to thermal comfort in the non-residential buildings.

1.2 Problem Statement

Air-conditioning and mechanical ventilation systems are the main sources of energy consumption for a non-residential building (Malaysian Standard, 2014). Any saving made on the energy consumption of this system will give significant impact on the building energy cost. Critical evaluation and advanced study is required in order to provide measures in achieving optimal building energy efficiency. In order to achieve thermal comfort inside an library building in the university and to choose the best design ventilation strategies for that building, it is very important to know the actual conditions of the indoor environment concerning temperature, CO_2 and relative humidity. This project examines IEQ field measurement for the Laman Hikmah library building in UTeM.

The project is aimed to answer the following question:

- Whether current energy usage is used efficiently or is being wasted and how to evaluate energy use for the building.
- Whether the physical parameters in the building are suitable with recommended human comfort zone specifications in accordance with available standards such as ASHRAE-55 and MS1525:2014.

1.3 Research Objectives

At present, there are various energy-saving methods available. The impact of energy conservation, viability of the operation, acceptance by the end user and the payback of the investment cycle are factors to consider when choosing appropriate energy-saving methods. The effectiveness of the same method used in the different building types affected by variables such as climate, habits of residents, ACMV system, enclosure properties, geometric properties, etc., and therefore, the final decision varies greatly. Researchers need to invest time and money with the thoroughness of the properties for building and different methods. There is no quick way to policy makers and engineers to make broad judgments about the appropriate energy-saving methods. About the study before, most of the studies done abroad aimed at specific zones of a country's climate, and various applied certain energy-saving methods are usually limited to one building. These specific study objectives below:

- To characterise the physical indoor environmental conditions of selected library building.

- To evaluate and analyse energy use in the library and identify the building energy index (BEI) of the building.
- To conduct a comparison between measurement parameters with the available standard such as ASHRAE-55 and MS1525:2014.

1.4 Scope of the Study

The scope of this study is to evaluate the electrical energy consumption in a library building, using the practical experiment method to measure the Indoor Environmental Quality parameter. This project also illustrates how heat changes result in different conditions and how sensitive is the comfort of heat associated with changes in different parameters. This study involves data collection and measuring physical parameters, such as Average Air Velocity, Average Flow, Average Operating Temperature, Average Relative Humidity, Lighting, and CO2 concentration.

- Reviewing and evaluating the current energy consumption.
- Obtain the physical characteristics of the building and collect gross sectional area of the building.
- Identify important physical parameters that may influence the system performance. Determine the relationship between energy consumption with the indoor condition.

1.5 Significance of the Study

The study of the building energy demand has become a topic of great importance, because of the significant increase of interest in energy sustainability. According to the circumstances, it can be possible to determine the energy performance of a building through a calculation model starting from building known features (forward approach) or to assess the energy use from energy meters (inverse approach).

Next, the consumption of the electrical energy that is used for air conditioning of buildings can be mitigated, leading to the cost reduction of generating electrical power. Hence, the aim of this study is to analyse energy use at UTeM Library, using the inverse approach, measured data for electricity and heating consumption is used. Collected information of buildings, and electricity and heating consumption is used to create a model. Creating a model of energy use helps in future building planning; it can provide useful information about most probable energy consumption for similar buildings, or predict energy use in different conditions. In addition, these models can be used to show impacts of possible energy savings measures and help in finding optimal way of reducing energy costs. It is also very important to have correct and reliable measured data. If a part of a building is leased to other users, there is a necessity for calculating bills for each tenant. There is increased interest in data error analysis and developing methods that can point out possible meters' malfunction. Also, without correct measured data, it is impossible to monitor and benefit from applying energy saving measures for increasing energy efficiency.

Economic Benefits: When the consumption of the electrical energy decreases, the amount of money used to build the power plant, maintenance, the fuel purchase, equipment and the staff also decreases. Hence, the cost of electricity bills for customers will be lower.

Environmental Benefits: Gaseous Emissions from electric power generation sources like sulphur dioxide emissions, nitrogen oxide emissions, and carbon dioxide emissions lead to an increase in air pollution in the earth. These emissions have brought about cases of smog, acid rain, and haze. In addition, these power plant emissions are arguably the precursor to the cause of climate change.

Health Benefits: The growing consumption of electric power leads to the increment of use of fuel, air and this consequently leads to water pollution, which is associated with many health problems such as, breathing problems, heart attacks, neurological damage, and