AIR-CONDITIONING & MECHANICAL VENTILATION AND LIGHTING RETROFIT THROUGH BUILDING SIMULATION

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This report is submitted
in fulfillment of the requirement for the degree of
Bachelor of Mechanical Engineering (Thermal-Fluid)

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Jun 2016

DECLARATION

I declare that this project report entitled " Air-Conditioning & Mechanical Ventilation And Lighting Retrofit Through Building Simulation" is the result of my own work except as cited in the references

Signature : .....

Name : .....

Date : .....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Thermal Fluid).

Signature : .....

Name of Supervisor : .....

Date : .....

DEDICATION

At first, I would like to dedicate my work to my beloved father and mother whose always encourage and push for tenacity ring in my ears. I would like to dedicate this work to my siblings for their unconditional support in everything.

ABSTRACT

Air-conditioning & mechanical ventilation system (ACMV) and lighting is the main contributors to total of the building energy consumption. In Malaysia, commercial building consumes around 32.7% of total energy. This project aims to develop an ACMV and lighting retrofit model using the FKM's campus technology. IES <VE> was used to simulate and predict the retrofit outcome of the academic building. The propose and prediction of ACMV and lighting retrofit is compare with the standard requirement from MS 1525:2014 and Green Building Index (GBI). The retrofitting plan is by adjusting the set point temperature to 24℃ can reduce the energy consumption for the ACMV system. Based on the simulation result, by introducing proper retrofitting, the amount of energy saving for one month is around 30.183 MWh or 15.7%. The number of artificial lighting were reduced to minimize the energy usage. Moreover, several retrofitting plan were also introduced in order to promote energy efficient of the building. Lastly, the retrofit plan can be achieved even without compromising the indoor comfort for the occupants.

ABSTRAK

Penghawa dingin dan sistem pengudaraan mekanikal (ACMV) dan lampu adalah penyumbang utama kepada jumlah penggunaan tenaga bangunan. Di Malaysia, bangunan komersial menggunakan sekitar 32.7 % daripada jumlah penggunaan tenaga setahun. Projek ini bertujuan untuk membangunkan model retrofit ACMV dan pencahayaan menggunakan teknologi kampus FKM. IES < VE > telah digunakan untuk merangsang dan meramalkan hasil penyesuaian semula bangunan akademik. Cadangan dan ramalan ACMV dan lampu retrofit adalah dibandingkan dengan keperluan standard dari MS 1525: 2014 dan Indeks Bangunan Hijau (GBI). Dengan melaraskan suhu titik set hingga 24°C dapat mengurangkan penggunaan tenaga untuk sistem penghawa dingin dan sistem pengudaraan mekanikal. Berdasarkan hasil simulasi, dengan memperkenalkan penyesuaian yang betul , jumlah penjimatan tenaga selama sebulan adalah sekitar 30,183 MWh atau 15.7 %. Bilangan lampu telah dikurangkan untuk mengurangkan penggunaan tenaga. Selain itu, beberapa pelan pemulihan peralatan juga telah diperkenalkan untuk menggalakkan kecekapan tenaga bangunan. Akhir sekali,pelan penyesuaian semula dapat dicapai tanpa menjejaskan keselesaan dalaman untuk penghuni .

ACKNOWLEDGEMENT

I would like to acknowledge and extend my heartfelt gratitude to the following persons who have made the completion of this project in a timely manner. I would like to express my deep and sincere gratitude to my supervisor, Dr. Tee Boon Tuan for his wide knowledge and advice. I am deeply grateful for his detailed and constructive comments, and his support throughout this work. Moreover, I wish to express my warm and sincere thanks to Encik Md Isa Bin Ali and Dr Yusmady Bin Mohamed Arifin in which be my panellist to evaluate my works. Besides that, I would like to thank the authority of Universiti Teknikal Malaysia Melaka (UTeM) for providing me with a good environment and facilities to complete the project. Finally, I cannot end without thanking my family for their encouragement and love.

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LIST OF ABBREVIATIONS

ABBREVIATIONS	DESCRIPTION
ACMV	Air Conditioning and Mechanical Ventilation
BEI	Building Energy Index
ECM	Energy Conservation Measures
EE	Energy Efficiency
EQ	Environment Quality
FKM	Faculty of Mechanical Engineering
GHG	Greenhouse gases
GBI	Green Building Index
IAQ	Indoor Air Quality
IES	Integrated Environmental Solution
IN	Innovation
MR	Materials and Resources
MS	Malaysia Standard
PMV	Predicted Mean Vote
RM	Ringgit Malaysia
SM	Sustainable Site planning and management
WE	Water efficiency
VE	Virtual Environment
UTeM	Universiti Teknikal Malaysia Melaka

LIST OF SYMBOLS

SYMBOLS	DESCRIPTION
kWh	kilowatt per hour
MWh	megawatt per hour
GWh	gigawatt per hour
kWh / m^2/ year	kilowatt hours per meter square year
m	meter
mm	millimeter
W	Watt
lx	lux
℃	degree Celcius
%	Percentage

CHAPTER 1

INTRODUCTION

1.1 Background

Currently, the world is facing a series of serious problem which are cause by the dramatic change of global climate which lead to global warming, the increasing levels of greenhouse gases (GHG), and high consumption of fossil fuels. Moreover, the increasing energy costs are causing a huge deleterious effect on today's society. Hence, many researches regarding efficient energy management has been carried out in order to achieve an optimal efficient energy management for a building or facility by reducing the energy costs. The energy costs can be reducing by proper approach and analysis through energy conservation measures (ECM). ECM can help to reduce the energy consumption in a building by conducting project and technology implementation. Energy retrofits and the implementation of conservation measures can be cost-effective means in reducing energy consumption in a building (Iqbal and Al-Homoud, 2007).

Generally, energy conservation measures (ECM) is a useful approach that can be applied for energy saving in a building without compromising the indoor comfort. A good indoor comfort in a building will provide a better environment for the occupants. ECM often provides better indoor air quality (IAQ) and enhances occupant productivity (Rahman et al., 2010). However, it is essential to find a balance between indoor comfort and energy consumption.

For developing country like Malaysia, the commercial building consume around 32.7% of total energy which is 40,309 GWh for 2013 and is expected to increase in the coming years (Tenaga, 2015). As Malaysia has a tropical rainforest climate which is hot and humid throughout the year, most of the buildings are installed with air-conditioning and mechanical ventilation (ACMV). ACMV help to maintain and improve indoor comfort and air quality. Most of the time, this system consumes the most energy among all building services, which comprises 30 to 60% of total energy consumption (Kwong et al., 2013). Beside than ACMV, lighting also contributes a high portion of energy consumption in a building. For office buildings, artificial lighting consumes about 20-35% of the total building electricity consumption in Hong Kong (Lam et al., 2003).

Air conditioning is controlling the air humidity by either increasing or decreasing its moisture content. Added to the control of the humidity is the control of temperature by either heating or cooling of air, the purification of the air by washing of 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 spaces, such air may or may not be conditioned (Rosli, 2012).

Recently, architects from around the world race to build greener, more environment friendly building to ensure earth sustainability. In Malaysia, the Malaysian Institute of Architects encourage people to build green building by introduce Green Building Index (GBI). GBI is Malaysia's industry recognized green rating tool for buildings to promote sustainability in the built environment and raise awareness among developers, architects, engineers, planners, designers, contractors and public about environmental issues and everyone responsibility to the future generations (Index, 2011). GBI is developed specifically for the Malaysian tropical climate, environmental and developmental context, cultural and social needs. GBI rating tool is basically consists of 6 main criteria such as

energy efficiency (EE), indoor environment quality (EQ), sustainable site planning & management (SM), materials & resources (MR), water efficiency (WE) and innovation (IN).

This study is intended to develop ACMV and lighting retrofit model of the academic building through building simulation software. Moreover, the aim is to propose and predict ACMV and lighting retrofit based on standard requirement from MS 1525 and Green building Index (GBI) for efficiency energy management. The retrofits can be achieved even without compromising the indoor comfort.

1.2 Problem Statement

The building is formerly known as Mars building or Cubic is an eight-storey building in Technology Campus used by Faculty of Mechanical Engineering of Universiti Teknikal Malaysia Melaka as shown in Figure 1.1. This building contains lecture rooms, offices and library. It is a commercial building which used for academic purpose. Air-conditioning and mechanical ventilation (ACMV) and lighting are the source of the energy consumption. A proper energy conservation measures (ECM) in the academic building can significantly reduce the energy consumption by approximately of 30% (Hywel et al., 2015). ACMV and lighting retrofit can be done by using building simulation software.

Figure 1.1: Building of Mechanical Engineering Faculty, UTeM.

1.3 Objective

The objectives of this project are as follows:

i. To propose ACMV and lighting retrofit based on Green Building Index (GBI) indoor environment criteria for selected case study building.

ii. To develop and predict the retrofit outcomes by using available building simulation software.

1.4 Scopes of Project

The scopes of this project are:

i. The case study is only focused on the building of Mechanical Engineering Faculty, Technology Campus

ii. Simulation data will consist of ACMV and lighting retrofit plan

1.5 Research Contribution

Energy conservation measures (ECM) is the approach that can be used to reduce the energy consumption in a building without compromising the indoor comfort of the occupants. ACMV and lighting retrofit based on the Green Building Index (GBI) for the academic building will result in reducing of energy costs.

The following are the list of justifications for the research:

i. As a reference for energy conservation measures in UTeM

ii. Promote sustainability of environment and energy efficiency

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discusses about energy conservation measures (ECM) and existing air-conditioning and mechanical ventilation (ACMV) and lighting in an academic building. Moreover, ACMV and lighting retrofit plan from other researches and criteria of Green Building Index (GBI) will be provided.

2.2 Energy Conservation Measures (ECM)

Generally, ECM is an approach that can be applied for energy saving and retrofit plan in a building. ECM is a good approach because it does not require compromising the indoor comfort for occupants. ECM provides a more efficient utilization of energy resources by reducing the energy consumption. ECM can be achieved by any or all of the following approaches such as technical measures, structural measures and social and behavioral measures (Diwan and Dwivedi, 2009). Technical measures are implementing or change in the type of machinery tools which are leak plugging and machine switching. Moreover structural measures are structural adjustments to increase the efficiency of the whole system without increasing the efficiency of its sub system while social and behavior measures are the simplest and virtually required no cost as they are related to the behavioral patterns of people.

2.3 Air-Conditioning and Mechanical Ventilation (ACMV)

Nowadays, ACMV is a crucial and important for human activities as it provide a comfortable environment for occupants in a building or space. The main purpose of ACMV is to provide thermal comfort and healthy indoor air quality through ventilation with filtration and dehumidification. Basically, ACMV is a whole system that consists of mechanical and electrical system which work together to provide thermal environment control in a building. ACMV consumes the most energy which comprises 30% to 60% of total energy consumption in a building (Kwong et al., 2013). The energy consumption is high mostly due to the improper control of the ACMV system which causes energy wastage. The energy wasted can be reduced by controlling the appliances and system using a control system while maintaining a comfortable and healthy environment in a building (Saad et al., 2007).

2.4 Types of ACMV System

Generally, there are two types of ACMV system that commonly used in building or houses to serve different purposes which are (Bhatia, 2011):

i.) Centralized air conditioning systems

ii.) Decentralized air conditioning systems

Selection of ACMV types is determine by many factors such as capital, operating, location and maintenance costs to provide the most appropriate performance for users. For example, residential housing, office building, shopping mall, hospital, factory, airport have different types of ACMV system because every building have its own design and operation.