Faculty of Mechanical Engineering

ENERGY SIMULATION ANALYSIS FOR LIGHTING IN AN ACADEMIC BUILDING

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Master of Mechanical Engineering (Energy Engineering)

2017

ENERGY SIMULATION ANALYSIS FOR LIGHTING IN AN ACADEMIC BUILDING

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A thesis submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the award of Master of Mechanical Engineering (Energy Engineering)

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2017

SUPERVISOR DECLARATION

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

Signature : ……

Supervisor : Dr. Tee Boon Tuan

Date : ……

DECLARATION

"I declare that this thesis entitled "Energy Simulation for Lighting in an Academic Building" is the result of my own research except as cited in the references. The thesis has not been accepted for any master and is not concurrently submitted in candidature in any other master.

Signature : ……

Author : Ahmad Nazrin Bin Ali @ Yusof

Date : …….

DEDICATION

I dedicated this thesis to my beloved family especially to my father and my mother, to my supervisor, Dr. Tee Boon Tuan and my friends

ACKNOWLEDGEMENT

First of all, thanks to God for giving me health, strength and opportunity to successfully completed this thesis. Eventhough there are few problems that I counter during conducting this project, but with God guidance and blessing, I finished my project.

I would like to thank to my beloved family especially my father and my mother, who's always give motivation and never stop pray for my success. They are my light and the root for my strength.

I also would like to express my gratitude to my supervisor, Dr. Tee Boon Tuan, who greatly support and encourage me while conduct this project. He has generously spending his time and never stops giving guidance to me. Without him, I would never successfully complete this project.

I would like to use this opportunity to express my gratitude to all parties at UTeM for their great kindness and cooperation. Last but not least, I would like to thanks to all my friends that gives support and helping me for finishing this project.

ABSTRACT

Optimizing the energy efficiency in a building is far more cost effective measure to reduce carbon emissions compare by using renewable energy while facing growing demand of electricity. Lighting is considered as one of the highest components within academic building in Malaysia for approximately of 19% electricity consumption. Effective lighting system is one of the Energy Conservative Measure (ECM) implement by UTeM's management since initiation of UTeM Energy Policy 2015 as an alternative to reduce energy consumption. The aims of this study is to simulate lighting distribution of existing lighting system and applied effective lighting system within Kompleks Makmal Kejuruteraan Mekanikal (KMKM) building without compromising indoor comfort. Thus, IES-VE software is selected as medium to simulate the existing lighting distribution and determine the most practical and energy efficient ECM using lighting system at KMKM building. Standard light level is strictly followed based on three sources namely as Malaysia Standard, Jabatan Kerja Raya (JKR) and IES Standard Illumination Level. Retrofitting lighting system for this study involved replaced inefficient existing lighting system which consists of T8 fluorescent and metal halide high bay with LEDs lamps together with minor adjustment on existing lighting layout. IES-VE simulation results show that both pre-retrofit and post-retrofit achieved recommended value. However, post-retrofit clearly have better illumination and more energy efficient. By implementing effective lighting system, 43.144 kW can be reduced monthly. This indicated, RM 30,235.20 annually of electricity bill is reduced while 55,500.48 kg CO_2 of carbon emission can be avoided for each year.

ABSTRAK

Mengoptimum kecekapan tenaga di dalam bangunan adalah jauh lebih kos efektif untuk mengurangkan pelepasan karbon berbanding menggunakan tenaga yang boleh diperbaharui di samping memenuhi peningkatan permintaan elektrik. Lampu dianggap sebagai salah satu pengguna elektrik terbesar di dalam bangunan akademik iaitu sebanyak 19%. Sistem lampu yang efektif adalah salah satu Langkah Konservatif Tenaga yang dilaksanakan oleh pihak pengurusan UTeM semenjak Dasar Tenaga UTeM 2015 sebagai alternatif untuk mengurangkan penggunaan tenaga. Tujuan kajian ini adalah untuk mensimulasi pengedaran lampu oleh sistem lampu semasa dan mengaplikasi sistem lampu efektif pada bangunan Kompleks Makmal Kejuruteraan Mekanikal (KMKM) tanpa menjejaskan keselesaan pengguna. Oleh itu, perisian IES-VE dipilih untuk mengkaji prestasi lampu semasa dan mengenal pasti ECM yang paling sesuai untuk digunakan. Tahap cahaya standard dipatuhi berdasarkan tiga sumber iaitu Malaysia Standard, Jabatan Kerja Raya (JKR) dan IES Standard Illumination Level. Menaiktaraf sistem lampu untuk kajian ini melibatkan penggantian lampu semasa yang tidak efektif iaitu lampu T8 pendarfluor dan lampu halida logam 'high bay' dengan lampu LED bersama dengan pengubahsuaian susunan lampu. Keputusan IES-VE simulasi menunjukkan pencahayaan mencapai nilai yang disyorkan bagi sistem lampu semasa dan selepas pengubahsuaian. Namun, selepas pengubahsuaian pada sistem lampu jelas menunjukkan pencahayaan yang lebih baik dan dan penggunaan tenaga yang lebih cekap. Dengan melaksanakan sistem lampu efektif, 43.144 kW dapat dikurangkan setiap bulan. Ini bermaksud, RM 30,235.20 bil elektrik dapat dikurangkan setiap tahun manakala sebanyak 55,500.48 kg CO2 pelepasan karbon dapat dielakkan bagi setiap tahun.

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LIST OF SYMBOLS

W	=	watt
kW	=	kilowatt
kWh	=	kilowatt per hour
lx	=	lux
h	=	hour
p	=	density
c_p	=	specific heat
K	=	kelvin
μ	=	viscosity
v	=	voltage
^oC	=	celcius
cm	=	centimeter
m	=	meter
%	=	percentege

LIST OF ABBREVIATIONS

UTeM	Universiti Teknikal Malaysia Melaka
KMKM	Kompleks Makmal Kejuruteraan Mekanikal
ECM	Energy Conservative Measure
IES-VE	Integrated Environmental Solution –Virtual Environment
IEA	International Energy Agency
EC	Energy Commission
JKR	Jabatan Kerja Raya
MS	Malaysia Standard
TNB	Tenaga Nasional Berhad
GBI	Green Building Index
RM	Ringgit Malaysia

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CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

Excesses and inefficient energy consumption is a significant economic and political issues around the world. The concern arises from the depletion of fossil fuels, global warming and the geopolitical issues related to the source locations for fossil fuels which mainly included coal, oil and natural gas. Fossil fuel consumption contributes to global warming when electricity producing coal-fired power plants emit carbon dioxide and sulfur oxide (Shafiee, 2008). Buildings are the largest energy consuming sector in the world and account for over one-third of total final energy consumption and equally important source of carbon dioxide emissions. Building energy consume 35% of global energy followed by transport and industry which is 30%. Then, other sectors including agriculture, forestry and non-specified consume 4% of the world energy. (IEA, 2010).

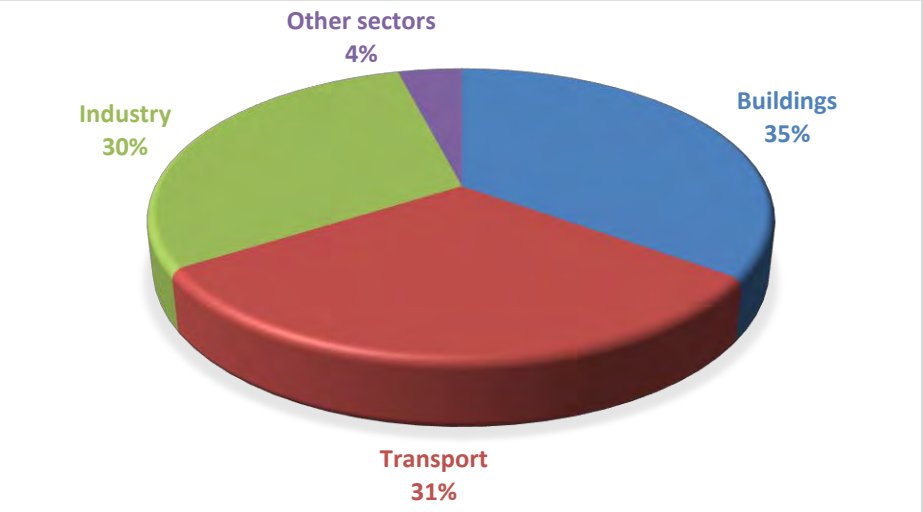


Figure 1.1: Final Energy Consumption by Sector and Building Energy Mix (IEA, 2010)

Facing the growing demand in electricity and in order to minimize the exploitation of polluting fossil fuels, several countries were inclined to renewable energy including biofuel, wind power, photovoltaic energy, hydro, geothermal, tidal and wave energy (Walid, 2015). However, optimizing the energy efficiency in any type of building is far more cost effective measure to reduce carbon emissions than by using renewable energy. Unfortunately, there is no magic silver bullet when it comes to energy efficiency in building. In other word, there does not exist one single item which can reduce residential, government, commercial and academic building energy consumption by 50% or more (BSEEP.2013).

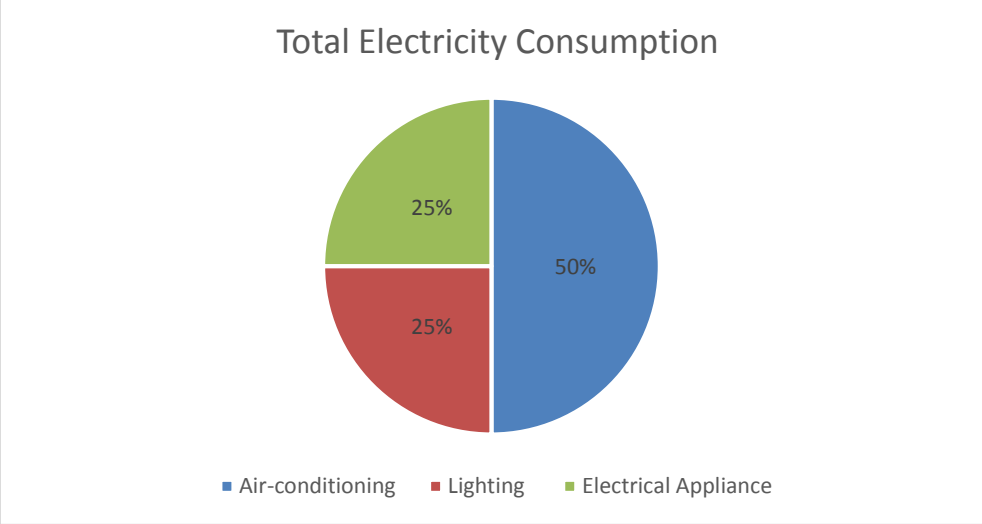


Figure 1.2: The Typical Energy Breakdown in Malaysia Office Building (BSEEP, 2013)

Malaysia is one of the country that develop and looking for energy efficiency technology due to several factors such as cost increment in building new power plants, continuing shortfall between electricity demand and supply and competing need for investment capital. Among all the electric consumers, lighting has one of the highest shares in academic building at Malaysia. Lighting account for approximately 19% of the electricity consumption. Utilization of energy efficient lighting technologies could save considerable amount of energy and reduce environmental effect (Fu, 2012). In addition, increasing of

tariff from 33.54 sen/kWh to 38.53 sen/kWh at January 2014 hit Malaysia population hard financially. Thus, energy efficiency technology and technique become vital for people nowadays

UTeM is the 14th public university in Malaysia and was established on 1 December 2000 with with sett 766 acres of lush verdant landscape. UTeM provides various sophisticated facilities such as lecture hall, hi-tech laboratories, sport complex and library. Some of these facilities such as library has wide range of operation hours which 24 hours for weekdays and 12 hour on weekend. Plus, well establish and great achievement achieved by UTeM attract a lots of people including students and staff or workers. These event leads to increase demand of electrical energy in the academic institutions that resulting in high cost of electrical bills. Therefore, efficient usage of energy is one approach that is being studied and implemented to reduce the electric energy demand in order to reduce electrical cost.

Since the initiation of UTeM Energy Policy 2015, university building have been encouraged to reduce energy consumption through the Energy Conservative Measure (ECM) and energy efficiency programs. For a university building, regardless of the enthusiasm to pursue energy-efficient building status, it must not compromise the function of the organization which is teaching and learning. They must never lost their organization purpose and strive for utilization of energy efficient technology while taking student and staff comfort and welfare into account.

M&V is the process of using measurement to reliably determine actual savings for energy, demand, cost and greenhouse gases within a site by an ECM. ECM is a useful approach for energy saving and retrofit plan in the building without compromising the indoor comfort. Therefore, the purpose of this study was to increase energy efficient or reduce energy consumption and maintain indoor comfort by proposing recommendation through technology improvement to lighting system at academic building. The case study is conducted at UTeM's facility which is Kompleks Sukan Kejuruteraan Mekanikal (KMKM) located on Ayer Keroh, Malacca.

Figure 1.3: Kompleks Makmal Kejuruteraan Mekanikal (KMKM)

1.2 PROBLEM STATEMENT

Since the establishment of UTeM, the electricity bills increase from time to time due to few factors including increasing number of student, staff and activities, increment of tariff, and inefficient use of electricity. Total electrical bill of Main Campus cost around RM 9,347,458.35 for one year which is from September 2014 to August 2015 with an average of RM 778,954.86 per month shown in **APPENDIX A** and average of RM 21,792.86 per month for Kompleks Makmal Kejuruteraan Mekanikal (KMKM) building with total of RM 261,514.35 for one year from July 2015 to June 2016 shown in **APPENDIX B**. This value is very high and cause burden to the UTeM management to cover organization's expense. Thus, UTeM Energy Policy has endorsed since June 2015 as the alternative to ensure that the energy consumption at the university campuses is reduced through Energy Conservative Measure (ECM) and energy efficient program. Effective lighting system is one of the ECM that implement by UTeM's management. Proper ECM introduce through energy simulation in order to promote energy efficient of lighting system at KMKM building. Furthermore, the speed and reliability of today's computers and the availability of suitable energy simulation software with optimization techniques has given the opportunity to take the advantages of building design for energy conservation decision making purposes. Thus, IES-VE software is selected as medium to research existing lighting system and determine the most practical and energy efficient ECM using lighting system at KMKM building.

1.3 OBJECTIVE

Using lighting technologies to increase energy efficiency is one field which can be research and deployed within academic buildings in the Malaysia. This dissertation intends to place a roadmap toward achieving reduced energy consumptions by deploying lighting technologies to improve lighting system in UTeM. This study used Kompleks Makmal Kejuruteraan Mekanikal (KMKM) building as a case study building to be modeled and simulated using IES software. Modeling is a faster and more efficient tool than experimental plug-and-try methods for improving and optimizing the energy management for any type of building. The purpose of this study is to research lighting distribution within the building and reduce energy consumptions of the building without compromise the performance and indoor comfort of the building. This study can be realized by fulfilling the following:

- To model and simulate the lighting distribution of an academic building.
- To identify and determine the potential of energy saving using effective lighting system
- To analyze energy consumption based on the lighting retrofit outcomes.

1.4 SCOPE

The scope of this study is focusing on the lighting system at UTeM's building and listed as below:

1. The study will be conducted at KMKM building
2. Current lighting system is determine.
3. Propose a lighting retrofit plan as saving energy approach.
4. Using IES software to model and simulate lighting performance.
5. Analyze lighting energy consumption based on retrofit plan.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, the research resources and literature review in the related field collected from previous study, reports, journals reports and historical data will be discussed thoroughly. It is an important method in order to get more understanding and knowledge in this field while completing this study.

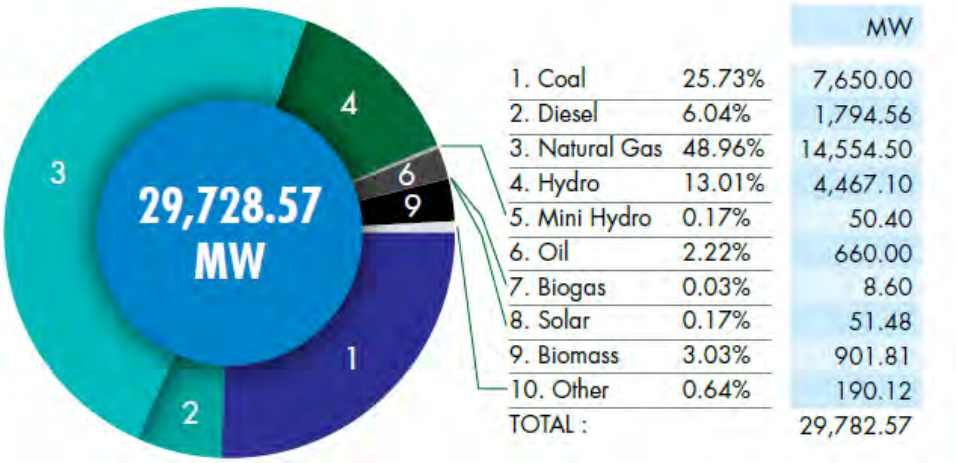
2.2 MALAYSIA ENERGY SOURCES

2.2.1 ELECTRICITY ENERGY IN MALAYISA

Electricity is an indispensable factor for Malaysia to constantly growing in industrialization, urbanization and population. The electricity sector in Malaysia is divided by two main sub-sectors namely thermal power plant and hydro-electric plants. Plus, there are three utility companies that supply electricity namely Tenaga National Berhad (TNB) in peninsular Malaysia, Sabah Electricity Supply Berhad (SESB) and Sarawak Electricity Supply Corporation (SESCO) (Sukri, 2009).

Generally, electricity generation in Malaysia is mostly depend on fossil which are coal, oil and gas. However, burning fossil fuels create environmental emissions such as carbon dioxide, nitrogen and sulphur oxide. In addition, the world oil crisis in the 1970s powerfully illustrated that concerns over resources scarcity were justified. These condition leads to the necessity for the diversification of energy fuels resources. Thus, this era triggered the development of energy-related legislation and policies to address energy requirements in worldwide including Malaysia.

Thus, to ensure the security of energy supply in Malaysia, the Four-fuel Diversification Strategy was introduced in 1981 as extension of the 1979 National Energy Policy. Next, the Five-fuel Diversification strategy was introduced in 1990 and will continue until 2020. The rationale of these policy are to reduce Malaysia's over dependency on oil in energy consumption and reduce environmental issues. Plus, these policy proposed renewable energy such as hydro, biogas and biomass as alternative energy sources. These policy in electricity sector intend to gradual change in fuel use from 74% gas, 9.7% coal, 10.4% hydro and 5% petroleum in year 2000 to 40% gas, 30% hydro, 29% coal and only 1% petroleum by year 2020. **Figure 1** below show electric generation capacity at year 2013 in Malaysia.



		MW
1. Coal	25.73%	7,650.00
2. Diesel	6.04%	1,794.56
3. Natural Gas	48.96%	14,554.50
4. Hydro	13.01%	4,467.10
5. Mini Hydro	0.17%	50.40
6. Oil	2.22%	660.00
7. Biogas	0.03%	8.60
8. Solar	0.17%	51.48
9. Biomass	3.03%	901.81
10. Other	0.64%	190.12
TOTAL :		29,782.57

Figure 2.1: 2013 Electric Generation Capacity at Malaysia (EC, 2015)