ENERGY EFFICIENCY ANALYSIS FOR THE LABORATORY COMPLEX

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A report is submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering (with Honours).

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018

DECLARATION

I declare that this project report entitled “Energy Efficiency Analysis for the Laboratory Complex” is the result of my own research except as cited in the references. This project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	....
Author	:	LEE JIA YI
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 Bachelor of Mechanical Engineering (With Honours).

Signature : ....

Supervisor : DR. TEE BOON TUAN

Date : ....

DEDICATION

To my beloved father and mother.

ABSTRACT

Building energy audit is widely used in the world energy policies to determine the respective energy usage and minimize the wastage of energy as buildings have hold the greatest potential in implementation of energy audit. It is important to understand the utilities' real operating conditions in the building and understand the building behavior before the energy audit is being undergone. In this thesis, energy audit has been implemented in UTeM Mechanical Engineering Laboratory Complex and some energy efficiency programs have been proposed. The two laboratories that have been focused in this project are Machine Workshop and Welding Workshop to compare the energy usage of heavily power consumed machine and the energy usage of air conditioning system. The steps of energy audit have included reviewing the historical data of the laboratory, visit to the laboratory, listing all the available equipment, estimation of power consumption, data collection using Chauvin Arnoux C.A 8435 energy meter and digital clamp meter as well as undergoing data analysis by comparing the estimated data and measured data. Besides from the energy consumption, the carbon footprint and energy usage intensity also have been taken into account in this thesis. At the last phase, energy conservation measures proposal and implementation of retrofit analysis have been performed based on the data obtained. From the measured data, it is found that Machine Workshop which consumes 4997.06kW per month has a higher monthly power consumption than the Welding Workshop which consumes 1454.42kW per month due to existence of heavy power machines and split unit of air conditioning system as well as most of the exact power consumption for equipment are at least 30% lower than their respective power rating. Therefore, it is important to undergo real measurement in energy audit besides from the estimation on calculations.

ABSTRAK

Audit tenaga telah luas digunakan dalam polisi tenaga sedunia untuk mendapatkan informasi tentang kegunaan tenaga dan mengurangkan pembaziran tenaga sedangkan potensi untuk melaksanakan audit tenaga dalam sektor bangunan adalah lebih tinggi berbanding dengan sektor lain. Pemahaman tentang keadaan operasi utiliti dalam bangunan yang benar dan struktur bangunan adalah sangat penting sebelum melaksanakan audit tenaga, Dalam tesis ini, audit tenaga telah dilaksanakan dalam Makmal Kejuruteraan Mekanikal Universiti Teknikal Malaysia Melaka dan beberapa program yang dapat meningkatkan kecekapan tenaga telah dicadangkan. Projek ini telah menfokuskan dua makmal dalam Makmal UTeM, iaitu Makmal Mesin dan Makmal Kimpalan demi mendapat perbandingan tenaga bagi kegunaan mesin yang bertenaga tinggi dan kegunaan sistem penyaman udara. Beberapa langkah telah dilaksanakan dalam audit tenaga seperti mengaji data makmal yang lama, melawat ke makmal, menyenaraikan mesin atau utiliti yang ada dalam makmal tersebut, menganggarkan kegunaan tenaga, mengumpul data menggunakan meter tenaga Chauvin Arnoux C.A 8435 dan Meter Amprobe serta menjalankan analisi data berdasarkan data yang dikutip dan anggaran. Selain daripada kegunaan tenaga, jejak karbon dan intensiti tenaga juga diambil kira dalam tesis ini. Dalam fasa yang terakhir, langkah-langkah untuk menjimatkan tenaga telah dicadangkan dan analisi retrofit telah dijalankan berdasarkan data yang dikumpul. Data kajian telah menunjukkan kegunaan tenaga bulanan Makmal Mesin adalah lebih tinggi daripada kegunaan tenaga bulanan Makmal Kimpalan sedangkan kegunaan tenaga bulanan bagi Makmal Mesin dan Makmal Kimpalan ialah 4997.06kW dan 1454.42kW disebabkan oleh mesin yang bertenaga tinggi dan sistem penyaman udara dalam makmal tersebut. Selain daripada itu, data kajian juga menunjukkan kegunaan tenaga kebanyakan utiliti atau mesin yang benar adalah 30% rendah daripada kadar tenaga. Secara ringkasnya, kajian ini telah menunjukkan kepentingan pengumpulan data yang benar dalam audit tenaga selain daripada menjalankan kiraan berdasarkan anggaran.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my greatest gratitude to my supervisor, Dr. Tee Boon Tuan from Faculty of Mechanical Engineering Universiti Teknikal Malaysia Melaka (UTeM) for his guidance and assistance towards completion of this project report. His supervision, enthusiastic helps and guidance in this report greatly enhance me to do every task successfully.

Secondly, I would like to express my gratitude to Encik Mohd Faisal bin Adam, chargeman from UTeM development department, Encik Zainal bin Hj.Mahdi, assistant engineer from UTeM development department, Encik Rashdan bin Seman, assistant engineer manager from Mechanical Engineering Laboratory Complex, Encik Asjufri bin Muhajir, assistant engineer from Air Conditioning Workshop, Encik Habirafidi bin Ramly, assistant engineer from Welding Workshop and Encik Mohd Hairi bin Md Rahim, assistant engineer from Machine Workshop for their assistance and efforts in the data collection and data measurement.

Special thanks to my parents, peers and siblings for their moral support in completing this project. Lastly, thank you to everyone who had been to the crucial parts of realization of this project.

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ABBREVIATION	DESCRIPTION
ACMV	Air Conditioning and Mechanical Ventilation
AHU	Air Handling Unit
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
AUD	Australia Dollar
C1	medium voltage category
CAD	Computer-Aided Design
CAE	Computer-Aided Engineering
CAM	Computer-Aided Manufacturing
CFL	Compact Fluorescent Lamp
CNC	Computer Numerical Control
CO_2	Carbon Dioxide
CRT	Cathode Ray tube
ECM	Energy Conservation Measures
EFFECTS	Efficient Energy & Thermal Management Systems Research Group
ENCON	Energy Conservation Opportunities
HVAC	Heating, ventilation and air conditioning
HP	Horsepower

IE2	High Efficiency
IE3	Premium Efficiency
IGA	Energy diagnosis and investment grade audit
ISO	International Organization of Standardization
KeTTHA	Ministry Of Energy, Green Technology and Water
LCD	Liquid Crystal Display
LED	Light-emitting diode
MEPS	Minimum Energy Performance Standards
MIG	Metal Inert Gas
PF	Power Factor
RM	Ringgit Malaysia
ROI	Return of investment
RPM	Rotation per minute
SESB	Sabah Electricity Supply Berhad
SESCO	Sarawak Electricity Supply Corporation
TNB	Tenaga Nasional Berhad
UTeM	Universiti Teknikal Malaysia Melaka
VSD	Variable Speed Drive
WTA	Walk-Through Audit

LIST OF SYMBOLS

SYMBOLS	DESCRIPTION
%	Percentage
^0C	Degrees Celsius
V	Volt
A	Ampere
h	Hour
kg CO_2/kWh	kilogram of carbon dioxide per kilo-Watt-hour
kW	kilo-Watt
kWh	kilo-Watt-hour
kW/day	kilo-Watt per day
kW/month	kilo-Watt per month
kWh/year	kilo-Watt-hour per year
kVA	kilo-Volt-Ampere
kVAR	kilo-Volt-Ampere Reactive
m/s	meter per second
s	second

CHAPTER 1

INTRODUCTION

1.1 Background

Energy efficiency is getting to be core in the world's energy policies since the attainability of all the energy policy's imperatives – reducing energy bills, decarbonisation, air pollution, energy security, and energy access are closely related to strong energy efficiency policy. Therefore, energy audit which is used to check the energy usage and minimize the wastage of energy is getting popular. (IEA, 2011) The process of energy audit has been divided into few steps which are analysis of the building and its utility data including study of the installed equipment and analysis of energy bills, survey on the utilities' real operating conditions, understand the building behaviour, evaluate the energy conservation measures and estimate the energy saving potential. (Stefano et al., 2013) Normally the energy performance indicator of school building will be operational profile, physical characteristics and total energy consumption which have included energy efficiency to compare energy levels between supply and demand, energy used for lighting (W/m^2), energy used for air conditioning($TR/100\ m^2$), annual energy consumption and total energy per unit area ($kWh/m^2/year$).

In these cases, buildings have hold the greatest potential in effective energy savings since 35% of the global energy has been consumed in buildings. The HVAC system and lighting system may contribute to the major energy usage in a building as about 56 % of the electrical energy is used in HVAC system of the building and 25% of electrical energy is used in the lighting system. (Karam et al., 2016) Most of the academic building in Asia country would have an older cooling system like split units which are controlled using thermostat by the staff daily. (Sofia et al., 2016) HVAC system which is a distribution system, equipment or terminal to provide air-conditioning to a building has included ventilation and space cooling. All the air conditioning system should be installed according to the Thermal Environmental Conditions for Human Occupancy, ASHRAE Standard. The comfort cooling has a recommended design dry bulb temperature in the range of 23℃ to 26℃, 0.15m/s to 0.50m/s of recommended air movement and 55% - 77% of recommended design relative humidity, while the lowest service illuminance for working interiors in a building is set to be 200 Lux. (STANDARD MALAYSIA, 2007) The common lights that used in a building are T5 and T8 fluorescent lights followings the Standard for Lighting Design of Buildings.(He Hua et.al, 2009) The power of lighting that used usually ranges from 50W to 80W. (Sofia et al., 2016)

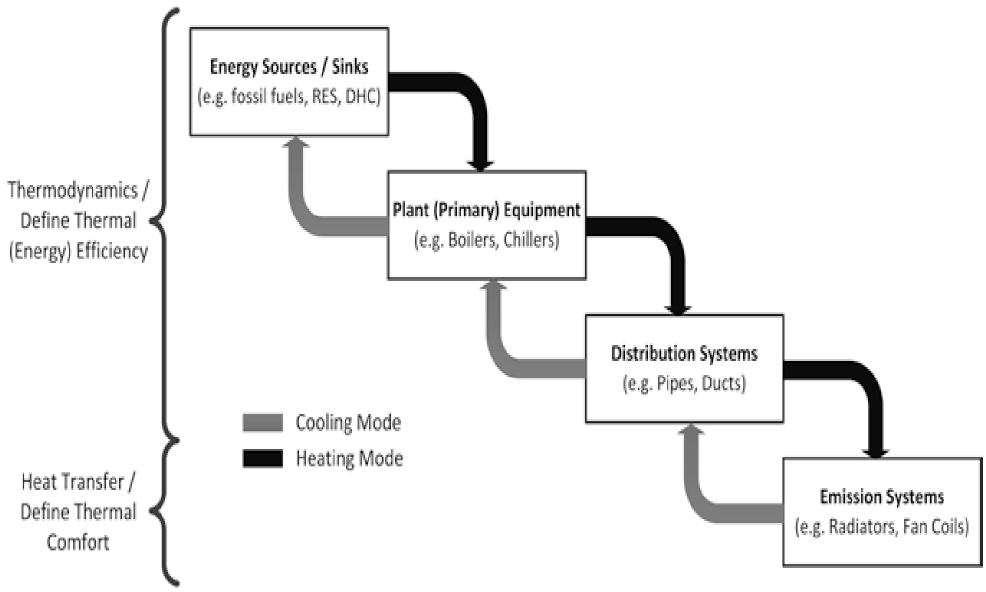

Figure 1.1: Rough Sketch of HVAC system (Sofia et al., 2016)

Besides that, energy audit is important to determine the energy usage during peak hours and non-peak hours in order to figure out the methods to reduce energy usage in an efficient way since Peninsular Malaysia the only one electric utility, Tenaga Nasional Berhad (TNB) has charged for the electricity usage according to peak period and non-peak period besides from the categories such as commercial category, industry category, mining category and specific agriculture. The peak period is from 8am to 10pm and the non-peak period is from 10pm to 8am.

In this case, UTeM Mechanical Engineering Laboratory Complex which is operating during weekdays has been selected to undergo energy audit. UTeM is a Malaysia public university which is established on 1 December 2000 with 7 faculties and variety of facilities such as sport complex, health centre, library, cafeteria and laboratories. It consists of UTeM Centre for Advanced Research on Energy to undergo research on energy and policy within the context of economic and environmental sustainability which supports the Energy Policy 1979. One of the research group, Efficient Energy & Thermal Management Systems (EFFECTS) Research Group is targeted to promote and conduct research in the areas of efficient energy and thermal management systems which pursue high energy efficiency and low carbon footprint in all the UTeM buildings.

UTeM Mechanical Engineering Laboratory Complex consists of six blocks which are Block A, Block B, Block C, Block D, Block E and Block F with total area of 8243.48m^2. It consists of air conditioning laboratory, vibro-acoustics laboratory, CAD/CAM/CAE Studios, Combustion Laboratory, Conditional Based Maintenance laboratory, Engine Performance Testing Laboratory, Fluid Mechanics Laboratory, Prototype & Innovation Laboratory, Instrumentation Laboratory, Materials Science Laboratory, Mechanics of Machine Laboratory, Racing Vehicle Development workshop, Structural Health Monitoring