UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Mechanical Engineering

ENERGY ANALYSIS FOR LIGHTING SYSTEM IN ACADEMIC BUILDING – CASE STUDY IN IKM BINTULU

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Master of Mechanical Engineering

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ENERGY ANALYSIS FOR LIGHTING SYSTEM IN ACADEMIC BUILDING – CASE STUDY IN IKM BINTULU

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**A Master Project Report submitted
in fulfillment of the requirements for the degree of Master of Mechanical Engineering
(Energy Engineering)**

Faculty of Mechanical Engineering

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DECLARATION

I declare that this thesis entitled "Energy Analysis for Lighting System in Academic Building – Case Study in IKM Bintulu" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

Name : Aisyah Gwynnie Chembat Akin

Date : ....

APPROVAL

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

Signature : ....

Supervisor Name : Dr. Tee Boon Tuan

Date : ....

DEDICATION

First of all I would like thanks to my beloved husband who always understand me and to my mother in law who always help me to guide my children and also to my mother and father who always support and give advice to me.

ABSTRACT

The main purpose of this project is to conduct an energy audit in academic buildings which are directly focused on the lighting system. To analyze and identify the energy consumption and efficiency of the academic building in IKM Bintulu is the main study throughout this project. 15% to 25% of the energy consumed at campus is from the usage of lighting and any energy efficiency measures in this area will provide very good opportunities especially in the economic branch. One of the two main reasons of more energy consumed from the common thought that it is more economical to leave fluorescent lighting on than to turn on and off as required. The second is that in the past lighting systems which uses older less efficient lamps and fittings, and due to the low costs of energy, over-lighting was common practice. Data collection will include lighting intensity measurement and energy calculation comparison. The outcome of the analysis will provide the input for energy efficient measures proposal.

ABSTRAK

Tujuan projek ini adalah untuk menjalankan audit tenaga di bangunan akademik secara langsung memberi tumpuan kepada sistem pencahayaan. Kajian ini adalah terutamanya untuk menganalisis dan mengenal pasti penggunaan dan kecekapan tenaga di bangunan akademik di IKM Bintulu. Dengan perakaunan lampu selama 15 hingga 25% daripada tenaga yang digunakan di kampus mana-mana langkah-langkah kecekapan tenaga dalam bidang ini akan menyediakan peluang yang sangat baik untuk penjimatan. Terdapat dua sebab utama mengapa lebih banyak tenaga digunakan oleh lampu di kampus daripada yang diperlukan. Pertama berpunca daripada persepsi umum bahawa ia lebih menjimatkan untuk meninggalkan lampu daripada untuk menghidupkan dan mematikan seperti yang diperlukan. Kedua adalah bahawa dalam sistem lampu yang lama telah direka untuk menggunakan lampu yang kurang cekap dan kelengkapan yang kurang memuaskan, dan disebabkan oleh kos tenaga yang rendah, penggunaan lampu yang lebih telah menjadi amalan biasa. Pengumpulan data adalah termasuk pengukuran keamatan lampu dan pengiraan penggunaan tenaga akan dibuat perbandingan. Hasil daripada analisis ini akan memberi input dan langkah-langkah yang berkesan untuk penjimatan tenaga.

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Thank to Allah and I would like to thanks to MARA to give me financial supporting to complete my study. Also thanks to my Director Tuan Hj. Azman bin Ali on his supporting and advice and not forget to my Supervisor Dr. Tee Boon Tuan who always advise and remembering me during the project and advance. I also thank to my friend who always advise and spent a time together to complete the final year project.

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LIST OF ABBREVIATIONS

BEF	-	Ballast Efficiency Factor
BEI	-	Building Energy Index
BF	-	Ballast Factor
CFL	-	Compact Fluorescent Lamp
CIPEC	-	Canadian Industry Program of Energy Conservation
EMS	-	Energy Management Services
HID	-	High Intensity Discharge
IESNA	-	Illuminating Engineering Society of North America
IKM	-	Institut Kemahiran MARA Bintulu
LED	-	Light Emitting Diode
LPW	-	Lumens Per Watt
MS	-	Malaysia Standard
SAD	-	Seasonal Affective Disorder
SI	-	International System Unit
UV	-	Ultraviolet

CHAPTER 1

INTRODUCTION

1.1 Background

The most energy consumed comes from electric lighting. Major energy saving can be gained by using more energy efficient equipment, effective controls and a well-made design. Less heat gain will be obtained by using less electric lighting, thus air-conditioning energy can also be saved in addition improving thermal comfort. An electric lighting design gives a great impact on visual performance and comfort by maintaining adequate ad appropriate illumination and at the same time control reflection and glare. Lighting retrofits are known as a process of replacing inefficient light systems with more advanced and high efficiency systems are. The success of a retrofit program depends on different parameters. such as policies and regulations, occupant's expectation, building specification, and human factors, which has the highest effect among other parameters (Ma et al., 2012) 15% to 25% of the energy consumed at campus is from the usage of lighting and any energy efficiency measures in this area will provide very good opportunities especially in the economic branch. One of the two main reasons of more energy consumed from the common thought that it is more economical to leave fluorescent lighting on than to turn on and off as required. The second is that in the past lighting systems which uses older less efficient lamps and fittings, and due to the low costs of energy, over-lighting was common practice.

1.2 Problem Statement

As what we know, most of the light used in the institution is the fluorescent lamp. But, whether the use of fluorescent lamp saves energy and costs? Therefore, this study will find the solutions on how to reduce energy usage and cost. The installation of fluorescent lamp can be installed according to the suitability of the place and the area of the building by making calculation. Besides that, a tool as Lux meter can be used to determine the brightness of each building. By comparison between LED and existing conventional fluorescent lighting will also be discussed to ensure the efficiency of electricity use can save electrical energy and costs.

1.3 Objectives

The purpose of this project is to conduct the energy audit in an academic building which directly focuses on the lighting system. The study is mainly to analyze and identify the energy consumption and efficiency of the academic building in IKM Bintulu. In particular, the objectives are to:

(a) To provide a tool that is needed to effectively monitor energy use within the academic building.

(b) To calculate the electricity usage in order to provide lighting in the building.

(c) To determine the feasibility of saving energy and money by using energy efficient lighting fixtures.

1.4 Scope of work

The scope of this study is focusing on the auditing approach of the lighting energy in IKM Bintulu academic building. All the important project scopes are listed as below:

(a) The study will be conducted in IKM Bintulu building.

(b) Understand and observe the current condition in the building.

(c) Conducting lighting monitoring by using digital lux meter.

(d) Propose a lighting retrofit plan with saving energy approach.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews on the lighting system that is usually installed in the building of the previous researcher including a project example from the researcher. Lighting or illumination is using lights to achieve a practical effect consisting of artificial and natural illumination. Besides that, some information on several parts of the project such as the lighting illumination and lighting component are also mentioned. The important data are collected from several sources such as websites, journals, books, magazines, handout etcetera.

2.2 Definitions of Energy Audit

Energy audits are a potent in uncovering operation and equipment improvement that will contribute in saving energy thus reducing cost and lead to better performance. Energy audits can be completed as a stand-alone effort but also can be piloted as a part of a bigger analysis across a group of facilities, or an entire portfolio (Michael et al., 2011).

Simple energy audit provides building owners with known low-cost or even no-cost recommendations and a general view on future planning. More complicated energy audits require a comprehensive energy efficiency capital investment plan in line with the owner of the building financial aims.

Growing energy costs have become an important concern and are expected to continue to upsurge in the predictable future. Businesses, institutions and consumers will be searching for more efficient products and resolutions. Business applications for more efficient products are available and even superior opportunities exist in the largely untapped residential market. Lighting is recognized as a main area for economic energy savings. Attaining lighting energy savings is deliberated as one of the essential energy efficiency measures with several opportunities and supporting benefits. Energy savings are generally calculated in kilowatt-hours, (kWh) and converted to Emission Reduction Credits or allowances, based on the method by which the energy was generated.

Energy audits are known to be the first step in reducing energy and improving the performance of one's building. Availability of power is a major factor of a developing country thus energy conservation is one of the great solutions to energy conservation. Energy audit is one of the effective parts which investigates the possible ways of energy conservation in a system (Shradha and Varsha, 2013).

Energy audit is defined as the verification, observing and analysis of energy including submission of technical report containing all the commendations of improving energy efficiency with the cost analysis and an action plan to reduce consumption (Mukesh et al., 2014).

(Sachin and Parthe, 2015) defined an energy audit as an organized procedure that obtains adequate knowledge of existing energy consumption profile of the site and includes a process examination, survey and analysis of energy flows for energy conservation in a building, process or system to decrease the amount of energy input into the system without affecting the output and also helps to recognize the factors that have an effect on the energy or power consumption.

Energy audits can be defined by manual CIPEC in 2002, namely energy audit systematic, well documented verification process of objectively evaluating energy audit evidence to be consistent with the criteria and followed by relationship of the results to the client. Energy audits commonly take the whole building approach by examining the building system, operation and maintenance procedures and schedules. Energy audits can be focused to specific systems such as the lighting, ventilation, heating or air-conditioning. In general, energy audits is a version of conservation ideas into realities by offering technically possible solutions with economics and other organizational deliberations with a specified time frame (Umesh, 2014).

The evaluation process was conducted to determine whether the building's exhaust and to determine the EMS to energy and communication standard, continued by the impact of the results to the client. Energy consumption can be reduced by conducting energy audits. Energy Audit is an important key-role in energy management services which applies analytical methods to assess the profile of energy use to develop energy efficiency measures in buildings EMS.

The energy audit is to identify several energy-saving methods that can be carried out in the company to reduce expenses by decreasing power losses and increase energy efficiency. To accomplish optimal energy usage in buildings, it is wise to lessen the waste of energy and mend energy efficiency, such as lighting and air conditioning. Furthermore, the audit will develop measures to achieve the EMS in building energy and cost -saving benefits. There are three levels of audits performed to achieve the objective of collecting data and making improvements to the academic buildings.

a) Level 1: Walk through energy audit

b) Level 2: Energy data analysis

c) Level 3: Standard energy audit

2.2.1 Level 1: Walk through energy audit

The majority of existing data used for the analysis of energy consumption and to facilitate factory performance is the walk through energy audit. This type of audit does not require a lot of measurements and data gathering and commonly known as the pre- audit.

This audit is carried out by taking the time and generally provides equal opportunities for energy efficiency. A correct observation will start in the first floor of the academic building and a second level based on a visual confirmation of members in the lighting system, the behavior of the occupants using the lighting system and the type of light bulbs that can be used to customize the audit dealt with in detail in the future.

2.2.2 Level 2: Energy data analysis

At this stage, it is mainly concerned on the evaluation and records obtained pursuant to the walk through audit. Economic analysis is usually restricted to simple calculations on energy consumption in each level based on the type of light bulbs used and the composition of the light. To identify energy performance and efficiency of lighting in selected areas of the audit, the information gathered was used.

2.2.3 Level 3: Standard energy audit

Based on the pre- audit results, energy audit types can be categorized in the use of energy research to provide a comprehensive analysis of installations surveyed, the breakdown of energy consumption and the first quantitative assessment of the energy used to enhance existing installations. Thus, it can provide retrofit to optimize energy savings and eases data analysis thus increase energy.

After necessary data collected for a specific building, an energy and cost analysis is highly proposed. Baseline energy use, data collected through the onsite valuation and financial impacts of energy efficiency measure setting up are taken into account during the analysis. Before beginning the analysis, the energy auditor should have a good understanding of the economic methodology and business criteria to ensure that the analysis is fairly compared with other investment opportunities and that cash flows match prospects. Energy analysis methodologies differ widely. Your project goals should inform the analysis methodology selected to avoid results that profit too much or too little detail. Distinctive analysis methodologies include spreadsheet analysis based on engineering formulas that account for variations in time of day and season, and whole-building hourly energy use analysis for larger buildings or buildings with complex mechanical systems.

The cost analysis considers current energy costs, measure operation costs and potential savings over time help to determine reasonableness recommendations. The financial method should be provided that the energy auditor will use to determine the order of implementation. Samples of financial methods include simple payback period, life cycle cost, in-house rate of return and discounted payback. Precise installation cost data is critical for the financial analysis. Undervaluing costs could result in inadequate budgeting for energy efficiency improvements, while overrating costs may cause facility decision makers to delay or deny an improvement project. The energy auditor should gather measure installation costs from a sample of vendors, and costs should include any specific considerations for your particular facility. Additionally, utility incentives and tax credits for any recommended measures should be taken into deliberation in any level of financial analysis.

The energy auditor's main deliverable for the energy audit is the finishing report. Any audit report should provide enough information to allow you to make informed decisions about next steps to meet your energy savings and financial goals. Audit reports include an inventory of current equipment, a summary of your building's current conditions and energy use, and a list of recommended no-cost, low-cost, and longer-term recommendations based on analysis of historical energy use and the onsite valuation.

2.3 Lighting

Energy is defined as the ability to do work and is transferred from one another and can be in different forms such as heat, mechanical, electrical, chemical, nuclear and not to forget light or radiant. Light is that portion of the electromagnetic spectrum that is observed by our eyes with a wavelength range between 380 and 780 nm (Wen-Tsai Sung and Jia-Syun Lin, 2013). Light is that which makes things visible. Light is defined as electromagnetic radiation or energy transferred through space or a material medium in the form of electromagnetic waves (definition in physics). Illuminating engineering defined light as visually assessed radiant energy – light is that part of the electromagnetic spectrum visible by the human eye. The visible percentage of the radiant energy that reaches the eye is absorbed by superior receptors (rods and cones) in the retina, which covers the inner wall of the eye. In the retina, the rods and cones change the radiant energy into electrical signals. The nerves transmit the electrical impulses to the brain where the light sensation is created. Good lighting is compulsory in improving the excellence of work; reduce human's fatigue, accidents. In industry is improves both quality and quantity of products (Shrada and Varsha, 2013). Lighting can distress the health of people in building. This goes beyond the safety aspects of providing enough brightness to see by; lighting affects mood and human circadian rhythms. The circadian system is systematized neurologically to drive bodily functions up and down every day and is a universal physiological regulatory mechanism. The timing of such circadian rhythms as body temperature is independent of an explicit knowledge of external clock time and, indeed, in the absence of periodic environmental cues, the internal clock produces a "subjective" day length that differs reliably from 24 hours. Humans living under investigational isolation conditions may cycle at lengths greater than 24 hours. This kind of aberration would pose the risk of continual lack of synchrony with the external world were it not for the ability of light to force a daily alteration in the internal clock