DEVELOPMENT OF ENERGY AUDIT SOFTWARE FOR LIGHTING SYSTEMS

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2ND JULY 2012

"I hereby declare that I have read through this report entitle "Development of Energy Audit Software for Lighting Systems" and found that it has comply the partial fulfilment for awarding the degree of *Bachelor of Electrical Engineering (Industrial Power)*".

Signature : …….....

Supervisor's Name : .....

Date : .....

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This report is submitted in partial fulfillment of requirements for the degree of Bachelor of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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I declare that this report entitle “Development of Energy Audit Software for Lighting Systems” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any degree.

Signature :……

Name : Ahmad Farid Bin Sapar

Date : 2nd July 2012

To my beloved mother and father

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Assalammualaikum Warahmatullahi Wabarakatuh ;

First of all, praise be to Allah S.W.T because of his willingness. Alhamdulillah I had successfully finished my Final Year Project entitled “Development of Energy Audit Software for Lighting Systems”. I was very fortunate to have a number of wonderful experience people who had a given me assistance and direction toward completing this project.

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ABSTRACT

Electricity energy is very important in human life, but much of the energy content of the available energy source is wasted by inefficiencies in the energy conservation and distribution processes. Building's energy-use accounted for the largest share of the final energy use by the commercial and residential sector. Air conditioners are shown to be the major energy users (57%) in office buildings, followed by lighting (19%), lifts and pumps (18%) and other equipment (6%). So, the energy audit is a useful method to preliminary estimate the saving potential of each building. Thus, this project conducts office building audits. Federal Tower of Melaka is used as the case study building and this project focuses on lighting systems. Initially, the pattern of existing lighting systems used in the Federal Tower of Melaka been analyzed in term of total power, energy consumption, electricity bill payment per month and illuminance level on each area. Next, five methods are proposed in this project by using new technology, namely, by installing sensor (motion sensor and infrared sensor), by replacing existing T8 fluorescent lamp with T5 Retrofit sensor, combination T5 Retrofit Saver and sensor, by replacing existing lighting systems with LED T8 and lastly combination with LED T8 and sensor. Analyses in term of its effect on energy consumption and electricity bill payment have been carried out. The total cost, annual profit and payback period for each method were also studied. This project also develops simple user-friendly calculator software called "GREEN calculux". The software can be used to calculate power consumption, energy consumption, electricity bill payment per day, per month and per year. It also includes the recommended lighting systems which contain five methods to reduce energy consumption based on calculation of simple payback period. Then, this software can check the illuminance level standard on each area based on guidelines on energy efficiency in buildings through the MS 1525:2007- Code of practice on energy efficiency and use of renewable energy for non-residential buildings by Department of Standards Malaysia[1]. Lastly, this software also can calculate the number of fitting required need to be installed in given specific area.

ABSTRAK

Elektrik adalah tenaga yang sangat penting dalam kehidupan manusia harian, tetapi banyak daripada kandungan tenaga sumber tenaga yang ada dibazirkan oleh ketidakcekapan pemuliharaan tenaga dan proses pengedaran. Penggunaan tenaga di bangunan menyumbang bahagian terbesar ke atas penggunaan tenaga oleh sektor komersil dan kediaman. Penghawa dingin adalah pengguna tenaga utama (57%), diikuti dengan lampu (19%), lif dan pam (18%) dan peralatan lain (6%). Jadi, audit tenaga adalah kaedah yang berguna untuk anggaran awal menyelamatkan potensi dalam setiap bangunan. Oleh itu, projek ini mengendalikan bangunan pejabat di mana Menara Persekutuan Melaka sebagai sumber rujukan dan tertumpu kepada sistem pencahayaan. Pada mulanya, corak bagi sistem pencahayaan yang sedia ada di Menara Persekutuan Melaka buat masa ini telah analisa dalam jangka jumlah kuasa, penggunaan tenaga, pembayaran bil elektrik setiap bulan dan setiap tahun dan tahap pencahayaan bagi setiap bidang. Seterusnya, 5 kaedah telah dicadangkan dalam projek ini dengan menggunakan teknologi baru, dengan memasang sensor yang mengandungi sensor gerakan dan inframerah, dengan menggantikan system lampu yang sedia ada dengan T5 Retrofit sensor, kombinasi T5 Retrofit Saver dan sensor, dengan menggantikan LED T8 dan akhir sekali gabungan dengan LED T8 dan sensor. Analisis dari segi kesan ke atas penggunaan tenaga dan pembayaran bil elektrik telah dilakukan. Jumlah kos, keuntungan tahunan dan tempoh bayaran balik bagi setiap kaedah ini juga telah dikaji. Seterusnya, projek ini juga membangunkan perisian kalkulator mudah mesra pengguna yang dipanggil "HIJAU calculux". Ia berfungsi untuk mengira penggunaan tenaga, penggunaan tenaga, pembayaran bil elektrik sehari, sebulan dan setahun. Ia juga termasuk sistem lampu yang disyorkan yang mengandungi 5 kaedah untuk mengurangkan penggunaan tenaga berdasarkan pengiraan tempoh bayar balik yang mudah. Kemudian, ia juga boleh menyemak tahap piawaian lux pada setiap kawasan berdasarkan garis panduan mengenai kecekapan tenaga di dalam bangunan melalui 1525:2007 MS - Kod amalan mengenai kecekapan tenaga dan penggunaan tenaga boleh diperbaharui bagi bangunan bukan kediaman oleh Jabatan Standard Malaysia [1]. Akhir sekali, projek ini juga boleh mengira bilangan keperluan pemasangan yang diperlukan akan dipasang di kawasan tertentu.

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RM	-	Ringgit Malaysia
GUI	-	Graphic User Interface
W	-	Watt
kW	-	Kilowatt
kWh	-	Kilowatt Hours
TNB	-	Tenaga Nasional Berhad
IL	-	Illuminance bare
cd	-	Candela
lm	-	Lumen
CRI	-	Color Rendering Index
I	-	Luminous Intensity
E	-	Illuminance
L	-	Luminance
K	-	Room Index
UF	-	Utilisation Factor
MF	-	Maintenance Factor
ILER	-	Installed Load Efficacy
n	-	Number of lamp each fitting
L	-	Length
W	-	Width
H_m	-	Ceiling to floor height – Ceiling to table height

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CHAPTER 1

INTRODUCTION

This chapter will discuss the project background, problem statement, project objectives, project scopes, and thesis outlines.

1.1 Project Background

Recently, the issue of energy conservation is widely reported in journal and thesis. There is a growing concern over energy consumption and its adverse impact on the environment. There are many types of energy such as heat energy, kinetic energy, potential energy, mechanical energy and electrical energy. Electrical energy is one of the energy that has significant role in the world nowadays. Inefficient use of energy today will give a bad impact to the next generation. Global warming is one example effect of the inefficient use of energy. Nowadays global warming phenomenon is a serious issue, this phenomenon happen because of increasing of carbon dioxides (CO_2) in our ozone surface. The increasing of CO_2 is an effect of fossil fuels burning to fulfill energy demand. Increasing of energy demand will make our earth more suffer. Next, in the short term, the most significant impact that we can see is the increase in electrical energy consumption in kilowatt hour (kWh) and electricity bill payment in Ringgit Malaysia (RM). To overcome this situation, it should be consumed efficiently. For this reason, the energy audit is a useful method to preliminary estimate the savings potential of energy and money.

The objectives of energy audit are to estimate the energy uses and losses and improve the energy efficiency. Accurate and complete of knowing the pattern of the building are essential factors to determine the energy audit's success. The energy audit is a very interesting and complex work. The building energy audit is a process to evaluate where the energy used in the building structure and to identify the opportunities of reduce

energy consumptions. Therefore, the first step is to estimate how much energy consumed in the building and to find out the saving potential. The major task in this project is to conduct a basic energy audit, which include lighting audit in Federal Tower of Melaka. This project was proposed and agreed by facility manager of Federal Tower of Melaka and Appendix A shows the permission letter to do the auditing at the building.

Observations in Federal Tower of Melaka had been done to find out what is the major problem with the existing lighting system. Here are the results; first problem is the brightness of the office workplace exceed the standard illumination. This is because some of the workplaces mostly have windows and sunlight directly through the workplace. Secondly, the Federal Tower have 21 levels of offices workplaces, thus three levels will be measured as references. Level 1 until level 5 have the same square per meter, so, level 4 will be used as reference. At Level 6 until Level 12, Level 11 will be used as reference, seems the square per meter remains the same. In Level 13 until Level 21, Level 20 will be used as reference. Thirdly, the light was switched on even there is no occupant in the office workplace. The energy wastages have contributed to the yearly increasing of electricity consumption in Federal Tower of Melaka. Therefore, this project aims to study and analyze the existing lighting system in Federal Tower of Melaka, and finally to propose 5 method to reduce electricity energy consumption.

1.2 Project Statement

Electricity energy is very important in daily human life, but much of the energy content of the available energy source is wasted by inefficiencies the energy conservation and distribution processes. In 2008, the commercial and residential sector accounted for 13.8% of the total final use in Malaysia. In terms of electricity, the sectors consumed 53.6% of electricity supplied during the period, of which 60% consumed by the commercial sector and the balance 40% by the residential sector [2]. Building's energy-use accounted for the largest share of the final energy use by the commercial and residential sector. A measured of a building's energy performance is estimated for Malaysia and compared with a number of selected countries. Air conditioners are shown to be the major energy users (57%) in office buildings, followed by lighting (19%), lifts and pumps (18%) and other equipment (6%). It is estimated that 77,569 MegaWatt hour

(MWh) of energy can be saved and huge reduction of emission achieved through the application of advance glazing, compact fluorescent lamps (CFL), insulation, housekeeping, and by raising thermostat set point temperature of air conditioners [3].

Energy audits are considered as one of the comprehensive methods in checking the energy usage and wastage in buildings. The term energy audit is commonly used to describe a wide variety of energy-related functions. Definitions range from a very simple and inexpensive process to one of high complexity, involving a detailed data analysis of simulated energy use, along with microeconomic numbers.

Thus, this software was developed will help facility manager to do the audit process. However, it will perform the audit to the lighting system only which is the largest element in daily electricity usage.

1.3 Project Objective

There are three (3) main objectives that need to be accomplished in order to make this project successful which are:

- To evaluate the electricity energy consumption pattern at Federal Tower Melaka.
- To develop user friendly Energy Auditing Software that;
    - Can do the auditing on the lighting system at Federal Tower Melaka Based on Malaysian Standard.
    - Can calculate the cost of energy consumption, energy savings in kWh, total cost savings in RM for each day of the lighting system based on the estimated time of use tariff and electricity.
    - Can select effective lighting equipment in the electrical energy consumption based on the brightness of the need for a space.
- To propose five strategies to reduce in term of kWh and electricity bill payment in RM per month and per year for Federal Tower of Melaka.

1.4 Project Scopes

These projects involve the lighting audit and propose the five strategies to improve energy efficiency at Federal Tower of Melaka. The building has 21 levels in total. Three separate levels with different square per meter are taken as references which are level 4, level 11 and level 20.

The development of energy audit software is built using Visual Basic and it based on the energy efficiency guidelines MS 1525:2007[1]. The data collection that based on worksheet parameter is need before the lighting audit is analyzed. It includes the characteristic of activity in the room, the dimension of the room, light level reading in lux, number of lamp per luminaries, lamp fixture and the lamp wattage. The cost of electricity of a lighting system can be calculated from the data collection. This cost calculation is based on the estimated duration of use of such equipment and charges set by the energy provider. This software also can perform calculations with the most effective brightness of a space based on several factors.

At the end of this software, facility manager will see the process of audit report results that includes of required amount of brightness, lighting equipment used, the cost of energy consumption, energy savings in kWh, total cost savings in RM for each day.

1.5 Thesis Outline

Chapter 1 briefly summarizes the project background and problem statements as well as elaborates the objectives, scope of the project and thesis outlines.

Chapter 2, describes the for literature review. The contents include about the global warming, Malaysia energy consumption, impact of energy consumption on the environment, lighting energy building, definition of energy audits, the types of energy audit and also energy audit tools from past review.

Chapter 3 is the research methodology of the project. It discussed in detailed the project development to complete the project. All steps from the beginning until the end of this project done.

The Chapter 4 present the preliminary audit. The preliminary audit described the pattern of existing lighting systems in Federal Tower of Melaka in term of usage of energy consumption (kWh), electricity bill payment monthly and yearly and standardize of average luminance lux level standard.

Chapter 5 describes the purpose of five strategies to reduce the existing lighting systems in Federal tower of Melaka. This chapter will conclude that the most profitable method to reduce in terms of reduction of energy consumption and bill payment. The payback period on each method will be discussed on this chapter.

Lastly, Chapter 6 presents the conclusion and recommendation of the whole project.

CHAPTER 2

LITERATURE REVIEW

This chapter discuss about the brainstorming related with the project. The sources are from past journals and book related with energy auditing for lighting systems.

2.1 Global Warming

Global warming gives a very bad effect to our life. It happens because of carbon dioxide (CO_2) emission due the use of fossil fuels as primary energy in meeting the increasing the electricity load. By burning of fossil fuel, it will emit several harmful gas and the major one is CO_2. According to World Meteorological Organization (WMO), the global average surface temperature has risen by 0.74°C since the beginning of the 20th century, and the temperature has risen by 0.18°C over the last 25 years [4]. That means, our earth become warmer year by year.

Therefore, it is our responsibility to take action to save our environment. User need to use energy efficiently and optimize energy consumption. Thus, we need to reduce our waste because it is the energy we saved, that will be the largest energy source. Whenever energy is saved, not only save money, it is also reduce the demand for fossil fuels such as coal, oil, and natural gas. Less burning of fossil fuels also means lower emissions of CO2, the primary contributor to global warming, and other pollutants. The average American produces about 40,000 pounds of CO_2 emissions per year [4]. Together, we use nearly a million dollars worth of energy every minute, night and day, every day of the year.

2.2 Energy Consumption

Energy consumption has been increasing quite sharply in Malaysia. The growth of energy consumption was around 5-6% per annum from year 2005 until 2008. The energy use in the industrial sector was driven increasing, which grew at 7% per year. The commercial and residential sector accounted for 13.8% of the total final energy use in Malaysia in 2008. The sector's final energy use was ranked at third position after the industry and transport sectors. In term of electricity, the sector consumed 53.6% of electricity supplied during the period, of which 60% was consumed by the commercial sector and balance 40% by the residential sector [2].Thus, building energy use accounted a lot of numbers of the final energy use by the commercial and residential sector. A measured of a building's energy performance is estimated for Malaysia and compared with a number of selected countries. Air conditioners are shown to be a major energy user (57%) in office buildings, followed by lighting (19%), lifts and pumps (18%) and other equipment (6%) [3]. Figure 2.1 illustrate the lighting energy consumption flow in Malaysia.

In Malaysia, commercial buildings were designed and constructed and regulated by the Uniform Building By-Law (UBBL). The By-law does not cover the buildings energy-use performance. However, the government is promoting commercial buildings to adopt energy efficiency through voluntary approach by providing a standard called MS1525:2007- Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-Residential Building [1].

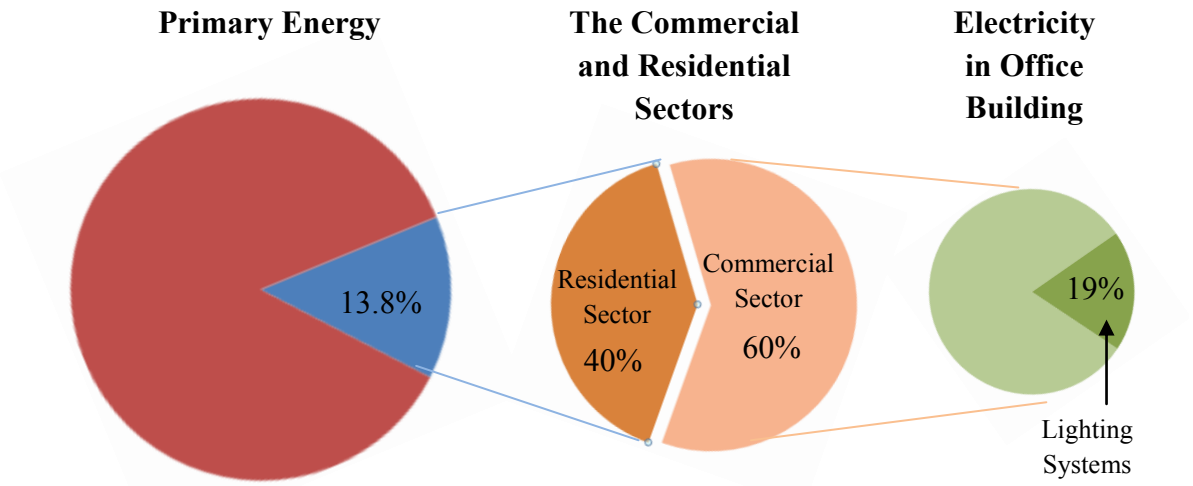

Figure 2.1: Lighting energy consumption flow

2.3 Impact of Lighting Energy Consumption on the Environment

The environment impacts of lighting are caused by the energy consumption of lighting, the material used to produce lighting equipment, and the disposal of used equipment. Emissions during the production of electricity and also as a result of the burning of fuel in vehicle lighting and in fuel-based lighting are responsible for most of the lighting-related greenhouse gas emissions. Hazardous based lighting are responsible for most of the lighting-related greenhouse gas emission. Hazardous materials such as lead, mercury are used in the lamps and ballasts, if not disposed properly, can cause harmful impacts on the environment. Lighting also affects the environment due to wastefully escaped light into the night sky (light pollution) [5].

The environment impacts of electric lighting depend on the electricity generation method. Thermal power generation system has the highest impact on the environment due to combustion fuel, gas emission, solid waste production, water consumption, and thermal pollution. Electricity generated from renewable energy source has the lowest effect on the environment. Lighting is one of the biggest causes of energy-related greenhouse gas emissions. The total lighting-related CO2 emission were estimated to be 1900 million tons (Mt) in 2005, which was about 7% of the total global CO2 emission from the consumption and flaring of fossil fuels. Energy efficient lighting reduces the lighting energy consumption and is not only inefficient and expensive, but also results in the release of 244 million tons of CO2 to the atmosphere every year, which is 58% of the CO2 emission from residential electric lighting globally. Replacing fuel based lighting with energy efficient lighting such as Light Emitting Diode (LED) will provide means to reduce greenhouse gas emission associated with lighting energy consumption.

2.4 Lighting Energy in Building

As mention before, lighting systems normally account for approximately 19% of electrical energy consumed in commercial building in Malaysia. Thus, lighting systems not only consume power directly to generate light, in air-conditioned building, but they also

indirectly account some of the power consumed by air conditioning systems, as the heat added by lighting has to be removed by building cooling systems. However, lighting is essential for buildings to ensure the comfort, productivity and safely of the building's occupants. Therefore, lighting systems need to be carefully designed to achieve the desired illumination level while using the minimum amount of energy.

This project focuses on offices building. Offices are designed to house working people engaged in thought and in a number of forms of communication (written, visual, telephone, computer, and face to face). Office lighting should enable workers to perform these tasks effectively. Since feeling of well-being, interest, and enthusiasm by the environment, consideration should be given to the design of office interiors in an effort to achieve a stimulating work place. Office lighting affects the appearance of the space and its occupants, and therefore their mood and productivity. Naturally, lighting should provide good visibility for the tasks. Although it is important to consider the luminous environment and the lighting visual tasks separately, these aspects must work together. The same lighting system may contribute to both, but typically, separate luminaries should provide or augment the visual task illumination.

By, energy audit from lighting system can be achieved by means such as optimizing lighting levels, improving the efficiency of lighting systems, using control, and day lighting (using natural light). This chapter provides a brief description of some basic concept of lighting followed by typical energy auditing measures for lighting systems.

2.5 Energy Audit

Energy audit is a crucial activity in every energy management strategy. It is the key to a systematic approach for decision-making in the area of energy management. The energy audit attempts to balance the energy inputs with its use and identify the energy streams in facility. It helps in quantifying the energy usage. Specific technical skills are needed so that the energy audit can be carried out efficiently.