

ELECTRICAL ENERGY AUDIT AND POTENTIAL ENERGY SAVING
MEASURES FOR COMMERCIAL BUILDING

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ABSTRACT

Electrical energy audit is an examination of the energy consumption of the equipment or system to ensure that energy is being used efficiently. It acts as a systematic assessment of the baseline energy consumption efficiency within a facility, followed by identification of energy efficiency improvement opportunities and cost-saving measures that can be implemented to ensure the efficient energy consumption in any building. The electrical energy audit has gained attention across all energy sectors such as residential, commercial, and industrial since energy consumption gives immediate impact on costs considerable and impact on environmental sustainability. Due to problem related to energy management and energy efficiency such as regulation imposed, cost and environmental factor, the electrical energy audit currently has been found as one of the methods that can ensure the sustainability of energy in the future since energy audit activities are able to determine suitable steps and precaution to be undertaken to use energy efficiently. This study measured the energy consumption on commercial building which is an office of building. The main purpose of this study is to evaluate the electrical energy consumption focused on commercial building that will contribute to the framework of potential energy saving measure for future implementation. Therefore, three objectives were focused on which are to evaluate the existing energy management practice of a commercial building, identify historical and present energy usage pattern of the building and proposed Energy Conservation Measures (ECMs) by evaluating the cost analysis for each ECMs proposed. Walk through or preliminary energy audit is performed to obtain data related. The data included the building details and end-use load cycles. Linear regression and statistical analyses were used to analyse all the data obtained from the preliminary audit and on-site measurement. Besides, significant variables were used to determine the actual energy consumption implementation cost and savings. By referring to Measurement and Verification Method (Option D – Calibrated Simulation), the General Algebraic Modelling System (GAMS) software is used to analyse the optimum energy consumed by the loads considered. Then, the framework of potential energy saving measure was proposed for future energy consumption used that covered on no/low-cost measures, medium cost measures and high-cost measures. The proposed energy saving measure show significant reduction in energy consumption and operating cost also show reduction that led to savings. The low-cost measure show reduction between 10% to 11% of energy saving. The medium-cost implementation shows the best performance in terms of payback period which is less than 1 year depending on ESM proposed. High-cost measure shows the best performance in energy consumption reduction around 90% of total usage. This proposed framework could enable energy consumption been monitor and propose saving measure can be implemented to achieve efficient energy use.

ABSTRAK

Audit tenaga ialah pemeriksaan penggunaan tenaga pemasangan atau sistem untuk memastikan tenaga digunakan secara cekap. Aktiviti ini merupakan satu penilaian yang sistematik sebagai garis panduan kecekapan penggunaan tenaga dalam fasiliti, diikuti dengan pengenalpastian peluang peningkatan kecekapan tenaga dan langkah penjimatan kos yang boleh dilaksanakan untuk memastikan penggunaan tenaga yang cekap di mana-mana bangunan. Audit tenaga elektrik merupakan alternatif yang diambil oleh pengguna domestik, komersial dan industri kerana aktiviti ini dapat memberi impak kepada pengurangan kos selain mempunyai impak positif kepada kelestarian alam sekitar. Berdasarkan kepada masalah berkaitan pengurusan tenaga dan kecekapan tenaga seperti peraturan yang dikenakan, kos, dan faktor persekitaran, audit tenaga elektrik dikenalpasti sebagai salah satu kaedah yang boleh memastikan kelestarian tenaga pada masa hadapan memandangkan aktiviti audit tenaga dapat menentukan langkah yang sesuai dalam menentukan penggunaan tenaga secara cekap. Kajian ini adalah bertujuan untuk mengukur penggunaan tenaga di bangunan komersial yang merupakan sebuah Bangunan pejabat. Tujuan utama kajian ini adalah untuk menilai penggunaan tenaga elektrik yang tertumpu kepada bangunan komersial yang akan menyumbang kepada rangka kerja langkah penjimatan tenaga yang berpotensi untuk dilaksanakan dalam masa terdekat. Terdapat tiga objektif yang ingin difokuskan pada kajian ini iaitu untuk mengenalpasti amalan penggunaan elektrik semasa di bangunan tersebut, untuk membuat analisis penggunaan elektrik sebelum dan semasa di bangunan tersebut, dan untuk mencadangkan langkah penjimatan elektrik yang boleh dilaksanakan di bangunan tersebut. Audit awal dilakukan untuk mendapatkan maklumat untuk di analisis. Data yang diperlukan adalah termasuk butiran bangunan dan beban gunaan akhir. Regresi linear dan analisis statistik digunakan untuk menganalisis semua data yang diperolehi daripada audit awal dan ukuran yang diambil di tapak. Selain itu, pembolehubah penting digunakan untuk menentukan kos pelaksanaan penggunaan tenaga sebenar dan penjimatan. Analisis data juga melibatkan penggunaan simulasi "*General Algebraic Modelling System (GAMS)*" untuk mendapatkan jumlah penggunaan tenaga yang optimum berdasarkan kepada masa operasi setiap peralatan di bangunan. Seterusnya, rangka kerja kadar penjimatan tenaga berpotensi telah dicadangkan untuk penggunaan tenaga pada masa hadapan yang melibatkan kadar kos rendah, kadar kos sederhana dan kadar kos tinggi. Cadangan kadar penjimatan tenaga menunjukkan pengurangan yang ketara dalam penggunaan tenaga, dan kos operasi juga menunjukkan pengurangan yang membawa kepada penjimatan. Langkah kos rendah menunjukkan pengurangan sebanyak 10-11% daripada jumlah penggunaan tenaga. Pelaksanaan kos sederhana menunjukkan prestasi terbaik dari segi tempoh bayaran balik iaitu kurang daripada 1 tahun bergantung kepada langkah penjimatan yang dicadangkan. Ukuran kos tinggi menunjukkan prestasi terbaik dalam pengurangan penggunaan tenaga, sekitar 90% daripada jumlah penggunaan. Rangka kerja yang dicadangkan ini membolehkan penggunaan tenaga dipantau dan langkah penjimatan yang dicadangkan dapat dilaksanakan untuk mencapai penggunaan tenaga yang cekap.

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LIST OF ABBREVIATIONS

GAMS	-	General Algebraic Modeling System
ESM	-	Energy Saving Measures
UTM	-	Universiti Teknologi Malaysia
ACSU	-	Air Conditioning Split Unit
WCPU	-	Water Cooled Packaged Unit
CWP	-	Condenser Water Pump
HVAC	-	Heating, Ventilation, and Air Conditioning
NFA	-	Net Floor Area
BEI	-	Building Energy Index
kW	-	kilowatt
kWh	-	kilowatt hour

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CHAPTER 1

INTRODUCTION

1.1 Research Background

This report presents the results of the preliminary energy audit performed at a commercial building. A government office building located in Kota Bharu has been chosen for an electrical energy audit. Electrical energy is very important and necessary for daily life usage to accomplish tasks. However, energy consumption from electrical energy usage will result in daily costs needed to be paid. Nowadays, most organizations depend on optimum energy consumption to increase savings through reducing energy consumption. An electrical energy audit is one of the ways to determine where energy consumption took place and identify where it may have losses. It can help to determine where the energy conservation measures (ECMs) can be implemented.

1.2 Problem Statement

Energy is essential for all human activity. Currently, the demand in energy continues to grow, to support the increasing human population. The immediate impact on costs is not only the main factor but also because of considerable impact on environmental sustainability. The conventional sources, fossil fuel is the biggest contribution in energy supply has limited lifespan of supply, and currently depleted day by day. The issue of energy management has gained attention across all industry sectors and has been considered in the global agenda to improve energy performance and greenhouse gas reduction in organizations.

Malaysia also shows interest in energy management issue. This country consumes increasingly more energy due to economy grows quickly. There are three leading energy sectors in Malaysia which is industry, transportation, and buildings that include both residential and commercial. Malaysia commercial and residential buildings contribute about a third to its entire energy consumption. In commercial building, the common issue related to energy management and energy efficiency is caused by several factors.

One of the factors identified is the imposed regulation by government itself. The Malaysian government has developed the National Energy Efficiency Action Plan (NEEAP) which focuses several key initiatives to save electricity and reduce electricity demand growth. The imposed regulation has urged the energy user to taken different initiative to cater energy usage. Other factors are due to the cost that need to be paid from the electricity usage. In commercial building, the problem such as power factor surcharge occurs due to poor or inefficient use of electricity. Power Factor is an index used to measure the efficient use of electricity with range of 0 - 1. The low power surcharge indicate that the power supplied is not fully utilized.

An energy audit is the only professional way to determine where the energy wastage and how much it is being lost. The main objective or goal of energy audit is to reduce the energy consumption without compromising comfort and quality of the building. From there, it can guide the management staff about how many resources are being needlessly wasted or how efficient the building. The process of energy audit is conducted with the aim to determine how and when energy is consumed in any organization. Hence, by recognizing the possibilities to cut down the energy usage will lead to increase the energy efficiency. At the same time, to ensure that there is sustainability of energy in the future, energy audit activities are necessary to determine suitable steps to be undertaken to use energy efficiently.

1.3 Objectives of Study

The objectives of the study are:

- (a) To evaluate the existing energy management practice
- (b) To determine energy usage pattern of the commercial building using simulation tool.
- (c) To propose Energy Conservation Measures (ECMs) for the commercial building by evaluating the cost analysis

1.4 Scopes of Study

This study covers energy audit in commercial building which is a government office building with net floor area of 5466.23 m². The 3 blocks building with 4 level each was assessed on their energy usage. The scope cover includes the evaluation of existing energy management practice. A preliminary energy audit was performed that include analyzing the monthly electricity, analyzing the baseline energy usage, and performed technical review. The main load of this building is considered that include lighting system, HVAC system, plug loads equipment such as computers and others. This electrical energy audit is expected to provide organization on energy saving measures (ECMs) that highly possible for implementation and was recommended together with financial analysis for each saving measures proposed. The electrical energy audit reporting was prepared that covers data on historical and present energy usage pattern, estimation of energy savings obtained before and after implementation of ECM and cost analysis on suggested ECMs.

1.5 Significance of Study

The significance of this study are as follows:

- a) The result obtained from data analysis of energy audit of the office building enables the building owner to identify where the energy wastage occurs in the building. The recommended energy saving measures can be reference for them to implemented it in stages and later provided energy saving. At the same time, it can increase energy efficiency since the power is fully utilize based on what been paid.
- b) The load optimization using simulation tool can acts as reference on proper load scheduling. The constraint declare will help building owner to manage their energy consumption and avoiding the energy loss by identifying daily maximum energy usage may be contributed to earn savings.

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