ENERGY CONSUMPTION PREDICTION AND SIMULATOR

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ABSTRACT

Energy audit is a method to analyse energy usage in a building, or area. This method is very effective but also very time and cost consuming. To help this issue, energy simulator is used to simulate the electrical energy consumption. Somehow, these simulators cannot correlate energy driving factor with energy consumption for commercial or industrial sites. It cannot predict electrical energy consumption based on occupant behaviour or various driving factors. For an institutional site that have many driving factors, such as students' activities, lecturers' activities, and others, it is hard to perform detail energy audit due to time and cost consuming. To help energy manager, new simulator that can predict electrical energy based on behaviours and driving factors is needed. Hence, this study is carried out to develop an excel template to predict electrical energy consumption for institutional site. Walkthrough energy audit is performed as an input data for the template. Data such as power rating, usage time and others is collected. Estimated electrical energy consumption obtained from simulator is compared with data from electric meter. Correction made to correlate predicted electrical energy consumption with real time electrical energy consumption. Result obtained will be one-year prediction of electrical energy consumption. Based on result, some energy saving measure will be proposed and its corresponding reduction in energy consumption and utility bill will be calculated.

ABSTRAK

Audit tenaga adalah salah satu cara untuk menganalisa penggunaan tenaga di dalam sesuatu bangunan atau kawasan. Cara ini adalah sangat berkesan tetapi memakan waktu yang lama dan sangat mahal. Untuk mengatasi isu-isu ini, simulator tenaga digunakan untuk mengsimulasi penggunaan tenaga elektrik. Walaubagaimanapun, simulator-simulator ini gagal mengambil kira korelasi antara faktor-faktor pemacu tenaga elektrik dengan penggunaan tenaga elektrik untuk sektor komersial ataupun sektor industri. Bagi sesebuah institusi pendidikan yang mempunyai banyak faktor pemacu tenaga elektrik, seperti aktiviti pelajar, aktiviti pensyarah, dan sebagainya, adalah amat susah untuk menjalankan audit tenaga yang terperinci disebabkan harga yang mahal dan waktu yang panjang. Untuk membantu pengurus tenaga, simulator baru yang boleh meramalkan penggunaan tenaga elektrik berdasarkan kepada faktor pemacu tenaga elektrik dan sifat penggunanya adalah amat diperlukan. Oleh sebab itu, kajian ini dijalankan untuk menbangunkan templat 'excel' untuk meramalkan penggunaan tenaga elektrik bagi sesebuah institusi pendidikan. Audit tenaga sepintas lalu dijalankan akan menjadi maklumat awal untuk templat itu. Maklumat seperti penarafan kuasa alatan elektrik, waktu penggunaan dan sebagainya akan dikumpul. Ramalan penggunaan tenaga elektrik daripada simulator akan dibandingkan dengan maklumat daripada meter elektrik. Pembetulan akan dibuat untuk mengkorelasikan ramalan penggunaan tenaga elektrik dengan penggunaan tenaga elektrik yang sebenar. Keputusan yang diterima adalah ramalan penggunaan tenaga elektrik bagi satu tahun. Berdasarkan keputusan ini, tindakan penjimatan tenaga elektrik akan dicadangkan dan pengurangan penggunaan tenaga elektrik dan bil elektrik akan dikira.

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LIST OF ABBREVIATIONS

ASHREA		American Society of Heating, Refrigerating and Air Conditioning Engineers
CSM		Continuous Monitoring System
CUSUM		Cumulative Sum Deviation Method
IEA	-	International Energy Agency
FiT	-	Fit-in Tariff
NPI	-	Normalized Performance Indicators
SCEE	-	School of Chemical and Energy Engineering
UTM	-	Universiti Teknologi Malaysia

CHAPTER 1

INTRODUCTION

1.1 Research Background

Energy is important to life and all living organism. There are many types of energy such as electrical energy, kinetic energy, potential energy, nuclear energy and so on. Electrical energy which its resources come from fossil fuels (coal, natural gas and petroleum), nuclear and renewable sources (solar, hydro, wind, biomass, tidal, geothermal and others) is utilise to ease human activities. According to International Energy Agency (IEA, 2018), 66.7% of world electricity generation is from fossil fuels, 22.7% from renewable sources and 10.6% is from nuclear fission, as per 2016 world electricity generation. High percentage dependencies of fossil fuels to generate electricity concerns many countries due to fact it releases pollutants that harms the environment such as global warming. A lot of effort had been taken to shift the world electricity generation from fossil fuels to renewables sources, such as including various policy and incentives to help renewables energy industry to bloom. In Malaysia, incentives such as Fit-in tariff is introduced to help renewable energy industry especially electricity derived from solar.

Despite a lot policy and incentives, renewable energy industry still failed to compete with fossil fuels sources. This is due to technological constraint, higher capital and operating cost, and others. However, sometimes energy is not use in efficient way. Utilising energy usage can help in reducing electricity demand. Energy audit is often used to audit if energy has been used in an efficient way. (Aldona and Pawel, 2016) stated that well defined energy efficiency improvement strategy can reduce energy consumption by 70%.

1.2 Problem Statement

Electrical energy consumption worldwide increased with Industrial Revolution 4.0. As for in 2017, more than 20,000 TWh have been consumed worldwide. Energy consumption increased at a rate of 2.6% per year. Most of the electrical energy consumption occurred in Asia, contributing almost 45% of world electrical energy consumption with China, India and Japan is the biggest consumer of electrical energy. This trend is expected to increase in future as world population increases. In Malaysia alone, 133 billion kWh had been consumed in 2018. Even though the increment is small based on year 2017 for Malaysia, Malaysia has been actively looking for an option to increase electricity production over the year.

Various policy had been introduced in Malaysia such as Five-Fuel Diversification Strategy 1999, Small Renewable Energy Program, National Green Technology Policy, Renewable Energy Act 2011, Fit-in Tariff (FiT) and others [4]. As Malaysian government had been ratified the Kyoto Protocol in September 2002 to reduce domestic CO2 emission as a effort to battle climate change and global warming. As to reduce greenhouse gases emission, renewable energy had to be used extensively or reduce consumption of electricity. Government had target 5% of renewable energy as a electricity source by 2010 but only 1.8% achieved. And by 2020 it is expected renewable energy share would increase to 3% from the total energy generated. Since the expected capacity for renewable not achieved, electricity consumption can be reduced to further reduce greenhouse gases emission.

Building account for 21% of global energy consumption, thus reducing energy consumption can reduce greenhouse gases release to the environment. The annual electricity consumption cost of Malaysian university campus reached nearly RM 1 billion. This is due to too many energy driving factors in a university or faculties. Such energy driving factor are number of students, number of lecturers, operating hours, and others. Since 2010, Ministry of Higher Education of Malaysia had insisted that all universities must conserve energy.

University Teknologi Malaysia (UTM) has introduced energy management policy in 23 May 2011, which objectives are to reduce carbon emission through efficient energy management, to reduce dependency on fossil fuels and to utilize renewable energy. Various energy driving factor needs to be identified so that electrical consumption can be analyse and the saving measure can be taken. Since there are too many driving factors, it is hard to predict electrical energy consumption for building in a university that has multiple functions.

There are many simulators to predict electrical energy consumption such as Simulation X, Simulink, DesignBuilder, SMACH, BEopt, Simergy, Gridlab-D which can be used for urban residential and developed residential area. These simulator tools simulate electrical energy consumption regardless of occupant behaviours. However, these simulator tools are unable to predict electrical energy consumption based on various driving factors. Prediction of electrical energy consumption for lecturer's room, class room, laboratories, meeting room, offices, corridor lights, toilets and other become very hard since there is only limited meter in School of Chemical and Energy Engineering (SCEE). Besides that, not all meter is working as intended, as some the meter around SCEE is faulty. There is also limited number of meters that can be monitored online in SCEE.

Thus, there is demand for another simulation tools that can be used to analyse electrical energy consumption based on its driving factors for a university, so that electrical energy can be predicted based on its driving factors, and estimated saving can be calculated if any improvement were to be implemented such as behaviour changes or new technology installation. By this, the amount of energy that can be saved and its corresponding reduction in cost and greenhouse gases can be identified as these will become a motivation for energy manager.

1.3 Research Objectives

The objectives of the research are:

(a) To conduct energy audit and analyze the energy driving contributors in a school.

(b) To relate each energy contributors to energy consumption through mathematical modelling.

(c) To develop an excel template to predict energy consumption based on its driving factors.

(d) To predict energy consumption and savings based on measures done virtually.

1.4 Scope

(a) All the research will be done in School of Chemical and Energy Engineering (SCEE).

(b) Data will be collected for selected buildings in SCEE.

(c) For selected buildings, energy audit will be done to analyse energy driving factor.

(d) Excel template will be developed to predict energy consumption

(e) Energy consumption will be predicted for one year

(f) Scenario analysis of different type energy saving measure, and its corresponding reduction in energy consumption and utility bill will be estimated.

1.5 Significate of the Study

This research helps in to identify energy driving factor in a school or faculty. Excel template created from the data of energy audit in SCEE can predict electrical energy consumption, thus eliminate the needs to install electric meter in every building in SCEE. Estimated saving from implementing energy saving measure can be analyse. The excel template created can be served as a simple database that can be extended to other school or faculty.

1.6 Summary of Dissertation

Chapter 1 introduce the background of the study, the problem statement, objectives and scopes of the study, and significance of the study. Chapter 2 discuss the literature review of energy analysis technique, energy audit, energy simulator, and previous related study of other authors. Chapter 3 describe the methodology of energy audit and model development used in this study. Chapter 4 includes the discussion of the result. Chapter 5 concludes the study with a summary of findings and recommendation for future work.

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