Faculty of Mechanical Engineering

INVESTIGATION OF ENERGY MANAGEMENT PRACTICE AND ACHIEVEMENT IN UTEM

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DECLARATION

I declare that this thesis entitled "Investigation of Energy Management Practice and Achievement in UTeM" 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 : Khairil Anwar bin Arifin

Date : 09 DEC 2021

APPROVAL

I hereby declare that I have checked this thesis and in my opinion this thesis is adequate in terms of scope and quality for the award of the degree of Master of Mechanical Engineering (Energy).

Signature : .....

Supervisor Name : Dr. Mohamad Firdaus bin Sukri

Date : 09 DEC 2021

DEDICATION

To my parents and family

ABSTRACT

Energy management strategy and practice in the building have attracted lots of attention in recent years. It is crucial, especially in a higher learning institution such as UTeM, which is classified as a large building and consumes more than 10 million kWh per year due to various functions, occupancy, and appliances. The holistic energy management strategy and practice not only the discovery of baseline energy use, benchmarking, and then only to provide reasonable return-on-investment solution. Hence, the research aims to investigate the energy management practice and achievement in UTeM by reviewing the energy management strategy and practice implemented and the benefits in terms of energy and cost-saving and carbon emissions reduction. The analysis of factors that influence energy consumption was also included. An appropriate model adapted from 7 elements in Energy Management Gold Standard (EMGS) certification, and survey approach by previous research had been designed to investigate the energy management practice and achievement in UTeM. The benefits of the implementation strategy were justified in terms of energy and cost-saving and carbon emissions reduction. Case studies were performed to demonstrate the factors that influence the energy consumption in UTeM. From the evaluation of measurement tools for energy management key practice, the progress and achievement in the planning and implementation phase were outstanding. However, the monitoring and evaluating phase was average. With achievement in EMGS 2-Star rating in 2019, it proved that the energy management practice had been put in place with the minimum 5% annual energy reduction from the baseline was achieved. The target for assessment on EMGS 3-Star rating is this year. Consequently, the monitoring and evaluating phase evaluation is expected to be improved where they continuously improve and sustain the energy reduction and integrating energy management with other standards. The energy and cost-saving achieved is 20,202,850 kWh or RM 7,374,040.62, equivalent to 14,021 tonnes of CO_2 emission reduction in the past five years. A method and regression equation for predicting the energy consumption from the independent variable, working and class days, was proposed. The regression equation was applied to the year 2020 to verify the energy consumption prediction accuracy. The total predicted energy consumption for 2020 is 12,901,643 kWh, with a variance of about -744,448 kWh compared to metered energy consumption. The negative variance represents the effect of ESMs implemented in the year 2020, which equals 605,830 kWh. The remaining energy consumption, 138,618 kWh, is probably because of the limitation of occupancy during RMCO, where only 70% maximum at one time of staff is allowed at the workplace by MKN. The findings of this study could be used as a guideline for commercial buildings especially higher learning institutions in Malaysia that consume a lot of energy to implement sustainable energy management strategies and practices.

PENYELIDIKAN AMALAN DAN PENCAPAIAN PENGURUSAN TENAGA DI UTEM

ABSTRAK

Strategi dan amalan pengurusan tenaga di dalam bangunan ini telah menarik banyak perhatian kebelakangan ini. Ini sangat penting terutamanya di institusi pendidikan tinggi seperti UTeM, yang diklasifikasikan sebagai bangunan yang besar dan menggunakan lebih dari 10 juta kWh tenaga elektrik setiap tahun disebabkan oleh kepelbagaian fungsi, penghunian, dan peralatan elektrik. Strategi dan amalan pengurusan tenaga yang menyeluruh bukan sahaja sebagai penentuan asas penggunaan tenaga, penanda aras, dan kemudiannya untuk memberikan penyelesaian untuk pulangan pelaburan sahaja. Oleh itu, penyelidikan ini bertujuan untuk menyelidik amalan dan pencapaian pengurusan tenaga di UTeM dengan mengkaji strategi dan amalan pengurusan tenaga yang dilaksanakan serta faedah dari segi penjimatan tenaga dan kos, dan pengurangan pelepasan karbon. Analisis untuk faktor-faktor yang mempengaruhi penggunaan tenaga juga disertakan. Model kaji selidik yang sesuai harus dirancang dengan teliti sebelum melaksanakan sebarang penyelidikan mengenai amalan dan pencapaian pengurusan tenaga ini bagi mendapatkan keputusan yang tepat dan optimum. Oleh itu, penyelidikan ini mencadangkan kajian yang berdasarkan pada 7 elemen dalam pensijilan Energy Management Gold Standard (EMGS) dan pendekatan kaji selidik yang diperkenalkan oleh Low (2008). Manfaat dari strategi pelaksanaan ini disahkan dari segi penjimatan tenaga dan kos, dan pengurangan pelepasan karbon. Kajian kes dilakukan untuk menunjukkan faktor-faktor yang mempengaruhi penggunaan tenaga elektrik di UTeM. Dari penilaian untuk kunci amalan pengurusan tenaga, kemajuan dan pencapaian dalam fasa perancangan dan pelaksanaan adalah sangat baik, namun tahap pemantauan dan penilaian berada pada tahap biasa. Dengan pencapaian dalam anugerah EMGS 2-Star pada tahun 2019, ini membuktikan bahawa amalan pengurusan tenaga yang dilaksanakan telah mencapai pengurangan tenaga tahunan minimum iaitu 5% dari asas penggunaan tenaga. Sasaran penilaian untuk anugerah EMGS 3-Star adalah pada tahun ini. Oleh itu, fasa pemantauan dan penilaian diharapkan dapat ditingkatkan lagi di mana mereka harus menyasarkan peningkatan atau sekurang-kurangnya mengekalkan kadar pengurangan penggunaan tenaga pada 5% dan mengintegrasikan pengurusan tenaga dengan piawaian lain. Penjimatan tenaga dan kos yang dicapai adalah sebanyak 20,202,850 kWh atau RM 7,374,040.62 bersamaan dengan penurunan pelepasan CO_2 sebanyak 14,021 tan dalam tempoh 5 tahun ini. Kaedah dan persamaan regresi untuk meramalkan penggunaan tenaga dari pemboleh ubah bebas, hari bekerja dan kuliah telah dicadangkan. Persamaan regresi diaplikasikan untuk data pada tahun 2020 untuk mengesahkan ketepatan anggaran penggunaan tenaga. Jumlah anggaran penggunaan tenaga untuk tahun 2020 adalah sebanyak 12,901,643 kWh dengan varians sekitar -744,448 kWh berbanding penggunaan tenaga dari bil elektrik. Varian negatif mewakili kesan ESMs yang dilaksanakan pada tahun 2020 yang bersamaan dengan 605,830 kWh. Penggunaan tenaga selebihnya, 138,618 kWh berkemungkinan besar kerana had penghunian semasa RMCO di mana hanya 70% maksimum kakitangan dibenarkan di tempat kerja pada satu masa oleh MKN. Penemuan kajian ini dapat dijadikan panduan untuk bangunan komersial untuk melaksanakan strategi dan amalan pengurusan tenaga lestari ini terutamanya institusi pendidikan tinggi di Malaysia yang mencatatkan penggunaan tenaga yang tinggi.

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ACE	-	ASEAN Center for Energy
AEMAS	-	ASEAN Energy Management Scheme
AHU	-	Air handling unit
ASEAN	-	Association of Southeast Asian Nations
ASHRAE	-	American Society of Heating, Refrigerating and Air-Conditioning Engineers
AVC	-	Assistant Vice-Chancellor
BAS	-	Building Automation System
BEI	-	Building Energy Index
BOD	-	Board of Directors
CO_2	-	Carbon dioxide
CDD	-	Cooling degree days
CEM	-	Certified Energy Manager
EAC	-	Energy Accounting Centres
EC	-	Executive Councils
EEI	-	Energy Efficiency Index
EMC	-	Energy management committee
EMEER 2008	-	Efficient Management of Electrical Energy Regulations 2008
EMGS	-	Energy Management Gold Standard
EnMS	-	Energy management system
ENPIs	-	Energy Performance Indicators
EPI	-	Energy Performance Index
GDP	-	Gross Domestic Product

GHG	-	Greenhouse gasses
HDD	-	Heating degree days
HVAC	-	Heat, Ventilation, and Air Conditioning
IPMVP	-	International Performance Measurement and Verification Protocols
ISO 50001	-	International Standard for Energy Management Systems
KPI	-	Key Performance Index
OSES	-	Occupational Safety and Environmental Sustainability
KUTKM	-	Kolej Universiti Teknikal Kebangsaan Malaysia
M&V	-	Measurement and Verification
MaPTeP	-	PTj Energy Management Matrix
MCO	-	Movement Control Order
MGTC	-	Malaysian Green Technology Corporation
MKN	-	Majlis Keselamatan Negara
MOH	-	Ministry of Health
MOHE	-	Ministry of Higher Education
NBEL	-	National Building Energy Label
OPTR	-	Off-Peak Tariff Rider
REEM	-	Registered Electrical Energy Manager
RC	-	Resistive-capacitive
SDG	-	Sustainable Development Goals
SEMS	-	Sustainable Energy Management System
SEU	-	Significant energy users
SSG	-	UTeM Seven Strategic Goal
TNB	-	Tenaga Nasional Berhad
TOR	-	Term of Reference
UNEP	-	United Nations Environment Program
UTeM	-	Universiti Teknikal Malaysia Melaka
VC	-	Vice-Chancellor

CHAPTER 1

INTRODUCTION

1.1 Overview

Energy management is an organized, systematic, and proactive approach to manage energy and is an essential factor that needs consideration in almost every industry. It is the process of monitoring and optimizing energy consumption to reduce energy consumption in a building. Therefore, energy management is considered a critical strategic area for cost reduction, developing new systems, and upgrading existing ones.

An energy management assessment is a method of determining how far a company has progressed in establishing and enhancing its energy management program. (Smith et al., 2016). In general, energy management assessments utilize a scoring methodology to determine where a company falls on the spectrum in a range of areas, focusing on an energy management program's cultural and organizational components.

1.2 Research Background

The commercial building is one of the highest sharing in the energy consumption which contributes to greenhouse gasses (GHG) emission. This research investigates the energy management practice and achievement in Universiti Teknikal Malaysia Melaka (UTeM). Higher learning institutions typically own a large number of buildings, resulting in increased energy usage overall. The increment of energy consumption signifies a high total level of carbon dioxide (CO_2) emissions and this resulting environmental impact. Buildings with excellent energy performance are a combination of good energy management strategies. One method to accomplish this is by proper energy consumption targeting and monitoring.

The application of management approaches to manage energy consumption and cost is known as energy monitoring and targeting.

By reviewing the energy management processes of UTeM buildings, the best criteria in an energy analysis can be discovered. It can be achieved by looking at energy usage patterns and the cooling degree days (CDD), working days, class days, and no of days per month that affect energy consumption and can help increase building energy performance.

The findings of this study could be used as a guideline for other higher learning institutions in Malaysia that consume a lot of energy to help them improve their energy intensity. Therefore, in-depth analysis and details on the energy management practice and achievement in UteM were carried out. A critical review will be presented to deliberate on the issues, challenges, and future recommendations of energy management practice and achievement in UTeM. The goal is to improve building performance, determine the cost-effectiveness of additional energy conservation and renewable energy schemes, and reduce environmental impact. As the vital approaches channeling it to energy efficiency, the building's energy consumption prediction and classification are essential to achieve the goals.

1.3 Problem Statement

The need for energy is continuously increasing in Malaysia, as presented in Figure 1.1. According to reports, Malaysian public universities use more energy each year (Abd-Razak et al., 2011) due to their activities and populations. As a result of the high monthly energy bill, which has been a source of concern for several parties, the Ministry of Higher Education (MOHE) has requested that all universities conserve energy (Choong et al., 2012). UTeM Main Campus, classified as a large building and consumes more than 10 million kWh per year, is committed to lowering GHG emissions through its Energy Policy and Solid and

Scheduled Waste Management Policy, supporting the government's goal. UTeM is one of the pioneers in energy management and recognition in EMGS for higher learning institutions and best practices in energy management. Due to this, UTeM's achievement was set as a benchmark in the commercial sector's energy management practice, especially in higher learning institutions.

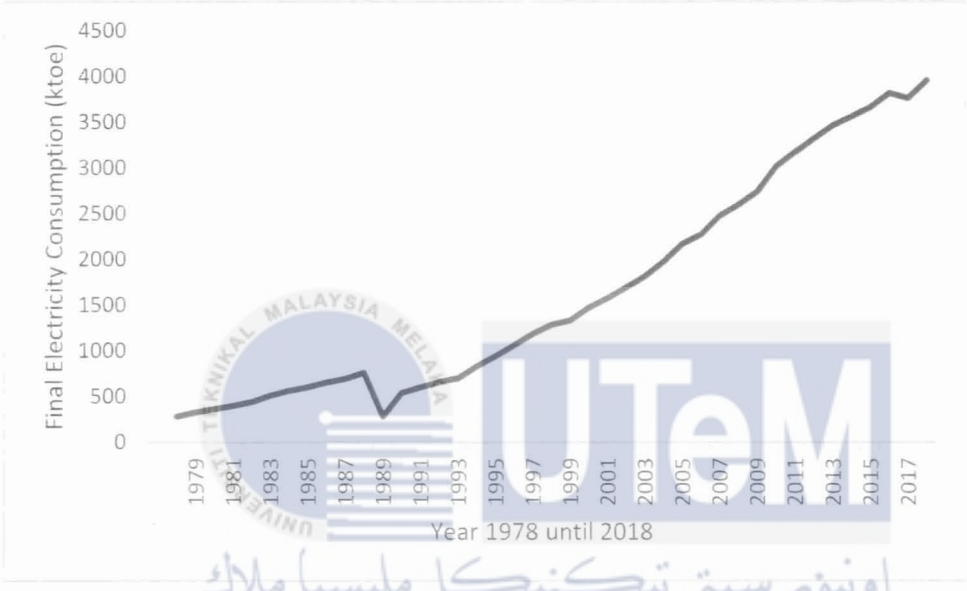

Figure 1.1 Final electricity consumption for the commercial sector (MEIH, 2021)

In terms of regulations, UTeM fell under the Efficient Management of Electrical Energy Regulations 2008 (EMEER 2008) as UTeM's energy consumption for six consecutive months exceeded 3,000,000 kWh. EMEER 2008 was established to encourage the efficient use of electricity. EMEER 2008's goals are to develop standards and norms for the usage of energy. It is crucial, especially in an educational building consisting of various functions, occupancy, and appliances (Bourdeau et al., 2018). Hence, a Registered Electrical Energy Manager (REEM) appointment is mandatory, as stated in Regulation 6 of EMEER 2008. The REEM must produce a half-yearly report to the Energy Commission on the building's energy performance, energy efficiency strategy, and energy-saving activities.

Thus, the investigation of energy management practice and achievement in UTeM summarizes all related energy management strategies and practices that are usefull for EMEER 2008 report.

1.4 Research Objectives

The research aims to investigate the energy management practice and achievement in UTeM. Thus, the objectives of this research are:

i. To review energy management strategy and practice implemented in UTeM.

ii. To justify the benefit of implementation strategy in terms of energy and cost-saving, and carbon emissions reduction.

iii. To analyze the factors that influence the energy consumption in UTeM.

1.5 Scope of Research

The scope of this study is limited to the following aspects:

i. Applying the Energy Management Gold Standard (EMGS) assessment developed by ASEAN Energy Management Scheme (AEMAS) to fulfill all study objectives.

ii. Applying the 47 energy management key strategies and practices outlined by Low (2008) in reviewing energy management strategy and practice implemented in UTeM.

iii. The main campus's energy consumption analysis is narrowed to electricity only, which was recorded from July 2014 until June 2021.

iv. The factors that influenced the energy consumption in UTeM are limited to cooling degree days (CDD), working days, class days, and the number of days in a month.

v. CDD data for the WMKM meteorological weather station was obtained from www.degreedays.net with a base temperature sets at 23.3°C.

vi. The CDD analysis covered overall energy consumption as baseload information was not available

vii. Working days included both academic and non-academic staff.

viii. Data validity was obtained from the statistical method.

1.6 Contribution of Research

The information presented in this thesis is primarily written for energy managers and other professionals associated with energy management. This report discusses the strategy and practice that implemented by Malaysian higher learning institutions in energy management. The energy managers in the higher learning institutions sector may find this research particularly useful, whereby it's also related to energy management certification. This study aims to present the performance of the energy management practice and achievement in UTeM. The research also explores the benefit of implementation strategy and the factors that influence the energy consumption in UTeM.

1.7 Thesis Outline

This thesis consists of 5 chapters. Chapter 1 of the thesis discusses a brief introduction to energy management and its importance nowadays. It will also focus on the problem statements, project objectives, and scope of work.

Chapter 2 reviews the basics of the energy management process and procedures. This chapter discussed the climate zone in Malaysia and the current practice of energy management. This chapter will also discuss 7 elements of the ASEAN Energy Management Scheme (AEMAS) energy management system, one of the leading energy management assessment and certification tools. This chapter will also contain the benefit of the implementation strategy, especially in energy and cost-saving, and carbon emissions

reduction. The factors that influence the energy consumption in buildings will also be briefly discussed.

Chapter 3 discusses the proposed methodology of reviewing key practice and achievement energy management, specifically in the university building. Based on the literature study, the EMGS assessment tool and surveys produced by Low (2008) are proposed to investigate the current energy management key practice and achievement in UTeM. The data collected from these tools were used to achieve the research objective.

Chapter 4 discusses all the data and results from the surveys and assessment. This chapter presents the achievement and performance of energy management key practice in UTeM, especially in terms of energy and cost-saving and carbon emissions reduction. The factors that influenced the energy consumption in UTeM will also be analyzed and discussed.

Chapter 5 presents the conclusion of this project and will also propose further works that can be done in the future. Some barriers and obstacles faced during this project will also briefly note in this chapter.