EVALUATION OF THE ELECTRICAL ENERGY EFFICIENCY OF THE NEW FACULTY OF MANUFACTURING ENGINEERING, UTEM BUILDING THROUGH LIGHT INTENSITY ANALYSIS

Submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Hons)

by

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I hereby declare this report entitled “Evaluation of The Electrical Energy Efficiency of the New Faculty of Manufacturing Engineering,UTeM Building Through Light Intensity Analysis” is the result of my own research except as cited in references.

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Date : June 2022

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons). The member of the supervisory committee is as follow:

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(DR RAHIMAH BINTI HJ ABDUL HAMID)

ABSTRAK

Pencahayaan menyumbang jumlah penggunaan elektrik tertinggi dalam sesebuah bangunan. Secara amnya pencahayaan akan menggunakan dari 20% hingga 50% daripada penggunaan elektrik. Penggunaan pencahayaan yang cekap dan berkesan boleh menawarkan penjimatan tenaga dan kos yang besar. Penyelidikan ini mencetus dan menganalisis pengurusan tenaga dalam bangunan dan membentangkan reka bentuk sistem pencahayaan cekap tenaga. Dalam pencahayaan buatan, kaedah untuk menentukan penerang adalah menggunakan model matematik contohnya Kaedah Lumen. Walaupun, kaedah tersebut tidak memerlukan banyak input komponen, adalah perlu untuk mendapatkan data daripada pembekal pencahayaan.dalam pada itu, maklumat mengenai penyelenggaraan bilik juga penting. Mendapatkan maklumat dalam Kaedah Lumen merupakan halangan dalam kajian ini. Matlamat laporan ini adalah untuk mengkaji Kaedah Lumen untuk memperkenalkan pelarasan dalam model pengiraan. Kajian ini tertumpu kepada bilik yang dipasang dengan lampu tiub. Bahagian pertama mencadangkan reka bentuk pencahayaan cekap tenaga yang membantu pengguna menentukan bilangan pencahayaan yang ideal yang diperlukan di lokasi terpilih. Bahagian seterusnya adalah untuk menentukan penggunaan tenaga dan kuasa pencahyaan bagi setiap lokasi yang dipilih. Penemuan utama dalam projek ini ialah reka bentuk pencahayaan cekap tenaga masih boleh dicapai tanpa mengorbankan keselesaan visual dan kualiti pencahayaan dan penggantian lekapan lama dengan peneraju baharu boleh meningkatkan kecekapan dengan banyak.

ABSTRACT

Lighting accounts for most of a building's electricity consumption. Lighting accounts for anything between 20% and 50% of total electricity use. Lighting used efficiently and effectively can save a lot of money and energy. This study initiates and analyses energy management in a building and presents a design for an energy-efficient lighting system. A mathematical model, such as the Lumen Method, is used to determine the luminaries in artificial lighting. Although the procedure just requires a few component inputs, data from the manufacturer is required. Information about room maintenance is vital, making using the Lumen Method to collect data a challenge in this study. This report examines the Lumen Method to introduce adjustment in the calculating model. This study focused on rooms installed with tube lamps. The first section proposes an energy-efficient lighting scheme that helps the user determine the ideal number of luminaries needed in the selected location. The next part is determining luminaries' energy and power consumption for every selected location. The project's ultimate goal is to demonstrate that energy-efficient lighting may be achieved without losing aesthetic comfort or illumination quality. Replacing old lights with new ones can improve efficiency significantly.

DEDICATION

Only

my cherished father, ABD Manaf Bin Manja

my respected mother, Norazian Binti Hanafiah

my loved brothers and sisters,

Noratikah Syahirah Binti ABD Manaf

Amirul Aiman Bin ABD Manaf

Amirul Hazim Bin ABD Manaf

Nor Fatihah Akma Binti ABD Manaf

Amirul Syahiir Bin ABD Manaf

for providing me with moral support, financial assistance, collaboration, encouragement, and understanding

Thank you so much, and I will always love you all.

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Last but not least, my appreciation goes to those who have helped me directly and indirectly in completing this report. I am very thankful that many people have supported and inspired me to carry out this project.

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LIST OF ABBREVIATION

MOE	-	Ministry of Education
MOHE	-	Malaysian Ministry of Higher Education
UTeM	-	Universiti Teknikal Malaysia Melaka
KPKA	-	Pejabat Keselamatan Pekerjaan dan Kelestarian Alam Sekitar
EMGS	-	ASEAN Energy Management Gold Standard
FKP	-	Fakulti Kejuruteraan Pembuatan
HVAC	-	Heating, ventilation and air conditioning
IoT	-	Internet of things
BK	-	Bilik kuliah
ECM	-	Energy Conservation Measures
DOE	-	Department of Energy
SOP	-	Standard operation procedure
EES	-	Energy efficiency standard
M2M	-	Machine to Machine
BACS	-	Building Control Automation and Control System
CIBSE	-	The Charted Institution of Building Services Engineers
RSMF	-	Room Surface Maintenance Factor.
LMF	-	Luminaire Maintenance Factor.
LLMF	-	Lamp lumen maintenance factor.
LSF	-	Luminaire Survival Factor.
SHR	-	Space to Height Ratio
LED	-	Light-emitting diode
Uo	-	Illuminance uniformity
UGR	-	Unified glare rating

LIST OF EQUATIONS

LIST OF SYMBOLS

W/m^2	-	Centimetre
m	-	Metre
%	-	Percent
N	-	Number of luminaries required -
A	-	Floor area to illuminate
E	-	Required lux
F	-	Initial lamp lumen
n	-	Lamp per luminaries
MF	-	Maintenance Factor
UF	-	Utilization Factor
L	-	Room length
W	-	Room width
H	-	Room height
K	-	Room index
ρ	-	Surface reflectance
W	-	Watt
kWh	-	Kilo Watt hours
lm	-	Flux
lm/w	-	Flux per Watt

CHAPTER 1
INTRODUCTION

This chapter describes the beginning of this research work, including the background, problem statement, objective, scope, and significance of the study. An evaluation of the electrical energy efficiency of the new Faculty of Manufacturing Engineering,UTeM building through light intensity analysis is carried out in this report.

1.1 Background

Electrical energy efficiency is defined as a reduction in power and energy demands from an electrical system that does not interfere with the normal operations of the building, industrial plant, or any other transformation process. (Circutor, 2015). SEEA, (2019) simply said that energy efficiency is using less energy to do the same work, i.e., eliminating energy waste. In Malaysian colleges, energy waste is expected due to inefficient energy consumption and a shortage of understanding among building users (Ng Sock Yen et al., 2010). Energy efficiency has several advantages, including supporting the system's long-term viability and the environment by lowering greenhouse gas emissions as a result of lower energy demand, improving the technical management of the installations by increasing efficiency and avoiding stoppages and breakdowns, and lowering the energy's economic cost as well as the installation's operating costs. While renewable energy technology can help achieve these goals, the most cost-effective and efficient strategy to minimise fossil fuel consumption is to improve energy efficiency. Every sector of the economy, whether it's buildings, transportation, industry, or energy generation, has a lot of room for efficiency gains. Both academia and industry are paying more attention to building energy efficiency design because it helps to minimise not just building energy consumption but also greenhouse gas emissions (Chen et al., 2020).

Malaysian universities are currently dealing with major energy waste concerns, which has resulted in a significant increase in annual energy costs, putting a strain on the institutions' annual budgets (Wen & Palanichamy, 2018). The Malaysian Ministry of

Education (MOE) and The Malaysian Ministry of Higher Education (MOHE) has encouraged all education centres to play their role to save energy. In Universiti Teknikal Malaysia Melaka (UTeM), Seven (7) Strategic Goals (SSG) 2021- 2025 have been proposed where the 6th goal is Smart and Dynamic campus, which highlight the importance of practising energy efficiency on the campus. To achieve this, the IoT energy measurement system has been installed in most faculties to monitor energy usage more efficiently. Pejabat Keselamatan Pekerjaan dan Kelestarian Alam Sekitar (KPKA) is the one who is responsible for monitoring and controlling the use of energy in UTeM with the help of the Energy Management Committee from each faculty. Due to roles played effectively and integrated by KPKA, UTeM had managed to record an outstanding success in saving about RM 9 million when the plan started in 2014. This achievement is a great success in 6 years UTeM which able to achieve electricity savings of 25 million kilowatt-hours (kwh). During this period of energy-saving achievements, UTeM also earned a double victory by triumphing not only on a local and national level but also on a global scale. Among the successes that have been achieved are the Melaka State Green Award 2016, the ASEAN Energy Management Gold Standard (EMGS) rating of 1 star in 2016, and the ASEAN Energy Management Gold Standard (EMGS) rating of 2 stars in 2018. Strategic formulas coupled with implementing sustainable operations through effective implementation and monitoring complement this success. Due to the positive outcome of implementing the energy efficiency plan, it is crucial to continue using the energy efficiently on the campus.

Faculty of Manufacturing Engineering,UTeM new building started its operation in January 2020. Previously, it was located at different buildings with different infrastructures. The new Faculty of Manufacturing Engineering,UTeM building does not have the IoT system installed yet, where the calculation of the usage of electrical energy in this building is not particularly monitored by the KPKA. The IoT system is planned to be installed in 2022, and the entire operation of this building has given the top management of UTeM a little bit of concern due to some new facilities offered here like lecture room, lecture hall, auditorium, etc. Building energy consumption mainly consist of three component like lighting, HVAC, and electrical equipment. Lighting serves many functions in a building, such as ambient illumination, task lighting, accenting specific features, and emergencies like safety and security. Thus, the condition of light in most situations is as crucial as the quantity of light. Lighting design at Lecturer’s room, lecture room and laboratory; for example, there is no study have been made yet on the reason why in the Lecturer's room where one switch

is pressed on, eight fluorescent lights will light up for a small space capacity. So, it is crucial to measure the size of the space and determine the appropriate number of required lights needed for such an area so that we can propose to the top management of FKP to reduce the lights if it is excessive. Pan et al. (2013) stated that artificial lighting needs electricity, and it is also a heat source during operation. Therefore, energy saving in lighting systems could be significant for reducing building energy consumption. Lighting accounts for 20-40% of overall energy consumption, and it is an area where there are numerous energy efficiency potentials in practically any structure, old or new (Wulfinghoff, 2009). Therefore, monitoring the energy efficiency in FKP is significant to help UTeM achieve its strategic goals in the future and promote more savings in electrical bill expenses. Therefore, this study evaluates the electrical energy efficiency of the new Faculty of Manufacturing Ebgineering,UTeM building through the light intensity analysis method.

1.2 Problem Statements

Faculty of Manufacturing Ebgineering,UTeM new building started operating in January 2020, consisting of all the facilities needed for the student, lecture, and staff. In this study that is going to be done at Faculty of Manufacturing Ebgineering,UTeM building, for the lecturer room, the contractor has installed eight lights in the room that will light up all by only one switch. It supplies inadequate lighting control by not permitting lights to be adjusted to particular needs. Based on the size of the lecturer room, the number of lights installed is entirely inappropriate. Other than that, the lights installed in some laboratories are pretty high. This leads to uncertainty about whether the lighting provided is suitable for activities in the space. It shows that it specifies the amount of light for general usage without seeing the needs of specific tasks. Reda (2021) stated that, in order to save energy, the mounting height should be reduced, and high-reflective colours should be used. Therefore, the utilisation factor of the space needed to be done to determine the required number of luminaries needed for the intended application. If excessive, lecturers are advised to use natural lighting more often and only use artificial lighting if necessary.

UTeM has an IoT Energy Monitoring system and Building Management System (BMS) to fully control the optimal use of energy, especially the use of more efficient air

conditioning systems, and this proves UTeM excels in conducting sustainable energy management in helping the country reduce CO^2 emissions and succeed National Energy Efficiency Action Plan (NEEAP: 2016-2025). But, the IoT system has not yet been installed in the FKPs due to the new building at the main campus of UTeM. Instead of the capital-intensive Scada system, the IoT allows campus-wide energy usage to be observed and stored efficiently and affordably. Instead of the capital-intensive Scada system, the IoT allows campus-wide energy usage to be observed and stored efficiently and affordably. With the advent of the IoT technology in the fourth industrial revolution (IR 4.0), the existing installed digital energy meter that has been equipped with an industrial communication protocol can be retrofitted to enhance its connectivity and observability (Shamshiri et al., 2019).

1.3 Objectives of Study

The objective of this study are as follows:

a) To identify the utilisation factor of the specified location at the Faculty of Manufacturing Engineering, UTeM building.
b) To determine the required number of luminaries(N) for each specified location.
c) To calculate the power (Watts) and energy consumption(kWh) of the installed lights at the specified location.

1.4 Scopes of study

The scope of this study are as follows:

(a) This study will only focus on the light intensity analysis for certain rooms at the new FKP building.
(b) The place of study is conducted at some rooms and laboratories in the new FKP building, which are:
    i. Lecture rooms (BK1-2, BK 5)
    ii. Lecture hall (Dewan Kuliah)
    iii. Lecturer's room (Professor's room and Lecturer's room)

iv. Laboratories (Rapid Prototyping Laboratory, Milling and Fabrication Laboratory, CAD/CAM Laboratory)

(c) The method used for the light intensity analysis is Lumen Method which is suitable for the interior light design.

1.5 Significance of Study

This study evaluates the electrical energy efficiency of the new FKP building through light intensity analysis. This study helps eliminate energy waste while providing a productive visual environment through energy-efficient use of the light in the faculty. Suppose the study shows that the number of lights installed is excessive. In that case, the right amount of light will be proposed to the faculty as a way of Energy Conservation Measures (ECM), and other ways like proposing the use of natural lights in the daytime, for example, will be made. This kind of awareness among all faculty members can be initiated through the findings of this study which in the long term could hopefully promote the use of energy in a more efficient way and simultaneously reduce the monthly electrical The light path emanating from the light source could have an unfavourable effect on the quality of light and limit energy efficiency gains if it is not correctly directed and circulated to the task or activity area through suitable lamp luminaires (fixtures). As a result, any energy-efficient lighting strategy should include luminaire selection, design consumption of the faculty and the operating cost that needs to be spent by the university. The light path emanating from the light source could negatively affect the quality of light and limit energy efficiency gains if it is not correctly directed and distributed to the task or activity area through proper lamp luminaires (fixtures). As a result, any energy-efficient lighting strategy should include luminaire selection and design. It indirectly helps to support the university's strategic plan to achieve the 6th plan and indirectly helps UTeM maintain achievements in practising energy efficiency on campus.

CHAPTER 2
LITERATURE REVIEW

This chapter explains all theories and fundamentals that help to establish the understanding of conducting this study. The data are gathered from published literature, books, magazines, and websites which focus on energy efficiency through light intensity analysis.

2.1 Overview of Energy Efficiency

A reduction in the amount of energy utilised per unit of service supplied is referred to as energy efficiency (Cutler and Christopher, 2006). The two significant systems offering standard building services are (1) Heating, Ventilation, and Air conditioning (HVAC) system and (2) lighting system. By introducing relevant technology, such as a lighting control system that integrates with the HVAC system, the energy efficiency of the overall system could be increased.

SEEA (2019) stated that energy efficiency is often referred to as a "least-cost resource," meaning it is the single most cost-effective productivity tool within an energy portfolio. Energy efficiency methods enable the creation of products, services, and benefits at the lowest possible energy cost. Furthermore, because energy efficiency reduces the amount of energy wasted, it has several significant advantages, including (1) the ability to postpone or eliminate the requirement for new electric power generation and transmission facilities and capacity, resulting in lower electric rates; (2) the power to lower rates for all consumers and reduce electricity bills for utility customers who engage in energy-saving programmes and rebates;(3) The chance to alleviate electric grid limitations and improve

grid reliability, particularly during peak hours;(4) environmental impact is lessened; (5) local economic growth and job creation; (6) enhanced citizen health, comfort, and productivity. Improving electrical energy efficiency is the key to this deadlock and an essential guarantee for energy conservation and emission reduction (Guang, 2020).

2.1.1 Energy Efficiency Standard (EES)

Energy efficiency as a resource should yield energy and require savings that can displace supply-side resources, including nonrenewable energy-based electricity. Demire (2018) stated that The US Department of Energy (DOE) set an energy efficiency standard (EES) for over 50 items, appliances, and equipment, including commercial, industrial, lighting, and residential products. These evaluations result in standards that offer the most remarkable possible improvement in energy efficiency while also resulting in significant energy savings. Dimera also claimed that these analyses result in standards that offer the most significant possible improvement in energy efficiency while also resulting in significant energy savings. The EES group produces techno-economic and environmental analyses for these products:

(a) Equipment cost and profit margin,
(b) Energy consumption,
(c) Energy consumption expense of a consumer's life cycle and the time it takes for them to get a return on their investment,
(d) Shipment,
(e) The national effect, which takes into account national energy savings and net present value for consumers.,
(f) Impact of Emissions,
(g) Impact on employment,
(h) Regulatory

From Malaysian Standards: (MS)1525:2019 - Energy Efficiency and Use of Renewable Energy for Non-residential Buildings stated that The Code of Practice provides