# ENERGY AUDIT AND RETROFIT OF LIGHTING SYSTEM AT INSTITUT LATIHAN PERINDUSTRIAN (ILP) TANGKAK, JOHOR

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# ABSTRACT

The global electricity consumption demand grows at 2.1% per year from 2018 to 2040. Historically, the growth of Malaysia demand from 2015 to 2020 is 16,822MW to 18,808MW, or at 2.3% annually. Nowadays, people are more concerned about energy efficiency and conservation in buildings. The government needs to ensure that energy is used at high efficiency and reduce waste. Since the commencement of operations, Institut Latihan Perindustrian (ILP) Tangkak has never conducted an energy audit. At present, energy audit is one of the effective approaches to identify efficient energy usages and cost saving. The purpose of this research is to conduct an energy audit in terms of study on the power and illuminance level for lighting, propose energy efficiency strategy of lighting system and to evaluate the proposed strategy in terms of techno-economic performance. This research presents the study of energy audit that will be conduct to analyze the lighting energy consumption pattern in library building at ILP Tangkak. Preliminary audit which involves a brief review of utility and building operation, observation and a walkthrough energy audit is performed as an input data for the baseline data. Real time data such as power rating, illuminance level and usage time will be collected. Existing lighting system which is T8 fluorescent tubes considered to examine the performance of the alternative efficient in terms of illuminance performance and energy performance of the proposed T8 and T5 Light Emitting Diode (LED) retrofit. Retrofitting of lighting on Library using DIALux software will be use to simulate in accordance to the MS1525 standard. Economic analysis including Payback Period (PP), Life Cycle Cost (LCC) and Annual Life Cycle Cost (ALCC) are indicators of economic performance that will be used. Energy Saving using T5 LED saves 11.5% more than T8 LED. The T8 LED technology shows lower PP and LCC value compared to T5. According to the ALCC, T5 LED technology shows lower value compared to T8 LED technology.

# ABSTRAK

Permintaan penggunaan elektrik global meningkat pada 2.1% setahun dari 2018 hingga 2040. Dari segi sejarah, pertumbuhan permintaan Malaysia dari 2015 hingga 2020 ialah 16,822MW kepada 18,808MW, atau pada 2.3% setiap tahun. Pada masa kini, orang ramai lebih mementingkan kecekapan tenaga dalam bangunan. Kerajaan perlu memastikan tenaga digunakan pada kecekapan tinggi dan mengurangkan pembaziran. Sejak mula beroperasi, Institut Latihan Perindustrian (ILP) Tangkak tidak pernah menjalankan audit tenaga. Audit tenaga adalah salah satu pendekatan yang berkesan untuk mengenal pasti penggunaan tenaga yang cekap dan menjimatkan kos. Tujuan penyelidikan ini adalah untuk menjalankan audit tenaga dari segi kajian tentang tahap kuasa dan pencahayaan, mencadangkan strategi kecekapan tenaga sistem pencahayaan dan menilai strategi yang dicadangkan dari segi prestasi tekno-ekonomi. Penyelidikan ini membentangkan kajian audit tenaga yang akan dijalankan dengan menganalisis corak penggunaan tenaga pencahayaan di bangunan perpustakaan di ILP Tangkak. Audit awal yang melibatkan semakan ringkas operasi utiliti dan bangunan, pemerhatian dan audit tenaga panduan dilakukan sebagai data input untuk data garis dasar. Data sebenar seperti penarafan kuasa, tahap pencahayaan dan masa penggunaan akan dikumpul. Sistem pencahayaan sedia ada iaitu tiub pendarfluor T8 dipertimbangkan untuk mengkaji prestasi alternatif yang cekap dari segi prestasi pencahayaan dan prestasi tenaga cadangan pengubahsuaian kepada lampu jenis T8 dan T5 Light Emitting Diod (LED). Pengubahsuaian semula sistem pencahayaan pada perpustakaan menggunakan perisian DIALux akan digunakan untuk simulasi mengikut piawaian MS1525. Analisis ekonomi termasuk Tempoh Bayar Balik (PP), Kos Kitaran Hayat (LCC) dan Kos Kitaran Hayat Tahunan (ALCC) merupakan petunjuk prestasi ekonomi yang akan digunakan. Penjimatan Tenaga menggunakan LED jenis T5 menjimatkan 11.5% lebih daripada LED jenis T8. Teknologi LED T8 menunjukkan nilai PP dan LCC yang lebih rendah berbanding T5. Mengikut ALCC, teknologi LED T5 menunjukkan nilai yang lebih rendah berbanding teknologi LED T8.

## TABLE OF CONTENTS

# LIST OF TABLES

## LIST OF FIGURES

# LIST OF ABBREVIATIONS

| | |
|---|---|
| $\Phi_v$ | Luminous Flux |
| $\eta$ | Luminous Efficacy |
| $R_a$ | Color Rendering Index |
| lm | Lumen |
| $\bar{E}_m$ | Illuminance Level |
| RE | Renewable Energy |
| ESMs | Energy Saving Measures |
| EEI | Energy Efficiency Index |
| ILP | Institut Latihan Perindustrian |
| FL | Fluorescent |
| LED | Light Emitting Diode |
| CCT | Correlated Color Temperature |
| MS | Malaysian Standard |
| EC | Energy Consumption |
| BS | Billing Saving |
| EB | Electricity Bill |
| TOE | Tariff of Electricity |
| CIC | Capital Investment Cost |
| OC | Operation Cost |
| PP | Payback Period |
| LCC | Life Cycle Cost |
| ALCC | Annual Life Cycle Cost |
| $CO_2$ | Carbon Dioxide |

# CHAPTER 1

## INTRODUCTION

### 1.1. Introduction

Global warming is a major threat across the globe these days. Global warming is considered when there is an increase in average air temperatures near the surface of Earth. This phenomenon has been observed closely by climate scientists. Based on the amount of data gathered and detailed observations of various weather phenomena, it indicates that Earth's overall temperature has risen in a significant number since the beginning of the Industrial Revolution that beginning in the 17th century[1].

The rise of earth temperature is caused by the Green House Gas (GHG) and carbon emission. The global temperature is continuing to rise, according to the Intergovernmental Panel on Climate Change (IPCC) [1], resulting in increased energy demand in buildings. In many nations, the construction industry is the largest consumer of electricity.

According to International Energy Agency (IEA, 2019), the global electricity consumption demand grows at 2.1% per year from 2018 to 2040. Historically, the growth of Malaysia demand from 2015 to 2020 is 16,822MW to 18,808MW, or at 2.3% annually. The COVID-19 pandemic had significantly reduced the overall demand in 2020. However, a new peak demand was recorded on 10 March 2020, just a week prior to the imposition of Movement Control Order on 18 March 2020. For the year 2021-2030 and 2030-2039, demand is projected to grow by 0.9% p.a. and 1.7% p.a. respectively[2]. See Figure *1.1*. As a result, Energy Saving Measures (ESMs) must be developed to reduce both energy consumption and emissions in the construction industry.

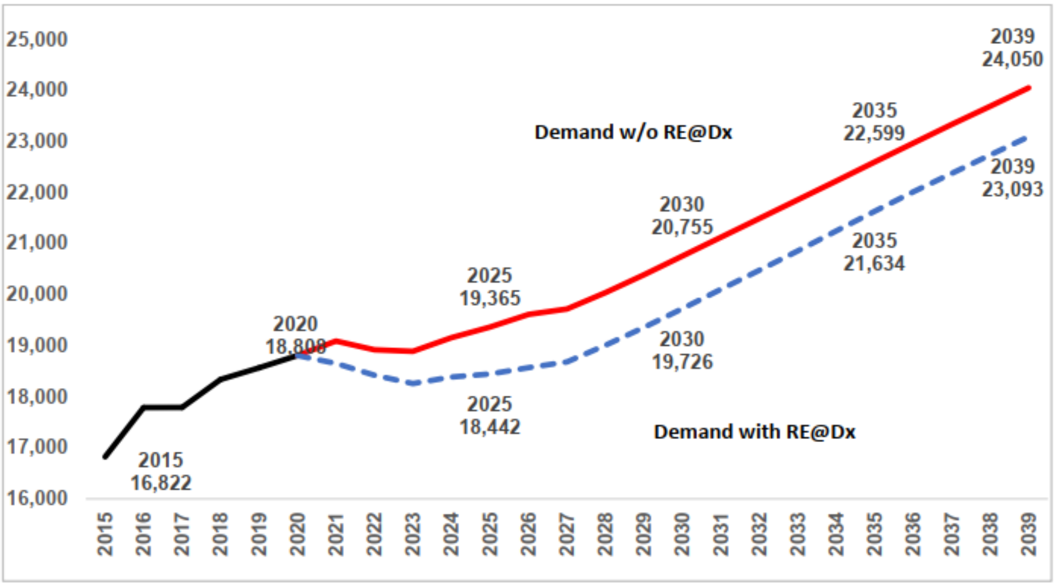


Figure 1.1 Peak Demand Actual 2015-2020 and Projection 2021-2039

In The Twelfth Malaysia Plan (12MP) from 2021 to 2025, Malaysia government continues to focus on aspects of energy management and renewable use for the generation of national electricity resources. This policy is implemented currently chaired by YB Datuk Seri Dr Shamsul Anuar bin Hj. Nasarah, Minister of Energy and Natural Resources.

The Government has revised the national Renewable Energy (RE) capacity mix target from 20% to 31% by 2025 for Malaysia decided by the Jawatankuasa Perancangan dan Pelaksanaan Pembekalan Elektrik dan Tarif (JPPPET) meeting held on 20 October 2020. The Government has also included large hydro resources as part of RE definition for Malaysia, consistent with practices adopted by other countries internationally. Current large hydro capacity in Malaysia stands at 5,684MW with Peninsular Malaysia contributes about 2,232 MW[2].

Several potential prospects for energy efficiency for cost-effective energy saving measures to reduce Green House Gases (GHG) and carbon emissions have been identified. One of the strategies implemented is apply ESMs through energy audit program that is often used to audit if energy has been used in an efficient way.

An energy audit is a method of determining how and where energy is consumed, how to manage it, and how much energy may be saved in a building or business[3]. This audit can assist building owners and operators in determining how much energy the facility consumes, where energy is lost, and which problem areas and improvements should be prioritized in order to make the structure more energy efficient.

The four purposes of audits are to clearly analyze energy consumption costs, to track how energy is used and wasted, to find consumption alternatives such as overhaul operations or use new equipment that can reduce energy costs and to conduct economic analysis on those alternatives[4].

Ali Alajmi[5] in his research, discovered that energy audits enable building owners to determine whether new energy-efficient equipment is suitable for their existing structure. Frequent energy audits and ongoing commissioning can improve operating efficiency and close the gap between expected and actual building performance.

## 1.2. Research Background

Malaysia has taken several pragmatic approaches to address the adverse impact from climate change caused by GHG and carbon emission. For instance, Malaysia has taken a constructive role by introducing the Energy Management Policy in commercial and industrial buildings to minimize energy waste as an effort to reduce GHG and carbon emissions.

In comparison with 2005 level, the Peninsular Malaysia power sector is set to reduce its emission intensity (of GDP) by 45% in 2030, which is in line with Malaysia's commitment in the 21$^{st}$ Conference of the Parties COP21 in Figure *1.2***.** Power sector commitment in providing sustainable energy pathway expected to continue in the future with a downward trajectory of emission intensity to 65% in 2039.

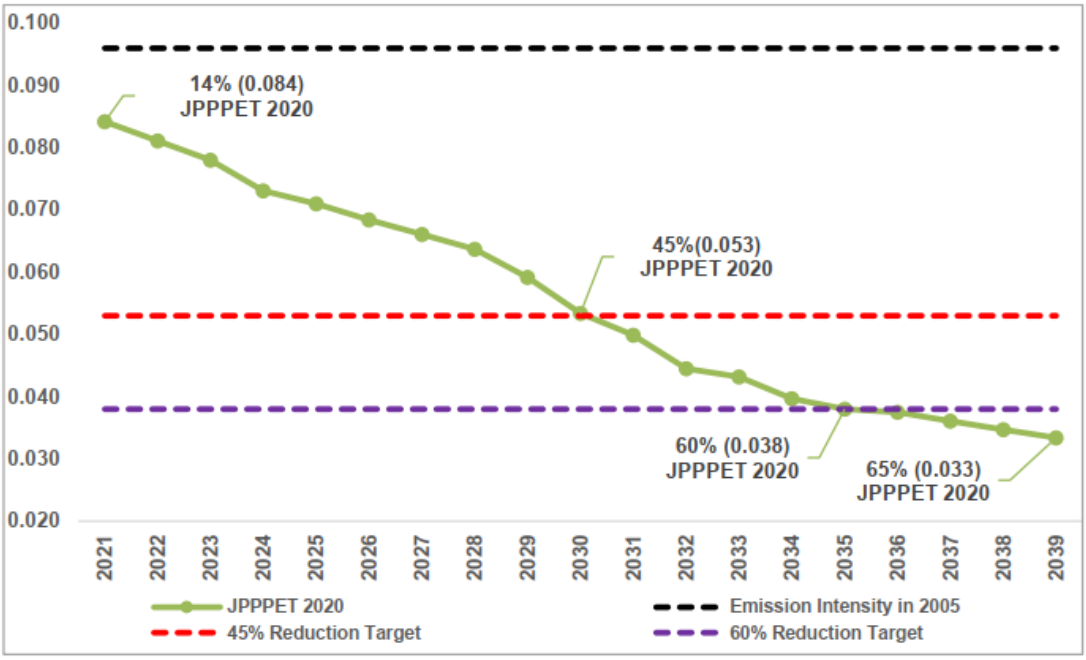


Figure 1.2 Carbon Emission Intensity Projection (kgCO2/RM) (2021-2039) for Peninsular Malaysia Power Sector

The National Energy Policy was also created to meet three goals which are providing a sufficient, safe, high-quality, and cost-effective energy supply, promoting energy efficiency, and ensuring that environmental considerations are included in energy production and usage[6].

The Efficient Electricity Management Regulations 2008 (EMEER 2008) is the legislation applicable to any establishment (building, industry, etc.) that uses electricity equivalent to or exceeding 3,000,000 kWh or more in any period not exceeding 6 consecutive months- also and came into force since December 2008 under the "Electricity Supply Act 1990."[7]. According to the rule, every installation meeting those conditions must conduct an energy audit, monitor use, implement efficiency initiatives, and submit status reports to Malaysia's Energy Commission (EC).

According from Malaysian Green Technology and Climate Change Centre (MGTC), electricity generation by the electric power industry in Peninsular Malaysia indicated that the production of greenhouse gases (GHG) from each kilowatt hour of electricity (kWh) involved a carbon emission rate of 0.694 kgCO2. In other words, energy saving in annual electricity consumption of 45,000 kWh is expected to reduce CO2 gas production by 31,230 kgCO2 per year. With the implementation of energy audit in an institution, able to reduce operation costs and be able to improve the performance of a better environment.

Energy efficiency standard index guided by building conservation practice policy, MS1525 namely Energy Efficiency and use of Renewable Energy for Non-Residential Buildings – Code of Practice. The Building Energy Index (BEI) is a formula that divides a building's total yearly energy consumption in kilowatt hours (kWh) by its floor area in square metres (m2). The BEI for a typical office building in Malaysia is 210kWh/m2 per year[8]. To obtain a standard building energy index efficiency, energy audits are used to regulate the use of electricity.

The goal of the energy audit is to examine the building's energy use by going over the audit in depth. In this regard, an energy audit is essentially a process of assessing the kinds and prices of energy usage in a structure, examining where energy is used in a building or plant, and suggesting ways to minimize consumption. The cost of the audit is proportional to the amount of data gathered and processed, as well as the number of conservation possibilities detected.

### 1.3. Problem Statement

Institut Latihan Perindustrian (ILP) Tangkak, under Jabatan Tenaga Manusia, Kementerian Sumber Manusia was established to provide formal technical training to industrial sector workers and secondary school leavers to enable them to gain skills in certain field. ILP Tangkak has 4 departments covering administration and library unit, electronic department, welding department and manufacturing department. The ILP was started operation in 13 Oktober 2000 built on 50 acres near the town of Sagil and can accommodate up to 600 students at a time. Since the commencement of operations, ILP Tangkak has never conducted an energy audit.

Wastage of electricity energy needs to be avoided to cut down energy costs of the building. The issue of rising electricity tariff prices, the increasing number of staff and students, changes in building operations, upgrading of infrastructure and upgrading of existing buildings will make electricity cost rising. This issue is a challenge to the management of the institute because it needs to reduce the cost of operation and at the same time must maintain and improve existing facilities.

The ILP does not yet have an energy audit team to carry out work to ensure energy is used at high efficiency and reduces wastage of energy consumption. However, several energy saving measures have begun to be implemented through the implementation of EKSA practices which have been introduced to all government agencies under the electricity saving clause.

Therefore, it is required to conduct an energy audit includes a study of lighting system operations, that have an impact on energy usage in order to identify areas where energy costs may be reduced. However, the implementation of ESMs after energy audit will be present. The further study about implementation of ESMs in lighting systems must be carried out.

Thus, an energy audit of an existing building is a well-known approach for allowing suitable and inexpensive retrofits to increase building energy efficiency and reduce GHG emissions. This is because high energy consumptions have some implications towards GHG emission.

## 1.4. Objectives of The Study

The objectives of this research are:

1. To study on the power and illuminance level for lighting.
2. To propose energy efficiency strategy of lighting system.
3. To evaluate the proposed strategy in terms of techno-economic performance.

## 1.5. Scopes of The Study

In order to achieve the research objectives, the following scopes of this research have been considered:

1. Collecting data of lighting energy consumption for Library.
2. Retrofitting of lighting on Library based on simulation study in accordance to the MS1525 standard.
3. The technical analysis involved two lamp technologies (two types of LED lamps)
4. The economic analysis includes payback period and life cycle cost analysis.

## 1.6. Significance of The Study

The significances of the energy audit are to understand current energy management practices, reduce the energy consumption without compromising safety, comfort and quality of the facilities. The owner of the building or industry also can understand the energy consumption in their premise, establish baseline energy performance and identify area of energy wastage and potential energy improvement.

At the same time, compliance with Electrical Energy Regulations 2008 (EMEER 2008) can be complied if the use of electricity consumes equal to or exceeding 3,000,000 kWh or more over any period not exceeding 6 consecutive months.

The proposed method research is fully complied with the Malaysian Standard MS 1525 in terms of average illuminance level. Various lamps will be tested to get more energy efficient and economical lamps. It can also be implemented in all types of building sectors, which are residential (e.g., landed houses), commercial (e.g., offices, hotels, schools, and hospitals), and industrial (e.g., factories) in order to reduce power consumption and improve visual comfort.

Besides, application of ESMs can improve the energy efficiency of electrical equipment in the building. It also provides greenhouse gas reductions of the built environment all around the world. As the last, energy audit system can be further expanded to commercial and residential buildings.

# CHAPTER 5

## CONCLUSION AND RECOMMENDATION

### 5.1 Conclusion

This chapter provides conclusions that will reflect the objectives of this study. In conclusion, this energy audit project has been successfully completed and the three objectives of this research have been achieved. The objectives which are to study the power and lighting levels for lighting in Institut Latihan Perindustrian Tangkak, propose energy efficiency strategies of lighting systems using 2 types of LEDs and lastly propose strategies in terms of techno-economic performance were evaluated. This energy audit focused on the library by retrofit the lights based on a simulation study using according to the MS1525 standard. The retrofitting process can provide more energy savings to this library and reduce carbon emissions to the environment. Based on illuminance performance results, to achieve the MS 1525 standard, only 213 lighting units are required if using T8 LED lights, while 138 lighting units are required if using T5 LEDs. Based on energy performance results, T5 LEDs contribute the highest energy savings compared to T8 LEDs which is 11.5% more than T8 LEDs. In terms of economic performance, T8 LED lighting technology shows lower *PP* and *LCC* values compared to T5 lighting technology respectively, but *ALCC* values using T5 LED lighting technology shows lower value compared to T8 LED lighting technology.

### 5.2 Recommendation

Future studies are suitable to be conducted on other appliances that contribute to high energy consumption such as air conditioners or chillers. The study can also be extended to other buildings such as administration, workshops and hostels. The use of advanced energy efficient technology in the lighting system is also suitable for the application. A comprehensive study will be able to produce better energy consumption analysis and more energy saving opportunities will be obtained in the future.

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