TECHNO-ECONOMICAL FEASIBILITY STUDY OF RETROFITTING UNIKL MICET OFFICE WITH OPTIMISED ENERGY-EFFICIENT LIGHTING

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TOWARDS GREEN AND SUSTAINABLE BUILDINGS (www.micet.unikl.edu.my/mgeeb)
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2. LITERATURE REVIEW
3. METHODOLOGY
4. RESULTS & DISCUSSION
5. CONCLUSIONS & RECOMMENDATION

TOWARDS GREEN AND SUSTAINABLE BUILDINGS (www.micet.unikl.edu.my/mgeeb)
INTRODUCTION

The energy audits carried out by Pusat Tenaga Malaysia (PTM) of office buildings in Malaysia revealed that the majority of Malaysian office buildings had Building Energy Use Index (BEI) in the range of 200 to 250 kWh/m²/yr. Office buildings are not only a major consumer of energy, but also a significant contributor of CO2 emissions.
INTRODUCTION

LITERATURE REVIEW

METHODOLOGY

RESULTS & DISCUSSION

CONCLUSIONS & RECOMMENDATION

Sustainable Iskandar Portal

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Malaysian Office Buildings
Continuous improvement of Energy Efficiency

LEO building (Putrajaya)

ZEO building (Bangi)

EC Building (Putrajaya)

Energy Indices (kWh/m²/year)

Normal buildings (Kuala Lumpur)

Typical Consumption
200 – 300 kWh/m²/year

Benchmark year: 2001

LEO Building 2006

EC Building

ZEO Building (2015)

(http://sustainableiskandar.com.my/)
Manual switch on/off lighting control system are typically used for Malaysian office buildings. Excessive and inappropriate use of artificial lighting contribute as wastage energy. Daylight is a renewable source, availability in Malaysia is relatively high and constant all year round.
OBJECTIVES

To reduce lighting energy consumption in the room using daylight dimming lighting control

Technical aspect

To determine return on investment (ROI)

Economic aspect

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SCOPE OF STUDY

- Postgraduate room in UniKL MICET
- Focused on energy efficiency upgrades scenario in the existing room.
- During working hours only (8.00 am till 5.00 pm)
- Various sky conditions
- Windows without blinds.
Li & Lam 2001 suggested daylight dimming control system can result in substantial energy savings in air-conditioned office buildings in Hong Kong. Comparative with the artificial lighting energy expenditures, the amount of energy savings due to day-lighting was 0.3 kWh/m² per week and 15.7 kWh/m² per year. It was found that percentage of energy savings in artificial lighting could be up to 50% for the perimeter offices. Moreover, it is envisaged that further electricity savings can be realised because of the reduction of heat gain from artificial lighting and hence, lower cooling load.

Li 2008 good quality of daylight provides not only more attractive and pleasing environment in interiors, but also creates a better indoor environment to improve working performance.
**INTRODUCTION**

**LITERATURE REVIEW**

**METHODOLOGY**

**RESULTS & DISCUSSION**

**CONCLUSIONS & RECOMMENDATION**

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**Table 1: Recommended average illuminance levels based on MS 1525:2007**

<table>
<thead>
<tr>
<th>Example of applications</th>
<th>Illuminance (Lux)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrequent reading and writing</td>
<td>200</td>
</tr>
<tr>
<td>Drawing office</td>
<td>300-400</td>
</tr>
<tr>
<td>General offices, shops and stores, reading and writing</td>
<td>300-400</td>
</tr>
<tr>
<td>Class room, Library</td>
<td>160 (240)</td>
</tr>
</tbody>
</table>

---

**Authors**  | **Year** | **Literature review**
---|---|---
Shen *et al.* | 2013 | visual comfort is gauged in terms of ability to maintain the illuminance in the desired range and daylight glare index below the acceptable norm.

Lu *et al.* | 2010 | key challenge is to provide stable levels of illumination even though natural light is not a stable light source: an office should have enough light to read and work, but **not so much that it causes glare and discomfort**.

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ROOM & SYSTEM DESCRIPTION

ROOM
Height: 2.71m
Floor area: 19.13 m²
Room volume: 51.84 m³

WINDOW
Orientation: North-east
Components: Single-pane, aluminium frame, and float glass
Dimension of single pane window: 113 cm high x 73 cm wide

LIGHTING
Ceiling-mounted fluorescent lights using class ‘C’ magnetic ballasts (10W)
Each luminaire: 2 x36W tube (T8 Fluorescent) and standard diffusers.

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To monitor energy consumption of electricity, two digital energy meter (model ADM-25S, supplied by: Andeli Group Co. Ltd) was fitted to the power switch of the **single-phase AC unit** and lighting system.

The electricity consumption of the air conditioner and lighting system was recorded at **15 min intervals** from **8.00 am to 5.00 pm** Monday to Friday.

The **specific energy consumption (SEC)** was determined from the slope of a linear trend line equation fitted onto electricity consumption versus time.

The result of energy consumption of both air conditioning and lighting were compared **before and after retrofitting**.
The dimmable electronic ballast was installed into the lighting fixture replacing constant electronic ballast.

Photosensors were installed at the front of the fitting.

A hole was drilled into the fitting to clip the filter cap in.

On the output side, the wires were connected to the lamps.

Photosensor was clipped into filter cap from the rear.
DATA ANALYSIS
(energy consumption)

\[
EC_{\text{lighting}} = \frac{N \times W \times OH}{1000}
\]

EC\text{lighting} is the total energy consumption of lighting system [kWh]

N is number of lamps

W is power used per fixture [W]

OH is the operation hour of the lighting [hour].

- The SEC [kWhr / hr] of the lighting was determined from the slope of a linear trend line equation fitted onto experimental data of lighting energy consumption versus time.
DATA ANALYSIS
(economical analysis)

\[ AES = AEC_{\text{baseline}} - AEC_{\text{improved}} \]  

(2)

\[ N_i = \frac{TI}{AES \times EC} \]  

(4)

AES - annual energy savings of lighting after retrofitting [kWh],
AEC_{baseline} - annual energy consumption of existing lighting system [kWh],
AEC_{improved} - annual energy consumption of improved lighting system [kWh].

\[ N_i \] - payback period for case \( i \) [years],
TI - total investment [RM],
EC - electricity cost [RM / kWh].
DATA ANALYSIS (reduction of CO₂ emission)

- CO₂ is the primary greenhouse gas produced through human activities.

- Hence, decreasing the CO₂ emissions are important to the world by decreased the combustion of fossil fuels which can be achieved through lower energy consumption.

- The reduction of CO₂ emission (ER) is reduction of CO₂ equivalent being released to the atmosphere (RA) because of decreased electrical energy consumption (EC).

- Based on typical energy mix for Malaysia, the CO₂ released to atmosphere (RA) is 0.62 tonnes CO₂ / MWh (Ministry of Natural Resources and Environment Malaysia 2011).

\[
ER = EC \times RA
\] (5)
Li & Lam (2001), Ihm *et al.* (2009), Saksit & Chuntamara (2011), Williams *et al.* (2012) showed that energy savings of 20 % to 60 % associated with lighting can be achieved by using daylight dimming control system.

<table>
<thead>
<tr>
<th>Day</th>
<th>SEC before retrofitting [kWhr/hr]</th>
<th>R²</th>
<th>Weather</th>
<th>SEC after retrofitting [kWhr/hr]</th>
<th>R²</th>
<th>Weather</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mon</td>
<td>0.1605</td>
<td>0.9951</td>
<td>Sunny</td>
<td>0.0892</td>
<td>0.9849</td>
<td>Sunny</td>
</tr>
<tr>
<td>Tue</td>
<td>0.1594</td>
<td>0.9949</td>
<td>Sunny</td>
<td>0.0932</td>
<td>0.9848</td>
<td>Sunny</td>
</tr>
<tr>
<td>Wed</td>
<td>0.156</td>
<td>0.9942</td>
<td>Sunny</td>
<td>0.0928</td>
<td>0.9862</td>
<td>Cloudy</td>
</tr>
<tr>
<td>Thu</td>
<td>0.1553</td>
<td>0.9949</td>
<td>Cloudy</td>
<td>0.093</td>
<td>0.9866</td>
<td>Sunny</td>
</tr>
<tr>
<td>Fri</td>
<td>0.1572</td>
<td>0.9951</td>
<td>Sunny</td>
<td>0.0938</td>
<td>0.9856</td>
<td>Sunny</td>
</tr>
<tr>
<td>Mon</td>
<td>0.1525</td>
<td>0.9941</td>
<td>Sunny</td>
<td>0.0943</td>
<td>0.9862</td>
<td>Sunny</td>
</tr>
<tr>
<td>Tue</td>
<td>0.1558</td>
<td>0.995</td>
<td>Sunny</td>
<td>0.0931</td>
<td>0.9806</td>
<td>Rainy &amp; sunny</td>
</tr>
<tr>
<td>Wed</td>
<td>0.1565</td>
<td>0.9947</td>
<td>Sunny</td>
<td>0.106</td>
<td>0.9894</td>
<td>Cloudy &amp; rainy</td>
</tr>
<tr>
<td>Thu</td>
<td>0.1516</td>
<td>0.9949</td>
<td>Cloudy &amp; rainy</td>
<td>0.0955</td>
<td>0.9872</td>
<td>Sunny</td>
</tr>
<tr>
<td>Fri</td>
<td>0.1613</td>
<td>0.9953</td>
<td>Sunny</td>
<td>0.0955</td>
<td>0.9872</td>
<td>Sunny</td>
</tr>
<tr>
<td>Ave</td>
<td></td>
<td></td>
<td></td>
<td>0.1566</td>
<td>0.9946</td>
<td></td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.0022</td>
<td></td>
<td></td>
<td>0.0018</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SEC savings: 40%
## Introduction

**ENERGY CONSUMPTION FROM AC ENERGY**

<table>
<thead>
<tr>
<th></th>
<th>BEFORE RETROFITTING</th>
<th>AFTER RETROFITTING</th>
<th>Weather</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SEC [kWhr/hr]</td>
<td>R²</td>
<td>T&lt;sub&gt;room&lt;/sub&gt; (°C)</td>
<td>SEC [kWhr/hr]</td>
<td>R²</td>
</tr>
<tr>
<td><strong>Mon</strong></td>
<td>0.8697</td>
<td>0.9996</td>
<td>26.65</td>
<td>Sunny</td>
<td>0.8533</td>
</tr>
<tr>
<td><strong>Tue</strong></td>
<td>0.8806</td>
<td>0.9995</td>
<td>28.04</td>
<td>Sunny</td>
<td>0.867</td>
</tr>
<tr>
<td><strong>Wed</strong></td>
<td>0.8408</td>
<td>0.9992</td>
<td>27.93</td>
<td>Sunny</td>
<td>0.8436</td>
</tr>
<tr>
<td><strong>Thu</strong></td>
<td>0.8437</td>
<td>0.9966</td>
<td>27.48</td>
<td>Cloudy</td>
<td>0.8358</td>
</tr>
<tr>
<td><strong>Fri</strong></td>
<td>0.8554</td>
<td>0.999</td>
<td>28.78</td>
<td>Sunny</td>
<td>0.8674</td>
</tr>
<tr>
<td><strong>Mon</strong></td>
<td>0.8763</td>
<td>0.9996</td>
<td>28.92</td>
<td>Sunny</td>
<td>0.8975</td>
</tr>
<tr>
<td><strong>Tue</strong></td>
<td>0.8935</td>
<td>0.9997</td>
<td>28.86</td>
<td>Sunny</td>
<td>0.846</td>
</tr>
<tr>
<td><strong>Wed</strong></td>
<td>0.8546</td>
<td>0.9996</td>
<td>26.71</td>
<td>Sunny</td>
<td>0.8438</td>
</tr>
<tr>
<td><strong>Thu</strong></td>
<td>0.8578</td>
<td>0.9997</td>
<td>27.82</td>
<td>Cloudy &amp; rainy</td>
<td>0.8664</td>
</tr>
<tr>
<td><strong>Fri</strong></td>
<td>0.9022</td>
<td>0.9997</td>
<td>28.85</td>
<td>Sunny</td>
<td>0.8536</td>
</tr>
<tr>
<td><strong>Ave</strong></td>
<td>0.8675</td>
<td>28.0±0.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Std. Dev.</strong></td>
<td>0.017</td>
<td></td>
<td></td>
<td></td>
<td>0.014</td>
</tr>
</tbody>
</table>

**SEC savings**: 1%
AVERAGE ROOM TEMPERATURE BEFORE & AFTER RETROFITTING LIGHTING

![Graph showing room temperature before and after retrofitting lighting](#)

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# ELECTRICITY CONSUMPTION, ENERGY SAVINGS, RETURN ON INVESTMENT CALCULATIONS AND CO2 AVOIDED FOR ENERGY-EFFICIENT LIGHTING

<table>
<thead>
<tr>
<th>Lighting Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>$P_{\text{lamp}}$ (T8 73lm/watt, Class ‘C’)</strong></td>
<td>36 Watt</td>
</tr>
<tr>
<td><strong>$P_{\text{ballast}}$ (T8)</strong></td>
<td>10 Watt</td>
</tr>
<tr>
<td><strong>$P_{\text{total}}$ (lamp+ballast)</strong></td>
<td>46 Watt</td>
</tr>
<tr>
<td><strong>No of lamps</strong></td>
<td>4</td>
</tr>
<tr>
<td><strong>Operation hour (9am-5pm)</strong></td>
<td>8 hours</td>
</tr>
<tr>
<td><strong>$E_{\text{total,day}}$</strong></td>
<td>1.472 kWh</td>
</tr>
<tr>
<td><strong>Electricity Tariff (RM / kWh)</strong></td>
<td>RM 0.312 /kWh</td>
</tr>
<tr>
<td><strong>$E_{\text{C_day}}$</strong></td>
<td>RM 0.46 /day</td>
</tr>
<tr>
<td><strong>$E_{\text{C_year}}$ (normal working days)</strong></td>
<td>RM 111.60 / year</td>
</tr>
<tr>
<td><strong>Calculation after retrofitted lamp with photo sensor (energy consumption)</strong></td>
<td>RM 44.64 / year</td>
</tr>
<tr>
<td><strong>40 % energy saving by using photo sensor</strong></td>
<td>RM 44.64 / year</td>
</tr>
<tr>
<td><strong>ROI</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total Investment</strong></td>
<td>RM 790.50</td>
</tr>
<tr>
<td><strong>$\text{ROI} = \frac{\text{Total Investment}}{\text{Savings per year}}$</strong></td>
<td>17 years 8 months</td>
</tr>
</tbody>
</table>

- Annual energy savings per year:
  
  $$\text{Annual energy savings per year} = 40\% \times 1.472 \text{ kWh} \times 243 \text{ days (working days)} = 143.08 \text{ kWh per year}$$

- Avoided CO₂ per year:
  
  $$\text{Avoided CO₂ per year} = 143.08 \text{ kWh per year} \times 0.62 \text{ kg CO₂ / kWh} = 88.71 \text{ kg per year}$$

*Based on typical 0.62 tonnes CO₂/MWh from gas fired power plants*
CONCLUSION

- Energy consumption decreased by 40% after retrofitting of the lighting.

- Room temperature and energy consumption of air conditioner also decreased by 0.7°C and 1%, resp. with the same temperature set point before and after installation of daylight dimming control system.

- The ROI of 17 years 8 months too long to recover cost of investment in energy efficient lighting system.

- Hope that these study findings will promote all UniKL campuses and public used energy efficient lighting and equipment thus the price of green products will be decreases.

- It is suggested to use one photosensor to control many lamps to reduce investment cost.

- The contribution of dimming (photosensor) and electronic ballast to energy consumption of light fixture should be determined.
Electricity tariffs to go up 10%-20% next year

Move in line with Government’s plan to gradually cut subsidies, says Ongkili

The move, he said, would be in line with the Government’s plan to gradually cut subsidies. It would also be in line with its efforts to boost efficiency and competitiveness in the Malaysian power industry, as well as to ensure sufficient returns to capital for utility company Tenaga Nasional Bhd to cover its costs.

A tariff hike will see rates for both industrial and households increase, but any hike for businesses will be mitigated against the need for them to remain competitive.

A home appliance that is rated at 1,000 watts, if left switched on for one hour, would use 1 kilowatt-hour (kWh) of electricity. A 10%-20% hike would translate into an increase of 3.35 sen/6.7 sen per kWh to 36.85 sen/40.2 sen per kWh.

This is based on the prevailing tariff rate of 33.5 sen per kWh, which is about 8.5 sen below the “true cost” of power at 42 sen per kWh.

In comparison, electricity tariffs in the Philippines and Thailand are 58 sen per kWh and 48 sen per kWh respectively.

Ongkili said the Government would implement a “stabilisation” programme to protect consumers, especially the low-income group, when the tariff hike takes effect.

Details of the programme have yet to be finalised.

The electricity tariff was last increased in June 2011 after the Government raised the subsidised gas price for the power sector to RM1.20 per million metric British thermal unit (mmBTU) from RM1.07 per mmBTU.

Gas accounts for about 50% of electricity generation in peninsular Malaysia. Costs accounts for 40%, hydropower about 30% and renewable sources around 2%.

Subsidies for the power sector are RM5.8 billion to RM12.8 billion per year, depending on the prevailing price of gas.

The Government’s share is RM0.5 billion and the rest is borne by Malaysian oil and gas company Petronas National Bhd.
Sumbangan satu peratus untuk dana pembangunan tenaga boleh baharu

**Pengguna penentu tenaga bersih**

**SECARA** dasarnya, peralihan kepada penggunaan sumber tenaga boleh baharu (TBB) bukan sahaja imanu mengurangkan keberkalan berterusan kepada sumber tenaga asli, malah secara tidak langsung membantu menyelamatkan bumi daripada terus menghadapi perubahan iklim secara mendadak.

Penggunaan alternatif tenaga bersih merupakan alternatif penting bagi menangani masalah pencemaran. Menyediakan kepelbagaian, keterbukaan dan kebebasan bagi agensi berkaitan tenaga bersih ialah satu cara yang efektif dalam industri bekalan tenaga elektrik negara.

**Berdasarkan perangkaan, lebih 90 peratus bekalan elektrik di Malaysia ketika ini disediakan oleh bahan api fosil seperti arang batu, minyak dan gas alam.**

Menyusutnya kecepatan kebangkitan kepada Tenaga Terapkan Perubahan iklim dihabisi dunia kini. Fakta ini mencerminkan pergerakan kearah akan mencari peluang untuk melakukan perubahan kepada sumber tenaga elektrik daripada sumber boleh baharu seperti solar, biohaz, biogas dan hidro kecil.

Sumber tenaga alternatif ini disampaikan kepada lima peratus dan ini peratus melalui campuran bekalan sumber tenaga negara menyelesaikan menjelang tahun 2015 dan 2020.

**Sumber tenaga**

Dengan meningkatkan penggunaan bekalan TBB, ini secara tidak langsung dapat mengurangkan keberkalan berterusan terhadap sumber tenaga boleh baharu. Oleh itu, untuk membantu menjaga konsep penting seperti arang batu, minyak dan gas alam.

Buat program penempahan tenaga bersih adalah keperluan yang penting. Menyediakan kepelbagaian, keterbukaan dan kebebasan bagi agensi berkaitan tenaga bersih ialah satu cara yang efektif dalam industri bekalan tenaga elektrik negara.

**PENGUNA PENENTU TENAGA BERSIH**

*Bapaian ansa* untuk dana pembangunan tenaga boleh baharu (TBB) bukan sahaja imanu mengurangkan keberkalan berterusan kepada sumber tenaga asli, malah secara tidak langsung membantu menyelamatkan bumi daripada terus menghadapi perubahan iklim secara mendadak.

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THANK YOU
REFERENCES


