UNIVERSITI TEKNIKAL MALAYSIA MELAKA

COST OF OWNERSHIP FOR EFFICIENCY LIGHTING ANALYSIS

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (Industrial Power) (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Industrial Power) (Hons.). The member of the supervisory is as follow:

Herlanda Windiarti
(Project Supervisor)

ABSTRAK

Kajian ini menunjukan tenaga dan duit yang boleh dijimat melalui sistem lampu di 7 ELEVEn Taman Kota Laksamana(TKL), Malaysia. Didapati 7 ELEVEn Taman Kota Laksamana(TKL), Malaysia yang masih menggunakan lampu jenis fluorescent. Kos analisis dilakukan dari segi tenaga yang boleh dijimatkan, jangka hayat lampu dan kos yang melibat sepanjang masa jangka hayat lampu. Rujuk dari MS1525, tahap cahaya yang tertinggi yang boleh diterima di kedai runcit adalah 500lux dengan mengunakan lampu LED T8 30W 3000Lm(CH-T8N-5730W-88-A3) boleh jimat 12.6% dalam sepuluh tahun banding dengan lampu Philips T8 3250Lm (TL-D 36W/827 1SL) sedia ada. Manakala dengan cahaya minimum yang boleh diterima dalam MS1525, Lampu LED T8 18W 1800Lm (CH-T8N-2835W-96-A3) boleh jimat sebanyak 46.8% sepanjang sepuluh tahun banding dengan lampu Philips T8 3250Lm (TL-D 36W/827 1SL) sedia ada. Lampu LED adalah pilihan yang paling jimat pada masa jangka panjang. Kesimpulan dari Analisis menunjuk sistem lampu yang bercekapan tinggi boleh membawa faedah dari segi penjimatan tenaga dan wang secara tak langsung mengurangkan pencemaran sekitar.

ABSTRACT

This study presents the potential energy saving of total cost of ownership through the lighting system in 7 ELEVEn Taman Kota Laksamana(TKL), Malaysia. The survey results indicate that most of the lighting system at 7 ELEVEn Kota Laksamana consists of fluorescent lamp. Cost benefit analysis of alternate choice with more efficiency lighting system in terms of potential energy can be save, life cycle cost of ownership analysis have been conducted. Highest range of brightness at average 500lux are required according to MS1525, using new LED T8 30W 3000Lm (CH-T8N-5730W-88-A3) Fluorescent lamp can save approximate 12.6% of costing over ten years duration compare to existing Philips T8 3250Lm (TL-D 36W/827 1SL). While minimum brightness at 200lux accepted according to MS1525, by using LED T8 18W 1800Lm (CH-T8N-2835W-96-A3) fluorescent lamp was the best choice with same fitting by reducing approximate 46.8% of total cost compare to existing Philips T8 3250Lm (TL-D 36W/827 1SL) fluorescent lamp. LED fluorescent are most efficient lighting choice refer to lux/watt , but higher initial cost may be part of the factor result investor take more time to consider using LED technology. Comparison of existing and retrofitting of lighting system based on the energy consumption is presented. From the analysis, it can be concluded that by using energy efficient lighting system has save a significant amounts of energy, cost, and also indirectly reducing emission.

DEDICATION

To my beloved parents, supervisor and friends

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

ROI	-	RETURN OF INVESTMENT
CLF	-	Compact Fluorescent Lamps
LED	-	Light Emitting Diode
MS1525	-	Malaysian lighting Standard
TKL	-	Taman Kota Laksamana
IR	-	Infrared
HID	-	High-Intensity Discharge
LCS	-	Lighting Control System
EC	-	Energy Consumption
GWh	-	Giga Watt hours

CHAPTER 1
INTRODUCTION

1.1 Background

This chapter describes the background of the study for Cost of Ownership efficiency lighting analysis. Brightness of lighting system in 7 ELEVEn are extremely bright when compare to other convenient store. The existing maintenance practice in 7 ELEVEn TKL is Failure based maintenance on lighting maintenance. The Staff will report to Head quarter when there is any damage occur on lighting. Normally when there is five unit of light fitting failure to function, replacement or maintenance work will be carry out by appointed contractor within a week from date of report. There is necessary to obtain a better lighting efficiency solution as part of our contribution to the society.

1.2 Problem Statement

One of the source of electricity consumptions in convenience stores are lighting system. Lighting efficiency research are needed to justify energy saving can be make. All convenience store need energy saving solution. The CEO of the convenience store can decide to buy the idea of energy saving base on their financial capabilities. The price of lighting efficient fixtures may fluctuate with respect of time**.**

1.3 Objective

There are two objective this research is mainly focus to determine best efficient lighting with suitable brightness and potential cost saving over 10 years of ownership.

1.4 Scope of work

The scope of this research work is to compare the energy consumption on existing lighting system with latest efficiency system for new technology lighting that able to achieve efficiency in a convenience store. The work focuses on cost of ownership analysis on existing T8 lighting system, T5 lighting system and LED lighting system. 7 ELEVEn located in Taman Kota Laksamana was used as a model where the research work was taken.

1.5 Contribution

To obtain more choice towards lighting efficiency concept for future convenience store reference.

1.6 Thesis Organisation

This report organize into five parts. Introduction were shown that the extreme brightness are the source that attracted author to do cost of ownership efficiency lighting analysis.

Second chapter is Literature review about different fact and idea from researcher to support lighting efficiency solution.

Third chapter is the Methodology conduct and the lighting efficiency analysis in 7 ELEVEn,

Fourth chapter is result and discussion found in 7 ELEVEn with cost of ownership over 10 years time frame,

Fifth chapter consist of conclusion. Author recommend replacing of high energy efficiency light fitting are practical in real life practice and lighting efficiency analysis can be taken in future work when there is new lighting technology or significant price drop.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

Recently many research works have been done on lighting efficiency by reducing energy consumption were presented by the researchers. In today's cost-competitive, market-driven economy, everyone is seeking technologies or methods to reduce energy expenses and environmental impact. Because nearly all buildings have lights, lighting retrofits are very common and generally offer an attractive return on investment. (John Fetters, 2004).

2.1.1 Lighting Guidance

There are several types of lighting application in the market that are relevant to this research.

2.1.1.1 Type of Lighting Technology

First is Incandescent Lighting Technology invented by Thomas Edison, the first commercialized electric lighting technology in year 1879. This incandescent lamps come in two general choice:

- Standard Incandescent Lamps are Inefficient but used in many applications throughout a facility.

- Halogen Lamps are more advanced incandescent lamp technology normally used to highlight merchandise and architectural features due to white light and "sparkle"

Second is Compact Fluorescent Lamps (CFLs) that have been specifically made in a compact form to replace incandescent lamps in traditional screw-in fixtures. These energy-efficient lamps come in a variety of styles and sizes are suitable for a different type of applications. ENERGY STAR(U.S. Department of Energy 2006) qualified CFLs use 75% less energy than a standard incandescent bulb and last up to 10 times longer. Replacing a 100-watt incandescent with a 32-watt CFL can save approximately $30 in energy costs over the life of the bulb (Rosslyn, 2001).

The long life of CFLs are easy to replace. In addition, CFLs are cool to touch, making them safer than hot incandescent and halogen lamps during operation.

Third is Improved Halogen Systems, many incandescent lamps can be replaced with halogen lamps for improvement in efficiency and service life. Many standard halogens (aside from some specialty applications) can be replaced with high performance "Infrared" (IR) halogen lamps. These lamps work by increasing the operating temperature of the halogen lamp, increasing efficiency. Though more efficient than other incandescent and halogen lamps, these lamps are still inferior in efficiency to fluorescent and HID lighting systems.

Fourth is Fluorescent Lighting is the "standard" technology for lighting spaces such as offices and classrooms, and is up to four times more efficient than the incandescent lamp. However, older, obsolete fluorescent lighting systems can result in poor light quality and flicker. Advancements in fluorescent lighting systems have resulted in the introduction of new systems that provide improved energy efficiency, lighting quality, and design flexibility

The primary components of standard fluorescent lighting systems are the ballast, which modifies incoming voltage and controls electrical current, and the lamp (bulb or tube), the source of artificial light.

Traditional Systems:

- T12 Fluorescent Lamps: One of the most common, but least efficient fluorescent systems. T12 lamps can be identified by 1.5-inch diameter.
- Magnetic Ballasts: Magnetic ballasts are common and still used extensively today due to low initial cost. However, these ballasts are considerably less efficient than new electronic ballast designs and are prone to flicker and humming (particularly as they age).

Energy-Efficient Fluorescent Lighting Systems: These systems, using T8 (1" in diameter) and T5 (5/8" in diameter) lamps, offer improved efficiency, higher intensity, and potentially longer life due to reduced degradation in light output over time. T8 and T5 lighting systems are constantly increasing in flexibility and are now applicable to a variety of task and accent lighting applications, as well as general lighting of larger space (Rosslyn, 2001).

Energy-Efficient Electronic Ballasts: When specifying a fluorescent lighting system, always specify electronic ballasts. These ballasts provide near flicker-free operation while using up to 30% less energy than magnetic ballasts (Rosslyn 2001).

High-Intensity Discharge (HID) Lighting Systems. Due to intensity, HID lighting systems are useful for lighting large areas from high ceilings, and range from 50 to 2,000 watts each. Older HID installations are often mercury vapor lamps, an extremely inefficient design. Like fluorescent lamps, HID systems have ballasts, and systems built before 1978 may contain potentially harmful substances such as PCBs (Polychlorinated biphenyls) (Rosslyn, 2001).

2.1.1.2 Type of Lighting Controls

Controls are a key part of any lighting system. Specify controls that maximise the flexibility of your system while eliminating light usage, often automatically. Common controls include (Prashant, 2013) :

- Bi-level Switching: Control of a lighting system in groups of fixtures or lamps, for example bi-level switching allows user to turn-half of the lights in a room off when full illumination is not required. Bi-level switching is commonly used in offices, conference rooms, and classrooms.
- Dimmers: Dimming lighting systems allow user to control the amount of light and save energy. Dimmers are available for fluorescent and incandescent systems. Daylight dimmers are special sensors that automatically dim room lights based on the amount of free and natural daylight available. Dimmers are commonly used in conference rooms, classrooms, restaurants, and libraries.
- Occupancy Sensors: These sensors detect the motion of room occupants, turning off lights in unoccupied areas and turning them back on when movement is detected. Occupancy sensors are commonly used in restrooms, classrooms, and warehouses.
- Daylight Sensor (Photocells): A common inefficiency of exterior lighting systems is a tendency to "day burn." This is when lights are on during the day, wasting energy and money. This problem can be prevented by installing light-sensitive controls that turn the lights on and off automatically based on daylight, thus producing convenient energy savings. Timers can be used, but do not react to changing daylight conditions.

Daylight can be harvested by simply not blocking windows, and by dimming/turning off the lights based on available daylight throughout your facility. Common daylighting strategies include (Prashant, 2013):

- Controlling window light through blinds
- Sky lights and "sun tubes"

- Light shelves
- Daylight dimming systems

2.1.1.3 Future Lighting System Technologies

In the last 20 years, light-emitting diode (LED) lamps have advanced from being indicators on consumer electronics, to an increasingly versatile and efficient lighting source. LED lighting has the potential to provide high efficiency, durability, and extremely long life (Blomsterberg 2011). Currently, LED lighting is largely restricted to specialty uses such as accent lighting, LCD monitor backlighting, exit signs as well as use in traffic signals, vehicle brake lights, and strings of coloured holiday lights. However, as the technology becomes more accepted in the market, its uses will expand and costs will become more competitive. A specific kind of LED, the organic light-emitting diode (OLED) promises to make energy efficient and designable light panels that can be used in a wide variety of architectural applications.

2.2 Suitable Brightness

Suitable luminaries, the technical term called Lighting Power Density or LPD. During the study presented in the article (Friedrich 2011), there are two highly energy-efficient lighting scenarios for evening office lighting (i.e. electric lighting that is typically used for approximately 2 hour in the evening). The first of these lighting scenarios (referred to as “Reference”-scenario, Lighting Power Density or LPD of 4.5 W/m2) has been successfully in use in many office rooms of the Solar Energy and Building Physics Laboratory’s experimental building, located on the campus of the Swiss Federal Institute of Technology in Lausanne, for several years. The second lighting scenario (referred to as “Test”-scenario, Lighting Power Density of 3.9 W/m2) is more energy-efficient, creates higher workplace illuminances but leads to an increased risk of discomfort glare.

This study was to meticulously compare the two lighting scenarios in order to find a lighting solution for evening office lighting that offers an optimal trade-off

between energy-efficiency, visual comfort and visual performance. The two tested scenarios are comparable to usual lighting scenarios in other office rooms in terms of subjective visual comfort. The study participants preferred the “Test”-scenario to the “Reference”-scenario. The performance in a paper-based task was significantly better under the “Test”- scenario than under the “Reference”-scenario. No significant differences in the performance during two computer-based tasks were found. It show that energy-efficient lighting with Lighting Power Densities of less than 5 W/m2) is already achievable in today’s office rooms without jeopardising visual comfort and performance. Less powerful electric lighting systems do not necessarily mean a decrease in visual comfort or performance; the results even show that better visual comfort and better visual performance can be achieved with less connected lighting power, (Friedrich 2011). This research show that work does not required at very bright condition to show efficiency, but slightly reduce brightness may achieve visual comfort level and lighting efficiency purpose.

Mean while, the awareness of electricity usage should be concern as reminded the event of oil crisis occurs in 1973 and 1978 because recently, enormous energy consumption once again become seriously while the energy resources are greatly reduce. Although new orientation have been carrying out by the governments to encourage use of alternative energy such as bio fuel, solar energy and biomass. But overall, it is too technology fixed. Practically, there are two kinds of energy saving: technological fixes and operational changes. Technological fixes is instrument base such as using motion sensor control lighting and air seal. However, technological fixes only is a temporary solution, it require no behavior changes of the users, it mean the user still can waste energy in the same way. On the other hand, the operational changes are the soft technology that require changes of human behavior, include both the facility manager and user. It is flexible and not so expensive compare to the previous. This research tends to explore the operational changes by examining the awareness of human being on energy conservation. The objectives of this research are to identify the factors that affect energy awareness and to develop an energy awareness conceptual and process model. Literature review and analysis will be carrying out to achieve the first and second objectives, the third objective will be achieved by using the questionnaire distribution and model evaluation. Expected

output of this thesis is the energy awareness development process model. The rational of the study are possibility of the model to advance the energy management to a new level, provides a systematic energy awareness guideline to the facility manager, reduces the cost of energy conservation and ensures a better environment. (Choong Weng Wai, 2005). Lighting user cannot be too dependent on high efficiency lighting only but also be aware when the lighting not in use, the lighting should be switched off when necessary.

2.3 Type of Energy Efficient Lamp

There is several type of energy efficient fluorescent Lamp in the market and being used recently There are four lamps vary in diameter (ranging from 1.5 inches, which is 12/8 of an inch for T12 to 0.625 or 5/8 of an inch in diameter for T5 lamps). Efficiency is another area that distinguishes one from another. T5 & T8 lamps offer a 5% increase in efficiency over 40-watt T12 lamps, and have become the most popular choice for new installations.

Researcher (Halco 2011) prove that instant start T8 retrofits are an excellent way to reduce energy usage in applications with T12 fixtures. Additionally, instant-start T8 systems allow existing fixtures to be utilized after 48" T12 lamps have been completely legislated out of general lighting applications. The wiring is slightly different, but with proper considerations and attention to detail, it can be accomplished easily and safely. Although linear fluorescent T12 lamps have been used in general lighting for many years in convenience store, recent legislation has set efficacy standards that are bringing the days of the T12 to an end. Environmentally friendly legislation is forcing consumers to switch to newer fluorescent technologies with far superior efficacy and colour quality. Considering the ever-increasing focus on energy and resource conservation, extended life, high efficiency products make quite a bit of sense.T12 lamps were originally designed for use with magnetic (electromagnetic) ballasts. For many years, T12 linear fluorescent lamps - paired with magnetic ballasts - were a very efficient lighting option compared to incandescent types. Now that most T12 lamps face extinction due to upcoming legislation, the fixtures that operate them must be retrofitted with ballasts