ENERGY SAVING THROUGH LED REPLACEMENT FOR STREET LIGHTING

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DEDICATION

Special dedication to

My mother, Che Fatimah Binti Che Ismail, my father, Syed Adnan Bin Syed Jaafar and my wife, Siti Mariyam Binti Sulong

And also to

My supervisor, Dr. Rasyidah Binti Mohamad Idris who guide me and encourage me throughout this report.

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Not forget my both parents and my wife whom always ready to help and support in morale and financial. I am also indebted to Kaneka Malaysia to give facility to do research and study until get fruitful result.

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ABSTRACT

Kaneka Malaysia Sdn. Bhd totally have 182 units of street lighting which is 53 percent are High Pressure Sodium Vapour (HPSV) lighting. All street lighting was controlled by timer. This traditional method is out of date and huge of energy waste mainly due to timer malfunction. Moreover, HPSV street lighting is very costly to maintain. On February 2019, audit for street lighting was carried out and result of energy consumption was 317.56kWh per day or 114,321.02kWh per year. Motivated from this audit, HPSV street lighting was proposed to replace with highly efficient Light Emitted Diode (LED) street lighting. To realise this project, the prototype was built by implemented a smart system of LED street lighting controller to gain reduction of energy consumption and introduction of smart controlling technique by using Internet of Things (IOT). The prototype is design by employ Arduino NANO, PIR Motion Sensor, ESP8266 module and Blynk platform as wireless communication tool. The brightness of the LED street lighting being controlled depends on the motion detected from 11:00pm until 7:00am. By implement this idea, energy consumption will be save 50 percent and cut 20 percent of maintenance cost.

ABSTRAK

Kaneka Malaysia Sdn. Bhd. mempunyai 182 lampu jalan secara keseluruhan di mana 53 peratus adalah pencahayaan Sodium Tekanan Tinggi (HPSV). Semua lampu jalan dikendalikan oleh pemasa. Kaedah tradisional ini sudah lapuk dan pembaziran tenaga yang besar kebanyakannya disebabkan oleh kerosakan pemasa. Selain itu, lampu jalan jenis HPSV sangat mahal kos penyelenggaraan. Pada Februari 2019, audit untuk lampu jalan telah dijalankan dan hasil penggunaan tenaga adalah 317.56kWh sehari atau 114,321.02kWh setahun. Bermotivasi daripada audit ini, pencahayaan lampu HPSV dicadangkan untuk digantikan dengan pencahayaan Diod Pemancar Cahaya (LED) yang kecekapan tinggi. Untuk merealisasikan projek ini, sebuah prototaip telah dibina dengan mengimplementasikan pengawalan pintar lampu jalan LED untuk memperolehi pengurangan penggunaan tenaga dan pengenalan kepada teknik pengawalan pintar Internet of Things (IOT). Prototaip ini direka bentuk dengan Arduino NANO, Sensor Pergerakan PIR, Modul ESP8266 and pelantar Blynk sebagai alat komunikasi tanpa wayar. Kecerahan lampu jalan LED dikendalikan bergantung kepada gerakan yang dikesan daripada jam 11:00pm sehingga 7:00am. Dengan melaksanakan idea ini, penggunaan tenaga akan menjimatkan 50 peratus dan mengurangkan 20 peratus kos penyelenggaraan.

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LIST OF ABBREVIATIONS

KM	-	Kaneka Malaysia Sdn. Bhd.
KPP	-	Kaneka Paste Polymer Sdn. Bhd.
LED	-	Light Emitted Diode
HPSV	-	High Pressure Sodium Vapour
KET	-	Kaneka Electec Sdn. Bhd.
TV	-	Television
LCD	-	Liquid Crystal Display
KIF	-	Kaneka Innovative Fibers
KAM	-	Kaneka Apical Malaysia Sdn. Bhd.
IMODA	-	Kaneka Imoda Sdn. Bhd.
SGA	-	Small Group Activity.
REEM	-	Registered Electrical Energy Manager
MH	-	Metal Halide
CO2	-	Carbon Dioxide
GSM	-	Global System for Mobile Communication
DB	-	Distribution Board
JSA	-	Job Safety Analysis
SHEQ	-	Safety, Health, Environment and Quality
SCM	-	Supply Chain Management
SHEQ	-	Safety, Health, Environment and Quality
PTW	-	Permit to Work
EIP	-	Electrical Isolation Permit
SS	-	Senior Superintendent
OSHA	-	Occupational Safety and Health Administration

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CHAPTER 1

INTRODUCTION

1.1 Company Background

Kaneka Malaysia Sdn. Bhd. (KM) is Japanese based company which is starting to corporate and established in Malaysia on August 1995. KM was located at Gebeng Industrial Estate. The first plant that had been built in KM premise is Kaneka Electec Sdn. Bhd. (KET) on September 1995. KET started to operate from 1996 but ceased its operation on 2008 due to downtrend consumption of color TVs and monitors and increasing LED and LCD TV trend on last decade. Along with KET, Kaneka Modifiers Sdn Bhd (MOD) was established and started to operate almost at same month with KET. MOD was produced a quality product of impact modifier which is had trade name Kane Ace. Kane Ace is main raw materials in many applications such as high impact pipes and fittings, PVC door, window frame and so on. Due to its transparent properties, Kane Ace is also used in packaging of tablets and blister packages for stationery, toys and general merchandise. Until 2010, KM were established three plants and company in Malaysia. Kaneka Eperan Sdn Bhd (KEP) and Kaneka Paste Polymers Sdn. Bhd (KPP) was started its operation on July 1996 and January 1999. Meanwhile, Kaneka Innovative Fibers Sdn Bhd (KIF) was produced first products on September 2010. KM does not turn back and moving forward by established another four plants and companies for 2010 year. Kaneka Apical Malaysia Sdn. Bhd. (KAM) and Kaneka MS Malaysia Sdn. Bhd were started its operation on February 2012 and May 2015. KAM plants consist of two companies and premises which are known as KAM-GS and KAM-PI. Kaneka Imoda Sdn. Bhd. (i-MODA) was latest and also the largest factory in KM which is started its production on July 2017.

1.2 Energy Saving and Energy Efficient in Kaneka Malaysia

KM is company that support and encourage staffs to initiate the energy saving and energy efficient practising. It was proved by hired external consultant and registered electrical energy manager (REEM), Ir. Hj. Abdul Aziz to assists and develop baseline energy saving and energy efficient strategy starting from 2014. Since Ir. Hj. Abdul Aziz become an external REEM and consultant, KM was complied with Energy Supply Act, *Efficient Management of Electrical Energy Regulations 2008* [1]. Ir. Hj. Abdul Aziz initiate to create Kaneka Malaysia energy team which participated almost of plant representatives and administration personnel. Energy Management's vision and mission was idealized by give the pressing to reduce energy consumption by five percent in 5 years. Therefore, management directors of KM were encouraged each plant in KM to develop their Small Group Activity (SGA) to drive an energy saving and energy efficient project.

1.3 Street Lighting Background in Kaneka Malaysia Sdn. Bhd.

In beginning of KM establishment in 1996, KM only had 83 street lightings surrounding plants and factory. However, due to establishment another four plants and factories in KM in 2010, street lightings drastically increased to 182 street lighting. In parallel, electricity consumption also increases drastically. Before 2010-year, street lighting electricity cost average about RM800.00 to RM 1,000.00 per month. However, after year 2010 and recent, KM need to bear the electricity cost of street lighting average about RM2,750.00 per month or average RM 33,000.00 per year.

Street lighting in KM have many fixtures with difference model. Most of street lighting's luminaires are High Pressure Sodium Vapor (HPSV), LED and Metal Halide (MH). Below Table 1.1 and Figure 1.1 are list of street lighting bulbs in KM plants.

Table 1.1 List of lighting and quantity in KM premise.

Nos	Lighting	Quantity
1	High Pressure Sodium Vapour	96
2	Metal Halide	4
3	LED	83
	Total	182

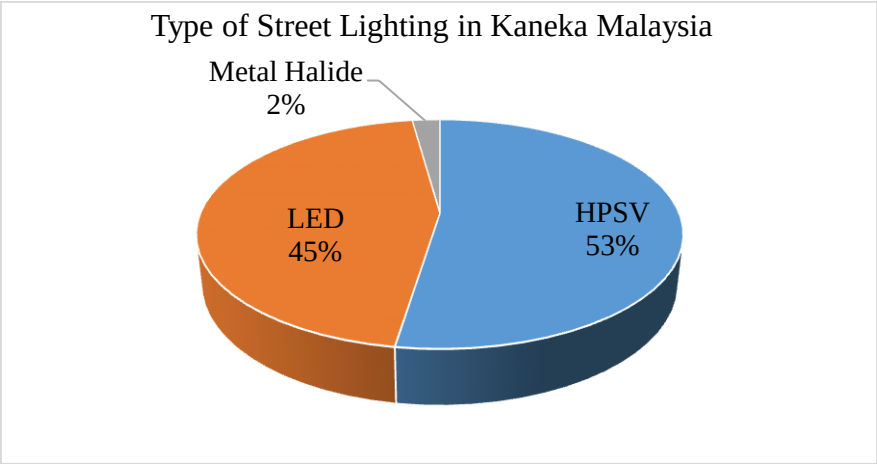

Figure 1.1 Type of street lighting's bulb in KM.

Purpose of outdoor lighting such as street lighting in premise compound is to enhance vision of operator and increases the security of property during night. In term of purpose, it slightly different between highway street lighting and premise street lighting. Most of street lighting in KM are used to illuminate roadways, parking lots, yards, sidewalks, plant site and building exteriors.

In KM, most of area have lighting levels that are greater than the OSHA minimums. Very good lighting increases the visibility of hazards, improves the safety of operator and provides a sense of security in the plant communities. The Occupational Safety and Health Administration (OSHA) Regulation 1926.56(a) stated that any construction areas, ramps, runways, corridors, offices, shops, and storage areas shall be lighted, with minimum footcandle levels ranging from 3 to 30 in various areas [2].

1.4 Problem Statement

On February 2019, energy audit for street lighting in Kaneka Malaysia was carried out. As a result, electricity consumption of street lighting is 317.56kWh per day or 114,321.02kWh per year. HPSV's bulb street lighting contributed a huge electricity consumption than LED street lighting and was observed very significant effect to electricity cost.

Every month, management of KM spends average RM500.00 per month and average RM6,000.00 per year in repair and maintenance (R&M) cost. Budget also increased since 2010 about 20%. Most of budget directed to HPSV street lighting in purchase of spare ballast, capacitor, ignitor and bulb.

LED lights are over 60% more cost effective in terms of maintenance. Due to LED's substantially longer life span, High Pressure Sodium Vapour (HPSV) and Mercury Vapour (MV) lamps would have to be replaced at least three to four times during the lifespan of an LED. Lifetime of HPSV lamp is around 5,000 hours while the LED lamp has lifetime over than 50,000 hours. In other hand, LED has lifetime 10 greater than HPSV lamps [3].

Weakness of conventional streetlight, such as uneven of light was identified. Yellow and amber colour of HPSV attains uncomfortable to lorry driver and operator as well as premise guard during night shift supervise. Compare with the white colour LED lamps, the vision was better, and light also become more even and sharp. The good feature of LED lamp is dimmable which can reduce it brightness using external controller.

Street lighting always turn on automatically at 7:00pm and turn off at 7:00am by conventional timer controller. Some location in KM, timer always malfunction and out of the setting. Because of that, street lighting will be remaining switch on until 9:00am to 10:00am or switch on too early at 6:40pm in evening. This routine caused waste of energy and increasing of electricity cost by 5% per day. Energy wasting also cause a more hundred-ringgit spending by KM management for only

street lightings. Figure 1.2 below shown the reality of electricity waste in one of plant in KM. This scenario of energy waste cannot be accepted by management of KM and raise my concern to introduce a reliable system to replace this existing controller.

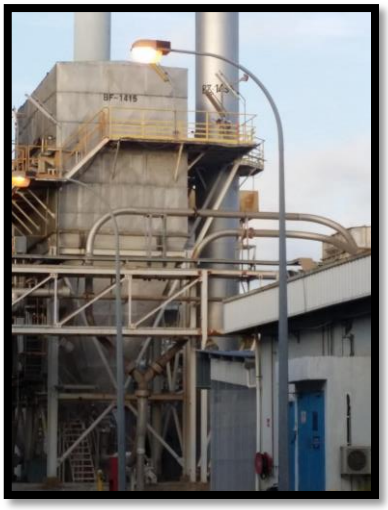

Figure 1.2 Street lighting condition

Another reason premise is implementing green technologies such as LED lighting is to reduce light pollution and carbon dioxide (CO2) emission. Many of the conventional lighting fixtures are not directing light properly, creating over expanding areas, and emitting light pollution into the atmosphere. Some of the problems related with light pollution are the disruption of the ecosystem, adverse and poor health effects created by carbon dioxide emissions, the obstruction of the night sky for astronomical studies, and the disturbance of neighbouring regions created by light trespass. LED lamps has lower annual greenhouse gas emission rather than HPSV lamp for example 250 watt lamp, the annual greenhouse gas emission is around 850kg while LED light only 355kg. This mean that LED has lower emission by percentage to 40% from HPSV lamp.

From observation in Kaneka Malaysia premise, street lighting has significant effect on the mood of animal life. For example, many insects are attracting to the light of street lighting even it is HPSV, Mercury Vapour or LED. The problem is when insects attract to the Mercury Vapour lamp, it effects 100% of animal life due

to chemical reaction and 47% for HPSV lamp. However, LED lamp only give lower impact between all light sources which is about 20% [4]. Due to that problem, maintenance cost to cleaning up the fixture especially Mercury Vapour lamp significantly higher than other lamps.

1.5 Motivation

Motivation of this project is to comply Industrial 4.0's vision of Kaneka Malaysia. By implement smart street lighting, we able to control the lit of street. More advance, we can switch on and off street lighting by access it through tablet or smart phone from remote location.

1.6 Research Objectives

The main objective is to evaluate and measure electricity consumption of existing street lighting in Kaneka Malaysia Sdn. Bhd. As per discuss in Introduction section, all 182 units of street lighting will be evaluating, measure and analyse. Energy audit will be carrying on realizing this objective.

Second objective to investigate the possibility of energy saving through replacement of conventional luminaire of street lighting with LED luminaire. LED street lighting will determine to be save about 30 percent of recent energy consumption in Kaneka Malaysia Sdn. Bhd. By reducing to 30 percent, we will achieve Kaneka Energy Management's objective which is targeted to reduce 5% total consumption within 5 years. To achieve this objective, economic analysis such as Return of Investment (ROI) and Simple Payback Period (SPP) will be carry on. Besides, energy survey also conducted for 55 respondents, mainly focus on operators and maintenance personnel.

Third objective is to analyse energy saving through LED Smart Street lighting hardware. Conventional controller targeted to be eliminated through introduction of smart street lighting control.

1.7 Scopes of Project

This feasibility study is limited in Kaneka Malaysia premises which consists of 182 units of street lighting. Overall studies are consisting of electricity consumption, maintenance cost, energy survey about street lighting and economic analysis (return of investment and simple payback period).

The circuit of prototype hardware will be suit for 5V, 5A after regulated by XL4015-5A module from 12V, 5A power supply. PIR motion sensor used as intelligent control and Arduino NANO is utilizing as microcontroller. For wireless control, ESP8266 was chosen as WIFI module. This hardware will be communication and control by using Blynk apps from android smart phone.

1.8 Methodology

To obtain a good result in the end of this project, feasibility study was conducted. Items number 1, number 2 and number 3 were covered for feasibility study phase meanwhile item number 4 for prototype or hardware implementation. Table 1.2 below is the lists of methods and techniques.

Table 1.2 Methodology and techniques that apply for this project.

Nos	Methodology	Techniques
1	Audit and survey	1. Counting units of street lighting in Kaneka Malaysia. 2. Carry out energy survey.
2	Measurement of parameter	1. Use clamp meter to measure current. 2. Use data logger to take current, voltage, power and harmonic reading.
3	Mathematical calculation and analysis.	1. Statistical technique such SPP and ROI. 2. Cost comparison technique. 3. Economical technique.
4	Design prototype for smart street lighting.	1. Electronic wiring technique. 2. Arduino NANO programming.

1.9 Thesis Outline

This thesis is divided into five chapters. Chapter 1 is introduction which are describe history background of Kaneka Malaysia Sdn. Bhd. and background of street lighting in this premise. In this chapter, problem statements, motivations, objectives and methodology were summarized and stated.

Chapter 1: Introduction was followed with Chapter 2: Literature Review which describes previous works by other researchers that gives motivation to carry out this project and work. Chapter 2 also presents the approach taken and mathematical tools used in their analysis.

Chapter 3 is describing about methodology that will used in this project. Data was collected and analysis for before and after. Also, survey for specific respondents in Kaneka Malaysia is carry on in order to get the solid reason and justification of problem statement that describe in Chapter 1. Smart street lighting prototype will be describing and elaborate in this chapter.

For chapter 4 is presentation the experimental results that close related with the chapter 3. In Chapter 3, method is present but for chapter 4, result and discussion will be detailed.

Chapter 5 is last chapter in this thesis which is conclusion overall of project. Also, in this chapter is presentation of the recommendation and point out next opportunities and potentials to improve the recent project.

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