Faculty of Engineering

AUTO- SYNC STREETLIGHT

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AUTO – SYNC STREETLIGHT

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ABSTRACT

In a growing country like Malaysia, where we are working to build smart cities, monitoring and autonomous control of street lights are crucial for reducing power usage. The paper describes a wireless sensor network and LED-based remote monitoring and control system for streetlights. The system, which controls streetlights, can be configured to operate automatically. According to seasonal changes, this control can adjust reasonably. In order to save even more electricity, this street light system also has a time cut-off feature and an automatic control pattern. As the sun sets, the LED will light up to 50% brightness. When vehicles pass by, the light will automatically turn on to its maximum brightness and then remain operating at 50% when there is no more presence of vehicles. Compared to streetlamps that remain lit at night, this design can save a significant amount of electricity. Additionally, this system features feedback capabilities that provide alerts in the event that a light is broken. The Blynk application will be used to send the notification, making it simple to locate and fix the broken led. The system can be widely used in all locations that require prompt control, including roadways, stations, mines, schools, and many other locations.

ABSTRAK

Di negara yang sedang berkembang seperti Malaysia, di mana kerajaan sedang berusaha untuk membina bandar pintar, pemantauan dan kawalan autonomi lampu jalan adalah penting untuk mengurangkan penggunaan kuasa. Kertas ini menerangkan rangkaian penderia wayarles dan sistem pemantauan dan kawalan jauh berasaskan LED untuk lampu jalan. Sistem yang mengawal lampu jalan, boleh dikonfigurasikan untuk beroperasi secara automatik. Mengikut perubahan bermusim, kawalan ini boleh melaraskan dengan munasabah. Untuk menjimatkan lebih banyak tenaga elektrik, sistem lampu jalan ini juga mempunyai ciri pemotongan masa dan corak kawalan automatik. Apabila matahari terbenam, LED akan menyala sehingga 50% kecerahan. Apabila kenderaan lalu lalang, lampu akan menyala secara automatik kepada kecerahan maksimumnya dan kemudian kekal beroperasi pada 50% apabila tiada lagi kehadiran kenderaan. Berbanding dengan lampu jalan yang kekal menyala pada waktu malam, reka bentuk ini dapat menjimatkan sejumlah besar elektrik. Selain itu, sistem ini menampilkan keupayaan maklum balas yang memberikan makluman sekiranya lampu rosak. Aplikasi Blynk akan digunakan untuk menghantar pemberitahuan, menjadikannya mudah untuk mencari dan membetulkan led yang rosak. Sistem ini boleh digunakan secara meluas di semua lokasi yang memerlukan kawalan segera, termasuk jalan raya, stesen, lombong, sekolah dan banyak lokasi lain.

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AC	-	Alternating Current
DC	-	Direct Current
IDE	-	Integrated Design Environment
ICT	-	Information Communication Technology
IOT	-	Internet of Thigs
IR	-	Infrared
LDR	-	Light Dependent Resistor
LED	-	Light Emitting Diode
PCB	-	Printed Circuit Board
TNB	-	Tenaga National Berhad
Wi-Fi	-	Wireless Fidelity

CHAPTER 1

INTRODUCTION

1.1 Background

Malaysia has been known as having political and economic stability by the Association of Southeast Asian Nations (ASEAN). Additionally, it is famous for being the No. 1 destination outside of Japan for Japanese citizens to live for the previous 11 years (since 2006). It is a multi-ethnic country with a population of approximately 31 million people subdivided mostly into three major ethnic groupings which are Indian, Chinese and Malay. Although Malaysia's economy shrank to 4.2% growth in 2016, it is forecast to have recovered rapidly to 5.4% growth in 2017, with additional growth predicted [1].

Malaysia's industry is getting more sophisticated and urbanised, as the country is one of the fastest urbanising regions in the globe. As the economy and job market evolve away from farming and toward industry and services, this trend is projected to continue. Over 1.31 million people call Kuala Lumpur home, making it Malaysia's most populated metropolitan city. Malaysia has many minor urban centres and three other cities with populations exceeding 500,000 civilians [2].

A smart city refers to a future approach to urban planning, development, and management that can address urban planning, urban services, development, and environmental management. Smart cities will be crucial in sustaining and expanding tomorrow's businesses. A smart city in Malaysia’s context is defined as "a city that employs advanced ICT and technology to address urban concerns such as increasing standard of living, stimulating economic growth, establishing a sustainable and secure environment, and fostering efficient urban management practices.” The goal of Smart City in Malaysia is to address urban concerns and challenges to achieve three key goals: a competitive economy, a sustainable environment, and improved quality of life [3].
To optimize public resources, more intelligence must be added to technical infrastructures and services in smart cities of the future. Smart street lighting is one of the smart systems

that must be included while developing a smart city. Street lighting is a significant aspect of a smart city since it brightens the city in the dark, ensuring the safety of road users and maintaining the city's appealing aspect. Public lighting, on the other hand, has been shown to lessen crime by up to 20% and road accidents by up to 35% [4].

The International Energy Agency (IEA) estimates, however, that worldwide lighting demand would increase by 80% by 2030, compared to 2005 levels. As the global population increases, more smart cities will be developed to meet this demand. As more smart cities are constructed, requirement for illumination, particularly street lighting, will increase. A street lighting system accounts for around 25%–30% of the energy consumed in a city [4]. Typically, streetlights are turned on for the duration of the night and then turned off during the day. Even if a street is vacant at night, the streetlights will remain illuminated. As a result, typical street lighting consumes a substantial amount of electricity.

Traditional streetlights (metal halide or high-pressure sodium) are powered by the conventional electrical grid fuelled by non-renewable fossil fuels. The conventional streetlights also consume much electricity due to their inefficient design, leading to environmental problems such as rising carbon dioxide (CO_2) emissions. Compared to more energy-efficient systems utilized in industrialized nations, many existing street lighting systems in Malaysia have comparatively high energy consumption and maintenance costs. Moreover, this conventional system costs a lot, from operational expenses to maintenance. Throughout 25 years, the total expenses of a typical street lighting installation consist of 85 % maintenance and electricity and only 15 % investment costs. Therefore, improving energy efficiency and minimizing maintenance costs are significant factors when designing a street lighting system [5].

To address this issue, a smart street lighting system based on sensor network technology and an adaptive control mechanism should be implemented to improve power saving, provide simplicity of maintenance, and cost savings. In addition, a smart street lighting system has dimming capabilities which help in reducing power consumption.

1.2 Problem Statement

The conventional streetlight consumes a lot of energy as it has a continuous operation of lighting during the night time. It turns on automatically at dusk and remains on till dawn. In Malaysia, the type of lamp that had been used is a clear type-High Pressure Sodium Vapour (HPSV) lamp with a range from 100 to 400-Watt tubular [6]. A streetlight usually will switch on average of 11 hours per day, from 7:30 p.m. to 6:30 a.m. On top of that, it also wastes a lot of electricity, particularly between 1 a.m. and 4 a.m. because, during this time, the road has the least traffic as most people are sleeping but the streetlight will remain illuminated throughout the night. This results in significant energy waste.

Moreover, Malaysia's final energy consumption per capita in 2020 was 2.7 toe. Electricity consumption per capita has risen from 3900 kWh in 2010 to 4600 kWh in 2020. This is far higher than in neighbouring countries. [7]. The energy consumed per year is increasing ever since 1990 which the pattern is clearly shows in Figure 1.1.

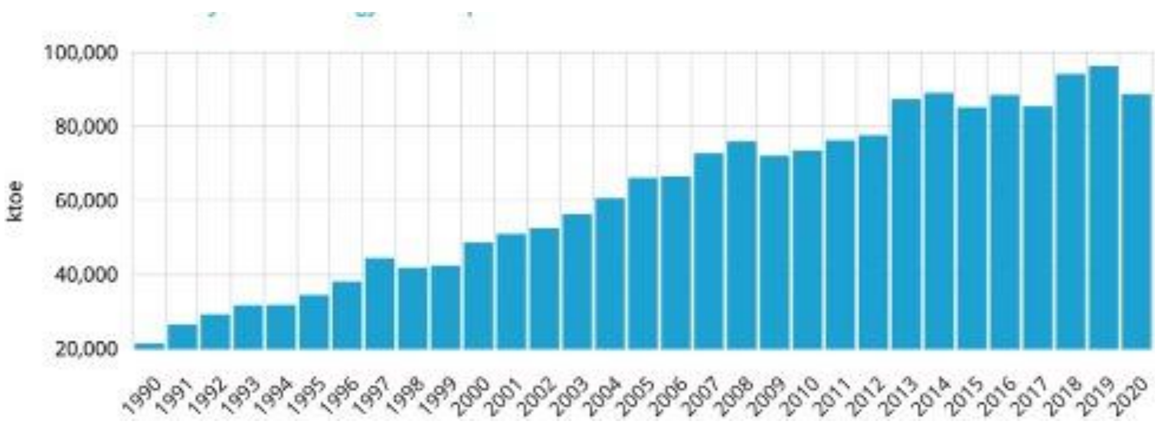

Figure 1.1: Total energy consumption 1990-2020 [8]

The sectors that contribute to the total energy consumption in Malaysia are industry,transportation, agriculture, and residential and commercial. Public lighting is also one of the contributors to this energy consumption. The latest data, public lighting in peninsularMalaysia’s electricity consumed was reported at 1,665.206 kWh mn in 2016. This recordis quite higher when compared to last year’s electricity consumption which is 1,356.599kWh mn in 2015. The pattern of electricity consumption keeps increasing in 2005 [8]. This can be referred to in Fig 1.2. As Malaysia develops and its population grows, more urban areas have been built to ensure civility. As a result, additional streetlights must be placed. In 2019, Peninsular Malaysia's local governments are responsible for approximately 367,000 streetlights [9]. This number will keep rising as more metropolitan areas are built. When the number of streetlights increases, the amount of electricity consumed increases, increasing energy consumption.

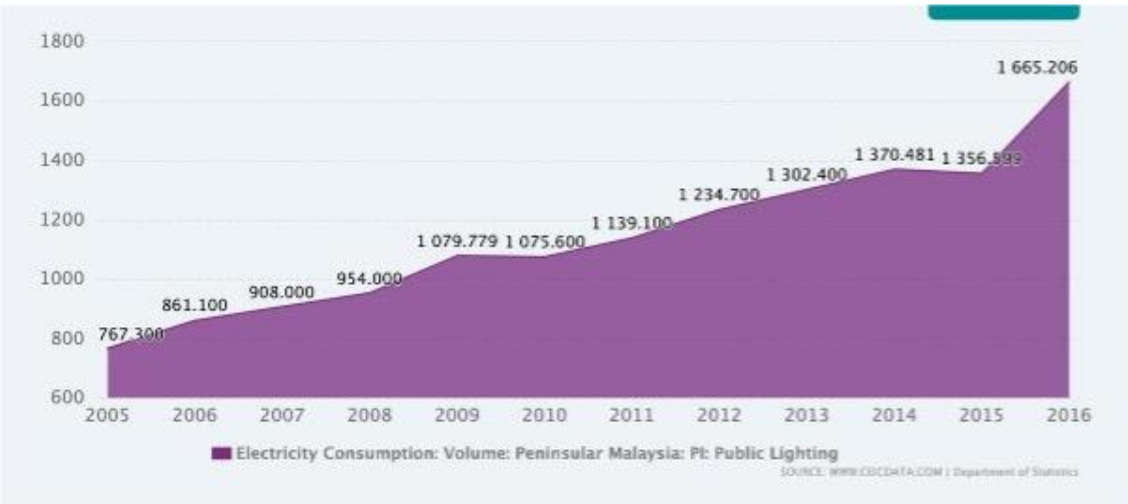

Figure 1.2: Electricity consumption of public lighting in peninsular Malaysia between 2005-2016 [9]

According to the tariff from Tenaga National Berhad (TNB) [10], the price of power is RM0.35/kWh. A streetlight usually operates 11 hours a day which makes the power consumed by it is between 1.1k-4.4kWh. It means that the streetlight pole can cost around RM155.89 -RM623.55 per year. Furthermore, traditional streetlight also requires explicit installation of electric poles which is a time-consuming and costly procedure [11]. Although conventional street lighting that utilizes HPSV lamps is a less expensive method to install, it requires regular maintenance. For instance, it did not last long, as it is only capable of operating for approximately 24000 hours, or 1000 days. Over time, the HPSV lamp's brightness decreases gradually, and the yields produced gradually decline even when the bulb is still emitting light. To provide enough light to the road, the bulb must be changed regularly. As a result, the expense of maintaining the streetlight rises significantly.

Additionally, it should be remembered that the government is responsible for not only lamps in cities, but also pays RM80 million annually on electricity bills and the cost of maintenance for streetlights on village roads nationwide, which adds to the government's burden. For instance, the government also needs to pay for the cost of illuminating the Federal Land Development Authority (Felda), the Federal Land

Consolidation and Rehabilitation Authority (Felcra), and the Terengganu Tengah Development Authority (Ketengah) districts [12].

Consequently, energy consumption contributes to a variety of environmental issues, such as air pollution, climate change, and greenhouse gases emission. Populationexpansion and economic development are two major factors contributing to the rise in energy demand. Malaysia's energy output is based on non-renewable energy such as coal,oil, and natural gas. Fig1.3 shows the amount of primary energy sources based on fuel type from 1990 and predicted until 2050 [13].

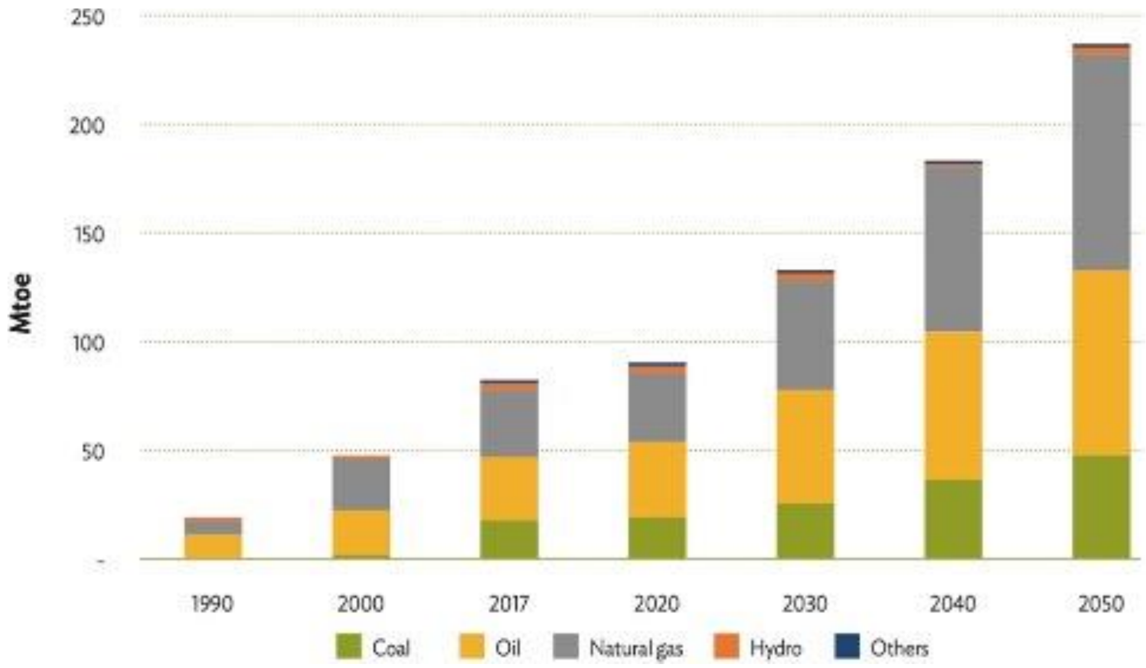

Figure 1.3: Primary Energy Sources based on Fuel Type [13]

The combustion of non-renewable energy harms the environment. For instance, fuel is composed of carbon and hydrogen atoms During the combustion process, carbon (C) from the fuel bonds with oxygen (02) in the air to form carbon dioxide (CO2). It is then necessary to release this carbon dioxide into the atmosphere. Study shows as a 1% increase in energy consumption will result in a 0.4172% increase in environmental degradation [14]. Exposure to CO2 gas can be hazardous to human health, causing issues such as impaired cognitive performance, kidney and bone failure, and inflammation. Exposure to CO2 levels as low as 1000 parts per million (ppm) can trigger this problem. Chronic exposure to levels ranging from 2000 ppm to 3000ppm, on the other hand, has been linked to kidney calcification and bone demineralization. [151. The total amount of carbon dioxide (CO2) emitted by energy combustion in 2020 was 262.2 million tonnes, Since 1961, Malaysia's CO_2 emissions have risen dramatically, from 14.7 to 262.2 million tonnes per year [16]. This country's CO_2 emissions reached a peak of 19.93 % and then decreased to -0.95 % in 2020, mainly as a result of pandemics. Hence, it is necessary to minimize the amount of energy consumed by implementing energy savings and energy efficiency improvements in order to mitigate the negative impact on society.

Thus, to address excessive energy waste and consumption, save electricity costs, and minimize negative effects on the environment and society's health, a smart auto-sync streetlight with dimming functions is designed. Dimming capabilities help in POWER conservation by ensuring that the bulb works at maximum capacity only when motion is detected within the IR sensor's range. If there is no motion, the illumination will dim to conserve electricity. This feature helps in the reduction of energy usage. When the energy consumed is reduced, CO_2 emissions are also reduced. Furthermore, this function will help in lowering the price of street lighting maintenance. When the light is not used to its highest capacity, its life is lengthened. As a result, the streetlight does not require regular maintenance.

1.3 Objectives

The following are the main objectives of this project:

- To study on current existing conventional and auto-sync lights technologies
- To design a flexible and efficient system in order to control the street lighting autonomously
- To compare the power consumption between proposed design and conventional streetlights

1.4 Scope of Study

This project is focused on the introduction of an auto-synchronizing street light system. This project proposes to design a streetlight system to optimize the energy consumed by street lighting using infrared and light detection and response (LDR) sensors. The scope of this project is to implement this proposed system into a prototype that has three street light poles. Hardware components include a NodeMCUI ESP8266, four LDR sensors, and three IR sensors. The NodeMCt ESP8266 will operate as the microcontroller for this prototype, which will be used to do computations. The infrared sensor is capable of detecting motion at a range of 1 to 5 meters. This helps in detecting vehicle motion as it approaches the streetlight pole. Thus, the streetlight will illuminate before the arrival of the vehicles. As for LDR sensors, each LDR sensor will be detecting the ambient light. When it detects that the lux level is less than 400 lux (sunset illuminances), it sends the data to the nodeMCW, which then illuminates the LED. Three additional LDRs will be installed below the LED to check the lamp's health. All of this data will be sent to the Blynk application. The next semester, this prototype will be created and tested, and the data collected will be evaluated. The block diagram of this system is depicted in Figure 1.4

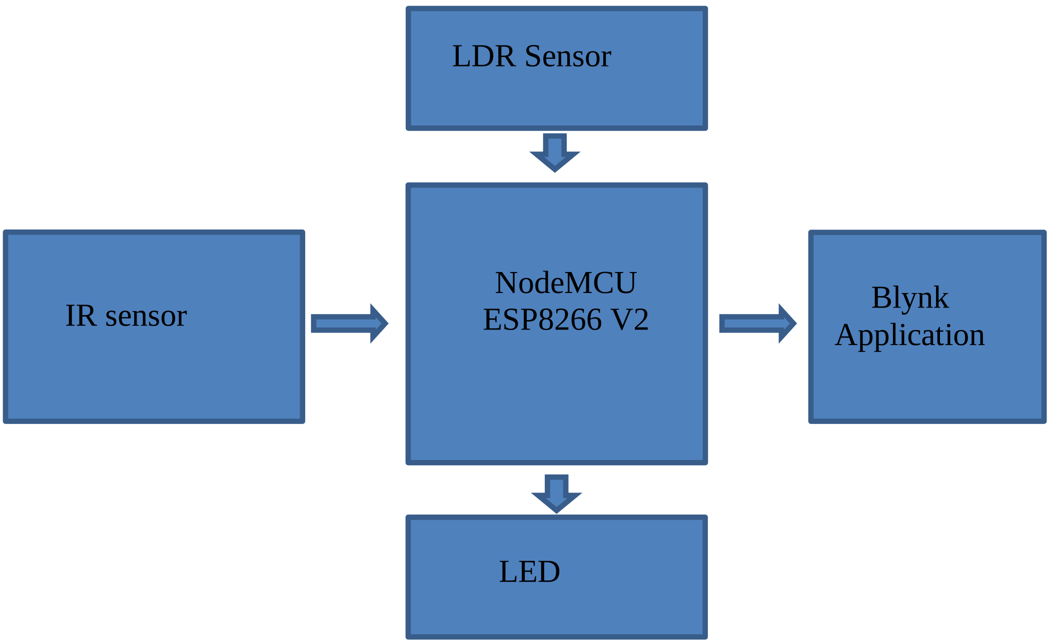

Figure 1.4: Block Diagram of proposed system

As this system is aimed at reducing electrical energy consumption, the dimming capabilities will be analyzed starting at a brightness of 10%. This setting will thereafter be increased in 10% increments. This step is crucial in determining the optimal illumination percentage to conserve energy while still delivering a sufficient level of illumination for road users' safety. To collect electricity usage data, the readings were measured when 10 motion of vehicles detected at each pole.

1.5 Report Outline

This part is dedicated to presenting a clear overview of contents to be discovered in the report:

Chapter 1 - Introduction

Chapter 1 introduces a brief idea of this project as a whole, including the importance of this system. This chapter also introduces the problem statement, objectives of this project, and scope of the study.

Chapter 2 – Literature Review

Chapter 2 includes of literature review of the existing related systems and documentation of the proposed system. The number of references from journals, research papers, and articles is used in the review and evaluation of the literature.These existing systems are analyzed and compared altogether to see their design to get the best features and also the limitations.

Chapter 3 - Methodology

Chapter 3 explains the approach and methods employed for this project. In this chapter, flow charts, block diagrams, and system designs are created to attain theexpected objectives and results. This includes both the cloud computing and hardware prototype of this proposed system