Evolution in Electrical and Electronic Engineering Vol. 2 No. 2 (2021) 474-483

EEEE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/eeee
e-ISSN : 2756-8458

Smart Street Lighting System

Muhammad Hasif Yahya[1], Roziah Aziz[1]*

[1]Faculty of Electrical and Electronics Engineering,
Universiti Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, 86400, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/eeee.2021.02.02.057
Received 06 July 2021; Accepted 03 August 2021; Available online 30 October 20211

Abstract: Nowadays, the populations of humankind are getting bigger every year. The increasing population has leads to the higher demand of electrical energy to fulfil users daily life. In Malaysia, the main resource in generating electrical energy was by converting non-renewable energy instead of renewable energy. Non- renewable energy has been used because it can produce a bigger output of electrical energy. However, this type of energy is expected to run out within a century. Thus, the usage of electrical energy must be efficient. Smart Street Lighting System (SSLS) has been proposed to replace the current street lights. SSLS is made up of two sensors which are PIR Sensor and Light Dependent Resistor (LDR). PIR Sensor used to detect the presence of vehicle while LDR is used to sense surrounding light intensity. Both sensors will determine either to open or closed the SSLS circuit. The circuit is closed when two conditions are met. The conditions are there is low intensity of surrounding light and there is a presence of vehicle detected by PIR Sensor. SSLS circuit is in open circuit when there are no demands, hence it controlled the usage of electrical energy efficiently. The result of this project has shown a lower value of kilowatt-hour which is up to a 44% decrease in power consumption.

Keywords: Smart Street Lighting System, Light Dependent Resistor, Microwave Radar Sensor

1. Introduction

In 2019, Malaysia's population is estimated around 32.6 million which is one percent higher than the population in 2018. Since the population getting bigger, the demand for energy resources getting increases. In 2017, the demands of Fossil fuels are accounted for 81% [1]. The main reason of highly demand amount of fossil fuels which are non-renewable energy was due to the lower cost and bigger output power. The fact that Malaysia sources of energy are relying to the non- renewable sources has causes a huge concern. This kind of energy will run out in less than one century. Since the output power produce by renewable energy are not as greater as non-renewable energy, the usage of the electricity must be efficient.

The increases of population cause leads to the growth of registered vehicle in Malaysia. According to Abdelfatah, A.S et al (2015) the number of vehicle has been increases by 60 percentages in between

Corresponding author: roziah@uthm.edu.my

years 2002 until 2014 [2]. The growth of traffic user is expected to be increases as the population increases.

Street lights are the major reason that causes higher electricity consumption. However, providing street lights is a compulsory as it is the main source of light that provide vision to the user during night time. According to Department of Statistic Malaysia Official Portal in 2019, the total road accidents reported in 2018 were 548,598 cases [3]. Majority of the accidents cases occurs during night time. Some of the cases were due to the failure of providing street lights.

2. Materials and Methods

The project block diagram of Figure 1 shows the process of completing this project step by step from the first to the last step. The first step is to design and simulate the Smart Street Light System circuit using Proteus 8 Professional Software. Then, data of road traffic volume is collected. After that, the total power consumes by a normal street light and Smart Street Light System will calculated and compared.

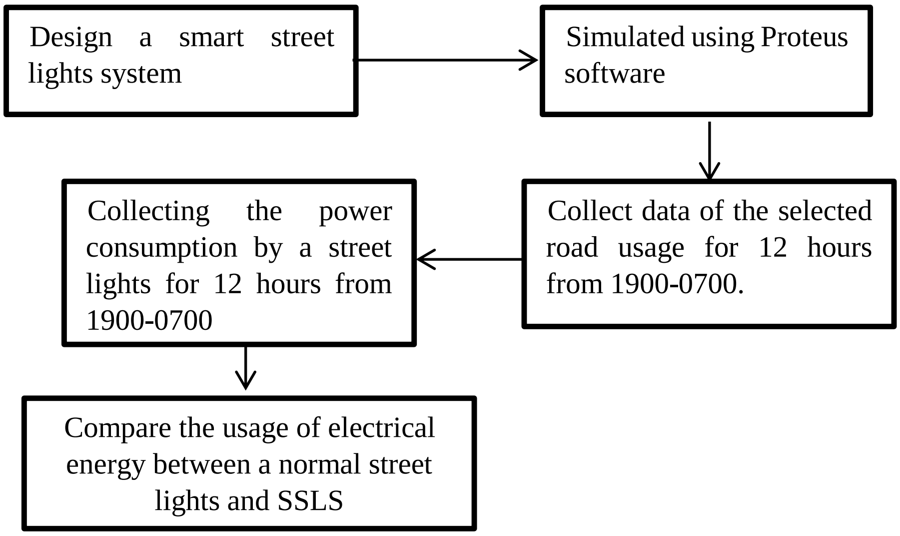

Figure 1: Project block diagram

2.1 Block diagram of the circuit

The circuit block diagram has been design by using Proteus 8 Professional software. The circuit are made up by a single phase voltage source, step down transformer, rectifier and several electronic components. The specification of the component is shown in Table 1 below.

Table 1: Specification of the components

Components	Unit	Specification
AC voltage source (VSINE)	1	325 Voltage peak to peak
Step down transformer (TRAN-2P2S)	1	Primary inductance = 365MH Secondary inductance = 1MH
Diode (IN4001)	4	-
Capacitor	1	100 uF
LDR	1	-
Resistor	2	1 kΩ
NPN transistor (BC547)	2	-
Relay	2	5 v
PIR Sensor	1	-
Lamp	1	120 v

Based on Figure 2, there were two sensor has been used which is LDR and PIR sensor. LDR is placed to sense the surrounding light intensity while PIR sensor used to sense any motion of vehicle passes. The circuit is designed to switch on the light with one condition. The condition is a presence of vehicle and the surrounding light intensity is low.

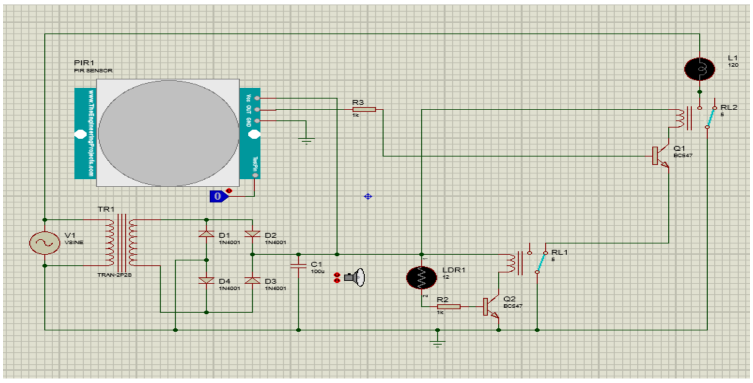

Figure 2: Block diagram of the circuit

The lamp only turn on when there is presence of vehicle and the light intensity is low. Based on Figure 3, two arrows have been placed to highlight the manipulated variable in the circuit. The red arrow shows a toggle input for PIR sensor. “0” indicates that there is no presence of vehicle while “1” demonstrates that there is a presence of vehicle. The blue arrow points towards the light intensity apply to the LDR. The result for this condition is the lamp turns on because both relay connected to the sensors are in closed state.

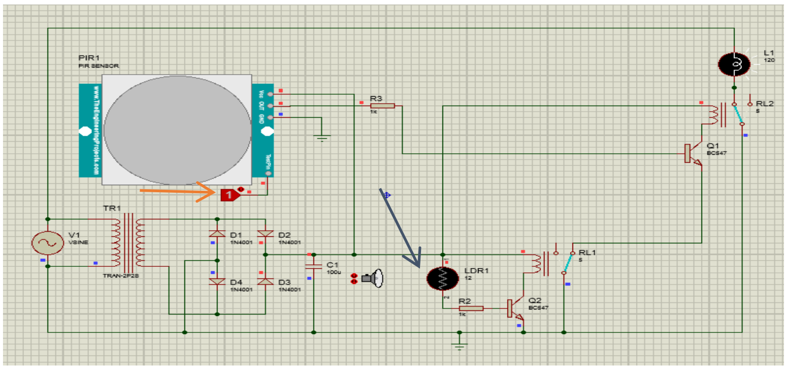

Figure 3: Block diagram of the circuit in the condition in closed circuit

2.2 Flow Chart of Smart Street Light System

Based on the Figure 4, Smart Street Lights System is controlled using LDR and MRS. LDR used to sense the amount of surrounding light while MRS is used to detect if there is any movement of vehicle. When the amount of light receive by LDR is sufficient, the system is turn of the lamp. The lamp only turn on when two conditions meet at the same time which is, the amount of surrounding light is low and there is a presence of car at the moment, otherwise the lamp remain off.

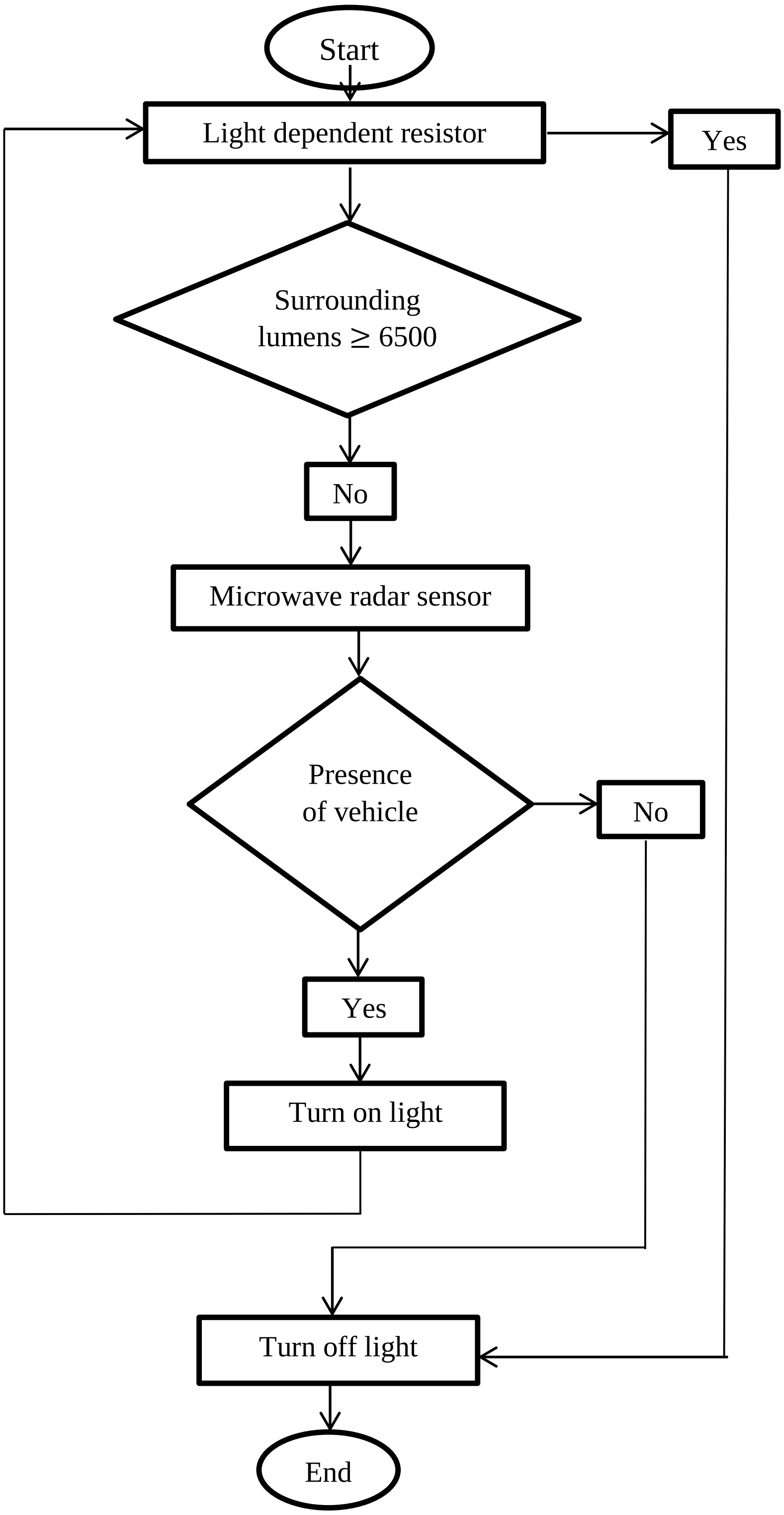

Figure 4: Flow chart of SSLS

2.3 Collecting Data

Collecting the data has been done by taking the data given by Jabatan Kerja Raya (JKR) Malaysia. The data provided by JKR is the amount of car that passes through the selected point for 16 hours start from 0600 until 2200 hours. Only several checkpoints such as JR403, JR 404 and JR409 have the data collected for 24 hours. For Jalan Kota Tinggi, there are three checkpoints which are JR403, JR404 and JR409. [13] Based on Figure 5, checkpoints JR403, JR404 and JR409 is in green colour.

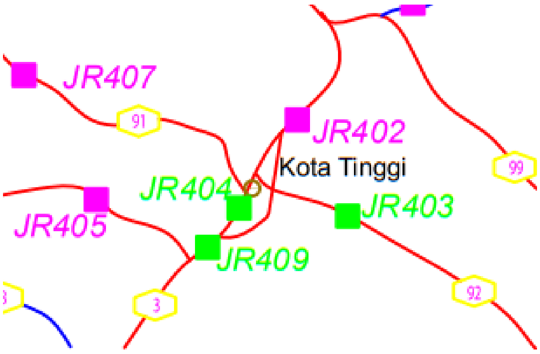

Figure 5: Map of checkpoints

2.4 Generating Data

Based on the collected data, comparison between 24 hours and 16 hours value for checkpoint JR403, JR404 and JR409 was calculated to estimate the percentage value of vehicle presence for another 8 hours which is from 2200 until 0600 hours. The block diagram of generating data is shown in Figure 6.

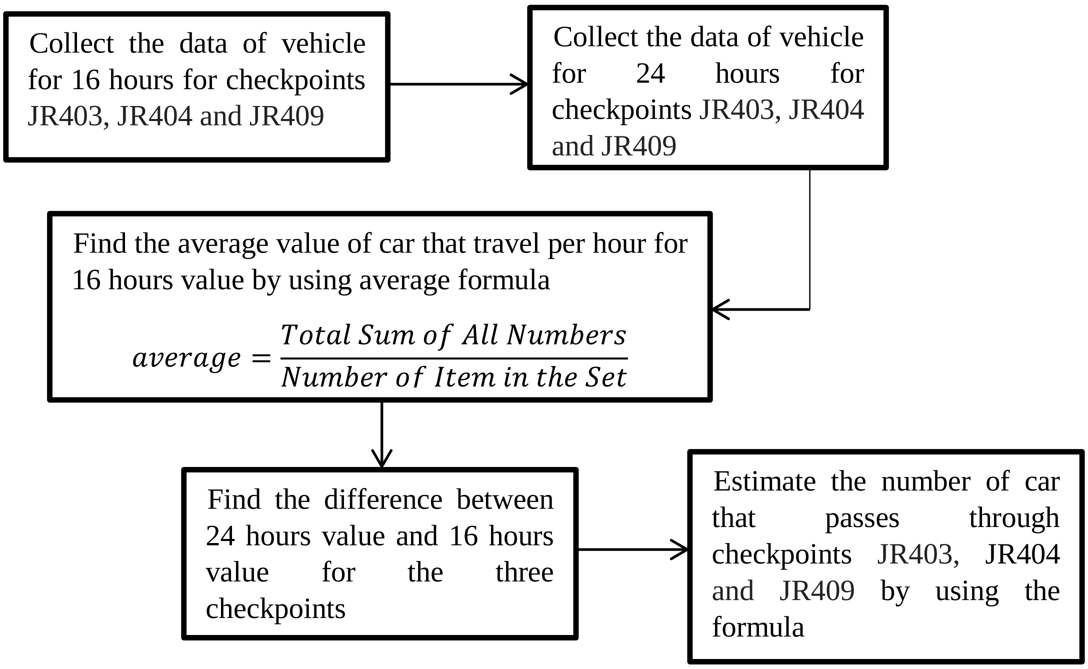

Figure 6: Generating Data Block Diagram

2.5 Comparison between normal street lights and Smart Street Lights System

Figure 7 shows the ower comparison block diagram. The comparison is done by calculating the normal street lights "NS" and Smart Street Lights System power consumption. After that, the amount of difference power "P "between them is calculated in percentage based on the current "i" and voltage "v" value from the SSLS simulation circuit.

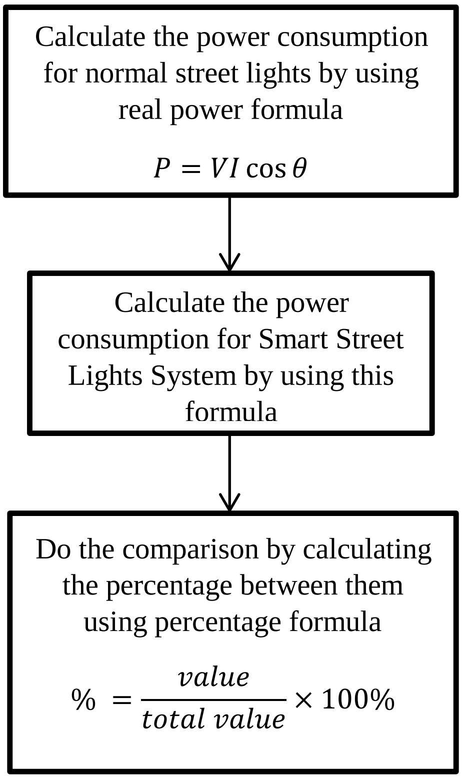

Figure 7: Power comparison block diagram

3.0 Results and Discussion

The data is collected from "Road Traffic Volume Malaysia (RTVM) 2011". Based on the data provided by RTVM, there are only a few stations has the recorded the amount of car passes for 24 hours. Since three stations from Kota Tinggi which are JR 403, JR 404 and JR 409 provide the 24 hour records, the data is tabulated in Table 2.

Table 2: The amount of car that pass through the stations

station number	24 hour	16 hour (0600-2200)	2200-0600
JR403	15548	14219	1329
JR404	22886	20244	2642
JR409	14680	13043	1637

The step use to estimate the total amount of car for 12 hour starting from 1900-0700 is firstly calculate the amount of car per hour for 16 hours by using average formula,

$$\text{average} = \frac{\text{Total Sum of All Numbers}}{\text{Number of Item in the Set}} \qquad Eq. 1$$

For JR403 station

$$\text{average} = \frac{14219}{16}$$
$$= 888.6875$$
$$\approx 889 \text{ unit}$$

Then, the average number is multiply by 4

$$889 \times 4 = 3556$$

After that, add the average multiply by 4 with 8 hours value starting from 2200-0600

$$3556 + 1329 \quad = 4885$$

The total cars pass through by each check points is shown in Table 3.

Table 3: The amount of car for 12 hours starting from 1900-0700

Check Points	Total Car
JR403	4885
JR404	7713
JR409	4898

Next, the time use by each car to pass through the checkpoint is assumed around 5 seconds. Thus the total amount of car for 12 hour starting from 1900-0700 is multiply by 5seconds.

$$4885 \times 5 \quad = 24425 \text{ seconds}$$

Then, convert 24425 seconds into hours by using this formula,

$$hour = \frac{seconds}{60\ second \times 60\ minutes} \qquad Eq.2$$

$$hours \quad = \frac{24425}{60 \times 60}$$

$$= 6.78 \text{ hours}$$

The total hours obtained by each check points is shown in Table 4.

Table 4: The amount of car for 12 hours starting from 1900-0700

Check points	Total hours
JR403	6.78 hours
JR404	10.71 hours
JR409	6.8 hours

Based on the result shown, the total energy consumption to turn on the street lights is expected to decreases.

3.1 Simulation Results

Based on the simulation, the voltage and current output graph for open circuit and closed circuit is shown below. The voltage graph for closed circuit and open circuit are same.

Based on Figure 8, the peak voltage value is 320 volts. The peak voltage then is converted into rms voltage by using single phase Vrms voltage,

$$Vrms = \frac{Vpeak}{\sqrt{2}} \qquad Eq.3$$

$$Vrms = \frac{320}{\sqrt{2}}$$

$$Vrms = 226\ volts$$

Based on Figure 9, the peak current value is 13.5 ampere. The peak current then is converted into Irms by using single phase Irms voltage,

$$Irms = \frac{Ipeak}{\sqrt{2}} \qquad Eq. 4$$

$$Irms = \frac{13.5}{\sqrt{2}}$$

$$Irms = 9.55\ amp$$

Based on Figure 10, the peak current value is 3.25uA. The peak current then is converted into Irms by using single phase Irms voltage,

$$Irms = \frac{Ipeak}{\sqrt{2}} \qquad Eq. 5$$

$$Irms = \frac{3.25uA}{\sqrt{2}}$$

$$Irms = 2.26uA$$

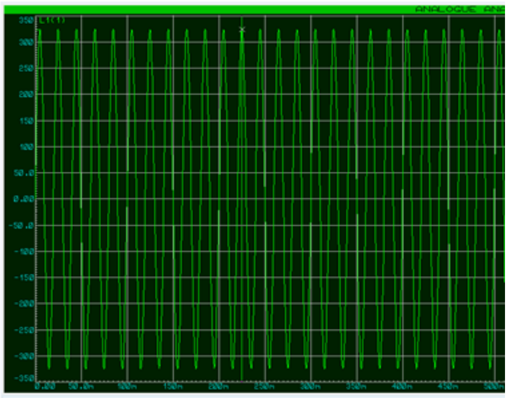

Figure 8: Voltage output graph for SSLS

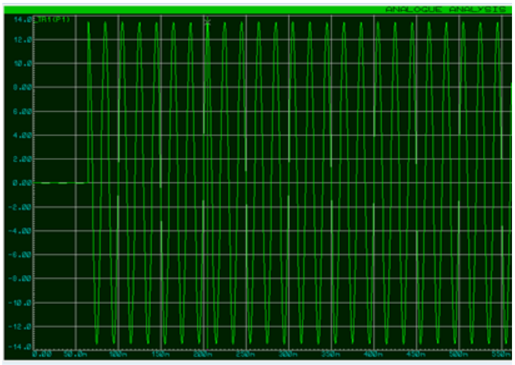

Figure 9: Current output graph for SSLS in closed circuit

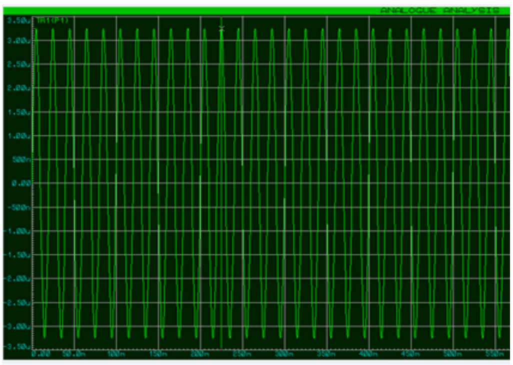

Figure 10: Current output graph for SSLS in open circuit

3.2 Comparison between Normal Street light and SSLS

The formula used to calculate the normal street lights power consumption were $kWh = kw \times h$, $kW = VI \cos\theta$. The total hour for the normal street lights to operate is approximately 12 hours starting from 1900 – 0700. The power factor used in the system is 0.85. Total power consumption per day for closed circuit is calculated below,

$$\frac{kWh}{day} = kW \times h \qquad Eq.6$$

$$kW \times h = Irms \times Vrms \cos\theta \times h \quad Eq.7$$

$$\begin{aligned} kWh &= kW \times h \\ &= Irms \times Vrms \cos\theta \times h \\ &= 9.55 \times 226 \cos 0.85 \times 12 \\ &= 25.89kWh \end{aligned}$$

The value of power consumption by a street light for all checkpoints is shown in Table 5.

Table 5: Power consumption

Station number	Operating hours	kWh/day
Normal street light	12	$25.89kWh/day$
JR403	6.78	$14.63kWh/day$
JR404	10.71	$23.11kWh/day$
JR409	6.8	$14.67kWh/day$

Based on the result shown in Table 5, the power consumption different can be calculated by using percentage different formula,

$$\% = \frac{value}{total\ value} \times 100\% \qquad Eq.8$$

For JR403

$$\begin{aligned} \%\ different &= \frac{14.63}{25.89} \times 100\% \\ &= 56\% \\ power\ percentage\ decreases &= 100\% - 56\% \\ &= 44\% \end{aligned}$$

The power consumption decreases percentage is shown in Table 6.

Table 6: Power consumption

Station number	kWh/day	Power Percentage Decreases
Normal street light	$25.89kWh/day$	0%
JR403	$14.63kWh/day$	44%
JR404	$23.11kWh/day$	10.74%
JR409	$14.67kWh/day$	43.34%

Based on Table 6, all stations are able to reduce the amount of the electricity consumption. Hence, Smart Street Lighting System has achieves the main objective which is to reduce the power consumption of a street light.

4. Conclusion

In conclusion, this project contains three main objectives which is to collect the data number of vehicle passes through several checkpoint stations, to design and simulate a Smart Street Light System and to compare the usage of electrical energy between a normal street lights and a Smart Street Lighting System. All of these objectives have been achieved and the result has been shown in Chapter 4. SSLS is believed to consume less power without decreasing its performance, thus it will benefits many party. The lower the usage of electrical energy will lower the demand. Since Malaysia electrical energy majorly came from non- renewable energy resources, the probability of having air pollution is getting lower.

Acknowledgement

The authors would like to thank the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia for its support.

References

[1] Ho, S. M., Lomi, A., Okoroigwe, E. C., & Urrego, L. R. (2019). Investigation of solar energy: The case study in Malaysia, Indonesia, Colombia and Nigeria. *International Journal of Renewable Energy Research*, *9*(1).

[2] Abdelfatah, A. S., Shah, M. Z., & Puan, O. C. (2015). Evaluating the sustainability of traffic growth in Malaysia. *Journal of Traffic and Logistics Engineering*, *3*(1).

[3] Quarter, M. E. P. T. (2019). from Department of Statistics Malaysia, reported by Rohaida binti Mohamad, released by Dato'Sri Dr. Mohd Uzir Mahidin, 15 November 2019.