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IeGRESAFE 2022

E-PROCEEDING OF

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"Sustaining the Resilient, Beautiful and Safe Cities for a Better Quality of Life"

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ORGANISED BY

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IMPROVING SAFETY IN SCHOOLS THROUGH SOLAR-OUTDOOR LIGHTING APPLICATION: A CASE STUDY OF SCHOOL IN PERAK TENGAH

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Abstract

Within the past decades, solar lighting application has become a cost-effective solution for many outdoor lighting requirements. New inventions in solar panel technologies, light-emitting diode (LED) and batteries have made it possible for many schools, especially in rural areas to significantly increase safety aspects and eliminate the electricity bills associated with outdoor lighting. Solar-outdoor lighting can provide high-quality lighting for more than 3 days and will provide illumination for areas that have limited access to grid-electricity supply, especially in remote and rural areas, whilst promoting safety awareness. Many studies have proven that with the occurrence of brightness at the external facade of a building, it will increase the safety level and avoid crime. Therefore, this paper tries explored on the potential of applying solar-outdoor lighting in order to improve the safety level of rural schools in Perak. A case study has been selected in the central Perak through a community-based approach project. It involves a practical application for the case study in order to identify suitable system requirements of the technologies in improving safety for the schools that have limited lighting due to financial constraints. It is found that, after the installation of these solar-outdoor lightings, this school managed to improve between 50% to 80% illuminance uniformity ratio around the schools especially at secluded areas.

Keywords: *Illuminance, Solar-outdoor Lighting, Rural School, Safety.*

INTRODUCTION

Solar energy has become significant these days and is gradually moving forward as a provider for the renewable energy resources. It will gradually replace carbon-producing energy in the near future. One of the technologies related to solar energy is the solar lighting application. Within the past ten years, solar lighting application has become a cost-effective solution for many building lighting requirements, whether indoor or outdoor applications (Qazi, 2017). The solar lighting system has become necessary in providing illumination for areas that have limited access to grid-electricity supply, especially in remote and rural areas, whilst promoting safety awareness (Ahmad, et al, 2020).

In rural areas in Malaysia, especially in schools, the use of lighting system, fans, and other electrical appliances are essential amenities. Although the power load of these electrical appliances is lower in comparison with different types of buildings, the frequent use within the 8 hours of school-time of these appliances has resulted in high energy consumption every month (Ahmad and Jamian, 2021). Indirectly, this would increase monthly utility bills if electricity tariffs continue to increase in the future. The consequences of this situation are the increase in management and operational cost that have a long-term impact on the Malaysian Ministry of Education. Therefore, one of the recommendations to control this issue is to implement a simple technology application that is inexpensive, able to provide self-sufficient electricity and at the same time, provide other benefit for the school. These criteria can be associated with solar lighting application.

Solar lighting application has been known to be cost-effective for many rural schools in the Asian region, especially in increasing safety aspects and eliminating the electricity bills associated with additional lighting (Ahmad, et al, 2020). It will not affect the existing infrastructure, since there is no underground wiring required (Axion Power, 2022). Through various indoor and outdoor lighting application, this technology can provide high-quality lighting for more than 3 days with minimal maintenance, since the solar panels are relatively easy to replace.

LITERATURE REVIEW

There are several ways for a school to uses solar lighting application. For rural schools in Malaysia, the type of outdoor lighting application is the most effective solution. Solar lighting can be installed at parking lots, school pathways and walkways, and to smaller application such as for signage (Axion Power, 2022). It requires a low-level lighting with LED flood fixtures, and at the same time promotes off-grid solar lighting solutions for safety aspect during the night-time (Ahmad and Jamian, 2021).

Since most of the rural schools in Malaysia are located near to the villages, forest and agricultural land, and have a huge school field, the use of this solar outdoor lighting application can give benefits to the school and nearby communities to lighten the space. Additional classes can also be held during night-time, if these additional lightings are to be provided.

Impact of Power Blackouts on Safety Aspect

One of the crucial aspects in school is to provide safety for the users, namely teachers and students. By creating safe environment, it enhances the protection level for the school community and the function of these schools can be utilised for many educational activities, especially during night time (Kawi, 2019). It will help teachers and school management to ensure the safety and security of the equipment and appliances in the classroom. Many studies have proven that brightness at the external facade of a building will increase the safety level by avoiding crimes, like burglary (Majid, 2017). Therefore, it is vital to have this additional lighting, especially during power outage.

When a power outage happens, several possibilities may occur. The learning and teaching activities may be disrupted (Astro Awani, 2017) where students need to be moved or replaced to a brighter space, for example school corridors (see Figure 1). Additionally, the danger of electrical shock (Suruhanjaya Tenaga, 2015), affecting the quality of life (Ahmad et al., 2018), damages of food storage (Nayan et al., 2017) and indirectly, may affect psychological mood and mental health (Ahmad et al., 2018) of the people.

Figure 1
Teaching and Learning in School Corridor During Blackout (Source: Astro Awani, 2017)

Usually, when the power blackout occurs, the power was only able to be restored to the building as early as 15 minutes (Spears, 2022). However, in most cases, most schools in the Malaysian rural areas will be without power for more than 2 hours (Suruhanjaya Tenaga, 2015). The disruption of this power may affect the operational of the schools (Mawhinney, 2016; Astro Awani, 2017) and sometimes, may leads to short-circuit that eventually leads to a threat of fire (Kawi, 2019) (See Figure 2).

Figure 2
Fire Threat in School Due to Power Short-Circuit (Source: Kawi, 2019)

The power blackout might also impact security aspect, especially theft or burglary problems during the night-time (Majid, 2017). With the absence or minimum lighting, it attracts robbery issues since in these schools, there are typically many expensive teaching appliances, like computers, printers, projectors, money from schools' collection and many more (Majid, 2017). Therefore, to ensure the schools' safety level, a sustainable power supply is required for this building. The aid of alternative energy applications such as solar energy to provide sustainable lighting is highly recommended. Since Malaysia has excellent solar radiation, given that Malaysia receives 4 to 5 kWh m^2 of solar radiation per day (Aziz, et al, 2016), it has a good potential in utilising this solar energy application for rural schools.

Types of Solar-Outdoor Lightings

There are various types of solar-outdoor lighting that could be installed at the rural schools. However, for a practical and cost-effective solution, two types of solar-outdoor lighting are recommended, namely (i) Roof-Mounted Photovoltaic System and (ii) Pole-Mounted Photovoltaic System.

1. Roof-Mounted Photovoltaic (PV) System

The standalone PV system is a simple system that is usually applied and installed at the building roof. It can be installed with i) a single array and, ii) multiple arrays (Pandey et al., 2016). This system can be linked directly to the outdoor and indoor lighting system of any schools (see Figure 3).

Figure 3

Roof-Mounted PV System (Source: Waters, 2020)

2. Pole-Mounted Photovoltaic (PV) System

Pole-mounted PV system are installed on steel poles that are secured into the ground and tightened with concrete and the solar module is mounted on the top of the poles. The advantage of this system is that it is rather impossible for any vandalism due to its height, and it can hold between 1 to 20 solar panels per pole. However, maintenance will be an issue as the panels are mounted high from the ground, as shown in Figure 4 (Axion Power, 2022).

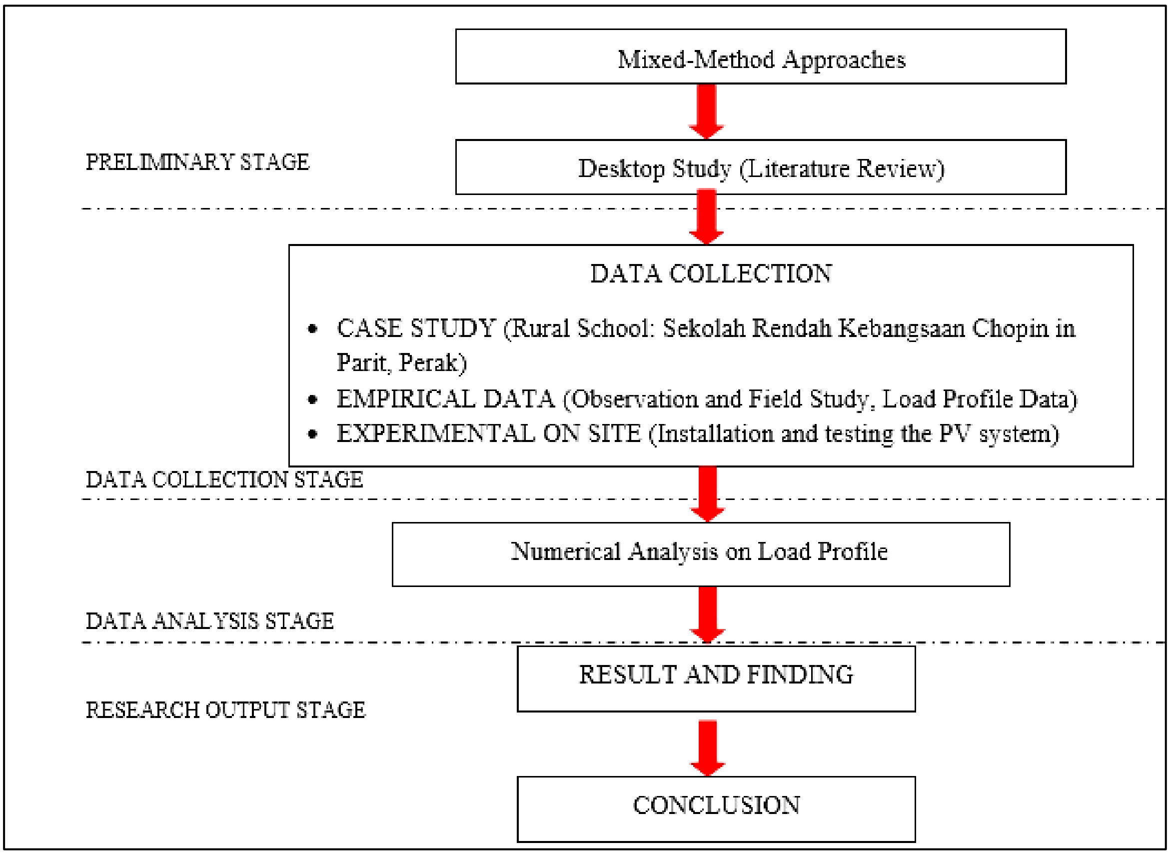
Figure 4

Pole-Mounted Photovoltaic (PV) System (Sources: Axion Power, 2022)

RESEARCH METHODOLOGY

The research methodology in this study involves mixed method approaches which cover four (4) research stages, which are (i) preliminary stage, (ii) data collection stage, (iii) data analysis stage and (iv) research output stage. Figure 5 presents the overall process of this research.

Figure 5
Research Methodology Process



The first stage involves the needs to identify the challenges and issues relating to the study through the compilation of literature review in a desktop study. Following that, a thorough data collection stage involving the case study, the observation and field study on the research location, and the experimental process which involving the installation and the testing of the PV system. At this stage, a lux meter has been used to measure the level of illuminance of the case study (before and after the installation of the system). In the third stage, quantitative methods have been utilized to evaluate the data and determine the final outcome of the study and findings by using the numerical analysis. At the end, an overall summary will be made to aid in the achievement of the targeted goals.

The Case Study

The case study selected is one of the rural schools in the Parit district in Perak, Malaysia, known as Sekolah Rendah Kebangsaan Chopin. This school is located in the village of Chopin Kanan, Parit, Perak, almost 60 km from the capital city of Ipoh, Perak (see Figure 6). It is a small school with one academic block for classes, one canteen, one security post and one building for the store room and restrooms located near forestry. This school block accommodates about 48 students and 12 teachers who directly face the solar radiation from the east of the school field. The duration for the installation of the system was officially carried out for 2 days involving technologists, volunteers, researchers and locals in a special community program. The observation period at the site lasted for 3 months (including the day of the system installation) involving researchers to collect data related to the level of efficiency of the installed solar outdoor lighting system.

Figure 6
The Case Study

This research aims not only to provide supplementary lighting to the school at night but also to provide awareness related of green energy among teachers and students in rural areas. A total of 9 sets of 25-watts solar panels and 6 sets of 10-watts solar panel were used for this project, integrating with outdoor-lighting applications and roof-mounted panels. Figure 7 presents the sketches of the location of each solar-outdoor lighting application mounted on the school's roof. Table 1 lists the types of the system. Whilst, Figure 8 shows the installation process of the system.

Figure 7
The Location of Each Solar-Outdoor Lighting Application

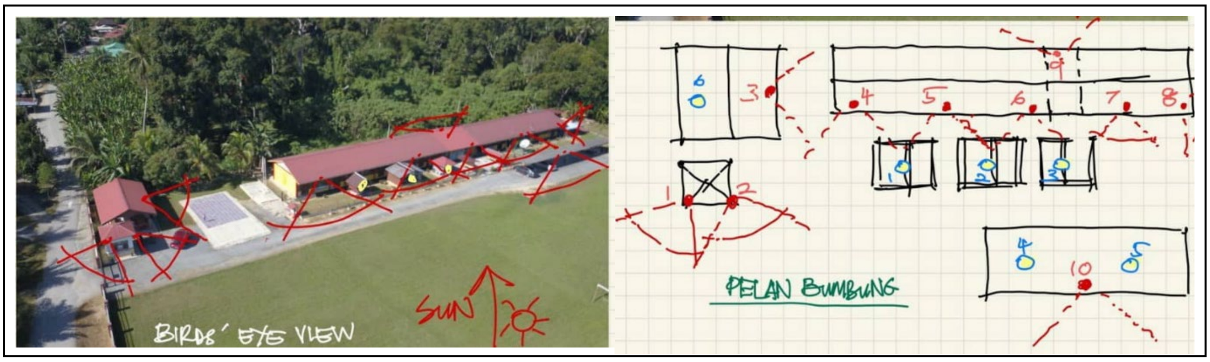


Table 1
Types of Solar-Outdoor Lighting for the Case Study

Unit	Power (Watt)	Types of Installation	Location	Quantities	Working Hours
9 set	25 watts	Roof Mounted	Canteen Security Guard House Academic Block (Classrooms)	1 2 6	5
6 set	10 watts	Roof Mounted	Parking Lot Room/Toilet Roof for Notice Board Gazebo	2 2 2	5

Figure 8
The Process of Installation and Testing for the Solar-Outdoor Lighting Application

FINDINGS

For this stage, a Lux Meter (model of Kyoritsu 5202 Lux Meter) has been used to measure the illuminance level in the case study during night-time. Table 2 shows the situation of the school before and after the installation of the system. It shows a huge difference in illuminance and brightness level of the school between before and after the installation of the solar-outdoor lighting system.

Table 2
The Installation of the Solar-Outdoor Lighting System for the Case Study (Before and After)

Location	Before	Lux Reading	After	Lux Reading
Parking Lot Roof		1		50
Academic Block (Classroom) Roof		1		80
Badminton Court (Next to Academic Block)		1.5		100
Gazebo Roof		1		200

Security Guard House Roof		1		175

After the installation, it is evident that the illuminance reading for each of the location in the case study has increased. The illuminance uniformity ratio is then calculated based on this lux reading collected from the Lux Meter. Uniformity ratio means the ratio between the average and minimum illumination as determined by measurements taken on space throughout the area to be lighted.

This formula has been used (EN 12464-1, 2021):

U2 = E (minimum) / E (maximum)

(i) U stands for: Uniformity
(ii) E stands for: Illumination

From the above formula, it should be noted that the light uniformity is the ratio of the illumination or lux level. Table 3 indicates the findings for this Illuminance uniformity ratio.

Table 3
The Illuminance Uniformity Ratio for the Case Study

Location	**E (minimum)**	**E (maximum)**	Illuminance Uniformity Ratio	Illuminance Uniformity Percentage Increased (%)
Parking Lot Roof	1	50	0.02	50%
Academic Block (Classroom) Roof	1	80	0.0125	80%
Badminton Court (Next to Academic Block)	1.5	100	0.015	67%
Gazebo Roof	1.5	100	0.015	67%
Security Guard House Roof	1.5	100	0.015	67%

DISCUSSION

Based on the research that has been conducted, after the installation of the solar-outdoor lighting, it is found that, this school managed to improve between 50% to 80% illuminance uniformity ratio around the schools especially at secluded areas. This shows how relevant any rural school is to install the solar-outdoor lighting applications to lighten the space, especially during night-time. It helps improve the vision, lit the space and increase the security level of the buildings

CONCLUSION

Solar lighting systems provide security and illumination in needed areas, especially in remote schools when grid power is unfeasible. It is also great in applications where it is cost-effective, easy to maintain and helps to increase the safety level of the rural schools, especially during night-time. In this case, it also helps to improve the ratio of the minimum lighting level of the selected areas in the school to the average lighting level.

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