PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 22 ISSUE 2 (2024), Page 131 – 142

ESTABLISHING A SUSTAINABLE SOLAR ENERGY COMMUNITY IN THE MALAYSIAN RURAL ENERGY LANDSCAPE: A CASE STUDY OF PERAK TENGAH, MALAYSIA

Nur Azfahani Ahmad[1], Nur Huzeima Mohd Hussain[2], Abd Talib Osman[3], Fiza Abdul Rahim[4]

[1]*Green Safe Cities (GreSafe) Research Group,*
[1,2]*Department of Built Environment Studies and Technology,*
College of Built Environment,
UNIVERSITI TEKNOLOGI MARA, PERAK BRANCH, MALAYSIA
[3]*Gas District Cooling (M) Berhad,*
KLCC, KUALA LUMPUR, MALAYSIA
[4]*Razak Faculty of Technology and Informatics,*
UNIVERSITI TEKNOLOGI MALAYSIA, KUALA LUMPUR, MALAYSIA

Abstract

The extensive reliance on conventional electricity from fossil fuels has heightened dependence in Malaysian communities, but escalating costs, CO2 pollution risks, and the depletion of fossil fuel resources signal its unsustainability. This study investigates the potential of solar PVs to shift rural communities away from fossil fuel-dependent electricity, aiming to foster self-sufficiency. The objective is to enable Malaysian rural communities to benefit from solar technology through a communal-sharing concept. A purposive sampling case study in central Perak reveals that solar energy applications offer communities sustainable electricity access. This approach addresses underutilised roof spaces in Malaysian communities, creating a model for sustainable, resilient living with self-sufficient electricity. Results show successful implementation, with a public building supplying solar-generated electricity to two houses and acting as community storage with a power system of 2 kWp for 24 hours. Illuminance levels improved by 50% to 80%. Town planners and engineers' support is crucial for nationwide dissemination, aligning with the 11th and 12th Malaysia Plan goals for sustainable electricity provision. This effort contributes significantly to achieving national development objectives focusing on providing sustainable electricity for the people.

Keywords: Photovoltaics, Rural Community, Solar Energy, Sustainable Electricity

[1] Assoc. Professor at Universiti Teknologi MARA Perak Branch. Email: nuraz020@uitm.edu.my

INTRODUCTION

The increasing trend of energy-dependent living in Malaysia has been heavily reliant on its fossil fuel resources, which have played a crucial role in generating national electricity and improving the overall quality of life in the society (Ahmad & Jamian, 2021). Additionally, these resources have enabled the government to subsidize electricity costs. However, the continued use of fossil fuels raises concerns about their depletion and poses threats to Malaysian energy security, especially in light of the South China Sea territorial conflict (Macaraig & Fenton, 2021). The local communities are particularly vulnerable to energy supply disruptions, highlighting the need for a more sustainable and secure energy model (Ahmad, et al., 2019).

This research aims to establish a sustainable community's model that ensures a consistent and secure electricity supply through the adoption of alternative energies, in particular solar energy for the rural development of Malaysia. This initiative aligns with the Malaysian rural development policy and supports the standpoint of planners in ensuring that rural developments are assessed for their environmental and economic impacts (Malaysia, 2021). In alignment with the 12th Malaysia Plan (12MP) initiative (under the pillar of Shared Prosperity and the dimension of Environmental Sustainability), the utmost focus is promoting sustainable citizen well-being through energy security. This aspect plays a crucial role in achieving the 12th Malaysia Plan (Malaysia, 2021). While global sustainable communities' models, such as 'Eco-village' (Hassan & Wall, 2017) and 'Co-housing' (Iberdrola, 2023) can be adapted to Malaysia, they currently lack a comprehensive solution to address the energy security challenges faced by a society that is heavily reliant on subsidized electricity. A concept of 'Rural Sustainability' was introduced by Ngah (2006), which defines the principles of a sustainable community. One of the fundamental aspects under this principle is the provision of sustainable electricity.

To tap into Malaysia's significant potential for establishing sustainable communities, this paper will focus on exploring key factors that demonstrate how solar photovoltaics (PVs) can power local communities and enable a more self-sufficient electricity supply. The paper tries to adopt an exploratory research design, primarily targeting middle and low-income communities.

The findings of this research will contribute to the formulation of a significant nexus living concept, integrating energy resources to ensure sustainable power supply for communities. Ideally, this living concept can be employed by the government to establish 'solar-communities', where solar energy is locally distributed through locals (Joshi & Yenneti, 2020). Significantly, this action may provide a future guideline for PLANMalaysia in establishing a more sustainable community for the rural energy development of this country (PLANMalaysia, 2020). By harnessing Malaysia's abundant solar energy resources, such sustainable communities can contribute to national energy security and reduce dependency on subsidized electricity, fostering a more sustainable and resilient energy landscape.

LITERATURE REVIEW

In 2022, the International Energy Agency (IEA) reported that global subsidies for fossil-fuel consumption amounted to USD$1 trillion, with electricity subsidies making up nearly 60% of the total (IEA, 2023). This report highlighted the issue of lower end-use prices resulting from subsidies, creating distorted price signals that encourage excessive electricity consumption. This raised concerns about the global population's electricity consumption habits. In the case of Malaysia, ensuring equitable distribution of electricity poses a challenge, as the risk of inadequate electricity production increases due to the South China Sea oil territorial issue (Macaraig & Fenton, 2021) and increasing electricity tariff (TNB, 2023). As energy insecurity issues are projected to rise, middle and low-income groups become vulnerable to various problems, such as higher electricity prices (TNB, 2023), frequent power outages, business closures due to blackouts, security issues, and reduced household incomes from closed-down businesses. These issues can ultimately lead to poverty and adversely impact national households. Solar-generated electricity is not only a clean and environmentally friendly source of energy but also plays a pivotal role in reducing pollution. Its affordability makes it a crucial component in addressing both environmental concerns and the energy needs of local communities. To address this, efforts are needed to establish a more sustainable community focused on securing energy resources, particularly by diversifying alternative energy sources (Joshi & Yenneti, 2020).

Under the 11th and 12th Malaysia Plan, the Malaysian government aims to promote sustainable lifestyles among its citizens (Malaysia, 2021), which prioritizes citizen well-being through securing energy resources. This is also has been supported by the Malaysia National Energy Policy (NEP) 2020-2024, which outlines the country's strategic directions and goals in the energy sector by addressing the key areas such as energy security, sustainability, efficiency, and affordability. The NEP 2020-2024 has listed the important criteria, as follows:

a) Diversification of energy sources that promote various renewable energy sources such as solar, wind, biomass, and hydropower.
b) Improving energy efficiency is able to enhance the overall productivity of energy use across different sectors, including residential areas.
c) Focusing on sustainability and environmental aspects that set targets for reducing carbon emissions and promoting environmentally friendly practices.

d) Ensuring energy security by enhancing domestic energy production and securing energy resources.
e) By providing energy affordability for consumers through strategic energy prices and subsidies effectively.

The United Nations (UN) report 2016 emphasized that communities must have diverse energy resources to avoid uncertainties and inadequacies in energy supply. Global sustainable communities have introduced models like Eco-villages (Hassan & Wall, 2017) and 'Co-housing' (Iberdola, 2023) communities that utilize various approaches to generate electricity while sharing ecological values. However, these green models have not yet provided a significant solution for maintaining energy security in nations like Malaysia, which is heavily reliant on subsidized centralized electricity. Abu Bakar et al. (2021) highlighted that, in establishing a sustainable community for Malaysia, it is essential to evaluate the communities by determining the human-nature connection with respect to the green initiative efforts. Thus, there is a need to establish a sustainable community model tailored to Malaysia's conditions.

Adopting a self-sufficient electricity lifestyle is a new and unfamiliar concept, especially for typical Malaysian communities (Ahmad & Jamian, 2021), particularly the middle and low-income groups accustomed to subsidized electricity from the government. Overseas examples have demonstrated that generating self-sufficient electricity can meet local energy demand, reduce the government's fiscal burden on energy, and contribute to the communities' self-sufficient energy (Joshi & Yenneti, 2020).

Community models like "Co-housing" groups have successfully generated their electricity through shared resources, such as biomass and solar energy generation (Iberdola, 2023). If adapted and modified to suit Malaysia's conditions, such community models could establish sustainable communities. With Malaysian abundant solar energy resources, with at least 10 sun hours daily, as indicated by Ahmad et al. (2019), harnessing and exploring this energy source could have a significant positive impact on the country.

However, with the increasing population, meeting the demand for energy becomes a challenge for the government, leading to competing access to energy security. The nation's fiscal burden will also increase. Therefore, communities must become sustainable in generating and utilizing energy. Additionally, Malaysia has been actively working on promoting solar energy adoption, including schemes and programs aimed at residential areas (see Table 1).

Table 1: Solar Energy Adoption Program (Since 2004) (SEDA, 2023)

The Malaysian Building Integrated Photovoltaic (MBIPV) Project (2004)	Feed-in Tariff (FiT) Program (2011-2019)	Net Energy Metering (NEM) Scheme (2019 – to date)	Green Technology Financing Scheme (GTFS) (2019 – to date)
The incorporation of solar photovoltaic (PV) elements into the design and construction of buildings. The foundation milestone towards the passing of the Malaysia RE and SEDA Acts 2011.	To encourage the adoption of renewable energy, including solar power, by residential users. Under the FiT system, homeowners who install solar photovoltaic (PV) systems can sell excess electricity generated back to the grid at a predetermined tariff. The FiT rates are typically set by the government and aim to provide an attractive return on investment for residential solar installations.	Allows residential solar PV system owners to offset their electricity bills by exporting excess energy to the grid. Under NEM, homeowners with solar installations can receive credits for surplus electricity produced, which can be used to offset the cost of electricity drawn from the grid during periods of low or no solar generation. This encourages homeowners to invest in solar panels for self-consumption and grid support.	A financial incentive that provides loans at a lower interest rate for individuals, including residential homeowners, looking to invest in green technologies, including solar energy systems. This scheme aims to make it financially more feasible for residents to install solar panels on their properties.

However, these schemes and programs primarily focus on high-income groups with strong financial capabilities and are essentially targeted for urban landscapes. The Malaysian government recognizes this issue and places great emphasis on the National Key Result Areas (NKRA) (PLANMalaysia, 2020) and the 11th and 12th Malaysia Plan objectives to make the country more energy self-sufficient and safe through the aid of renewable energies for all income groups (Malaysia, 2021). Given the vital role of energy in society and the abundant resources of solar energy in Malaysia, this paper explores opportunities for co-locating solar energy technologies in local communities (using public buildings) to cater to their energy demands and explore the limited availability of sustainable community models linked to the nexus of solar technologies in Malaysia.

RESEARCH METHODOLOGY

This research employs an exploratory mixed-method research design, which integrates both quantitative and qualitative methods in a sequential manner to explore the viability of establishing solar-sustainable communities in Malaysia.

The research aims to introduce the concept of a community grid to a typical community in Malaysia, enabling them to utilize excess electricity by sharing it within the community neighborhood. Given that not all households can afford a PV system (Ahmad et al., 2019), community buildings in the case study can be utilized for generating, storing, and distributing electricity.

The research began with a qualitative approach, focusing on observing and identifying suitable areas for co-locating solar energy technology in alignment with the local conditions of the communities. The study emphasizes generating solar energy as a means of achieving self-sufficient electricity from public buildings, thereby promoting sustainable energy practices within the community. It assessed the feasibility of generating electricity from the panels and sharing it with the communities through nearby public buildings, such as schools, mosques, or hospitals. A quantitative study was also conducted to evaluate the feasibility of co-locating solar PV technologies in selected areas. This study involved small-scale modelling and simulation of selected case studies to provide input for the development of the solar-community model. Finally, specific empirical data on the energy output of the solar panels were established and compiled over a 24-hour duration.

By adopting the research process outlined in Figure 1, the electricity produced by solar PV panels is fed into the community's grid system by a designated user acting as the 'generator' (a public building equipped with PVs). Individuals without PV panels can then directly purchase electricity from the PV generator. This approach can be integrated with public buildings in the community, such as schools, public clinics, mosques, and town halls, all of which can be equipped with solar PVs. For this research, a school has been selected since most rural communities have a public school.

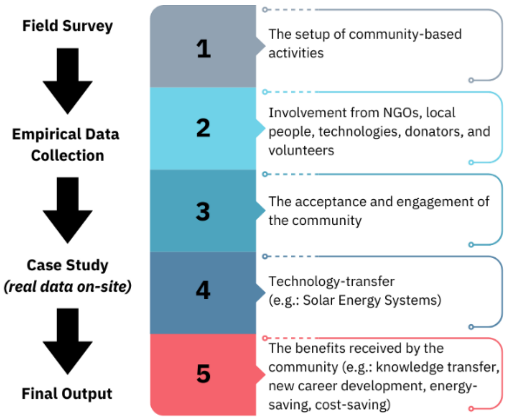

Figure 1: The Research Process
Source: the authors (2023)

In a rural community, the community leader can play a crucial role as the focal person responsible for managing the distribution of energy among these shared facilities. This cost-effective solution benefits the community as it allows for the installation of solar PVs on multiple public buildings with the involvement of many stakeholders. At the same time, it provides technology exposure for rural communities.

DATA COLLECTION AND ANALYSIS

The analysis of the case study is based on data gathered through field research, including site visits to the selected case study. Typically, roofs in Malaysia hold significant potential with vast areas and slopes generally less than 20°, making them well-suited to receive ample solar irradiation. With the full capacity of the roof areas on public buildings, the establishment of a successful solar community can become feasible. For this study, a typical school in a rural area in Perak Tengah, Malaysia, has been selected, representing a public building actively used by the community (see Figure 2).

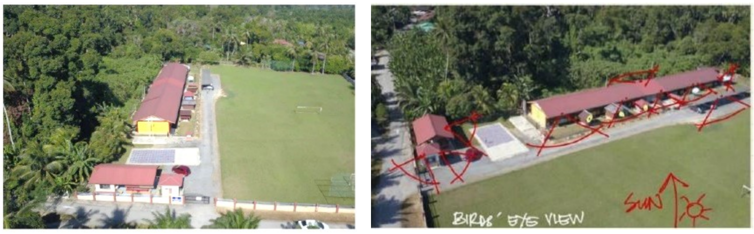

Figure 2: The Selected Case Study - A Public School in Perak Tengah, Malaysia

The observation and field survey period spanned for about 3 months, including the load profile collection by using data power logger and a pilot test involving an actual PV-system installation. Additionally, a small-scale simulation was conducted, and researchers compared the results with the actual collected data on the efficiency of the installed solar system (see Figure 3). The temperature on the day of installation was 27°C, and the sky condition was clear.

Figure 3: The Actual Process of the Research on Site.

Typically, only 10% of the average roof area of public buildings in the case study, which has an overall roof area of 1300 m^2, is required for installing solar PV panels. A small-scale simulation by PVSyst software (PVSyst, 2023) has illustrate the solar capability for this school which facing the east-direction with the consideration of this 10% (See Figure 4).

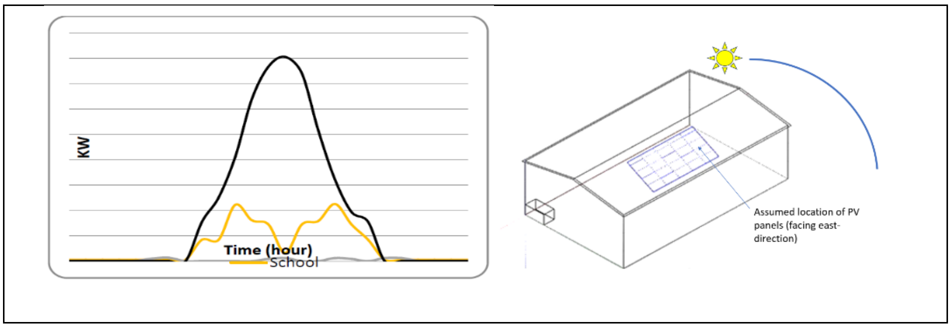

Figure 4: The Simulation Process Runs by PVSyst Software and The Load Profile of PV System Generated from the Roof of the Public School for 24-hours

This size is feasible and cost-effective for the buildings, considering the power requirements of the local community are small, if located in rural areas. This school holds the potential to supply solar-generated electricity from its panels and serves as electricity storage for the community. A 2 to 20 kWp PV system is deemed feasible for the school (Ahmad et al., 2019).

In this study, 10% of the overall area of the roof's building is approximately 130 m^2 (from 1300 m^2 of roof area) and has been installed with the solar PV system. To achieve an optimal peak of energy load, a 2-kWp stand-alone solar PV system with an efficiency of 20% was recommended for a pilot test (Ahmad et al., 2019). At the actual site, the system was successfully installed on the school's roof, and it was connected to the storage battery, inverter, and solar charge controller. Between 7 pm and 7 am of the next day (12 hours), the PV-systems effectively powered the outdoor lighting of the school, demonstrating the significant potential for increasing the number of installed solar panels on the roof. Figure 4 also illustrates that the energy received from the sun is substantial from the morning (7 am) until the afternoon (12 pm) and gradually decreases after noontime.

During this stage, a Lux Meter (Kyoritsu 5202 Lux Meter device) was used to measure the illuminance level at the site during nighttime. Table 2 illustrates the school's illuminance and brightness levels before and after the solar PV system installation, revealing a substantial difference between the two periods.

Table 2: Total of Improvement for the Illuminance and Brightness Level

Point	The Illuminance Condition is darker (Before the Installation)	The Illuminance Level (Before the Installation)	The Illuminance Condition is brighter (After the Installation)	The Illuminance Level (After the Installation)
Point 1		0 lux		50 lux (>50%)
Point 2		1 lux		80 lux (>80%)
Point 3		1.5 lux		100 lux (>67%)

From Table 2, it can be found that a public school can play a significant role in assisting communities by storing the surplus energy generated from PV panels and providing this energy to the locals when required. The findings have shown that with the aid of solar PV for this school, it can illuminate the surrounding areas, including the nearest residents, especially during nighttime.

DISCUSSION

According to the conducted research, the installation of solar PV system resulted in a significant improvement of 50% to 80% in the illuminance level around the school. This highlights the relevance and importance of schools as the catalyst of a community to adopt solar PV applications, especially during nighttime. These installations contribute to enhanced visibility, lighting of the surroundings, and increased security levels in the community. Significantly, public schools can assist the communities by storing the excess energy generated from the PV panels and sharing this energy with the locals when needed. This becomes particularly crucial during prolonged power blackout issues or flood disasters, where the power infrastructure is often disrupted due to flooding.

In this research, it is estimated that if the average daily sunlight hours are 5 hours, with the minimum 2 kWp system:

a) ***Daily Energy Production (kWh)***=2 kWp×5 hours (Solar Peak Hours) = 10 kWh/day
b) ***Daily Energy Usage for School Lighting (kWh) (from 7 pm to 7 am)*** = 0.3 kWp×12 hours usage =3.6 kWh/day
c) ***Excess Daily Energy (kWh)*** = 10 kWh/day – 3.6 kWh/day = 6.4 kWh/day

With the aid of batteries, an energy storage device can store electrical power and connect to a plug for a power source, known as the charging station. Buildings may act as a charging station, allowing nearby villagers to access electricity from a community-shared PV for basic electricity usage. With an excess of 6.4 kWh per day, it can power at least two rural houses, considering a consumption of 3 kWh of energy for each house. An actual energy production can vary based on factors like weather conditions, shading, and the orientation and tilt of the solar panels. Consequently, this energy-sharing can help provide energy security for rural communities. If a larger system, for instance, a 20 kWp system, is invested, a greater excess of energy-sharing can be provided in the communities, benefiting a higher number of rural residents from this energy.

The concept of energy-sharing can be implemented to foster a sustainable solar community. Community involvement is vital, enabling residents with limited financial resources to access solar energy facilities through sharing with other community members with higher incomes. A community leader, along with various stakeholders, can organize and facilitate this energy-sharing concept for the locals.

A comprehensive approach is recommended for the Government to provide holistic assistance to local communities, ensuring that these people can achieve self-sufficiency and sustainable electricity. With the assistance of town planners and engineers, this ideal concept can be effectively disseminated throughout the country, contributing to the achievement of the 11th and 12th Malaysia Plan's goal of providing sustainable energy for the people. Ideally, the concept of a sustainable solar community can be visualised like in Figure 5. A public building can function as a public solar energy station, storing all the energy generated from PV panel systems in its battery banks locally. The locals can then access this stored power by using extension outlets for lighting or powering other electrical appliances in their houses.

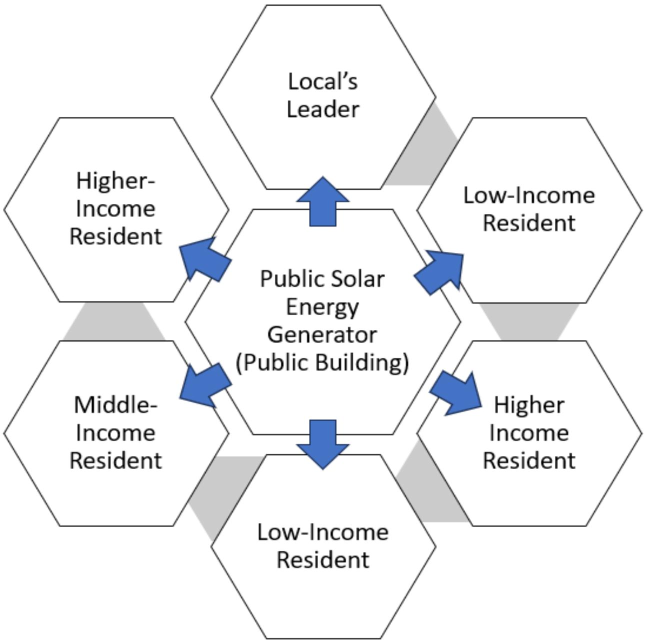

Figure 5: The Concept of a Sustainable Solar Community for Malaysia
Source: the authors (2023)

CONCLUSION

This study successfully investigates the potential of a sustainable solar community model that capitalizes on utilizing large community areas as co-locations for solar energy technologies. It encourages resilient practices, enabling communities to achieve energy independence through solar technologies while establishing public buildings as nexus hubs to promote overall sustainability in energy generation. This approach effectively addresses energy insecurity issues among locals, fostering energy generation and increasing self-sufficiency, ultimately contributing to the development of sustainable communities in Malaysia.

ACKNOWLEDGEMENT

The authors wish to thank the Malaysian Ministry of Higher Education for the FRGS grant (2019-2021) and all volunteers involved in this project, especially the staff from the College of Built Environment of UiTM Perak, Malaysia.

REFERENCES

Abu Bakar, A., Mustapa, S. I., & Mohammad, N. (2021). Green City Initiatives: Human-Nature Interaction. *Planning Malaysia*, 19(15). https://doi.org/10.21837/pm.v19i15.921

Ahmad, N.A and Jamian, J.J (2021). The Installation of Solar Photovoltaics for Charity Homes in Rural Malaysia: A Community-Based Approach. *International Journal of Smart Grid and Clean Energy*, 10(4), October 2021, 278-285, DOI: 10.12720/sgce.10.4.278-285

Ahmad, N.A., Che Ahmad, A., Byrd, H. and Hussain, N.H. (2019). Self-Sufficient Electricity Lifestyle: The Feasibility Study. *International Journal of Innovative Technology and Exploring Engineering* (IJITEE), 8(5S), 277-281, ISSN: 2278-3075.

Hassan, A. & Wall, G. (2017). The Ecovillage: Concept and Applications. 10.4018/978-1-5225-2107-5.ch004.

Iberdrola. (2023). Collaborative Housing (Cohousing) - Cohousing, The Sustainable Model for Collaborative Housing, retrieved from https://www.iberdrola.com/social-commitment/cohousing

International Energy Agency (2023), Fossil Fuels Consumption Subsidies 2022 Report, retrieved from https://www.iea.org/reports/fossil-fuels-consumption-subsidies-2022

Joshi, G. and Yenneti, K. (2020). Community Solar Energy Initiatives in India: A Pathway for Addressing Energy Poverty And Sustainability? *Energy and Buildings*, 210, 109736, ISSN 0378-7788, https://doi.org/10.1016/j.enbuild.2019.109736

Macaraig, C. E., & Fenton, A. J. (2021). Analyzing the Causes and Effects of the South China Sea Dispute: Natural Resources and Freedom of Navigation. *The Journal of Territorial and Maritime Studies*, 8(2), 42–58. https://www.jstor.org/stable/48617340

Malaysia (2021), Twelfth Malaysia Plan (12MP), retrieved from https://www.malaysia.gov.my/portal/content/31186

Ngah, I. (2006). Rural Sustainability: An Examination of the Practice of Sustainable Development Principles in a Rural Community in Malaysia. *Planning Malaysia,* 1(1). https://doi.org/10.21837/pm.v1i1.35

PLANMalaysia (2020), Safe City Programme, Official Portal of Town and Country Planning Department, Ministry of Local Government Development, Retrieved from https://www.planmalaysia.gov.my/index.php/pages/view/296

PVSyst (2023), Official Website at https://www.pvsyst.com/

SEDA (2023), https://www.seda.gov.my/reportal/fit/, retrieved on 24 Dec 2023.

TNB (2023). Press Statement on Tariff Adjustment (July-Dec 2023) for Peninsular Malaysia by NRECC, Retrieved from https://www.tnb.com.my/announcements/press-statement-on-tariff-adjustment-july-dec-2023-for-peninsular-malaysia

Received: 29th Feb 2024. Accepted: 3rd May 2024