International Journal of Technical Vocational and Engineering Technology [iJTvET]
e-SSN2710-7094, ISSN 2710-7086
Vol.3, No.1, 2022

# IMPLEMENTATION NET ENERGY METERING (NEM) GOMEN SCHEME FOR KUANTAN COMMUNITY COLLEGE WITH 66KW GCSPV SYSTEM AS ENERGY-SAVING AND PROFIT

Ahmad Zairi Bin Mohd Zain[*,1], Cik Siti Nor Suhaila binti Che Amat[2]
[1]*Human Resource Management Division,*
*Ministry of Higher Education, Malaysia*

[2]*Kolej Komuniti Kuantan,*
*Ministry of Higher Education, Malaysia*
**Corresponding author: zairizain@gmail.com*

## Abstract

The rising environmental crises and energy demand have stimulated renewable resources and the advancement of renewable energy technology. Solar energy together with biomass, hydro, wind and as well other different renewable resources, is a naturally alternative energy source. Solar energy has immense potential as a significant source and becoming the most appealing and preferred option in Malaysia. The introduction to the net metering system, NEM GoMEn scheme by SEDA provides an opportunity for Kuantan Community College to venture into the renewable energy business. A previous study has been made using a design calculation method to propose a PV system. This continuity research will use a different approach to evaluate the feasibility of implementing a NEM GoMEn towards a rooftop solar photovoltaic (PV) system at Kuantan Community College. To assess the new method's performance, the methodologies include an overview for 12 months of data in electricity demand and solar irradiation with PV system modelling and simulation. The PV system modelling includes four main blocks; the solar PV System, Block A Kuantan Community College, NEM Metering and NEM GoMEn Scheme. These models and approaches gave a better result than the previous study regarding electricity bill savings, payback period, $CO_2$ avoidance and numbers of the tree planted. The PV systems of 66kWp solar system capacity could produce 88174kWh saving of energy and save RM44880.62 in annual electricity bills while avoiding 56343.25kg of $CO_2$ through renewable energy. All the computations models and simulations are developed in MATLAB/Simulink environment.
*Keywords: - solar photovoltaic, grid-connected, NEM, energy-saving, profit, Matlab/Simulink*

## 1. Introduction

According to the United Nations, more than 80% of the world's primary energy needs are met by oil, gas (fossil fuels) and coal. Based on current trends, energy requirements is predicted to rise merely 50% over the next two decades, potentially resulting in an energy crisis (Sumathi et al., 2015). Like most countries, Malaysia has relied on fossil fuels as primary energy sources, especially in the electricity sector. Malaysia's immediate energy demand has risen by 21471 thousand tons of oil equivalent (ktoe) from 1990 to 79289 in 2011 and will keep increasing over the years (Wong et al., 2015).

The environmental crises and climate change are significant issues due to the excessive utilization of fossil fuels. The release of greenhouse gases, mainly CO2, depletes the ozone layer contributes to pollution and global warming. Renewable energy (RE) can be a game-changer for a country's energy crisis and economic development, mitigate harmful environment, and lessen climate change by minimizing fossil fuel consumption. In 2001, the Malaysian government introduced a push for renewable energy (RE) as a cleaner alternative solution, recognizing that rapidly diminishing resources cannot replenish fast enough to meet such unrelenting consumption (Oh et al., 2018). Malaysia recently produced 8% of its energy from renewable sources, but it has agreed to reach 20% through 2025 (Vaka et al., 2020). In comparison to most RE technologies, solar photovoltaic systems possess resulted in remarkable development in Malaysia and spanning the nation (Sreenath et al., 2020).

## 2. Literature Review

Solar PV is amongst Malaysia's most nuanced developing industries, outpacing other renewable energy sources because of numerous RE resources on the planet, namely the sun and excessive solar irradiation ranging from 4.21 kWh/m$^2$ to 5.56 kWh/m$^2$ (Azhari et al., 2008). Solar PV also offers low maintenance expense and low prices contrasted to different RE technologies and can be mounted on small such as rooftop or large scale. Small-scale grid-connected rooftop PV system provides feasible solar evaluations in urban locations, does not cost land, and saves transmission and distribution expenses. Consequently, this system's number of installations increases and associated research has been fast developing (Anang et al., 2021). To hasten and publicize nationwide solar PV installation, Malaysia's Sustainable Energy Development Authority (SEDA) has unveiled several incentives and programs, including Feed-In Tariff (FIT), Net Energy Metering (NEM), Large Scale Solar (LSS), Self-Consumption (SLCO), a Green Income Tax Exemption (GITE), a Green Investment Tax Allowance (GITA), and Renewable Energy certification installation (Saleheen et al., 2021). Feed-in-Tariff (FIT) was offered in 2011. One of the FIT scheme goals was to support the RE industry growth. The utility compensates users for producing renewable energy they generate (Razali et al., 2020). In 2016, NEM scheme was presented in Malaysia to replace the FIT scheme.

The NEM 2.0 was introduced on January 1, 2019, to stimulate NEM implementation with a new 500MW quota. The actual net energy metering strategy was implemented, allowing excessive solar PV generated energy to be exported back to the grid on a "one-on-one" offset basis. From 2021 to 2023, the new Net Energy Metering 3.0 program (NEM 3.0) is introduced to feature more prospects for electricity consumers to assemble solar PV systems on their roofs premises to save on their electricity bill. NEM 3.0 is sorted into three (3) new initiatives; NEM Rakyat Program, NEM GoMEn Program and NOVA Program. NEM GoMEn Program focuses on energy generated by the solar PV installation on government property. The introduction to the NEM GoMEn Program provides an opportunity for Kuantan Community College to venture into the field of renewable energy in the near future. Regarding the study on electricity load or demand forecasting by Mohd-Zain (2020, 2021), the percentage of reduction in electricity saving in Kuantan Community College is getting smaller every year. The reduction or saving in electricity consumption (in percentage) for each year is 10.34% (2017), 10.42% (2018), 6.64% (2019) and 3.71% (2020). This is predictable, especially if the same electricity is used from the same load. One way to increase significant electricity savings is by replacing obsolete loads or appliances with new and more efficient ones. However, replacing this equipment will involve time-consuming and high costs. Another alternative is to explore sources of income that can reduce the cost of electricity in Kuantan Community College, namely, from renewable energy such as solar energy. The initiative from SEDA like NEM GoMEn program looks promising as a significant step.

By using design calculation, the study on evaluation of technical and economic (techno-economic) potential as well as the feasibility of implementing a net metering system (NEM GoMEn) towards a rooftop solar photovoltaic (PV) system at Kuantan Community College have been conducted (Mohd-Zain, 2021b). This paper will study a new approach by modelling and simulating the 66kW Grid-Connected Solar Photovoltaic System using MATLAB/Simulink. The result will be compared to the previous study.

## 3. Methodology

The methodology of the study is provided in this section. The activities consist of a data overview for electricity demand and solar irradiation data and a summary of PV system modelling and simulation in MATLAB/Simulink. The workflow of this study is shown in Figure 1.

### *3.1 Data overview*

Block A from Kuantan Community College has been selected as a case study. Block A consumes more electricity than Block B and Block C, and therefore, the solar PV grid-connected system will be design for space on the rooftop Block A. (Mohd-Zain, 2021b). Mohd-Zain (2021a) mentioned that implementing the Movement Control Order (MCO) to control the COVID-19 pandemic throughout 2020 and 2021 will drastically reduce load or electricity demand at Kuantan Community College. Therefore, the electricity data used in this study will be in 2019. Table 1 indicates electricity demand (kWh) and bill (RM) by months for Block A in 2019.

Reliable details on the intensity of solar radiation at a specific location are critical to advancing solar energy-based projects. This information is used in project design, cost evaluation, and efficiency calculations (Mohammad et al., 2020). Therefore, solar irradiation data by month that will be used for the location will be referred to the data from Meteonorm software (Meteotest, 2020) and cross-reference with the study by Shaari et al. (2010) and SEDA Malaysia (2016). The difference between the annual irradiation data in this study is shown in Table 2. The data show no significant difference between the 3 (three) sources, and it will not have a notable impact on total solar energy production. Solar irradiation data from Meternorm will be choose as it is simulated and calculated to the closed one to year 2019 with tilted plane of 30$^{o}$.

### *3.2 PV system modelling and simulation*

A MATLAB/Simulink model was developed by Tan et al. (2016), and the file can be accessed and downloaded at MATLAB Central website. The researcher, Tan et al. (2016), used this model to compute 100kW Solar PV System and compare the FiT and NEM scheme outcomes. For this study, some changes are made to the model as an adjustment of 66kW PV system, 200 unit of 330W solar module or panel, NEM GoMEn Scheme, and in line with load/demand and solar irradiation data. The overview of the complete model is displayed in Figure 2. The model consists of 4 main blocks, 66kWp PV System, Block A Kuantan Community College, NEM Metering and NEM GoMEn Scheme.

Figure 1:The workflow of the study

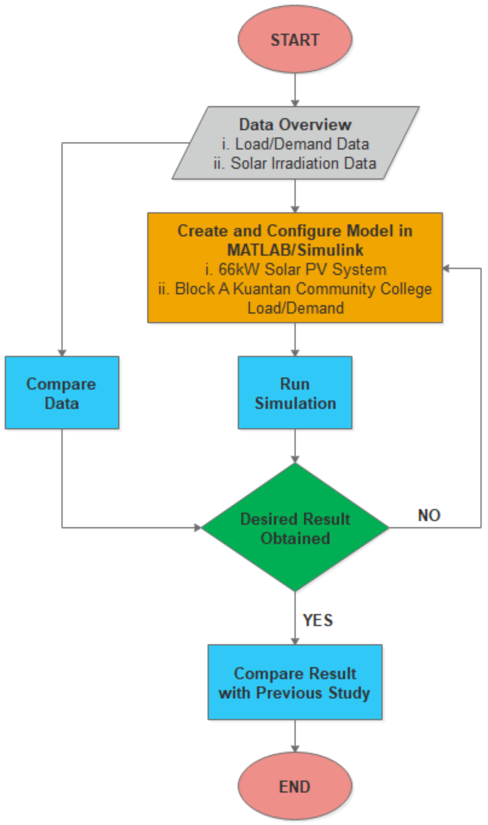


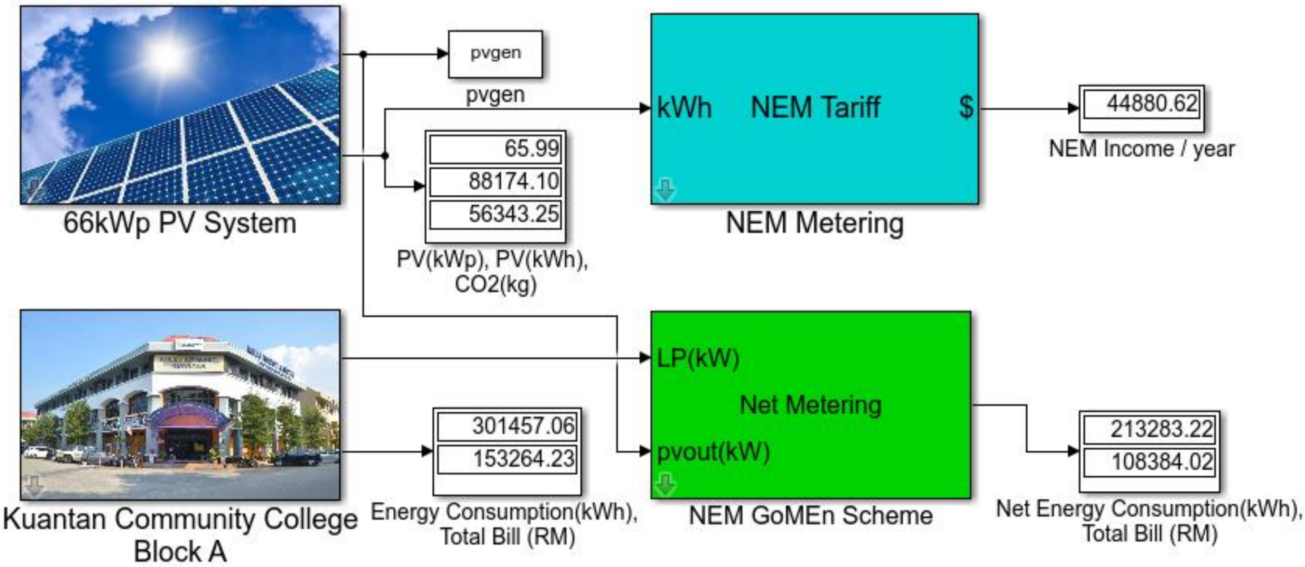

Table 1: Electricity demand (kWh) and bills (RM) by months for Block A in the year 2019

| Months | Electricity Demand (kWh) | Electricity Bill (RM) |
|---|---|---|
| January | 28235.00 | 14356.82 |
| February | 22721.00 | 11550.19 |
| March | 29981.00 | 15245.53 |
| April | 29145.00 | 14820.01 |
| May | 21650.00 | 11005.05 |
| June | 17984.00 | 9139.06 |
| July | 29097.00 | 14795.57 |
| August | 26174.00 | 13307.77 |
| September | 28015.00 | 14244.84 |
| October | 26382.00 | 13413.64 |
| November | 20763.00 | 10553.57 |
| December | 21310.00 | 10831.99 |
| **TOTAL** | **301457.00** | **153264.01** |
| **AVERAGE** | **25121.42** | **12772.00** |

Table 2: Annual Irradiation Data

| Sources | Annual Irradiation ($kWhm^{-2}$) |
|---|---|
| Meteonorm (2020) | 1631.00 |
| Shaari et al. (2010) | 1663.80 |
| SEDA Malaysia (2016) | 1682.77 |

Figure 2: Overview of the System Model




The 66kWp PV System block consists of solar irradiation data, PV array model, inverter and $CO_2$ avoidance computation. The block model will simulate the power generation output based on solar irradiation and efficiency inverter. This 66kWp solar PV system was modelled based on a previous study and design calculation of 200 units of QPEAK DUO-G5 330W monocrystalline solar PV module (Mohd-Zain, 2021b). The PV System model is defined by Equation (1), where $PV_{generated}$ is the energy generated from PV module, $I_{mp}$ is the maximum power current, $V_{mp}$ is the maximum power voltage, $N_{string}$ and $N_{array}$ is the number of strings and array, $H_m$ is solar irradiation in $kWhm^{-2}$, $k_{der}$ is deration factor meanwhile $\eta_{inv}$ is the inverter efficiency.

$$PV_{generated}(t) = (I_{mp} \times N_{string}) \times (V_{mp} \times N_{array}) \times H_m(t) \times k_{der} \times \eta_{inv} \;\ldots\ldots(Equation\ 1)$$

NEM Metering block will calculate the annual NEM income based on power generation output using Equation (2).

$$NEM_{income}=RE_{kWh}\times NEM_{rate} \;\ldots\ldots(Equation\ 2)$$

The Kuantan Community College Block A model's consumption and computes its tariff and bill. This block contains a load or demand profile to compute the energy consumption bill using Malaysia commercial building Category B tariff. Meanwhile, the NEM GoMEn Scheme block will calculate the Net Energy Consumption with the total bill and be defined as Equation (3).

$$Net_{kWh}=Load_{kWh}- RE_{kWh} \;\ldots\ldots(Equation\ 3)$$

Reducing carbon dioxide emissions through low carbon development such as PV systems is appropriate to combating climate change. NEM scheme contributes to the same reduction of $CO_2$ emission. To reduce carbon emissions, energy conservation, renewable energy development and tree planting are required (Jo et al., 2019). The reduction of $CO_2$ emissions is specified in Equation (4). For this study, in Peninsula Malaysia, the rate of $CO_2$ emission is 0.639 kg and approximately 21 kg $CO_2$ is absorbed per tree planted (SEDA Malaysia, n.d.).

$$CO_2\ Reduction= RE_{kWh} \times Rate_{CO2} \;\ldots\ldots(Equation\ 4)$$

## 4. Findings and Analysis

Miah et al. (2020) study stated that battery storage-based solar PV plants account for more than 40% of overall project costs. Therefore, the PV block system that has been modelled is a grid-connected system that does not necessitate any battery storage. From the simulation, the best configuration of PV array connected is 20 modules in string yielding up to 6.6kWp, 10 arrays to form a 66kWp PV System and a single unit central inverter with the efficiency of 98%, as presented in Figure 3.

Figure 3: Best PV Array Configuration of System Model

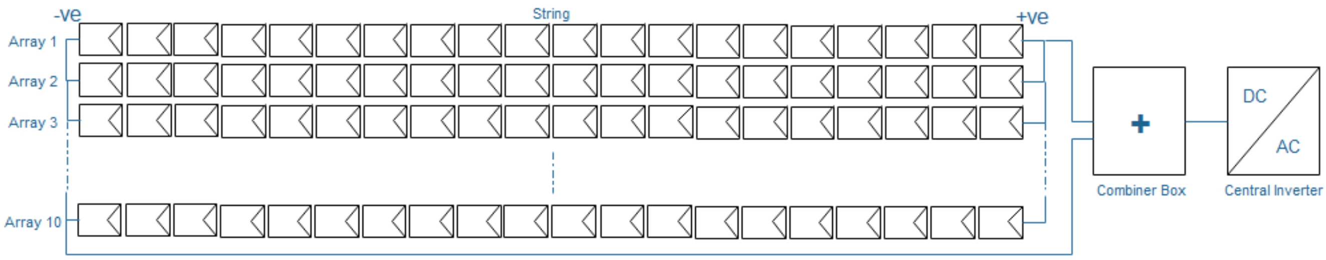
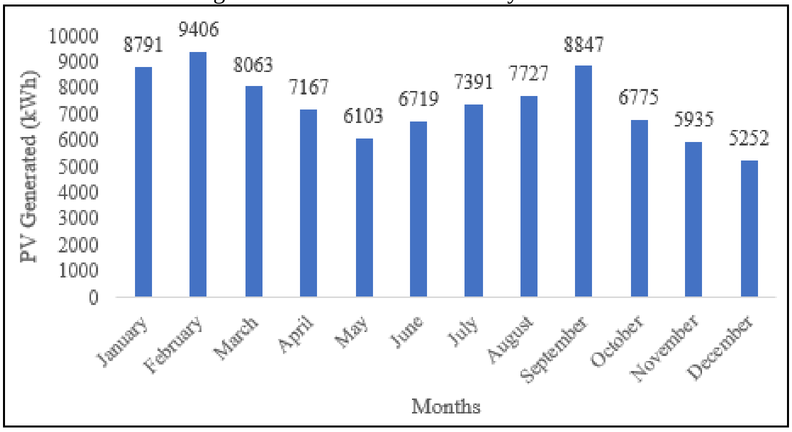



Figure 4 indicates the PV generated power by months. This graph is initiated by referring to Equation (1). The highest energy generated is 9406kWh in February, while the lowest generated is 5252kWh in December. The energy generated is dependent on the availability and intensity of solar energy on the surface and at the point of observation, which is from solar irradiation data. It can be observed that the graph trend is also affected by weather (cloudy, rain and monsoon season). In general, a 66kWp system can generate a total 88174kWh of energy and reduce the building's net energy consumption to 213283.22kWh annually.

Figure 4: PV Generated Power by Months




Using NEM GoMEn scheme as a reference and Equation (2), potential annual saving from the PV model system is RM44880.62 annually or approximately RM3740.05 monthly. Appertain exact total cost on the previous study; the scheme will reduce the monthly bill by 29.3% (from RM153264.23 to RM108384.02) with a return of investment (ROI) of 18.9% per annum and a highly encouraging payback period of 5.30 years. Based on Equation (4), $CO_2$ emission avoidance can be calculated from the energy generated PV system and emission rate. For 88174kWh energy generated from the PV system, $CO_2$ emission avoidance will be as 56343.25kg annually and equally to 2683 mature or fully grown trees need to be planted to absorb the same amount of carbon dioxide.

In summary, the comparison between the modelling simulation from this study and the proposed PV System (Mohd-Zain, 2021b) is proven in Table 3. Throughout Table 3, the modelling and simulation method provides better results than the proposed PV System design calculation from the previous study regarding monthly savings, payback period, $CO_2$ avoidance, and numbers of trees planted. However, the differences are not imperative and significantly impact the system or user. The result shows that both modelling simulation and proposed PV system using design calculation are suitable and practicable.

Table 3: Comparison between Modelling Simulation and proposed PV System

| Parameters | Modelling Simulation | Proposed PV System | Differences |
|---|---|---|---|
| PV system capacity (kWp) | 65.99 | 66.00 | 0.01 |
| Monthly saving (RM) | 3740.05 | 3732.50 | 7.55 |
| Payback period (years) | 5.30 | 5.32 | 0.02 |
| $CO_2$ avoidance (kg) | 56343.25 | 56229.40 | 113.8 |
| No. of tree (units/year) | 2683 | 2678 | 5 |

## 5. Conclusion

This research evaluates the feasibility of installing a grid-connected solar PV system on the roof of Block A, Kuantan Community College, using modelling and simulation in MATLAB/Simulink. Using the same parameters as the previous study, it is estimated that a 66kWp solar PV system may be placed, generating 88174kWh and saving of RM44880.62 annually. The beneficial economic indicators perform better monthly bills reduced by 29.3%, a shorter year for a payback period of 5.30 years with an 18.9% return (ROI). In conclusion, the modelling and simulation give better results than design calculations from the previous study. Still, both methods are practicable, show many potentials and offer many benefits in terms of energy-saving, profits and environment to consumers, the government, and electric utility.

**Acknowledgement**

The authors are grateful to the Kuantan Community College for providing the necessary support, data and platform for this research.

## References

Anang, N., Syd Nur Azman, S. N. A., Muda, W. M. W., Dagang, A. N., & Daud, M. Z. (2021). Performance analysis of a grid-connected rooftop solar PV system in Kuala Terengganu, Malaysia. *Energy and Buildings*, *248*, 111182. https://doi.org/10.1016/j.enbuild.2021.111182

Azhari, A. W., Sopian, K., Zaharim, A., & Al Ghoul, M. (2008). A new approach for predicting solar radiation in tropical environment using satellite images - Case study of Malaysia. *WSEAS Transactions on Environment and Development*, *4*(4), 373–378.

Jo, H. K., Park, H. M., & Kim, J. Y. (2019). Carbon offset service and design guideline of tree planting for multifamily residential sites in Korea. *Sustainability (Switzerland)*, *11*(13). https://doi.org/10.3390/su11133543

Meteotest. (2020). *Meteonorm Software* (8.03). https://meteonorm.com/

Miah, M. A. R., Rahman, S. R., & Kabir, R. (2020). Techno-Economic Assessment of Net Energy Metering Implementation for Rooftop Solar PV in a Commercial Building in Bangladesh. *Proceedings of 2020 4th International Conference on Green Energy and Applications, ICGEA 2020*, 95–99. https://doi.org/10.1109/ICGEA49367.2020.239712

Mohammad, S. T., Al-Kayiem, H. H., Aurybi, M. A., & Khlief, A. K. (2020). Measurement of global and direct normal solar energy radiation in Seri Iskandar and comparison with other cities of Malaysia. *Case Studies in Thermal Engineering*, *18*(October 2019), 100591. https://doi.org/10.1016/j.csite.2020.100591

Mohd-Zain, A.Z . (2020). Load Forecasting using Artificial Neural Network : Study Case at Kolej Komuniti Kuantan. *Politeknik & Kolej Komuniti Journal of Engineering and Technology*, *5*(1), 34–51.

Mohd-Zain, A.Z . (2021a). Electricity Demand Forecasting At Kuantan Community College As Impact Of COVID-19 Pandemic. *Journal of Engineering and Social Sciences*, *1*(1), 102–110.

Mohd-Zain, A.Z . (2021b). Techno-Economic Grid-Connected Solar Photovoltaic Potential Assessment based on Net Energy Metering (NEM) GoMEn Scheme in Kuantan Community College. In *Penyelidikan dan Inovasi Hijau MPCCSustAWARD21* (pp. 366–378).

Oh, T. H., Hasanuzzaman, M., Selvaraj, J., Teo, S. C., & Chua, S. C. (2018). Energy policy and alternative energy in Malaysia: Issues and challenges for sustainable growth – An update. *Renewable and Sustainable Energy Reviews*, *81*(May 2016), 3021–3031. https://doi.org/10.1016/j.rser.2017.06.112

Razali, A. H., Abdullah, M. P., Mat Said, D., & Hassan, M. Y. (2020). Annualized Electricity Cost of Residential Solar PV System under Malaysia's NEM Scheme. *ELEKTRIKA- Journal of Electrical Engineering*, *19*(1), 50–54. https://doi.org/10.11113/elektrika.v19n1.204

Saleheen, M. Z., Salema, A. A., Mominul Islam, S. M., Sarimuthu, C. R., & Hasan, M. Z. (2021). A target-oriented performance assessment and model development of a grid-connected solar PV (GCPV) system for a commercial building in Malaysia. *Renewable Energy*, *171*, 371–382. https://doi.org/10.1016/j.renene.2021.02.108

SEDA Malaysia, S. E. D. A. (n.d.). *CO2 Avoidance – SEDA Malaysia*. Retrieved February 4, 2022, from http://www.seda.gov.my/statistics-monitoring/co2-avoidance/

SEDA Malaysia, S. E. D. A. (2016). *Solar Irradiation Data for Malaysia*.

Shaari, Sulaiman; Omar, Ahmad Maliki; Haris, Ahmad Hadri; Abdul Rahman, Rafiza; Sulaiman, S. I. (2010). *Solar Photovoltaic Power : Irradiation Data for Malaysia*.

Sreenath, S., Sudhakar, K., & Yusop, A. F. (2020). Technical assessment of captive solar power plant: A case study of Senai airport, Malaysia. *Renewable Energy*, *152*, 849–866. https://doi.org/10.1016/j.renene.2020.01.111

Sumathi, S., Ashok Kumar, L., & Surekha, P. (2015). Solar PV and Wind Energy Conversion Systems: Introduction to Theory, Modeling with MATLAB/SIMULINK, and the Role of Soft Computing Techniques. In *Green Energy and Technology*. http://link.springer.com/10.1007/978-3-319-14941-7

Tan, R. H. G., & Chow, T. L. (2016). A Comparative Study of Feed in Tariff and Net Metering for UCSI University North Wing Campus with 100 kW Solar Photovoltaic System. *Energy Procedia*, *100*, 86–91. https://doi.org/10.1016/j.egypro.2016.10.136

Vaka, M., Walvekar, R., Rasheed, A. K., & Khalid, M. (2020). A review on Malaysia's solar energy pathway towards carbon-neutral Malaysia beyond Covid'19 pandemic. *Journal of Cleaner Production*, *273*, 122834. https://doi.org/10.1016/j.jclepro.2020.122834

Wong, S. L., Ngadi, N., Abdullah, T. A. T., & Inuwa, I. M. (2015). Recent advances of feed-in tariff in Malaysia. *Renewable and Sustainable Energy Reviews*, *41*, 42–52. https://doi.org/10.1016/j.rser.2014.08.006