International Journal of Engineering & Technology, 7 (3.20) (2018) 952-955

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Feasibility Study of Implementing Solar Photovoltaic Systems under Net Energy Metering Scheme in UTeM

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Abstract

The Malaysian government has introduced the Net Energy Metering (NEM) programme in November 2016 as one of the measures to encourage the development of renewable energy in Malaysia. In light of this, this paper aims to investigate the feasibility of installing solar photovoltaic system in UTeM under this NEM scheme. To achieve this, historical solar irradiation profiles were obtained from the commercially available database. This is to estimate the expected solar output generation. This is important as the amount of solar generation will ultimately translate into the revenue that is needed to justify the investment decision. As a state funded university, UTeM is enjoying a special subsided electricity tariff rate. Hence, the analyses have suggested that the rate of return of such an initiative is relatively low and unattractive for the investor in the economic point of view.

Keywords: *Net energy metering, solar photovoltaic system, economics*

1. Introduction

The world has made a concerted effort to combat climate change through the Paris Agreement [1]. One of the many measures that have been implemented worldwide is to harness the inexhaustible renewable energy with the aims to reduce carbon emissions. As such, wind and solar energy are the largest contributors in terms of capacity in providing green energy to the grid by displacing the dirty fossil fuel generation [2]. At the initial technology deployment stage, special scheme has been designed to encourage the private investment into the renewable energy sector. In this regard, Feed-in Tariff (FiT) and Net Energy Metering (NEM) Scheme are amongst the initiatives that have been in place by the government to springboard the development of wind and solar energy in their respective countries.

In this respect, the Malaysian government has allocated a total capacity of 500MW to be implemented under the Net Energy Metering (NEM) programme for year 2016 to 2020 [3]. This NEM programme has been introduced after the FiT scheme received overwhelming response from the public and the available quota was fully taken up. The fundamental motivation behind this NEM scheme is to encourage the deployment of renewable resources at the consumer level. Having said that, the energy produced from the solar photovoltaic (PV) system will be consumed locally first. Any excess of energy will be exported to the grid and sold to the distribution licensee such as Tenaga Nasional Berhad (TNB) at the prevailing displaced cost. [4]. However, the uptake of NEM quota from the public has been very low [5]. This could due to the relatively high levelized costs of energy for solar system in Malaysia as compared to the subsided electricity tariff [6]. Nevertheless, to the best knowledge of the authors, there is no published work on the systematic analysis on the feasibility of implementing NEM scheme in Malaysia. Therefore, this paper aims to investigate the viability of installing solar PV system at UTeM under the current NEM programme.

2. NEM Concept and Requirement

The fundamental principle of NEM is to encourage installation of PV systems for self-consumption. As an incentive, any excess energy can be exported and sold to the Distribution Licensee (DL), in this case TNB, at the cost of displacement as determined by the Energy Commission. Examples of companies or industries that can benefit from this scheme are those that operate only on weekdays. During the weekend, the energy generated from PV can be exported and sold. Payments will be done in the form of credits, which can then be used to offset the bill. The formula of calculation is shown in Equation 1. Unused credits can be carried forward for a maximum of 24 months before it expires. To record the energy activities, a bidirectional meter will be installed at the premise.

$$\text{Net billing} = \left[\text{Energy consumed (kWh)} \times \text{Gazetted Tariff}\right] - \left[\text{Energy exported (kWh)} \times \text{Displaced Cost}\right] \quad (1)$$

NEM is awarded based on quota and application must be submitted to governing body, Sustainable Energy Development Authority (SEDA). The maximum capacity is determined based on the consumer category. For commercial and industrial

consumers, the capacity must not exceed 75% of maximum demand, while for low voltage customers; it must not exceed 60% of the fuse rating. This is to ensure that the installation is mainly for own consumption and not to generate continuous credits to offset bills. Furthermore, systems larger than 72 kW require a NEM Assessment Study to ensure it does not pose unnecessary risk to grid operation

3. Demand and Solar Irradiance Profiles

As discussed earlier, the generated solar energy will first be consumed at the consumer's premises and the excess sold to the distribution licensee. There is a difference between the current displaced cost and the electricity tariff according to the consumer's category, such as residential, commercial and industrial. Hence, the correlation between the demand and solar generation profiles will be of great importance in the NEM project study. Fig. 1 shows the demand profile for UTeM main campus for the period of one (1) week in January 2018. It can be clearly seen that during the weekdays, the demand peaks between 9AM to 5PM and the demand remains fairly low during the weekend. Thus, the weekdays demand profiles in UTeM correlate well with the solar generation profiles as shown in Fig. 2.

This implies that apart from reducing energy used from the TNB grid, the installation of solar PV system in UTeM has the potential to reduce peak demand and the associated maximum demand charges. In addition, it can be observed from Fig. 1 that excess solar energy will be exported to grid during the weekend if the capacity of solar PV system exceeds 500kW.

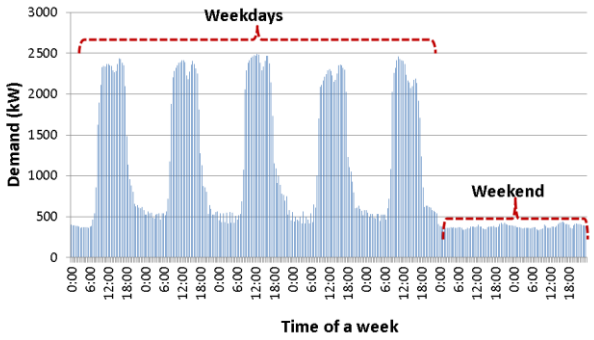

Fig. 1: One week demand profiles for UTeM main campus.

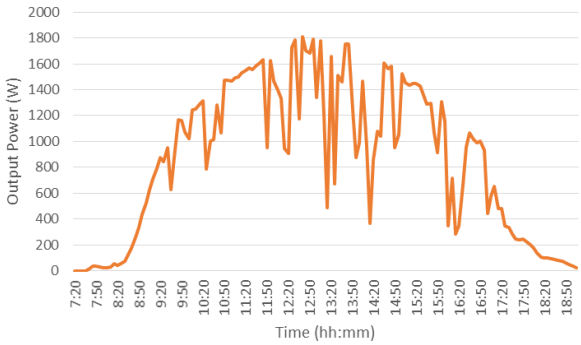

Fig. 2: Example of daily solar generation profile.

The other important consideration of NEM project analysis is the amount of solar irradiation resources that is available on the project location. Fig. 3 shows the simulated average of solar irradiation in Melaka. The values are generated using Meteonorm, a software that uses stochastic models to generate typical annual profiles for PV system design. As can be seen from Fig. 3, March is the month with the highest level of solar irradiation. On average, Melaka receives a total of 1660 kWh/m^2 of solar energy on the yearly basis. As a comparison, Alor Setar which is located at the northern part of Peninsular Malaysia has 1804 kWh/m^2. The difference is approximately 8.7%. Broadly speaking, the NEM project which is implemented in Alor Setar would be more profitable as compared to the project implemented in Melaka.

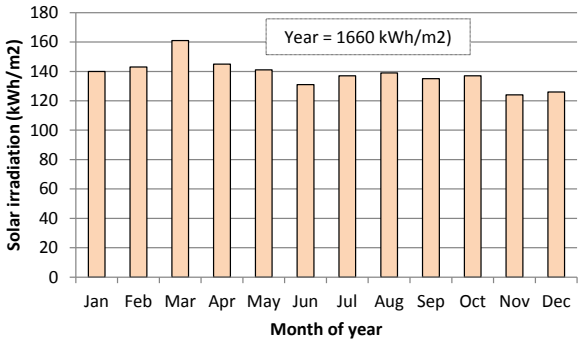

Fig. 3: Average monthly solar irradiation in Melaka, Malaysia

4. Case Study

The roof spaces of the building blocks at the Faculty of Electrical Engineering (FKE) have been identified for this specific case study. The buildings' bird eye view is as shown in Fig. 4 below. This is also to comply with the Energy Commission's guideline on NEM implementation which clearly stated the allowed types of installation method. For ground mounted system, it may be allowed on case by case basis subjected to Commission's approval [4].

Fig. 4: Bird eye view of the faculty building blocks.

The available rooftop areas on the faculty buildings are estimated to be between 5000 to 6000 m^2. This would allow approximately 700 kWp of solar system to be installed after considering shading and other design requirements. The latest commercially available solar module specifications shows that in generally, an area of 6 m^2 is needed to install 1 kWp of crystalline-based solar module. Hence, broadly speaking, the module's efficiency is around 16.6%.

Solar Generation Analysis

Fig. 5 shows the monthly comparison between energy generated from the 700 kWp solar system and energy consumed by the faculty buildings. The solar generation analysis was based on the solar resources in Melaka as shown in Fig. 3 with assumed 20% system losses. While actual energy consumption data collected from the faculty buildings were considered in this analysis. As the solar generation profiles generally coincide with the demand profile from the faculty, approximately 50% of faculty's electricity energy used could be displaced by the proposed 700

kWp solar system. Nevertheless, given the proposed solar system capacity is higher than the UTeM's peak demand during the weekend period (see Fig. 1), it is expected that some excess of solar energy will be exported to the grid and receive credit at the displaced cost of RM0.238/kWh. This is 35% lower than the current UTeM electricity tariff rate of RM0.365/kWh.

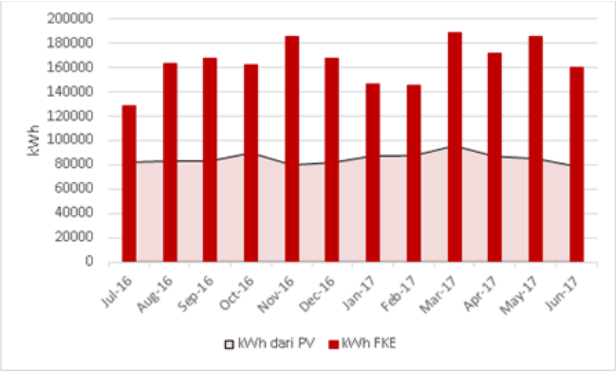

Fig. 5: Comparison between solar generation and energy consumption at FKE.

Economic Analysis

Table 1 shows the key parameters and assumption used in this feasibility study. The estimated system costs were based on the information given by an established solar system integrator in Malaysia. In addition, it was further assumed that on average, the solar system can contribute to 20% of maximum demand charges reduction. Nonetheless, this value is conservatively assumed and deserved further evident and justification.

The simple payback period analysis shows that it will require 8.7 years for the proposed solar system under NEM scheme to fully recover its initial investment costs. Having long term contractual agreement with TNB, the internal rate of return can be approximated as 11.5 % (reciprocal of simple payback period). This calculated rate of return is yet to consider the potential solar system degradation, as well as any maintenance costs that might incur over the technical lifespan of the system. Hence, the economic viability of implementing solar system in UTeM under the NEM scheme is considered unattractive to the prospective investors. It is worth noting that UTeM is a non-profit public university, and hence does not entitle for any tax incentives under NEM programme.

Table 1: Economics Analysis And Key Assumptions

PV Capacity **(a)**	700	kWp dc
Estimated unit cost	4.5	RM/W
Estimated system cost	3.15	RM 'million
Estimated annual solar generation	929.6	MWh
Average monthly solar generation **(b)**	77.47	MWh
Electricity tariff rate **(c)**	0.365	RM/kWh
Maximum Demand (MD) rate **(d)**	30.30	RM/kW
Monthly electricity bill offset **(b x c)**	28275	RM
Monthly MD bill offset **(a x d x 0.2)**	4242	RM
Estimated total monthly bill offset	**32,517**	**RM**
Simple Payback Period	**8.7**	**Year**

Further Discussion

The above presented case study has considered medium voltage general commercial tariff (Tariff C1) with maximum demand charges of RM 30.30/kW and RM 0.365 for all kWh used. This C1 tariff has significant difference with the domestic tariff (Tariff A) of which the electricity price will increase for higher kWh consumed as shown in Table 2 below. Thus, domestic consumer with higher electricity bill will have a more attractive business case. However, this is true only if the consumer's demand profiles correlate relatively well with the solar generation profile so that maximum solar generated energy are consumed within the premise, and minimum excess energy exported to grid. Fig. 6 shows the typical residential area demand profiles and the solar generation pattern. It can be clearly observed that solar generation profile does not correlate well with the residential demand curve. This means a larger portion of solar energy generated during the midday will be exported to grid with lower displaced costs credit. Hence, this is the main disadvantage for the domestic consumer to install solar PV system under the NEM scheme. This also explains the sluggish uptake of NEM quota from the domestic sector.

Table 2: Domestic Tariff For Monthly Kwh Used

Tariff A - Domestic Tariff (from 1 Jan 2014)		
For the first 200 kWh (1 - 200 kWh)	cent/kWh	21.8
For the next 100 kWh (201 - 300 kWh)	cent /kWh	33.4
For the next 300 kWh (301 - 600 kWh)	cent /kWh	51.6
For the next 300 kWh (601 - 900 kWh)	cent /kWh	54.6
For the next kWh (901 kWh onwards)	cent /kWh	57.1

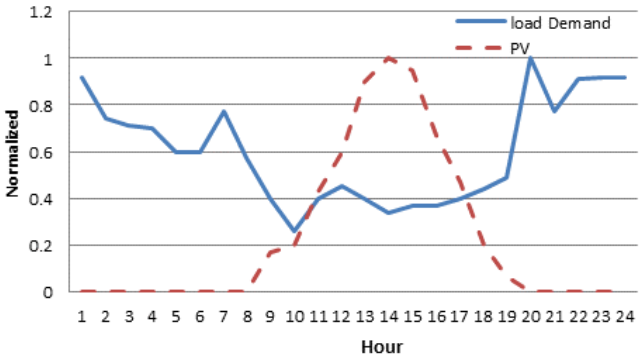

Fig. 6: The residential demand and the PV generation profiles [7].

In short, the feasibility of implementing solar PV system under NEM programme will depend on three (3) major conditions. Firstly, the correlation between solar generation profile and demand profile. Secondly, the tariff rate of the electricity energy that solar generation is going to displaced and lastly, the eligibility for tax incentive such as Investment Tax Allowance (ITA) and Capital Allowance (CA) for commercial customer.

5. Conclusion

From our findings, solar NEM programme is not economically attractive to implement in UTeM. The primary beneficiaries for this program are industries that have peak demand that coincides with solar noon and eligible for the tax incentive. By installing PV systems, they can reduce their electricity bills by reducing their maximum demand and getting charged with lower tariff brackets. For UTeM, having a fixed tariff rate rather than an increment-based rate implies that there are no incentives to shift the loads other than to reduce peak demand. Furthermore, it has to be emphasized that NEM payments are only in the form of credits used to offset the electricity bills. This also negates the interest on deploying solar PV under the current NEM scheme.

Acknowledgement

Hayder Salah Mohammed would like to gratefully thank the UTeM Zamalah Scheme for providing his PhD scholarship.

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