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A Comparative Study of Feed in Tariff and Net Metering for UCSI University North Wing Campus with 100kW Solar Photovoltaic System

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Abstract

The Feed-in Tariff (FiT) has been implemented in Malaysia since 2011 and end in 2016. Net metering will be the next renewable energy implementation mechanism. This paper presents the comparative study of FiT and Net metering for UCSI University North Wing Campus solar photovoltaic system at the economy and energy perspective. A 100kWp solar photovoltaic (PV) system model, real recorded solar radiation and university campus energy consumption data are used for this study. The 100kWp solar PV system, university campus, FiT, Net metering and CO2 avoidance computation models are developed in MATLAB/Simulink to simulate the solar PV system for FiT and Net metering cost and energy computation. The study found that the monthly energy bill cost saving for FiT and Net metering are 4.91% and 3.51% respectively. The return of investment of solar PV system implementation for FiT and Net metering are 11.5 and 16.1 years respectively. This study provides an insight cost and energy analysis for FiT and Net metering for the university campus.

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Keywords: Feed in Tariff; Net metering; Solar Photovoltaic

1. Introduction

The increased utilization of solar photovoltaic renewable energy development had expanded rapidly due to continuous decline in photovoltaic system prices in recent years [1]. To promote the utilization of renewable energy,

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Feed-in tariff (FiT) mechanism has been implemented in the Malaysia since year 2011 by incorporating renewable energy Act 2011, where 1.6% of Renewable Energy Fund (KWTBB) will be collected from the customers of Tenaga Nasional Berhad (TNB), the largest and sole utility company in Malaysia. The collected fund is channelled to Sustainable Energy Development Agency (SEDA) a government agency setup to manage and administrate the FiT mechanism. FiT policy is to offset the high investment cost of renewable energy [2]. It guaranteed fixed tariff rate and long contractual period up to 21 years [3]. While the electricity bill remains, the offset of the investment cost is done by selling the generated energy to the utility company at a higher tariff rate.

Feed-in tariff (FiT) has been implemented in the Malaysia since year 2011 and has reached its maximum capacity quota in end of 2015. Net metering will be the next renewable energy implementation mechanism. Net metering system implies that an algebraic deduction is performed between the electrical energy produced by the PV system and the energy consumed [4]. The Net metering allows consumers to consume the electricity generated from the renewable energy system. Given the case that the system generated excess energy, it could be sold to the utility company [5].

Both FiT and Net metering mechanism helps to reduce the energy consumption and bill by implementing renewable energy generation. However, the cost and energy outcomes of FiT and Net metering are not identical due to the difference in its mechanism. However, Net metering mechanism can potentially use to shave off the peak demand of power as well as energy consumption in a building, particularly for commercial building operations in day time during office hours, where solar radiation is available. Therefore Net metering can leads to reduction of maximum demand (MD) charges and the overall electricity bill. In Malaysia, the MD time frame is 30-minute intervals. The total load that is supplied within this time frame will be charged at a significantly high rate [6]. In this paper, a comparative study of FiT and Net metering schemes for UCSI University North Wing Campus solar photovoltaic system at the economy and energy perspective.

2. Methodology

To investigate the energy and cost difference between the two schemes, a MATLAB/Simulink model was developed to compute the outcome of FiT and net-metering scheme. The overview of the complete model is shown in Fig. 1. It consists of a total of 4 main blocks, there are solar PV system, university campus, FiT and Net metering block. The details of each block is elaborate is the following subsections.

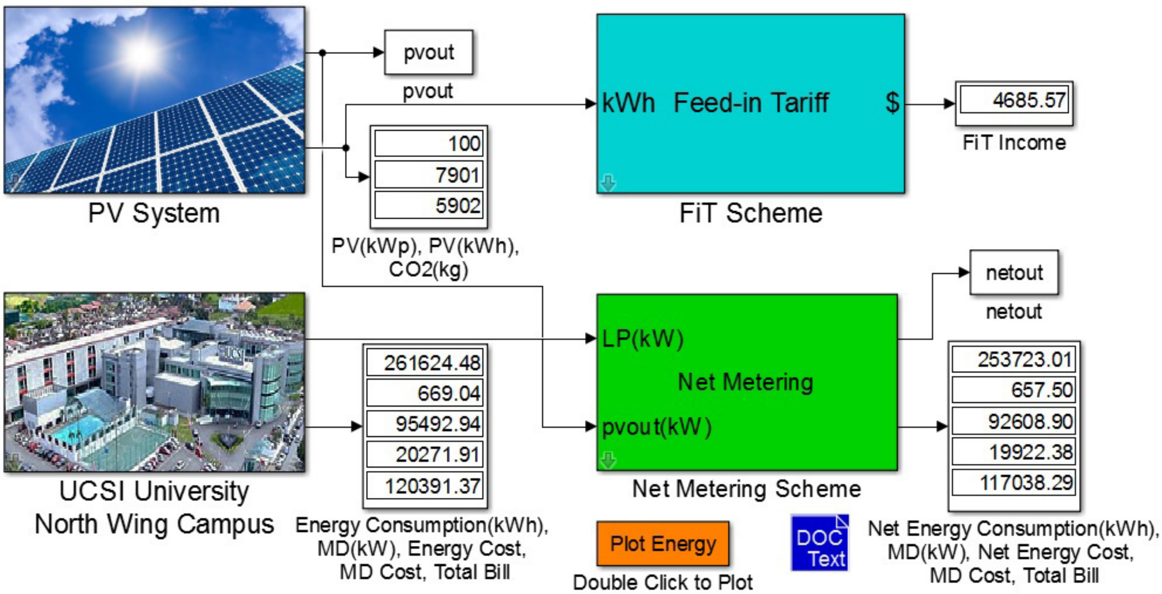

Fig. 1. System overview

2.1. PV System Block

The PV system block model simulates the PV array power generation output. It computes the generated power based on solar irradiance and the efficiency of the inverter. The PV system block consists of solar irradiance data, PV array model, inverter model and CO_2 emission avoidance computation. The PV array model is defined by equation (1), where PV_{array} is the power generated from the array, I_{mp} is the individual PV module maximum power current and V_{mp} is the individual PV module maximum power, N_{module} is the number of modules connected in a string, N_{string} is the number of strings and G is the solar irradiance in W/m^2. The string inverter model is defined by equation (2), where PV_{array} is the PV array power output and η_{inv} is the inverter efficiency.

$$PV_{array}(t) = (I_{mp} \times N_{string}) \times (V_{mp} \times N_{module}) \times G(t) \quad (1)$$

$$PV_{out}(t) = PV_{array}(t) \times \eta_{inv} \quad (2)$$

Since both FiT and Net metering schemes contribute to the same reduction of CO_2 emission. The CO_2 emission computation is included in the PV system block. The reduction of CO_2 emission is defined in equation (3) where RE_{kWh} is the energy generated from any renewable energy resources and $Rate_{CO2}$ is the CO_2 in kg produce for every kWh energy generated from conventional power plant in the country. For this study, the university campus location is in Peninsula Malaysia therefore an average of 0.747kg CO2 emission rate is used [7].

$$CO_2 = RE_{kWh} \times Rate_{CO2} \quad (3)$$

For this study, a 100kWp solar PV system is model to simulate the energy generation using solar irradiance data obtained from the meteorological department. The 100kWp solar PV system is model based on the actual available roof area on one of the academic building Block. The 100kWp PV array was modelled using 400 pieces of 250W PV module from Kyocera KD250GH-4FB2. The PV array are configure to have 20 modules in a string yielding up 5kWp per string. A total of 20 strings will be connected to form a 100kWp array. A single unit of 100kW central inverter PVS800-57-0100kW-A from ABB with efficiency of 98% are selected to model the PV system.

2.2. UCSI University North Wing Campus Block

The UCSI University North Wing campus block model the campus energy consumption and computes it tariff, peak demand and bill. The entire campus load profile are obtained from main supply feeder energy monitoring system. The University campus block contain the load profile in 30 minute average interval to computes the energy consumption bill based on Malaysia commercial building tariff. In Malaysia commercial building tariff system, there is a rebate known as Imbalance Cost Pass-Through Tariff Rebate (ICPT) which is MYR 0.0152 for every kWh of energy consumed. UCSI University campus is registered under commercial building C1 category, which qualified the campus for ICPT rebate. However, this discount does not apply to MD charges. On top of that, there is also a renewable energy Fund (KWTBB) collected by to fund the FiT mechanism. In C1 tariff category, the electricity supplied by TNB is sold at a fixed rate of MYR 0.365 per kWh regardless of when it is consumed. The maximum demand (MD) charge is MYR 30.30 per kW. Lastly the Goods and Services Tax (GST) of 6% to be charged on the bill. The ICPT, KWTBB, Usage and Bill are defined in equations (4), (5), (6) and (7).

$$ICPT = kWh \times 0.0152 \quad (4)$$

$$Usage = (kWh \times 0.365) + (MD \times 30.30) \quad (5)$$

$$KWTBB = Usage \times 1.6\% \quad (6)$$

$$Bill = (Usage - ICPT) \times GST + KWTBB \tag{7}$$

2.3. Feed-in Tariff Block

The FiT block computes the generated energy and cost from renewable energy resources that is distributed to the grid. The campus does not consume any energy from the PV system. In other words, the total amount of energy drawn from the utility grid remains, whereas the generated energy from the PV system is sold back to the utility company as of 2016 at a premium rate of MYR 0.593 per kWh as defined in equation (8). This selling price is 62% greater than the buying price of MYR 0.365 per kWh, which profits the consumers.

$$FiT = RE_{kWh} \times FiT_{rate} \tag{8}$$

2.4. Net Metering Block

Net metering block computes the net energy after utilizing the PV system generated energy. In commercial building such as UCSI University, the load consumption period is from 9:00 to 17:00 during day time when sunlight are available for renewable energy generation through the PV system. Net metering system is consider suitable for the university campus that operates at this hour because the Malaysia weather is considerably consistence throughout the whole year where the solar irradiance intensity peaks between 12:00 to 14:00, which falls between the peak demand period of the campus. The net energy consumption is defined in (9) where kWh is the energy consumption and RE_{kWh} is the generated renewable energy.

$$Net_{kWh} = kWh - RE_{kWh} \tag{9}$$

With net metering scheme, the maximum demand power can be shaved off by the PV generated power as defined in equation (10) where MD(T) is the peak power occurred at a given time which can be identified from the load profile and $PV_{out}(T)$ is PV generated power at a given time when peak power occurred. The net energy and maximum demand usage is defined in (11) and the total bill can be computed using equation (7).

$$MD_{shaved} = MD(T) - PV_{out}(T) \tag{10}$$

$$Usage = (Net_{kWh} \times 0.365) + (MD_{shaved} \times 30.30) \tag{11}$$

3. Results and Discussions

For this study, three different case has been simulated. There are campus without PV system, campus with PV system with FiT scheme and campus with PV system with Net metering scheme. Fig. 2 shows the load profile of the campus before and after the shaving with PV system. The highest power generated is 82.91kW on the 21st day of the month. The energy consumption trend of the campus are very consistent. It can be observed that the trend of the graph repeats after five high peaks and two low peaks every week, where the high peaks are Monday to Friday and the two low peaks are Saturday and Sunday.

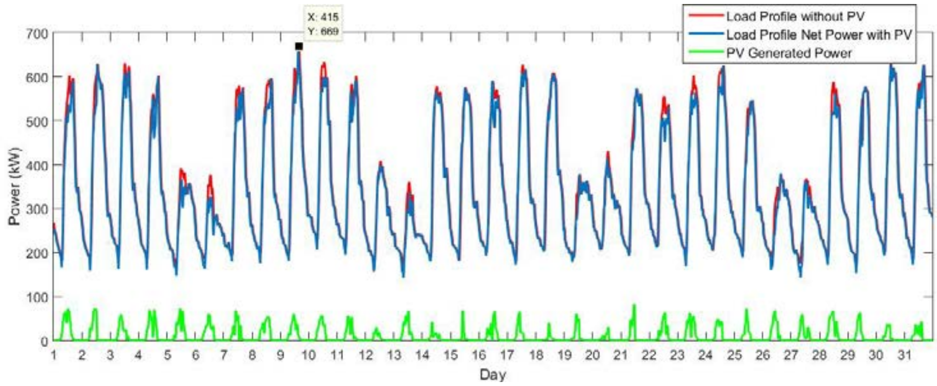

Fig. 2. Load profile without PV, with PV net energy and PV generated power

It can be clearly seen that the campus power usage reaches its peak between 12:00 to 14:00 daily. This is the time period where the solar irradiance is also at its peak except raining or cloudy day. As mentioned earlier net metering fit the daily solar irradiance pattern of the location where the peak sun hour is very consistent throughout the year. For this particular month load profile the maximum demand happen on the 9th day and it is 669kW and net metering system was able to shave the MD down to 657kW. The shaved demand is not significant because at the time of maximum demand peak power the solar irradiance was only 117.7W/m^2 due to cloudy day. This leads to the PV system only generate 11kWof power. Table 1 tabulate the energy consumption, maximum demand, PV generated energy and CO_2 emission for all three cases. In summary with 100kWp PV system is able to generate 7901kWh of energy in a month and the net metering scheme is able to reduce the net energy consumption 253723kWh.

Table 1. Energy consumption, maximum demand, PV generated energy and CO2 emission for all three cases.

	Without PV System	Feed-in-Tariff	Net Metering
Energy Consumption (kWh)	261624	261624	253723
Maximum Demand (kW)	669	669	657
PV Generated Energy (kWh)	0	7901	7901
CO_2 Emission Avoidance (kg)	0	5902	5902

The installation cost for solar PV system in 2016 Malaysia is about MYR 6500 per kW. A system size of 100kWp in this study costs approximately MYR 650,000. To compare the monthly saving and return of investment for both scheme, the study period is set for 21 years based on the FiT contract period in Malaysia. The FiT and Net metering saving can be determined in equation (12) and (13). The return of investment in years can be determined in equation (14). The net profit or saving after the years of return of investment for both schemes can be determined in equation (15) in which $T_{contract}$ is the contractual years and T_{ROI} is the ROI years.

FiT saving = Total Bill (without PV) – Total Bill (FiT) (12)

Net Metering saving = Total Bill (without PV) – Total Bill (Net Metering) (13)

$$ROI = \frac{TotalInvestmentCost}{MonthlySaving \times 12} \tag{14}$$

$$\text{Profit/Saving} = (T_{contract} - T_{ROI}) \times 12 \times \text{MonthlySaving} \tag{15}$$

The energy consumption cost, maximum demand charges, FiT income, total bill, monthly saving, return of investment and profit/saving after ROI for all three case are summarized in Table 2. The FiT scheme monthly profit is MYR 4685.57 and ROI is about 11.5 years and generates a net profit of MYR 534154.98 for 9.5 years considering 21 years of the contractual period. Whereas Net metering scheme monthly saving is MYR 3353.08 and ROI of 16.1

years and saving of MYR 197161.1 for 4.9 years after ROI years. Overall, a 100kWp PV system with FiT scheme reduces the monthly bill by 4.91%, and Net metering scheme reduces monthly bill by 3.51% compared to the standard tariff without PV system. The profit and saving for both scheme are low because the PV system of 100kWp is too small and only generates about 3% of the total energy consumption of the campus.

At a monthly perspective it is only about 1.5% differences between FiT and Net metering schemes and this gap can come close to FiT profit if the solar irradiance is high at the time of peak power in the month for better peak shaving for commercial tariff user with maximum demand charges. For 21 years long term, FiT is clearly more beneficial with additional 270% profit as compared with net metering, however in reality FiT scheme has it quota limitation and cannot run forever as it is only a kick start mechanism to encourage renewable energy installation. Whereas net metering scheme is more sustainable scheme to encourage renewable energy installation in the near future as the cost of PV system continue to decline.

Table 2. Summary of energy consumption tariff, maximum demand, FiT income, monthly saving, return of investment, profit/saving

	Without PV System	Feed-in-Tariff	Net Metering
Energy Consumption Tariff Charge (MYR)	95492.94	95492.94	92608.90
Maximum Demand Charge (MYR)	20271.91	20271.91	19922.38
Income (MYR)	0	4685.57	0
Total Bill (MYR)	120391.37	120391.37	117038.29
Monthly Saving (MYR)	0	4685.57	3353.08
Return of Investment (Years)	0	11.5	16.1
Total Profit/Saving after ROI	0	534154.98	197161.1

4. Conclusion

The comparative study of FiT and Net metering schemes for UCSI University North Wing campus with 100kWp PV system has been presented in this paper. A MATLAB/Simulink model was developed to simulate both FiT and Net metering scheme. From this study the FiT scheme have better cost efficacy and shorter return of investment years, and the Net metering scheme can perform better if the solar irradiance is strong during the maximum demand period of the month. Although Net metering did not perform well in comparison with FiT scheme in this study, the results still shows that the maximum demand and overall load consumption of the campus is being reduced. Both scheme are able to save at least 3.5% off the standard monthly bill without PV system and contributes to avoid 5902 kg of CO_2 emission. The MATLAB/Simulink model can be used to simulate different size of PV system to look into many what if scenario to determine the optimum cost energy performance for both FiT and Net metering scheme. The MATLAB/Simulink model is made available by the author for reader to download at Mathworks official MATLAB Central File Exchange link below https://www.mathworks.com/matlabcentral/fileexchange/58580

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