On-Grid Photovoltaic System for Maximum Demand Reduction at Taylor’s University Lakeside Campus

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Abstract— Demand charge of Taylor’s University Lakeside Campus (TULC) electricity usage constitutes 30% of its electricity billing. This means TULC’S maximum demand coincides with the system demand of its power supply provider which charge customer at higher rate under this condition. To reduce the, demand a grid-connected photovoltaic (Grid-PV) module was introduced as a secondary source. The application of this secondary source to reduce maximum demand is yet to be explored and thus hereby presented. The selection of critical load adopted by this Grid-PV system was done through power flow analysis using ETAP® network modeling software. PV sizing was done for the load selected and power flow analysis was conducted to analyze the impact of on-grid PV. It is reported in this work that, an average reduction of 11% on maximum demand can be obtained through the implementation of Grid-PV.

Keywords— Maximum Demand, Photovoltaic, Power Flow Analysis

1. Introduction

Taylor’s University Lakeside Campus (TULC) is a modern campus that comprises educational and commercial facility [1]. The campus has an average monthly electricity usage of 980MWh and average maximum demand (MD) of 3000kW. The average monthly bill is RM 304,208.76 whereby 30% of the total monthly bill was from demand charges [2]. At TULC the tariff C1 which is used for medium voltage general commercial customer is applied. The standard maximum demand charge imposed is RM25.90 per kW which is can also be considered as peak period rate [3].

Malaysia is a hot and humid country which has an average of 12 hours of daily sunlight and average irradiance per year of 1643 kWh/m², making it viable for solar energy implementation[4], [5]. Solar energy is regarded as the cleanest technology for electricity production. Typically there are two types of solar PV system which for on-grid and off-grid application. On-grid systems are PV system which is implemented with grid connection. Whereby, off-grid systems stand-alone system used for small scale application[6].

The objective of this research is to reduce the costs spend on demand charges with the introduction of solar energy to act as a secondary source for the TULC campus which reduces the daily energy consumption during the time of peak period. Taylor’s University Power Flow Model (TUPFM) developed using network modeling tool and an on-grid PV system which is tapped to critical load selected with respect to size of area available for implementation is designed and tested.

2. Research Methodology

Fig.1 shows the block diagram methodology applied for this research. Analysis on maximum demand curve for TULC was conducted to determine the average maximum demand of the system. The electrical network diagram for the campus is modeled using ETAP® as shown in Fig. 4 and load analysis was done to determine the highest power demand of the system. Fig.2 shows that main switch board (MSB) 3 and MSB 4 as the highest contributor for the maximum demand due to high power consumption. MSB 3 is connected to critical sub-loads that have high calculated maximum demand size that will not be viable to size PV with the area available at the campus. Therefore, MSB 4 is opted whereby; it is a mixture of lighting load and critical load. The load selected to be tapped with PV is shown in Fig.3 that is expected to operate consistently compared to other sub-loads that used to power lighting loads which are inconsistent.

The size of PV was based on assumption to power the load for working hours from 9a.m to 5p.m. PV selected is polycrystalline that is suitable for hot and humid condition of Malaysia. The inverter opted is grid tied since it is an on-grid PV system. Load and fault analysis was conducted on TUPFM that was modeled in ETAP®. This is done to analyze the system response to On-Grid and Off-Grid. The results obtained was analyzed on demand reduction and cost savings.

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3. Calculations

The ratio (\(A_{MSB}\)) of selected critical load (\(CL_k\)) to average load of MSB 4 (\(AP_{MSB}\)) was computed as follows

\[
A_{MSB} = \frac{CL_k}{AP_{MSB}}
\]  

(1)

Assuming the selected critical load is tapped to PV; new average load of MSB 4 (\(NP_{MSB}\)) can be computed by using power consumed by MSB 4 (\(P_{MSB}\))

\[
NP_{MSB} = P_{MSB} - (A_{MSB} \times P_{MSB})
\]  

(2)

Based on the new loading of MSB 4, percentage difference (\(\%Diff_{MD}\)) between existing maximum demand (\(P_{MD}\)) and new maximum demand (\(P_{MD}(new)\)) was computed

\[
\%Diff_{MD} = \frac{P_{MD} - P_{MD(new)}}{P_{MD}} \times 100\%
\]  

(3)

Percentage saving (\(\%Savings\)) was computed using new maximum demand cost (\(NMD_{RM}\)) and existing maximum demand cost (\(EMD_{RM}\)) as follows

\[
\%Savings = \frac{EMD_{RM} - NMD_{RM}}{EMD_{RM}} \times 100\%
\]  

(4)

4. Results and Discussion

Based on Fig.4 it is noted, that there is a decrement in the power demand as the new maximum demand is lower compared to the existing maximum demand. Thus, this proves that the implementation of on-grid PV to power the critical load reduces the maximum demand. This reduction was taken on the basis that the PV is capable of supplying the demand of the critical load at maximum demand period. Based on Fig.5 it is shown that savings can be made through the implementation of grid-PV on the critical load of MSB 4. Whereby, the PV does not brings return of income but it provides saving through reducing maximum demand charges.

5. Conclusions

There is significant impact on the maximum demand with the installation of PV, an average reduction of 11% between new maximum demand and existing maximum demand obtained. Based on the reduction in maximum demand, an average of 9% savings can also be obtained in maximum demand charges. Thus, it can be concluded that implementation of grid-PV can reduce the maximum demand during peak period.

References


