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Voltage Profile Analysis of Small-Scale Solar Photovoltaic System under Different Load Profile

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ABSTRACT – This paper presents an analysis on voltage profile of small-scale solar photovoltaic system under different load profile. Field measurements have been carried out at point of common coupling for the on-grid solar photovoltaic system installed at Faculty of Electrical Engineering, UTeM. The respective analysis was conducted on actual voltage and current profile during weekday (high load) and weekend (low load). An example of load at UTeM is used for PV system voltage profile analysis. The key findings suggest that voltage profile on different load shows no significant difference, which indicates there will be no occurrence of reverse power flow.

1. INTRODUCTION

Installation of small-scale solar photovoltaic (PV) system at the low voltage distribution network has been widely spread in Malaysia, which primarily driven by the Feed-in Tariff (FiT) incentive scheme of which the solar investor will get paid at the premium rate for the solar energy exported to the grid [1]. Nevertheless, such installation will introduce new technical challenges to the existing grid, such as power quality, reverse power flow and network protection issues [2].

Researches on PV in Malaysia have discussed on solar radiant energy prediction [3-4], PV module performance [5], cell material [6], inverter [7], harmonic distortion [8]. However, the actual field of voltage profile for solar PV system under different load profile are not substantially reported in the literature. Therefore, this paper aims to analysis the voltage profile of small-scale solar PV system under different load profile. Actual field measurements have been carried out on 12 single-phase inverters connected at the point of common coupling (PCC) for the on-grid solar PV system installed at different locations in UTeM.

The next section of the paper will describe on the solar PV system installed in UTeM, followed by the analysis and discussion of the collected field measurement data. Finally, the paper is concluded with major findings of this work.

2. METHODOLOGY

The Faculty of Electrical Engineering, UTeM has installed grid-connected solar PV systems with four different module technologies at different locations. Each of the systems is equipped with three units of 2kW single-phase inverter. Total solar PV capacity for each systems is 23.88kW as shown in Table 1. The installation method for all solar PV system is free standing with different azimuth angle (from south to south-east). In addition, the outputs of these four PV systems are terminating at the PCC. The field measurement in this work were taken at this PCC as shown in Figure 1. The measurement device that has been installed at this PCC is SIEMENS SENTRON PAC4200 energy power meter. It is important to note that the connection of the 12 single-phase inverters to the main grid was arranged in the balance manner. Any imbalance occurred in the system is caused by external factors such as a temperature, shading, module mismatch, weather conditions and etc.

Table 1 Solar PV array capacity.

System	PV array capacity (kW_p)
Mono-crystalline	6.12
Poly-crystalline	5.88
Thin-film	6.24
Heterojunction	5.64
Total	23.88

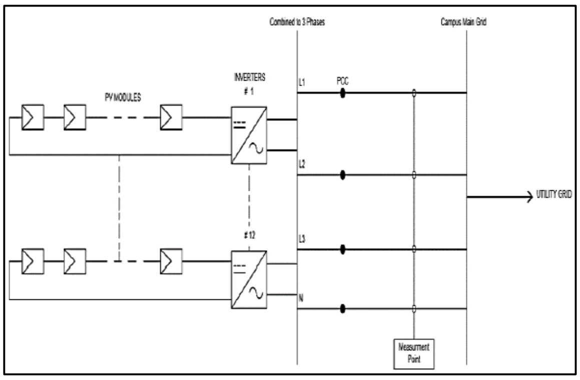

Figure 1 Schematic diagram for the solar PV system.

3. RESULTS AND DISCUSSION

Figure 2 and 3 show the actual voltage and current profile in one-minute time resolution recorded on 8th August 2018 (weekday) and 11th August 2018 (weekend), respectively. The measurement was carried out at the PCC for the on-grid solar PV system installed at Faculty of Electrical Engineering (FKE), UTeM. In view of voltage profile comparison between weekday (Figure 2) and weekend (Figure 3), there was no significant difference even though the loading on weekend is much lower than on weekday.

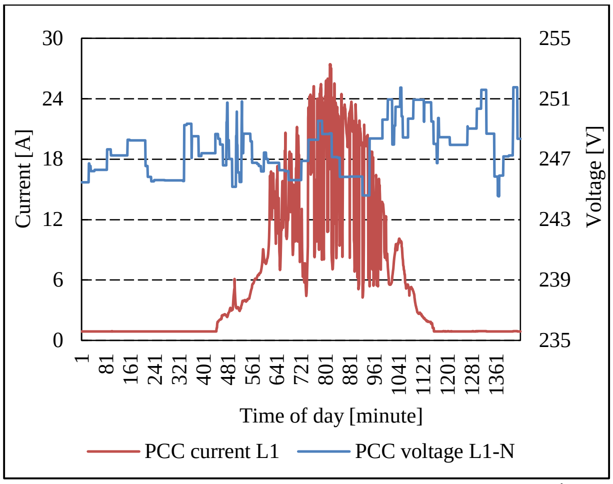

Figure 2 Actual voltage and current profile on 8th August 2018 (Weekday) measured at PCC for on-grid solar PV system installed at FKE, UTeM

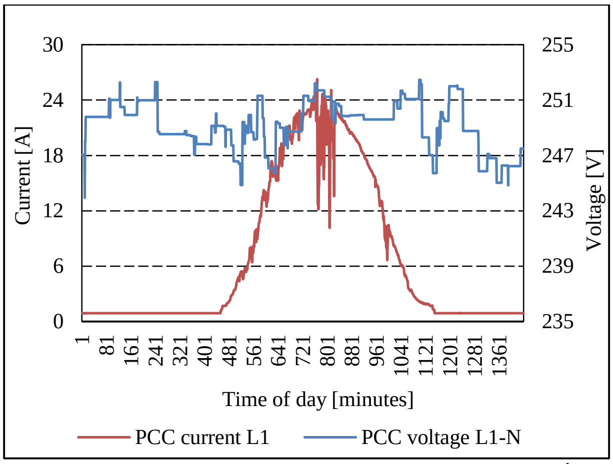

Figure 3 Actual voltage and current profile on 11th August 2018 (Weekend) measured at PCC for on-grid solar PV system installed at FKE, UTeM

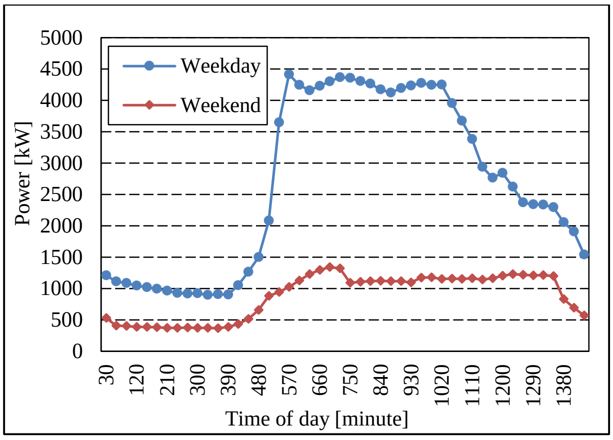

Figure 4 Example of load profile at UTeM main campus on weekday and weekend.

An example of the load profile for weekday and weekend at UTeM main campus in 30-minutes resolution as shown in Figure 4. Maximum demand for weekday and weekend is 4.41MW and 1.34MW, respectively. As discussed earlier, since the total capacity for four distributed solar PV output installed at UTeM is approximately 24kW$_p$, which represents approximately 0.5% of the UTeM peak demand, there will be no occurrence of reverse power flow. This is confirmed by the recorded data as shown in Figure 2 and Figure 3. Thus, larger capacity of solar PV output is needed for occurrence of reverse power flow in UTeM. The voltage fluctuations were mainly caused by the activation of on-load tap changer at the incoming 33/11kV primary substation.

4. CONCLUSION

Actual field measurements have been carried out at the PCC for the on-grid solar PV system under different load profile. The presented study shows the comparison of voltage and current profile between weekday and weekend. For voltage profile comparison, there was no significant difference, which indicates that there will be no occurrence of reverse power flow. This is confirmed since PV output is approximately 0.5% of the UTeM peak demand. Larger capacity of solar PV output is needed for occurrence of reverse power flow in UTeM.

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