Analysis and Classify the Variability Index of the Irradiance for Grid-Connected System Photovoltaic in UTeM

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ABSTRACT – Malaysia is currently using Net Energy Metering (NEM) by installing Photovoltaic grid-connected system to utility which is helping to reduce non-renewable energy consumption. However, as one of tropical country that have dynamic and static clouds that causing variability irradiance which is nearly impossible to avoid generating distortion power. In this paper, 2017 radiation data will be analyzed by using Variability Index (VI) method and will be studied to show the values of VI. A weather station in FKE contains pyranometer device that utilized to get actual irradiance data. Different day values and the whole year will be analyzed and classified.

1. INTRODUCTION

Nowadays, using Photovoltaic (PV) system as a power plant is the target to generate clean electricity without affecting the environment causing global warming. In addition, the price of PV system has been reduced over the past years due to the given supporting from development countries [1]. Tropical countries such as Malaysia has convenient weather for PV technology due to the plentiful of the solar irradiance of average 1643 kWh/m$^{2.}$ [1], [2]. However, Malaysia climate keep changing frequently due to cloud passing, the power generation from PV system is not stable and impose fluctuation to power grid. The solar irradiance intermittency has direct impact on PV power output [3], [4]. Passing clouds, overcast and variability irradiance can be classified by using method called Variability Index (VI). In other words, VI is the method which utilizes real irradiance data that have been collected to understand and classified the weather condition specifically for clouds.

2. METHODOLOGY

Offering different methods for calculating the variability irradiance specifically the actual measured irradiance will give us more details about the clouds effect on solar radiation [5]. VI defined as the ratio between G_{act} the actual tilt irradiance that have been measured and G_c the ideal irradiance that is used as reference for clear sky irradiance signal as shown in equation (1) [5], [6].

$$VI = \sqrt{\frac{\sum(G_{act}(k) - G_{act}(k-1))^2}{\sum(G_c(k) - G_c(k-1))^2}} \quad (1)$$

When VI equal 1 it shows clear sky day however it's impossible to get ideal clear sky irradiance due to some losses of the solar irradiation while reaching the PV panels. In addition, for dynamic and static clouds the VI values can reach above 1 and it shows the variability irradiance in overcast cloudy day [6]. Calculating the VI by using actual irradiance data that have been collected for the whole 2017 by device called Pyranometer. The Pyranometer (Kipp&Zonen CM 11), measures the global and tilt irradiance and it is located at the roof of FKE building. Figure 1 shows The Pyranometer device connecting to weather station - which located inside PV laboratory- with ethernet line from campus to get and save the collected data. The data of tilt irradiance will be used in the calculation due to it is in the same angle as PV panels and to know exactly the values of the irradiance that reached to the PV panels.

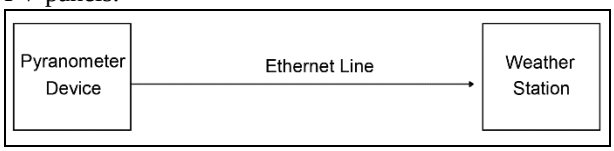
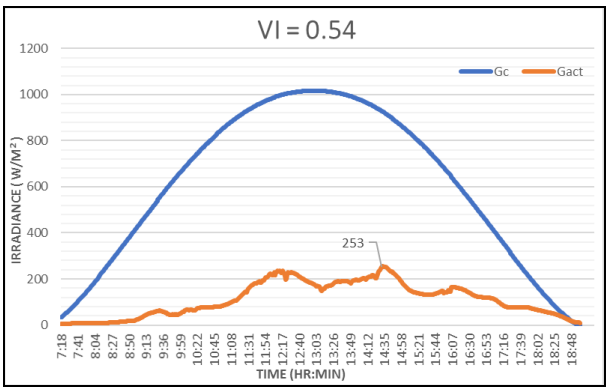


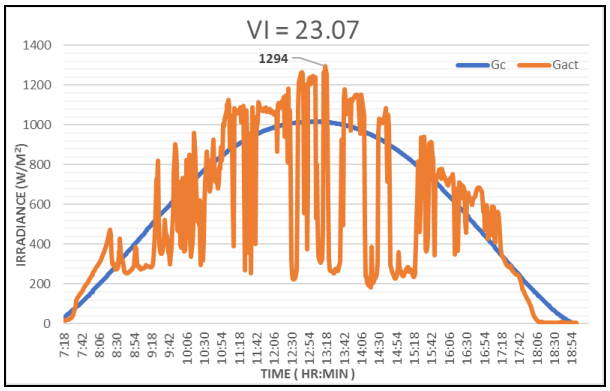
Figure 1. Simple diagram for weather station connection

3. RESULT

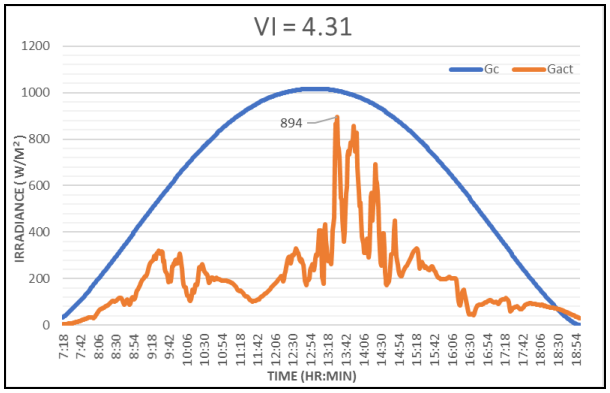
The results have been recorded in 1-minute interval for more instantaneous values to analyze the whole data with detailed results [7]. Figure 2 shows Enormous variations in the actual tilt irradiance in three different days with different VI. It can be clearly noticed that in VI= 0.54 and VI= 4.3, the maximum G_{act} that have been recorded were 253 and 894 W/m^2 respectively, which mean if the days where overcast and cloudy it will give us very low irradiance. Meanwhile, in VI= 23.07 the maximum irradiance was 1294 W/m^2 which mean this day was having variability irradiance with lots of fluctuation due to passing clouds.



(a)



(b)



(c)

Figure 2. Different of G_{act} in different VI values (a), (b) and (c)

Figure 3 shows that 99% of VI that higher than value 1 had variability irradiance caused from passing clouds. Meanwhile, 1% of VI values where below 1 which mean only 6 days from the whole year where having statics clouds that caused from overcast. This clearly show it is unusual to have perfect clear sky in Malaysia with tropical weather.

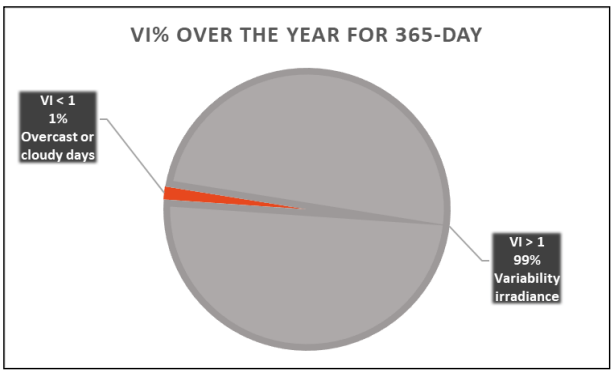


Figure 3. 365 days Variability Index% data

4. CONCLUSION

As Malaysia is one of the tropical countries with frequent cloud passing, it is not usual to have complete clear sky day. Nevertheless, it is common to have irradiance level of more than 1100 W/m^2. Some VI value that more than 1 shows that these days could have cloudy day more than passing clouds. However, passing clouds cause huge variation in the irradiance that can cause reduction for G_{act} in few minutes only.

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