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The Effect of Dynamic Weather Conditions on Three Types of PV Cell Technologies – A Comparative Analysis

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Abstract

The competition among numerous PV cell technologies in the market has necessitated the performance comparison and the viability of these technologies in actual weather conditions. This paper has presented an analysis of the impact of dynamic fluctuations in irradiance and temperature on the performance of different PV cell technologies. The study is aimed to give valuable information about the response of three different PV cell technologies such as monocrystalline, multicrystalline and thinfilm modules to different atmospheric conditions and the analysis is carried out according to Sandia standards. It is observed that all the three PV technologies reacted differently to different irradiance and temperature conditions, which in turn influenced their energy output.

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Keywords: Dynamic weather; PV module;Silicon solar cells,;Thinfilm solar cell

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1. Introduction

Since primary energy sources such as fossil fuels are rapidly depleting, owing to the increase in energy consumption, renewable energy sources have become promising in meeting the future energy demands. Of all the various renewable sources, use of solar energy has been increasing rapidly because it is bountiful and pollution free (Selami et al., 2014).

Generally, the PV industry is dominated by crystalline silicon technology (mono and multicrystalline), followed by thin-film technology. The energy generated by these different photovoltaic devices is an important aspect to be

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considered in choosing suitable technologies for efficient photovoltaic electricity. Previous studies show that each of the PV technologies currently available in the market has some merits and limitations while operating in different climatic conditions (Gottschalg et al., 2013, Carr et al., 2004, Cristina et al., 2014, Sharma et al., 2013).

PV module parameters provided by manufacturers are mostly tested and evaluated under standard test conditions (STC). However, the real time operating conditions are different from STC. This is mainly due to the fluctuations in environmental factors such as irradiation, temperature and clouds that may affect the performance of PV modules (Jia-Ying et al. 2013). Henceforth, better knowledge about the performance of PV systems in real weather conditions is essential for correct product selection and increased power generation. The aim of this paper is to analyse the effect of fluctuating irradiance and temperature on the performance of different PV cell technologies. Three types of module technologies are considered for the analysis.

2. PV Cell Characteristics

Fig.1 shows the single diode circuit model of PV cell (Bagnall et al. 2008, Aissa et al. 2012, Pallavee et al. 2013). It is represented as a nonlinear DC current source, since its power output varies with various environmental conditions.

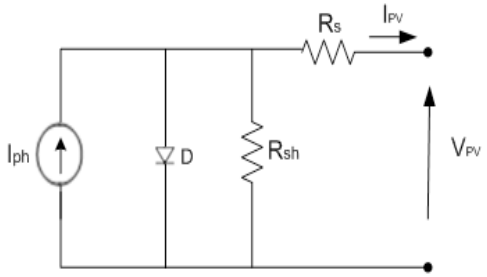

Figure 1 Equivalent circuit of a PV cell

The current-voltage characteristics of the PV cell are obtained using the following equation [Ashish et al. 2008]:

$$I_{PV} = I_{ph} - I_0\left[e^{\left(\frac{V_{PV}+R_s I_{PV}}{V_T}\right)} - 1\right] - \frac{V_{PV}+R_s}{R_{sh}} \quad (1)$$

Here I_{PV} is PV cell output current, V_{PV} is PV cell output voltage, I_{ph} is light generated current of the PV cell, I_o is cell reverse saturation current, V_T is thermal voltage, R_s is series parasitic resistance of PV cell and R_{sh} is the shunt parasitic resistance of PV cell respectively.

However, fluctuations in temperature and irradiation in actual weather conditions may affect the characteristics in different ways [Green 1998, Maria et al., 2013, Farivar et al., 2013, Elami et al., 2014] such as variations in open circuit voltage and short circuit current of the PV cells. This in turn leads to degradation of power output in PV modules. The effects of temperature and irradiance on the on current-voltage characteristics of the PV cell are shown in Fig.2.