EFFICIENCY ANALYSIS OF POLYCRYSTALLINE AND AMORPHOUS SOLAR CELLS IN CLOUDY SKY CONDITIONS OF QUETTA

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Abstract

Amongst the renewable energy resource solar energy has achieved a high remark. The solar energy being a sustainable energy source is used now-a-days for power generation. There are several ways to employing the solar energy directly. For example the use of PV technology for direct conversion of sunlight into electricity and the other method is the use of solar thermal systems e.g. solar collectors. Researchers around the world showed that the efficiency of the solar cells is greatly affected by the climate of a particular region, such as Omubo-Pepple et al. (2009) showed that there exists a strong relationship between solar irradiance and cell temperature on the efficiency of solar cells. Mieke (1998) compared the efficiency of two different types of solar cells for a hot climate of *Jilkminggan* (*Australia).* In this research paper the efficiencies of the p-si and a-si technology are compared in a cloudy sky condition.

Keywords: Polycrystalline, amorphous, efficiency, cloudy sky condition

Introduction

The discovery of photovoltaic effect in 1839 by Alexandre-Edmond Becquerel was the first building block towards the development of photovoltaic (PV) device or solar cells, which showed that when light falls on a metallic plate, electric current is generated (Fraas and Partain, 2010). In 1894, Charles Fritts informed Werner Seimens (a German inventor) about the photovoltaic effect in gold layered semiconductor; however this solar cell had a poor efficiency (< 1%) (Fraas and Partain, 2010). Regardless of its poor efficiency, development of PV devices started from this remarkable achievement and is still going on. Quetta is the capital city of Balochistan (Province of Pakistan), geographically it lies at 30° 15' N and 66° 53' E, 1,685 meters (5,531 feet) above sea level. The average temperature of Quetta is 13°C, and the winds blow with an average speed of 3m/sec. There has been very little rain fall in the past ten years. The average annual rainfall for Quetta city is 213mm, whereas the average annual relative humidity remains 40% (Pakmet web).

The performance of a various types of solar cells can be evaluated by means of comparison for a particular climate condition. In this paper the performance is analyzed by considering average data in the cloudy sky condition. The three sigma rule is used after finding the standard deviation from the mean value of the individual panel. The greater deviation from the mean value shows the poor performance of the solar panel in the cloudy weather conditions.

Equipment detail

The solar modules used in the experimentation were "Kaneka G-EA 060 thin film amorphous solar cell by Kaneka Corporation" and Q-Cell ASL 65W-12V polycrystalline by "Akhtar Solar Group" solar modules were selected. Details and specification of these two solar modules and equipment used is given in Table (1) and table (2) respectively.

Table (1). Kaneka and Q-cell solar panel specifications

Characteristics	KANEKA (a-Si)	Q-CELL (p-Si)
Peak Power	60 W	65 W
Open Circuit Voltage	91.8 V	21.6
Short Circuit Current	1.19 A	4.2
Dimensions	960mm x 990mm	760 mm x 660 mm

Table (2). Specification of instruments used

Instrument	**Measurement**	**Model**	**Measuring Range**
Solar power meter	**Solar irradiance**	**TES-1333**	**0-2000 W/m^2**
Volt meter	**Voltage**	**Peak Tech 3340 DMM**	**DCV 400 mV/4/40/400/1000 V - 0,1 mV; ± 0,5% + 2 dgt.**
Ampere meter	**Current**	**Peak Tech 3340 DMM**	**DCA 400/4000 µA/40/400m A/4/20 A - 0,1 µA; ± 1% + 3 dgt.**

Method of experimentation

The KANEKA G-EA060 and Q Cell ASL 65-12 solar modules were mounted on the roof of the house located at 30^0 10' 43.9" N 66^0 59' 07.1" E. The mounting stand was designed for multiple tilt angle adjustments of the solar modules. The modules were aligned south for maximum annual output using a compass. The tilt angle of the mount was adjusted at 44^o from the horizontal axis to achieve the maximum possible efficiency. This tilt was calculated using an online solar tilt calculator (solar handbook web). The data was collected manually using the digital equipment. The operating time for the experiment was 8:30 hours in which the data was taken after every 30 minutes. The experimentation was performed for a period of 15 days. The 50W and 24W loads were used for Keneka and ASL solar panel respectively. The circuit connections are shown in fig (1).

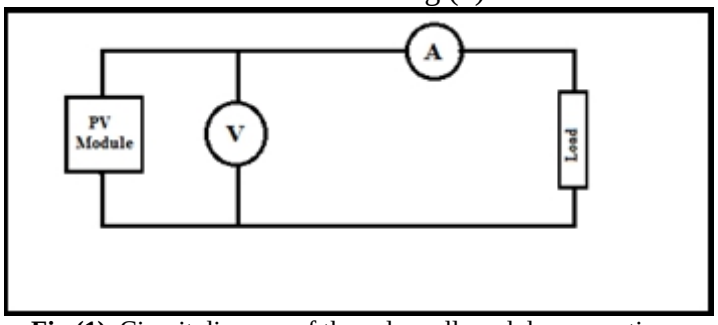

Fig (1). Circuit diagram of the solar cell module connections

The efficiencies of both solar panels were calculated using the formula given below

$$\eta = (V_{max} \times I_{max}) / (A \times i) \qquad \eta = (V_{max} \times I_{max}) / (A \times i) \qquad (1)$$

A = area of solar cell module

V_{max} *and* I_{max} are the optimum voltage and current of the solar cell respectively and i is the solar irradiance.

Results

Fig (2) depicts the efficiency calculated by average input parameters for p-si under cloudy sky conditions. The efficiency has a mean of 11.98% and a stand deviation of 4.424. Hence, a standard deviation of 3 will be 7.272. This yields 61 % of the mean value of efficiency for p-si solar cell.

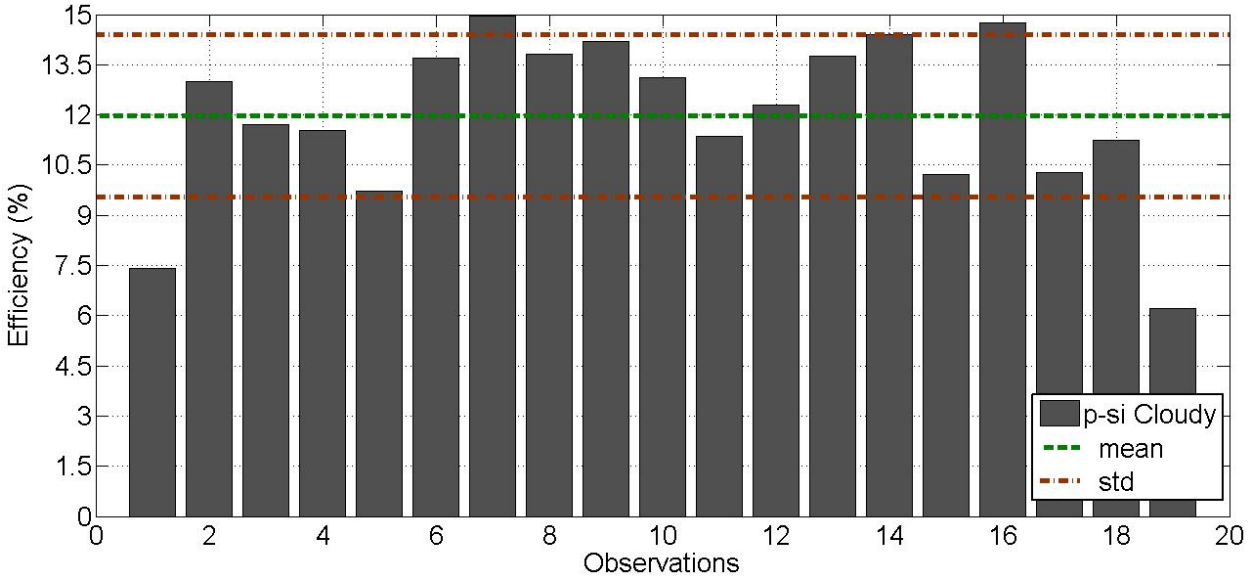

Fig (2). Efficiency deviation for p-si under cloudy sky conditions

Consistent with p-si, efficiency for a-si was obtained and is depicted in Fig (3). It shows that the efficiency has a mean of 3.823. The standard deviation is 0.7674. So, a standard deviation of 3 is 2.3022, which is 60.2 % of the mean value

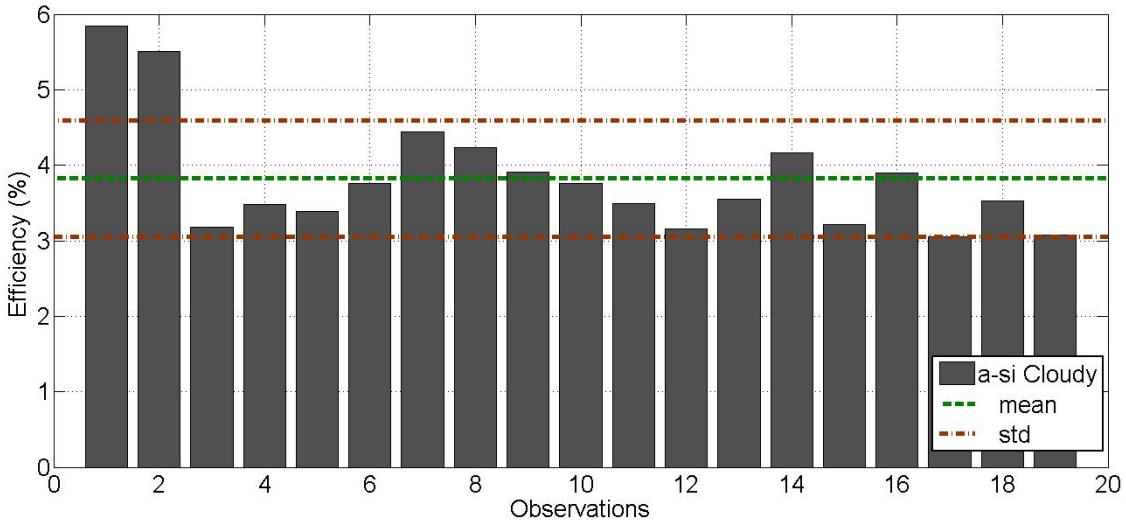

Fig (3). Efficiency deviation for a-si under cloudy sky conditions

The plotted results indicate the significance of this paper. In these graphs fig (2) and fig (3), the variation of the efficiency from its mean value is shown. The results are given in table (3).

Table (3). Comparison of Efficiencies

Solar Module Type	Mean Efficiency		Standard Deviation (SD)		3SD		Tolerance 3SD=X % of mean	
	Sunny	Cloudy	Sunny	Cloudy	Sunny	Cloudy	Sunny	Cloudy
Poly-crystalline	12.09%	11.98%	0.9468	4.424	2.8404	7.272	23.5%	61%
Amorphous	3.82%	3.12%	0.2562	0.7674	0.7686	2.3022	24.6%	60.2%

Conclusion

The deviation in the efficiencies of a-si and p-si panels is actually the tolerance values across the mean efficiency (Bajorski, 2011). Low tolerance indicates value lies near the mean whereas large tolerance means value lie away from the mean (Grafarend, 2006). Thereby low tolerated values suggest high whereas the large tolerance means low efficiency. For cloudy sky condition the results showed that the p-si panel has high tolerance is less efficient. This is because the p-si has a broad spectral response and the impact of this spectrum is not much greater in cloudy days. On the other hand we have the thin film a-si which has a very thin spectral response peaks for low wavelengths. The efficiency of a-si modules is therefore better under cloudy conditions. From table (3) it can be seen that the tolerance level difference of p-si and a-si solar modules is not much i.e. about 0.8%, therefore p-si solar cells can be effectively adopted for power generation in climate of Quetta.

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