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Impact of Environmental Factors on the Working of Photovoltaic Cells

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Abstract

This paper discussed the stimulation of diffused and global sun rays on the site of Pakistan, striking the PV cell, is done for varying environmental conditions. This is done with the help of model used for spectral transmittance. Different effects are examined including efficiency of various types of PV cells, variation in whole intensity and the distribution of spectrum on short circuit current. The outcome shows an inverse relationship between turbidity and short circuit current. In the case of global sun rays the reduction of short circuit current due to turbidity is 4.4% for monocrystalline PV cell, 4.8% for multicrystalline PV cell and 7.33% for amorphous PV cell but in case of diffuse sun rays it increases. The relationship between short circuit current and water vapors is also inverse but this effect shows only in case of global sun rays. The decrement in the short circuit current due to water vapor is 4.6% for moncrystalline, 4.39% for multicrystalline, and 0.19% in case of amorphous. The increment in the air mass causes decrement in the short circuit current for various kinds of PV cells. But in case of monocrystalline and multicrystalline there is an increment in efficiency due to air mass effect while the efficiency of amorphous decreases.

Keywords: PV cell; sun ray; global; diffuse.

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1. Introduction

The utmost significant factors that explain the working of PV cell are: The Temperature, how the solar irradiance is distributed spectrally, and the total solar irradiance.

These three factors describe the working condition of a solar cell [1-10]. Generally those who design PV cells estimate the quality of their PV cells by assessing their efficiency according to SRC which is "Standard Reporting Conditions" and these conditions include temperature at 25^o C, solar irradiance at 1000 W/m^2, AM with the spectral reference of 1.5. Practically the occurrence of these conditions is not possible [1] as these conditions do not take metrological and real land or geographical conditions, of the place where the PV cells are installed, into account. At ground level both the spectral changes and intensity changes occur to irradiance due to factor like covering of clouds, water vapors and turbidity etc [7-9]. As it is difficult to get measurements of spectrum on vast scale the impact of changing spectrum of sun on the working of various PV gadgets is still not evaluated. So strategies should be developed and explained to evaluate the impact of changing environmental conditions on the working of PV cells. The primary reason for the accompanying segments is to know that how PV cells work under changing diffuse and global solar irradiance, under changing air mass and turbidity. This is done by using the model of spectral irradiance (for clear skies) [10].

The density of photocurrent Jsc can be measured with the help of following equation:

$$Jsc = \int E(\lambda) SR(\lambda) d(\lambda) \qquad (1)$$

Where E(λ) is the irradiance and SR(λ) is the spectral response.

1.1. Effect of Turbidity

As the turbidity increases the short circuit current decreases but this decrement is different for different PV cells depending upon its spectral response. The percentage of this decrement is as follows 4.4% for monocrystalline PV cell, 4.8% for multicrystalline PV cell and 7.33% for amorphous PV cell. This decrement in the current is more in case of monocrystalline PV cell as the area covered by its spectral response is bigger in size as compare to that of multicrystalline cells. The case of amorphous cell is a bit different as its spectral response covers area narrow in size and lesser than both of monocrystalline and multicrystalline PV cell but most of its spectral response consists of the wavelengths that's been reduced or lessened by turbidity due to which the decrement percentage of amorphous is greater than the other two. The impact of turbidity is shown in **Figure 1** and **Table 1** shows the summarized results.

1.2. Effect of Water Vapors

Increasing water vapors only affect monocrystalline and multicrystalline PV cells as it would decrease solar irradiance at large wavelengths but its effect on amorphous PC cells is negligible. The relationship between water vapors and efficiency is shown in **Figure 2**. Spectral intervals of only narrow size is affected by water vapors and at these wavelengths spectral response is very weak as compared to the ones that are affected by turbidity. So the decrement in the output current is less in case of water vapors as compared to that of turbidity. The summary of results is shown in **Table 2.**

Table 1: Impact of Turbidity on different Si PV cells in case of global and diffuse solar irradiance

Turbidity	Jsc (mA cm-2) mono-Si		Jsc (mA cm-2) multi-Si		Jsc (mA cm-2) a-Si	
	Dif	Glb	Dif	Glb	Dif	Glb
0.1	2.97	32.63	3.68	37.76	1.48	9.6
0.2	4.65	32.25	5.65	37.29	2.08	9.41
0.3	6.19	31.89	7.45	36.84	2.61	9.24
0.4	7.61	31.55	9.1	36.42	3.09	9.07
0.5	8.92	31.22	10.61	36.01	3.51	8.93

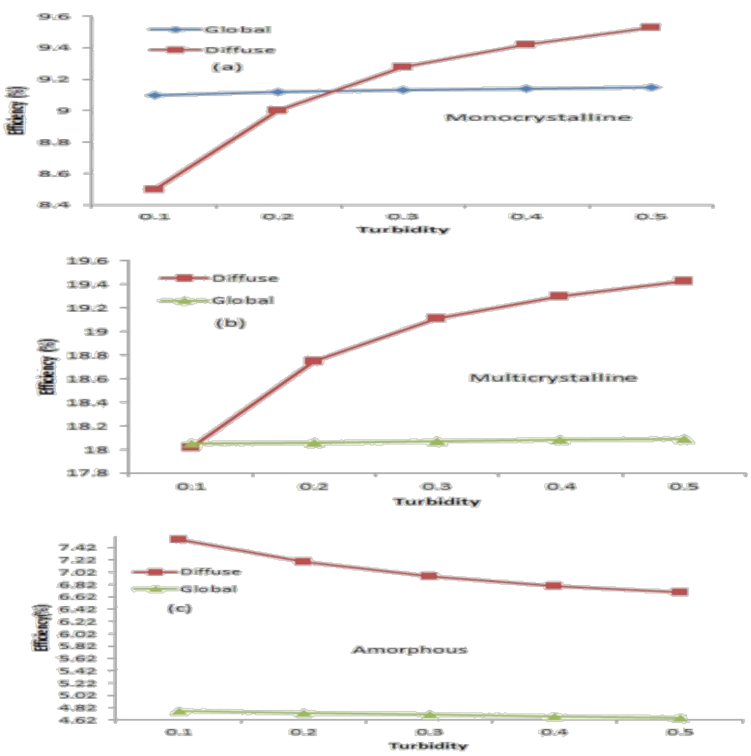

Figure 1: Turbidity v/s Efficiency of (a) monocrystalline, (b) multicrystalline, (c) Amorphous PV cell

Table 2: Impact of Water Vapors on different Si PV cells in case of global and diffuse solar irradiance

Water Vapor	Jsc (mA cm-2) mono-Si		Jsc (mA cm-2) multi-Si		Jsc (mA cm-2) a-Si	
	Dif	Glb	Dif	Glb	Dif	Glb
0.5	2.97	32.63	3.68	37.76	1.48	9.6
1	2.95	32.26	3.66	37.36	1.48	9.59
2	2.92	31.78	3.63	36.82	1.48	9.59
3	2.91	31.44	3.61	36.45	1.48	9.59
4	2.89	31.17	3.6	36.15	1.48	9.58

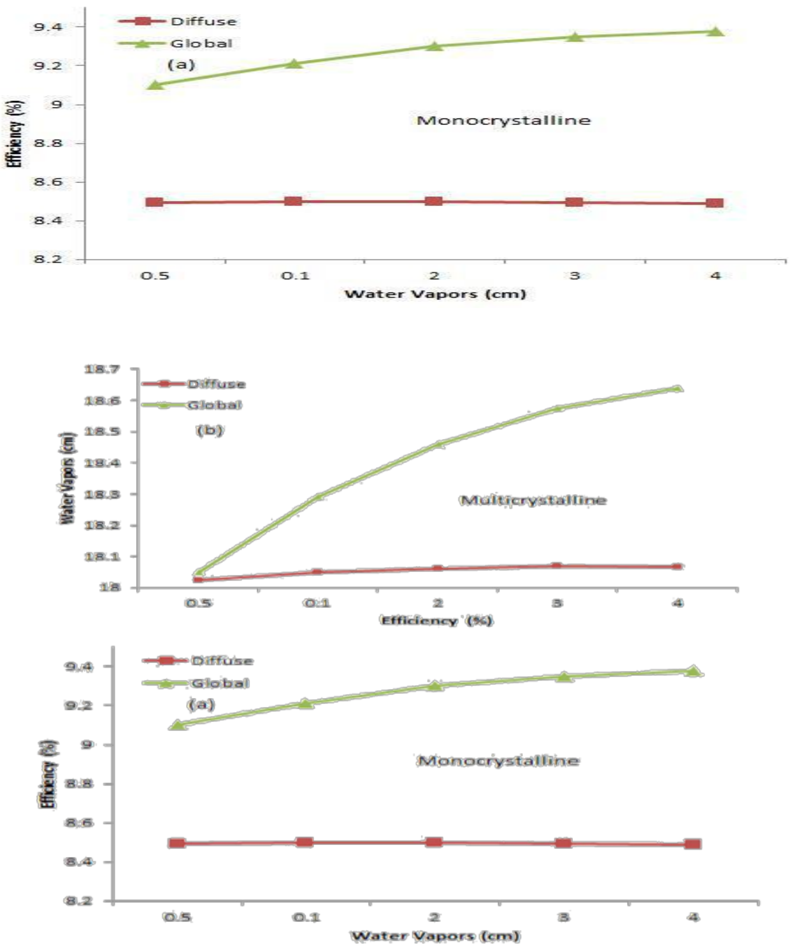

Figure 2: Water Vapors v/s Efficiency of (a) monocrystalline, (b) multicrystalline, (c) Amorphous PV cell

1.3. Effect of Air Mass

The impact of air mass on short circuit current is shown in the **Table 3**. In different types of PV cells the output current would reduce with increase in the air mass but the efficiency of PV cells is in direct relation with air mass which means increasing air mass would cause the efficiency of mono and multicrystalline PV cell to increase. However amorphous PV cell shows deviation in this manner as its efficiency also decreases with the increasing air mass. The relation between air mass and efficiency is shown in **Figure 3**.

Table 3: Impact of Air Mass on different Si PV cells in case of global and diffuse solar irradiance

Air Mass	Jsc (mA cm-2) mono-Si		Jsc (mA cm-2) multi-Si		Jsc (mA cm-2) a-Si	
	Dif	Glb	Dif	Glb	Dif	Glb
1.031	2.97	32.63	3.68	37.76	1.48	9.6
1.058	2.94	31.71	3.65	36.69	1.47	9.31
1.148	2.87	29.02	3.55	33.56	1. 43	8.48
1.327	2.73	24.74	3.38	28.59	1.35	7.17
1.666	2.51	19.18	3.1	22.13	1.24	5.47
2.370	2.16	12.75	2.66	14.68	1.05	3.52
4.341	1.59	6.05	1.94	6.93	0.73	1.56

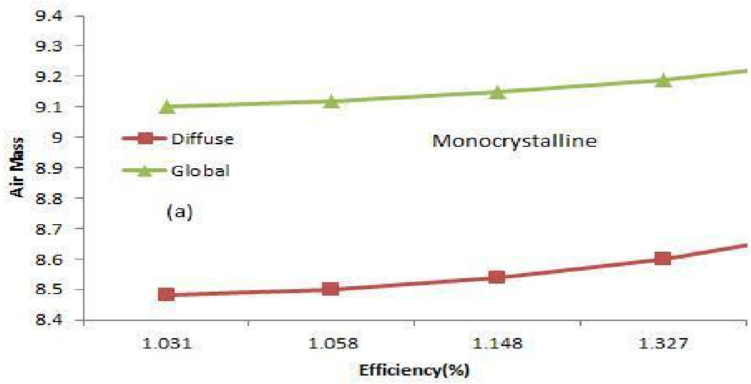

Figure 3: Air mass v/s Efficiency of monocrystalline PV cell

2. Conclusion

The stimulation of diffused and global sun rays on the site of Pakistan, striking the PV cell, is done for varying environmental conditions by using spectral irradiance model (Spectral2). The experimental study illustrates that there is an increment in the efficiency of monocrystalline and mlticrystalline PV cells with the increment in the air mass and turbidity on the other hand there is decrement in efficiency of amorphous PV cell. This effect is more visible in case of diffuse irradiance. The relationship between efficiency of PV cell and atmospheric water vapors but only in case of global sun irradiance while in case of diffuse solar irradiance there is no impact of water vapors on the efficiency of PV cells.

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