Effect of Humidity on the PV Performance in Oman

Hussein A Kazem, Miqdam T Chaichan, Iman Mohammed Al-Shezawi, Hanan Saif Al-Saidi, Hanan Sulaiman Al-Rubkhi, Jamila Khamis Al-Sinani and Ali H A Al-Waeli
Faculty of Engineering, Sohar University, PO Box 44, Sohar, PCI 311, Oman
Email: h.kazem@soharuni.edu.om

Abstract- This paper presents the effect of relative humidity on the performance of the Photovoltaic (PV). Three types of PV (Polycrystalline, Monocrystalline and Amorphous Silicon) have been tested to investigate the effect of humidity on the performance. PV system connected to measurements humidity, current and voltage. Results obtained show that the output current, voltage, and power increase with low relative humidity. The efficiency of the PV is high when the humidity low. Hence low relative humidity enhances the performance of PV systems.

I. INTRODUCTION

Oman is rich in solar energy; sunshine time is more than 3600 hours every year. The solar radiation on the desert area each year is equivalent to hundreds of thousands of times Oman's total generating capacity. PV power generation provides perhaps the main way to develop and use solar energy, because it is pollution-free energy that is available everywhere, not subject to geographical restrictions and it does not involve the consumption of any fuel. At the same time, it can operate unmanned, and requires short construction periods [1]-[2].

The latitude and longitude of Oman is 16 40 N, 59 40 E. The climate is generally very hot, with temperatures reaching 54 °C (129.2 °F) in the hot season, from May to September. In addition, the climate of Oman remains dry (no rainfall) and extremely hot, but also is humid in the coastal region throughout most of the year. Humidity and dust plus the lack of rainfall are barriers to using PV [3]-[7].

The electricity demand has been increased with a logical increment PV cost which still several times higher than the cost from the conventional power generation [8]. For solar energy, PV is considered to have good potential for overseas application and industry. With the increasing use of PV systems it is vital to know what effect active meteorological parameters such as humidity, dust, temperature; etc has on its efficiency.

Humidity describes the quantity of water vapor in a gas like air.The temperature of both the water vapour and air are the same? Since the capacity of air to hold water vapour is primarily a function of temperature then warmer air has a greater capacity for holding water vapour than cooler air [9]. Relative humidity defined as the ratio of water vapour actually in the air to the maximum water vapour the air can hold at a given temperature. If air is relatively dry compared to its capacity, the relative humidity percentage is low. Because of temperature, condensation and evaporation relative humidity varies [10].

In this study we used three types of solar panel. Monocrystalline solar cells these are prepared from thin wafers of silicon, sliced from large crystals that have been grown under carefully controlled conditions. Typically, the cells are a few inches across, and a number of cells are laid out in a grid to create a panel. Qualified to the other types of cells, they have a high efficiency, sense you will obtain more electricity from a given area of panel. Polycrystalline solar cells are cheaper to construct silicon wafers in polycrystalline form, as the conditions for growth do not need to be as tightly controlled and the newest type of panel is based on amorphous silicon is Amorphous Solar. The silicon atoms are not ordered in a crystal lattice at all.

In order to improve the accuracy of methods currently used for characterizing the performance of PV in their actual use environment, it is of importance to investigate the effect of ambient variables on the PV module output. In Oman humidity often peaks at 90% thanks to the area's low elevation. Therefore, the objective of this paper is to do a preliminary investigation on the effects of humidity on the reception of solar. The humidity reduced the amount of visible solar radiation reception, while humidity and wind speed both acts as cooling agents that increase the output of a PV module by reducing the module temperature [11].

V. B. Omubo *et al*, 2009 using a B-K Precision modules 615 Digital light instrument and PV modules in Port Harcourt. The effect relative humidity on the efficient conversion of solar energy to electricity was studied. Results obtained show that there is a direct proportionality between solar flux, output current and efficiency of the PV module. Relative humidity and solar flux has an insignificant effect on the output voltage of the PV module. The manufacturer's maximum power of 16W was nearly achieved under the operating temperature of 43ºC, with low relative humidity of about 77% and solar flux of about 79klux. Also, current of about 18.42×10^{-1}A producing an efficiency of about 82% was recorded [12].

Katkar *et al*, 2011 the quick enlargement of PV modules has bent promising business environment in the near future. Conversely for wide-scale application PV is identified to be of good potential. Also the electricity cost from PV is still several times higher than from the conventional power generation. There study summarizes test procedures and results of the performance and efficiencies uniqueness of solar cells, in attendance study relate to do study of the effect of humidity on the performance of solar cell and evaluate solar cell efficiency

for the different weather conditions. The investigation shows that the characteristic of silicon solar cell with the different humidity levels varies efficiency of solar cell. The efficiency of solar cell increases from 60 % humidity 9.702 % to 48 % humidity 12.04 % after further it becomes 2.37 % at 29 % humidity [13].

E. B. Ettah *et al*, 2012 investigated in Calabar, Nigeri The effect of relative humidity on the performance of solar panels in. consequences demonstrate that low relative humidity between 69% and 75% favoritism increase in output current from solar panels. Voltage output stabilized between relative humidity values of 70% and 75% as well increased with decrease in relative humidity. These outcomes entail that efficiency (power) of solar panels is high during low relative humidity period, being an indication of high performance. Therefore low relative humidity enhances the performance of solar panels [9].

In this paper the effect of humidity on PV system have been studied. Also, measurements have been taken for current, voltage and humidity of different technologies for eight hours per day for 30 days (June 2012) to calculate power of PV and efficiency. Moreover, analysis of the results and how this system is evenhanded have been done.

II. Measurements and Calculations

Humidity & IR temperature meter (Extec EA25) was used to measure relative humidity. A digital multi-meter and charger controller was used to measure current and voltage outputs of the solar panel, Controller, battery and load. Three different types of solar panels are Polycrystalline, Monocrystalline and Amorphous Silicon has been investigated.

The three types of PV's have been installed horizontally (facing the sun). The output terminals of the PV, battery and the load were connected to the input terminals of the charger controller. After that the current and voltage readings are taken directly from the screen display. The Humidity & IR temperature meter was set appropriate and relative humidity readings were taken simultaneously with voltage and current every 30 minutes.

TABLE I
PV Ratings

Monocrystalline	Polycrystalline	Amorphous silicon
Out peak power 10W	Out peak power 10W	Out peak power 10W
Open circuit voltage 21.9V	Open circuit voltage 21.3V	Open circuit voltage 35V
Short circuit current 0.63A	Short circuit current 0.66A	Short circuit current 0.66A
No. of cells 36	No. of cells 36	No. of cells 36
Power tolerance 0/+3%	Power tolerance 0/+3%	Power tolerance 0/+3%
Max. power voltage 17.5V	Max. power voltage 17.3V	Max. power voltage 18V
Max. power current 0.57A	Max. power current 0.58A	Max. power current 0.46A
size of module 350*285*28mm (1.5kg)	size of module 440*283*28mm (1.5kg)	size of module 615*305*68mm (1.5kg)

The three PV's have the same ratings but with different dimensions as shown in table I.

The area of PV is found as follows:

$$Area = Length \times Breadth \quad (m^2) \tag{1}$$

TABLE II
Area of PV Panels

Type	Length	Breadth	Area
Amorphous	61.5 cm=0.615m	30.5cm=0.305m	0.1875 m^2
Monocrystalline	35cm=0.35m	28.5cm=0.285m	0.0997m^2
Polycrystalline	44cm=0.44m	28.3cm=0.283m	0.1245m^2

The power is calculated as follows:

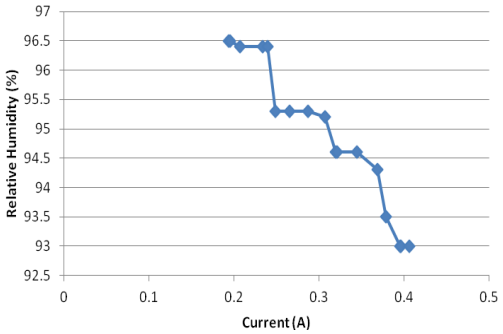
$$Power = Voltage \times Current \quad (Watt) \tag{2}$$

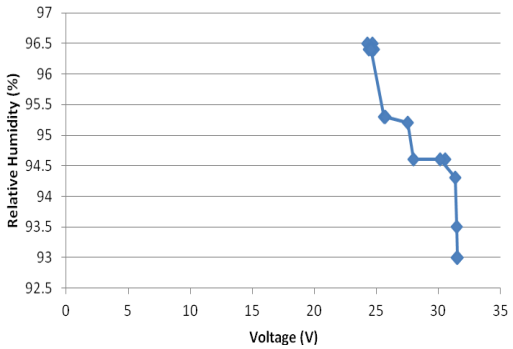
Finally the efficiency is calculated as follows:

$$Efficiency = \frac{power \text{ of PV panel}}{\text{area of PV panel} \times 1000 W/m^2} \times 100 \tag{3}$$

A. Amorphous Silicon PV

Amorphous Silicon PV has been used and it is found that when relative humidity increases, current and voltage relatively decreases as shown in Fig. 1. Between the relative humidity of 93% and 96.5%, the current is reduced from 0.4 A to 0.2A and the voltage reduced from 31.0 V to 24.5V. Also, power and efficiency have been calculated using equations 2 and 3. It is found that the power and efficiency have inverse proportionality with humidity.





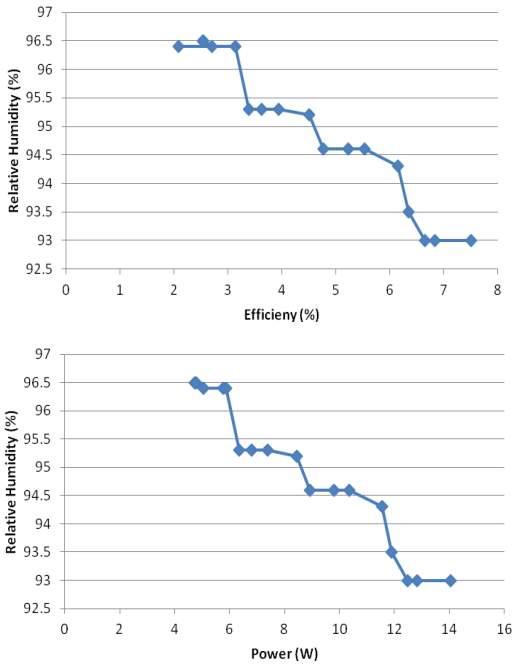


Fig. 1 Relative humidity against current, voltage, power and efficiency for Amorphous Silicon PV.

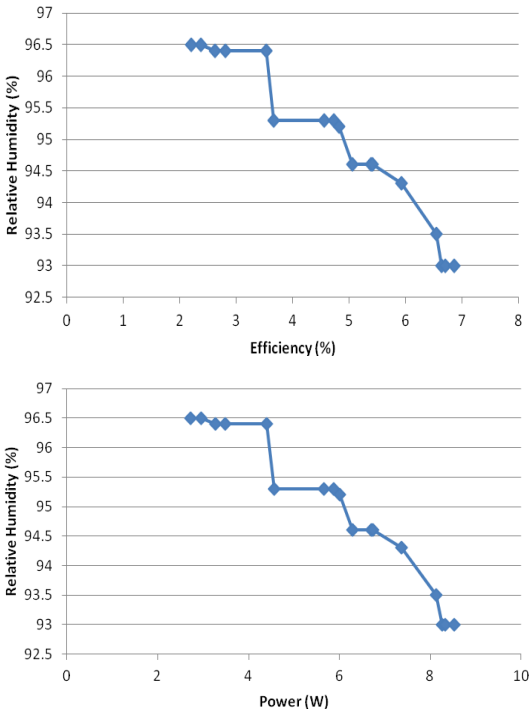


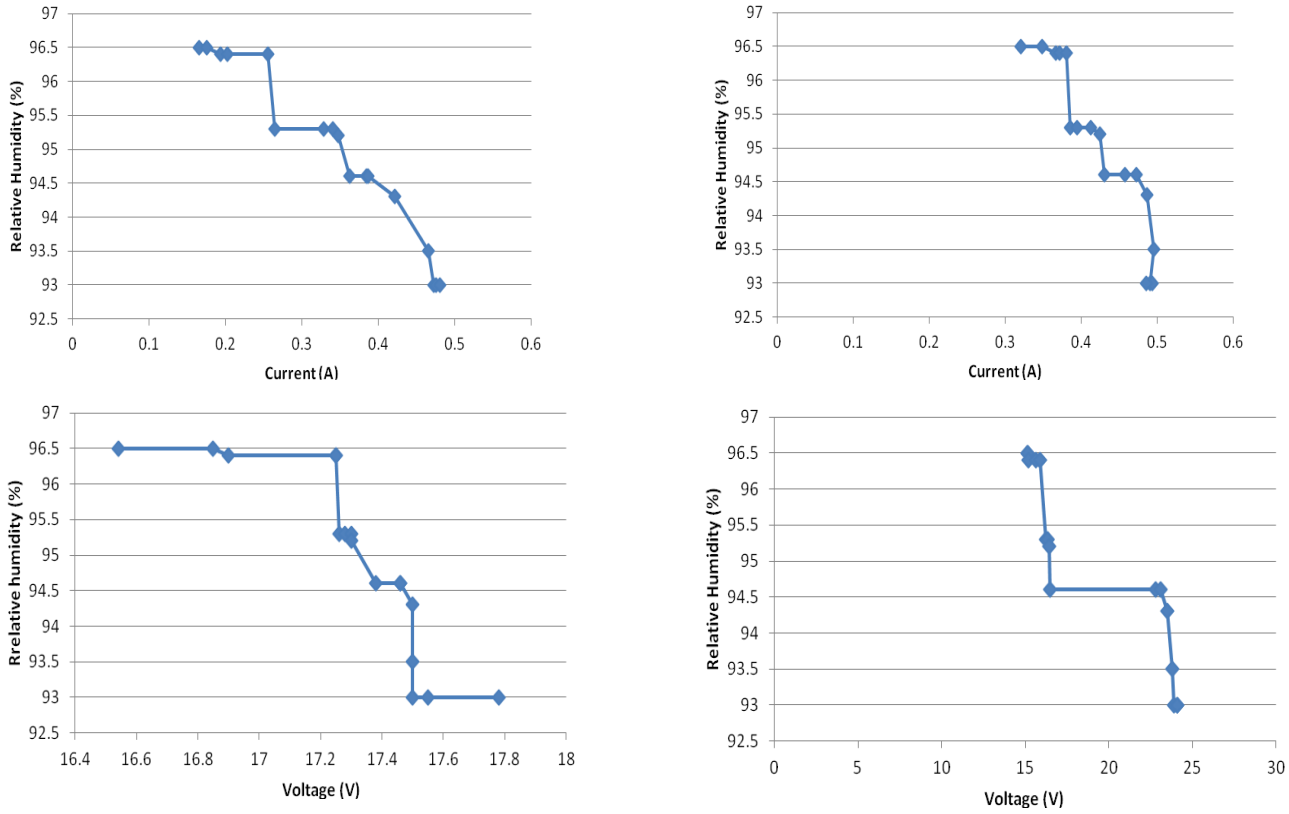
Fig. 2 Relative humidity against current, voltage, power and efficiency for Polycrystalline PV.

B. Polycrystalline PV

In the case of Polycrystalline the effect of relative humidity shows (see Fig. 2) that when we have decreasing in humidity the voltage, current and efficiency are increasing.

C. Monocrystalline PV

Result shows the same trend of the inverse proportionality between humidity and voltage. The same thing applied for the current, power and efficiency as shown in Fig. 3.



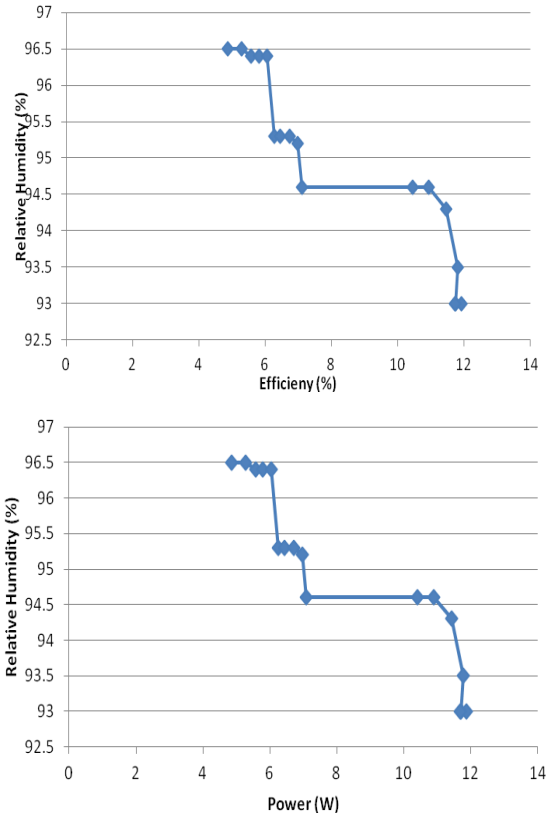


Fig. 3 Relative humidity against current, voltage, power and efficiency for Monocrystalline PV.

Also, the result shows that the efficiency has increased from 5% at 95.3% relative humidity and reach 12% at relative humidity 93%.

Figure 4 shows the relationship between humidity and efficiency for different technology. In general it has been found that the PV efficiency increases with decrease of humidity. It is clearing seen that the Monocrystalline have the highest efficiency in comparison with other type of technology.

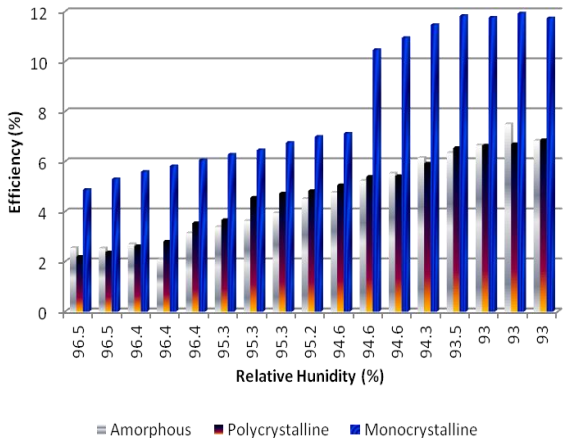


Fig. 4 Relative humidity against efficiency for Amorphous, Polycrystalline and Monocrystalline PV's.

III. Conclusions

The performance of photovoltaic is effected by some of the environment parameters like wind speed, dust humidity, temperature, etc. How much is this effect is depending on the parameter amount and PV technology. This paper investigates the effect of relative humidity on PV performance.

In this study three types of solar photovoltaic; Monocrystalline, Polycrystalline and Amorphous silicon have been investigated outdoor to check their performance variation with respect to the high relative humidity in Oman.

Relative humidity affects efficiency of photovoltaic as it affects the current, voltage and power. Result shows that when we have decreasing in relative humidity the voltage, current and efficiency increased. Also, it is found that Monocrystalline panel has the highest efficiency when relative humidity is decreased with respect to other technologies. The expansion of this study is to test the effect of humidity and dust in Oman.

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