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Innovation The Research Concept

Effect of Temperature and relative Humidity on Photovoltaic Performance based on Experimental Study

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Abstract

Global warming and climate change are the big environmental threat for humanities in present time due to excess use of fossil fuel for energy. To reduce dependency on conventional energy sources solar energy is considered as one of the most important renewable sources. The efficiency of solar panel depends on several electrical and environmental parameters. In this research paper the effect of relative humidity and temperature on the output power of a solar Photovoltaic (PV) was studied. With a sustained observation during July and August, 2019, ambient temperature, panel surface temperature, ambient humidity and panel surface humidity data was collected in Ajmer. Results obtained for the power and efficiency of the PV panel reveals that high relative humidity is responsible for the degradation of the panel for the tested period. When the relative humidity increased the PV's current and power output are decreased, while current and power output increased with increasing temperature. The correlation coefficient R between humidity and current, humidity and power, humidity and temperature, voltage and temperature is negative and the values are -0.8316,-0.7876 and -0.7873, -0.8877 respectively. While correlation coefficient R between current and temperature, power and temperature is positive and values are 0.7576 and 0.7086 respectively.

Keywords: Solar Energy; Humidity; Photovoltaic Performance; Efficiency

Introduction

With increasing population and rapid industrial development petrol and electricity prices increases day by day. Not only financial problems but also environmental problems such as global warming, climate change etc raises due to extensive use of fossil fuels. One of the possible solutions of these problems is use of renewable energy sources and solar energy is one of them. Using unlimited and inexhaustible energy of the sun electricity is generated by the photovoltaic solar cell. These cells convert solar radiation into electricity by the use of property of semiconductor PN junction device. Over the last decade there had been rapid improvement in solar cell efficiency. To reduce the cost of PV system installation and to enhance its efficiency various efforts are being made by researchers in all over the world. Solar cell efficiency depends on many unavoidable factors, some of them are technology related and some of them are environmental related. Since sunlight is fragmentary so solar PV system cannot convert photon into electron at a constant rate. Hence the power delivered at a particular instant is still a function of climatological factors (1).Longitude and latitude of the location, dust deposition, Probability of dust storm, height of installation, ambient temperature, relative humidity, wind velocity, shading and bird dropping is the main factors which decide the adequacy of solar system installed. In the current study temperature and relative humidity effect on the performance of PV was investigated. Relative humidity is the ratio between the amounts of moisture in the air at a particular temperature to the maximum moisture air can withstand at the same temperature. Study by Hussein and Miqdam indicated that as the relative humidity in Sohar city increases from 67% to 95%current reduces by 95% (2). When light hits water droplets it may be reflected, refracted or diffracted. These effects deteriorate the reception level of incoming solar radiation (3)-(4). With Polycrystalline, Monocrystalline and Amorphous

Silicon PV module Kazem et al investigated the effect of relative humidity on the power output. They concluded from the study that the output voltage, current and power decreases with high relative humidity. When the relative humidity is low the efficiency of the PV is high. So for best optimization of solar energy relative humidity must be low (5). In their research work Tan et al studied the effect of wind speed and humidity on PV. They found that trend of wind speed has a reverse effect on relative humidity. For a continuous and long duration contact of PV modules to humidity responsible for the ingress water into module and decrease performance (6).In eastern Nigeria the effect of temperature on the performance of a photovoltaic solar system was investigated by Ike. They reveled from the data from his work that the panel efficiency is high for low ambient temperature compared with high ambient temperature (7). By using basic equation Fesharaki et al proposed a relation between efficiency, sun radiation and temperature In cloudy climate they indicated a decrease in the efficiency of the PV module with increase in temperature(8). The band gap of the intrinsic semiconductor depends on temperature. As temperature increases, band gap contracts meaning more incident light is absorbed. This results a larger photocurrent because a high percentage of the incident light has enough energy to force charge carriers from the valence band to the conduction band (9). Hence solar cells have a positive temperature coefficient of current. In the recent study, a statistical analysis has been done with the Pearson correlation coefficient software to show how the ambient temperature and relative humidity of the solar module are correlated with power output of the panel.

Aim of the Study

To find the Effect of Temperature and relative Humidity on the Performance of solar model so that this study could be used for the future development of PV models.

Materials and Method

Study Area

Ajmer is located at 26^0 27'N and $74^0$44'E.It is surrounded by the Arawali ranges. In the east, it has plain land while in the west it is hilly. Western part comprises many valleys of sandy desert. Anasagar, Foy sagar and Pushkar Lake are prominent lakes of this region as shown in Figure 1

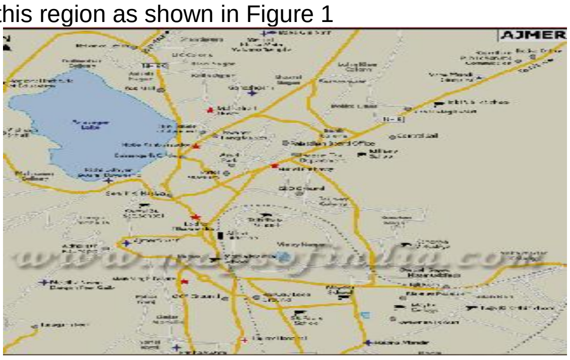

Figure 1.Map of study area (Ajmer)

Materials Used

1. Topsun 4W Polycrystalline solar panel with dimensions 255mm×185mm×17mm, current and voltage.
2. LM 8000 weather meter
3. Digital Multi-meter

Figure 2.Solar Panel and LM 8000

Test Content and Methods

In this research work the solar panel was mounted about 75 cm above the roof on a platform and exposed to the direct solar radiation. The test was performed every 30 minutes in the daytime from 10:00 A.M. to 2.30 P.M. during which the weather parameter ambient temperature and relative humidity were synchronously measured for the alternate days of the month of July and August 2019 with LM-8000 weather meter. The outputs of the PV panel (short circuit current and open circuit voltage) were recorded with the help of a multimeter. Relative humidity was recorded at a fixed place so that there is no change in the moisture content of the air. Variation in temperature was recorded with time. Panel surface temperature was recorded using the temperature sensing Probe fixed with panel. From the obtained data, the power from the panel was calculated with the equation.

$$P_{mea}=V_{mea}\times I_{mea} \qquad (1)$$

$$P_{max}=V_{max}\times I_{max} \qquad (2)$$

$$\eta p = \frac{P_{mea} * 100}{P_{max}} \qquad (3)$$

…1

Pmax was calculated by equation (2) and the normalized power output efficiency assessed with equation (3) as computed by Basir at el (10).

Results and discussion

Results

The results were obtained from a practical analysis of the effect of humidity and temperature on a Topsun 4W polycrystalline solar panel using LM 8000 weather meter. The value for the temperature and humidity were recorded from the environment and on the solar panel by LM 8000 weather meter. Using digital Multi-meter the open circuit voltage and short circuit current from the solar panel were recorded.

Graphical Analysis and Discussion

In order to assess the correlation of the humidity and temperature with voltage, current, power and efficiency, correlation coefficient and the coefficient of determination R^2 used by the Pearson correlation coefficient software. Data are presented below each figure. Figure3 express very strong positive correlation between ambient temperature and panel temperature. It shows that the ambient temperature surrounding the panel influence how hot the panel will get.

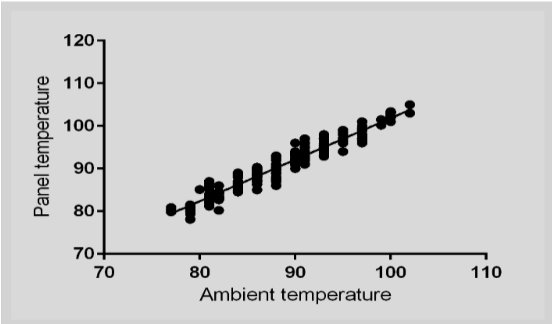

Figure 3.Panel temperature versus ambient temperature

Y=0.9740*X+4.4444

R= 0.9745, R^2 linear =0.9496

Figure 4.shows graph between ambient humidity and panel surface humidity. The reference line has positive slope, indicating that the ambient humidity determine how muggy the panel surface will be.

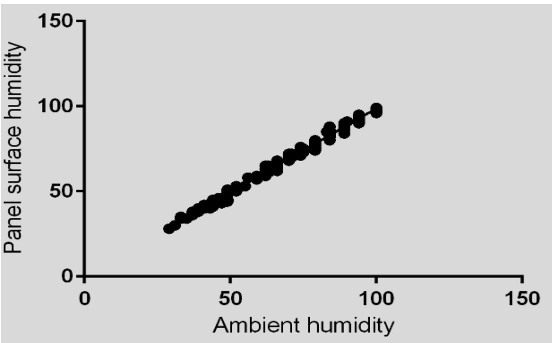

Figure4. Ambient humidity versus Panel surface humidity

Y=0.9842*X+0.2839

R=0.9973, R^2 linear =0.9946

Panel temperature and panel surface humidity data were shown in Figure 5.This has a very strong negative correlation coefficient R= (-0.9230) which means that as panel surface humidity expands, Panel temperature scale downs.

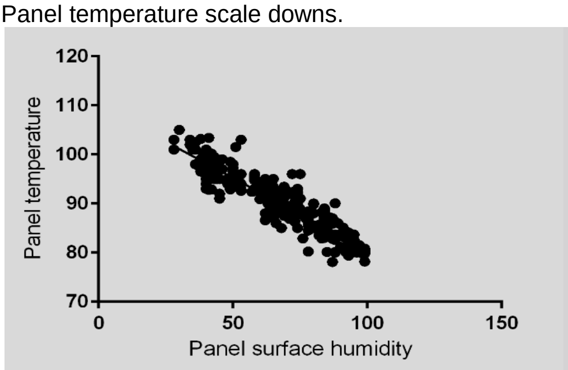

Figure5.Panel temperature versus Panel surface humidity

Y=-0.2956*X+110.0

R=-0.9230, R^2linear =0.8519

Figure 6.presents strong negative correlation between panel surface humidity and current which means high panel surface humidity go with low current

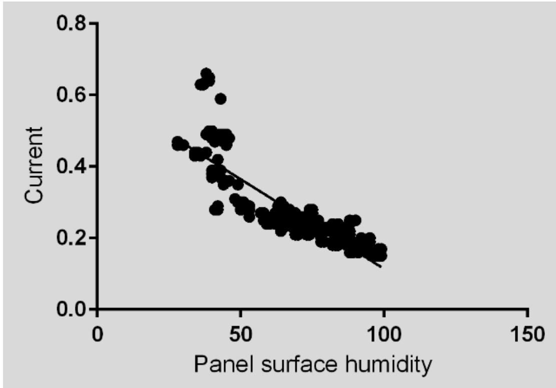

Figure 6. Current versus Panel surface humidity

Y=-0.005014*X+0.6155

R=-0.8520, R^2 linear =0.7260

Current against panel temperature were displaying in figure 7. High current achieved up to 98^0F, after that the current starts dropping.

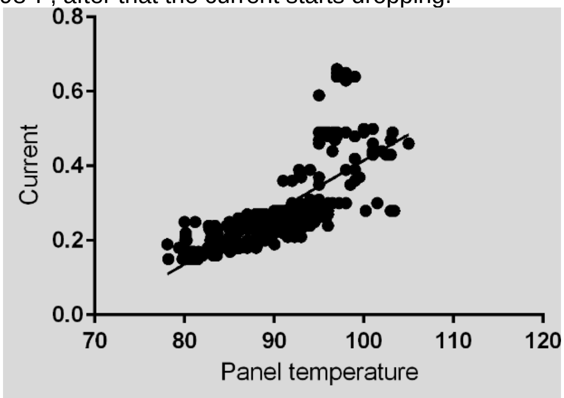

Figure7. Current versus Panel temperature

Y=0.01392*X-0.9776

R=0.7576, R^2linear =0.5740

Voltage versus Panel temperature data were pictured in figure 8.

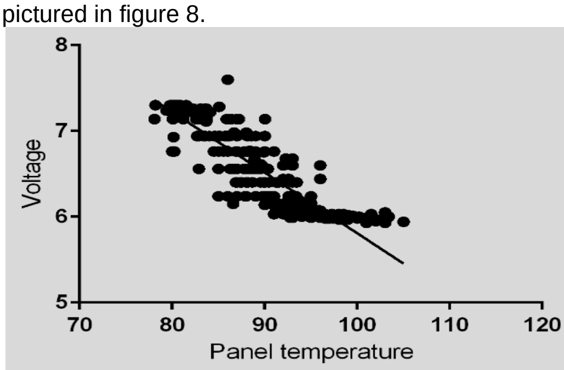

Figure8. Voltage versus Panel temperature

Y=-0.07074*X+12.88

R=-0.8877, R^2linear =0.7881

Fig. 9 shows the degradation in the PV power with the relative humidity increment.

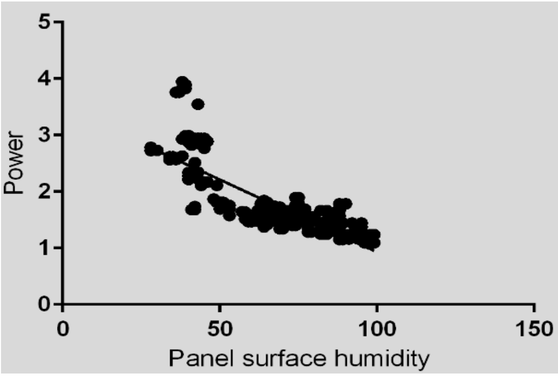

Figure9. Power versus Panel surface humidity

Y=-0.02565*X+3.495

R=-0.8021, R^2linear =0.6434

Power versus Panel temperature data were expressed in fig.10 showing a craggy positive slope which has an increment until it reaches 98^0F.

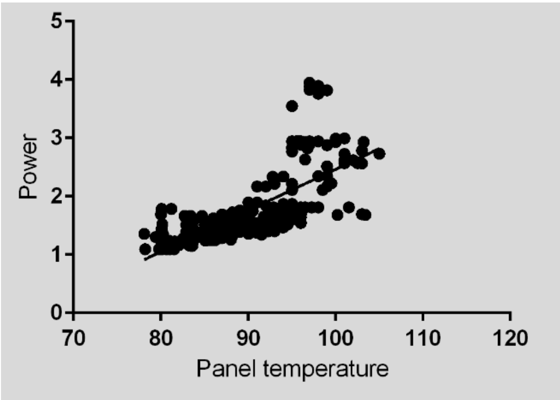

Figure10. Power versus Panel temperature

Y=0.07076*X-4.613

R= 0.7086, R^2linear =0.5022

Power versus efficiency data with very strong R=.9986 presented in fig.11

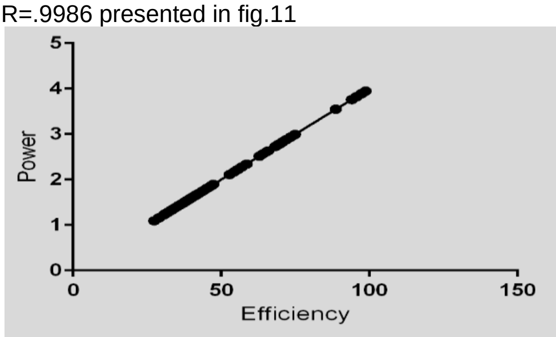

Fig.11 Power versus Efficiency

Y=0.0400*X-6.207e-008

R=0.9986, R^2 linear=0.9972

Conclusion

The relative humidity is the important source of the depletion in solar cell current, voltage, power, and efficiency. From the recorded environmental data, the humidity varies with temperature variation, so also is the rate at which the solar system can supply power to an external circuit. Correlation coefficient R and the coefficient of determination R^2 of the humidity with current, voltage, power and efficiency, has been calculated. From the results it is clear that humidity is in an inverse strong correlation with current, voltage and power. Power is maximum, below 35% humidity level and after that humidity drastically affects the power of the Solar Panel.

Suggestions

Since humidity is an environmental variable which depends on the location and after observing desperate change in power when it comes to change in humidity level, solar panel should be designed in such a way which has less effects of humidity level on the Power output.

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