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Effect of Water as a Rays Filter on the Performance of PV Module

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Abstract

Surface temperature has been found to be an important parameter affecting the efficiency of solar cells. Current study 80 °C. The Solar spectrum is divided into three bands. Ultraviolet, Visible and Infrared. Photovoltaic Panels have the capacity to convert only visible light into the electricity while ultraviolet and infrared tends to increase the panel temperature which in turns decreases the efficiency of PV Panels. Filters have been made to block UV and Infrared bands and allows only Visible to pass. An experimental setup was developed for performance investigation of two 50 Watt PV panels under the real conditions in an open climate of a Pakistan's city, Sahiwal. Two 50W panels were used for the experiments; Reference PV panel, while other PV panel is developed with 8mm thick transparent glass boundary making hollow space to be filled by water of thickness 25mm. The experimental results shows a temperature drop of 8.57 °C with power increment of around 1.46%. Hence, proposed study can be an effective approach to control solar cell temperature so that maximum performance can be achieved.

Keywords: solar spectrum, photovoltaic panel, transparent glass

1. INTRODUCTION

Fossil fuel burning is considered a major source to compete the growing energy demand in today's world. Fossil fuels including Oil, Gas and Coal is also the most responsible for climate disaster and global warming. Also the sources of fossil fuels are in limited quantity and in order to commensurate with the increasing energy demands a very big quantity of these fuels has to burn. And this unequal supply and demand chain only results in higher energy prices in addition to pollution and carbon emission. The ultimate solution to all this is Renewable Energy. Renewable energy encircles the technologies like Wind energy, Solar, Hydroelectricity, Wave energy and geothermal energy. All these sources are very promising In terms of carbon emissions and clean energy production. But the most abundant energy source in the world is Sun which is the fundamental of solar energy[1]. Solar cells converts light from the sun into direct current. When the sunlight in the form of photons strikes the surface of panel it excites the charge carriers, and these charge carriers is our current. Conventional solar cells are made from semi-conductor materials mainly from silicon, which become conductor at high temperatures and insulator at low temperatures. Not only the sources of solar energy are abundant but also the silicon is the second most abundant material in the earth crust making another promising future for solar energy. But one of the major problems with solar panels is their low efficiencies, a commercially available panel of polycrystalline type only has an efficiency of around 16-18%. Even this not enough the environmental factors like dust, air , moisture and most dominantly elevated temperatures plays a significant role in lowering the PV efficiencies[2]. Some remedies must be taken in order to mitigate the effect these factors on PV panel efficiencies.

2. THEORY

In this paper we are going to address the most responsible environmental factor which cause the lower efficiencies in PV panel that is temperature. A myriad of solutions has been proposed in the past relating to the cooling of solar panels. Mainly two type of cooling techniques are available i.e. active [3]–[8] and passive [9], [10] cooling techniques. The only difference is that active techniques requires some external power source to make cooling methodology work, while passive don't. In addition to that, use of PCM (phase change material) [11], [12], and Nano fluids [13]–[17] also have application in cooling PV panels. Another technique is the use of filters of different fluids, these filters design so that only a specific wavelength of sunlight pass-through. Sunlight comes in three different wavelengths i.e. infrared rays (IR) about 54%, ultraviolet 4% (UV), and visible light comprises of 42% of the solar spectrum. The purpose of the filters is to allow only the visible light of the spectrum to pass through as the other two wavelengths i.e. infrared and ultraviolet only works to increase the PV temperature which leads to lower efficiencies. This project aims to control the solar panel temperature by using water as a rays filter.

3. MODELING AND SIMULATION

UV-Vis (Ultraviolet Visible Spectroscopy) is used to measures the absorption of light across the ultraviolet, visible light and near infrared wavelengths through a liquid sample. The infrared and UV content in solar radiation transmitted through PV cell is the main cause of temperature increase of cell. A layer of water of thickness 25mm placed in front of cell enclosed in a transparent glass of 8mm thickness will absorb much of this ultraviolet and infrared radiation. The water used in the glass made filter is 2.42 gallons. Simple transparent glass of thickness 8mm was used to cover the boundary of plate. Length and Width of glass is 26.75 x 21.8 inches as in fig-1. UV-Vis Spectroscopy indicates that water absorbs ultraviolet and infrared radiation more effectively than visible light. A graph is drawn from the results of UV-VIS spectroscopy fig-2, performed at COMSATS University Islamabad.

Fig-1 Experimental PV Panel

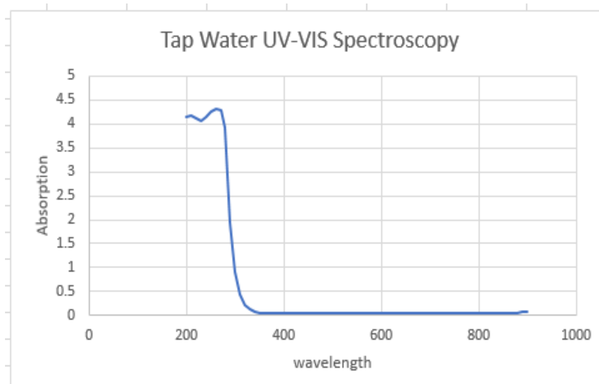

Fig-2 UV-VIS Spectroscopy

The testing site was at the roof of management sciences department at COMSATS University Islamabad, Sahiwal Campus. Experimentation was carried out during the month of May with average solar radiation of 852 W/m^2. For the sake of data collection Prova-210 IV-curve meter was used key specifications in Table-1. Similarly, for the solar intensity measurement seaward irradiance meter 200R was utilized key specifications in Table-2. In addition to all these a standard PV panel of same specifications is also used without any filtration measure to observe the increase in performance. The specifications of the PV panel taken under consideration are shown in Table-3.

Table-1 key Specifications of IV Curve Meter

Power P_{max}	500W
Voltage at (P_{max}) V_{max}	60V ± 1% accuracy
Current at (P_{max}) I_{max}	12A ± 1% accuracy
PV Panel Area Setting	$0.001m^2$-$9999m^2$
Standard Light Setting	$10W/m^2$ -1000 W/m^2
Opera. Environment	5°C-50°C

Table-2 key Specifications of Irradiance Meter 200R

Irradiance	Values
Display range	0-1500 W/m^2
Measurement range	100-1250 W/m^2
Resolution	1 W/m^2
Temperature	Values
Display range	-30°C- +125°C
Measurement range	-30°C- +125°C
Resolution	1°
inclinometer	Values
Display range	0-90°C
Measurement range	0-90°C

Table-3 Specification of PV panel

Glass type	Tempered glass
lamination	EVA
Power $_{max}$	50W
Voltage $_{max}$	17.4V
Current $_{max}$	2.89A
Voltage $_{max}$	22.0V
Current $_{Isc}$	3.03A

The related parameters including maximum power, maximum efficiency, solar irradiance, and performance ratio are calculated to understand the experimental results.

$$P_{max} = V_{max} \times I_{max} \quad (1)$$

$$E_D = E_H / \cos \delta \quad (2)$$

$$\eta_p = (P_{mean} / P_{max}\,(STC)) \times 100 \quad (3)$$

$$PR = Y_f / Y_r \quad (4)$$

4. RESULTS

Average Temperature Variation

Fig-3 shows that providing a water layer resulted in a difference of temperature. Variation of average surface temperature of modules is plotted with time. Minimum temperature for reference module was observed at 9:00am that was 42 °C and that for experimental module was 32°C.Maximum temperature was observed at 01:00pm for reference module that was 58°C and for experimental module was 50 °C.

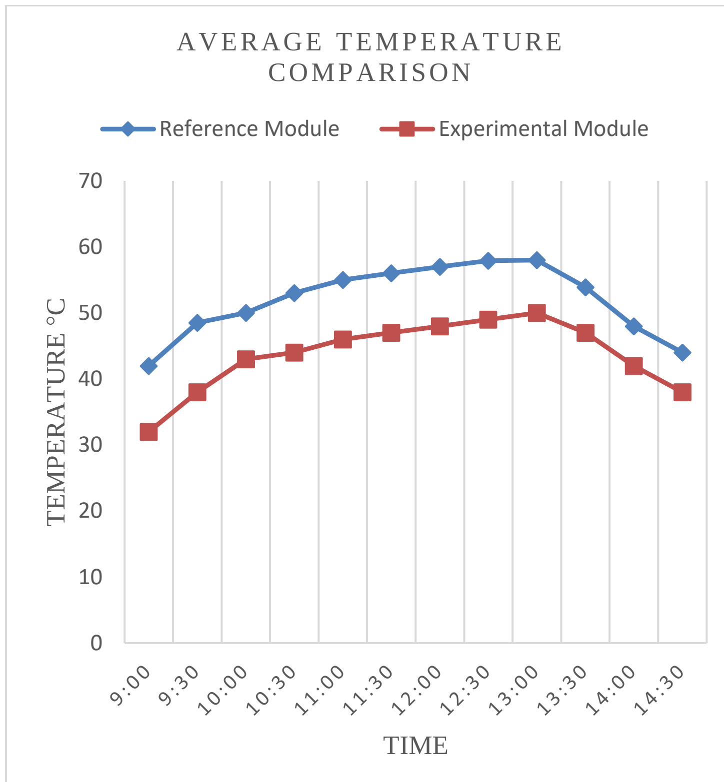

Fig-3 Average Temperature Variation

Comparison of Average Efficiency

Fig-4 is interpreted as a relationship between temperature and PV panel's efficiency. The efficiency of experimental module increases when its temperature becomes less than the reference module. Minimum efficiency was observed 11.95% and 12.19% for reference module and experimental module respectively at 09:00am. Maximum efficiency was observed 12.73% and 12.47% for experimental module and reference module at 1:30pm respectively.

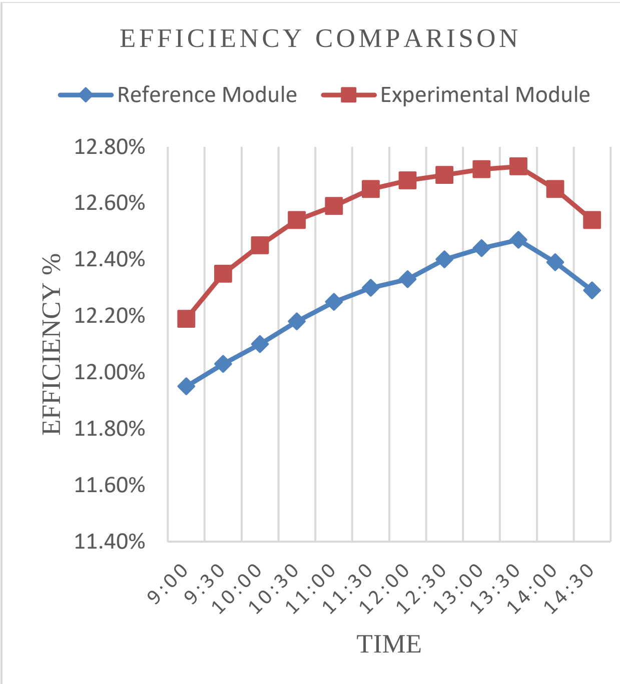

Fig-4 Comparison of Efficiency

Comparison of Power Output

Fig-5 shows us the comparison of power output of reference module to the experimental module. A significant increase in power output is observed by decreasing temperature of module. Overheating reduces the power output of panels. Minimum power output was observed 26.8W for reference module and 27.15W for the experimental module at 9:00am. Maximum power output observed was 27.68W for reference module and 28.82W for experimental module at 12:00pm. Decrease observed in the graph is due to the high temperature of Panel.

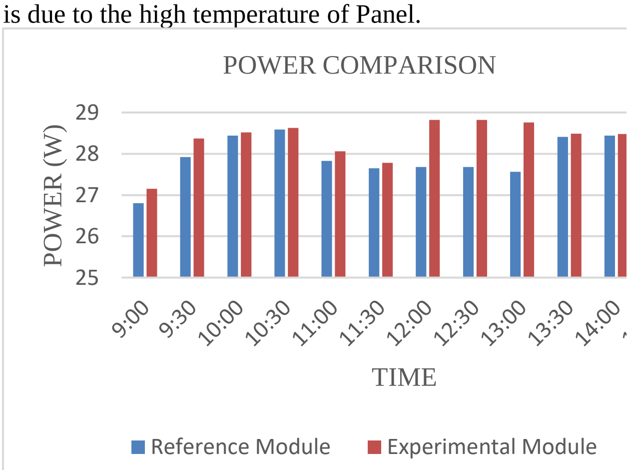

Fig-5 Power Output Comparison

Comparison of Average Performance Ratio

Fig-6 shows us the comparison of performance ratio of reference module to the experimental module. Minimum Value for Performance ratio observed was 61.5 and 63 for reference and experimental module respectively at 12:00pm. Maximum performance ratio observed was 72.1 and 74.6 for reference and experimental module respectively at 09:30am.

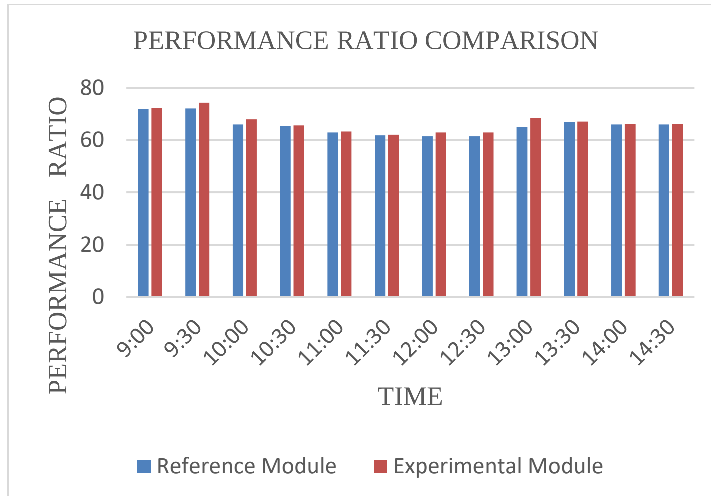

Fig-6 Average Performance Ratio Comparison

5. CONCLUSIONS

An average temperature difference of 8.57°C was observed with irradiance of 852W/m^2 at average ambient temperature of 40°C. This resulted about 1.46% increase in power output and 2.45% increase in efficiency of PV module. By increasing the experimental scale of this research, further testing can also be checked. Instead of using water as filter any other filter i.e. Nano-fluids can be used that absorbs UV and Infrared radiation and allow visible light to pass through.

NOMENCLATURE

PV	Photovoltaic
I_{SC}	Short Circuit Current
V_{OC}	Open Circuit Voltage
P_{MAX}	Maximum Power
V_{MAX}	Voltage Maximum
PR	Performance Ratio
Ed	Direct Irradiance

Y_F	Final Yield
Y_R	Reference Yield
Exp	Experimental

REFERENCES

[1] DECC, "Renewable Energy Sources," *DUKES 60th Anniv. Dig. United Kingdom Energy Stat. 60th Anniv.*, no. May, pp. 50–53, 2009.

[2] M. Gürtürk, H. Benli, and N. K. Ertürk, "Effects of different parameters on energy - Exergy and power conversion efficiency of PV modules," *Renew. Sustain. Energy Rev.*, vol. 92, no. January, pp. 426–439, 2018.

[3] M. Ali, H. M. Ali, W. Moazzam, and M. Babar Saeed, "Performance enhancement of PV cells through micro-channel cooling," *AIMS Energy*, vol. 3, no. 4, pp. 699–710, 2015.

[4] G. Colţ, "Performance evaluation of a PV panel by rear surface water active cooling," *2016 Int. Conf. Appl. Theor. Electr. ICATE 2016 - Proc.*, pp. 1–5, 2016.

[5] S. Nižetić, D. Čoko, A. Yadav, and F. Grubišić-Čabo, "Water spray cooling technique applied on a photovoltaic panel: The performance response," *Energy Convers. Manag.*, vol. 108, pp. 287–296, 2016.

[6] Y. Sun, Y. Wang, L. Zhu, B. Yin, H. Xiang, and Q. Huang, "Direct liquid-immersion cooling of concentrator silicon solar cells in a linear concentrating photovoltaic receiver," *Energy*, vol. 65, pp. 264–271, 2014.

[7] M. Rahimi, P. Valeh-E-Sheyda, M. A. Parsamoghadam, M. M. Masahi, and A. A. Alsairafi, "Design of a self-adjusted jet impingement system for cooling of photovoltaic cells," *Energy Convers. Manag.*, vol. 83, pp. 48–57, 2014.

[8] H. Bahaidarah, A. Subhan, P. Gandhidasan, and S. Rehman, "Performance evaluation of a PV (photovoltaic) module by back surface water cooling for hot climatic conditions," *Energy*, vol. 59, pp. 445–453, 2013.

[9] F. Grubišić-Čabo, S. Nižetić, D. Čoko, I. Marinić Kragić, and A. Papadopoulos, "Experimental investigation of the passive cooled free-standing photovoltaic panel with fixed aluminum fins on the backside surface," *J. Clean. Prod.*, vol. 176, pp. 119–129, 2018.

[10] M. Chandrasekar, S. Suresh, T. Senthilkumar, and M. Ganesh Karthikeyan, "Passive cooling of standalone flat PV module with cotton wick structures," *Energy Convers. Manag.*, vol. 71, pp. 43–50, 2013.

[11] R. Stropnik and U. Stritih, "Increasing the efficiency of PV panel with the use of PCM," *Renew. Energy*, vol. 97, pp. 671–679, 2016.

[12] G. Anderes, "Einflu?? der Oberfl??chenspannung auf den Stoffaustausch zwischen Dampfblasen und Fl??ssigkeit," *Chemie Ing. Tech.*, vol. 34, no. 9, pp. 597–602, 1962.

[13] L. Idoko, O. Anaya-Lara, and A. McDonald, "Enhancing PV modules efficiency and power output using multi-concept cooling technique," *Energy Reports*, vol. 4, pp. 357–369, 2018.

[14] A. H. A. Al-Waeli, M. T. Chaichan, H. A. Kazem, K. Sopian, and J. Safaei, "Numerical study on the effect of operating nanofluids of photovoltaic thermal system (PV/T) on the convective heat transfer," *Case Stud. Therm. Eng.*, vol. 12, no. May, pp. 405–413, 2018.

[15] M. S. Y. Ebaid, A. M. Ghrair, and M. Al-Busoul, "Experimental investigation of cooling photovoltaic (PV) panels using (TiO2) nanofluid in water -polyethylene glycol mixture and (Al2O3) nanofluid in water- cetyltrimethylammonium bromide mixture," *Energy Convers. Manag.*, vol. 155, no. July 2017, pp. 324–343, 2018.

[16] M. R. Salem, R. K. Ali, and K. M. Elshazly, "Experimental investigation of the performance of a hybrid photovoltaic/thermal solar system using aluminium cooling plate with straight and helical channels," *Sol. Energy*, vol. 157, pp. 147–156, 2017.

[17] S. R. Abdallah, I. M. M. Elsemary, A. A. Altohamy, M. A. Abdelrahman, A. A. A. Attia, and O. E. Abdellatif, "Experimental investigation on the effect of using nano fluid (Al2O3-Water) on the performance of PV/T system," *Therm. Sci. Eng. Prog.*, vol. 7, pp. 1–7, 2018.