International Conference On
Innovation in Renewable Energy & Power
Barcelona - Spain 7-9 December, 2018

Improving photovoltaic panel efficiency using water cooling

R. Maouedj[1], M. Benmedjahed[1], B. Berbaoui[1], A. Mammeri[1] and D. Saba[1]

[1] Unité de Recherche en Energies renouvelables en Milieu Saharien, URERMS, Centre de Développement des Energies Renouvelables, CDER, 01000, Adrar, Algeria.

Abstract. The paper proposes a design to improve the electrical efficiency of PV panels using Water Hybrid Photovoltaic Thermal (PV-T) system. The objective of the present work is to reduce the temperature of the solar cell in order to increase its electrical conversion efficiency.

The prototype composed by two side by side identical photovoltaic modules. The first PV module cooled by water while the second one was considered as standard. The electrical and thermal performances of the system are investigated under ambient temperature conditions in ADRAR, South of ALGERIA during July 2018 where the average annual solar irradiance is more than 1100 W/m² and the temperature is more than 48 °C.

1 Introduction

Many papers in the literature have discussed analytically, numerically and experimentally the performance of cooling panels PV using different designs and techniques (methods and strategies) (S. Nizetic et al. 2016; Zeyad A. Haidar, 2016; Layth Mohsin et al. 2018).

Saurabh Mehrotra et al. (Saurabh Mehrotra et al. 2006) studied the PV panels cooling using water. Solar cell immersed in water was monitored under real climatic conditions. The results show that the PV panel efficiency has increased about 17.8% at water depth 1cm.

Alzaabi et al. (Alzaabi et al. 2014) studied solar hybrid photovoltaic thermal (PV/T). The proposed system composed of a polycrystalline PV panel with a solar thermal collector adhered to its backside. The results show that the PV panel temperature reduced significantly and the electrical power output for the PV/T system increased by 15 to 20 %.

Shenyi Wu (Shenyi Wu and Chenguang Xiong. 2014) studied a passive cooling method that utilizes rainwater as cooling media and a gas expansion device to distribute the rainwater. The results show that on a design day, the passive cooling system reduces the temperature of the cells and increases electrical efficiency of the PV panel by 8.3%.

Nikhil Pradeep Chonde et al. (Nikhil Pradeep Chonde et al.2016) Studied performance improvement of PV module by using an exhaust fan. The integration of solar energy operated exhaust fan in solar PV system can cause the air flow at the bottom surface effecting cooling to the panels and enhancing the electrical output and increasing its efficiency by 3.99 %.

The rest of this paper is organized as follows. The experimental setup description presented in Sections 2. The experimental results and discussion is presented in Section 3. The study conclusions are given in Section 4.

2 Experimental rig description

An experimental setup has been developed to study the effect of cooling by water on the performance of photovoltaic panel. The PV system is installed in the Renewable Energy Research Unit in Saharan Medium (URER-MS) in Adrar in Algeria.

Figure (1) shows the cooling of PV system which built in this study . PV system setup consists of two 75W PV panels having area of 0.667 m^2.

The panels tilt angle are set to 28 deg with respect to the horizontal, which is the local latitude of Adrar (Latitude 00° 17’ W, Longitude 27° 49’ N), Algeria, so as to face in the south direction.

3 Measurements

During the testing period, from 05/07/2018 to 07/07/2018 (6.00am to 9.00 pm), the following data were regularly measured:

- Temperature measurements are important in this experiment, are measured by Kthermocouples which can sense the temperature from 0°C - 300°C. The temperatures measured are: ambient temperature, PV panel temperature, inlet water temperature, outlet water temperature and temperature of the backside of both the panels (panel with and without cooling).

- A pyranometer CM 11 was used to capture global solar irradiation.

- Also the current & voltage are measured.

A data acquisition system was also installed and connected to the computer for recording the data for every 1 min.

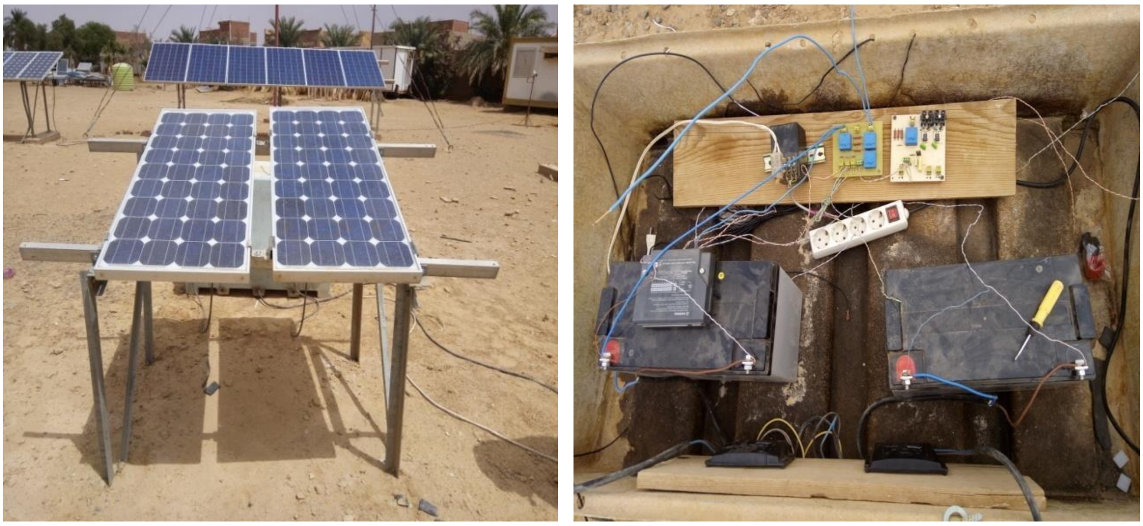

Fig.1: The outdoor experimental of PV system with and without cooling system

4 Results and discussion

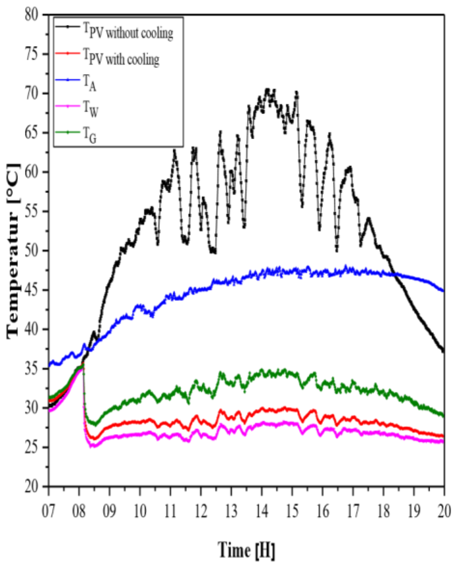

Fig.2: Evolution of the temperature during 05 July 2018.

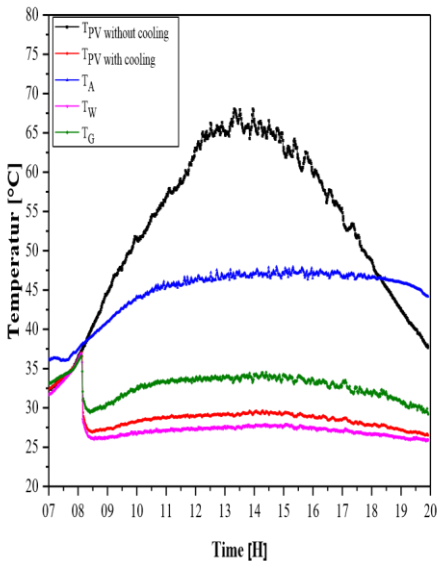

Fig.3: Evolution of the temperature during 06 July 2018.

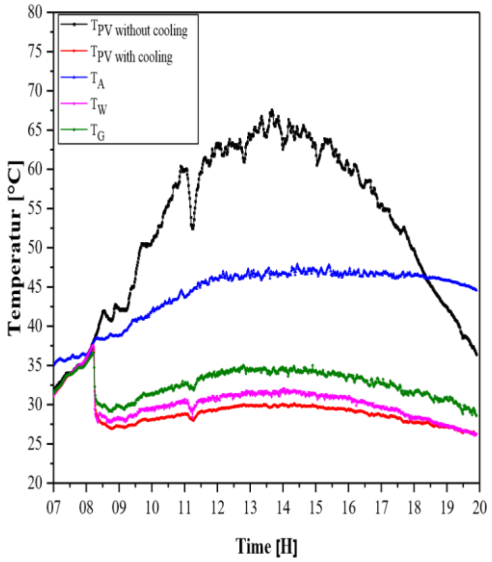

Fig 4: Evolution of the temperature during 07 July 2018.

Where:
$T_{PV\ without\ cooling}$: Temperature of the backside of PV Panel without cooling.
$T_{PV\ with\ cooling}$: Temperature of the backside of PV Panel with cooling.
T_A: Ambient temperature.
T_W: Water temperature.
T_G: Hybrid sensor glass temperature.

Time [Hour]	Solar radiation [w/m²]	T_{PV} with cooling [°C]	T_{PV} without cooling [°C]	TA [°C]	TG [°C]	Tw [°C]	ΔT T_{PV} without cooling - T_{PV} with cooling
7	16,7	33,4	33,8	36,2	33,5	33,6	-0,3
8	100,0	30,2	39,8	36,1	31,5	30,7	7
9	300,3	27,6	46,2	38,1	30,4	28,8	14,5
10	535,5	28,4	55,1	41,3	32,0	29,9	20,9
11	699,4	28,9	59,0	42,8	33,1	30,3	23,4
12	672,7	29,7	62,8	44,5	34,3	31,2	25,5
13	658,5	29,8	65,4	45,7	34,4	31,5	27,6
14	854,9	29,9	64,4	46,5	34,4	31,6	26,5
15	944,3	29,5	62,0	47,3	33,9	31,0	24,8
16	664,4	29,0	58,4	47,3	33,2	30,3	22,3
17	545,7	28,2	53,0	47,3	32,1	29,2	18,7
18	362,1	27,5	45,8	47,2	31,1	28,0	13,7
19	172,0	26,7	39,4	46,9	29,8	26,8	10
20	37,2	25,9	32,0	45,9	27,4	25,6	5,7
21	16,7	26,5	29,8	36,2	27,5	26,2	3,2

Table 1: Data of solar radiation and temperature during 05 July 2018.

Table1. In the end, the over-temperature $\Delta T = T_{PV\ without\ cooling} - T_{PV\ with\ cooling}$ was the difference in PV cell temperatures between the PV module with cooling and the PV module without cooling**.** The maximal over-temperature $\Delta T = \Delta T_{max} = 27{,}6$ °C is recorded at 13:00h.

	TPV without cooling [°C]	TPV with cooling [°C]	TA [°C]	Tw [°C]	TG [°C]
	05 July 2018				
Tmax	70,5	35,7	48,1	35,3	35,5
Tmin	29,8	26,0	35,4	25,1	27,8
	06 July 2018				
Tmax	68,1	37,0	48,0	36,9	36,6
Tmin	31,4	26,5	36,0	25,8	29,2
	07 July 2018				
Tmax	67,6	37,3	47,9	37,6	36,6
Tmin	29,2	26,2	34,5	26,1	28,6

Table 2: Daily minimum and maximum temperatures

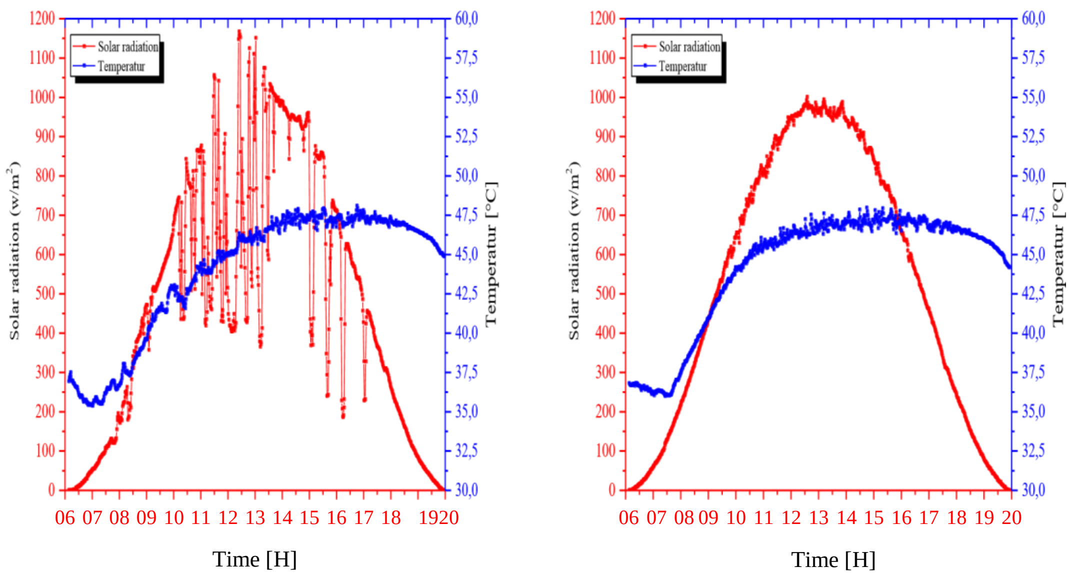

Fig.5: Solar radiation and ambient temperature on 05 July 2018.

Fig.6: Solar radiation and ambient temperature on 06 July 2018.

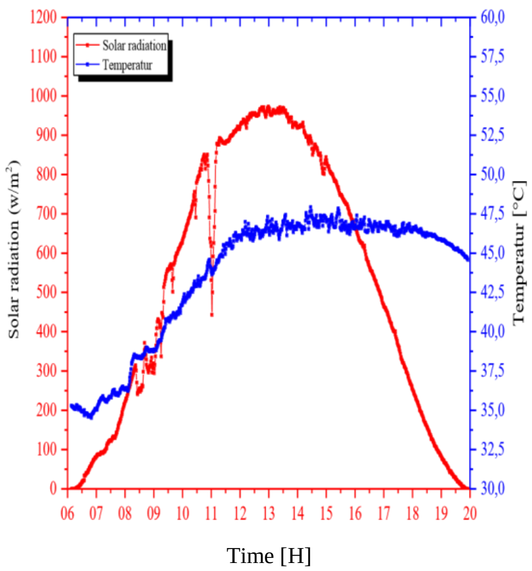

Fig.7: Solar radiation and ambient temperature on 07 July 2018.

Figure 5 represents solar radiation and ambient temperature on 05 July 2018. The maximum solar radiation occurs at 12:27 p.m which was 1167.24 W/m² and the maximum ambient temperature was 48.08˚C which occur at 16:47 p.m.

Figure 6 represents solar radiation and ambient temperature on 06 July 2018. The maximum solar radiation occurs at 12:39 p.m which was 1001.17 W/m² and the maximum ambient temperature was 47.97˚C which occur at 14:49 p.m.

Figure 7 represents solar radiation and ambient temperature on 07 July 2018. The maximum solar radiation occurs at 13:30 p.m which was 971.99 W/m² and the maximum ambient temperature was 47.92˚C which occur at 14:31 p.m.

5 Conclusion

The photovoltaic panel efficiency is sensitive to the panel temperature and decreases when the temperature of the panel increases. In order to overcome this problem, an experimental setup has been developed to cool the PV panels using water circulation through the collector at the backside of the PV panel.

From the results, PV panel without cooling system has the lower output power when compared to the PV panel with cooling systems.

Therefore, finally, it is concluded that this system may be a better solution to increase PV panel's efficiency for the Saharan regions, where solar irradiation is ample and ambient temperatures are very high.

References

1. Alzaabi A.A., Badawiyeh N.K., Hantoush H.O. and Hamid A.K. *Electrical/thermal performance of hybrid PV/T system in Sharjah, UAE*. International Journal of Smart Grid and Clean Energy, vol. 3,pp. 385, Oct 2014.
2. Layth Mohsin, Ahmad Sakhrieh, Ahmad Aboushi, Amer Hamdan, Eman Abdelhafez, and Mohammed Hamdan; *Optimized cleaning and cooling for photovoltaic modules based on the output performance*. Thermal Science: Year 2018, Vol. 22, No. 1A, pp. 237-246.
3. P. Nikhil. Chonde, A.R. Suryavanshi, G. S. Tasgaonkar. *Performance Improvement of PV module by using an exhaust fan.* (May 2016). International Engineering Research Journal. 1190-1194.
4. S. Mehrotra, P. Rawat, M. Debbarma and K. Sudhakar. *Performance of a solar panel with water immersion cooling technique*. International Journal of Science, Environment ISSN 2278-3687 (O) and Technology, Vol. 3, Nº 3, 2014, 1161 – 1172.
5. S. Nizetic, D. Coko, A. Yadav, F. Grubišic´-Cabo; *Water spray cooling technique applied on a photovoltaic panel: The performance response*. Energy Conversion and Management 108 (2016) 287–296.
6. Shenyi Wu and Chenguang Xiong. *Passive cooling technology for photovoltaic panels for domestic houses.* International Journal of Low-Carbon Technologies 2014, 9, 118–126.
7. Zeyad A. Haidar; *Cooling of solar PV panels using evaporative cooling*. Journal of Thermal Engineering. Yildiz Technical University Press, Istanbul, Turkey. Vol. 2, No. 5, pp. 928-933, October, 2016.