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Review

Renewable and Sustainable Energy Review

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Abstract

The review introduced in this paper depends upon point by point survey of the Zeroed on the utilization of phase change material (PCM) for PV-Module. Thermal regulation & electrical efficiency improve the impact of high temperatures. On PV power age has been analyzed and the discoveries have featured the significance of visible high temp. guideline for PV-model. Different cooling technique utilized to keep up better PV execution are examined and the as of late arising PV-PCM framework idea for high-temperature guidelines is presented.

A comprehensive paper review of best in class part of this innovation like framework improvement, execution, assessment material choice, heat remove improvement mathematical model, reproduction, and application in practice is given. The PVST-PCM system for example coordinated with a sunlight base warm (ST) system. Has subsequently been explored as the put-away intensity can be extricated for the warm application. The double PCM jobs exhibit huge application possibilities for consolidated innovation in any case. Both PV-PCM and PVST-PCM framework (system) are still mostly in the exploration and research faculty test stage, with clear extension for viable application yet with orderly difficulties. Ideas for the future work are introduced.

Keywords: PV-PCM, PVST-PCM, Solar thermal radiation, Electricity converter, solar power system, Optimum temperature, Optimum working temperature, Solar panels.

Introduction

Now a days technologies are increasing day-by-day which requires fossil fuels which has been in limited quantities under the ground level on earth so we tries to shift on renewal sources of energy. Here we use such as solar energy, wind energy, hydro energy, etc.

Solar or Photovoltaic (PV) cells are made of semiconductors materials that can convert sunlight into electricity. When the sunlight is falls on the surface of the solar cells in the form photons and it convert in electricity by the help of converter. In solar power system the PV cells are heated more due to solar thermal radiation and decrease the efficiency of PV cells so we use different type phase change materials and different types of technique which is maximum heat transfer to the environment and further reduced the heat of PV cells and increase its efficiency.

Material and methods

Ideal working temperature for solar panels

The optimum working temperature of solar panels, according to solar panel manufacturers, is 77F (25C). Solar panels are expected to absorb the maximum amount of sunlight and convert it to usable power at this temperature (peak efficiency).

Previous research agrees on the optimum temperature recommended by manufacturers but expands it to be a range. According to many research findings, the average temperature range is 59F-95F (15C-35C).

Effects of overheating on solar panels

Reduces efficiency

With proper cooling, you should expect your solar panels' efficiency to be near the top of the standard efficiency range (19-23%).

Causes regular maintenance

High temperatures have an impact on all electronics, including solar panel components.

Negative financial effect

Overheating causes energy loss, which means you're paying more for electricity.

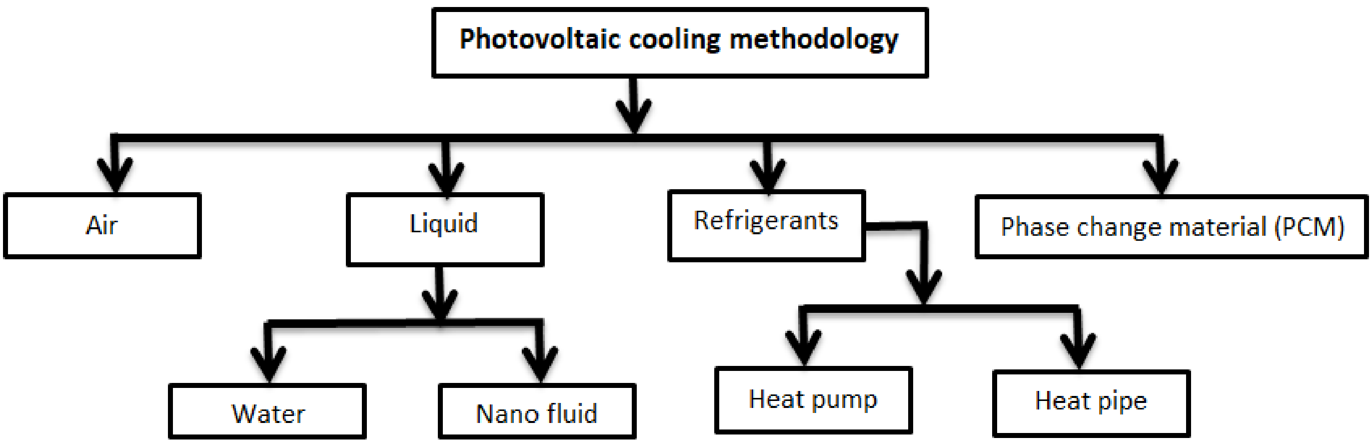
Methods of cooling

(Ma et at., 2014; Sainthiya et al., 2017) Various types of cooling technologies to use enhance the efficiency of PV-module like as Air based, heat pipe-based, and phase change material PCM) based. There are two types of cooling technique used –

1. Active cooling system
2. Passive cooling system

Active cooling system refers in which the device consume power supply. In active cooling like as fans, motors and water pump on the surface onto the panel to remove heat from it. Although an active system consume power so it is used situation where the added efficiency to the panels is grater then the energy demanded to the power system.

Passive cooling system refers in which reduce temperature of PV system by absorbing heat from it without consuming any type of additional power source. In the PCM there are many types of methods of passive cooling options available such as copper and aluminium, or an array of fins and other type of extruded surface of solid of maximum heat transfer to the surrounding. Passive cooling does not required any type of power consumption to drive the system. Phase change material (PCM) thermal regulation is also passive cooling methods. The passive cooling methods are mostly used as compare to the active cooling methods because in the passive cooling methods not require any electrical power consumption so its require less maintenance.



Literature review

(Sarikarin et al., 2019) Using methods cooling enhancement of photovoltaic cell via the use of phase change material in a different designed container shape and find the result-

- **Groove type**- the temperature that is decreased by 4.764 °C and the electrical power increased by 0.466 Watts, resulting to an increase of electrical efficiency by 4.042 percent.
- **Tube type-** the temperature that is decreased by 5.265 °C and the electrical power increased by 0.505 Watts, resulting to an increase in electrical efficiency by 4.307 percent.
- **Fins type-** the temperature that is decreased by 6.167 °C and the electrical power increased by 0.596 Watts, resulting to an increase in electrical efficiency by 4.858 percent.

So we found that maximum temperature decreased by 6.167 °C and electrical efficiency increased by 4.858 % in fins-type containers. (Lim et al., 2018) Investigating the Performance Improvement of a Photovoltaic System in a Tropical Climate Using Water Cooling Method and Find the Result- the temperature distribution profiles of the solar panels were obtained from the thermography images taken by the thermography camera, and they were compared with the temperature readings from the temperature sensors. The thermography images of the solar panels before and after the water-cooled with a flow rate of 20 L/min are shown in Figure The readings from the temperature sensors are listed in Table 1 the thermography images were taken within 1 minute after the water cooling was started. The average temperature was reduced by 24.4°C within a minute.

Table 1: The readings from the temperature sensors

Sensor	T1	T2	T3	T4	T5	T6	T7	T8	T9
Before cooling °C	56.2	61.9	58.7	59.7	63.3	63.1	56.0	58.0	58.5
After cooling °C	35.1	35.0	34.9	35.5	35.4	35.6	34.8	34.8	34.9

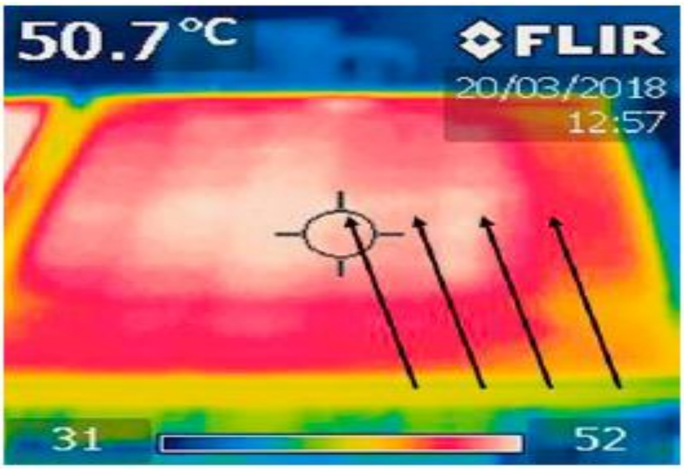


Figure 1: Thermography image before cooling water was Temp. varies across the solar panel.

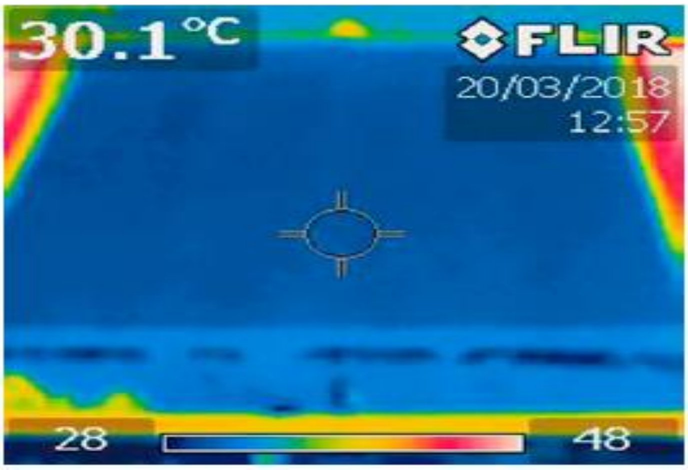


Figure 2: Thermography image was taken within 1 minute after cooling water was supplied. A uniform temp. distribution was observed across the solar panel.

(Bashir et al., 2018) Performance investigation of PV modules by back surface water cooling method used and find the result- experiment was performed on the top roof of the Department of Mechanical Engineering, MUST, for different sunny days of two months (July and August 2015). It was assumed that there was 1-D heat input (perpendicular to the front glass). The maximum power, electrical efficiency, thermal efficiency, and overall efficiency of two different PV modules were measured and the comparison is presented here. The results showed that there is a considerable efficiency increment with the back surface cooling of PV modules. Days of measurements were sunny. Figure shows the hourly average solar irradiance from 8:00 AM to 5:00 PM. The average solar radiation increased linearly up to 12 p.m. and then decreased after that. The highest average solar irradiance measured was 971 W/m2.

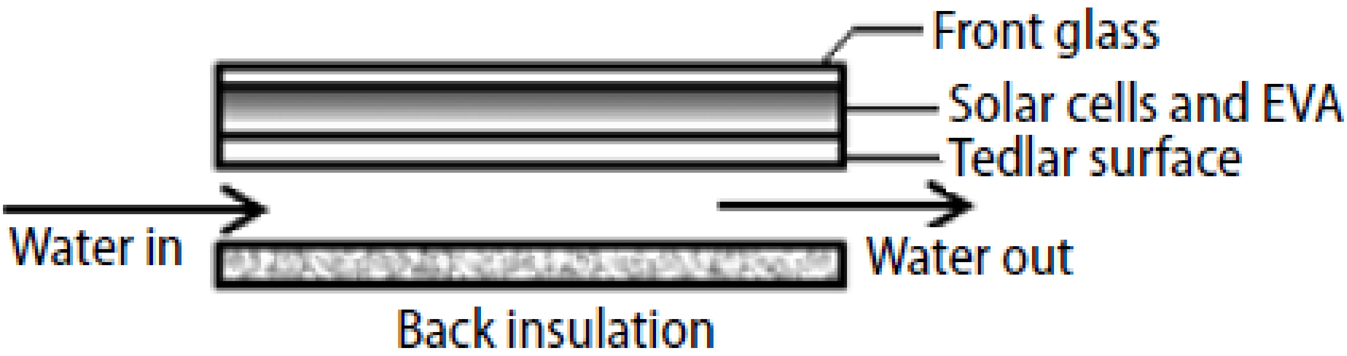


Figure 3: Cross-section of the PV module with dust

Figure 4: Experimental set-up; PV modules with cooling and without cooling

(Azzouzi et al., 2013) "Improving silicon solar cell efficiency by using the concept of the impurity photovoltaic effect (IPV) to enhance the cell conversion efficiency. The concept of IPV is based on the insertion of deep defects in the solar cell. They investigate the effect of the impurity and structure parameters on silicon solar cell characteristic.

(Abd-Elhady et al., 2013) Enhancing the performance of photovoltaic panels by water cooling and find the result- It is found that a rise in the solar cells temperature by 10 ºC from 35ºC to 45ºC results in decreasing the efficiency of the cells from 12% to 10.5% the average efficiency decreased by 12.5%. The cooling system was operated to solve the overheating problem, where it was observed from Figure 5 that operating the cooling system for 5 min results in a decrease in the solar cells temperature by 10ºC, and an increase in the solar cell efficiency by 12.5%.

(Agyekum et al., 2021) Effect of dual surface cooling of a solar photovoltaic panel on the efficiency of the module: experimental investigation and find the result by this method The maximum output power of 15.04 W was recorded around 11:30 am when the highest solar irradiation was recorded during the experiment for the cooled PV panel, whiles the uncooled panel recorded 11.60 W during that same period. This is about a 29.66% improvement in the energy yield as a result of the implementation of the cooling approach proposed in this study. The average power for the entire experimental period for the cooled panel is 13.03 W compared to 10.00 W for the uncooled PV panel. It can be said that the 23.55˚C reduction of the temperature as presented earlier in this research led to an overall increment of 30.3% in the output power. As shown in Figure 6.

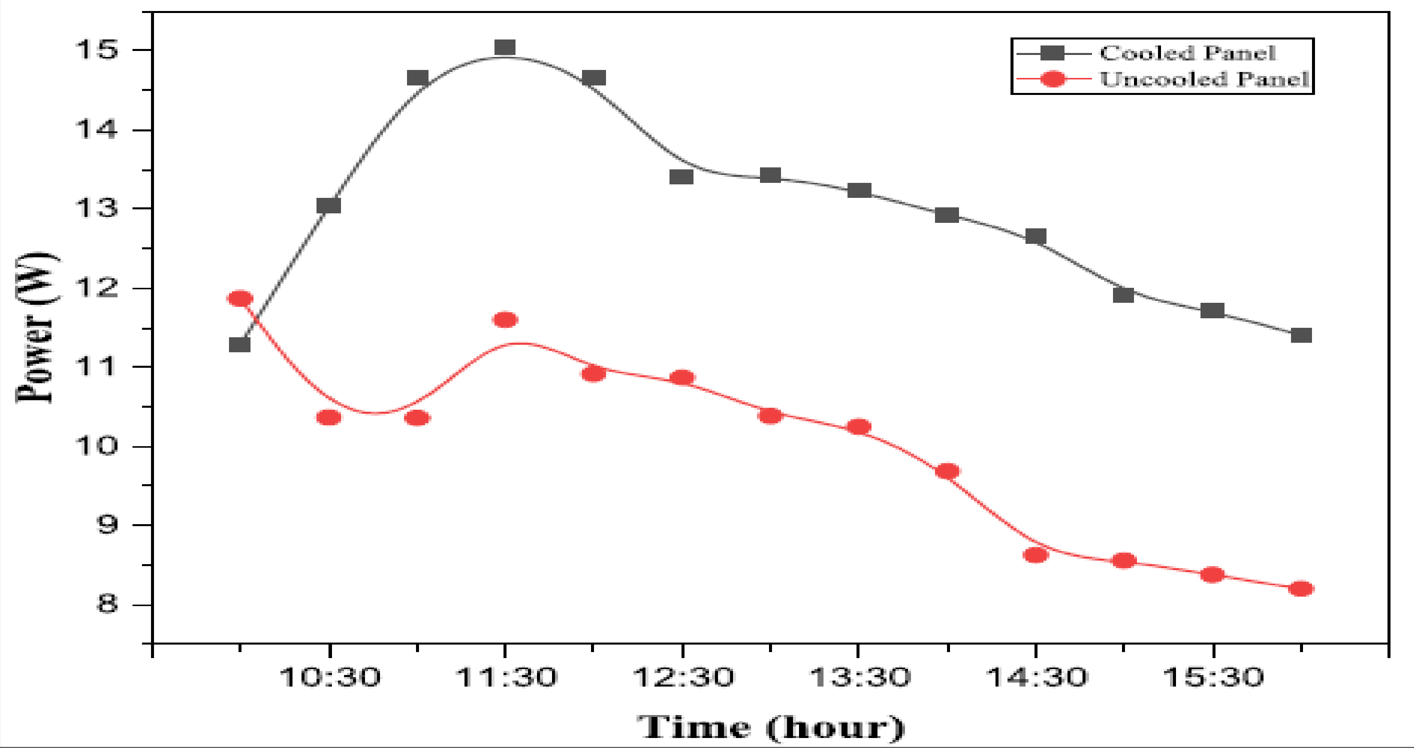


Figure 5

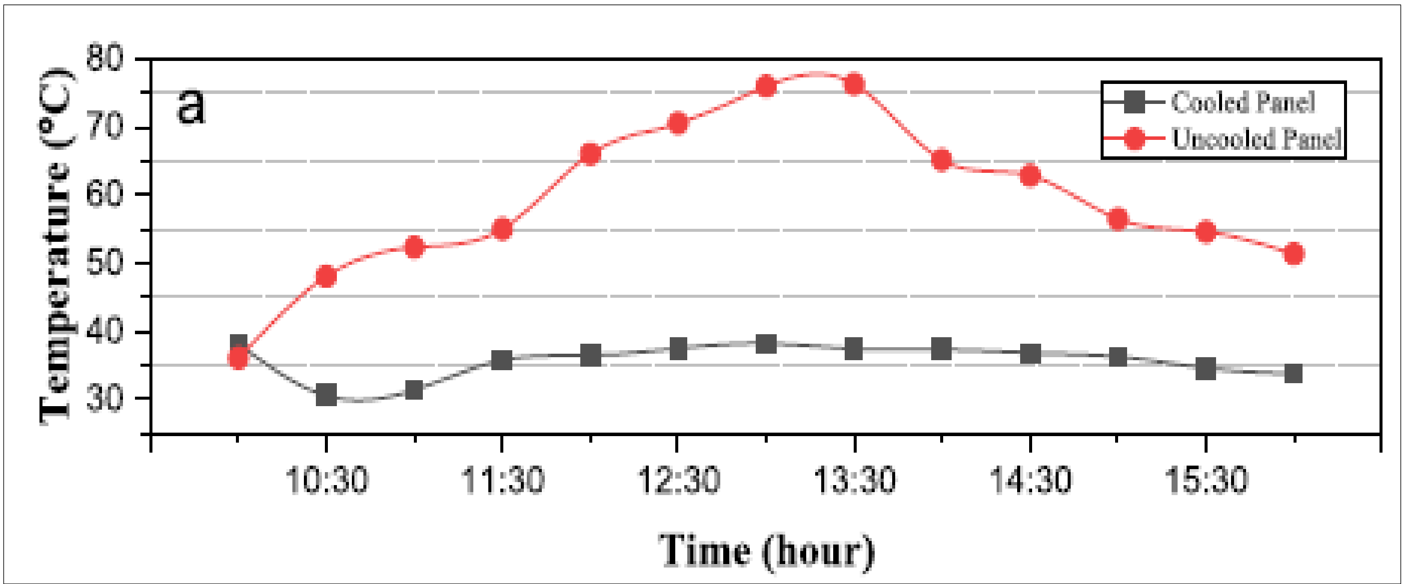


Figure 6

(Elminshawy et al., 2018) Performance of PV panel coupled with geothermal air cooling system subjected to hot climatic, in this methods EAHE (Earth Air Heat Exchanger) use as geothermal air cooling and find the result- The performance of the PV module was researched using geothermal cooling. A significant PV surface temperature drop up to 24.5% is achieved and improvement in the PV module output power up to 18.90% is achieved. PV electrical efficiency is increased up 22.98% using proposed cooling system. The LCE (levelized cost of energy) for (PVC) is improved by 12% using geothermal cooling.

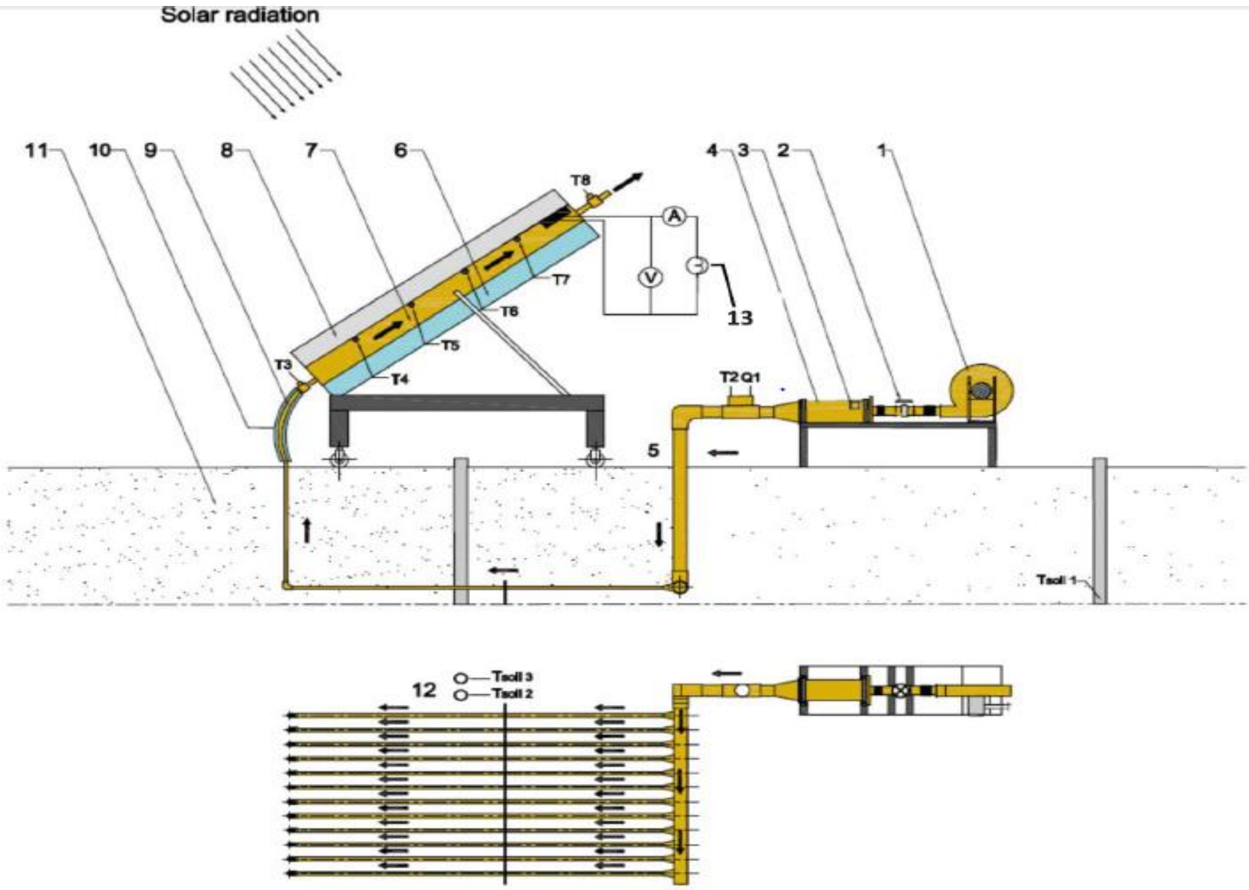


Figure 7

Figure 7 Schematic diagram of the experimental test rig, 1- air blower, 2-control valve, 3-temperature control, 4- air heater, 5-inlet to EAHE, 6-insulation, 7-air cooling channels, 8-PV module, 9-pre-cooled air exit, 10-exit pipe insulation, 11-soil, 12-soil temperature locations, *Tsoil2* and *Tsoil3*, 13- electrical load, DC bulbs (24 V).

(Sarikarin et al., 2019) conducted experiments for PCM passive cooling. Three PCM boxes, i.e. grooved, tubed, and finned configurations, were investigated. Data were recorded during the period 11.00 am–1.00 pm where the solar irradiance was almost constant at high values. The preliminary results are shown in the Table given below. The temperatures of the two PV modules, with and without cooling, were monitored. The module without cooling had a temperature of 50–55 °C and the ambient temperature during the test was 29–35 °C with an average of 32.9 °C. Thus, when cooling the module with palm wax in the finned container, the heat was absorbed by the palm wax to change it from solid to liquid phase.

PCM container	Grooved	Tubed	Finned
Avg. temperature of PV without PCM cooling (°C)	54.8	54.4	57.9
Avg. temperature of PV with PCM cooling (°C)	50.1	49.1	51.8
ΔAvg. temperature of PV (°C)	−4.7	−5.3	−6.1
Avg. ambient temperature of PV (°C)	31.4	29.3	32.9
Avg. power output of PV without PCM cooling (W)	11.82	12.35	12.77
Avg. power output of PV with PCM cooling (W)	12.28	12.86	13.37
Δ Avg. power output of PV (W)	+0.46	+0.51	+0.60
Avg. energy conversion efficiency of PV without PCM cooling (%)	9.84	9.91	10.20
Avg. energy conversion efficiency of PV with PCM cooling (%)	10.23	10.32	10.68
Improvement of energy conversion efficiency of PV (%)	+4.04	+4.31	+4.86
Avg. irradiance (W/m^2)	871	910	919

Figure 8

(Hachicha et al., 2015) Enhancing the Performance of a Photovoltaic Module Using Different Cooling Methods and Find the Result For almost the same irradiance back cooling is able to decrease the temperature of the PV cell by 1.7% compared to the uncooled case, while the power is increased by 2.3%. For front cooling, an increase of 3.6% in output power has been observed and the open circuit voltage increases from 20.38 V to 20.72 V. A significant decrease of 11.3% of the cell temperature is observed with front cooling leading to an increase of electrical efficiency by 3.6% respect to the uncooled case. The cell temperature is decreased by 7.7°C using the double cooling corresponding to a drop of 18.3 % compared to the uncooled case. As a consequence, the maximum power point is increased by 5.5% which is consistent with the temperature coefficient for silicon solar cell (0.065%/K). The short circuit current is almost constant for different scenario and only a slight decrease is observed when double cooling were implemented. The electrical efficiency and the fill factor of the PV panel have been calculated for different cooling techniques and compared to the uncooled case. In the table, double cooling shows an increase of 4% in electrical efficiency of the PV panel which means a relative increase of 0.5%/K. However, the fill factor is increased by only 2.9% which corresponds to a relative increase of 3.5%/K.

Table 2: Electrical performance of the pv panel

	η (%)	FF
No cooling	10.58	0.686
Back cooling	10.81	0.692
Front cooling	10.78	0.700
Double cooling	10.99	0.706

Conclusion

This review investigated the different types of cooling techniques to achieve the maximum power output by decreasing the PV cell temperature. PV cooling via fin heat sink offers enhanced heat transfer area to promote a more significant heat transfer rate from the rear surface of the PV module to the ambient mainly via natural convection. This method can be considered as the most economical in comparison to the other passive cooling techniques, technically feasible under different climatic conditions, and easy to implement or install. In the heat transfer mechanism by natural convection, the heat flow is highly dependent on the geometry of the surface (heat sinks) and its orientation.

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