

## Comparative Analysis of the Performance of PV Panels Using Various Cooling Systems

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### ABSTRACT

*Certain materials with a higher specific heat capacity are effective heat storage materials. All of the radiation can't be converted into electricity by photovoltaic panels. Only a small portion is transformed into electrical energy; the remainder is transferred to heat, raising the cell's operating temperature. A higher operating temperature reduces the cell's efficiency. In this study, we investigate the impact of various cooling approaches on operating temperature, including phase change material cooling, thermoelectric cooling, nanotube cooling, etc. The purpose of the article is to assess the varied parameters of the panel after cooling and to make recommendations regarding which cooling method gives greater efficiency. The panel temperature is also tuned for three different environmental circumstances. The investigation comes to the conclusion that water spraying from the panel's front and back causes the greatest temperature change and increases panel efficiency.*

**Keywords:** PV Panels; Cooling Systems; Thermoelectric Cooling.

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### 1.0 Introduction

As the second decade of the twenty-first century approaches. Our engineering technology is always evolving. We are constantly looking for better products, tools, and spaces to suit our demands and make our daily tasks easier [1]. The instinct of people is to seek out as much comfort as they can. Humans are constantly looking for different techniques to achieve comfort and ease for daily jobs. To run such massive gear or equipment, a significant amount of electrical energy is required [2]. We are nowadays trying to generate power from traditional energy sources that use [3].

The generated electricity is then stepped up to high voltages to ensure that when it is transmitted over long distances, there will be less power loss at the destination [4] before being stepped down to the required voltage for distribution. However, because this electricity was produced using conventional energy sources, which have a finite lifespan, it is not possible to use them indefinitely. We must choose alternative energy sources that are limitless in nature; these sources are referred to as renewable energy sources, such as solar energy [6]. As options for renewable sources of energy, there are wind energy, tidal energy, and wave energy [7].

The most practical element in the entire conversion process is used in the photoelectric effect [8], which makes use of semiconductor material [9]. Semiconductor materials have properties that fall somewhere between those of metals and those of non-metals. It implies that they can exhibit characteristics of under various circumstances [10]. After of the, the electrons in these materials'

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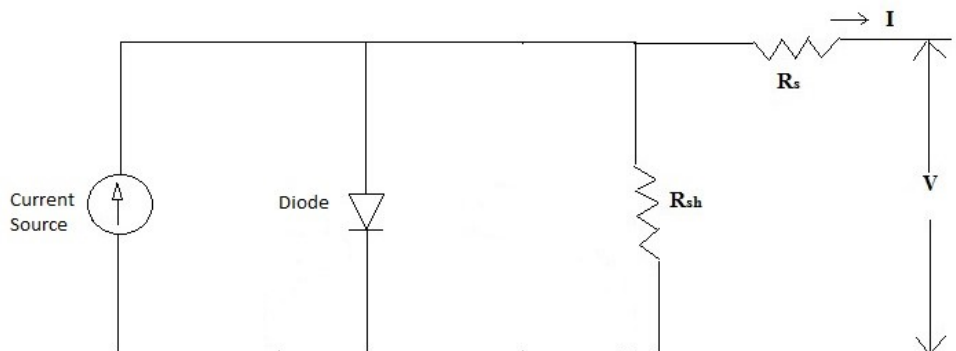
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valence band are excited to move into the conduction band. When this happens, A black-surface absorber is used in solar panels to absorb solar thermal energy and transmit it to a fluid that circulates inside [11]. The current in the circuit is created by the movement of these electrons.

The efficiency of a solar thermal system is governed by a number of mechanisms, which in turn depend on how well heat transfer processes work [12]. The solar panel itself needs to be improved, but there is also a chance of increasing solar conversion efficiency. All photons are absorbed by the ideal solar panel, which then transforms them into heat and transfers it to a fluid medium. Higher fluid thermal transfer, higher output temperatures, and higher temperatures lead to increased power cycle energy conversion.

**Figure 1: Individual Solar Unit Used for Generation**



$$V_{OC} = \frac{kT}{q} \ln \left\{ \frac{I_L}{I_0} + 1 \right\} \quad (1)$$

$$I_{Total} = I_0 \left\{ e^{\frac{qV}{kT}} - 1 \right\} - I_L \quad (2)$$

$$F.F = \frac{V_M I_M}{V_{OC} I_{SC}} \quad (3)$$

$$\eta = \frac{V_{OC} I_{SC} F.F}{P_{Rad}} \quad (4)$$

$$L_{min} = \frac{D(1-D^2)R}{2f} \quad (5)$$

$$C_{min} = \frac{D}{R \left( \frac{\Delta V_O}{V_O} \right) f} \quad (6)$$

**Table 1: Characteristics of Solar Unit**

Sr.No.	Factors	Value
1	Units	80
2	Maximum generation	215.15 W
3	$V_{Pmax}$	28 V
4	$I_{Pmax}$	8.45 A
5	$V_{OC}$	39.3 V
6	$I_{SC}$	8.84 A
7	Temp. coefficient for open circuit voltage	-0.296 % / °C
8	Temp. Coefficient of short circuit current	0.204 % / °C
9	Size for solar units	9 m <sup>2</sup>

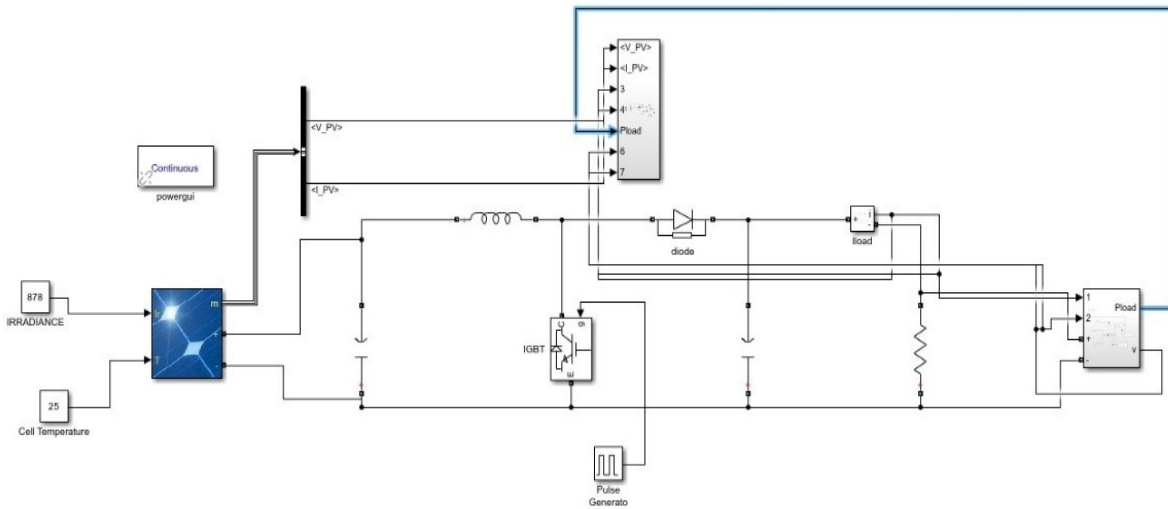
**Table 2: Contrast of Various Strategies**

Sr. No.	Strategy	Variation	Advantages
1	Liquid	34	Costly
2	Passive Way	9 °C	Without power
3	Active Cooling	14 °C	High temperature variation
4	PCM Cooling	17 °C	Reliable
5	Nano Fluid	19 °C	Not heavy
6	Thermoelectric	29 °C	Power production
7	Liquid immersion	28 °C	Higher output

We can see from the above table that we will currently use seven cooling techniques for the aforementioned PV panel, each of which has a known impact on operating temperature. These results were obtained after various authors conducted their experiments.

**2.0 Matlab Model**

**Figure 2: Simulink Model**



The performance of PV panels is simulated using the MATLAB model mentioned above. Certain power, voltage, and current observations can be made by altering the environment.

**3.0 Results**

**Table 3: Variation in Temperature Following the Use of Respective Strategy**

Sr. No.	T <sub>CELL</sub>	Liquid	Passive	Active	PCM	Nanofluid	Thermoelectric	Submersion
1	74	42	67	62	58	55	49	49
2	68	37	59	56	56	49	45	44
3	58	28	49	47	46	39	36	36

**Table 4: Solar Panel Characteristics after Respective Strategy**

Sr. No.	T <sub>cell</sub>	Strategy	V <sub>pv</sub> (V)	I <sub>pv</sub> (A)	P <sub>pv</sub> (W)	P <sub>max</sub> (W)	F. F <sub>new</sub>		
1	44	Liquid	32.4	4.12	122.5	181	0.623	18.3 %	22 %
	65	Passive	29.80	4.42	97.45	164.56	0.645		18.9 %
	64	Active	27.12	4.51	98.57	166.81	0.65		19 %
	56	Pcm	25.45	4.65	102.65	169.79	0.66		19 %
	57	Nano	24.78	4.72	104.8	172.02	0.672		19.7 %
	49	Thermo	32.89	4.87	107	176.43	0.686		18.1 %
	48	Submersion	34.91	4.67	111	177.16	0.69		18.2 %
2	37	Liquid	34.12	4.72	127.48	166.89	0.591	18.4 %	18.7 %
	59	Passive	27.46	4.56	98.7	151.45	0.567		18.2 %
	56	Active	28.78	4.57	102.9	156.67	0.574		18.4 %
	55	Pcm	32.81	4.58	107.2	158.24	0.553		19.7 %
	49	Nano	32.52	4.62	109.4	159.76	0.561		19.9 %
	44	Thermo	34.24	4.76	114.5	162.98	0.575		19.4 %
3		Submersion	34.45	4.78	116.6	165.92	0.587	19.07 %	19.5 %
	27	Liquid	32.12	4.97	146.4	178.67	0.695		19.56 %
	49	Passive	34.45	4.67	126.1	163.89	0.642		18.6 %
	48	Active	35.89	4.89	127.7	165.94	0.649		19.24 %
	47	Pcm	35.56	4.76	121.9	168.6	0.658		19.2 %
	39	Nano	36.87	5.74	124.45	166.45	0.665		19.4 %
	39	Thermo	37.45	7.89	129.78	174.78	0.679		19.9 %
	38	Submersion	38.8	8.89	140.24	177.54	0.681		21 %

The performance metrics for solar panels are listed in the table above and are obtained when a cooling technique is used on the panel. Because the operating temperature of the panel is affected differently by each cooling method, The efficiency of the panel has dramatically increased from 16 to 20 percent.

#### 4.0 Conclusion

The aforementioned results show a strong correlation between a solar cell’s operating temperature and its performance metrics. Since phase change materials have a life cycle of about 2000 cycles and cause a temperature decrease of about 15 °C, solar cells suffer from lower performance parameters at higher operating temperatures. According to the panel’s characteristics, since phase change materials have a life cycle of about 2000 cycles and cause a temperature decrease of about, open circuit voltage decreases as a result of the heat. The panels’ efficiency increased by 1.9 percent when submerged in water at a specific depth because of the greater temperature change (about 25oC). However, by analysing the aforementioned results, one can infer that the panel will be more efficient the closer the operating temperature is kept to the surrounding air temperature., but this method faces significant implementation challenges due to its non-toxic nature. Since phase change materials have a life cycle of about 2000 cycles and cause a temperature decrease of about 15 oC, they also exhibit. This study comes to the conclusion that using maximises its efficiency and should be used widely to extract more power from a given system.

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