JFSA

Journal of Futuristic Sciences and Applications
Vol. 2(1), Jan-Jun 2019, pp. 19-23
doi: 10.51976/jfsa.211904
www.gla.ac.in/journals/jfsa

Increased PV Panel Performance Using PCM Cooling Approach

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ABSTRACT

Photovoltaic panels perform worse at low operating temperatures, it is bad for PV panel performance when operating temperatures are low and efficient. A portion of this spectrum is converted into electrical power when light rays strike the PV pane plate, while the remainder of the spectrum raises the temperature of the cell. About 75 to 80 percent of the light that reaches the screen increases the temperature of the cell. The effect of phase change material on operating temperature is investigated by simulating the thermodynamical equations involved in the heat transmission of the panel in the PCM domain. Temperature variation is accomplished for four different time periods of the day with various irradiation levels and environmental factors. In order to compare effectiveness at 25° C and a typical irradiation of 1000 W/M2, observations will be kept.

Keywords: *Photovoltaic; Efficiency; Fill Factor; Short Circuit; Open Circuit.*

1.0 Introduction

As fossil fuels are quickly running out, the loss has gradually decreased in recent years [1]. It has actually come to light. In order to determine the available stocks, it is crucial to first assess the rate of extraction of the various energy sources [9]. Gas and oil are particularly examples of this. The figure thus obtained will be used to estimate the time frame for the fully available sources, eliminating the need for renewable energy and briefly describing these alternatives [2]. Men's quality of life has improved due to the widespread use of commercial fuel. The negative effects on the environment are perhaps the most significant. The first silicone solar cell was demonstrated about 50 years ago. However, technology has advanced significantly over the last 20 years, with the top cell performance certified at over 24%. Electrical and optical cell architecture has improved the principal operator [3].

In the first area, less highly doped material is present inside the cell, and more cell connections and surface areas are passive. The cell's improved light collection and reduced reflection had a significant effect optically. The performance of silicon cells has increased thanks to these features by 24.7%. These design innovations have recently been successfully incorporated into consumer goods using cells that are currently available on the market and have an efficiency of 17–18%. As a result, it seems reasonable to assume that silicon films only a micron or two thick should be capable of achieving notable cell efficiencies [4].

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Doi: 10.51976/jfsa.211904

Crystalline silicone makes up more than 90% of the silicone used to create solar cells. Si Wafer PV module production has increased by more than 30% over the past ten years. such an important contribution. Wafer-based solar crystalline silicon cells are incredibly effective, with laboratory cells reaching a record efficiency of 24.7 percent and commercial modules having an efficiency of 12 to 18 percent [5]. Amorphous Si molecules have a relatively straightforward atomic structure. The result is that the content has significant flaws. Several slow bonds lead to the carrier's wide recombination.

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

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

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

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

The CIGS and CdTe polycrystalline materials that can be used to make PV cells [6] Both of these distances are within the band, so a solar cell only needs a thin layer of material. One of the most alluring methods to create robust, affordable [7] panels is to make solar cells from thin, crystalline silicone films. For many reasons, crystalline silicone is a popular material in thin film technology and is excellent for solar cells [8]. It has proven to have excellent and reliable cell quality. The development of affordable solar energy is a potential replacement for a power system made up of a network of local grid clusters. [9].

We can be broadly categorized as commercial and for-profit establishments [10]. A developed country like the United States gets the majority of its energy from commercial sources, and emerging economies like India use business and nonprofit sources almost equally

Figure 1: Circuit Diagram for a Solar Cell Diode

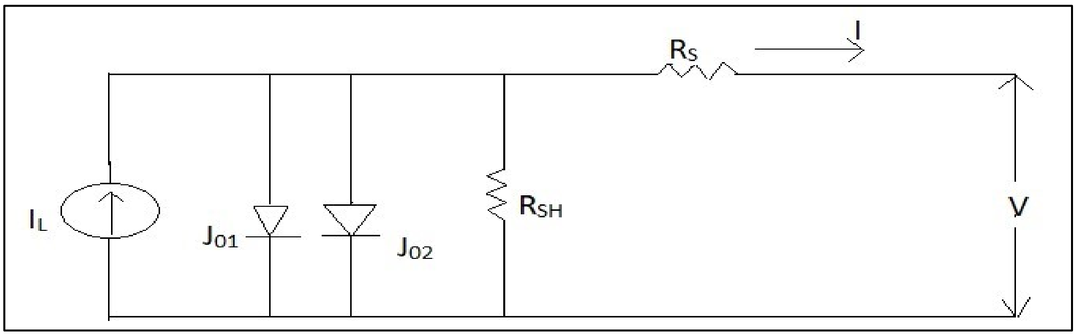
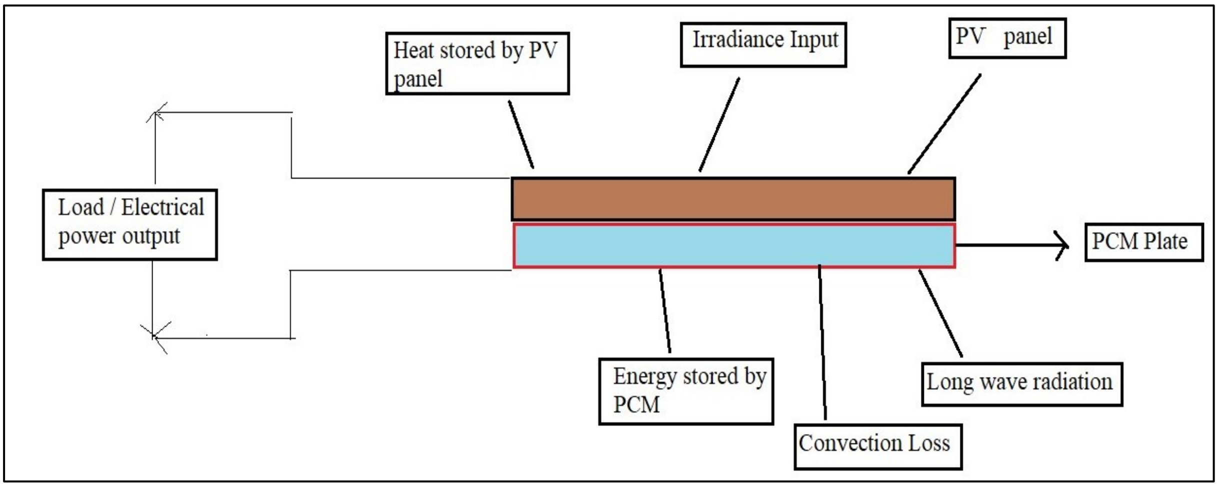


Table 1: Specifications of PV Panel

Sr. No.	Parameter	Value
1	No. of cells	70
2	Max. Power (Pmax)	216.15 W
3	V_{Pmax}	24 V
4	I_{Pmax}	8.25 A
5	V_{OC}	46.3 V
6	I_{SC}	8.84 A
7	Temperature Coeff. Of Voc	-0.16 % / °C
8	Temperature Coeff. Of Isc	0.2 % / °C

2.0 PCM Cooling Technique

Figure 2: Physical Overview of PCM Material



Due to the fact that it maintains PV panels at a constant temperature for a predetermined period of time, it is one of the best techniques for cooling solar PV cells [11]. This cooling technology makes use of a class of materials called phase change materials, which have a large heat storage capacityThe material goes through a phase transition, changing from a solid to a liquid state [12], as a result of its capacity to store heat, but the temperature of the module stays constant throughout the conversion process. Since the operational temperature of the module is now within a range of temperatures lower than the initial temperature and all other parameters are improving, a specific constant temperature is established for the module to operate at for a specific amount of time [13]. The phase-change material was an RT35 coating with a thickness of 0.02 m.

$$C_{PV}\frac{dT_{PV}}{dt} = I_{reff} - Q_R - P_E - Q_{CV} - Q_H \quad \ldots(5)$$

$$I_{reff} = \varphi * \alpha \quad \ldots(6)$$

$$Q_R = \varepsilon_P\, \sigma \left[T_{PV}^{\ 2} + T_S^{\ 2}\right]\left[T_{PV} + T_S\right] \quad \ldots.(7)$$

$$T_S = 0.037536\left[T_{amb}^{\ 1.5}\right] + 0.32\left[T_{amb}\right] \quad \ldots(8)$$

$$\frac{d\,T_{PV}}{dt} = \left\{\frac{\varphi*\alpha - \sigma\,\epsilon_P\{(T_{PV}^{\ 2} + T_S^{\ 2})(T_{PV} + T_S)\} - C_{FF}\left(\ln\frac{K_1\,\varphi}{T_{PV}}\right) - Q_H - Q_{cv}}{C_{PV}}\right\} - \frac{\text{Conduction}}{C_{PCM}} \quad \ldots(9)$$

We can see how PCM affects the cell temperature by solving the aforementioned equation (9) and using MATLAB's SIMULINK model to solve the aforementioned dynamic formulation.

3.0 Results and Discussion

Table 2: Change in temperature after application of cooling technique

Sr. No.	I_R	T_{PV} (Before Cooling)	T_{PV} (After Cooling)	P_{max} (Before Cooling)	P_{max} (After Cooling)
1	1200	27	26	211.69	211.89
2	840	72.04	59	154.20	157.76
3	840	66.51	52.97	147.85	167.98
4	820	57.45	45. 37	156.68	170.81
5	858	62	48	164.43	180.58

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Here, we can observe the temperature changes caused by cooling techniques without changing the irradiation level under the same conditions, from 68°C to 62°C and from 72°C to 56°C.

Table 3: Characteristics of Solar Unit Before Application of Strategic Cooling

Sr. No.	I_R	T_{PV}	V_{pmax}	I_{pmax}	P_{max}	V_{oc}	I_{sc}	F. F	η
1	1200	27	29.39 V	7.65 A	212.68 W	38.14 V	7.98 A	0.83	0.214
2	840	74.08	25.07 V	6.86 A	152.2 W	28.84 V	7.74 A	0.78	0.189
3	840	68.41	25.75 V	6.45 A	156.05 W	34.54 V	7.70 A	0.77	0.188
4	820	59.35	25.86 V	7.45 A	158.38 W	32.77 V	7.56 A	0.76	0.192
5	868	62	25.33 V	7.68 A	171.33 W	34.53 V	7.76 A	0.74	0.195

Table 4: Characteristics of Solar Unit After Application of Strategic Cooling

Sr. No.	I_R	T_P	V_{pmax}	I_{pmax}	P_{max}	V_{oc}	I_{sc}	F. F	η
1	1200	28	29.38 V	8.39 A	214.68 W	37.14 V	8.85 A	0.823	0.249
2	840	58	25.86 V	7.2 A	165.66 W	34.61 V	7.682 A	0.764	0.245
3	840	52.95	26.48 V	7.19 A	162.98 W	36.28 V	7.629 A	0.798	0.256
4	820	47.35	34.4 V	7.08 A	165.71 W	35.4 V	7.583 A	0.776	0.267
5	858	49	36.05 V	7.59 A	175.58 W	38.05 V	7.452 A	0.7673	0.297

The table above shows that as the temperature rises, the panel's performance declines. For instance, at 65°C, the fill factor is roughly 72 percent and the efficiency is roughly 18 percent. It is possible to raise the efficiency to about 17.5°C by controlling this degradation.

4.0 Conclusion

The open circuit voltage decreases as temperature rises. The statistics mentioned above show that this variation shows that as panel temperature rises, output voltage decreases linearly while current increases exponentially. 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. 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 Consequently, the efficiency of the photovoltaic system as a whole was increased by the use of phase change materials.

References

1. Skoplaki E, Palyvos JA (2009) On the temperature dependence of photovoltaic module electrical performance: A review of efficiency/power correlations. Sol Energy 83:614–624 . https://doi.org/10.1016/j.solener.2008.10.008

2. Tina GM, Rosa-Clot M, Rosa-Clot P, Scandura PF (2012) Optical and thermal behavior of submerged photovoltaic solar panel: SP2. Energy 39:17–26 . https://doi.org/10.1016/j.energy.2011.08.053

3. Bahaidarah H, Subhan A, Gandhidasan P, Rehman S (2013) Performance evaluation of a PV (photovoltaic) module by back surface water cooling for hot climatic conditions. Energy 59:445–453 . https://doi.org/10.1016/j.energy.2013.07.050

4. Odeh S, Behnia M (2009) Improving photovoltaic module efficiency using water cooling. Heat Transf Eng 30:499–505. https://doi.org/10.1080/01457630802529214

5. E. Radziemska (2003) The effect of temperature on the power drop in crystalline silicon solar cells. Renew Energy 28:3100723

6. Habeeb LJ, Mutasher DG, Abid F, Abd M (2018) Cooling Photovoltaic Thermal Solar Panel by Using Heat Pipe at Baghdad Climate. Int J Mech Mechatronics Eng IJMME-IJENS 17:

7. Zhou Z, Sun X, Bermel P (2016) Radiative cooling for thermophotovoltaic systems. In: Proc. of SPIE. pp 1–8

8. Thennarasu.SP, Vasanthakumar.v, Rajan.n V, Vijay.G, Manimaran.M (2018) Increasing The Efficiency of The Solar Panel Using Thermoelectric Module. IJARIIE-ISSN(O)-2395-4396 4:2207–2213

9. Salman A, Williams A, Amjad H, Bhatti MKL, Saad M (2015) Simplified Modeling of a PV Panel by using PSIM and its Comparison with Laboratory Test Results

10. Sangdot R, Patel PH, Student PG, Professor A (2016) A Review on Photovoltaic Panel Cooling Using Heat Pipe. Int J Sci Dev Res 1:573–576

11. Kalaiselvan S, Karthikeyan V, Rajesh G, Kumaran AS, Ramkiran B (2018) Solar PV Active and Passive cooling technologies – a Review. 2018 Internat2018 Int Conf Comput Power, Energy, Inf Commun (ICCPEIC)ional Conf Comput power, energy, Inf Commun 166–169 . https://doi.org/10.1109/ICCPEIC.2018.8525185

12. Deshmukh A V, Chopade CS (2017) A Review on Cooling Techniques of Photovoltaic Panel Using Thermoelectric Module and PV / T Collector. VJER-Vishwakarma J Eng Res 1:88–94

13. Zubeer SA, Mohammed HA, Ilkan M (2017) A review techniques of photovoltaic cells cooling. In: E3S Web of Conferences 22, 00205 (2017) ASEE17