A Review on Improvisation of Solar Panel Efficiency Using Distinct Cooling Techniques

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ABSTRACT: The impact of temperature rises and thermal resistance on solar panels, as well as various cooling methods for efficiency enhancement, are reviewed in this article. The production of electric power and the efficiency of solar cells decrease as the temperature rises. The kind and temperature coefficient of solar panels have an impact on temperature reduction. Panels have a temperature coefficient of -0.3 to -0.5 percent per degree Celsius. The goal of this study is to find the optimum cooling method for the solar system. In this article, a thorough evaluation of water, air, and PCM (Phase Change Material) cooling systems is conducted, and it is discovered that water cooling on both sides of the panel is more effective, with a 14.1 percent improvement in efficiency. Temperatures may be lowered by up to 20°C. Self-cleaning of panels will be aided by water cooling, which will increase panel efficiency.

KEYWORDS: Efficiency, Photovoltaic (PV) Cells, Solar Panel, PCM.

1. INTRODUCTION

The globe is now grappling with a variety of energy scarcity issues. Renewable and non-renewable energy sources may both be used to generate energy. Coal, natural gas, and petroleum are commonly utilized non-renewable resources. According to the Global Change Data Lab in Oxford, United States, global energy usage till 2016. Currently, coal is used to create the majority of energy, but coal, natural gas, and other fossil fuels are expensive, and the by-products produced have negative impacts on the environment and human life. Solar energy is a significant and readily accessible source of renewable energy on the planet. Solar energy offers a number of benefits over other resources, making it the preferred and recommended option. The sun's power reaches the planet in the amount of 1.81011MW. According to the National Renewable Energy Laboratory (NREL) in the United States, the amount of sunlight received by the globe in one hour is sufficient to satisfy the yearly energy requirements of all humans on the planet. People have begun to intelligently use solar energy for energy generation, with solar energy output doubling every twenty months since 2010, according to statistics obtained by "Bloomberg." According to the “Solar Energy Industries Association” U.S., solar installation increased by 43 percent in early 2016 [1].

The conversion efficiency of a PV cell is optimum around 10-20%, with the remainder being converted to heat [2]. Heat raises the temperature of the PV system's working temperature. The efficiency of solar cells diminishes when the temperature of the solar panel rises above working temperature, according to the study. Every PV model includes a temperature coefficient of solar cell that varies depending on the kind of solar cell. For example, when the temperature of a standard silicon solar panel reaches 25°C, the temperature coefficient drops by -0.4 to -0.5 percent per degree Celsius. As a result, cooling solar panels is critical for minimizing temperature-related losses. Cooling may be accomplished in a variety of ways. For example, water, air, and PCM. A review of several cooling methods is presented in this article [3]–[5].

1.1 Different types of solar panels are available:

Solar energy is a genuinely dependable and efficient source of electricity, but the initial installation costs are expensive. It is unquestionably advantageous in terms of produced electricity if the appropriate kind of panels is chosen in accordance with the environment. In the past ten years, the use of various kinds of solar panels has increased in businesses. By creating effective methods for turning sunlight into energy, this has aided in the generation, utilization, and storage of solar energy [6]. There are many different kinds of solar panels on the market. When it comes to solar panel choosing, sunlight is a crucial consideration.

1.2 The impact of temperature on the efficiency of solar panels and energy generation

The output of solar panels may be substantially reduced when the temperature rises. The effectiveness of solar panels decreases as the temperature rises. The output voltage of a solar panel falls linearly as the temperature rises, but the output current grows exponentially [7], [8]. The effectiveness of PV cells is usually determined by the cell type under standard test conditions (STC) (Monocrystalline silicon, thin-film amorphous silicon and polycrystalline silicon). Solar cell efficiency is often evaluated under standard test conditions (STC) with PV cell temperature of 25°C, irradiation of 1000 W/m2, and air mass, AM=1.5.

Solar panel temperature rises as it absorbs solar radiation, reducing electrical conversion efficiency; a water circulation system cools the solar panel and helps to enhance solar panel output, according to the study paper. The figures below demonstrate that around 25°C, we have the most power, and as the temperature rises, power decreases.

All of the testing was done by Quassy Hassan et al. under real-world circumstances. On their university building, they installed panels with a slope angle of 7.5 degrees from the horizontal and an azimuth degree of 20 degrees. The findings revealed that energy output decreased during hot periods, whereas energy production increased at normal temperatures. The total electrical output without temperature impact was 940 kWh for polycrystalline silicon PV modules of 1000W, whereas the electrical production with temperature effect was 921kWh. It was also discovered that rising temperatures have a detrimental effect on the efficiency of solar panels in general. According to Hamed Tavasoli et al., when the temperature of a PV panel rises, the voltage of the panel increases while the panel current drops somewhat.

1.3 Cooling Techniques Types:

1.3.1 Using Air Type PV/T Cooling Method:

In an air-type photovoltaic system, air serves as the working medium for collecting heat energy. It may flow via the channels beneath the cells or between the top of the cover plate and the cells, and it is occasionally built with dual air channels [9], [10]. When compared to water-typed PV/T systems, air-typed PV/T systems have both benefits and drawbacks. The construction of an air-typed PV/T system is very basic, and the cost is cheap. The disadvantages include the fact that the collector will operate at a high temperature and that the efficiency will be poor. Y.M. Irwan et al. evaluated maximum power of various PV panels with and without air conditioning mechanisms, as illustrated in fig.3. He discovered that by lowering the working temperature by 2 - 3°C, the air cooling system improves output power by around 6- 14 percent.

- *Natural Ventilation:*

  Natural ventilation is used to decrease the temperature of PV panels using ambient air movement. Wind and large interfacial patterns are used to achieve heat transmission. The PV cell temperature swings and very high panel temperature during peak isolation are also disadvantages of this technology. Yun et al. investigated a vented PV façade and discovered that the panel's peak temperature was 55.5°C, compared to 76.7°C for a panel without ventilation.

  - *Forced ventilation:*

  This heat-removal method involves forcing air through the front and rear of PV panels. This method requires a large quantity of fan power. Active ventilation with forced convection, according to Krauter et al., may improve electrical production by 8%.

1.3.2 Using Phase Change Material:

PCMs are materials that change phase reversibly in response to temperature. They may absorb or reject heat depending on the situation. The heat capacity of PCM is very high, and it may be used to keep the panel temperature constant. A container loaded with PCM is used to arrange PCM on the rear side of the panel. PCM is made up of aluminium cells in various forms, such as triangular and half-circular, that assist to melt the material.

Huang et al. discovered that when the solar intensity was 1000 w/m2 in the summer and the ambient temperature was 20°C, the temperature of the front panel surface could be kept constant at 36. 4°C by utilizing PCM. Biwole et al. additionally demonstrate that under continuous solar radiation of 1000w/m2, the PCM can keep PV panel temperatures below 40°C for two hours. It was also discovered that PCM is used to keep the panel temperature closer to the ambient temperature. The selection of a suitable PCM is critical in PCM cooling. S.S. Chandela, Tanya Agarwal discusses the importance of selection criteria while choosing a PCM and how to choose one based on those factors. The temperature and output power of the PV PCM system illustrated in Fig. 4 improve by 6% in certain areas, according to Smith CJ, Forster PM, Crook R.

2. DISCUSSION

To determine the optimum cooling method for solar panels, all cooling methods are thoroughly investigated. Natural ventilation in an air type PV/T cooling system may reduce temperature by up to 55.5°C, compared to

76.7°C in a panel without ventilation. Natural ventilation, on the other hand, is dependent on atmospheric conditions. It changes depending on the surrounding weather and location. Forced ventilation improves electrical production by 8%, but cooling fans use more energy and raise the overall cost of the system, which is not cost-effective. At steady radiations of 1000W/m2, Phase Change Material (PCM) maintains temperatures below 40°C for short periods of time, however PCM is costly and requires a separate setup for storing PCM material. It has a 6% increase in production efficiency. Another essential method is the use of water to cool the body. This method may be applied to the front, back, or both sides of a panel in three different ways. It increases efficiency by 10.3% on the front side and cools by 11.84 percent on the rear side. However, it works best when used on both sides, increasing efficiency by around 14.4%. Water cooling is also used to clean PV panels, which increases efficiency even further.

3. CONCLUSION

The effectiveness of a solar panel is greatly affected by its temperature. When the temperature of a solar cell exceeds its specified working temperature, its efficiency drops. This study found that by reducing the temperature from 54°C (non-cooled) to 24°C and utilizing water cooling on both sides of the panel, efficiency may be improved by approximately 14.1 percent (Cooled). This method outperforms all others since it improves efficiency while also allowing for self-panel cleaning without the need for additional setup.

REFERENCES:

[1] B. Koteswararao, K. Radha Krishna, P. Vijay, and N. Raja Surya, “Experimental Analysis of solar panel efficiency with different modes of cooling,” *Int. J. Eng. Technol.*, 2016.

[2] R. Arshad, S. Tariq, M. U. Niaz, and M. Jamil, “Improvement in solar panel efficiency using solar concentration by simple mirrors and by cooling,” 2014. doi: 10.1109/iCREATE.2014.6828382.

[3] A. Sahay, V. K. Sethi, A. C. Tiwari, and M. Pandey, “A review of solar photovoltaic panel cooling systems with special reference to Ground coupled central panel cooling system (GC-CPCS),” *Renewable and Sustainable Energy Reviews*. 2015. doi: 10.1016/j.rser.2014.10.009.

[4] X. Tang, Z. Quan, and Y. Zhao, “Experimental Investigation of Solar Panel Cooling by a Novel Micro Heat Pipe Array,” *Energy Power Eng.*, 2010, doi: 10.4236/epe.2010.23025.

[5] M. M. Musthafa, “Enhancing Photoelectric Conversion Efficiency of Solar Panel by Water Cooling Fundamentals of Renewable Energy and Applications,” *J. Fundam. Renew. Energy Appl.*, 2015.

[6] M. E. Flowers, M. K. Smith, A. W. Parsekian, D. S. Boyuk, J. K. McGrath, and L. Yates, “Climate impacts on the cost of solar energy,” *Energy Policy*, 2016, doi: 10.1016/j.enpol.2016.04.018.

[7] A. R. Amelia, Y. M. Irwan, W. Z. Leow, M. Irwanto, I. Safwati, and M. Zhafarina, “Investigation of the effect temperature on photovoltaic (PV) panel output performance,” *Int. J. Adv. Sci. Eng. Inf. Technol.*, 2016, doi: 10.18517/ijaseit.6.5.938.

[8] M. Saidan, A. G. Albaali, E. Alasis, and J. K. Kaldellis, “Experimental study on the effect of dust deposition on solar photovoltaic panels in desert environment,” *Renew. Energy*, 2016, doi: 10.1016/j.renene.2016.02.031.

[9] X. Li, J. Niu, and N. Gao, “Co-occupant’s exposure to exhaled pollutants with two types of personalized ventilation strategies under mixing and displacement ventilation systems,” *Indoor Air*, 2013, doi: 10.1111/ina.12005.

[10] J. H. Kim, J. G. Ahn, and J. T. Kim, “Demonstration of the performance of an air-type photovoltaic thermal (PVT) system coupled with a heat-recovery ventilator,” *Energies*, 2016, doi: 10.3390/en9090728.