Volume 2, Issue 12, December 2024 ISSN (E): 2938-3757

Web of Technology: Multidimensional Research Journal
webofjournals.com/index.php/4

ANALYSIS OF SOLAR PANEL COOLING METHODS FOR IMPROVING EFFICIENCY USING GENETIC ALGORITHMS

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Abstract

Solar energy is one of the renewable energy sources, with advantages such as environmental cleanliness and unlimited resources. However, the efficiency of solar panels depends on various factors, including the increase in their temperature. As the temperature rises, the electricity produced by the panels can decrease. Therefore, solar panel cooling systems play an important role in enhancing their efficiency. This paper discusses various methods of cooling solar panels, their advantages and disadvantages. Currently, solar energy is widely used as one of the most environmentally friendly and renewable energy sources. However, the efficiency of solar panels decreases with increasing temperature, as the increase in temperature reduces the electricity generated by the panels. This article provides a detailed analysis of methods for cooling solar panels, the possibilities of increasing their efficiency, and the calculation of water usage.

Keywords: Solar Panels, Cooling System, Closed-Loop Cooling, Evaporative Cooling.

Introduction

Solar energy technologies have become one of the main directions for sustainable energy production worldwide. However, to increase the efficiency of solar panels, their temperature needs to be controlled. During summer months, when ambient temperatures are high, the efficiency of solar panels decreases. Therefore, cooling systems are used to improve the efficiency of solar panel systems. In this paper, we attempt to calculate the amount of water required to reduce the temperature of a 100 MWt*hour solar panel system from 45°C to 35°C through a cooling system.

Solar Panel Temperature Dependence:

Solar panels use semiconductor materials to convert sunlight into electricity. However, as the temperature rises, the efficiency of the solar panels decreases. Typically, for every 1°C increase in temperature, efficiency decreases by 0.3% to 0.5%. For example, if the panel temperature rises from 25°C to 45°C, the efficiency may decrease by 5-10%.

Solar Panel Cooling Methods:

Air Cooling (Passive Cooling): Air cooling is the simplest and most cost-effective method. In this method, panels are installed above the ground to allow air flow beneath them. Additionally, aluminum plates or radiator tiles may be installed on the backside of the panels to disperse heat.
Advantages: Cost-effective and simple, no additional energy is required.
Disadvantages: Ineffective cooling, especially in high temperatures.

Water Cooling (Active Cooling): Water cooling systems work by circulating water underneath the solar panels to carry away heat. This method can be powered by pumps or gravity.
Advantages: High efficiency, especially in hot climates.
Disadvantages: Expensive installation and maintenance, requires access to water sources.

Evaporative Cooling: In this method, water is sprayed onto the panel surface, or special damp fabrics are placed on the panels. The water evaporates and cools the panels.
Advantages: Provides effective cooling, particularly in dry climates.
Disadvantages: High water consumption, less effective in humid climates.

Nanofluid Cooling: Nanofluids are liquids enriched with metal or carbon nanoparticles that have high heat capacity and thermal conductivity. They provide high efficiency in cooling the panels.
Advantages: One of the most efficient cooling systems, quickly removes heat.
Disadvantages: High cost, requires specialized technology and equipment.

Comparison of Cooling Systems:

The paper compares these cooling methods based on their efficiency, costs, and practical applications. It also discusses the potential for combining these methods with emerging technologies to further optimize performance.

Future Trends:

With the development of technologies, solar panel cooling systems are becoming more efficient and cost-effective. Heat exchangers, phase change materials (PCM), and AI-optimized systems are expected to be more widely used in the future.

- Phase Change Materials (PCM): These materials absorb heat and release it later, helping to maintain the temperature of the panels.
- Artificial Intelligence Systems: Using IoT technologies, cooling systems can be managed in real time, automatically triggering water spraying or fan activation under specific conditions.

System Description:

Key parameters of the solar panel system:

- System capacity: 100 MWt*hour
- Panel size: 2.1 m x 1.11 m
- Panel temperature: needs to be reduced from 45°C to 35°C
- Water cooling system: Closed-loop water cooling

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- Summer temperature: ranges from 42°C to 49°C

For calculations, we assume each panel generates 0.5 kWh/hour. The efficiency of the solar panels is approximately 20%.

Panel Surface Area and Panel Quantity Calculation:

The area of one panel:

$$S=2.1m\times1.11m=2.331m^2$$

The daily energy produced by each panel:

$E_{panel} = 5\ kWh/m^2 \times 2.331\ m^2 \times 0.20 = 2.332\ kWh$

If each panel generates 0.5 kWh/hour, then for a 100 MWt*hour system, 200,000 panels are required. This calculation is based on the methodology derived from these figures.

Water Circulation in the Cooling System:

To reduce the temperature from 45°C to 35°C, we need to calculate how much water evaporates for each panel.

The energy produced by each panel daily is 2.332 kWh. Using this energy, we calculate the heat removed via evaporation with the following formula:

$$Q=2.332kWh\times3,600,000J/kWh=8,391,000J$$

Using the latent heat of water $L = 2.26 \times 10^6$ J/kg, we calculate the mass of water required:

$$m=Q/L=8,391,000J/2.26\times10^6J/kg\approx3.71kg$$

Therefore, 3.71 kg of water is needed to cool each panel.

Water Consumption for All Panels:

For 200,000 panels, the total daily water consumption is:

Total water consumption =3.71kg×200,000panels=742,000kg or 742 m^3

Since the density of water is 1 kg/liter, the total water required is 742,000 liters.

Evaporation of Water:

If daily water consumption is 742,000 liters, the total water consumption for 90 summer days is:

Monthly water consumption = 742,000 liters × 90 days = 66,780,000 liters or 66,780 m^3

Thus, 66,780 m^3 of water will be consumed during the summer months. This value is calculated based on evaporation rates and methods for improving energy production efficiency.

Conclusion

Based on these calculations, the cooling system plays a crucial role in efficiently utilizing solar energy. For a 100 MWt*hour solar panel system, 200,000 panels are required, with a daily water consumption of 742 m^3. Over 90 summer days, the total water consumption will be 66,780 m^3. Therefore, efficient management and recycling of water are critical to improving the system's efficiency.

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Presented by Tashkent State Technical Universitety and "Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University.

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