

Review of different types of solar cooling system for photovoltaic panel

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Abstract

Photovoltaic panels generate electrical energy from sunlight, but they lose efficiency as the temperature exceeds 25°C (STC). For each degree Celsius rise, they may lose efficiency by 0.4-0.5%. This paper reviews various solar cooling technologies used in photovoltaic panels, their models, impacts of temperature on them, and efficiency increases according to some studies done recently. The main purpose of this paper is to compile information that could be used to develop extensive research on solar cooling technologies for photovoltaic panels. Passive cooling does not use any additional energy and is economical and straightforward to deploy. Some examples are radiative cooling by using special paint that dissipates heat into space, evaporative cooling by using water evaporation (effective in arid areas), natural convection cooling using fin-based or heat sink-based systems, and phase change material (PCM), which absorbs and releases heat to maintain temperature control. However, passive cooling technologies have fewer cooling capabilities under extremely high temperatures. The active cooling system works with the help of pumps or fans to improve the cooling process. The water-based PV/T (hybrid cooling) system utilizes the flow of water behind or at the back side of the panel in order to generate both electrical and hot water. This approach may lead to electrical efficiency of up to 10-20% and thermal efficiency of up to 50-60%. Moreover, there are other active cooling methods including forced air flow, spraying/jetting impingement and nanoparticle-based fluid cooling (nanofluid, Al₂O₃ or CuO). The hybrid and advanced cooling systems include thermoelectric, floating PV panels, microchannel or heat pipe methods. Higher temperatures cause lower voltage and power output of the PV modules. Several studies show that effective cooling helps to decrease the panel's temperature of 10-49°C, resulting in increasing electrical efficiency of 5-47%. Hybrid PV/T systems are widely used due to generating both electricity and heat with efficiency being more than 60%.

Modeling of the system is typically carried out via application of energy balance equation, CFD analysis or with TRNSYS or MATLAB software programs. Important parameters are solar radiation, ambient temperature, flow rate and material properties. The cooling techniques can significantly improve the efficiency and life of solar PV panels. The passive cooling technique is appropriate for cheap cases whereas the active and hybrid types have higher efficiency. Further studies for obtaining low cost, durability, and efficiency in different climatic regions is also conducted.

Keywords: photovoltaic panels; solar cooling systems; passive cooling; active cooling; electrical efficiency.

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