Performance and Economic Feasibility of Hybrid Photovoltaic/Thermal/Phase Change Materials and Dusty Panel System: A Comparative Study

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Abstract:

Using PCMs in photovoltaic/Thermal (PV/T) systems effectively enhances solar system performance by lowering the temperature of photovoltaic (PV) cells, which improves their efficiency and helps manage heat. This study compared two studies on the variations of PV/T/based phase change materials (PCM) integration. The study focuses on a two-sided serpentine flow PV/T/PCM system, reporting a maximum electrical efficiency of 17.52% and a thermal efficiency of 79.93%. The research examines the performance of a similar system under dusty conditions, where the PV/T/PCM with a dusty system achieved an electrical efficiency of 14.83% and a thermal efficiency of 73%. Both analyses indicate a key role for PCM in improving performance, although dust load diminishes it. An economic study found that, despite the initial high setup costs of the PV/T/PCM system, it is financially viable, as it significantly reduces operating costs over time, especially in tropical countries like Malaysia. These findings suggest that the PV/T/PCM system holds promise for sustainable energy generation in regions with high solar intensity, such as Malaysia. The performance under both normal and dusty conditions indicates its potential to be a reliable source of clean energy. Furthermore, the economic feasibility of the system makes it an attractive option for countries looking to lower their carbon footprint and

energy costs in the long term. With further research and development, the PV/T/PCM system could become a key player in renewable energy solutions worldwide.

Keywords:
Photovoltaic-thermal (PV/T) systems, phase change materials (PCMs), thermal absorber, dust mitigation, economic viability.