Hybrid Photovoltaic/Thermal System: Thermal Energy Storage Integrated with Self-Cleaning System: Comparative Investigation and Comprehensive Performance Analysis

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Abstract:

Photovoltaic/thermal (PV/T) hybrids have received significant attention worldwide due to the growing interest in integrated hybrid transformation technologies. This study critically compares three innovative PV/T configurations: parallel serpentine-flow PV/T (P-S-PV/T), a PV/T system utilizing phase change material (PCM)-based thermal energy storage (TES), and a self-cleaning (SC)-assisted PV/T with PCM. The performance indicators of the various components are evaluated using a thermodynamic approach grounded in energy and exergy analysis under diverse climatic conditions. The PV/T-PCM-SC system demonstrated superior performance, achieving electrical and thermal efficiencies of 11.91% and 77.60%, more than 20.4% and 3.8% higher than the PV/T serpentine baseline system. Exergy analysis indicated low-efficiency levels, with an overall exergy efficiency of 15.60% for the system integration, which is favorable concerning high-quality energy utilization. The paper offers a comprehensive list of design variables for optimizing the performance of hybrid PV/T systems regarding thermal regulation and dust removal techniques.

Keywords:

PV/T hybrid system, Phase change material, Thermal energy storage, self-cleaning, energy, exergy.