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Energy, exergy and environmental analysis of glazed and unglazed PVT system integrated with phase change material: An experimental approach

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Highlights

- Three different systems of PV unit, glazed and unglazed PVT/PCM are fabricated.
- Freezing problem of coolant in cold areas is solved by using mixtures of EG and pure water.
- Glazed PVT/PCM with EG 50% is more suitable for cold climate conditions.
- From environmental viewpoint, PVT/PCM with pure water has the highest CO_2 mitigation.

Abstract

In the current study, the effects of using a mixture of pure water and ethylene glycol (EG) with a mass ratio of 50% on the performance of glazed and unglazed photovoltaic thermal systems (PVTs) integrated with a PCM layer (PVT/PCM) are investigated. The studied coolant fluids are pure water, pure EG (EG 100%), and a mixture of pure water and pure EG with a mass ratio of 50% (EG 50%). The outdoor experimental tests are performed at Mashhad, Iran on sunny days in August, and a thermodynamic study including energy and exergy analysis is carried out to assess the efficiencies of two PVT/PCM systems. The results show, although the thermal energy efficiency of PVTs is decreased by mixing EG and pure water, the thermal exergy efficiency is enhanced. In addition, both overall energy and exergy efficiencies of the PVT/PCM system reduce when EG is added as an impurity to the pure water. The results also indicate that the percentage of the energy losses decreases in glazed cases of water-based PVT/water, PVT/EG (50%), and PVT/EG (100%) by 9.28%, 23.33%, and 48.58%, respectively compared to the unglazed systems. In addition, environmental investigation indicates that, compared to the PV unit, using a PVT system significantly benefits CO_2 mitigation from both thermodynamic approaches. Finally, the water/EG mixture introduces as an appropriate coolant fluid due to lower freezing point and higher overall energy and exergy with respect to pure EG and suggested for cold climate conditions.

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Keywords

Energy, Exergy and environmental analysis; Thermodynamics; Photovoltaic thermal systems; Glazed and unglazed; Phase change materials