

# Integration of emerging PCMs and nano-enhanced PCMs with different solar water heating systems for sustainable energy future: A systematic review

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## ABSTRACT

Solar water heaters (SWHs) are primarily used to generate hot water to meet daily needs in domestic and industrial applications. Due to its technical and economic practicality, solar water heating has been widely exploited for use of solar energy. However, the inconsistent availability of solar radiation and lack of energy storage facilities restrict its utilization. Thermal energy storage materials (Phase change materials and nano-enhanced phase change materials) are key solutions for effectively harvesting thermal energy from solar radiation. Integrating phase-change materials (PCMs) and nano-enhanced phase-change materials (NE-PCMs) with SWHs overcome the constraint of only being used during the daytime and making them more efficient. The main aim of this systematic review article is to summarize and highlights the key results of recent studies on SWHs integrated with PCMs and NE-PCMs for domestic and industrial water heating applications. This study also highlights the technical issues associated with SWH systems. In addition, the perspectives, recommendations, and future improvements of the SWH systems integrated with PCMs and NE-PCMs are explored to overcome the technical barriers to their practical use. In conclusion, the thermal performance of SWHs with the help of PCMs and NE-PCMs increased significantly, and the cost of the system was reduced, resulting in a shorter payback period compared to conventional SWHs. Also, there is a considerable reduction in CO<sub>2</sub> emissions from an environmental perspective. It is intended that this study will provide new insights to the researchers to design and develop highly efficient SWH systems.

## KEYWORDS

Evacuated tube collectors; Flat plat collectors; PCMs and NE-PCMs; Photovoltaic/thermal collectors; Solar water heaters (SWHs)

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