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Phase change materials and nano-enhanced phase change materials for thermal energy storage in photovoltaic thermal systems: A futuristic approach and its technical challenges

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ABSTRACT

In recent years, photovoltaic thermal (PVT) systems have emerged as an imperative research area due to the escalating demand for energy worldwide. Phase change materials (PCMs) considered as the most suitable materials to harvest thermal energy effectively from renewable energy sources. As such, this paper reviews and explains the various aspects of PCM and Nano-Enhanced PCM (NEPCM) integrated PVT systems. The novel and recent developments in PVT research focusing on cooling and thermal energy storage with PCM and NEPCM and their applications in the heating ventilation and air-conditioning (HVAC), building integrated photovoltaic thermal systems (BIPVT), building integrated concentrated photovoltaic thermal systems (BICPVT) are critically summarized. In addition, this review also accentuates the different methods of preparing NEPCM and their thermo-physical properties at different operating temperatures for targeted applications. The present paper also highlights the use of nanofluid, PCM, and NEPCM in extracting the thermal energy from the commercially available for PVT system. In conclusion, this review recapitulates the effort taken by researchers around the world in enhancing the thermal performance system. It is also expected this review will provide greater insight to the new researchers in recognizing the fundamental science behind the development of thermal performance system and the mechanism to enhance further the overall performance of the PVT system.

1. Introduction

The steep growth of the human population and technological development has increased the demand for energy hastily. The overproduction of the energy to meet the market has resulted in the depletion of fossil fuel (prime source of energy generation). Congruently, human activities related to energy production and use have resulted in environmental issues triggering changes in climate conditions (melting of ice in the south and north poles), ozone depletion, and global warming. These environmental issues can be minimized by using renewable energy resources such as bioenergy, solar energy, and geothermal energy [1]. Amidst the different clean energy resources, the most favorable is solar energy. Due to its affluence, pollution-free, and is freely available makes it viable for agricultural, residential, and commercial utilization [2]. Although solar photovoltaics acquires high initial capital, this technology is recognized worldwide and entails lower operating and maintenance cost [3]. The International Energy Agency (IEA), in their published work in 2014 [4], estimated that photovoltaics would account for sixteen percent of total energy production by 2050. At the end of 2019, the global accumulative installed photovoltaic capacity had touched 653GW, and by 2050, the international energy agency expects solar photovoltaics to reach 4.674 TW (4674 GW). Fig. 1 illustrated the significant growth of the use of photovoltaic between 2004 and 2019. From the renewable resource scenario, half of the solar power is produced in China and India, making them the largest solar power producers in the world [5,6].

The solar energy is transmuted into electrical power through photovoltaic (PV) panels. About 7–20% of solar irradiation is transmuted into electricity, whereas the rest of the energy is absorbed or

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