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Integration of Icf Walls as Diurnal Solar Thermal Storage with Microchannel Solar Assisted Heat Pump for Space Heating and Domestic Hot Water Production

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Abstract : In Canada, more than 32% of the total energy demand is related to the building sector. Therefore, there is a great opportunity for Greenhouse Gases (GHG) reduction by integrating solar collectors to provide building heating load and domestic hot water (DHW). Despite the cold winter weather, Canada has a good number of sunny and clear days that can be considered for diurnal solar thermal energy storage. Due to the energy mismatch between building heating load and solar irradiation availability, relatively big storage tanks are usually needed to store solar thermal energy during the daytime and then use it at night. On the other hand, water tanks occupy huge space, especially in big cities, space is relatively expensive. This project investigates the possibility of using a specific building construction material (ICF – Insulated Concrete Form) as diurnal solar thermal energy storage that is integrated with a heat pump and microchannel solar thermal collector (MCST). Not much literature has studied the application of building pre-existing walls as active solar thermal energy storage as a feasible and industrialized solution for the solar thermal mismatch. By using ICF walls that are integrated into the building envelope, instead of big storage tanks, excess solar energy can be stored in the concrete of the ICF wall that consists of EPS insulation layers on both sides to store the thermal energy. In this study, two solar-based systems are designed and simulated inTransient Systems Simulation Program(TRNSYS)to compare ICF wall thermal storage benefits over the system without ICF walls. In this study, the heating load and DHW of a Canadian single-family house located in London, Ontario, are provided by solar-based systems. The proposed system integrates the MCST collector, a water-to-water HP, a preheat tank, the main tank, fan coils (to deliver the building heating load), and ICF walls. During the day, excess solar energy is stored in the ICF walls (charging cycle). Thermal energy can be restored from the ICF walls when the preheat tank temperature drops below the ICF wall (discharging process) to increase the COP of the heat pump. The evaporator of the heat pump is taking is coupled with the preheat tank. The provided warm water by the heat pump is stored in the second tank. Fan coil units are in contact with the tank to provide a building heating load. DHW is also delivered is provided from the main tank. It is investigated that the system with ICF walls with an average solar fraction of 82%- 88% can cover the whole heating demand+DHW of nine months and has a 10-15% higher average solar fraction than the system without ICF walls. Sensitivity analysis for different parameters influencing the solar fraction is discussed in detail.

Keywords : net-zero building, renewable energy, solar thermal storage, microchannel solar thermal collector
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