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Abstract:

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Thermodynamic Evaluation of Supercooled Seasonal Heat Storage at the Drake Landing Solar Community

This study evaluates the simulated performance of a supercooled sodium acetate trihydrate (SAT), $NaCH_3CO_2{\cdot}3H_2O$, long-term heat storage system (LTHSS) under the same conditions as the borehole thermal energy storage system (BTES) at the Drake Landing Solar Community (DLSC) in Okotoks, Alberta, Canada, based on performance reports from July 2007 to June 2013. DLSC is a housing development composed of 52 NRCan R-2000 certified high-efficiency single-family homes, serviced by a total of 2,293 m^2 of flat plate solar-thermal collectors mounted on the rooftops of each home's detached garage. The district heating system stores solar heat from the flat plate collectors into 240 m^3 of above-ground water storage for short-term use and 34,000 m^3 of earth in the BTES for long-term heat storage. A gas boiler supplies supplemental heat whenever the solar heating and storage supplies fail to meet the district heating load.

The purpose of the present study was to evaluate the potential for integrating advanced phase change materials (PCMs, e.g., supercooled SAT) in seasonal heat storage applications, such as at DLSC. The final system was designed to store up to 1,460 GJ of excess summer heat for later use in the winter and operates with a minimum 63.8 % seasonal heat storage efficiency that is independent of storage duration and exceeds the long-term BTES heat storage efficiency at DLSC for all reported seasons (≤ 54 %). This study determined that seasonal heat storage performance at DLSC could improve considerably by replacing the BTES with a modular, supercooling SAT seasonal heat storage system. Modular thermal masses give the proposed system far greater performance in the first season (87 % solar heating fraction vs. 55 % measured at DLSC) and the proposed system can achieve 100 % solar heating fractions for three of the six years studied, for which the BTES only realized a cumulative solar fraction of 91 % (also 94 % vs. 78 % respective six-year cumulative solar fractions). Lastly, with the improved net heat storage density of the supercooled SAT PCM (220 kJ/L PCM-only; 176 kJ/L for the system) over that of sensible heating in the BTES (< 75 kJ/L), the PCM system would require only 24 % (indoors) of the total heat storage volume at DLSC.