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COMBINED SHORT- AND LONG-TERM HEAT STORAGE WITH SODIUM ACETATE TRIHYDRATE FOR SOLAR HEAT SUPPLY IN BUILDINGS

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SUMMARY
Because of its ability to preserve latent heat of fusion at room temperature in supercooled state, the phase change material (PCM) sodium acetate trihydrate (SAT) can be utilized for combined short and long-term heat storage in buildings. This was experimentally proved with a novel solar combisystem demonstrator including a segmented heat storage prototype, consisting of 4 flat units containing 200 kg of SAT composites each. A numerical model of the demonstrator was developed in TRNSYS environment. Ongoing system simulation indicates potential for more efficient domestic hot water and space heating supply. Further, based on experience with flat units, an inexpensive, cylindrical heat storage unit of the same PCM volume as one flat unit was designed and tested. Results showed that 27 kWh of heat can be stored. After cooling to room temperature, 11 kWh (long-term storage potential) were discharged during SAT composite solidification.

HEAT STORAGE WITH STABLE SUPERCOOLING OF SAT
SAT has a melting point of 58°C and a latent heat of fusion of 264 kJ/kg (Zalba et al., 2003). It was identified as suitable phase change material for heat storage in households for space heating and domestic hot water supply. After melting above 78°C (Araki et al., 1995) SAT can cool down to the ambient temperature without solidifying and remain stable in supercooled state. The solidification can be initiated and the heat of fusion released later when heat is in demand. This concept was successfully applied to flat prototype heat storage units (Dannemand et al., 2016). Additives are used to prevent phase separation when SAT is supercooled below its melting temperature. Kong et al. (2016) investigated different stabilizers and concluded that SAT composites with HD 310, a liquid polymer prototype solution, had high heat of fusion after supercooling periods.

NOVEL SOLAR COMBISYSTEM DEMONSTRATOR
Englmair et al. (2018) reported the design and the functionality of a solar heating system with 22.4 m^2 solar collectors, a heat storage prototype consisting of four 200 kg PCM storage units and a 735 L water tank (Fig. 1). It was built (part of the former EU-COMTES project) in a prototype test facility at Technical University of Denmark to apply domestic hot water and space heating demand patterns of a Passive House in Danish climate.

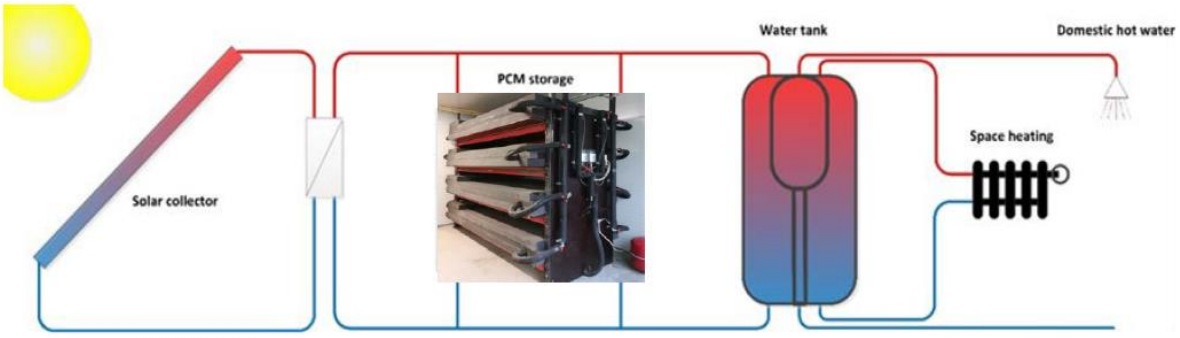

Fig. 1: Diagram of the demonstrator system layout

Fluctuating heat transfer rates from the solar collectors peaked at 16 kW. An automated sequence for combined operation of the water tank and a variable number of PCM units were set by a LabView control system. Fast charge of a single PCM unit (250 minutes) was possible.

During discharge heat transfer rates reached 4 kW. TRNSYS types of the segmented PCM storage, the water tank and of the system controller were developed and validated. Preliminary results on system simulation showed higher solar fractions of building heat supply with more than 4 PCM units.

TESTING OF ECONOMIC HEAT STORAGE UNITS

A cylindrical heat storage prototype based on standard components of water heat stores (Fig. 2a) was designed as a more economic storage unit. It was manufactured by the Danish company NILAN A/S and contained 200 kg of SAT composite and 70 L of water. Performance evaluation of a test sequence is presented in Fig. 2b:

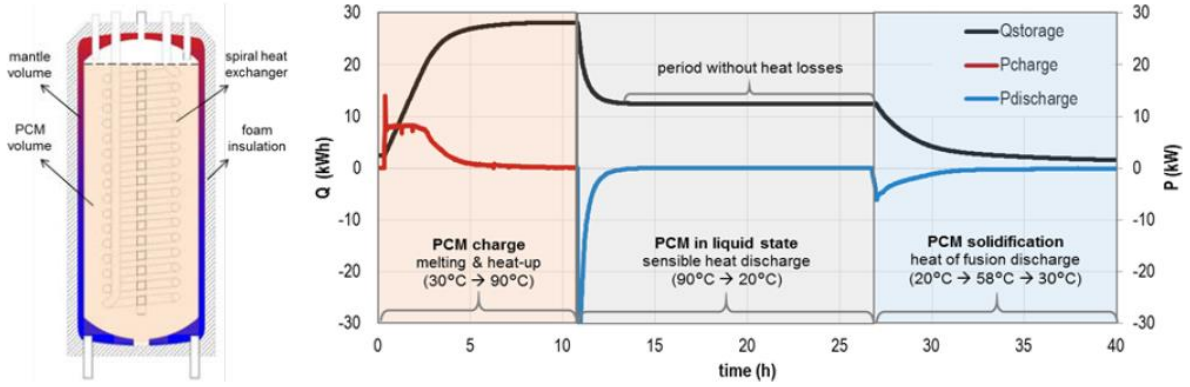

Fig. 2: a) Diagram of cylindrical heat storage; b) Development of heat transfer rates and heat content during test.

During 10 hours charge from initially solid PCM state 27 kWh of heat were stored. Then it was discharged and the storage cooled down to ambient temperature within 2 hours. After a heat-loss-free storage period, 11 kWh (long-term storage potential) were discharged during SAT composite solidification.

CONCLUSIONS

The heat storage concept of utilizing stable supercooling of SAT for combined short- and long-term heat storage was proved in system scale. A storage unit with inexpensive industrial components showed a significantly higher effective storage capacity than water stores of the same volume. In general, storage units containing melted PCM worked like water vessels in the temperature span from 20 to 90°C with the additional feature to bridge energy supply gaps over weeks or months. This potentially enables more efficient solar heating or heat pump applications in domestic buildings. TRNSYS simulation of the novel solar combisystem will elucidate its potential for more efficient solar heat supply of a Passive House in Danish climate.

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