Thermochemical heat storage: system integration for building heating

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The word energy demand continuously grows with the world's population and global technology progress increasing. The proportion of renewable energies remains at a persistently low level and consequently, the use of fossil fuels increases, with obvious consequences for environment (fossil fuel reserves depletion, greenhouse gas emission, global warning, pollution for crude oil, coal or nuclear fuel extraction and transformation). Concurrently, the energy costs increase causes supply difficulties. One of the alternatives to fossil fuels is renewable energy (solar, wind, hydroelectric, biomass, ...). The central problem of these energy sources is the intermittent heat and power supply and the seasonal supply demand imbalance. Indeed, in our temperate countries, the solar gain is the greatest during summer, while the energy needs are the highest in winter (for domestic heating, for example). To overcome these issues, energy storage systems can be applied in particular to solve the mismatch between energy needs and supply. If the storage systems for electrical energy are today efficient and well-developed, heat storage systems still need to be improved. Among the heat storage systems, the thermochemical heat storage emerges for its efficiency, especially for low-grade heat supply for domestic heating purpose. It is based on a reaction between two materials (salt / water, zeolite /water, …) to release the stored heat when required. When solar gains are sufficient, the solar heat is used to separate the two materials, generally by a dehydration reaction (storage). Theheat can be then stored at ambient temperature without energy loss (E. Sculler *et al.*, 2022).

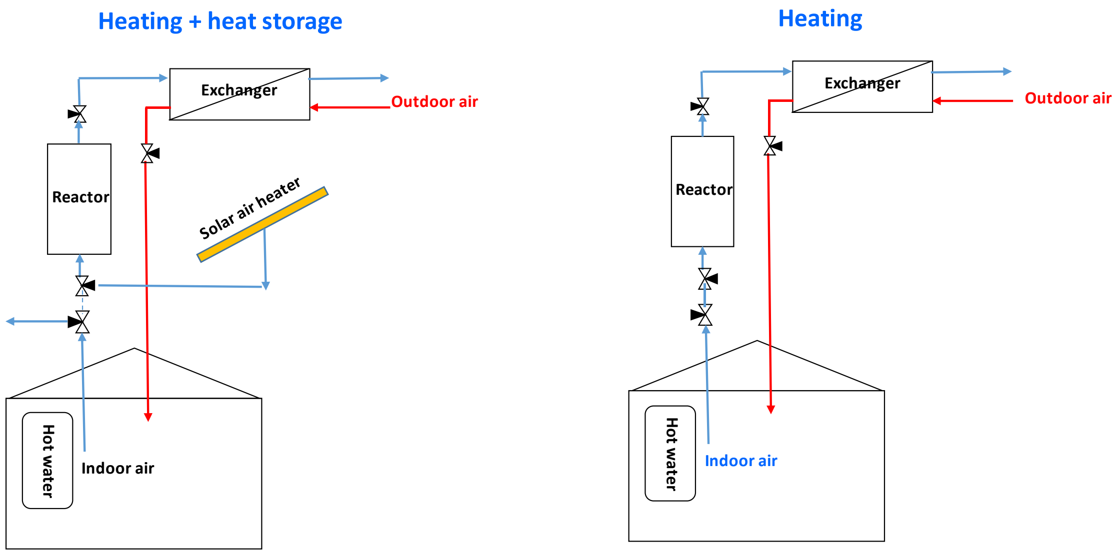

Figure 1: system operation for domestic heating, a) heating and heat storage, b) heat released for home heating

Figure 1 shows a possible implementation of the system in a single house heating system and the operating phases of heat storage (a) and heat release (b). The ventilation system is used as water and heat carrier. First, when the climatic conditions are favourable (a), the dry air heated by the solar heater go through the storage reactor in order to dehydrate the material and exchanges heat with the fresh air coming from outside for heating the building.
When heat is needed (cool and cloudy weather, figure 1b), stale indoor air (humid) is drawn in by the ventilation, go through the reactor and warm the fresh inlet air.
The main challenge is to estimate the necessary indoor air mass flow rate, the amount of storage material, the percolation rate in the reactor for having the desired temperature, the power, the duration and the delay to release heat. For this, a numerical modelling was developed to simulate different scenarii of heat release. Indeed, the heat

and mass transfer are investigated in the reactor by solving differential mass balance (air and water) and heat balance (air and solid material) equations. A one-dimensional unsteady modelling was developed and used to optimize the operating system parameters.

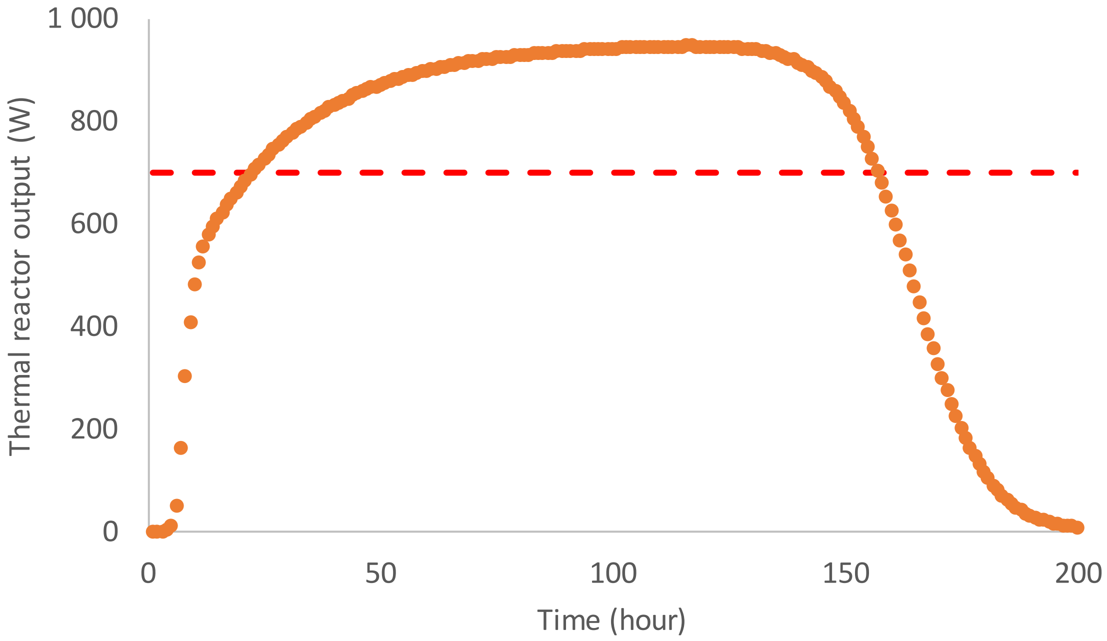

Figure 2: heat released function of time

Figure 2 shows the heat power released versus operating time for a reactor (ϕ = 1m, L = 1,7m) containing 1000 kg of zeolite 13X. The simulation is conducted for a passive house (100 m²) that requires less than 15 kWh/year/m² (corresponding to an average thermal power of 700 W) for heating. The inlet humid air (T = 20 °C, H = 50%) is mechanically extracted (100 m^3/h) and it is used as water carrier. The results show that the system can provide the required thermal power for heating up a single house during 6 days. The start-up time is of about 4 hours and after 8 hours 80% of heat is provided.

The outlet air temperature is about 48°C during steady operation, allowing the heating-up via the cross-flow exchanger of fresh air at a suitable temperature.