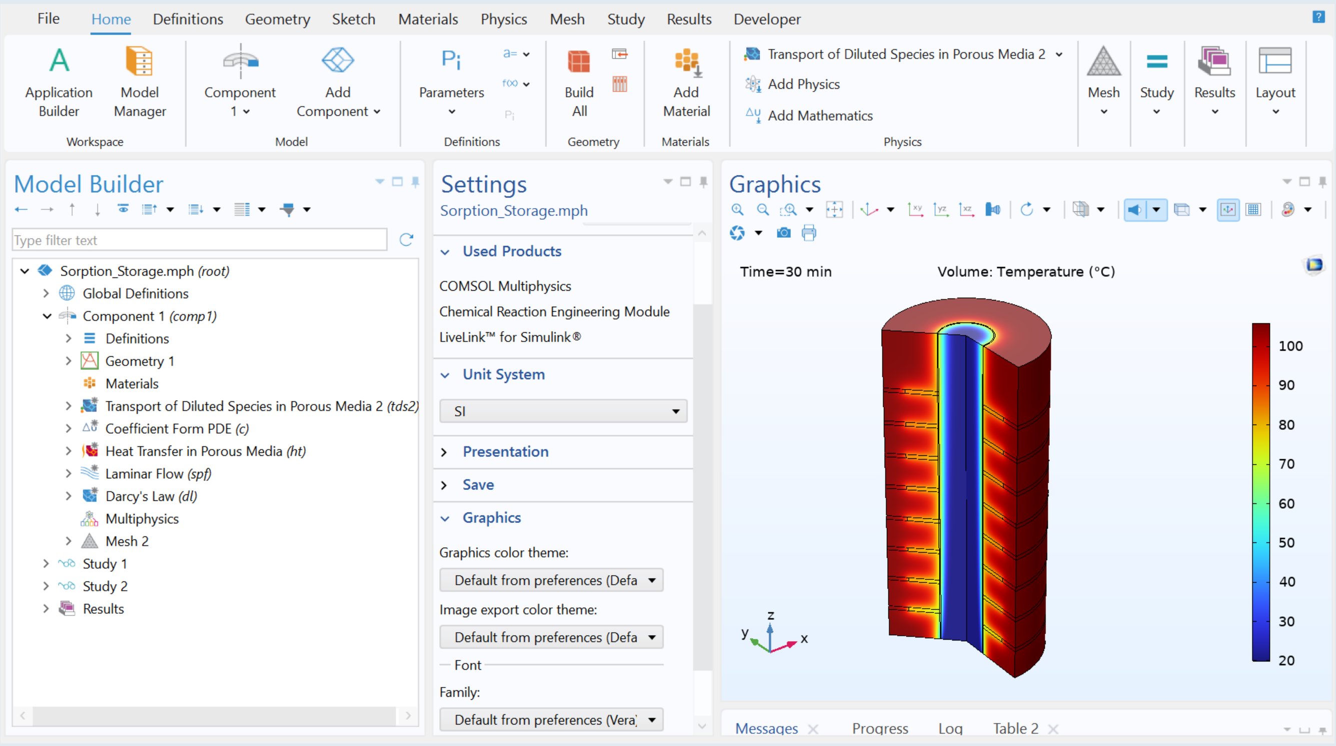

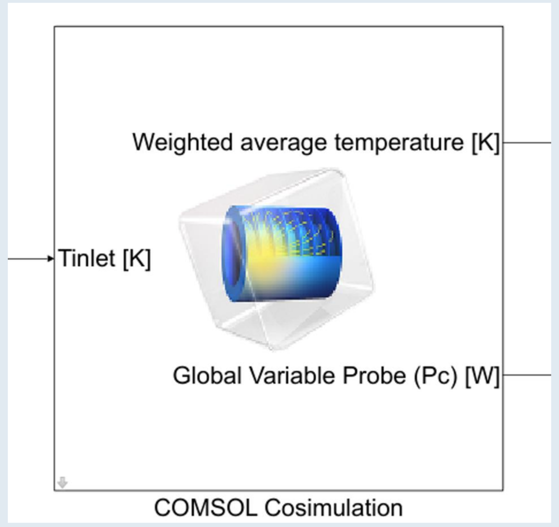

COMSOL®/Simulink-Coupling for Optimization of Sorption Heat Storage in Residential Buildings

Quantify seasonal performance of sorption storage by linking reactor-level CFD with building-scale control and demand profiles and demand profiles.

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Abstract

Sorption heat storage can raise the renewable heat share in buildings, but is hard to assess under realistic, time-varying operation. This study evaluates a closed zeolite–water reactor integrated into a residential energy system using a co-simulation framework that links a high-resolution reactor model to a whole-building model. The setup enables dynamic testing of operating strategies, solar availability, and heating demand without sacrificing reactor-scale fidelity. Results show stable coupling and credible seasonal behavior; the storage reduces auxiliary heating demand during cold periods and exploits high-temperature solar windows for charging, indicating improved utilization of renewable heat. Sensitivity analyses highlight the importance of flow control and temperature thresholds for avoiding thermal stress while maintaining output temperature suitable for radiator circuits. Overall, the framework provides a practical path to design and control optimization of sorption storage in buildings and supports scenario studies across climates and load profiles.

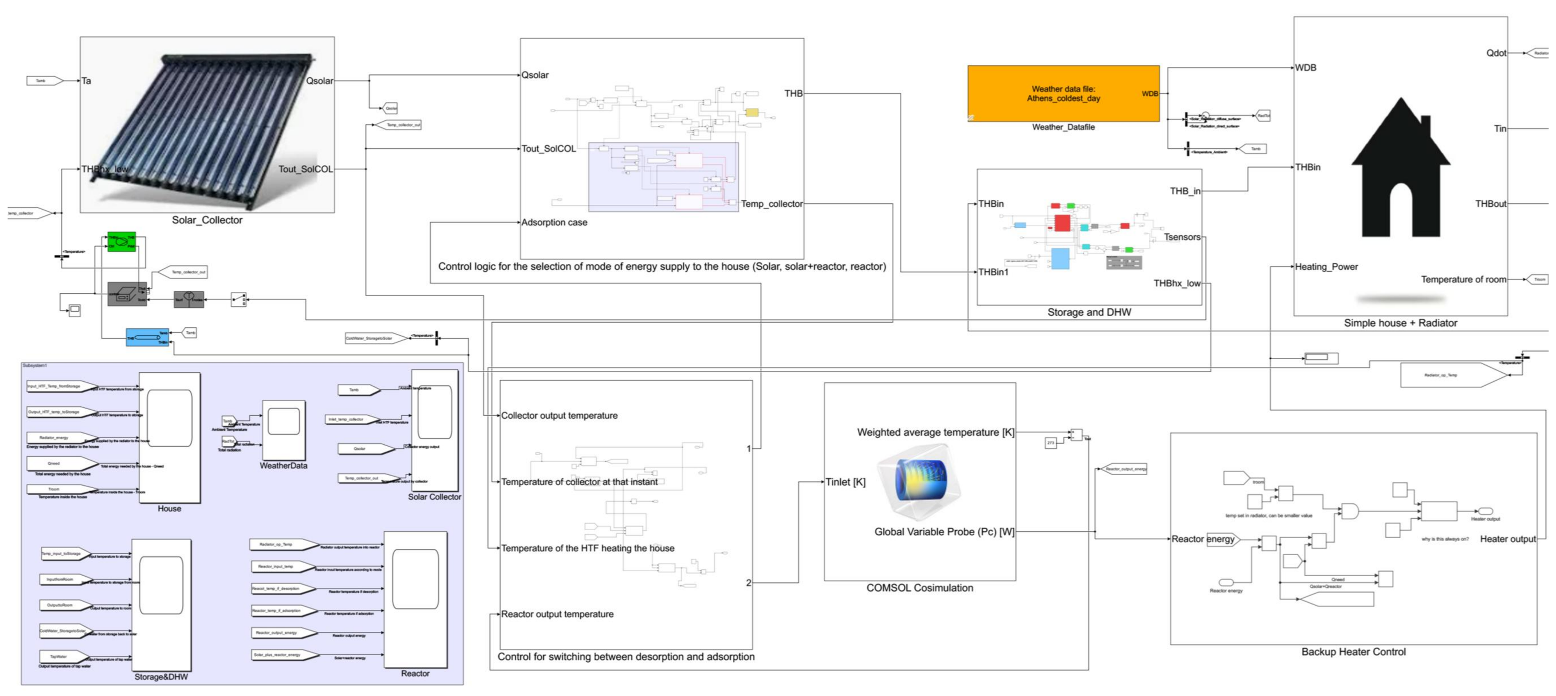

Figure 1. COMSOL®–Simulink Integration of a Zeolite–Water Sorption Reactor within a Building Energy System.

Methodology

A spatially resolved sorption-reactor CFD model (COMSOL Multiphysics®) was implemented with user functions for kinetics and temperature/moisture-dependent properties; vapor flow used Darcy's Law, bed transport Heat Transfer in Porous Media + Transport of Diluted Species, and HTF channels Laminar Flow. The reactor was exported as an FMU and linked via LiveLink™ for Simulink to a building model composed of CARNOT blocks (Simple House SFH15, radiator, solar collector, water storage, auxiliary heater). During runtime, Simulink provided HTF inlet temperature and mass flow as boundary conditions; COMSOL® returned outlet temperature and useful power for control execution and energy accounting, with priority logic: solar → reactor → auxiliary heater, and mode switching at $T_c = 120°C$.

Results

The co-simulation, Figure 1, ran stably with a variable-step ode45 solver, and seasonal results met setpoints under the T_c=120°C switching rule. Winter (Athens, 2–8°C): the collector stayed below 120 °C, so the reactor remained in adsorption mode; room temperature held at 20 °C, and DHW stayed 40–60°C, as shown in Figure 2; runtime of 1,273 s for 1 day and 2,927 s for 4 days. Spring (10–20°C): periods with T_c>120°C triggered desorption with short delays when solar fell below demand; indoor temperature maintained 20–21 °C; runtime of 1,343 s. Summer (26–37 °C): daytime T_c>120°C produced desorption; nighttime T_c<120 °C switched to adsorption, storing heat mainly for DHW. Autumn (16–22 °C): the collector did not exceed 120 °C, the reactor stayed in adsorption, and DHW held 40–50 °C; runtime of 1,168 s.

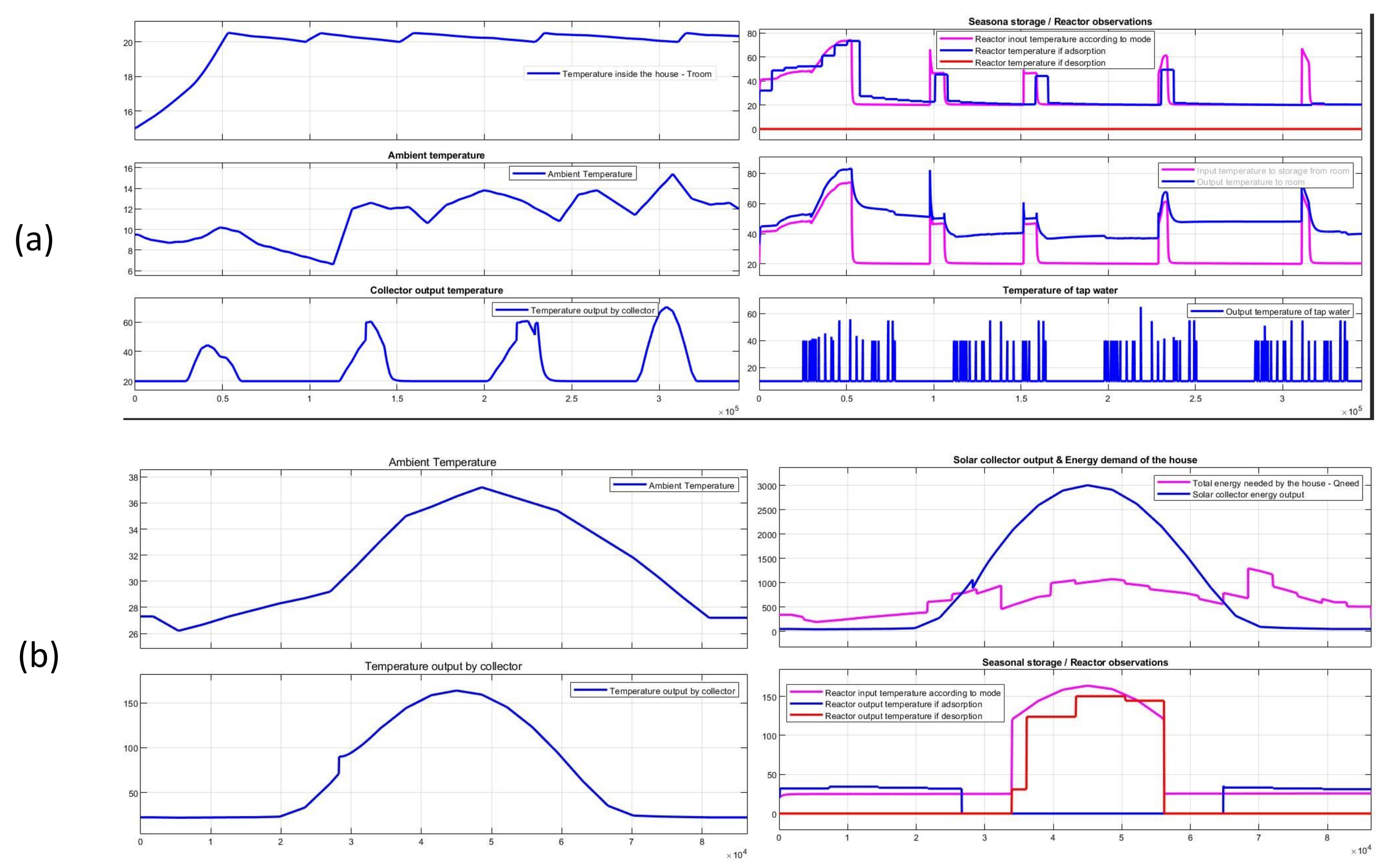

Figure 2. Overall simulation results for (a) 4 days of winter and (b) the hottest day of Summer in Athens.

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