Lucerne University of
Applied Sciences and Arts

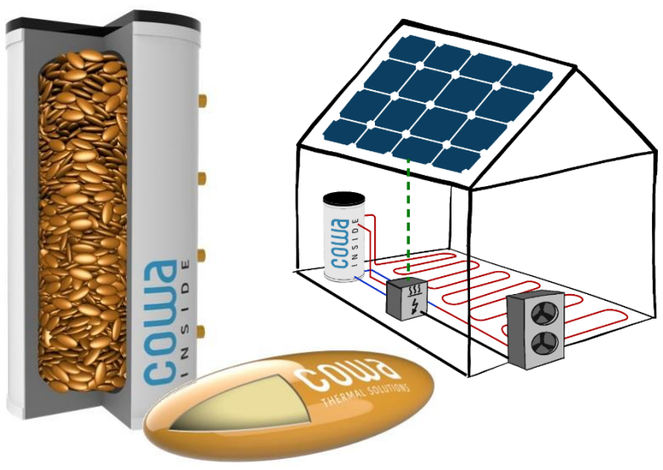
HOCHSCHULE
LUZERN

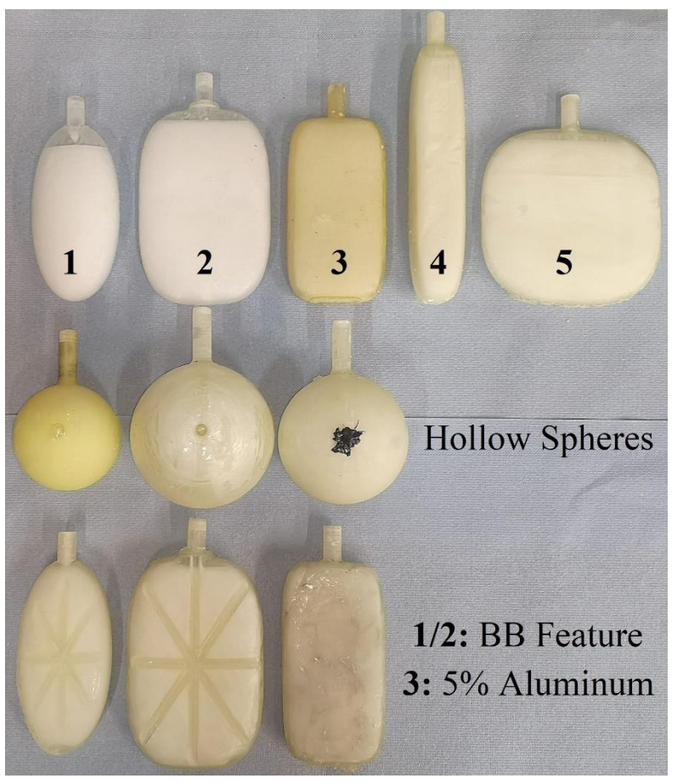
Technik & Architektur
FH Zentralschweiz

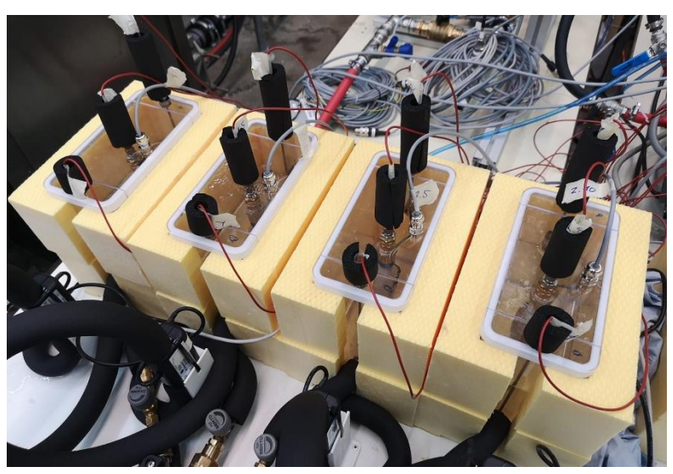
MSE | MASTER OF SCIENCE IN ENGINEERING

Master-Thesis Engineering, Energy and Environment

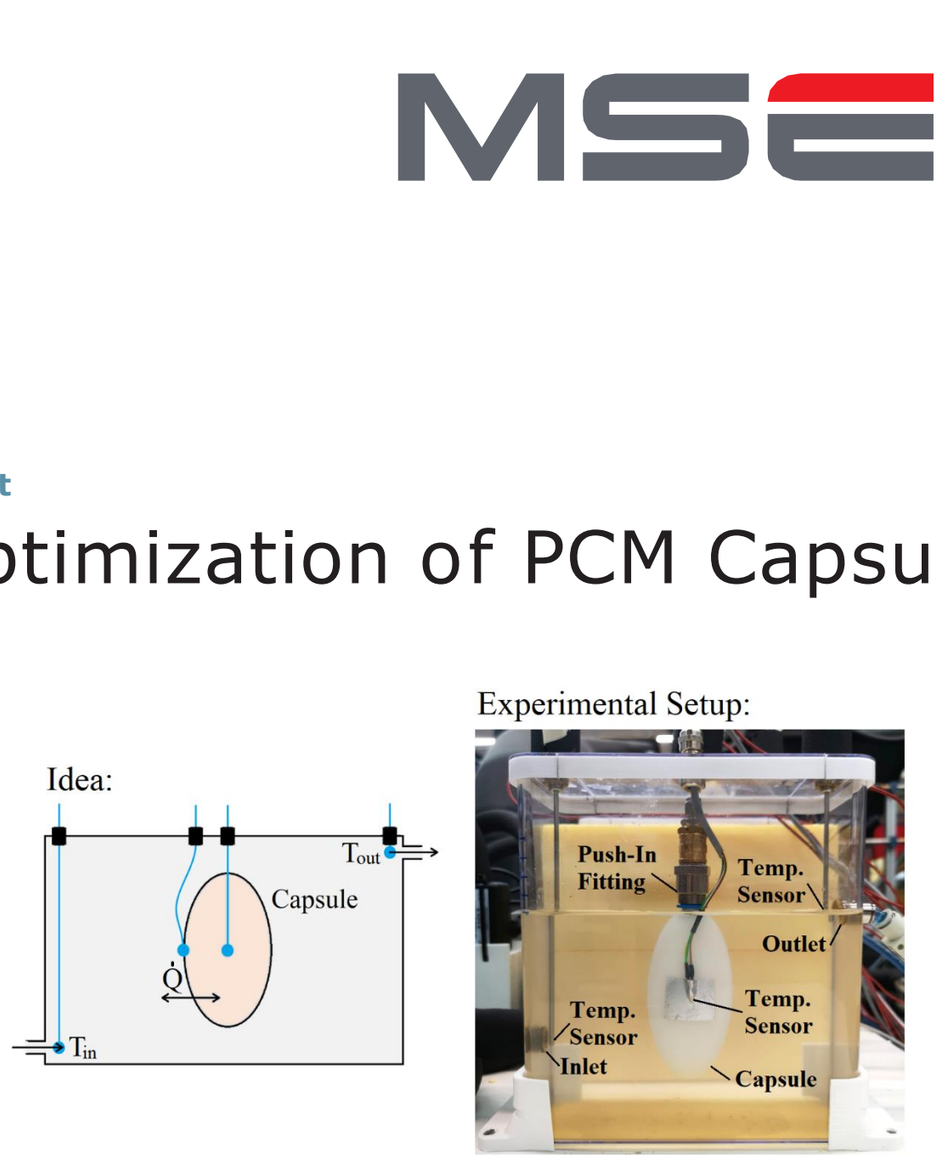
Geometry and Energy Optimization of PCM Capsules

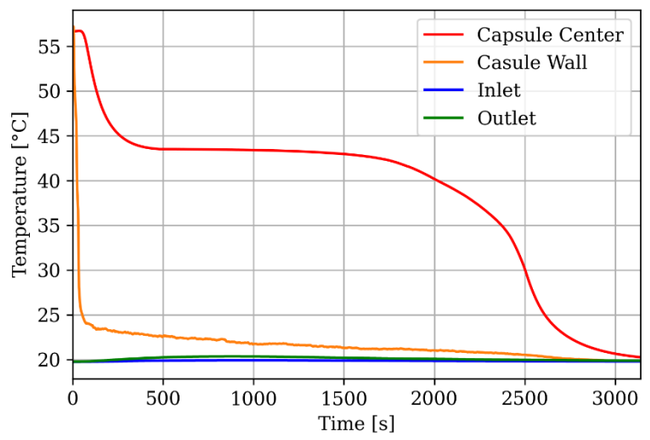


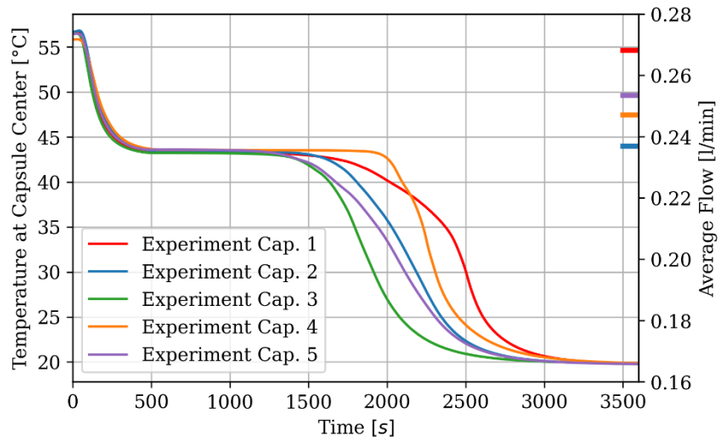


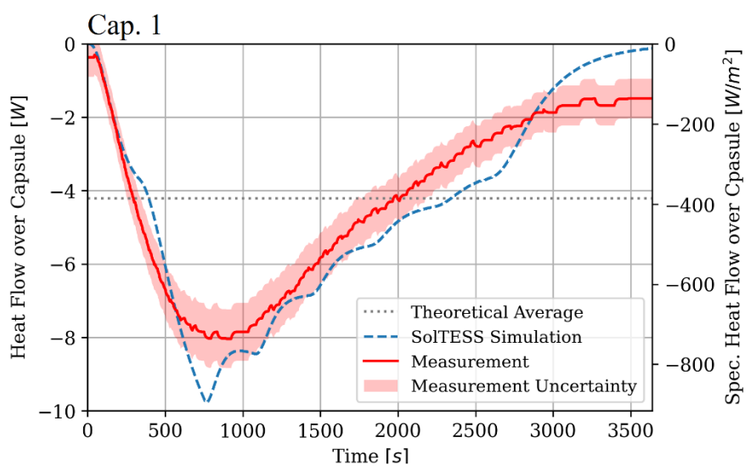


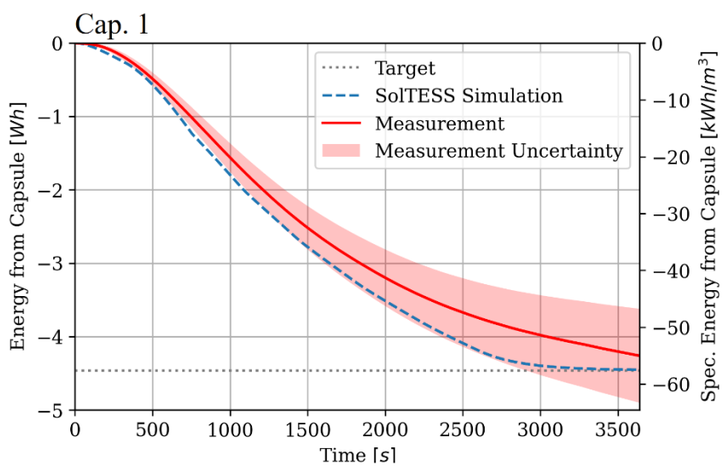
Experimental Setup:

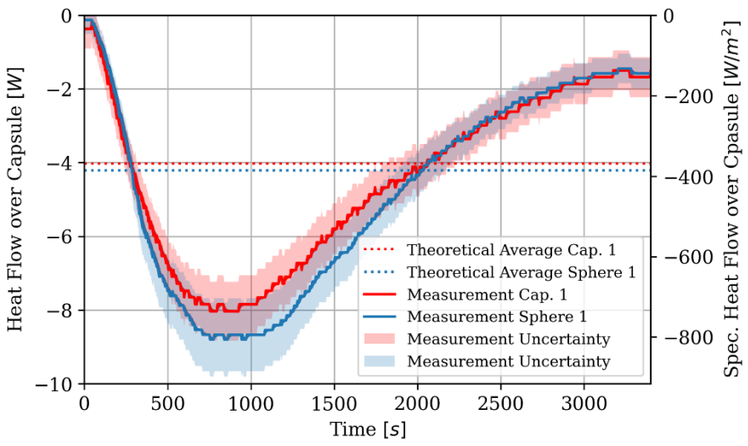


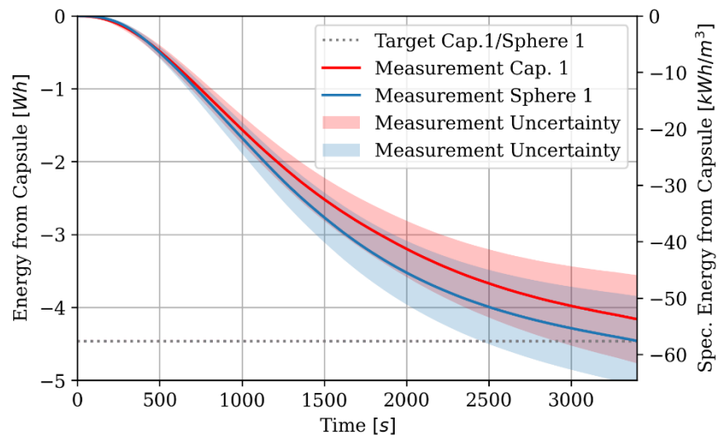












Problem statement

An important step in the implementation of renewable energy in buildings is formed by photovoltaics (PV) and solar thermal (ST) energy. The availability of these energy forms is highly dependent on environmental conditions and solar irradiation. Thermal energy storage (TES) systems play a crucial role in bridging intermittent availability.

Cowa Thermal Solutions AG, a spin-off from the Lucerne University of Applied Sciences and Arts, develops compact TES systems based on phase change materials (PCM) for building technology and industrial plants. Excess PV electricity is used to drive a heat pump which charges the storage unit during the day. When no PV power is available, the building is heated by the storage tank as the PCM solidifies and releases the stored heat to the heating system. The PCM is contained in capsules which are added to the TES system in the form of a packed bed. The main challenge in dimensioning the storage system is the interplay between storage capacity and appropriate discharge and charge rate. The capsule size and geometry thereby play a decisive role.

The aim of this work is to compare different modeling approaches of single capsules and to choose a suitable model to represent a capsule. The model is to be validated with an experimental setup which can evaluate the charging and discharging behavior of single capsules. Different capsule geometries are tested and compared to the simulated results of the model. Finally, a mathematical model is established, which determines the performance of individual capsules depending on given boundary conditions.

Solution approach

In a first step, different modeling approaches of macro encapsulated PCMs are investigated. The experimental setup is designed and built and the charging/discharging behaviour of individual capsules is evaluated. A single capsule is placed in a tank, water is circulated around it, and the temperature change across the tank is evaluated. The experimental results are compared to the simulation models. A mathematical model is chosen and elaborated. The resulting SolTESS model is used to compare different capsules. Additionally, the behavior of additives in PCM and geometry features were examined. A general mathematical relationship between capsule geometry and discharge performance was determined. Finally, the most promising geometry of a single capsule was found.

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