

Disentis, 28.01.2022

Kompakte Thermische Energiespeicher: Schlüsselkomponente zukünftiger Energiesysteme in Gebäuden

Simon Maranda

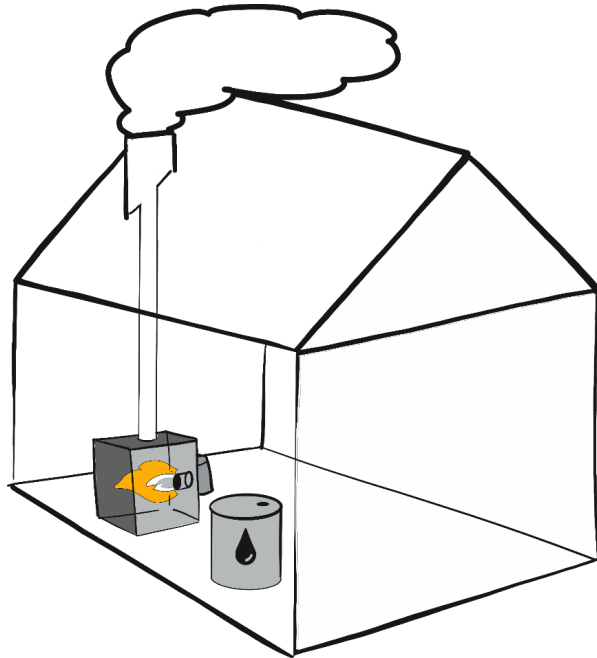
Hochschule Luzern, Competence Center Thermal Energy Storage

HSLU Hochschule
Luzern

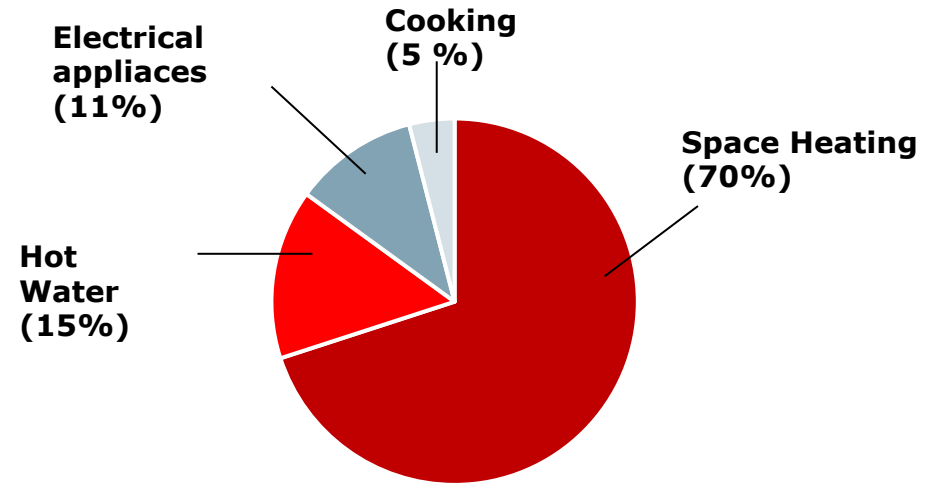


Schweizerische Eidgenossenschaft
Confédération suisse
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**Innosuisse – Schweizerische Agentur
für Innovationsförderung**



Gebäudesektor in Europa:



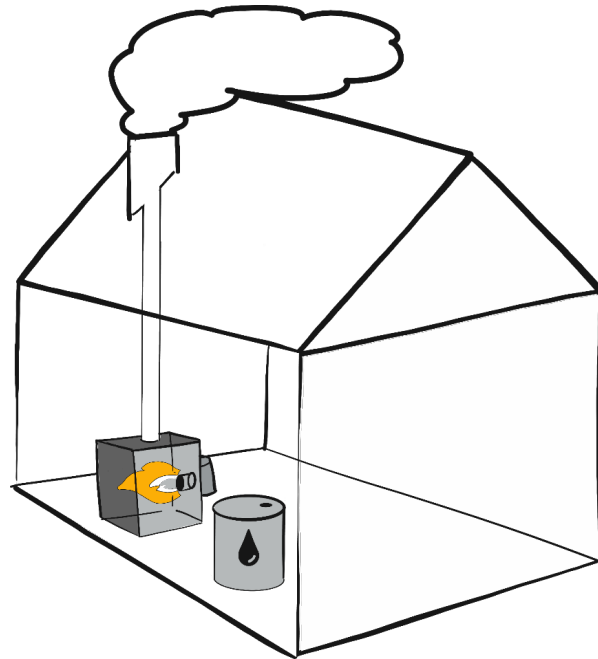
75% Öl und Gas



**Gebäudesektor: 36% des
gesamten CO₂ Ausstosses**

Quelle: 2020, Global Status report for buildings, UN environment programme

Ausgangslage: Öl und Gas → PV + WP



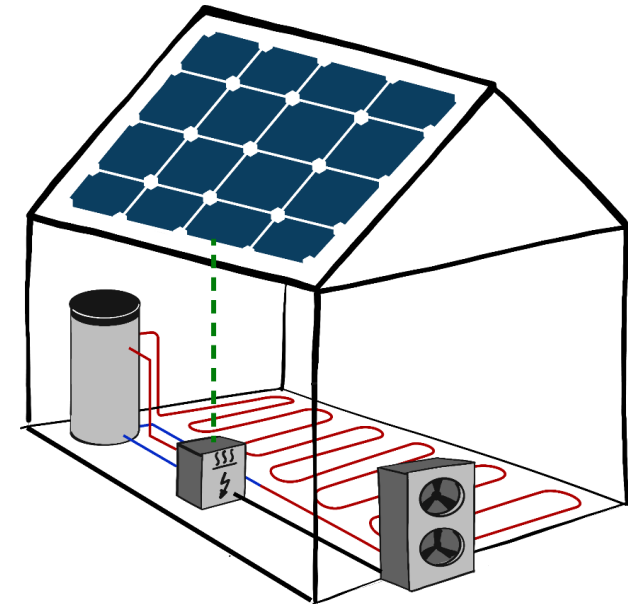
Market Drivers

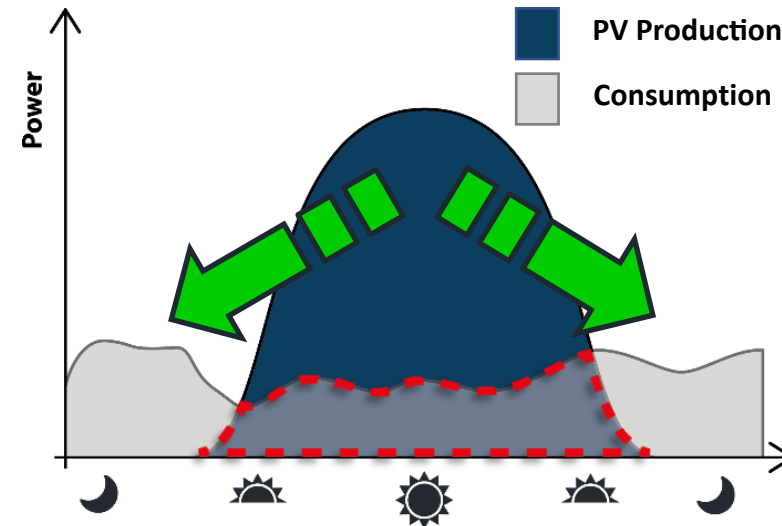
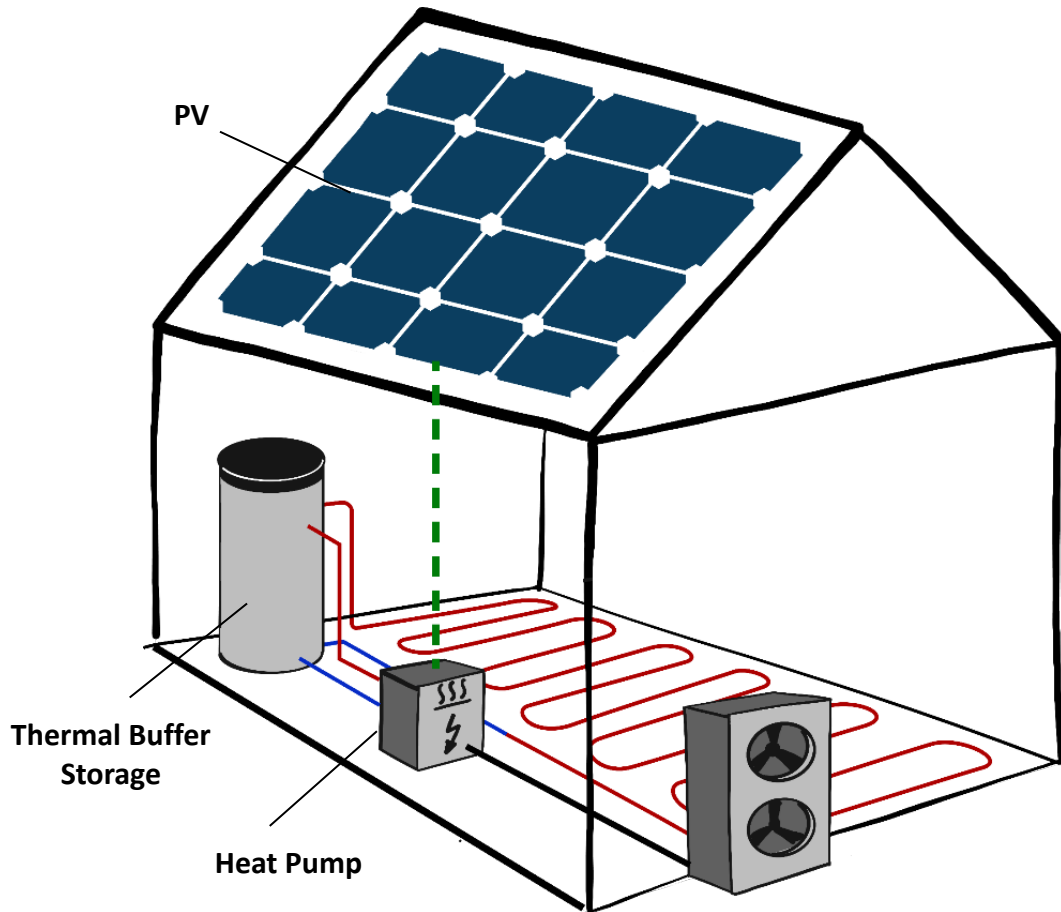


**PV Market:
+11%**



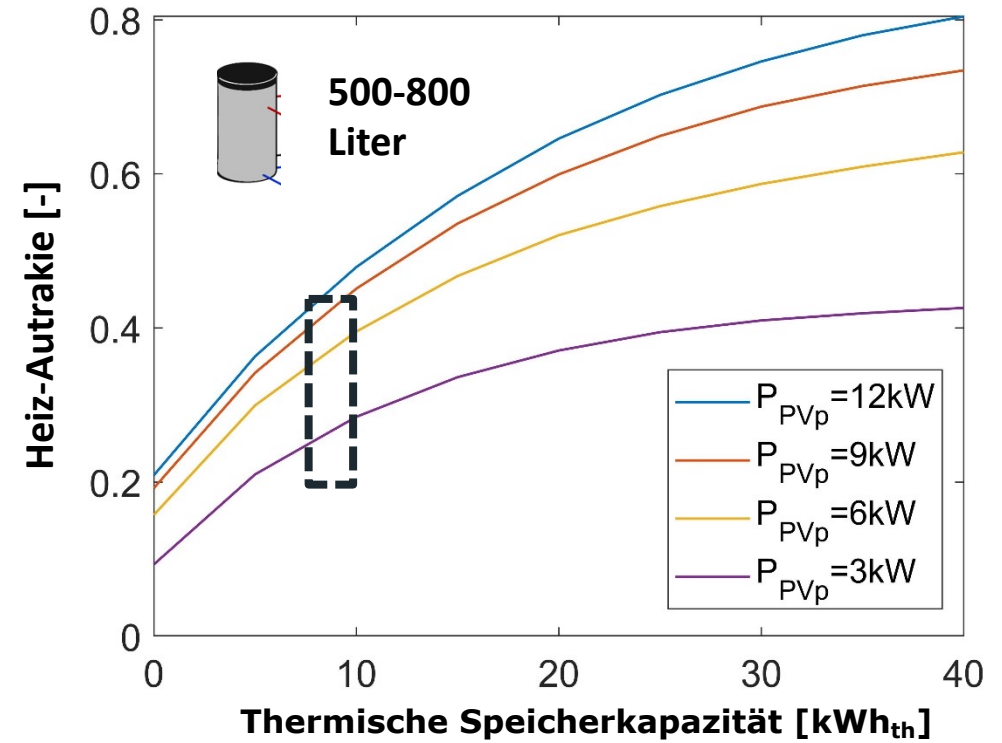
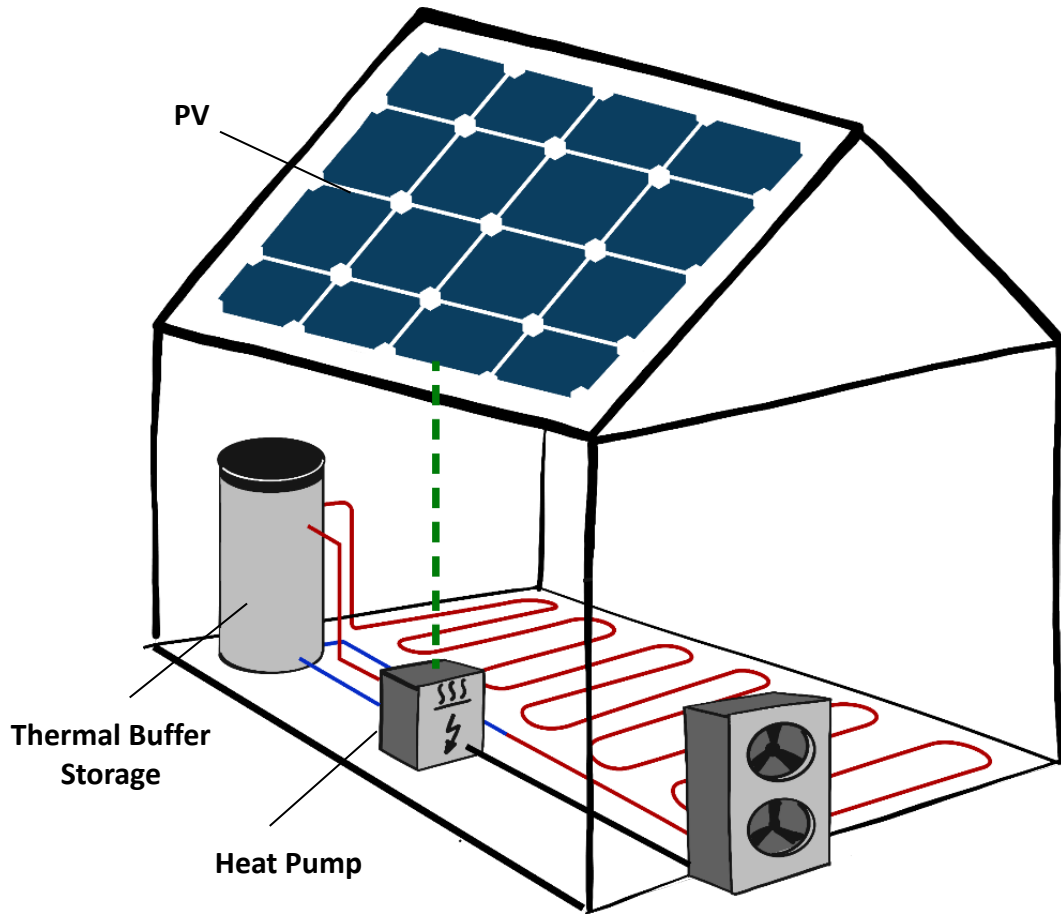
**Heat Pump
Market: +40%**



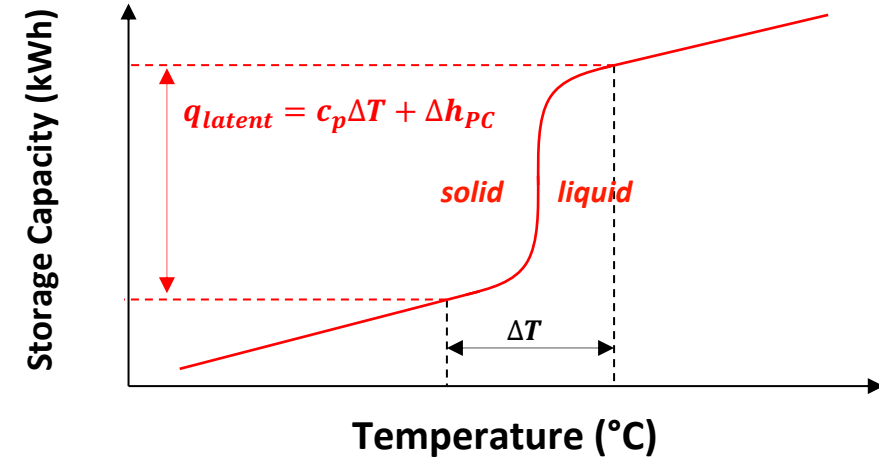
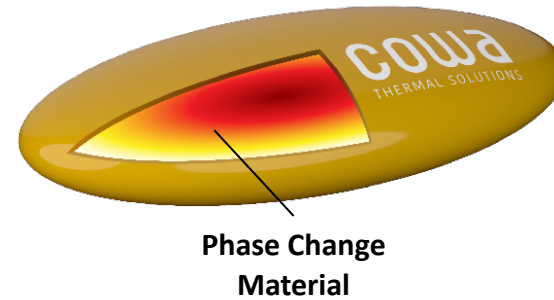


Heiz-Autarkie: < 30%

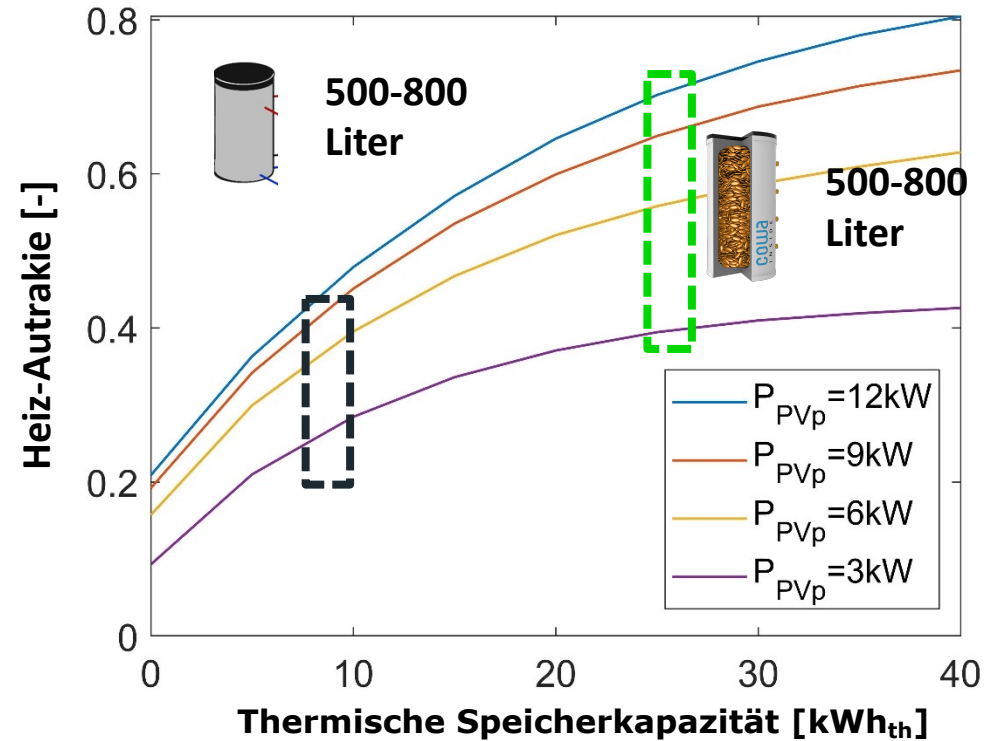
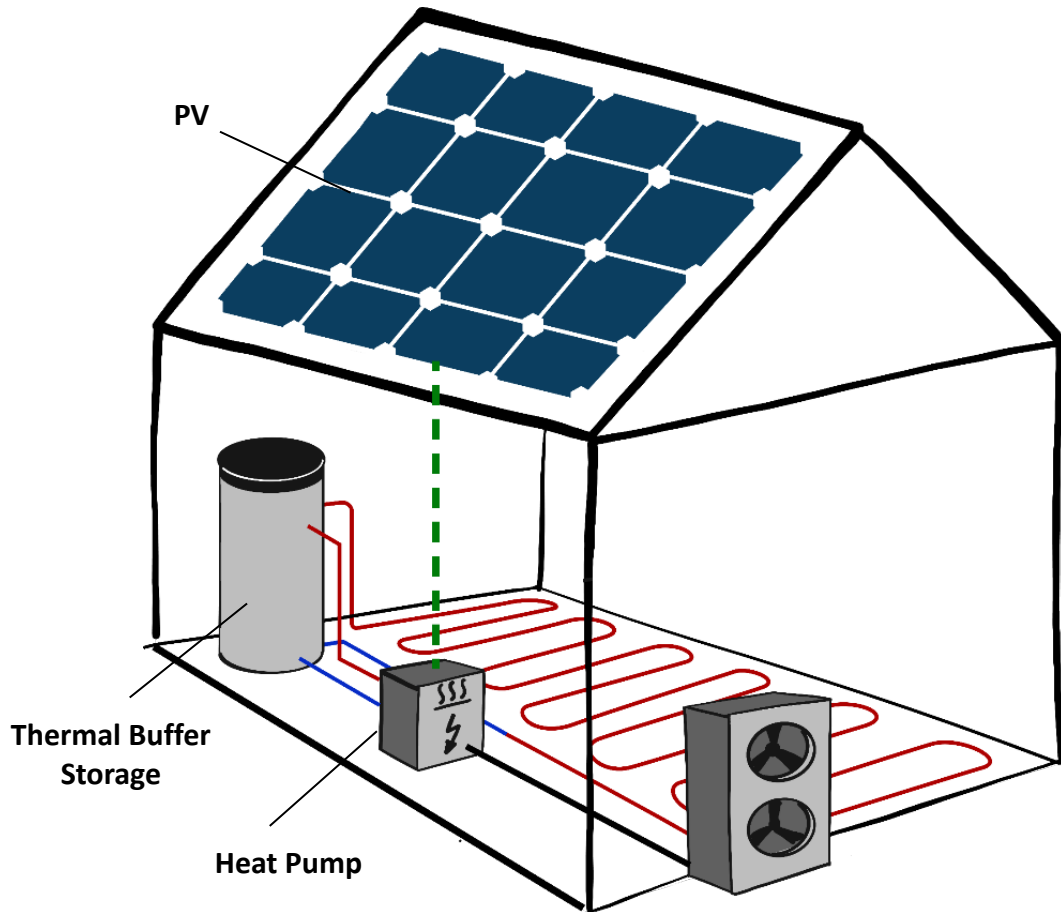
Lösungsansatz: Speicherkapazität erhöhen



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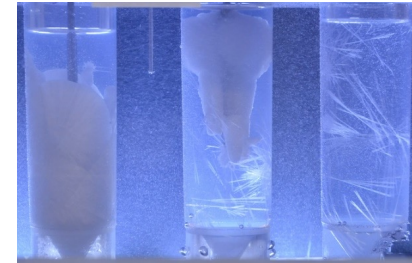
- **Speicherung thermischer Energie durch Ausnutzung Phasenwechsel fest / flüssig**
- **2-4 x höhere Speicherkapazität als Wasser**



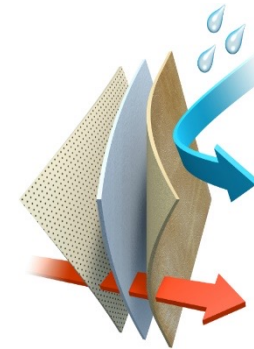
**Verdoppelung
Heizautarkie**



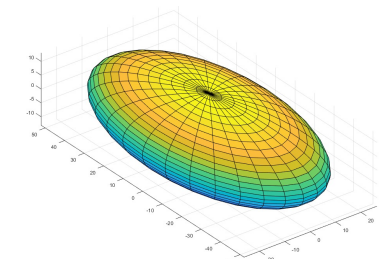
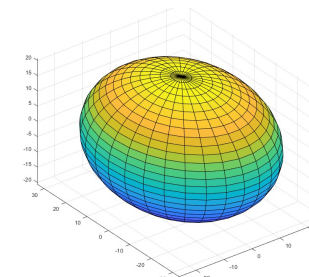
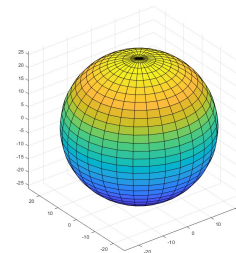
Phase Change Material



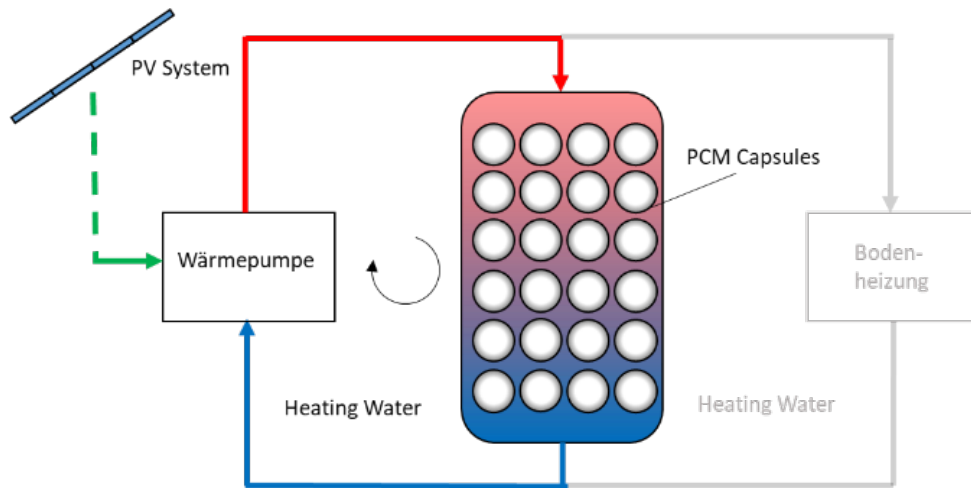
Encapsulation Material



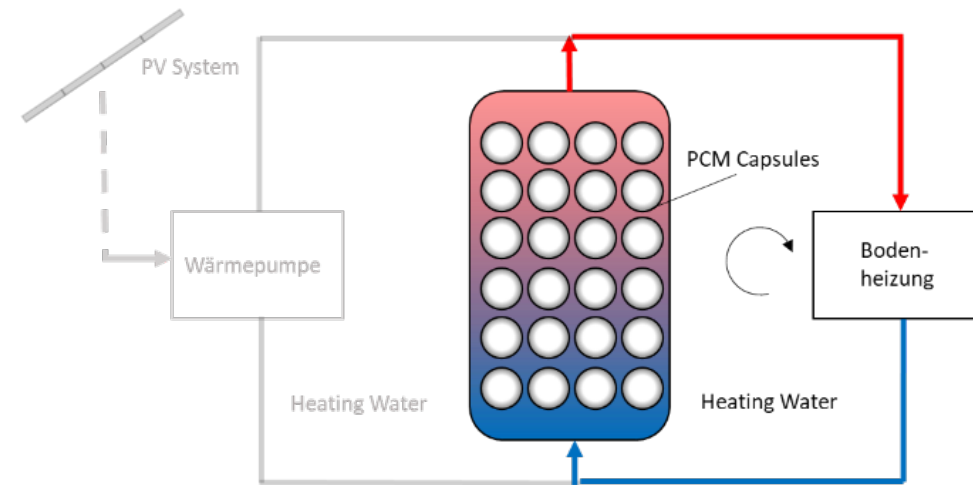
Design & Performance



Beladen

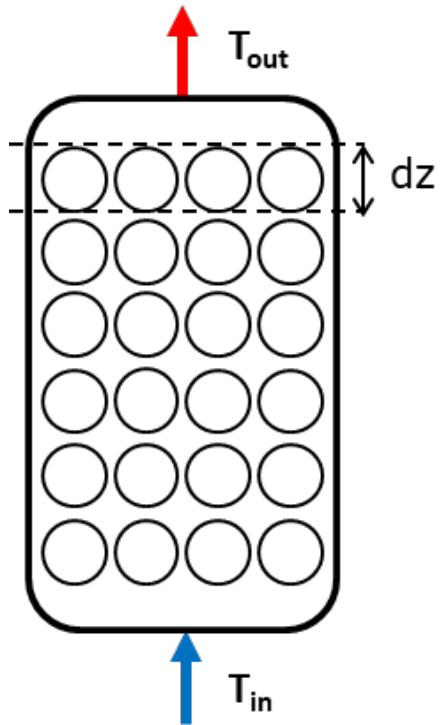


Entladen



Ziel: Validiertes Modell für die Simulation des Be- und Entladevorgangs

System - Modell



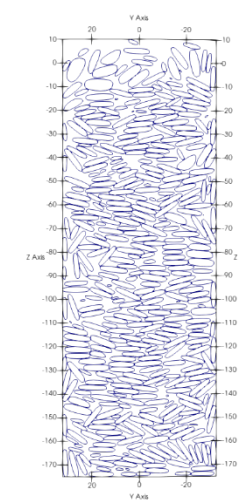
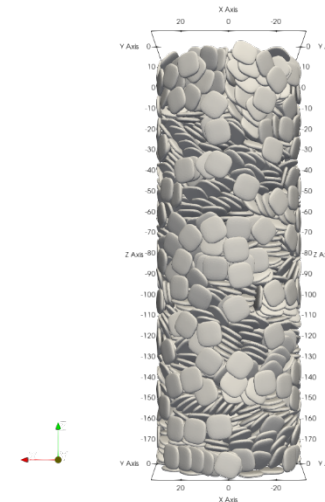
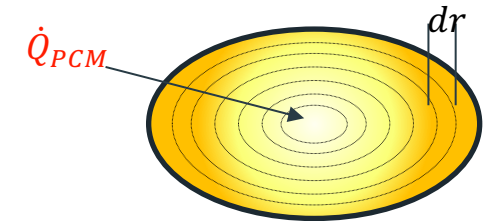
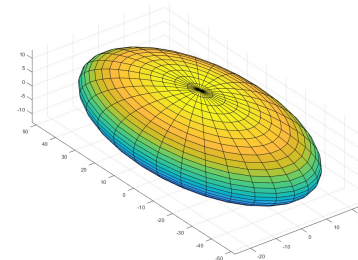
$$\rho c_p \frac{dT_W}{dt} = \lambda \frac{d^2 T_W}{dz^2} - u c_p \frac{dT_W}{dz}$$

$$\rho c_p \frac{dT_W}{dt} = \lambda \frac{d^2 T_W}{dz^2} - u c_p \frac{dT_W}{dz} + \frac{\dot{Q}_{PCM}}{dz}$$

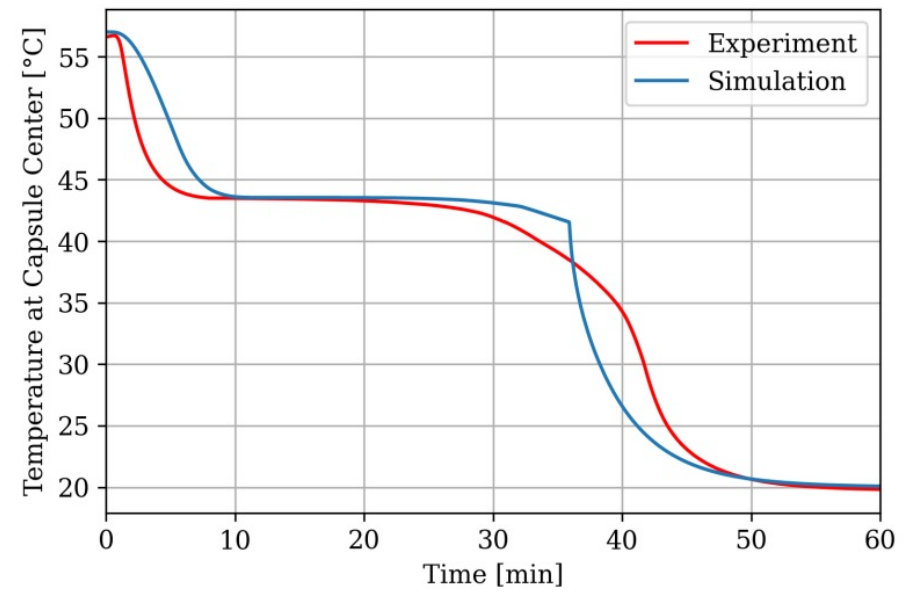
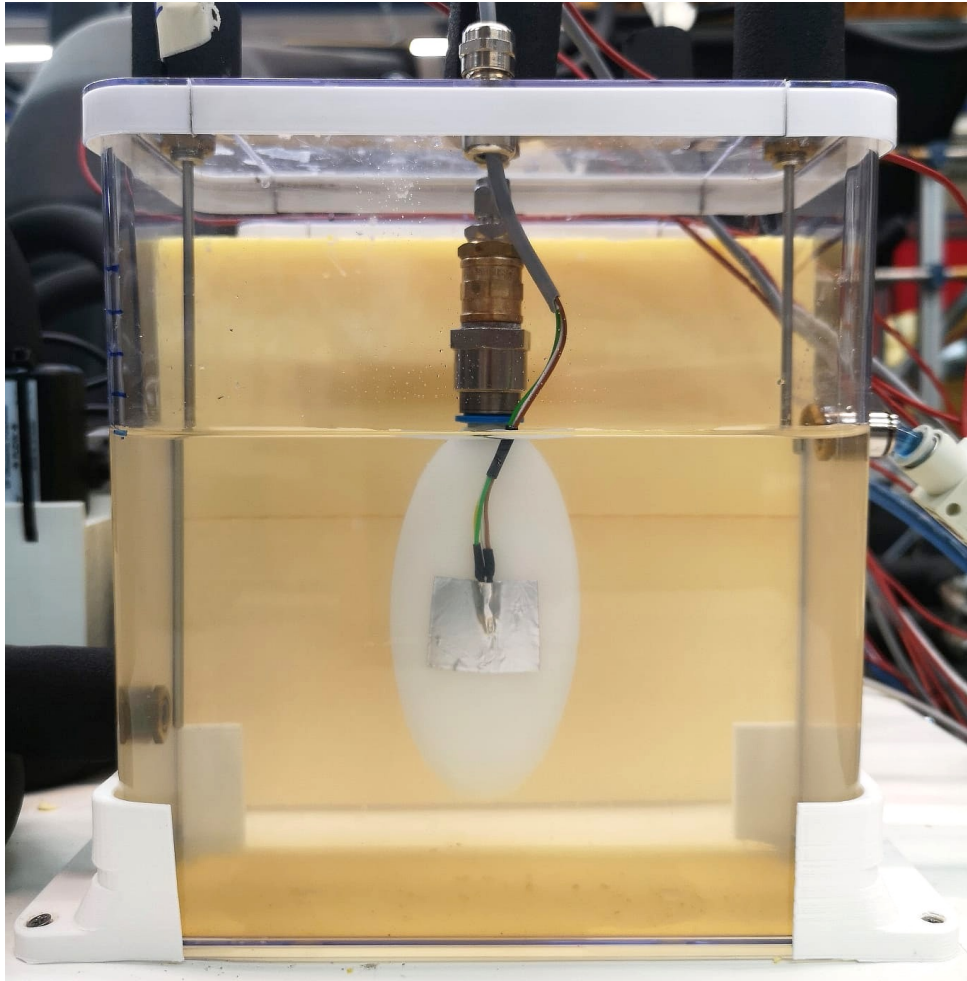
Modellierung der Kapsel

$$\dot{Q}_{PCM} = \alpha A (T_W - T_{PCM})$$

$$\rho c_p (T_{PCM}) \frac{dT_{PCM}}{dt} = \frac{1}{r^2} \frac{d}{dr} \left(\lambda_{pcm} r^2 \frac{dT_{pcm}}{dr} \right)$$



Vergleich Modell / Experiment: Kapsel

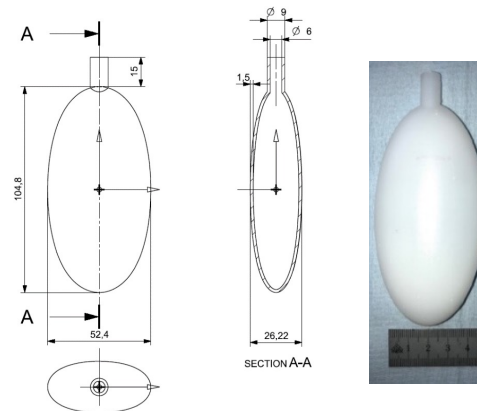




Storage unit:

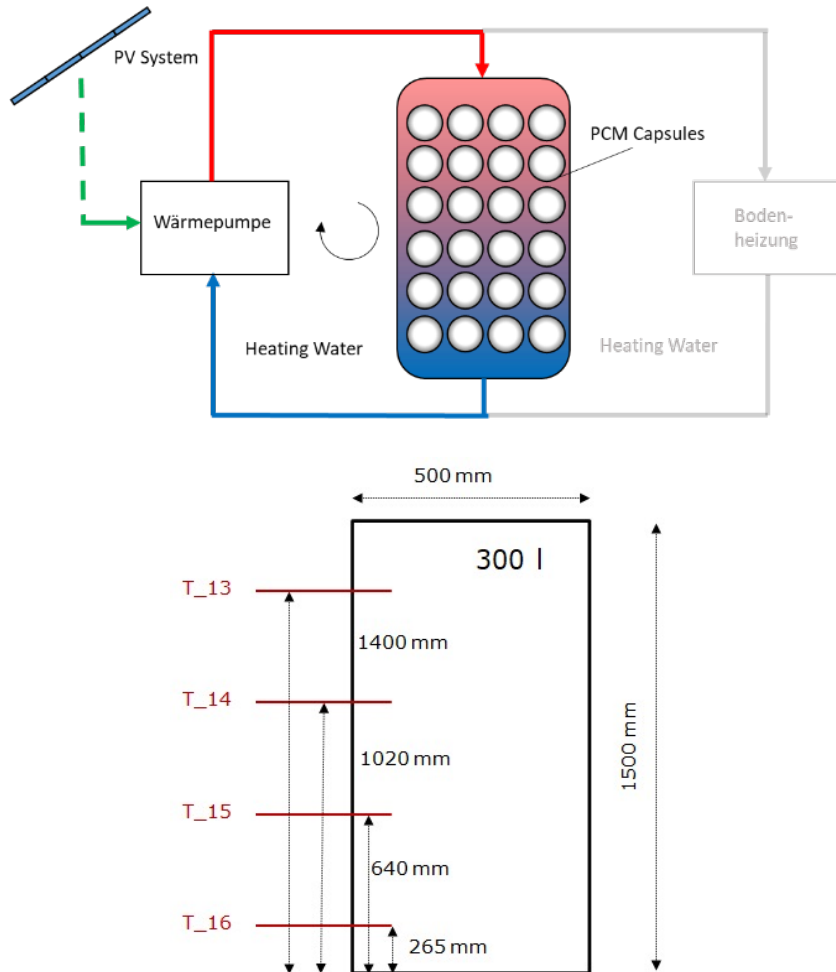
- **Volume: 300 L**
- **Heat Pump: 2.8 kW**
- **Number of Capsules: 2'500**

Kapseln (1. Generation):

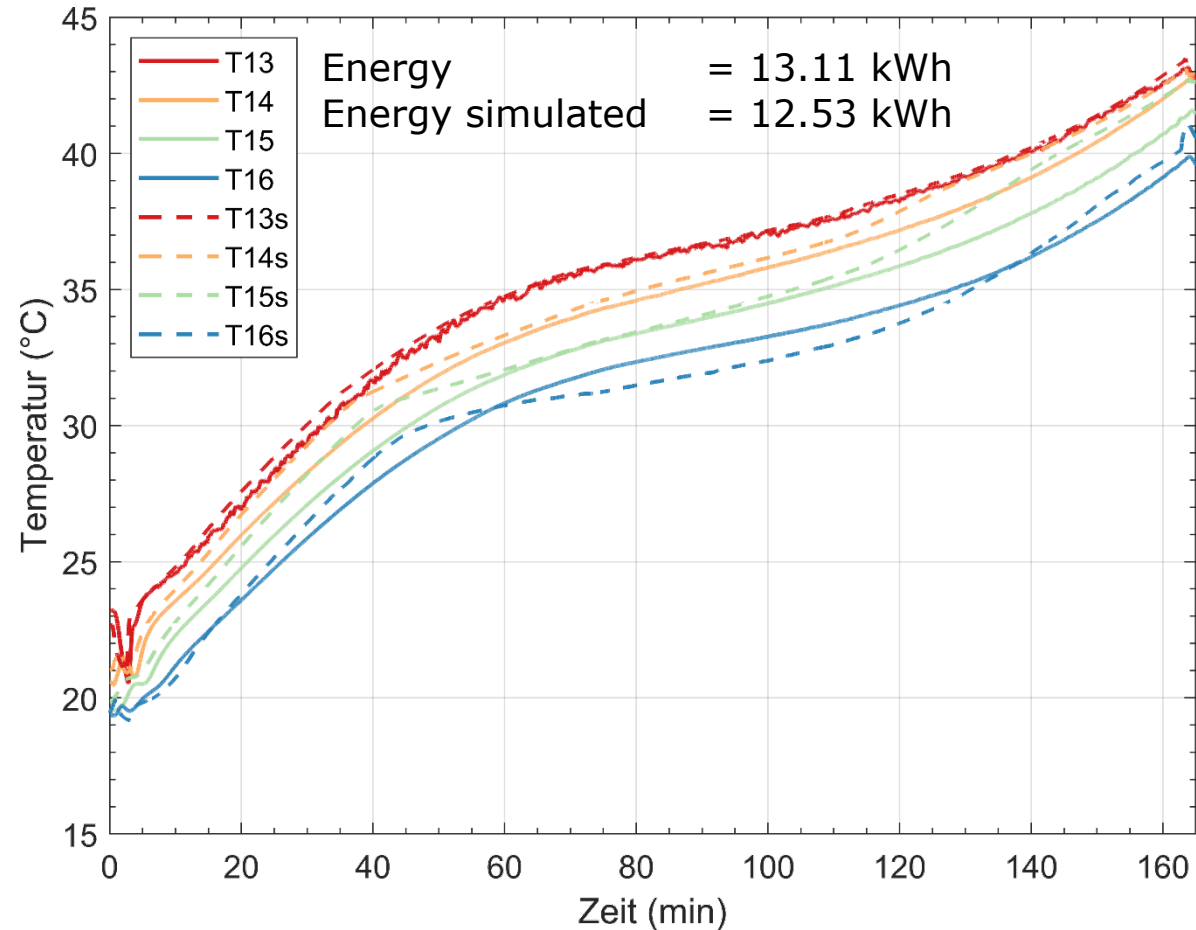


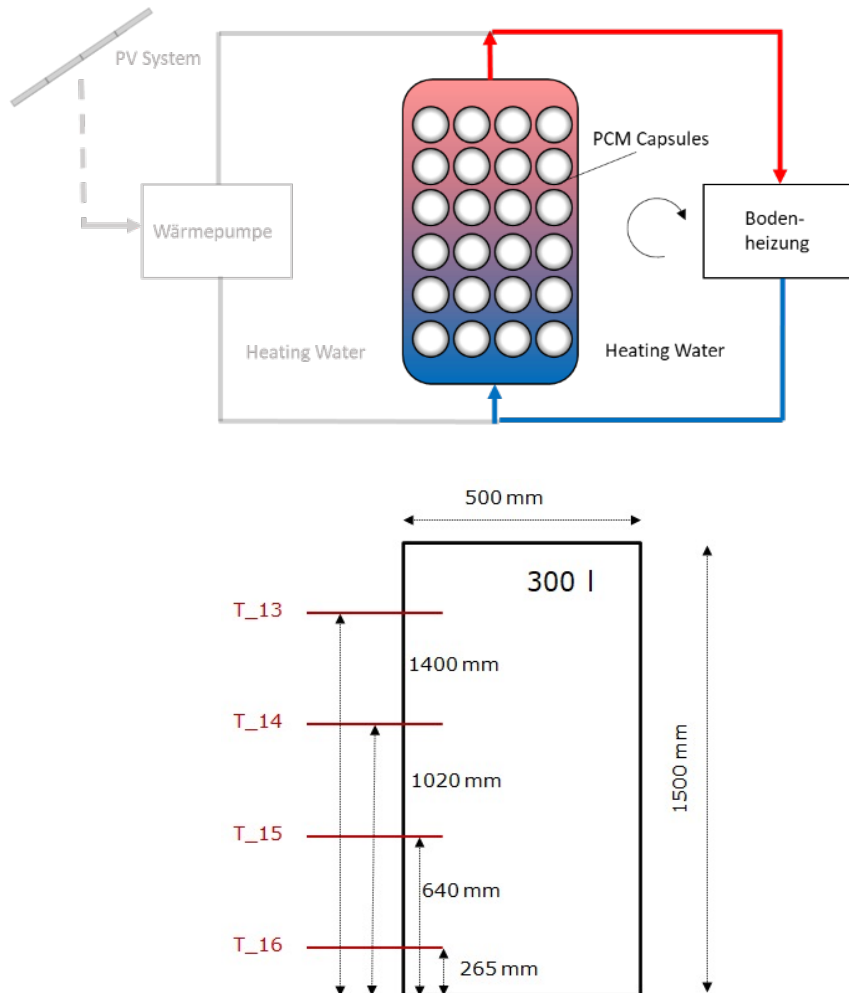
Phase Change Material:

- **Salt Hydrate**
- **Phase Change Temperature $T_{PC} = 31^{\circ}\text{C}$**
- **Phase Change Enthalpy $\Delta h_{PC} = 200 \text{ J/g}$**

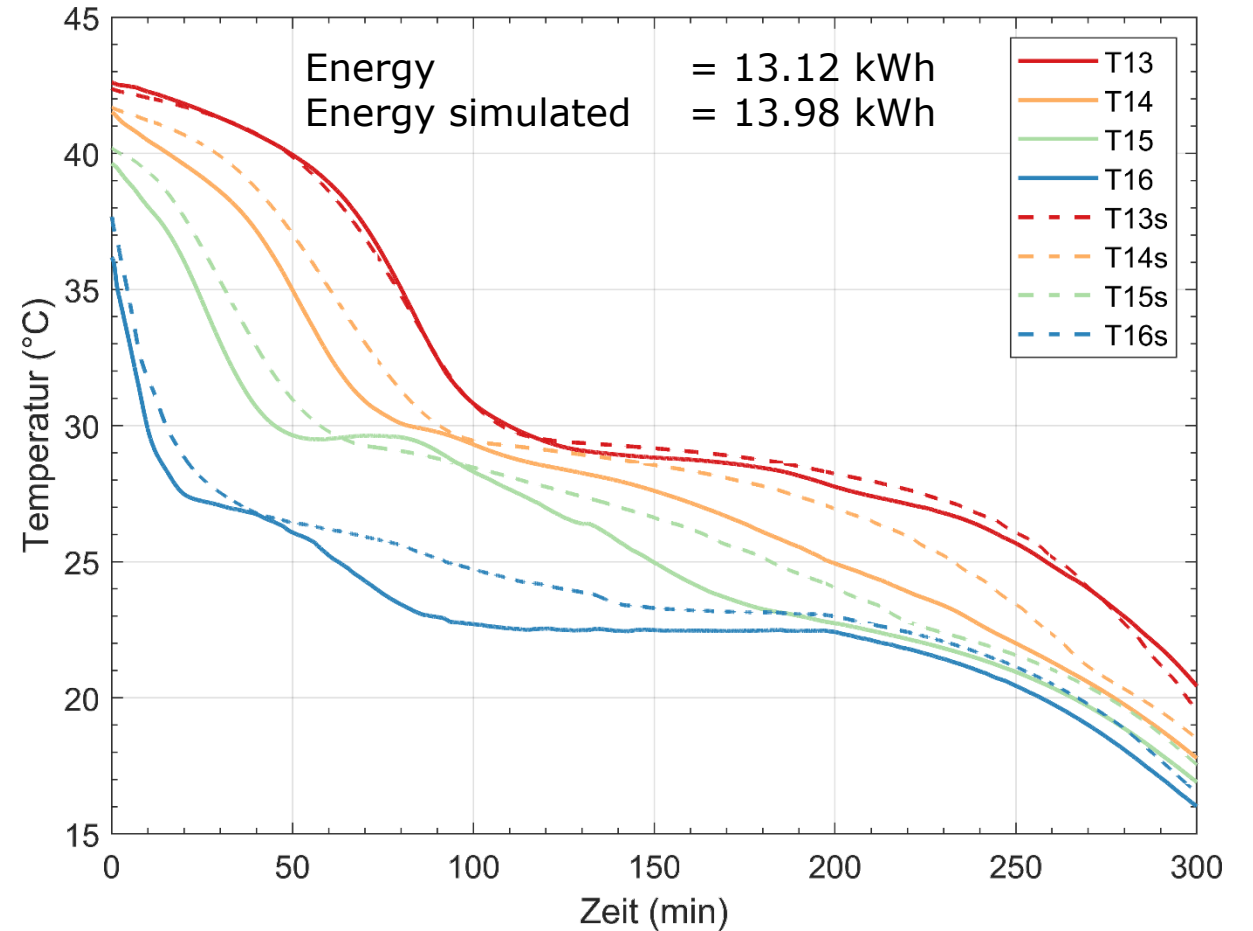


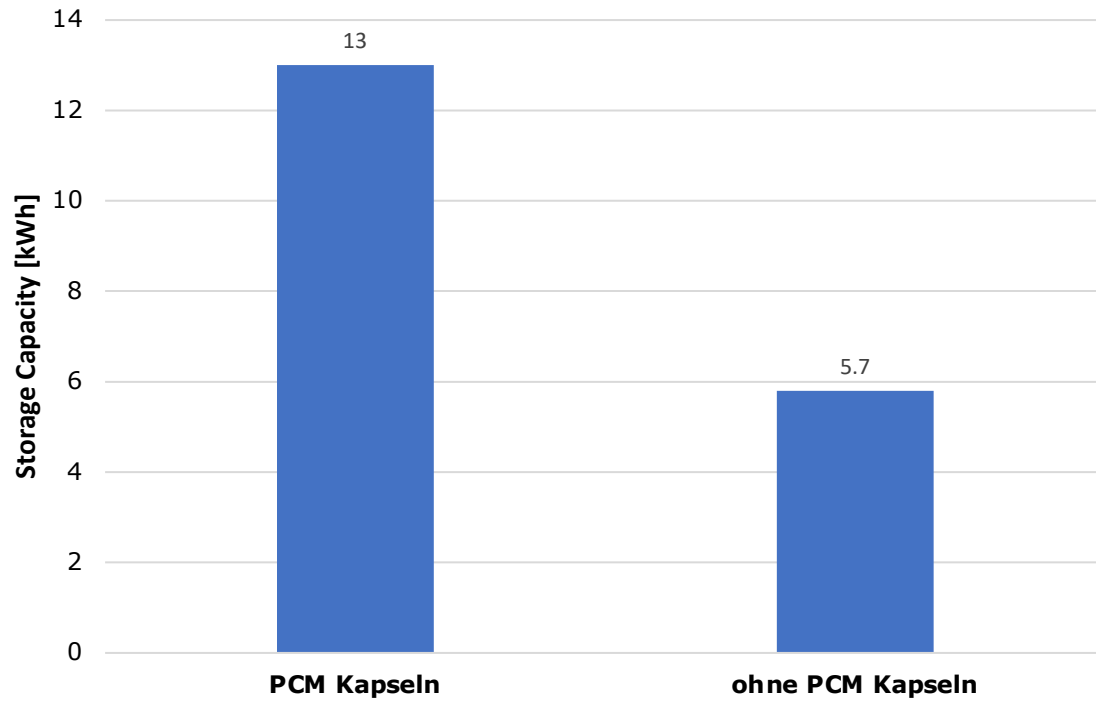
Beladen





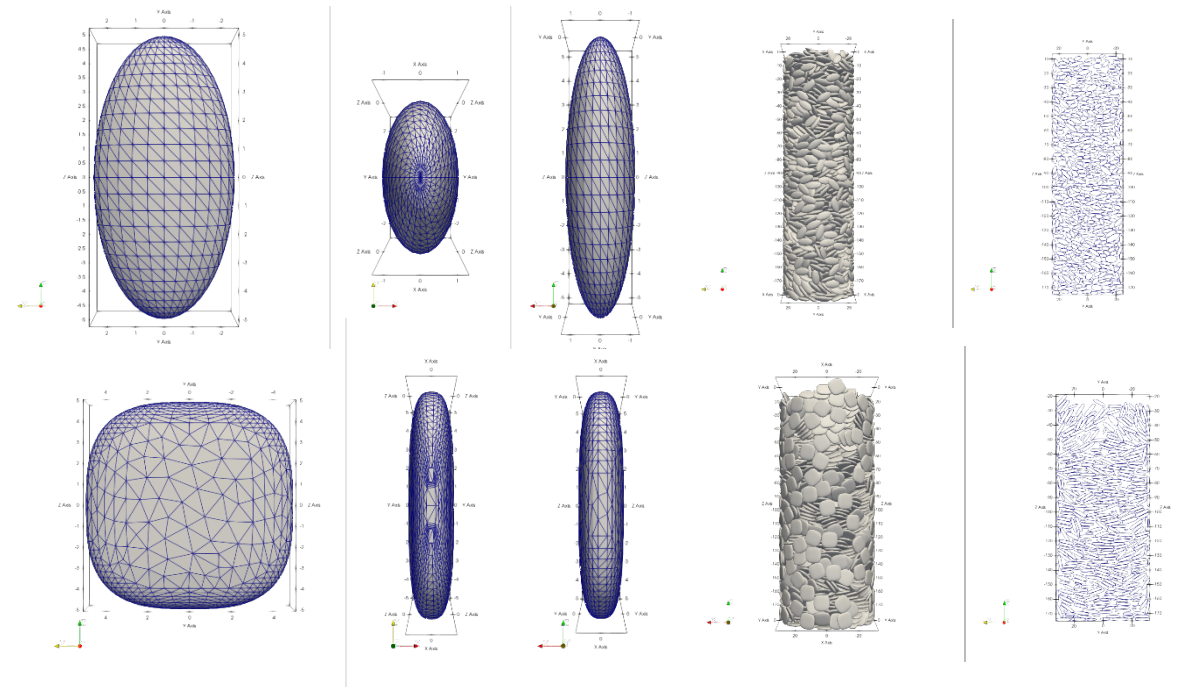
Entladen





Optimierung Kapselgrösse

- **Wärmeübertragung (Fläche)**
- **Kapazität (Packungsdichte → Form)**
- **Kosten (Kapselgrösse)**





Tests mit optimierter Kapsel im Labor



Pilotanlagen im Feld: Mehrfamilienhaus, Horgen 2022 (Rennovation), 1 m³

Herzlichen Dank!

HSLU Hochschule
Luzern

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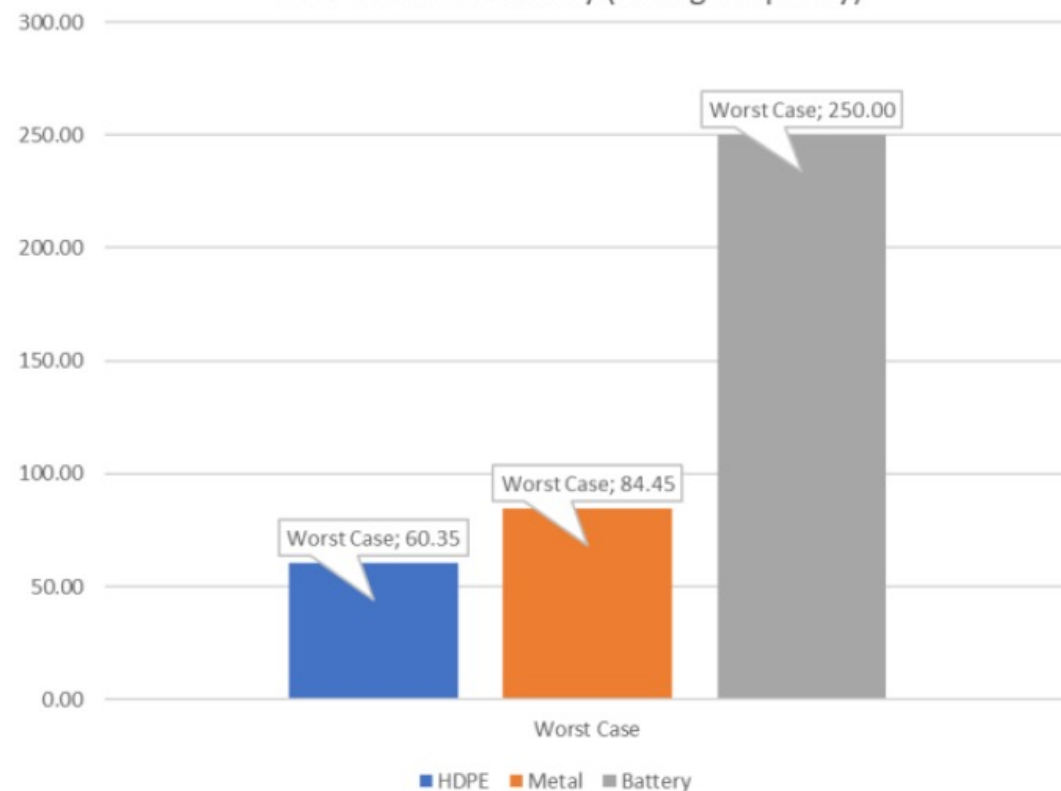
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$[(kg\ CO_{2\ eq})/kWh]$ GWP Cowa vs. Battery (storage capacity)



$[(g\ CO_{2\ eq})/kWh]$ GWP Cowa vs. Battery (life time thermal energy delivered)

