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Hochschule Luzern
Technik & Architektur

THERMAL ENERGY STORAGE

STK-Meeting 24.11.2020

“Calorimetry in the field of thermal energy storage”

Hochschule Luzern – Technik & Architektur
CC Thermal Energy Storage

Lukas Müller, Oliver Fellmann, Simon Maranda, Jörg Worlitschek

Agenda

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Competence Center «Thermal Energy Storage»

Thermal Energy Storage and its applications

Phase Change Materials development

Lucerne School of Engineering and Architecture

12 Competence Centers

- Typology and Planning in Architecture
- Structural Engineering
- Building Envelope
- Center for Integrated Building Technology
- iHomeLab
- Electronics
- Mechanical Systems
- Fluid Mechanics and Hydro-Machines
- Thermal Energy Systems and Process Engineering
- Thermal Energy Storage (CCTES)
- Intelligent Sensors and Networks
- Biosciences and Medical Engineering

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Sebastian Ammann


Braulio Barahona


Robert Beaufait


Matthias Berger


Roger Buck


William Delgado


Oliver Fellmann


Ludger Fischer


Robert Gandia


Damian Gwerder


Reto Hendry


Adina Hochuli


Stefan Krimmel


Janine Leiggener


Esther Linder


Simon Maranda


Jorge Martinez Garcia


Andreas Melillo


Patrick Meyer


Adrian Müller


Lukas Müller


Eva Odermatt


Poppy O'Neill


Rebecca Ravotti


Lukas Roth


Louis Schibli


David Schiffmann


Benjamin Schroeteler


Philipp Schütz


Helene Sperle


Anastasia Stamatiou


Marcel Troxler


Willy Villasmil


Silvan von Arx


Remo Waser


Jörg Worlitschek


Roger Zimmermann

Vision

Storing heat & cold and temperature stability for a climate neutral future.

We assess and develop thermal storage solutions for buildings, districts and industry. Material analytics, component development, energy system models and data science help us to validate our systems' performance in real world applications. We aim for a sustainable, resilient climate neutral future.

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Facts and Figures

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35 running projects with industry

4 PhD, 26 peer reviewed publications in 2019

2 Spin-Offs

4 Mio CHF turnover

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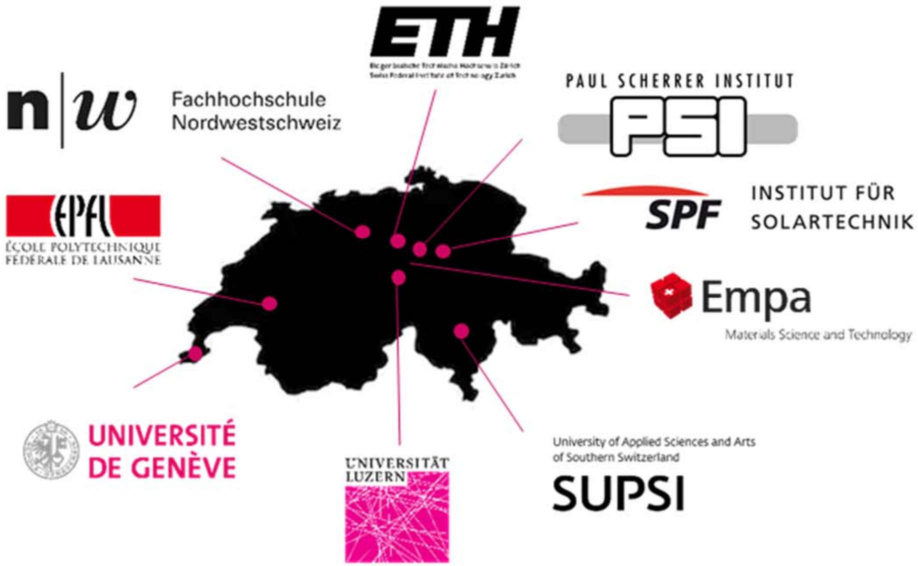
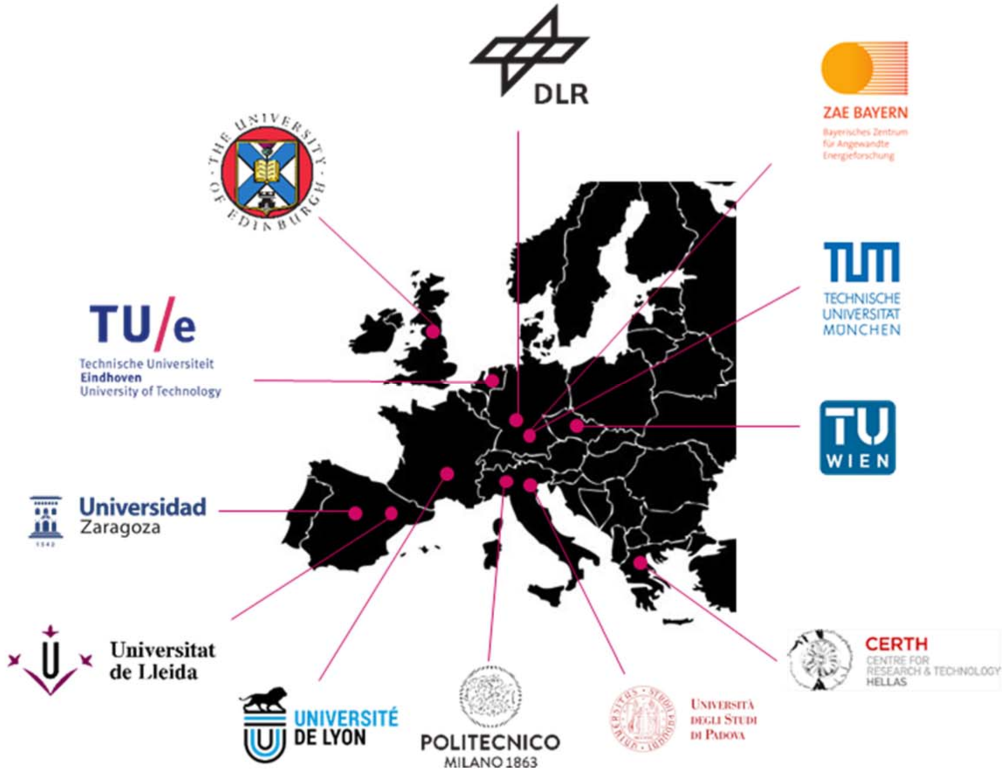
National and International network





Cooperation with Industry

swisscom
METTLER TOLEDO
Jenni Energietechnik
swisspor
meier tobler
tiko
Sunamp Heat Batteries™
V ZUG
BMS
Internationales Kompetenz-Zentrum für Energieeffizienz
STEP TEC
NILAN® OUTSTANDING INDOOR CLIMATE
FAFCO®
Blaser. SWISSLUBE
hpa
ewl
NUSSBAUM RN
MAN
MAN Energy Solutions
MIGROS
Leutenegger + Frei AG
Regionalwerke Baden
ARISTON THERMO GROUP
misurio
CRODA
Innovation you can build on™

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We are experts in…

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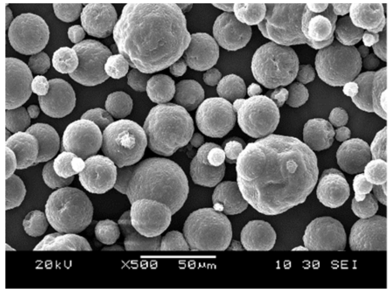
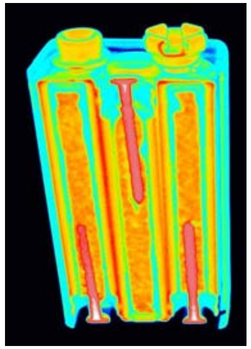
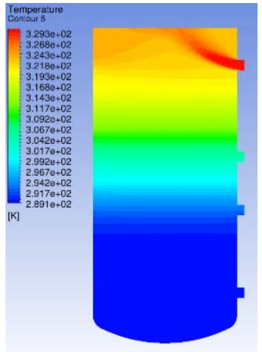


Material characterization and optimization

Pilot plants and fundamental research





System modelling and optimization of components

Assessment, data science and monitoring of energy systems

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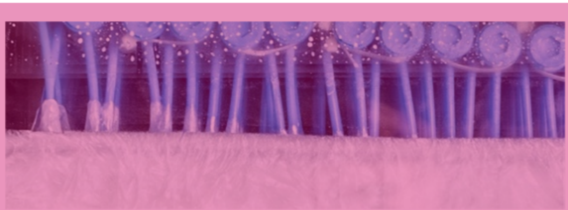
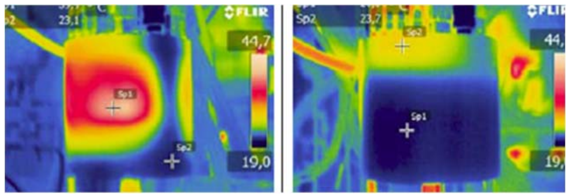
Assessment of Storages

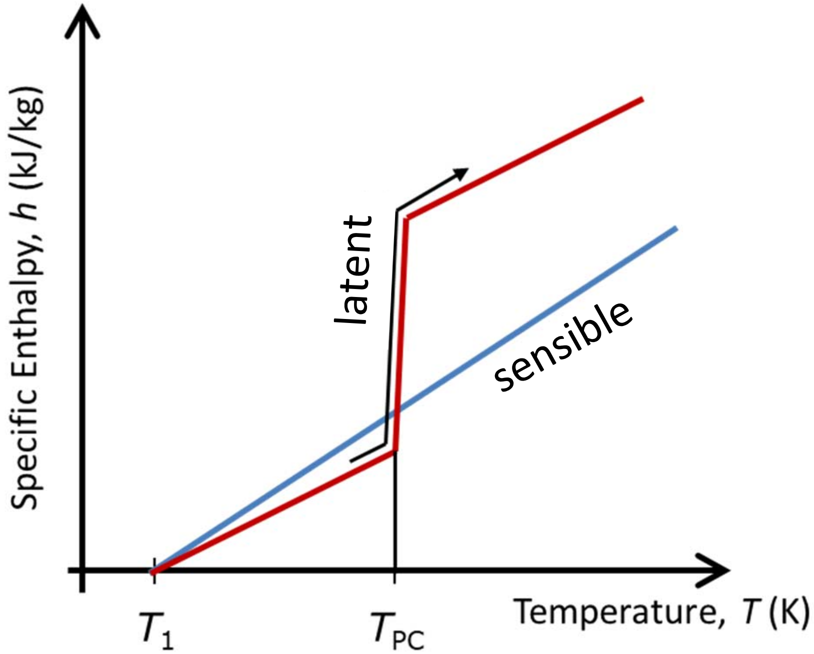
Sensible / Seasonal Energy Storage



Latent Energy Storage



Temperature Stability



Characteristics

- Heat or cold storage in a **melting / solidification** process
- **Phase Change Material (PCM)** as storage medium

Comparison with sensible storage:

- ✓ 2-8 times higher energy density than water
- ✓ Steady T_{output}
- × Low heat transfer coefficient
- × Higher cost

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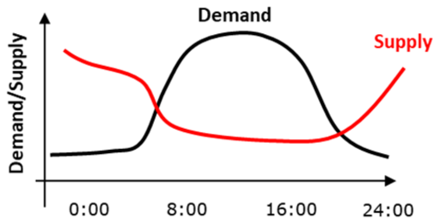
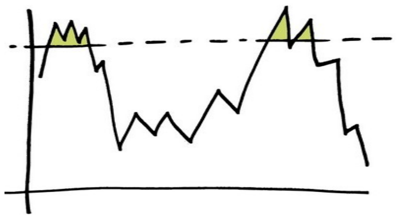
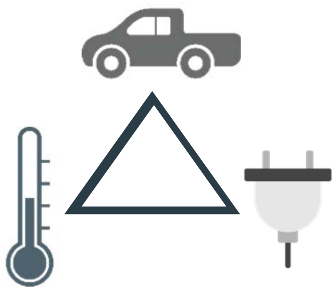
Applications



Decoupling Demand & Supply



Peak-Load Shifting



Sector Coupling
«Power2Heat»

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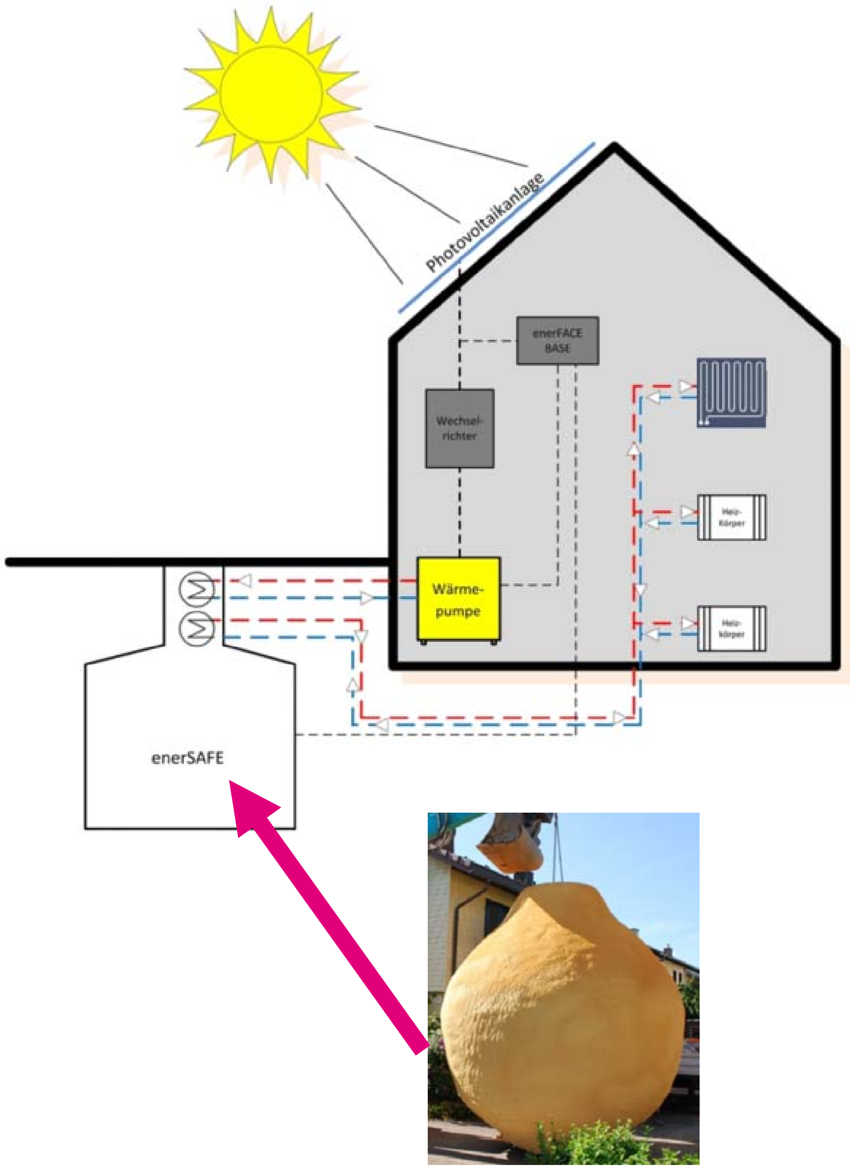
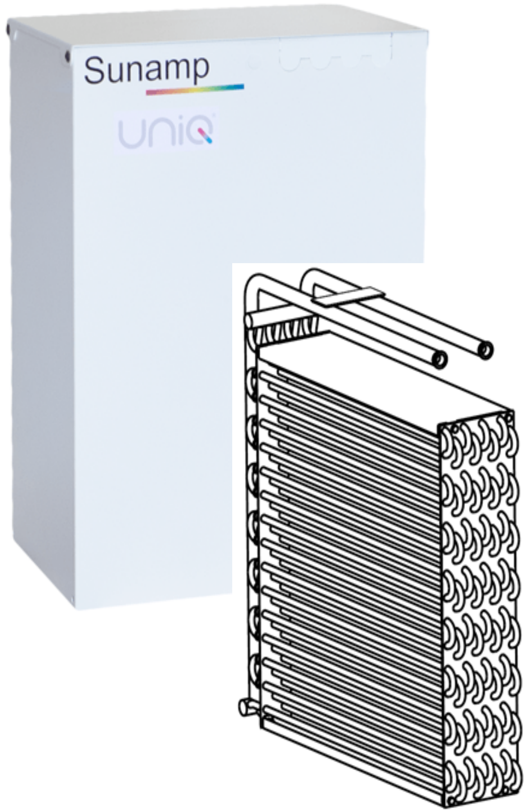
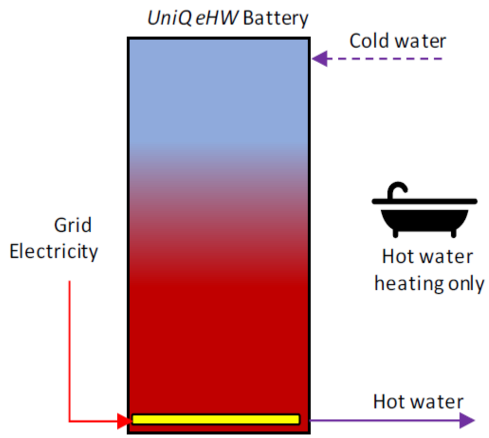
Latent Energy Storage: Overview







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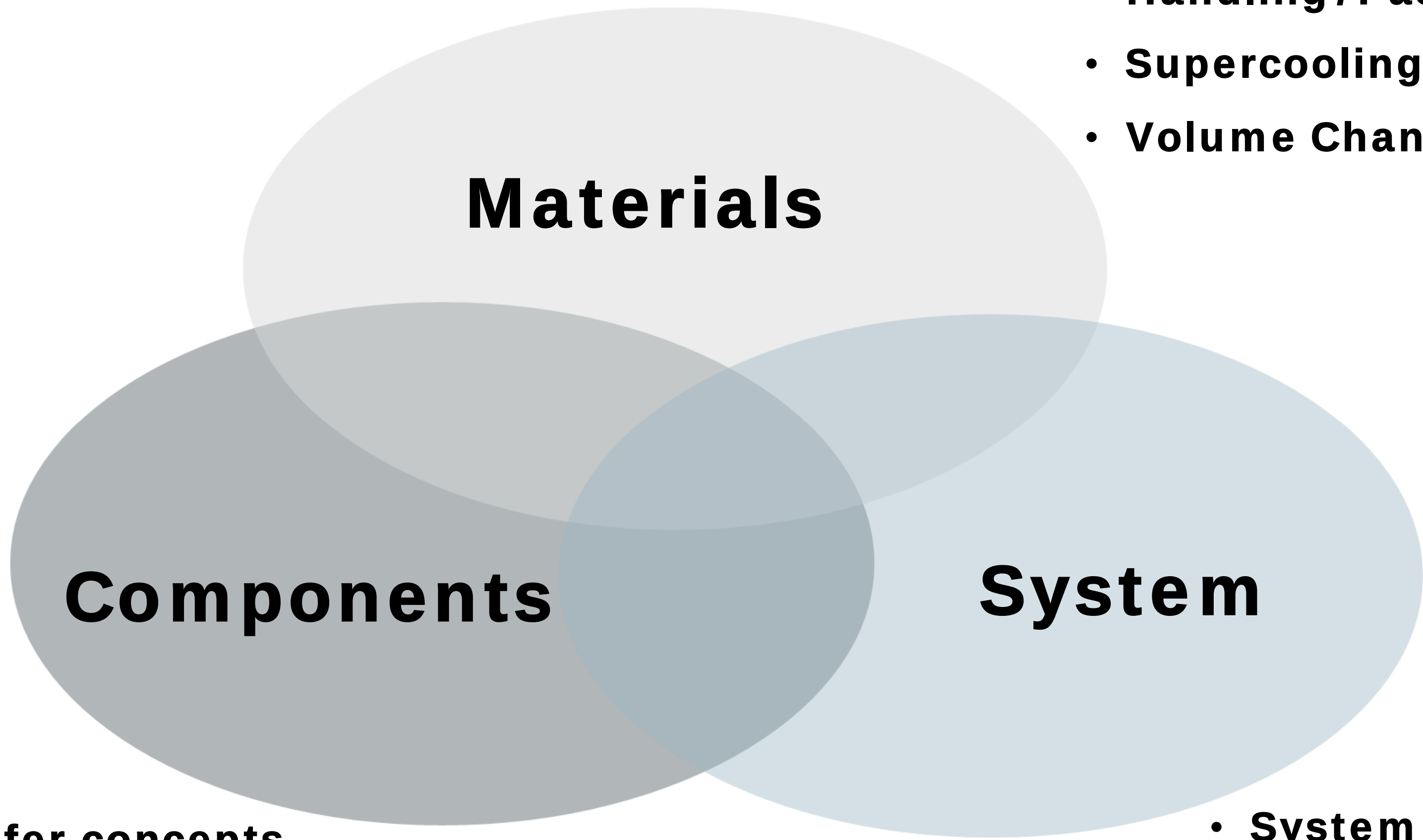
Latent Energy Storage: Overview

- Long-term stability
- Handling / Packaging
- Supercooling
- Volume Change



- Heat transfer concepts
- Material compatibility

- System Modeling
- System Integration
- Design rules

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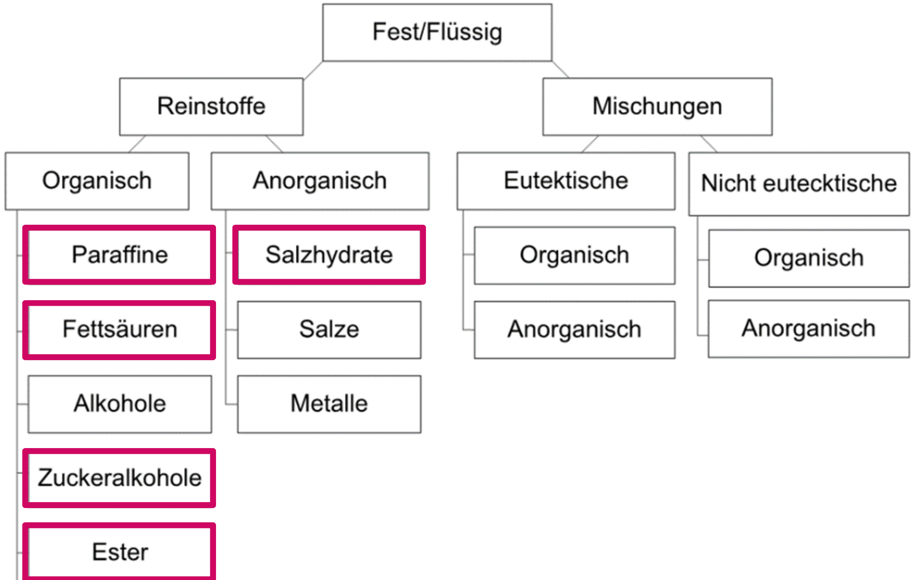
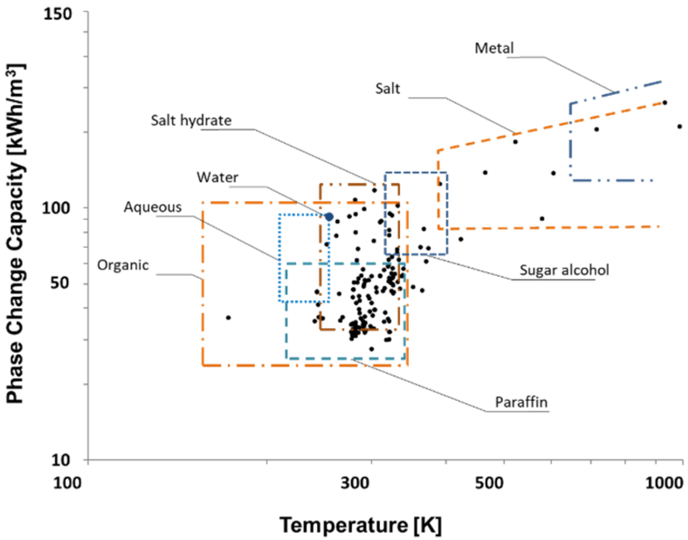
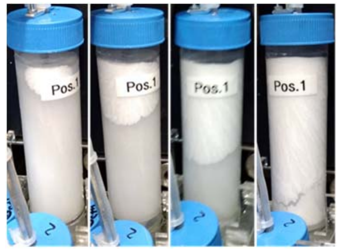
Phase Change Materials (PCM)





Material Analysis

Stability Tests



Compatibility Tests

Production

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Latent Energy Storage: Properties

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Thermo-physical

Melting Temperature (Thermocouple)

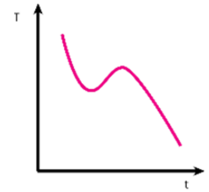
ENTHALPY (DSC; CALORIMETERS); Density (Hydrometer, Buoyancy)

Heat Flux (DSC + sapphire)

Thermal Conductivity (THB)

Segregation (T, Enthalpy, Energy Balance (T & $\dot{m}$))

Kinetic



Supercooling (T (Thermocouple), t (Timer))

Crystallization growth rate

Chemical & Physical Stability

Corrosion rate (weight)

Swelling ratio, Extraction Content (weight)

Diffusion

COMPOSITION (KFT)

Sharma, S. D., & Sagara, K. (2005). Latent Heat Storage Materials and Systems: A Review. International Journal of Green Energy, 2(1), 1–56. https://doi.org/10.1081/GE-200051299

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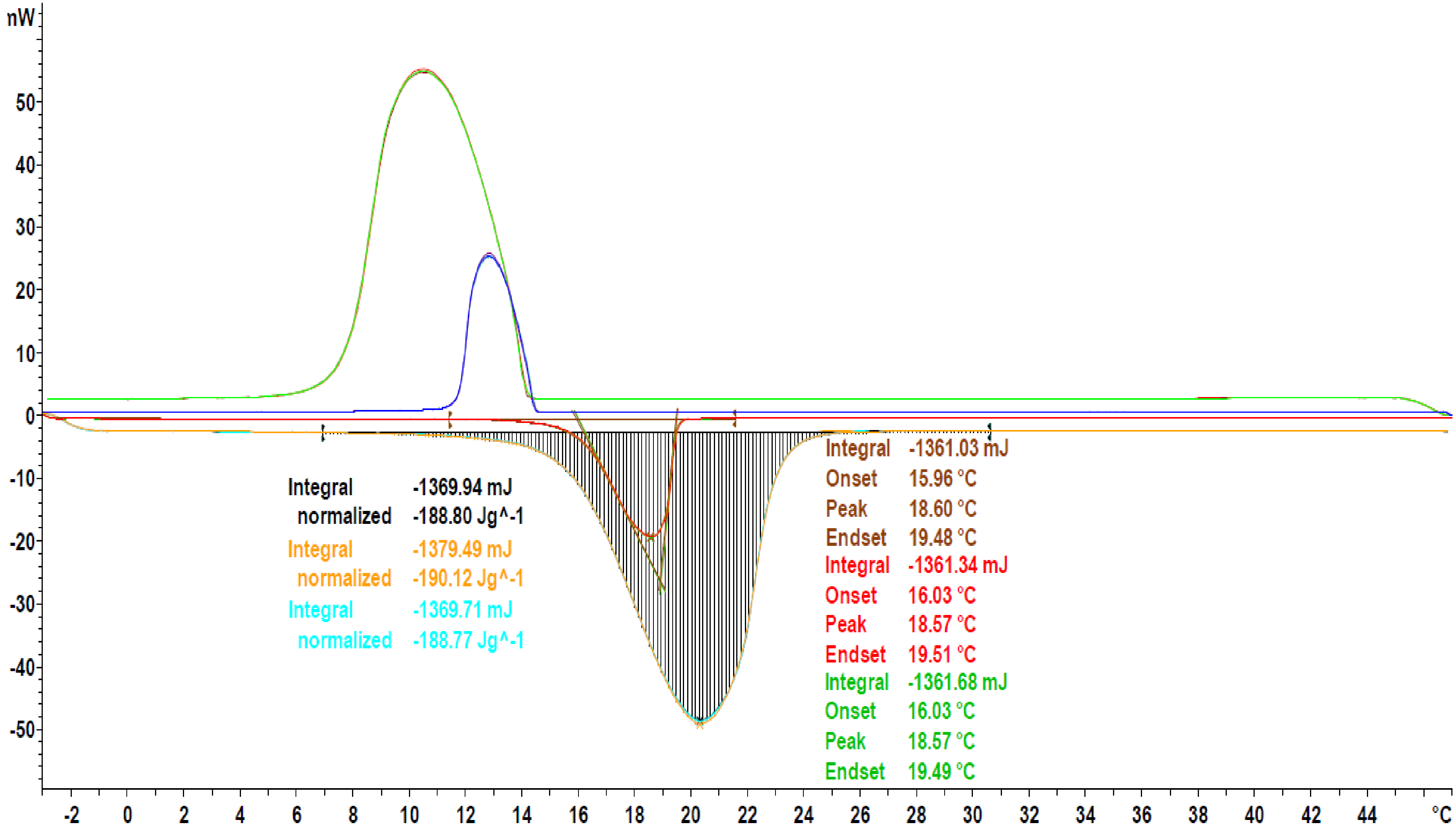
Latent Energy Storage: DSC



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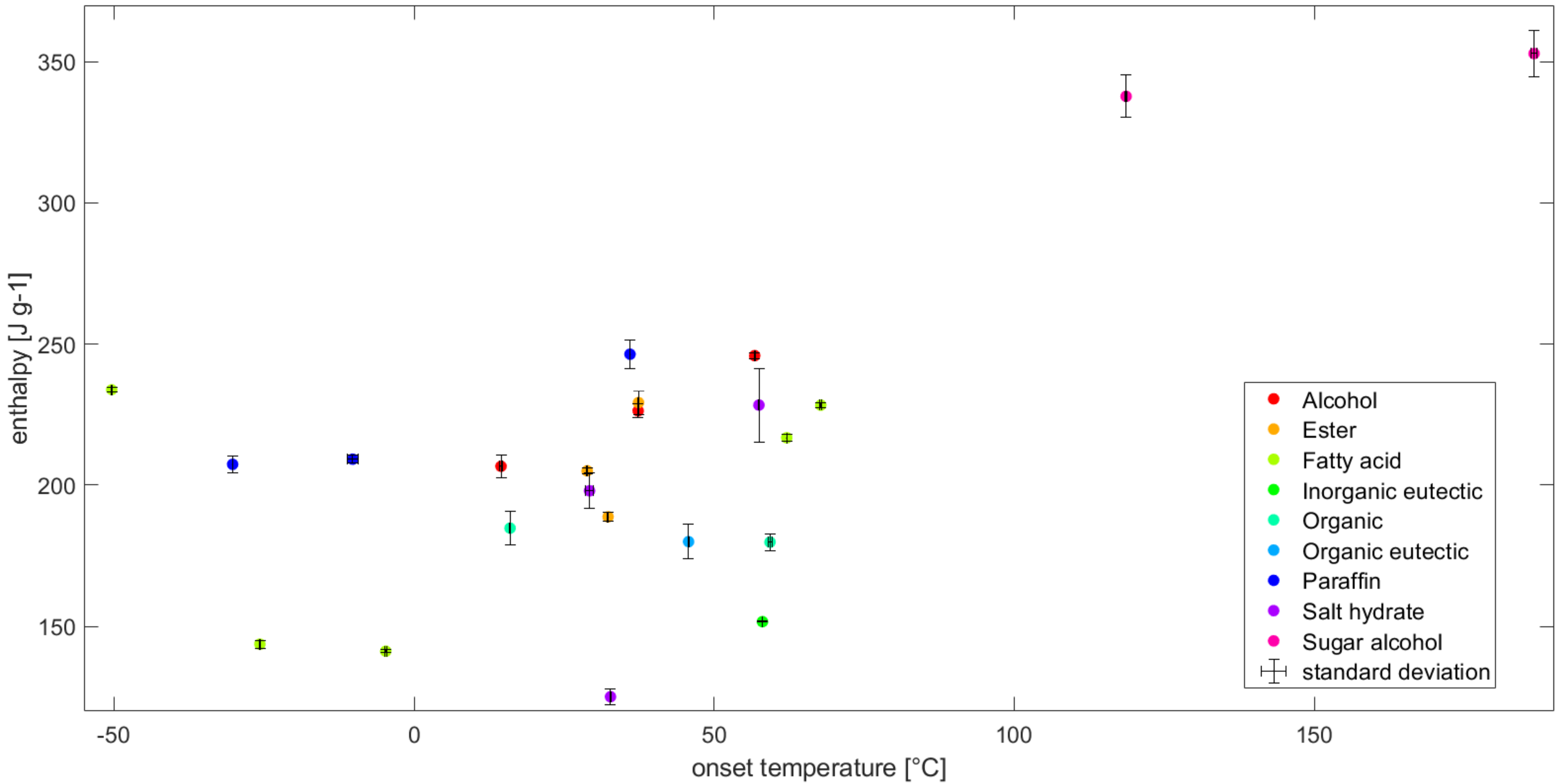

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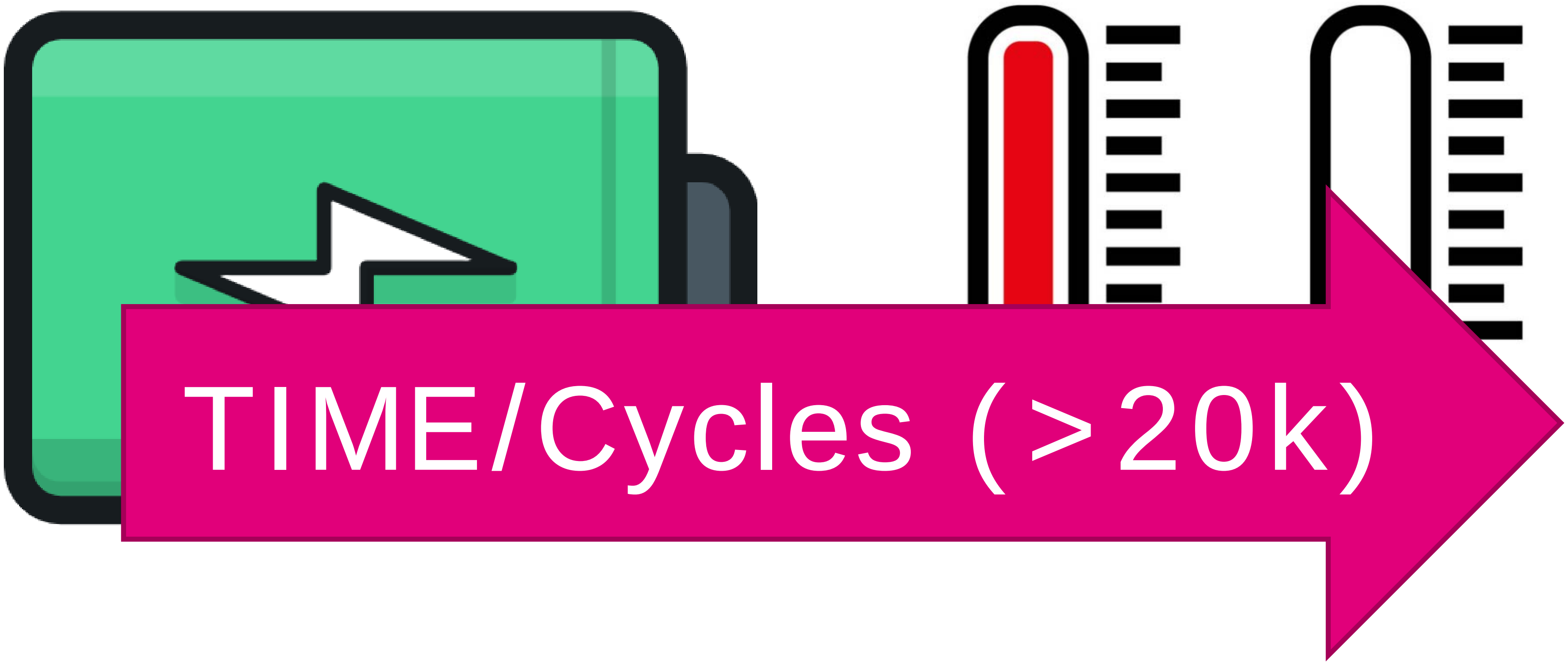
Latent Energy Storage: Properties



Enthalpy
J/g or kWh/m^3

Phase change temperature
Melting and solidification

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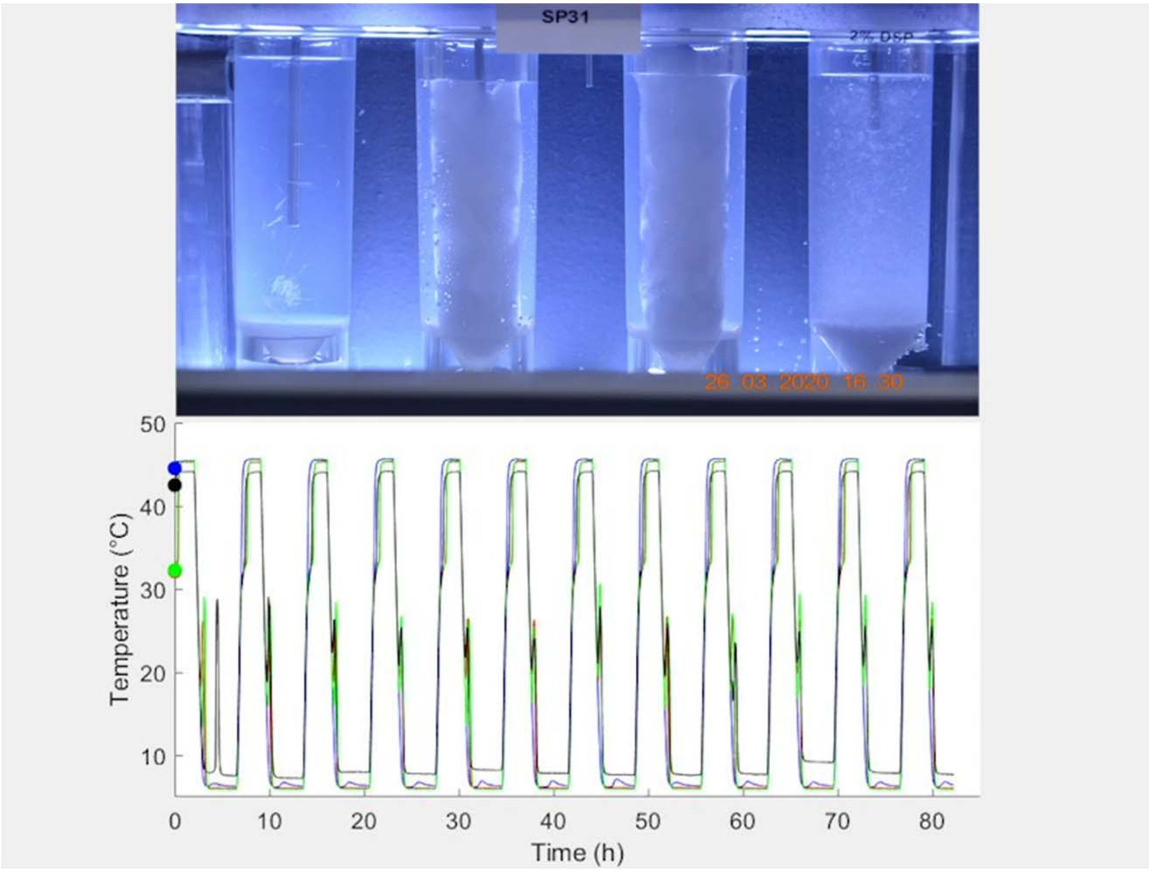
Latent Energy Storage: Thermal Cycling



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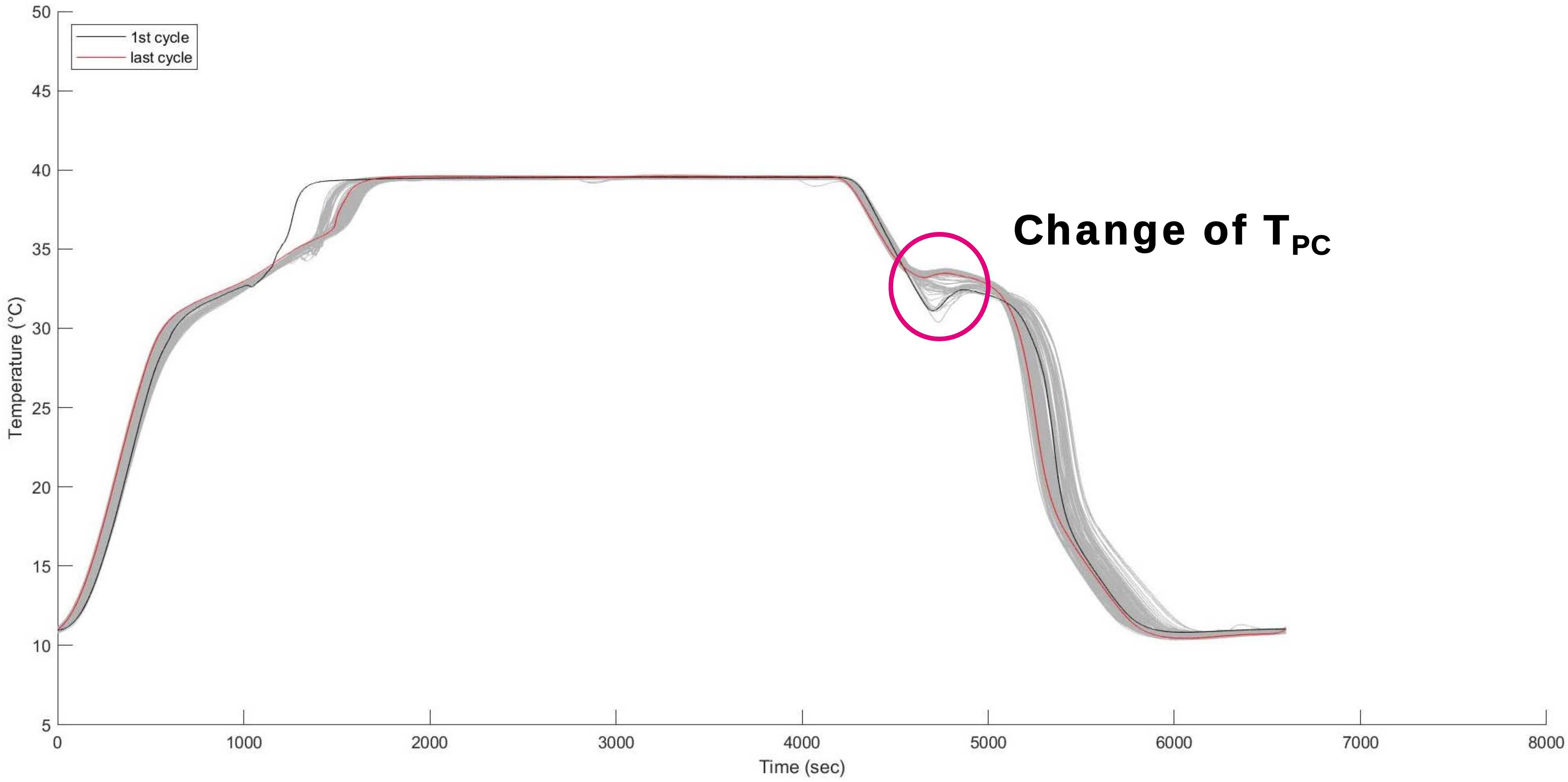
Latent Energy Storage: Thermal Cycling



Assessment before / after cycling:

- **Enthalpy**
- **Phase change temperature**

Challenges with DSC

- **Sample manipulation required**
- **Very small sample amount**
- **Sampling -> inhomogeneous mixtures after cycling**

=> alternatives to DSC

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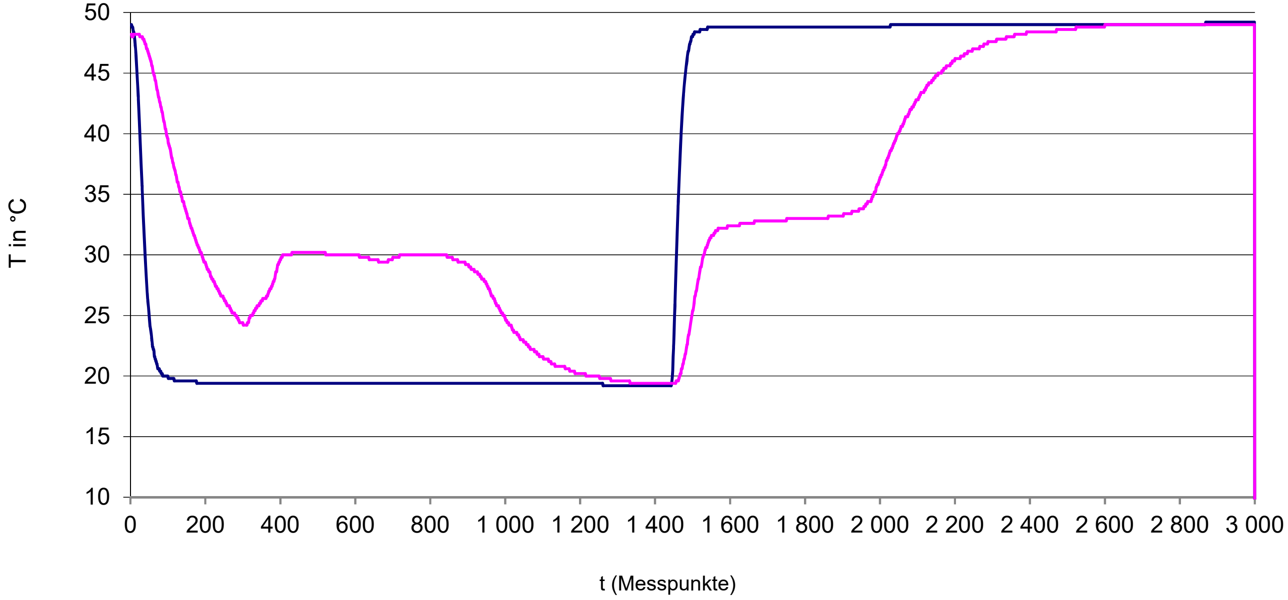
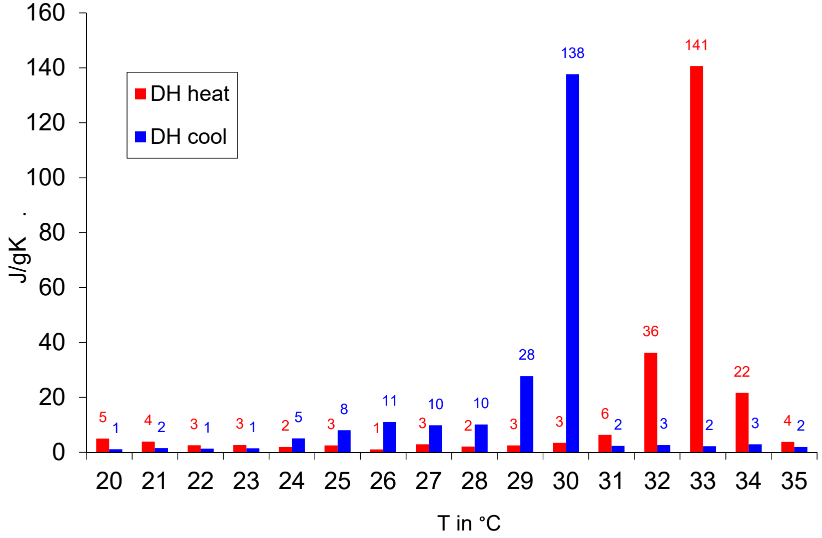
Latent Energy Storage: 3-layer calorimetry





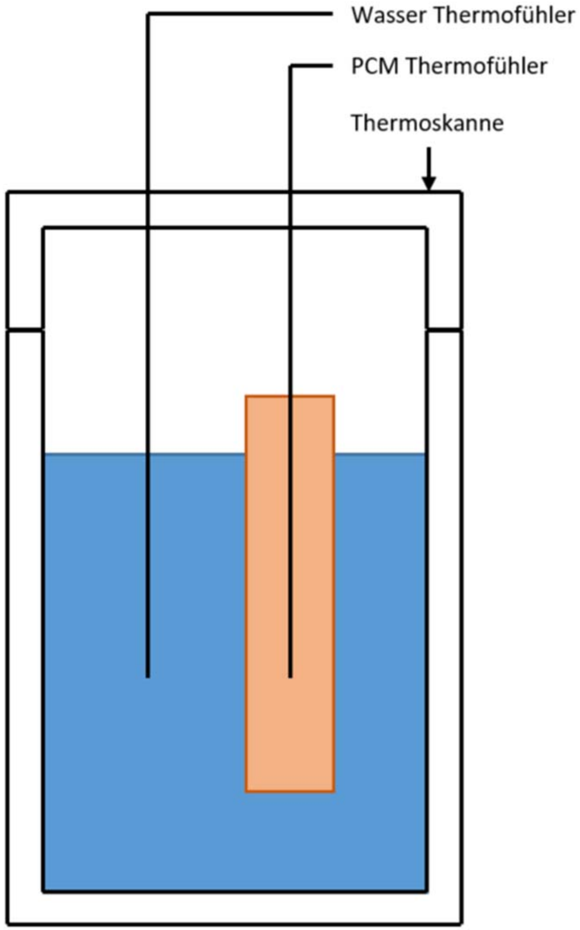
Enthalpy

Heating **240 J/g**

Cooling **227 J/g**

Challenges with 3LC

- Confined sample geometry
- Commercial solution
- Long Measurement time


Wasser Thermofühler
PCM Thermofühler
Thermoskanne

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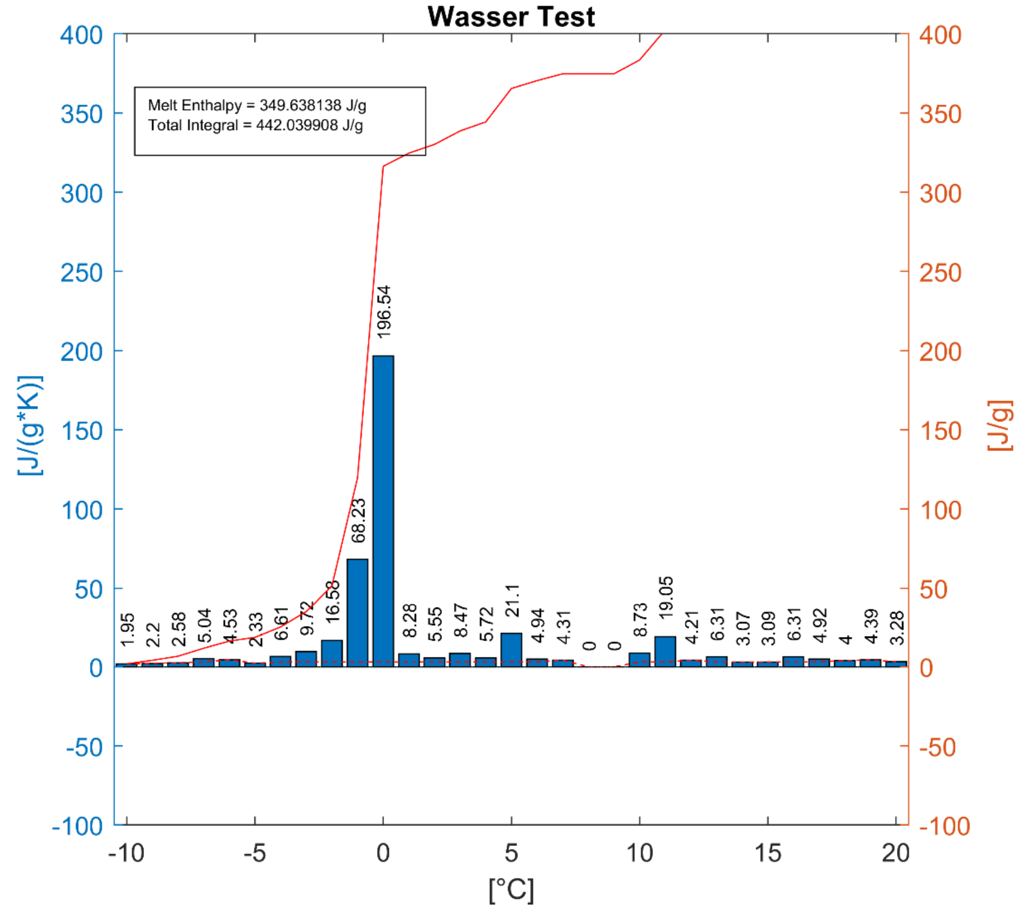

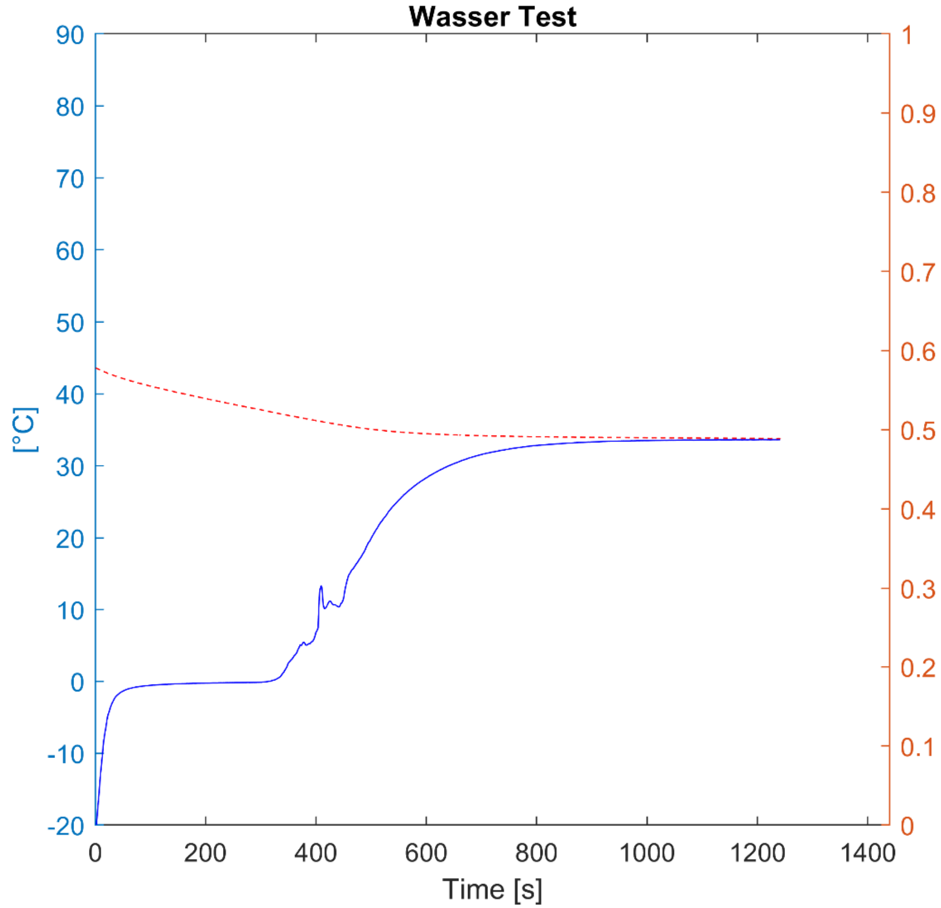

Challenges with Drop calorimetry

- Calibration substances
- Positioning of thermal probe

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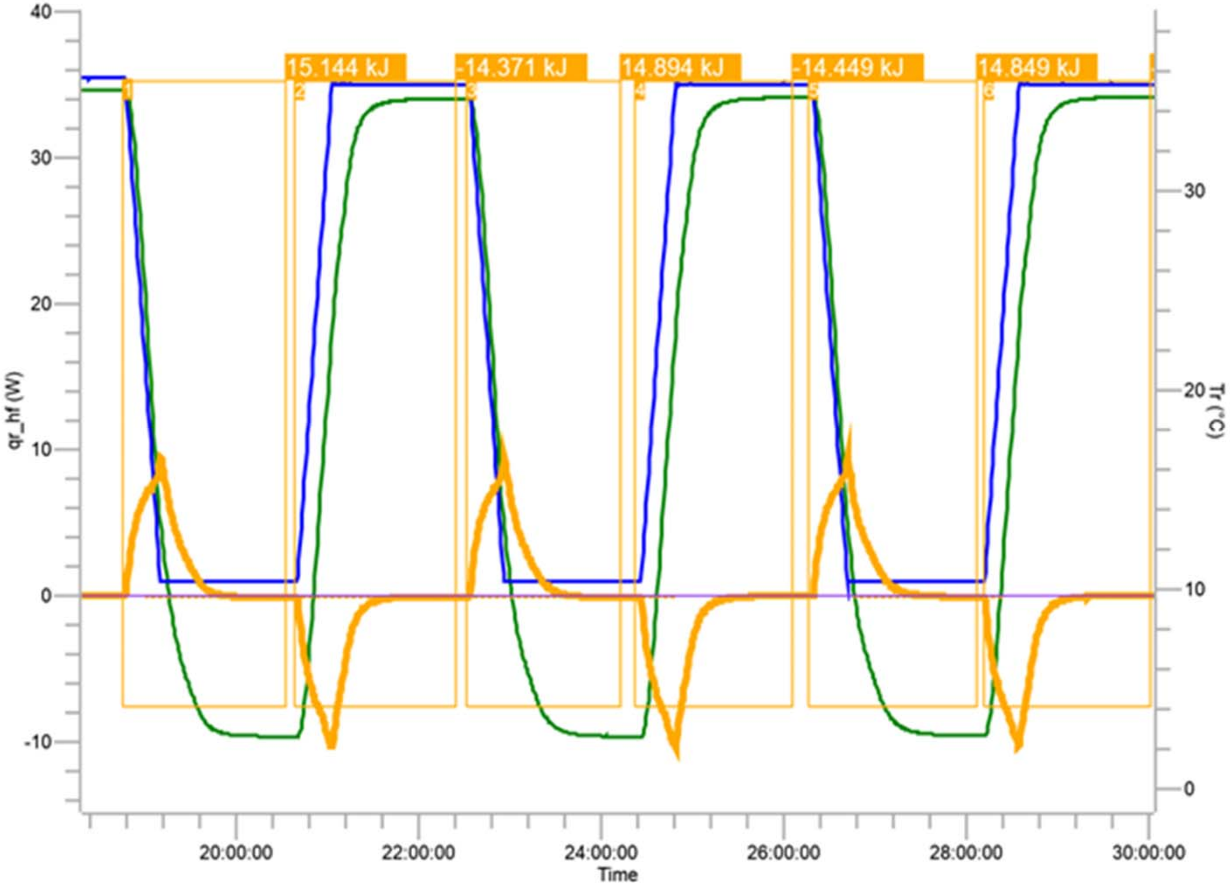
Latent Energy Storage: Easymax HF Cal



Challenges with HF Cal

- Bulk crystallization
- Heat Transfer Medium
- No complete insight in calculation software
- «Noise»

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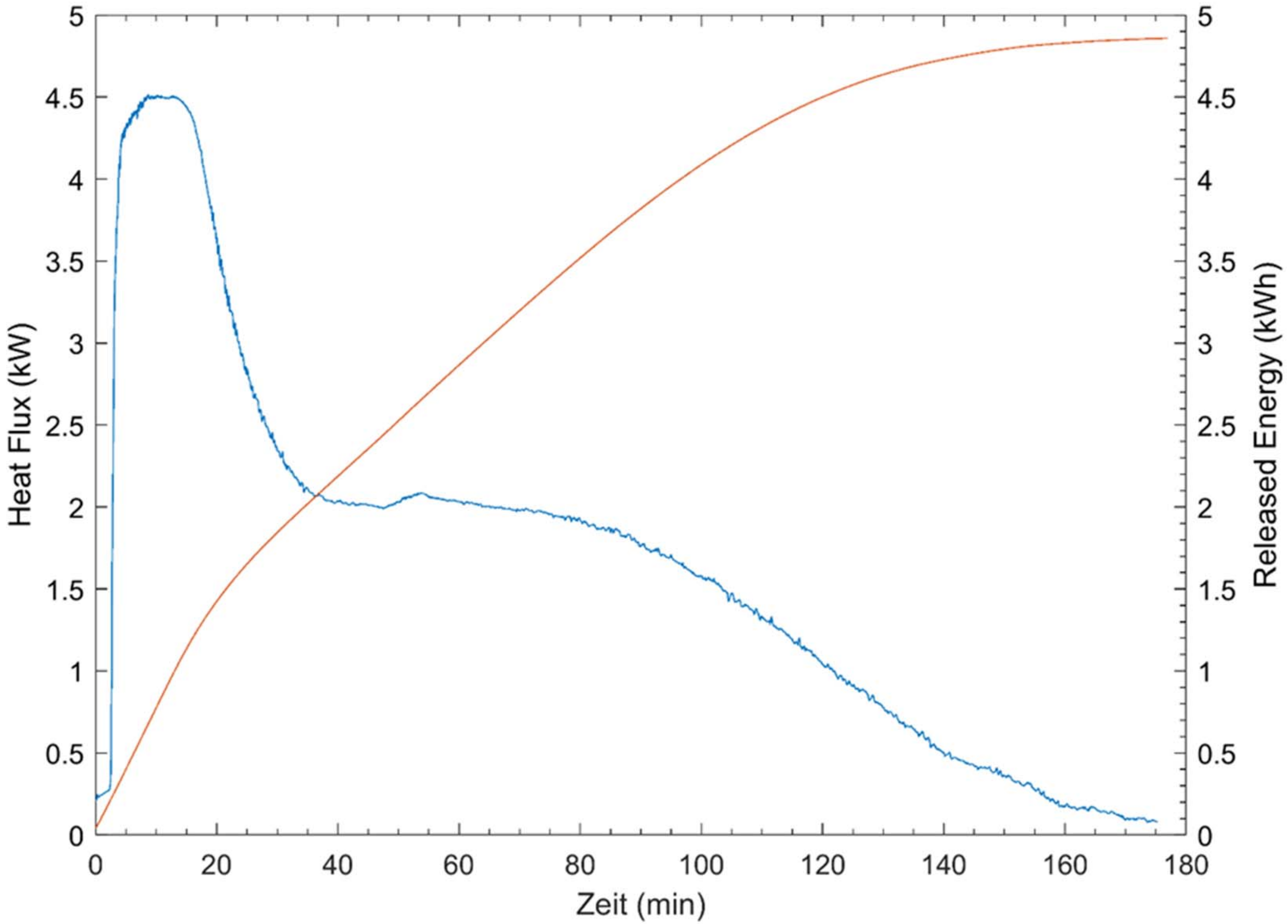
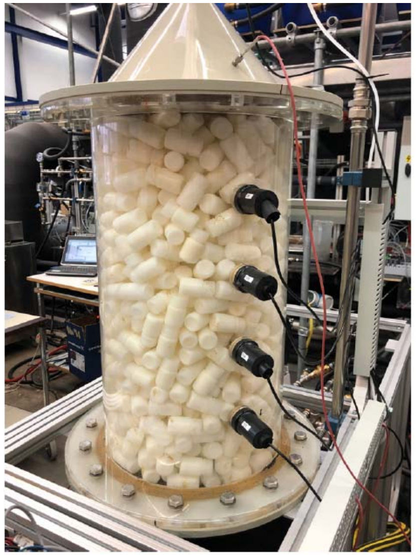
Latent Energy Storage: Online measurements





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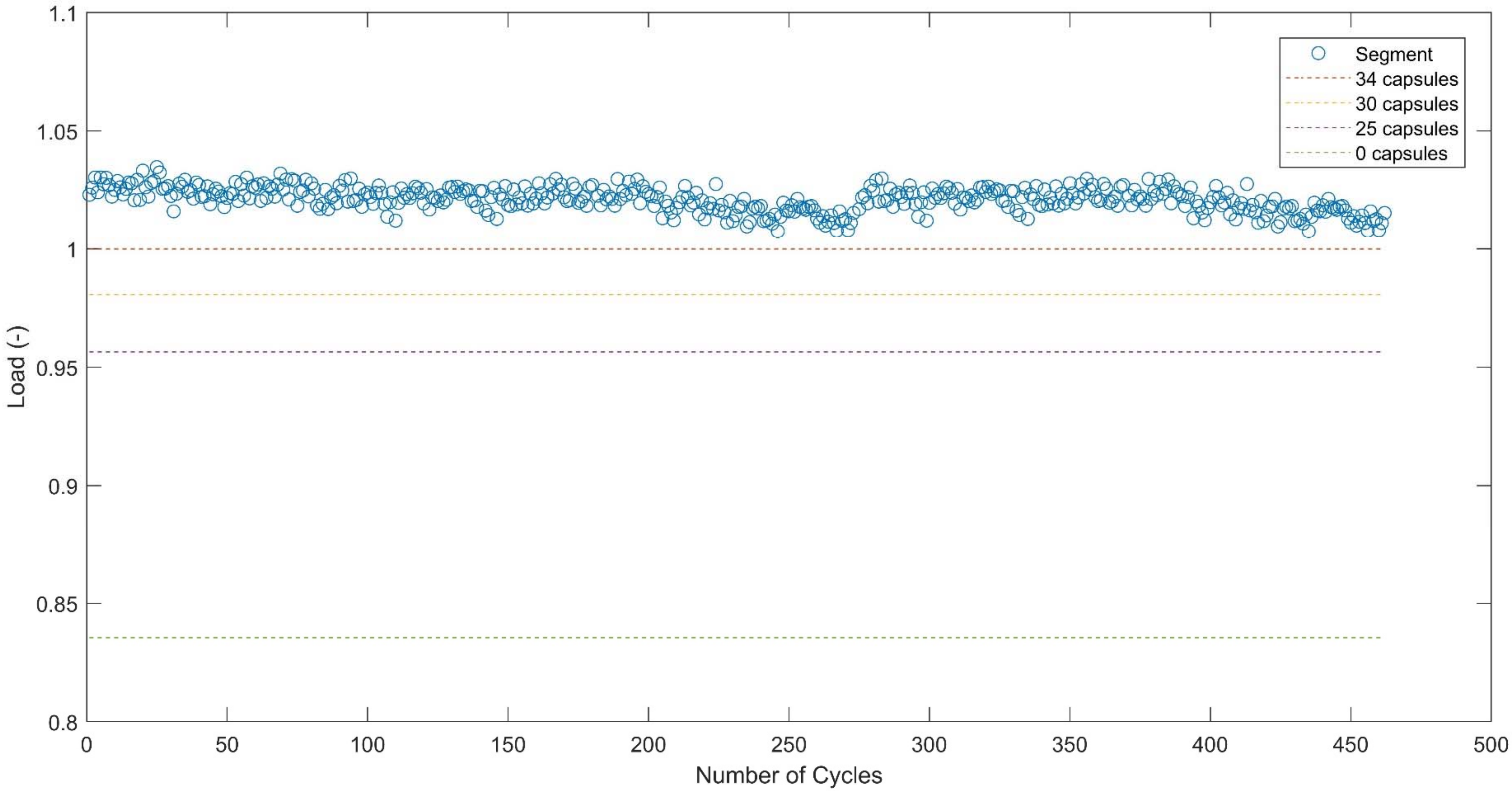
Latent Energy Storage: Online measurements



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Conclusions

- **Complementary calorimetry measurements**
- **Precise and accurate measurements**
- **Less sample handling**
- **Environmental conditions crucial**

Thank you for your attention!

Questions?