Analysis of the thermal management of a high-temperature methanol fuel cell using a latent heat storage

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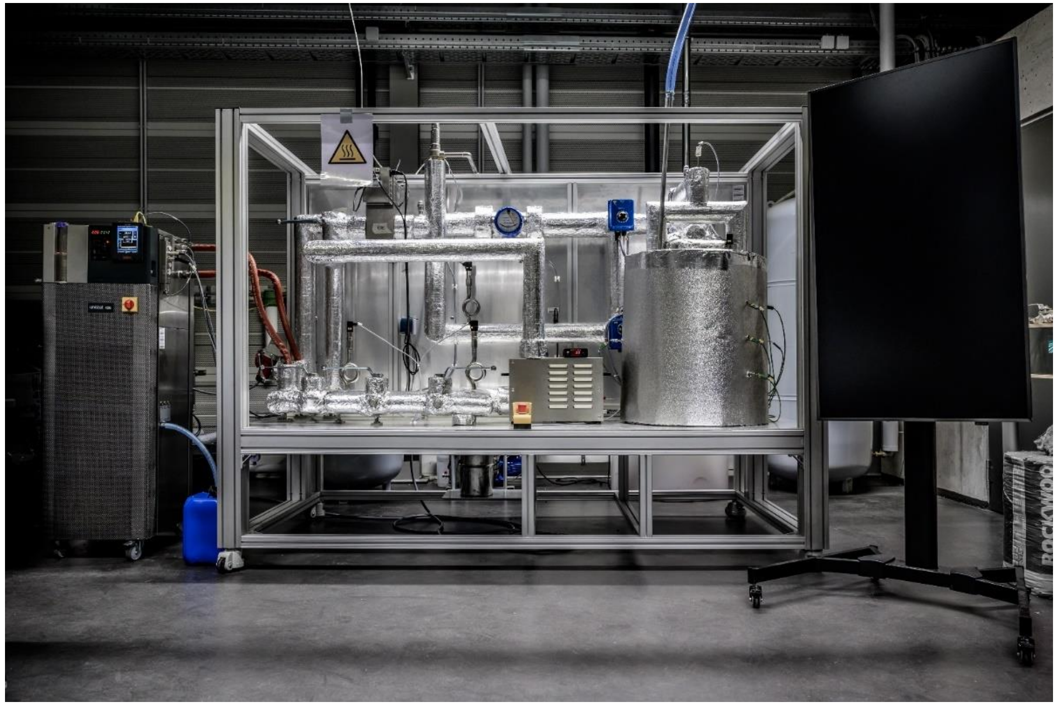

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Agenda

1. Motivation
2. Boundary conditions for the latent heat storage and the test rig
3. Project Overview
4. Experimental results
5. Proof of concept
6. Conclusion

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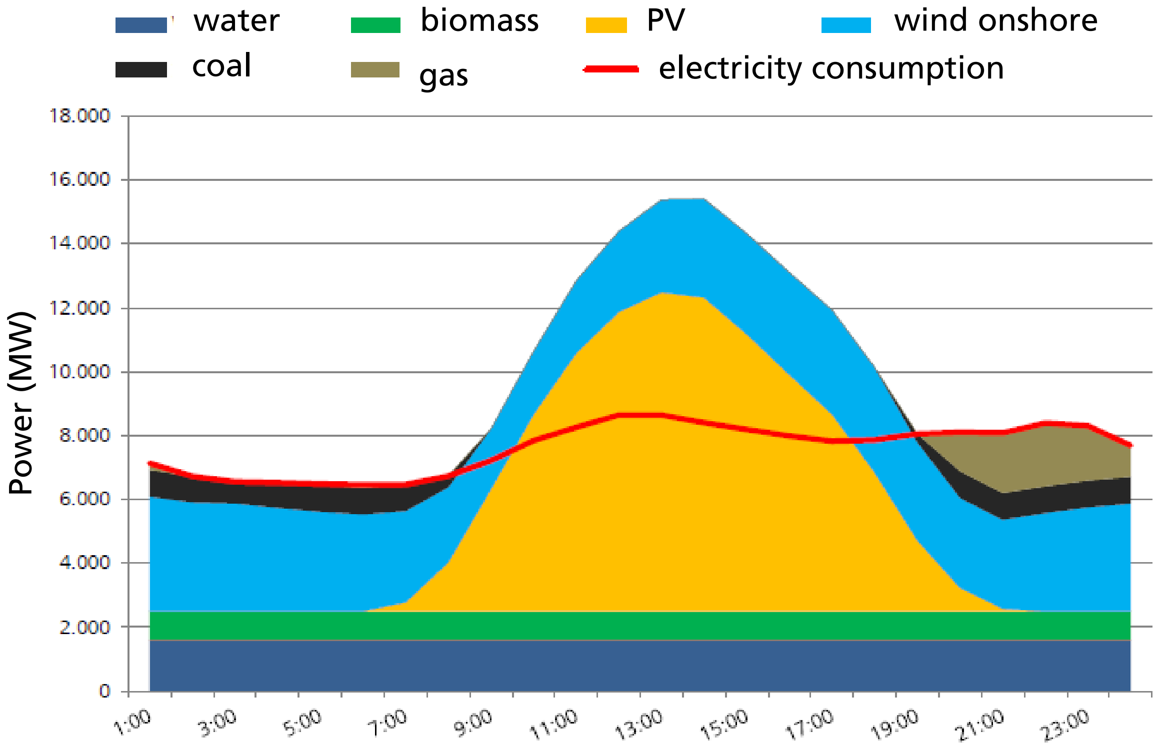
Motivation

[1]



[2]

Electricity for one day in May in Germany, 2023

Rising share of renewable enegies ➡ rising need of storage technologies

[1] https://www.agrarheute.com/energie/solar-windkraftanlagen-ideal-kombikraftwerk-459071, last access: 09.03.2021
[2] P. Rundel et al., „Speicher für die Energiewende“, Fraunhofer UMSICHT, 2013

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Project Overview

Boundary conditions

Supported by:

Federal Ministry
for Economic Affairs
and Energy

on the basis of a decision
by the German Bundestag

Part of the joint project „Decentralized decoupling of power generation and energy supply through onsite methanol production and methanol fuel cells (MFC)"

Latent heat storage

Charging Process

$T_{\text{waste heat}} = 433$ K

$P_{\text{fuel cell}} = 1.3$ kW

Discharging Process

$T_{\text{start up fuel cell}} = 373$ K to 403 K

$P_{\text{start up fuel cell}} = 1.05$ kW in 1 hour

high-temperature methanol fuel cell

Image: Siqens

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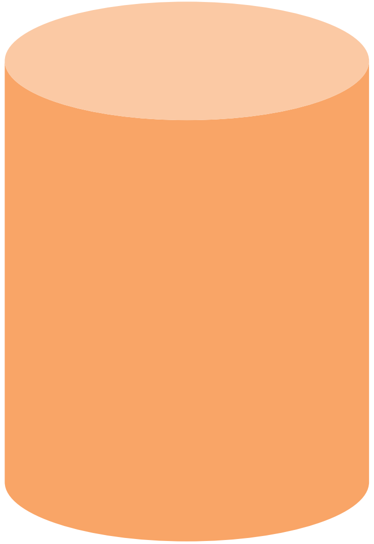
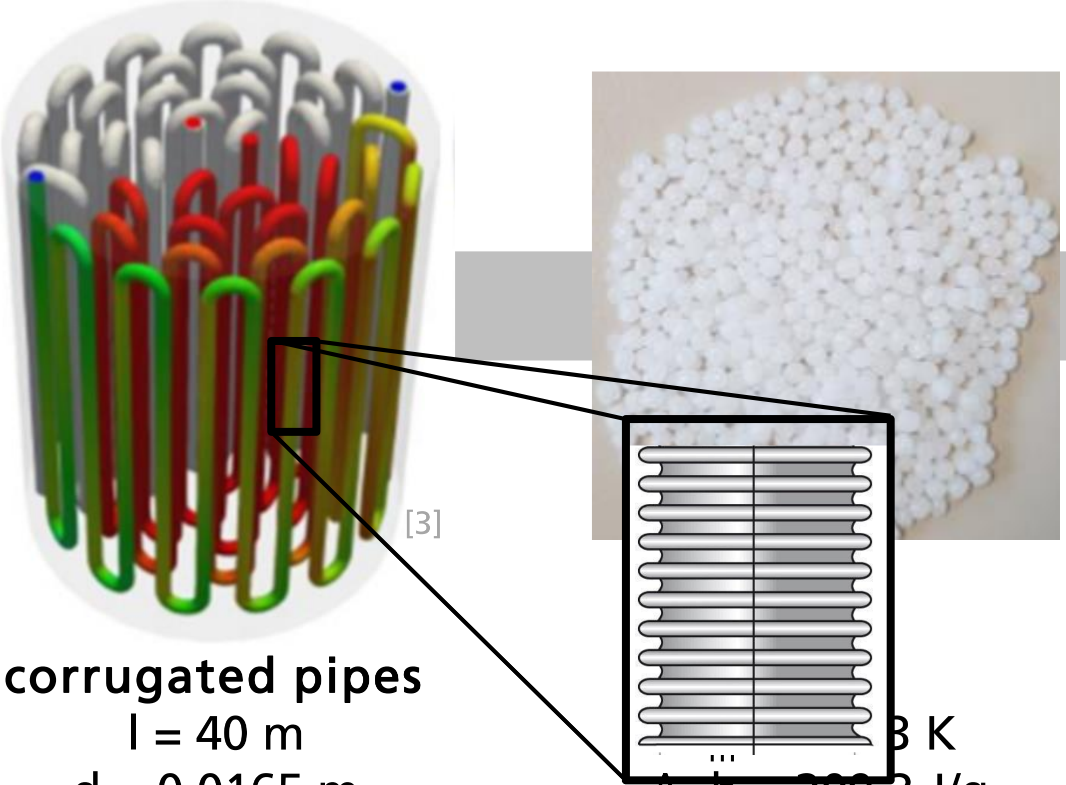
Project Overview

Storage Design

Tank design



heat exchanger design



corrugated pipes

l = 40 m

d = 0.0165 m

phase change material

3 K

$\Delta_m h = 209.3$ J/g

final storage tank

[3] L. Deinert et al. „Design and Performance Analysis of a Latent Heat Storage for the Operation of a High-Temperature Methanol Fuel Cell"
In: *Proceedings of the 14th International Renewable Energy Storage Conference 2020 (IRES 2020)* : Atlantis PressParis, 2021 (Atlantis Highlights in Engineering)

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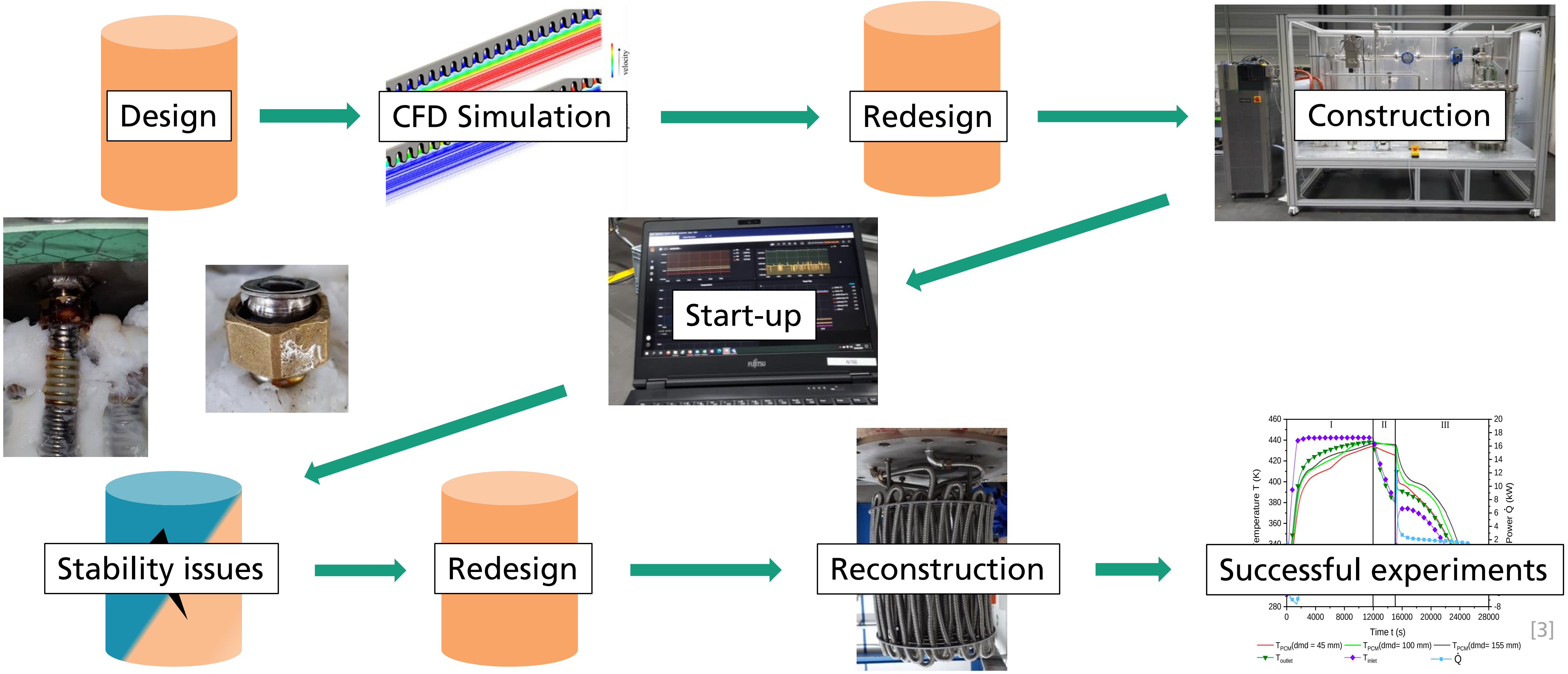
Final test rig

- $T \leq 523$ K and $p \leq 6$ bar
- $\dot{V} \leq 0.4\,\frac{m^3}{h}$
- Silicone oil as heat transfer fluid
- Meassurement equiment ($\dot{V}$, T and p) before and after the storage tank
- Variable flow paths

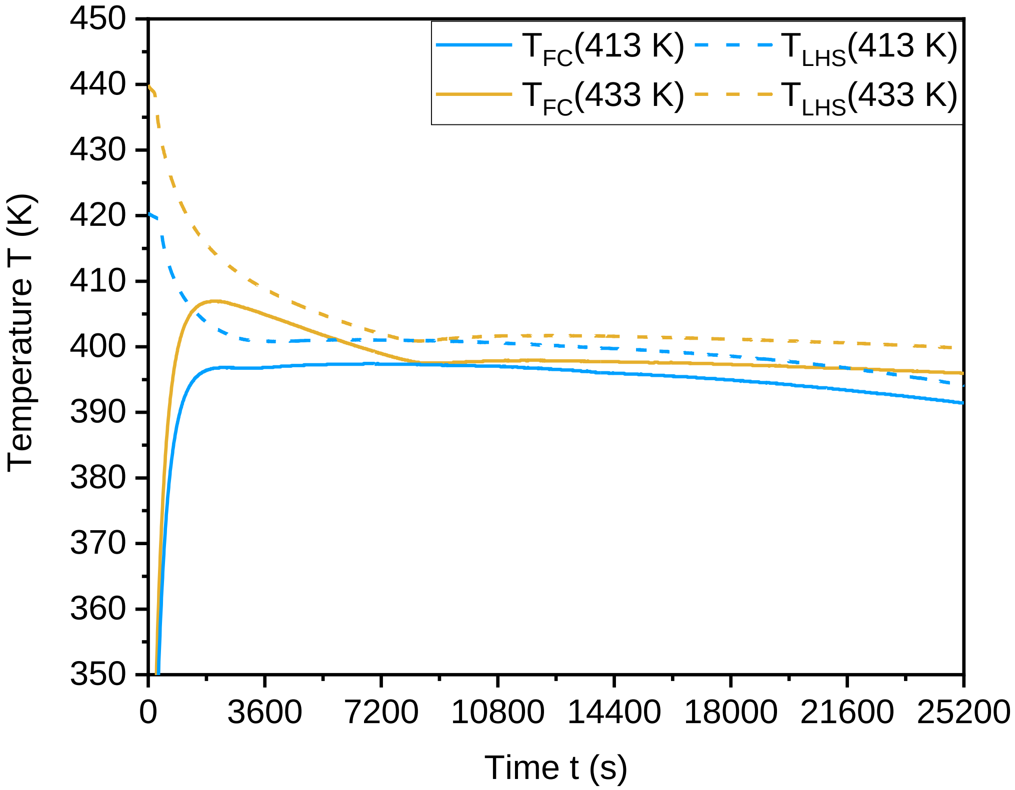
a) Thermostat
b) Connections fuel cell
c) Pump
d) Latent heat storage

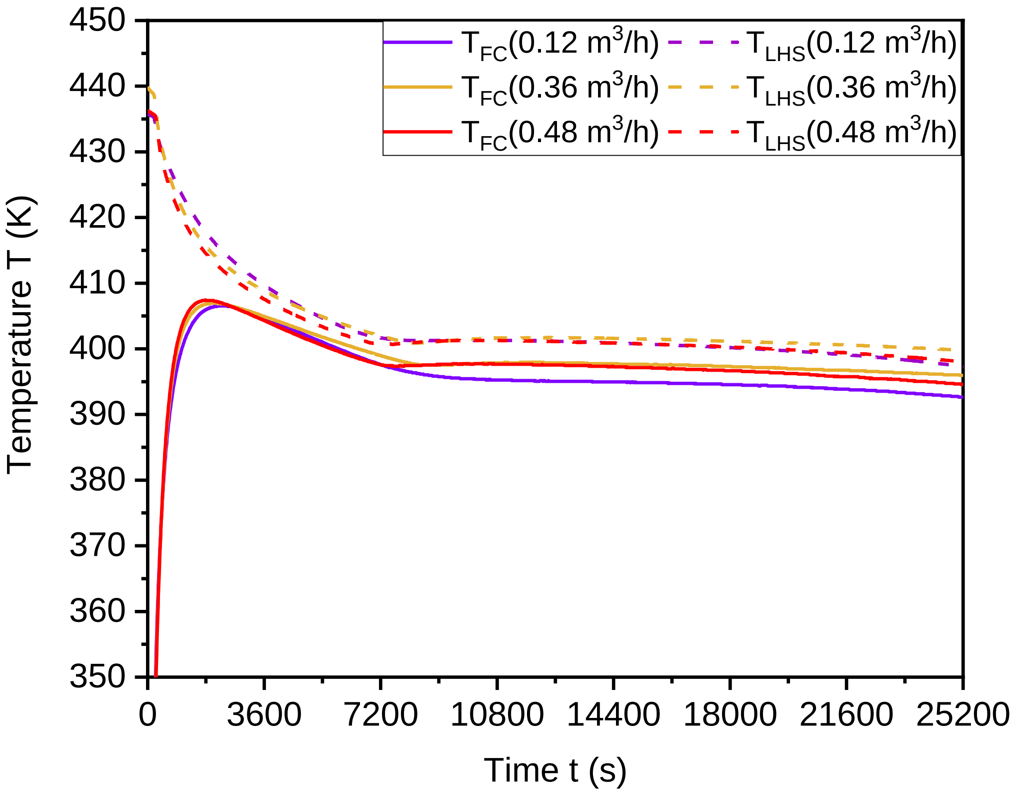
Optimization process



Experimental results

Preheating of fuel cell without start-up





Test conditions: $\dot{V} = 0.36\ m^3/h$ $\qquad T_{storage} = 433\ K$

- Rising volume flow leads to faster heating
- Higher storage temperature rises FC temperature in the beginning

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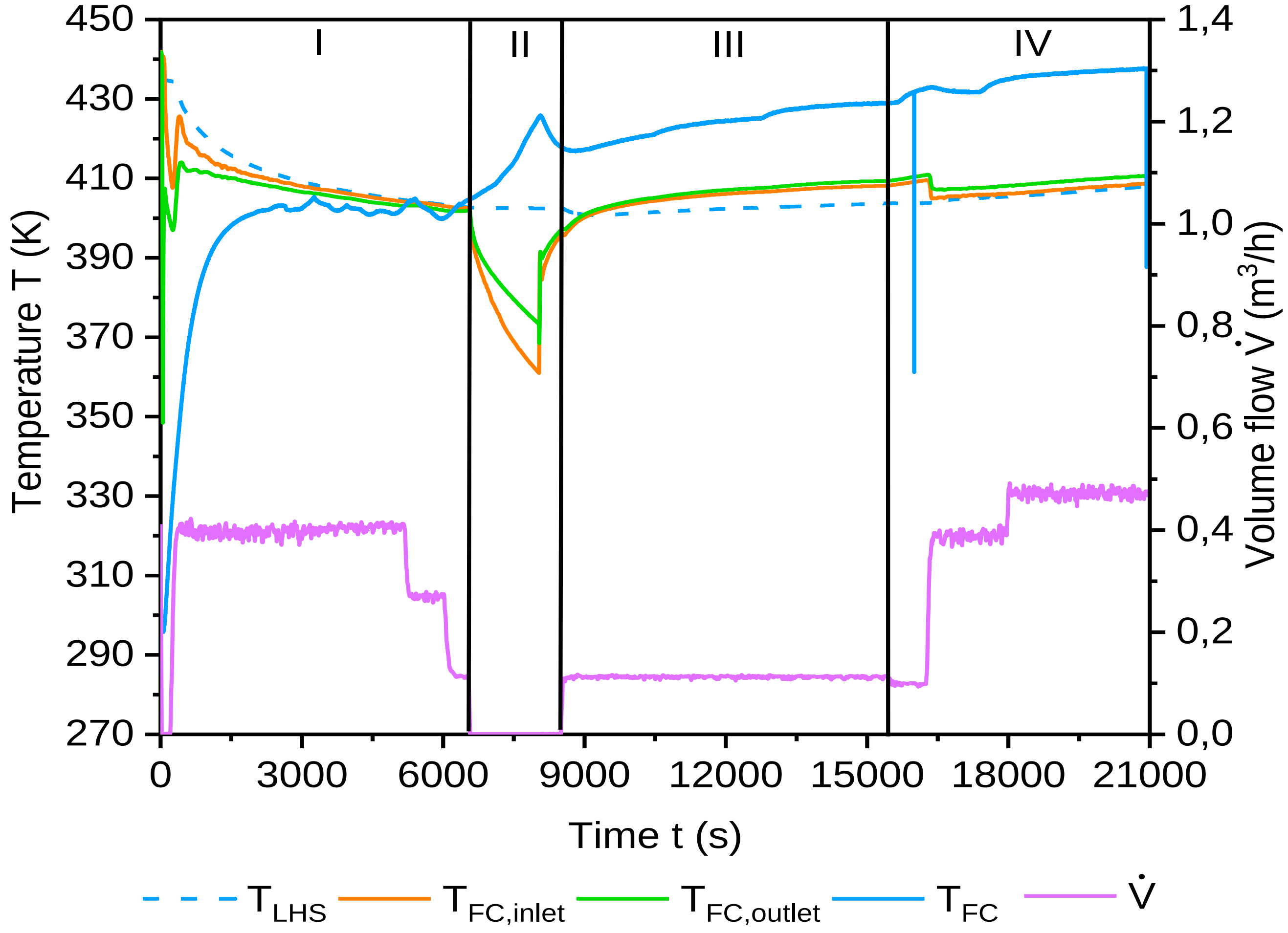
Experimental results

Proof of concept – preheating of FC and charging of LHS



(I)	Preheating FC Discharge LHS
(II)	Start-up FC
(III)	Operation FC Charge LHS
(IV)	Optimisation thermal output

➡ Proof of the feasibility to use LHS for the thermal management of FC

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Conclusion

- Development of latent heat storage to flexibilize the operation of a methanol fuel cell
- Feasibility and functionality of HDPE as a storage material is proven together with its cycle stability
- Determination of the optimum operation point of the storage in combination with the fuel cell
- Proof of concept with experiments in pilot plant scale

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Thermal Energy Storage

Thank you for your attention!

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