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High-temperature thermal energy storage with liquid metals

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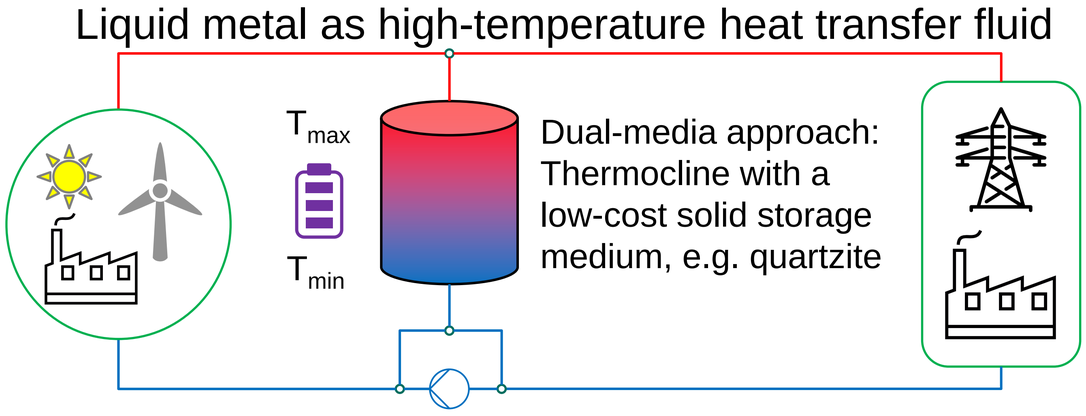
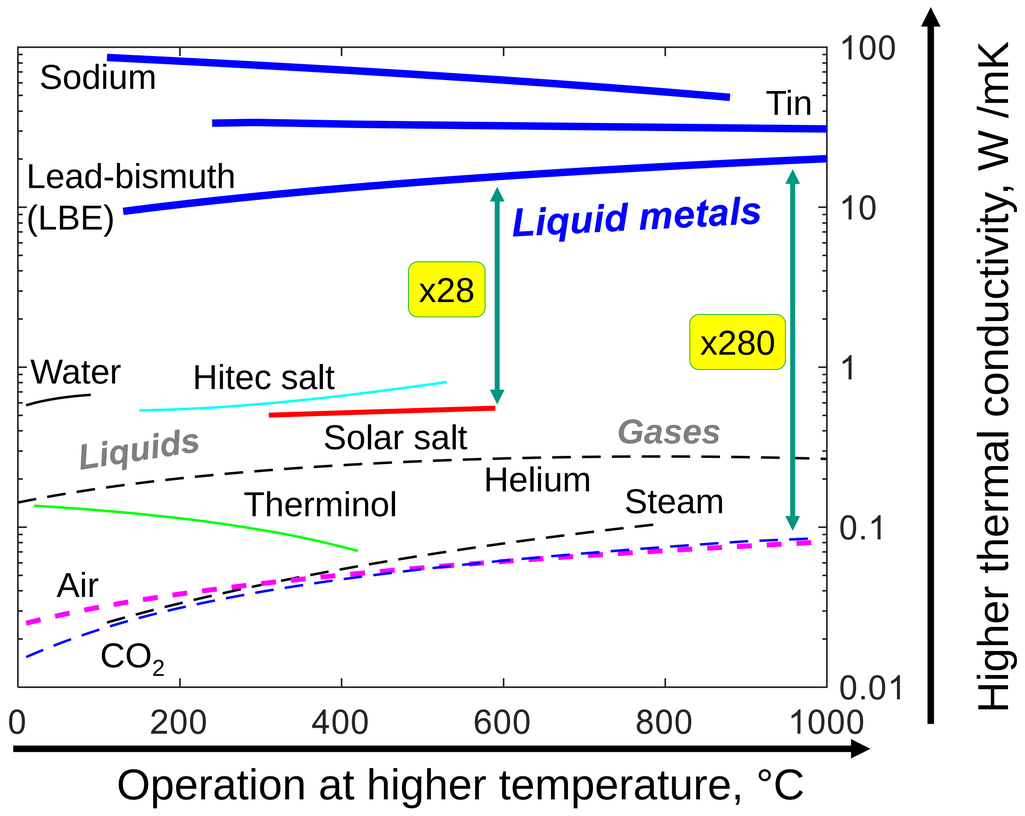
Motivation

Liquid metal as high-temperature heat transfer fluid



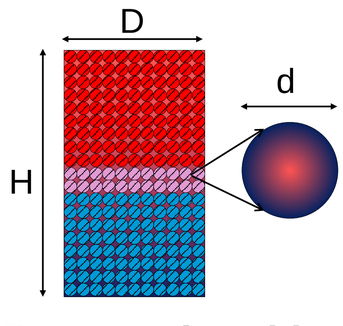
- Integration of renewable energies and residual heat from industrial processes
- (Power-to-) Heat-to-X applications at high temp., e.g. power or fuels (H_2)

Why liquid metals as heat transfer fluids?



- Stable liquids at high temperature and low pressure
- Efficient heat transfer due to high thermal conductivity
- Limitation: lower heat capacity → dual-media approach

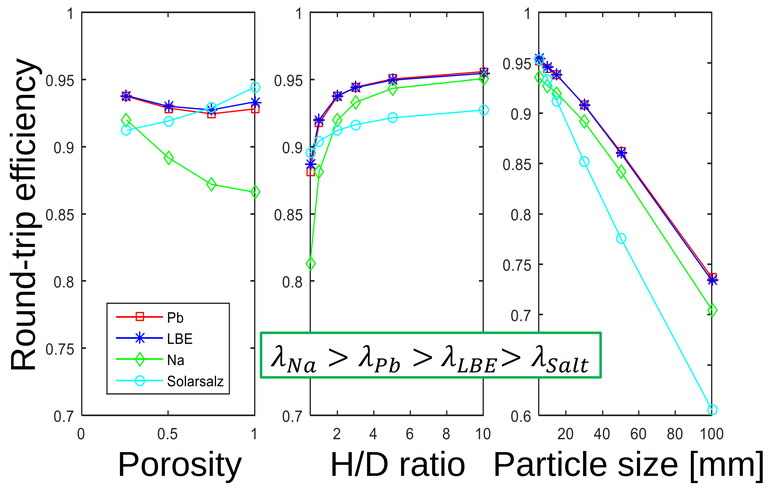
Optimization strategies for a LM-thermocline



Best results with:

- Low porosity
- Small particles
- Large H/D ratio
- Fast cycles
- Reduced stand-by

- Model validated with salt + oil data [1]
- Challenge for liquid metals: axial heat transfer in the thermo-cline region



Demonstration scale: NADINE initiative

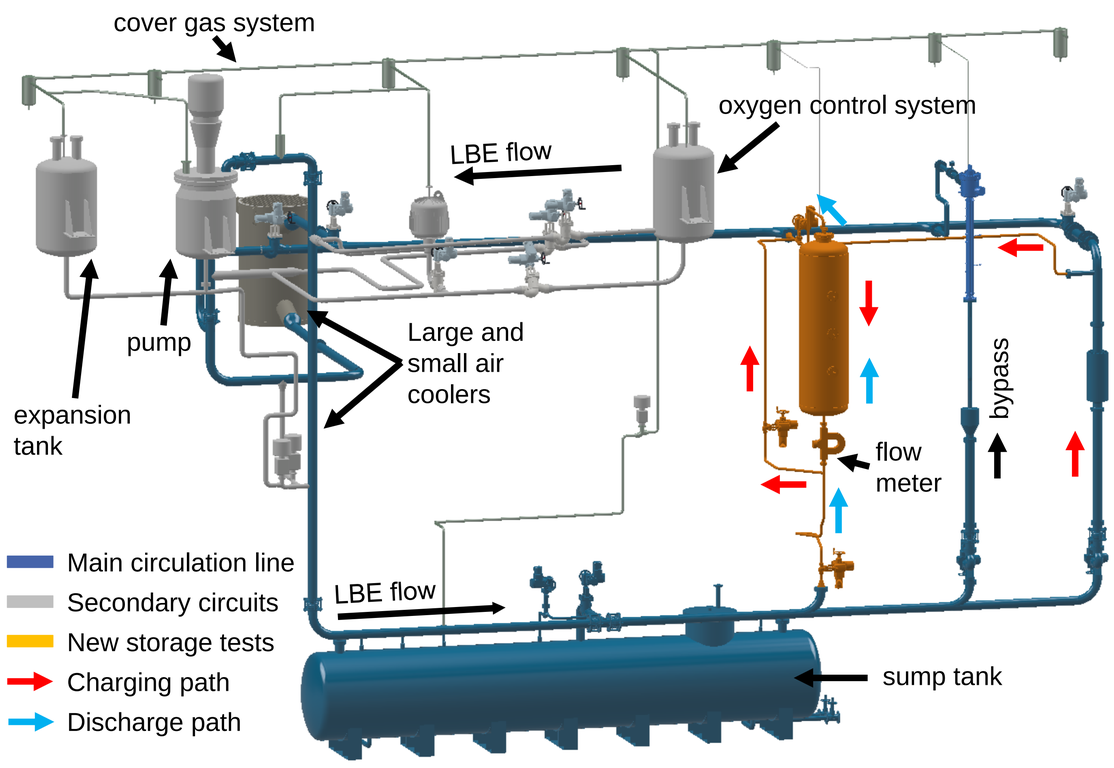
- National Demonstrator for Isentropic Energy Storage
- Joint initiative by University of Stuttgart, DLR and KIT
- Modular approach: liquid metals for highest temp. range

LM-module A: dual-media, large capacity

LM-module B: sodium only, rapid response

Support infrastructure: study of structural materials for T up to 1000°C (in sodium, lead, tin, …), instrumentation, …

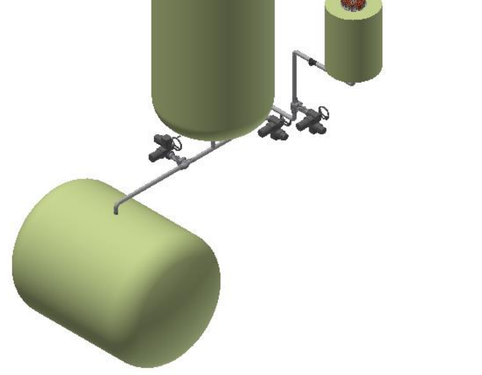
Proof-of-concept in an existing facility



- THEADES facility uses LBE (T=200-450°C), up to 500 kW
- Thermo-cline tests in laboratory scale: ca. 100 kWh_{th}

New experimental facility planned for demonstration of system and further test of key components

- Capacity: 1.0 MWh
- Power: 500 kW
- T = 350-750°C
- Uses lead and quartzite
- Key component: storage vessel H=3.2m, D=1.2m (3.7 m^3)
- Additional ports for installing components (heat exchangers, reactors) to be tested in flowing LM environment



[1] Niedermeier, K. et al (2018). Performance of molten sodium vs. molten salts in a packed bed thermal energy storage. *Applied Thermal Engineering* 141, 368-377

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