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 ($H_2$)

**Optimization strategies for a LM-thermocline**

- Model validated with salt + oil data [1]
- Challenge for liquid metals: axial heat transfer in the thermo-cline region
- Best results with:
  - Low porosity
  - Small particles
  - Large H/D ratio
  - Fast cycles
  - Reduced stand-by

**Proof-of-concept in an existing facility**

- THEADES facility uses LBE ($T=200-450^{\circ}C$), up to 500 kW
- Thermo-cline tests in laboratory scale: ca. 100 kWh_th

**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

**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

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

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

- Capacity: 1.0 MWh
- Power: 500 kW
- $T = 350$-$750^\circ$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

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