Institute of
Engineering Thermodynamics

Thermal Energy Storage Developments in the Department Thermal Process Technology

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Introduction

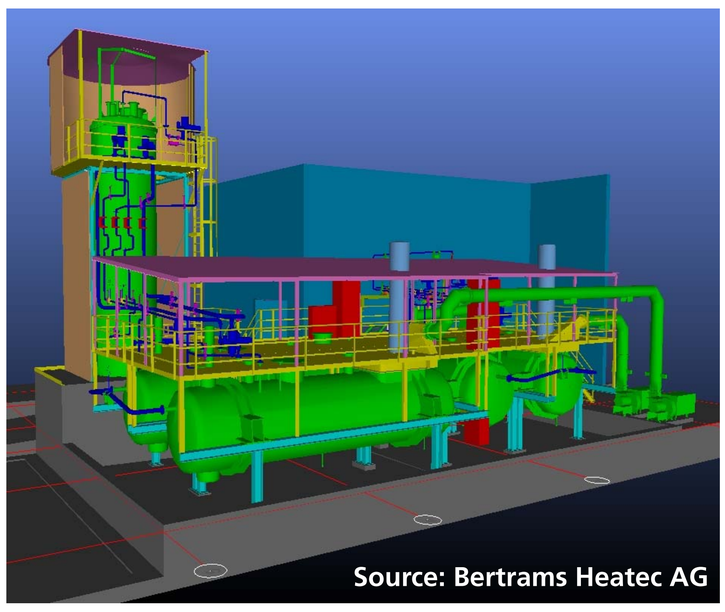
Thermal energy storage (TES) research is primarily concerned with the development of high-temperature heat storage for different applications:

- Concentrated solar power (CSP)
- Industrial process heat
- Improvement of flexibility of conventional power plants and combined heat and power (CHP)
- Advanced adiabatic compressed air energy storage (AA-CAES)
- Conversion of excess renewable electricity (Power-to-heat)
- Thermal management in vehicles

The developments cover the stages material development and characterization, component modeling, laboratory experiments, pilot plant tests and system integration.

Sensible heat storage in liquids

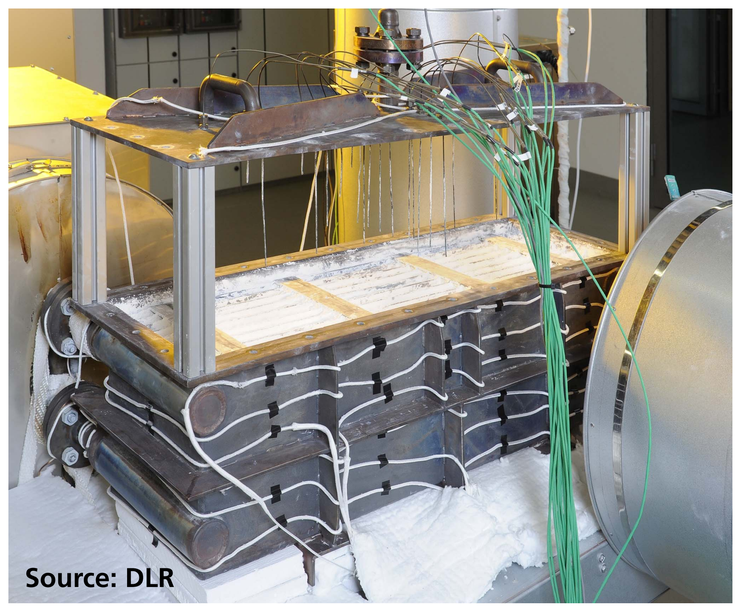
Commercial CSP plants utilize the two-tank molten salt concept. Research focuses on the development of alternative salt systems, alternative tank concepts (e.g., thermocline) and high-temperature component and material aspects. In cologne, a molten salt test loop is in a design stage.



Drawing of the planned Test Facility for Thermal Energy Storage in Molten Salts (TESIS) next to the DLR CeraStorE-Building

Thermochemical heat storage (TCS)

This technology is in an early development phase compared to sensible and latent heat storage.
TCS systems utilize reversible gas-solid reactions. Advantages include a high storage density, as well as the feasibility of loss-free long-term storage and heat transformation.



Indirectly heated test bed with 8 kWh capacity stored thermo-chemically in calcium hydroxide/calcium oxide

Sensible heat storage in solids

The regenerator storage is a direct contact concept with air or flue gas as a heat transfer fluid. Applications include AA-CAES and CSP plants such as power towers with air receivers.

Pilot-scale test-bed HOTREG at DLR Stuttgart

Latent heat storage

Latent heat storage systems utilize phase change materials (PCMs) for isothermal storage. Target applications include direct steam generation (DSG) CSP plants and industrial process heat.

PCM-Evaporator module in Carboneras, Spain (14 tones of sodium nitrate, T_m = 306 °C)

Summary

The diversity of fluids and storage materials results in several high temperature TES concepts. In addition, the DLR research group examines several novel materials and concepts such as sensible heat storage in natural stones, intermediate fluid concepts and movement of reaction beds.
High temperature TES is as a key and cross-cutting technology to:

- increase efficiency (e.g., process industry)
- add operational flexibility (e.g., conventional power plants)
- establish a link between power and heat applications (e.g., power-to-heat)
- enable dispatchability of CSP plants

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