Technology: Liquid Salt Storage

GENERAL DESCRIPTION

Mode of energy intake and output

Power-to-power (and heat)
Heat-to-power (and heat)
Heat-to-heat

Summary of the storage process

In liquid salt storages, thermal energy is stored by heating and cooling an anhydrous liquid salt melt, typically a mixture of nitrate/nitrite salts. Liquid salt storages usually consist of two flat-bottom tanks at a high and a low temperature level as well as one or several heat exchangers (Fig. 1, 2).Single-tank thermocline systems including filler materials are being examined as well, particularly for their potential cost reduction. In dual-tank systems, during charging or heat absorption, liquid salt is taken from the cold tank, heated via a heat exchanger or electrically, and fed into the hot tank. During unloading or heat extraction, liquid salt is taken from the hot tank, cooled via a heat exchanger, and fed into the cold tank. During this process, superheated steam is usually generated and then fed into a turbine to generate electricity. Therefore, loading and unloading changes the fill levels of both tanks, but their respective temperatures remain constant. Depending on the employed salt, possible working temperatures range from 170-560 °C for nitrate and nitrite salt mixtures. In practical operation, the temperature must never drop below the crystallisation point. The maximum operating temperature is limited by various factors such as corrosion, salt decomposition, and salt vapour pressure. Liquid salt storages already find commercial application in solar thermal power plants. New multi tank designs for industrial purposes are on their way to commercialisation.

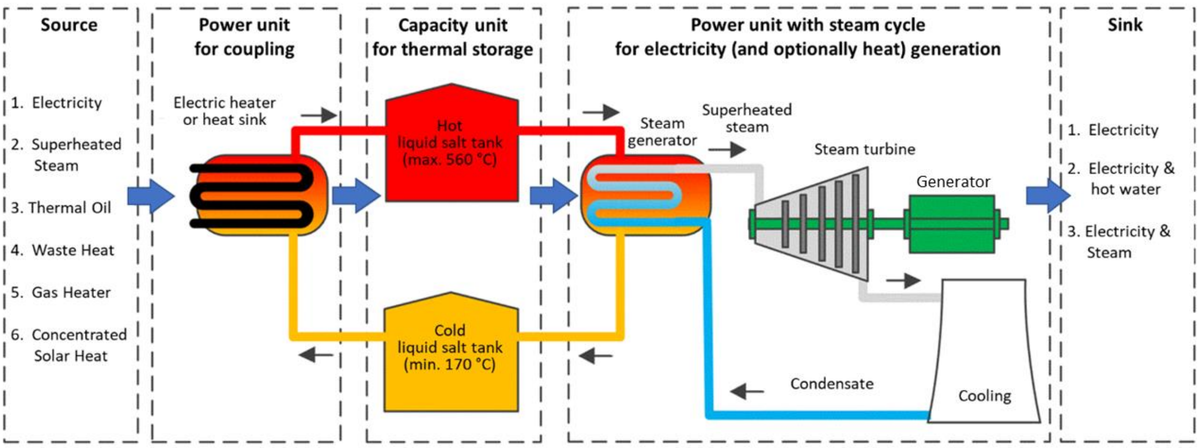

Figure 1: Options for using liquid salt storage technology with three subsystems: Power unit for charging (left); capacity unit for storage (centre); power generation unit for discharging (right) (source: DLR)

Figure 2: Liquid salt storage in a solar thermal power plant (source: Andasol 3)

Focus on provision of power or energy

Provision of power and energy on power plant scale

Suitable fields of application

Solar thermal power plants as well as potential new applications: industrial process heat, storage of electricity (also retrofitting of conventional power plants)

Technology-Readiness-Level (TRL)

4-9

State of development/commercial availability

The technology has been commercially used in solar thermal power plants since 2010 (TRL 9). Topics with demand for R & D (TRL 4 and above) are cost reduction (e.g. single-tank storages), increasing efficiency (e.g. higher temperatures) and reliability (e.g. qualification and standardisation of salt components, process improvement, service life issues)

TECHNICAL SPECIFICATIONS

Specific energy storage density	kWh/m³	kWh/t
	75-200	40-110
Specific power density	kW/m³	kW/t
	Depends on heat exchanger	
Typical/feasible storage size	MWh_{out}	MW_{out}
	Up to 5 GWh_{th}	Up to 300 MW_{th}
Storage efficiency	95-99 % (Heat-to-heat)	
Storage duration	Hours-days, typically 8 hours	
Response time	Minutes	
Service life (maximum)	Cycles	Years
	> 10,000	> 20
Loss per time in %	About 1 % of the storage's capacity per 24 h	

Notes on these specifications

The specific performance of latent heat storages may be significantly increased through appropriate measures. Current research indicates that 250-450 kW/m³ (or 160-250 kW/t) may be achieved. Such high-performance storage units would tend to be used for minute to day storage.

ECONOMIC SPECIFICATIONS

Investment cost per kW

Depends on the application

Investment cost per kWh

20-70 €/kWh_{th}

Operating and maintenance cost (based on investment/kW and kWh)

About 1 % of overall investment per year

Notes on these specifications

The necessary investment per kW of energy provided depends largely on the type and size of the power components, these depending on the application (Fig. 1).

The investment cost per kWh for the storage unit depends largely on the temperature spread.

For further information, see

- G. Glatzmaier (2011) Developing a Cost Model and Methodology to Estimate Capital Costs for Thermal Energy Storage, Report NREL/TP-5500-53066, https://dx.doi.org/10.2172/1031953
- T. Bauer, C. Odenthal, A. Bonk (2021) Molten Salt Storage for Power Generation, Chemie Ingenieur Technik, 93 (4), 534-546. https://doi.org/10.1002/cite.202000137
- J. Dersch, et al. (2021) Blueprint for Molten Salt CSP Power Plant, Report to project grant # 0324253A, https://elib.dlr.de/141315/