Next-Gen Molten Salt TES Technology for Advanced Carnot Batteries

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Large-scale molten salt thermal energy storage (MSTES) is a commercial technology in the concentrating solar power (CSP) application with the worldwide installed capacity of about 21 GWh_{el} and an average storage duration of 7 h [1]. The major advantages of MSTES include the medium itself (inexpensive, non-toxic, non-pressurized, non-flammable), the possibility to provide high temperature superheated steam for power generation and large-scale commercially demonstrated storage systems (up to about 4 GWh_{th}) as well as separated power components (e.g., heat exchangers) and capacity components (tanks) for constant temperature and power levels during charge and discharge [1]. MSTES could not only be utilized in CSP but also new fields of application, e.g., industrial processes, conventional power plants and electrical storage (e.g., power-to-heat-to-power (PtHtP) systems - Carnot battery (CB)) [1], [2].

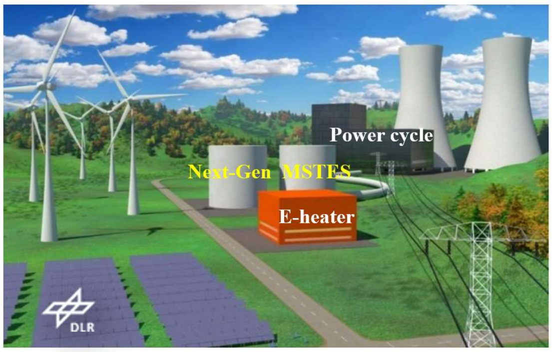

Fig.1: Advanced CB with electric storage efficiency over 50% using next-gen MSTES.

MSTES has been used in several large-scale Carnot batteries (CBs) under commercial demonstration, construction or development, due to its low storage costs (CAPEX of about 20 USD/kWh_{th}), safety and location independence, e.g., AES Andes 560MW Carnot battery in Chile [3], 20MW/240MWh Green Electricity Molten Salt Storage plant in China [4]. As shown in **Fig. 1**, these CBs generally consist of a molten salt e-heater to charge the MSTES system with low-cost excess renewable electricity from grid, a molten salt steam generator to provide superheated steam with the heat stored in MSTES and a power cycle (e.g., conventional steam Rankine power cycle SRPC) to generate the electricity (and heat) on demand [2]. Its round-trip electricity storage efficiency is mainly limited by the thermal-electric conversion efficiency of the power cycle (about 40% for the conventional SRPC) [2]. The MSTES systems in these CBs [2]-[4] mostly use Solar Salt ($NaNO_3$-KNO_3 60-40 wt%) with the limited operating temperature of 560°C due to thermal decomposition and corrosion, which leads to the inlet temperature of the steam turbine not higher than 550 °C and limited efficiency of the power cycle. In this work, an advanced CB with operating TES temperature higher than 700°C is proposed, which contains an advanced MSTES system (>700°C) and power cycle (e.g., supercritical CO_2 Brayton power cycle, SCBPC) for a higher energy conversion efficiency (>50%) and lower levelized cost of storage (LCOS) [5]. The next-gen molten salt TES technology based on chlorides is such a promising advanced MSTES technology used in the advanced CB, and has low material costs (<0.35 USD/kg) and excellent thermophysical properties (e.g., high thermal stability >1000°C) [5]. Two of the largest challenges in upscaling of Chloride-MSTES are the low-cost and effective corrosion control of the molten chlorides and selection of affordable structural materials for low CAPEX and long lifetime. The R&D progress in corrosion control and process upscaling will be presented in this work.

References

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