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Resistive Thermal Energy Storage: an Electricity Storage Alternative for the Australian Grid

Charles-Alexis Asselineau, Mahesh Venkataraman and Wojciech Lipinski and John Pye

Solar Thermal Group, Research School of Engineering, The Australian National University
E-mail: charles-alexis.asselineau@anu.edu.au

As the share of variable renewable electricity generation technologies on the grid increases, issues arise from the mismatch between the generation and demand profiles. Large-scale and cost-effective electricity storage is needed, in combination with demand-side management, to close the gap between the generation profile of photovoltaic and wind power and the demand curve [1]. A range of technologies have been suggested for electricity storage; available commercial solutions for grid electricity storage include lithium-ion battery storage, compressed air energy storage and pumped hydroelectric storage [2]. In this study, we present a cost analysis for an alternative energy storage system and compare it with the aforementioned technologies.

The new technology is based on the commercially-available molten-salt thermal energy storage technology already used in concentrated solar thermal power plants. The system uses two tanks containing the usual ‘solar salt’ eutectic mixture (KNO_3-$NaNO_3$) connected to a steam generator, turbine and alternator [3], but uses electrical resistive heaters instead of a solar-thermal receiver as the heat source for the hot tank (Figure 1). In this way, the hot tank can be charged using electricity from the grid and discharged the normal way through a steam turbine power block.

Using publicly available cost data [4] and conservative component cost assumptions for the resistive thermal energy storage system [5], we develop and benchmark a levelised cost of storage (LCOS) model and evaluate the LCOS of several technologies. We show (Figure 2) that Resistive Thermal Energy Storage (RTES) appears to be highly competitive with currently-available systems, despite the significantly lower round-trip efficiency arising from the irreversibilities in both charging (converting electricity to energy stored as heat) and discharging (converting heat back to electricity via steam turbine). While other electricity storage systems based on thermal energy have been suggested in the

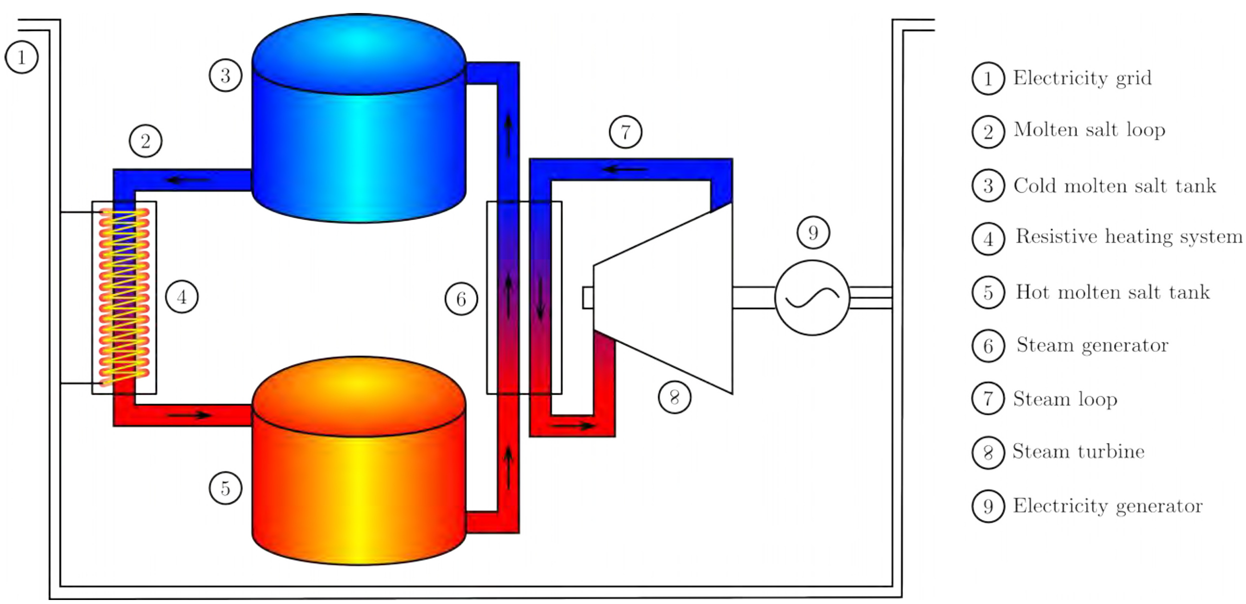

Figure 1. Resistive thermal energy storage system schematic diagram.

scientific literature [6, 7] or at the pre-commercial stage [8, 9], molten salt thermal energy storage is already a commercial, large scale and low-cost energy storage option but has not been evaluated as a storage medium for direct electrical resistance heating.

In light of these results we examine the potential of the technology in more detail and analyse the influence of the storage capacity and component cost reductions on the overall economical feasibility. It is found that increasing the storage volume significantly reduces the cost of RHES.

We conclude this study by suggesting some of the potential opportunities for such systems in a large renewable penetration scenario including the absence of geographic location requirements resulting in potential reductions in frequently overlooked transmission costs [10].

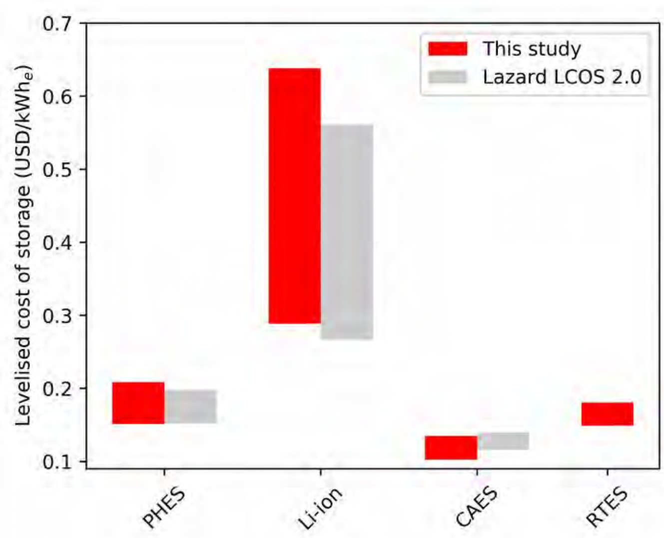

Figure 2. Levelised cost of storage for pumped-hydro energy storage (PHES), lithium–ion batteries, compressed air energy storage (CAES) and, new in this study, resistive thermal energy storage (RTES), with a comparison of results from this study to those of Lazard [4].

References

1. P. Denholm and M. Hand (2011). *Energy Policy* **39**, 1817 - 1830.
2. A. Gallo, J. Simões-Moreira, H. Costa, M. Santos and E. M. dos Santos (2016). *Renewable and Sustainable Energy Reviews* **65**, 800 - 822.
3. N. Blair, A. Dobos, J. Freeman, T. Neises, M. Wagner, T. Ferguson, P. Gilman and S. Janzou (2014). System Advisor Model, SAM 2014.1.14: General Description, TP-6A20-6101, NREL.
4. Lazard Ltd (2016). Levelized Cost of Storage Analysis 2.0, 'Insights' Report, Lazard.
5. NREL, *'System Advisor Model (SAM) Version 2017.9.5'*, https://sam.nrel.gov/. Accessed 10 Jul 2018.
6. J. Kesseli (2011). Brayton Power Conversion System, Scientific Report (to OSTI), Brayton Energy, LLC.
7. A. Thess (2013). *Phys. Rev. Lett.* **111**, 110602.
8. *'1414 Degrees thermal energy storage system'*, https://1414degrees.com.au/. Accessed 16 Jul 2018.
9. Sir Joseph Swan Centre for Energy Research, *'National Facility for Pumped Heat Energy Storage'*, http://www.isentropic.co.uk/. Accessed 16 Jul 2018.
10. F. Cebulla, J. Haas, J. Eichman, W. Nowak and P. Mancarella (2018). *Journal of Cleaner Production* **181**, 449 - 459.