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Thermal Batteries: A Preliminary Assessment of Technologies and Cost

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Abstract

As we rapidly transition to a low-carbon future as mandated by the Paris agreement, it is becoming apparent that the bulk of electricity supply will be from renewable technologies such as solar photovoltaics and wind turbines. While in most locations there is significant capacity to have unconstrained renewable generation, some areas are rapidly approaching or have arrived at the need for storage to firm up supply and maintain a stable electrical network. Currently, this can be done a number of ways including electrochemical batteries or pumped hydro. However, there are issues with these technologies such as high cost, lack of durability (heat and cycling), or location dependency. One technology that is starting to gain a lot of focus which doesn't necessarily suffer from the aforementioned drawbacks is the thermal (carnot) battery. In this concept electricity is converted to heat and stored thermally. This heat can then be used directly or converted to electricity using turbines, engines, or thermo-electric generators (*Figure 1*).

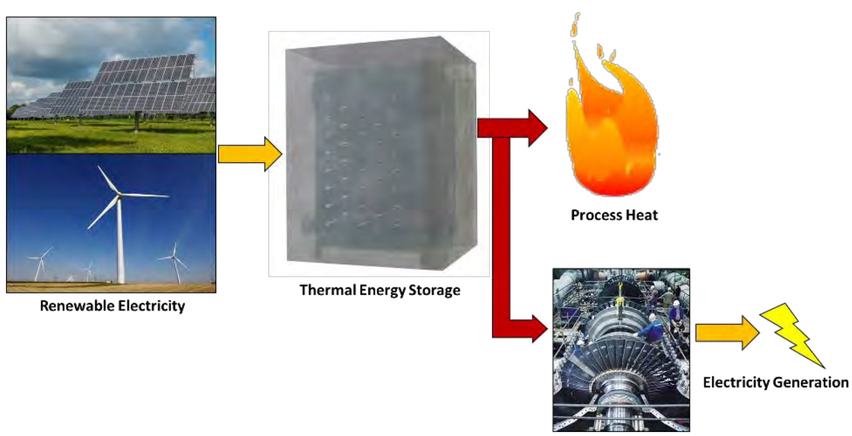

Figure 1- Basic Schematic of a Thermal Battery

Therefore, the current study intends to explore the possible technologies that could be employed as thermal batteries, what the likely technological risks are, and what are the costs associated with particular technologies or concepts.

Investigated Thermal Energy Storage Systems

Several concepts are being investigated domestically and internationally and include sensible solid or liquid systems, latent heat systems, and thermochemical systems. Additionally, combinations of these concepts are investigated (hybrid).

Metrics of Assessment

Each concept is assessed dependent on several factors including technology readiness, safety, environmental impact, ease of integration (for electrical generation and existing infrastructure), useful capacity, and cost. The advantages and disadvantages of each concept is also discussed.

Preliminary Results

A summary of some preliminary results from this investigation are shown in *Figure 2* and *Table 1* below.

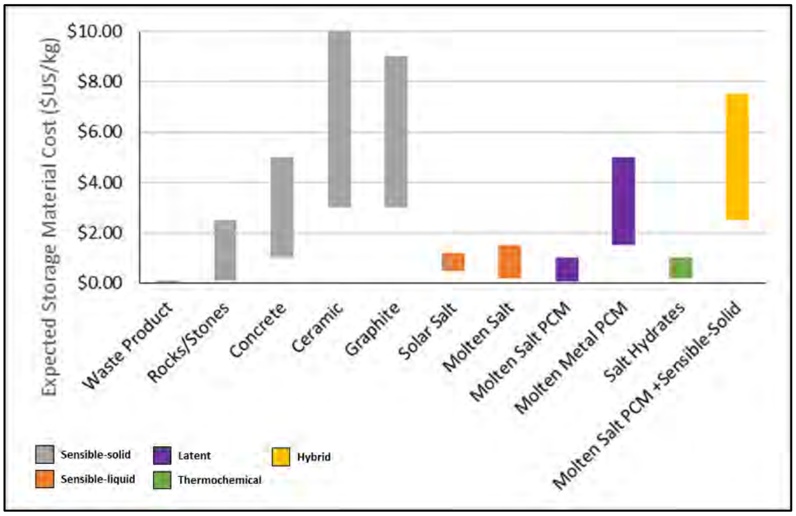

Figure 2- Expected Storage Material Cost for Several TES Concepts

Table 1- Technology Deployment, Safety, and Environmental Factors of Selected Concepts

Storage Material	**Heat Transfer Material**	**Technology Readiness**	**Safety Impact**	**Environmental Impact**	**Ease of Integration**	
					Process Heat-Air	*Steam Production*
Waste product	Air	Low	Low	Low	Simple	Complicated
Rocks/Stone	Air	High (Deployed at scale)	Low	Low	Simple	Complicated (but proven)
Graphite	Steam	Med/High (Demonstration in progress)	Low	Low	Slight complications	Simple
Solar Salt	Solar Salt	High (Deployed at scale)	Low/Med	Low/Med	Slight complications	Slight complication (but proven)
Molten Salt PCM	Molten Salt HTF	Low/Med (Lab-scale)	Low/Med	Low	Slight complications	Slight complication
Molten Metal PCM	Steam	Med/High (Demonstration in progress)	Low/Med	Med/High	Slight complications	Simple
Salt Hydrate	Steam	Med/High (Demonstration in progress)	Low	Low	Slight complications	Simple