Cost Benefit and Technical Challenges of Molten Metal Thermal Energy Storage

The biggest limitation to solar energy is cost effective energy storage. Photovoltaic panel’s cost has decreased significantly over the last decade but batteries are too expensive for grid level storage. Concentrated solar power (CSP) with molten salt thermal energy storage can deliver dispatchable electricity to the grid but is currently twice as expensive as fossil fuel power plants. CSP costs can be reduced by storing sunlight at higher temperatures and powering a more efficient power cycle.

Achieving higher temperatures in a CSP plant presents many challenges, the first of which is identifying a storage fluid that is stable at 1350°C and inexpensive. Solar salt degrades at temperatures above 600°C. A promising alternative to salt is molten aluminum-silicon. Al-Si is fully liquid at 822 °C, and even at 1350°C, it remains liquid with a vapor pressure less than 10⁻⁶ atm. Furthermore, Al-Si has an enormous heat of fusion, 2.5 times that of water, which translates to an energy dense, inexpensive thermal storage material. However, traditional steel based components, such as pumps, piping, and storage vessels, cannot be used with Al-Si due to the high temperatures involved and the accelerated corrosion that would occur. Our group is investigating refractory calcium aluminate castable cement as a containment material for molten metal CSP. Economic modeling show a potential 35% reduction in CSP levelized cost of electricity by switching from molten salt to molten metals.