



Materials for Energy Storage in CSP

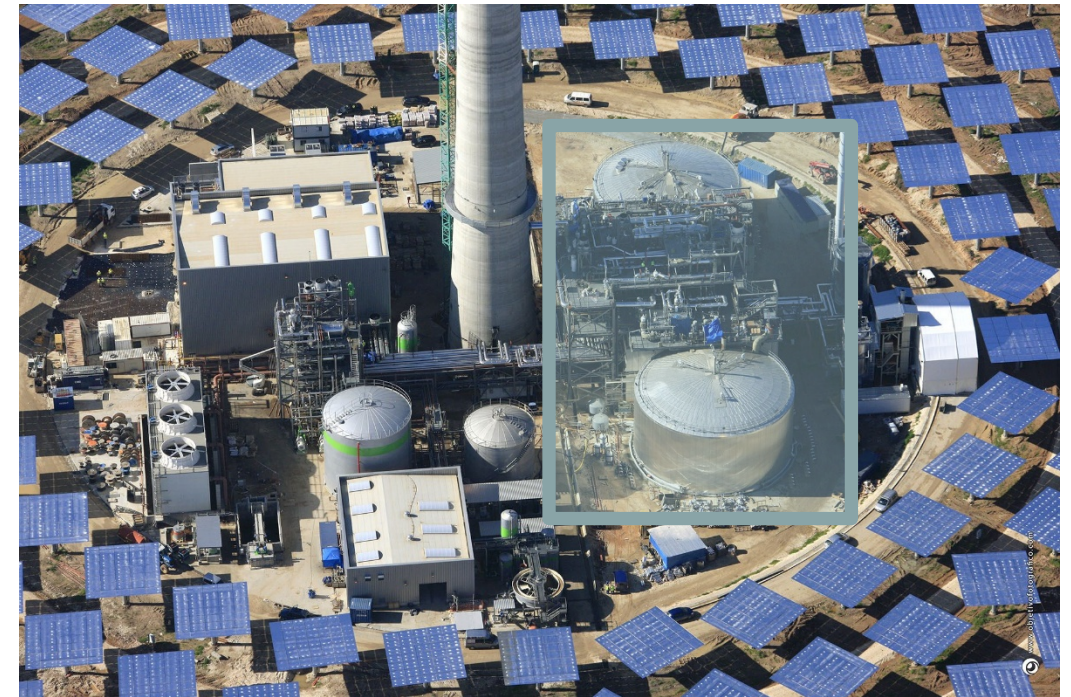
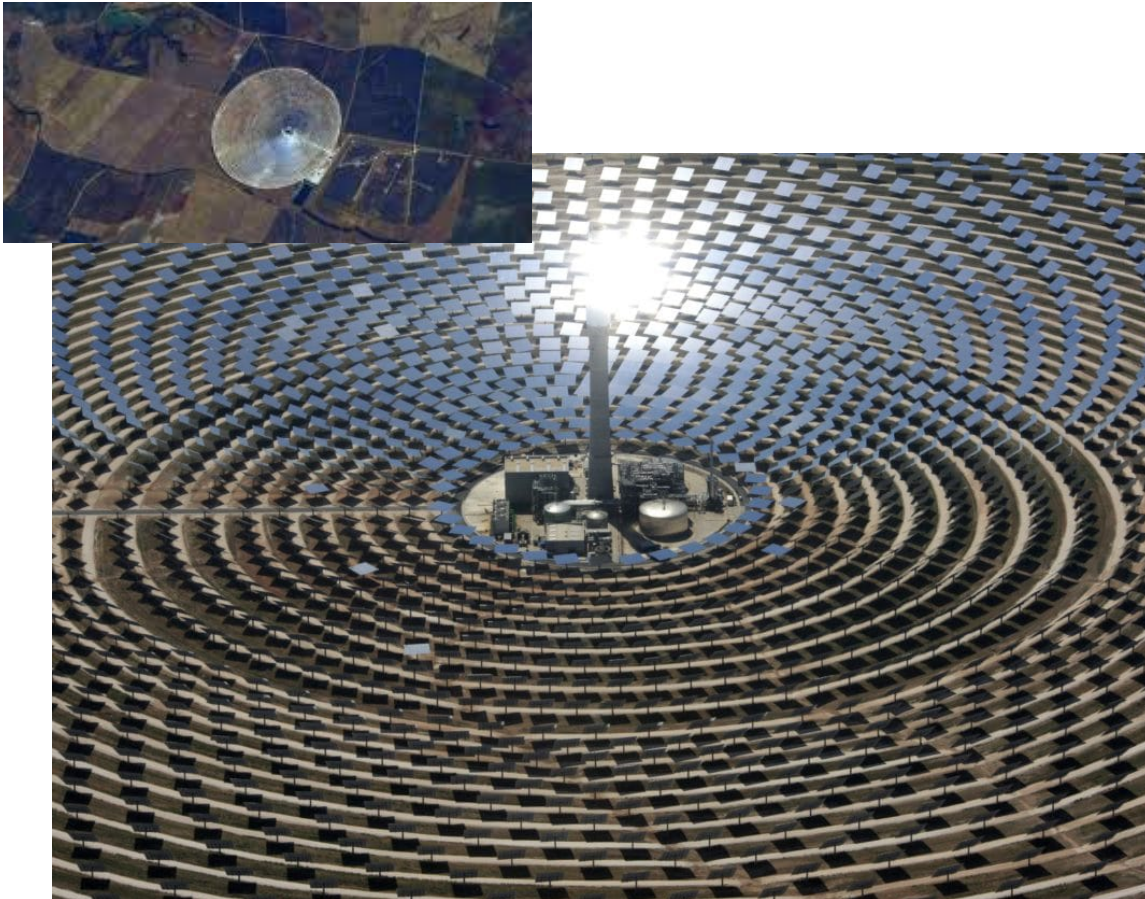
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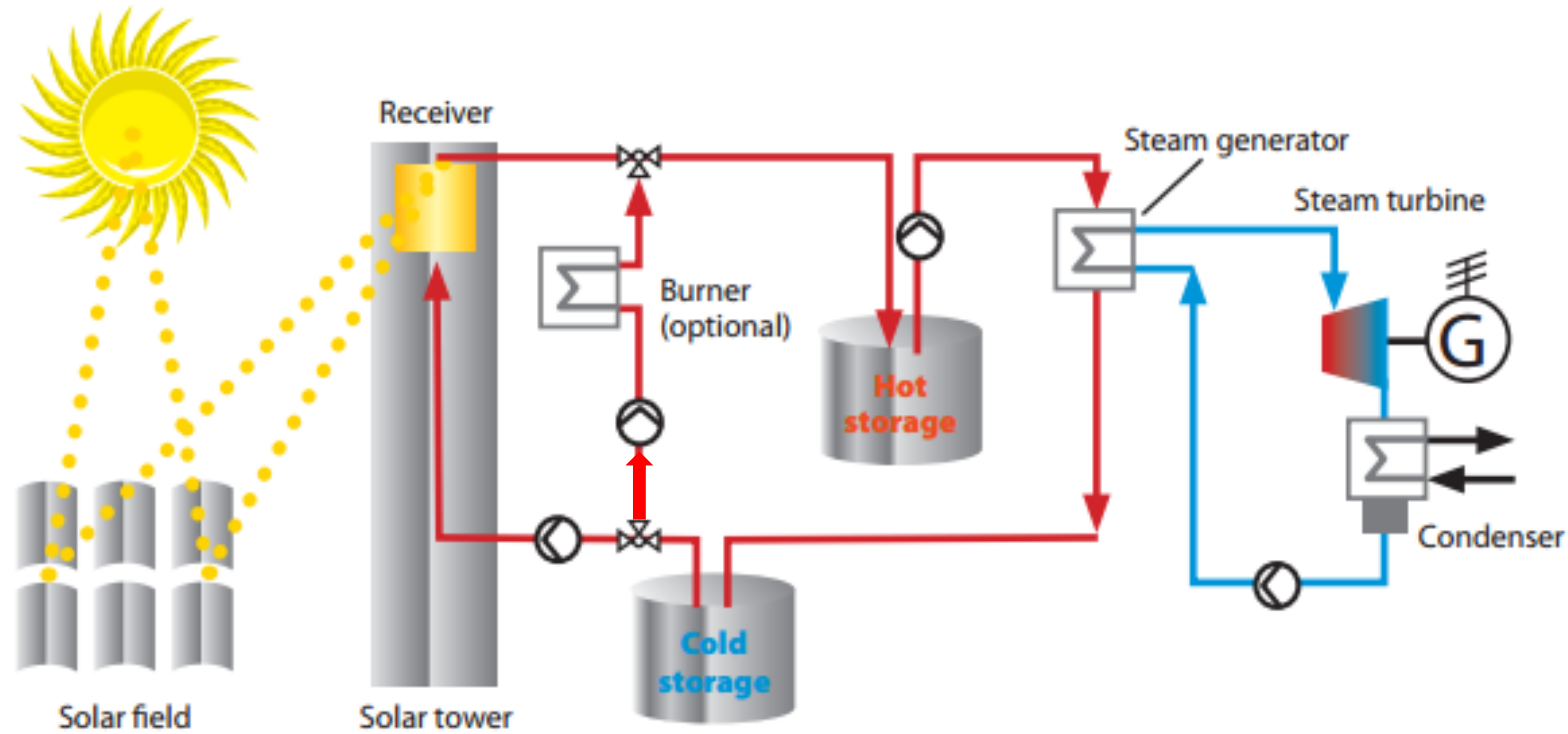
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Gemasolar



Source: Adapted from Guliano, Buck and Eguiguren, 2011

60% NaNO_3 -40% KNO_3

Sensible heat storage

Current comercial technology: Molten salts to store sensible heat



Limitations of molten solar salts

- High investment costs of salt (HTF), tanks and heat exchangers.
- High freezing temperatures (238°C).
(electric heat tracing)
- Maximum working temperature (565°C) due to thermal degradation.
- Low thermal conductivity ($\sim 1 \text{ W} \cdot (\text{m K})^{-1}$)



Is there room for improvement?



- Nanofluids using nanoparticles: oxides, metals, graphene

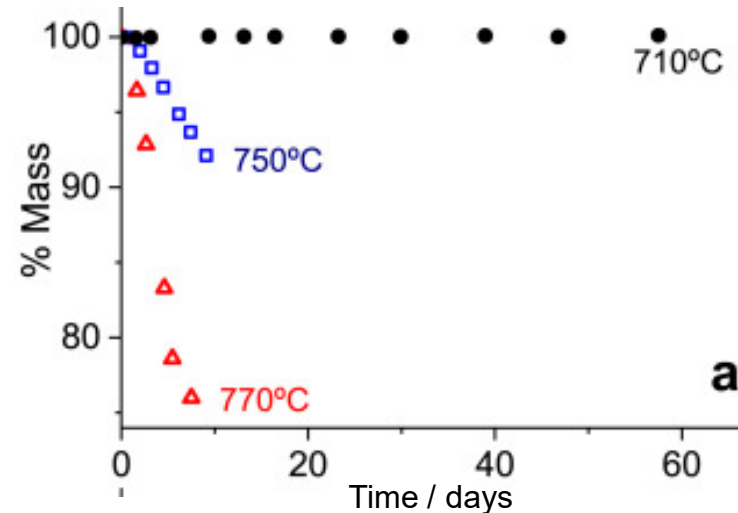
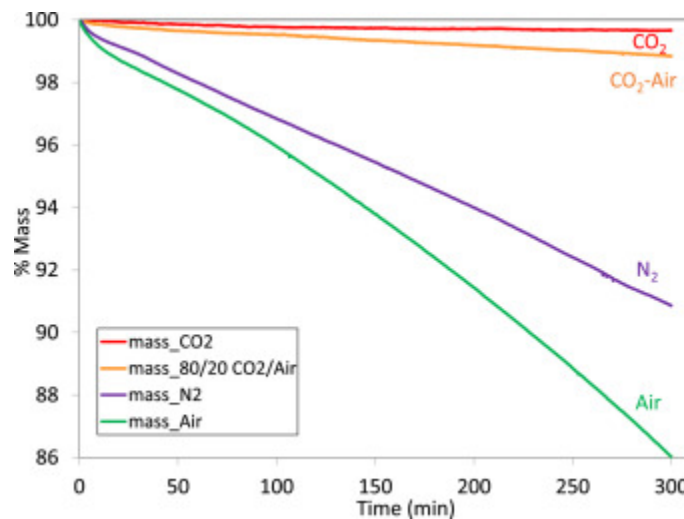
Improvement in thermal transport properties

Other properties, Cp, rheology, thermal stability are affected



- Other mixtures: sulfates, carbonates, hydroxides, chlorides, metal, etc

eutectic mixture $\text{Li}_2\text{CO}_3\text{-Na}_2\text{CO}_3\text{-K}_2\text{CO}_3$



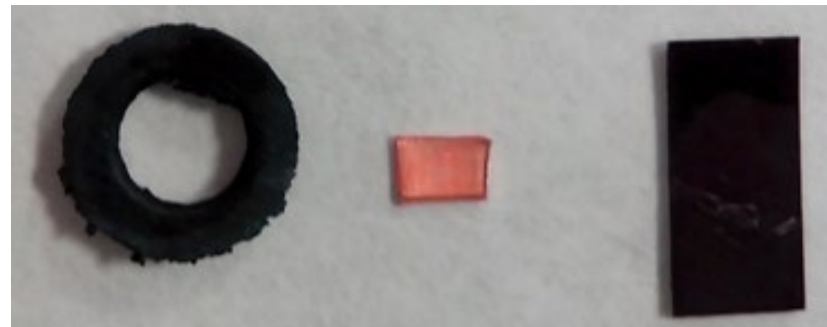
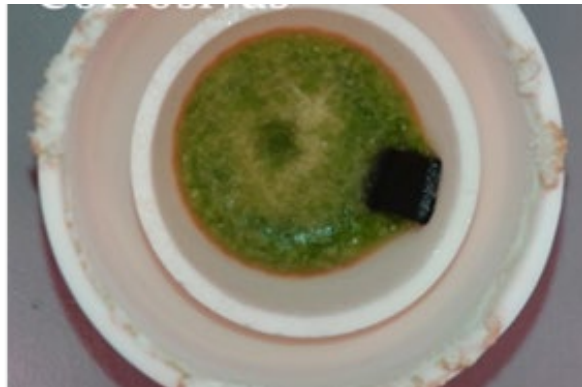
[Solar Energy Materials and Solar Cells](#) Volume 188, 15 December 2018, Pages 119-126

[Renewable Energy](#) Volume 151, May 2020, Pages 528-541



Materials compatibility

- Corrosion (pipes, tanks, hydraulic systems, measuring devices)
- Mechanical stress (thermal Cycles)



- Research in materials is required: new alloys, coatings, ceramics



- Latent heat storage (LHS). Phase change material (PCM)





- Thermochemical energy storage (TCES)

High energy density

Long-term energy storage

- Redox: $\text{Co}_3\text{O}_4/\text{CoO}$ 844 kJ/kg. Perovskites $\text{La}_{0.3}\text{Sr}_{0.7}\text{Co}_{0.9}\text{Mn}_{0.1}\text{O}_{3-\delta}$ 250 kJ/kg
- Hydrogenation/dehydrogenation; MgH_2 2811 kJ/kg.
- Hydroxylation/ dehydroxylation: $\text{Ca}(\text{OH})_2$ 1426 kJ/kg.
- Carbonation/calcination: CaL. **Socratces**. 1703 kJ/kg



- Thermochemical energy storage (TCES)
 - Kinetics (sometimes slow)
 - Cyclability (inactivation)
 - Heat exchange (low thermal conductivity)
 - Materials compatibility



SOCRATCES





THANK YOU FOR YOUR ATTENTION

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