Concentrating Solar Power and Thermal Energy Storage

Clifford K. Ho
Sandia National Laboratories
Concentrating Solar Technologies Dept.
Albuquerque, New Mexico
ckho@sandia.gov, (505) 844-2384

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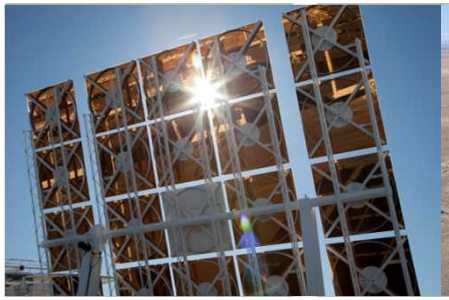

U.S. DEPARTMENT OF ENERGY

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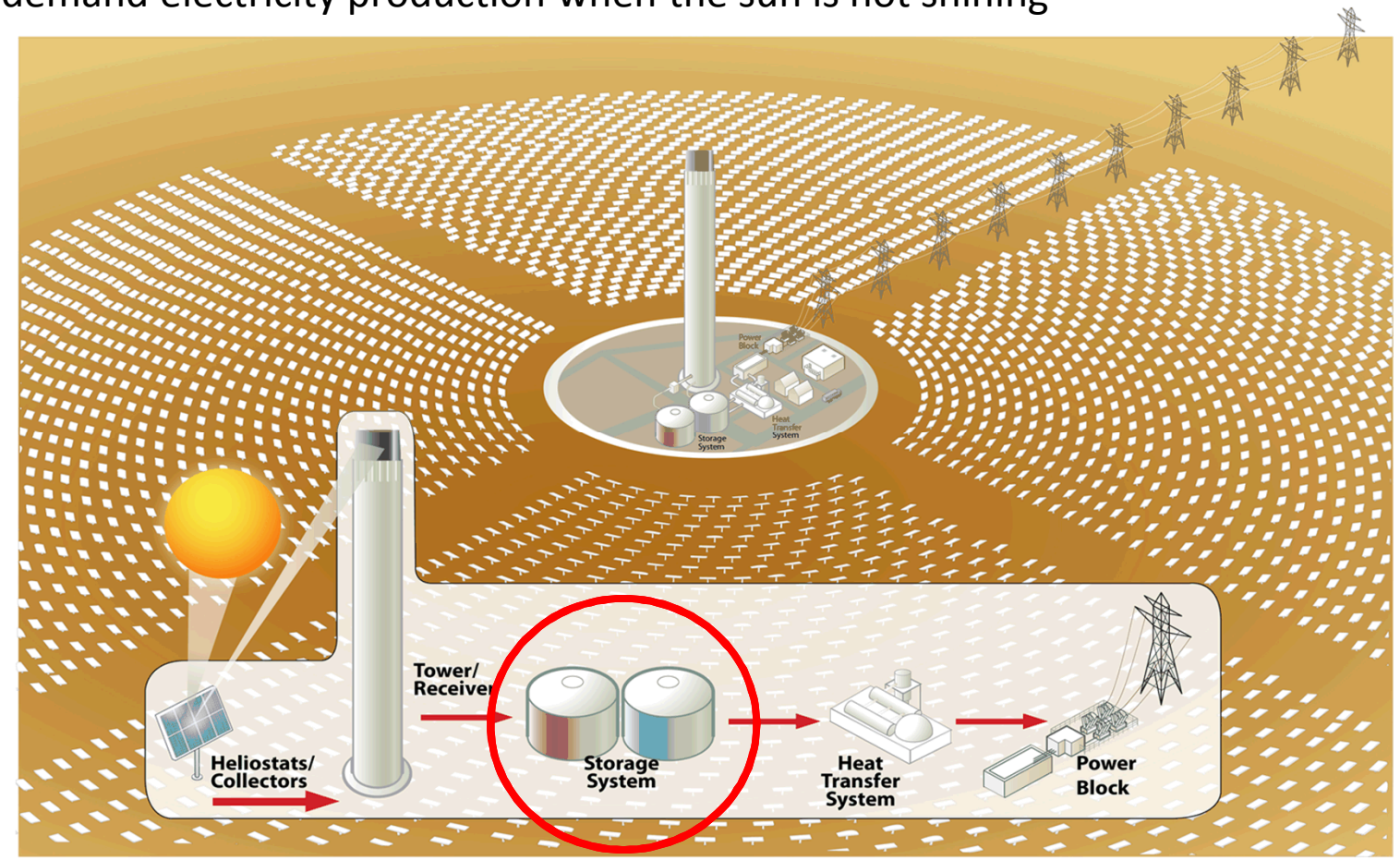
CSP and Thermal Energy Storage

- Concentrating solar power uses mirrors to concentrate the sun's energy onto a receiver to provide heat to spin a turbine/generator to produce electricity
- **Hot fluid can be stored as thermal energy efficiently and inexpensively** for on-demand electricity production when the sun is not shining



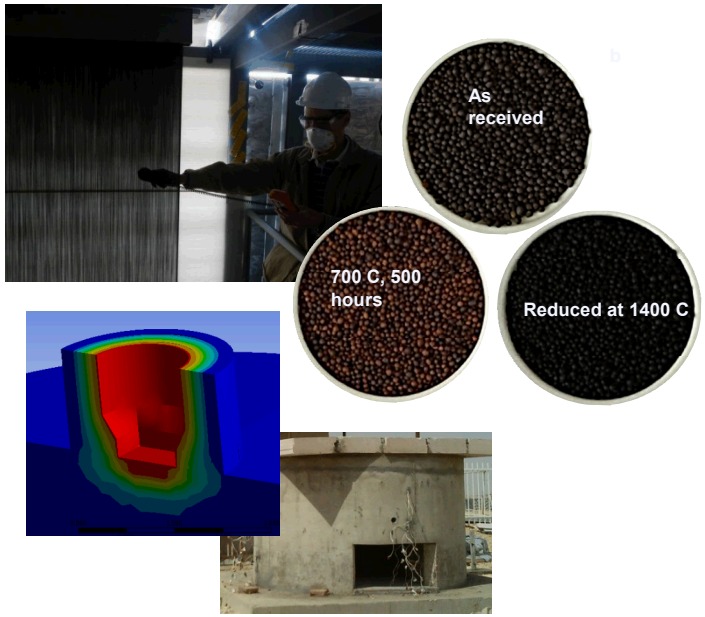
Types of Thermal Energy Storage

- Sensible (single-phase) storage
  - Use temperature difference to store heat
  - Molten salts (nitrates, carbonates, chlorides)
  - Solids storage (ceramic, graphite, concrete)
- Phase-change materials
  - Use latent heat to store energy (e.g., molten salts, metallic alloys)
- Thermochemical storage
  - Converting solar energy into chemical bonds (e.g., decomposition/synthesis, redox reactions)

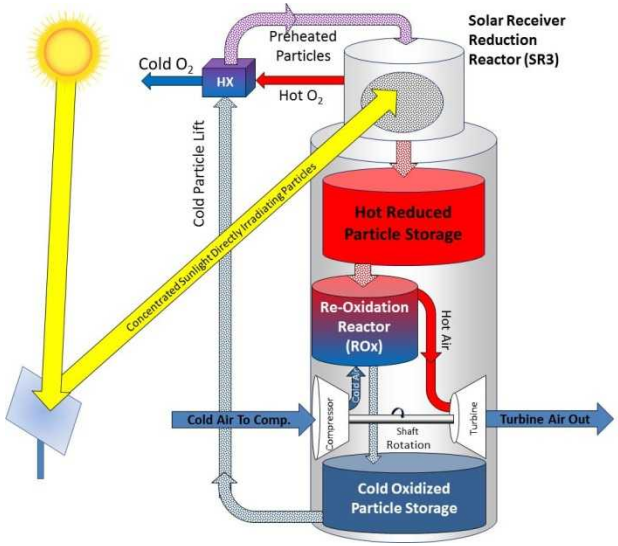
Molten-salt storage tanks at Solana CSP plant in Arizona. Credit: Abengoa

Sandia Research in Thermal Energy Storage

Corrosion studies in molten salt up to 700 C in “salt pots”

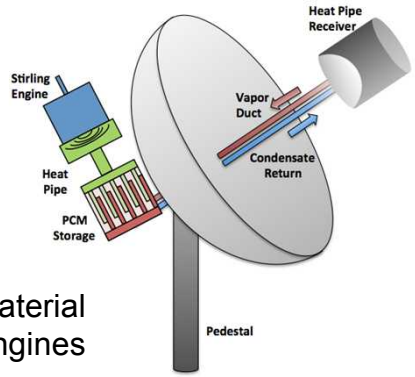


Ceramic particle storage and heating with falling particle receiver



Thermochemical particle storage with reduction/oxidation of perovskites

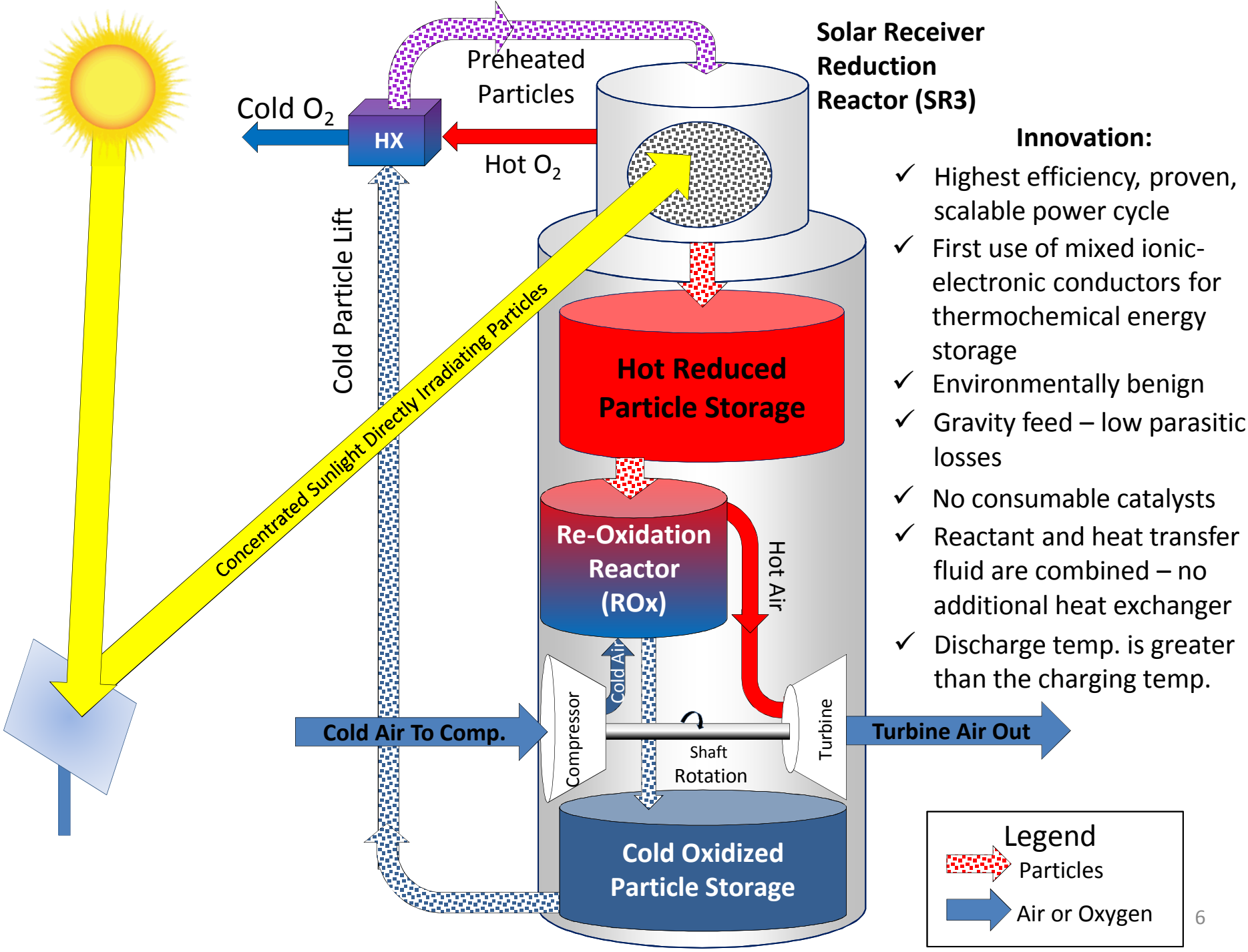
Component testing with molten-salt test loop



Latent phase-change material storage in dish engines

Thermal Energy Storage Goals

- Capable of achieving high temperatures (> 700 C)
- High energy and exergetic efficiency (>95%)
- Large energy density (MJ/m^3)
- Low cost (<\$15/kWh_t; <\$0.06/kWh_e for entire CSP system)
- Durable (30 year lifetime)
- Ease of heat exchange with working fluid (h > 100 W/m^2-K)


Solar Receiver Reduction Reactor (SR3)
Preheated Particles
Cold O_2
HX
Hot O_2
Cold Particle Lift
Concentrated Sunlight Directly Irradiating Particles
Hot Reduced Particle Storage
Re-Oxidation Reactor (ROx)
Hot Air
Cold Air
Cold Air To Comp.
Compressor
Shaft Rotation
Turbine
Turbine Air Out
Cold Oxidized Particle Storage
Innovation:
✓ Highest efficiency, proven, scalable power cycle
✓ First use of mixed ionic-electronic conductors for thermochemical energy storage
✓ Environmentally benign
✓ Gravity feed – low parasitic losses
✓ No consumable catalysts
✓ Reactant and heat transfer fluid are combined – no additional heat exchanger
✓ Discharge temp. is greater than the charging temp.
Legend
Particles
Air or Oxygen