Efficient Solar Thermal Electricity Unlocked: Sodium Heat Pipes in the Solar Furnace

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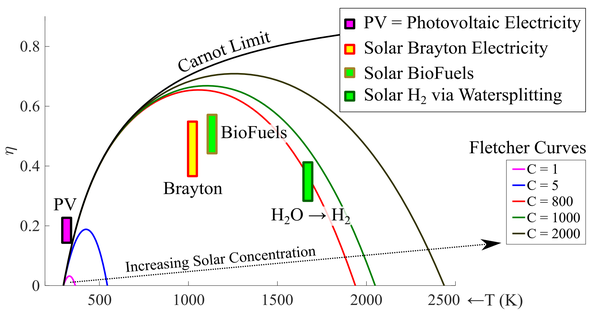
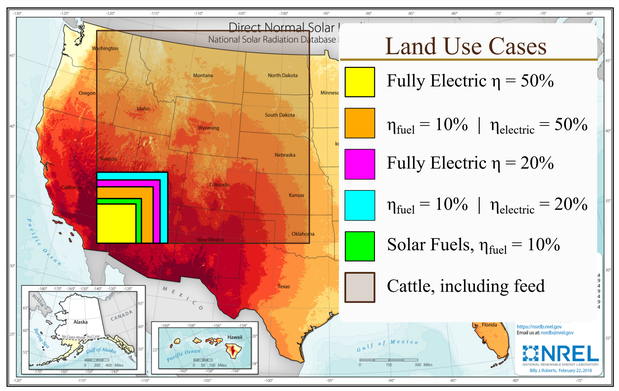
Concentrated Solar Power

Projected Benefits:
→ Sunshot CSP Target \$0.05 / kW·hr
vs. \$0.06-0.08 / kW·hr cost for PV
→ CSP 50% efficiency vs. 20% for PV



→ Efficiencies correspond to different cycles
→ Brayton and BioFuel offer highest efficiencies
→ Higher efficiencies require less land

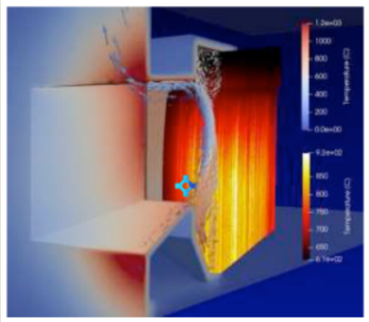
Going Solar - Land Use



→ Colored boxes are land area to support U.S. demand
→ Brayton and BioFuel have smallest boxes
→ Less required space, easier to implement

Heat Pipes and On-sun Testing

An Opportunity for Heat Pipes

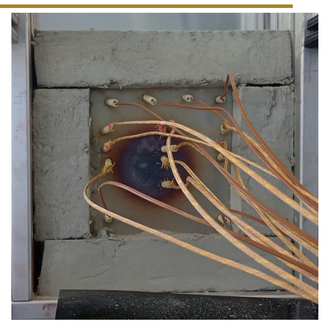


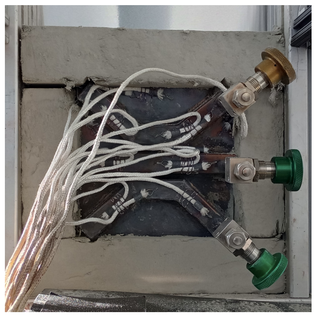
Sandia National Labs Report: SAND2021-14614

→ Falling particle receivers (FPR) will power advanced "Brayton" cycles
→ FPR hot spots force lower running temperatures to avoid failure, lowering efficiency
→ Heat pipes enable higher efficiencies by conducting heat uniformly across the plate

Experimental Setup

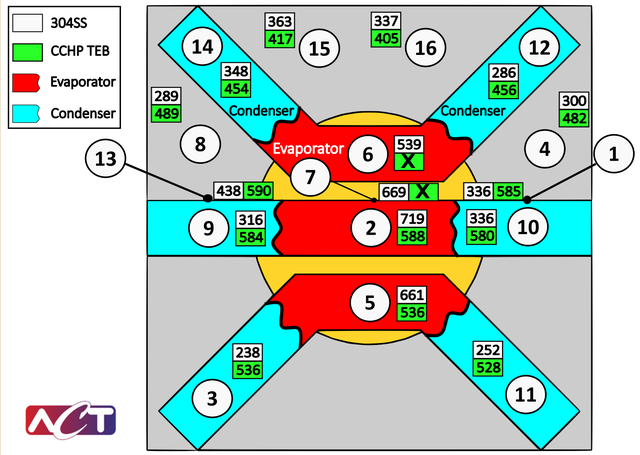
Plane 304 Stainless Steel Plate (304SS)
→ In-house, custom-welded Type K Thermocouples
→ Centralized oxidation shows hot spots

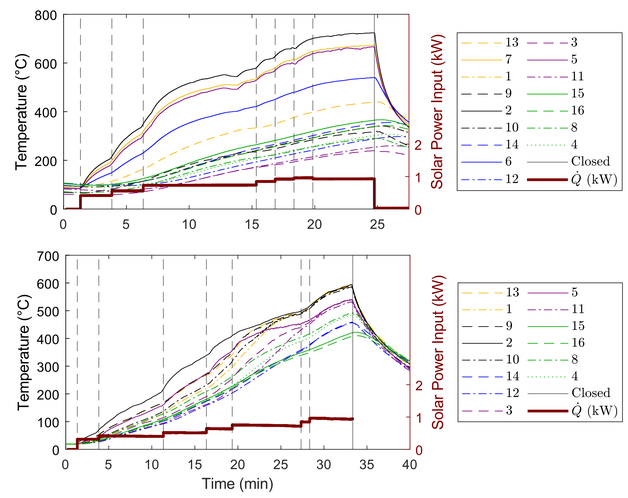




Constant Conductance Heat Pipe Thermally Enhanced Board (CCHP TEB)
→ Thermocouples mounted in identical locations
→ Heat pipes mounted onto back face
→ Charged with Sodium

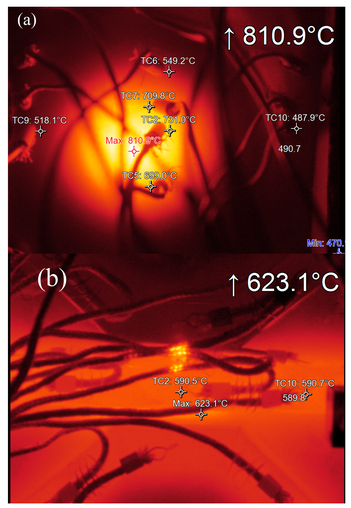
Results





→ 304SS temperature range 423°C (top)
→ CCHP TEB temperature range 185°C (bottom)
→ Heat pipes activate at ~23min, ~400°C

→ Heat pipe temperature range of 10°C in the CCHP TEB middle heat pipe
→ Temperature range of 403°C in the 304SS at middle heat pipe locations
→ Other areas not directly connected by heat pipe are still more uniform
→ Thermocouples provide point measurements
→ Infrared camera reveals detailed

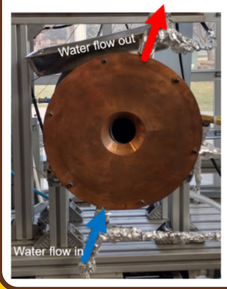


→ 304SS hot spot in the center (top)
→ CCHP TEB uniform temperature (bottom)
→ Concomitant measurements IR and TCs

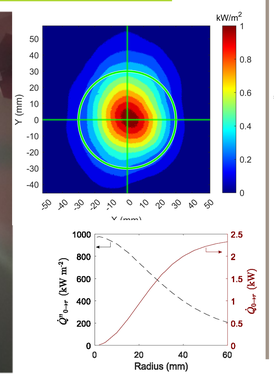
Measuring and Modeling Power Input

Calorimeter

→ Measures solar input by change in water temperature

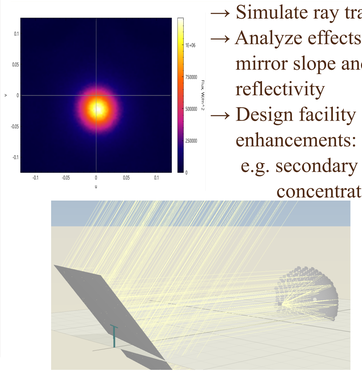


Flux Measurement



Facility Model with Tonatiuh ++

→ Simulate ray tracing
→ Analyze effects of mirror slope and reflectivity
→ Design facility enhancements: e.g. secondary concentrator



Solar Furnace Next Steps

☼ Phase II DOE Grant proposal in preparation may consider: larger scale demonstration, higher power
☼ Solar Hydrogen Project will require higher operating temperatures.
☼ Thermoelectrics as another application?

Support and Project Partner

SBIR·STTR America's Seed Fund™ POWERED BY SBA
DOE SBIR Phase I: Award DE-SC0023832

Advanced Cooling Technologies

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