U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

# Concentrating Solar-Thermal Technologies for Industrial Process Heat


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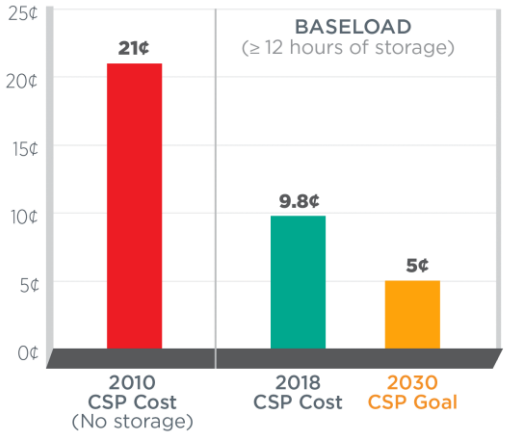
# Concentrating Solar-Thermal Power Status and Goals

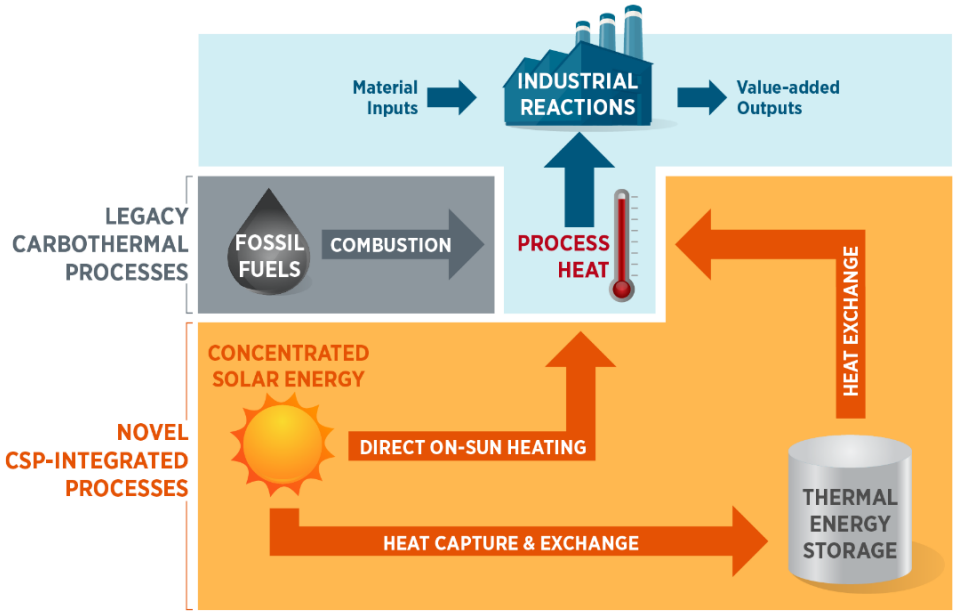
The goal for SETO's CSP research is to achieve **$0.05/kWh** for dispatchable CSP with >12 hours of thermal energy storage (TES), with a 50% thermal-to-electric power cycle efficiency at a turbine inlet temperature of > 700 °C




## Where we are now:

- **Modeled LCOE of $0.095/kWh for a U.S. plant with 14 hours of TES**
- **1.7 GW CSP deployed in the U.S., 6.3 GW globally**
- **5.1 GW of global deployment is parabolic trough, 1.2 GW is tower**
- **45% of global tower capacity and 34% of trough capacity has 6 or more hours of storage**
  - With > 33 GW-hours of Thermal Energy storage operating globally

# Concentrating Solar Thermal (CST) for Decarbonization of Industrial Process Heat




**Priority Research Areas:**

- Reduce the levelized cost of heat, **with thermal energy storage**, in temperature ranges of high priority to industrial processes
  - Roughly \$0.02/$kWh_{th}$ would be competitive with natural gas
- Improve the **thermal efficiency** of solar-thermal-coupled processes
- Develop long-duration, thermochemical storage of solar energy (i.e. **solar fuels** and chemical commodities)

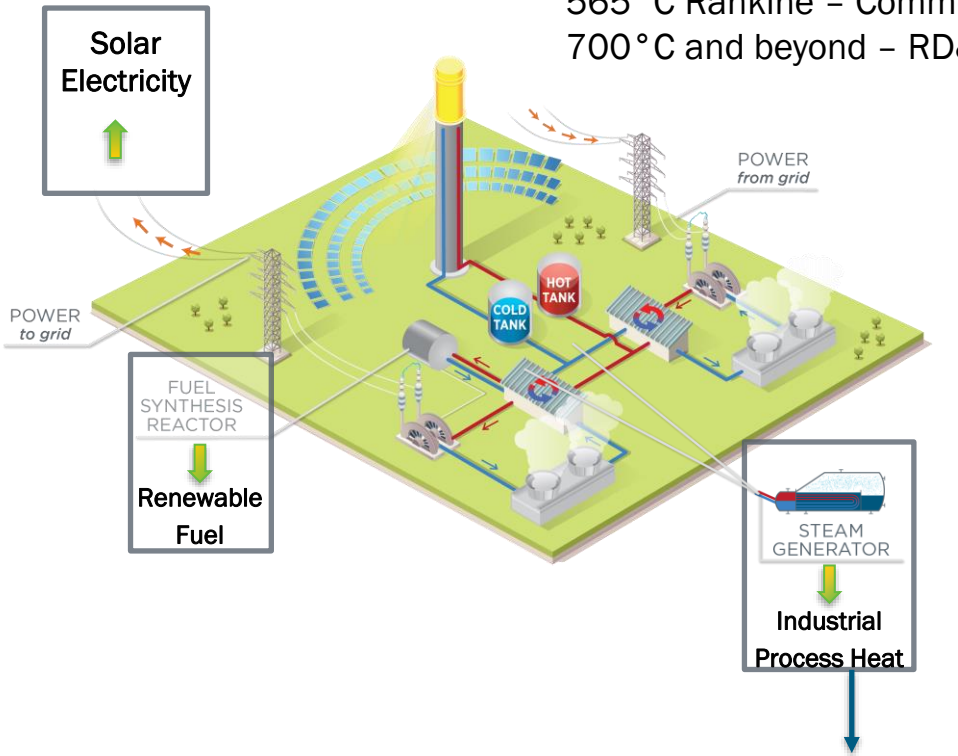
**SETO Goals by 2025:**

- Define system concepts and key components for solar process heat for carbon-emissions-intensive, high-heat-demand industries

# Concentrating Solar-Thermal Technology for Power and Heat-Based Applications

## Tower Technology

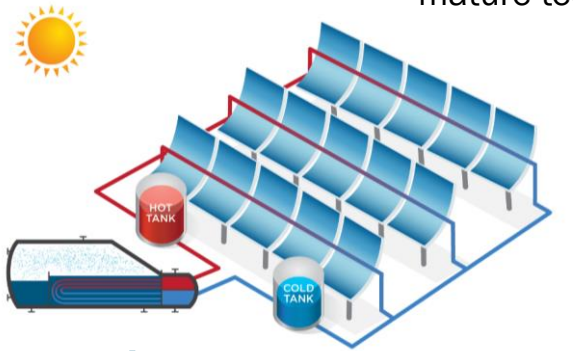
565°C Rankine – Commercial
700°C and beyond – RD&D




Mid to High (>500°C to 1000°C) Process Heat

## Trough Technology

mature technology



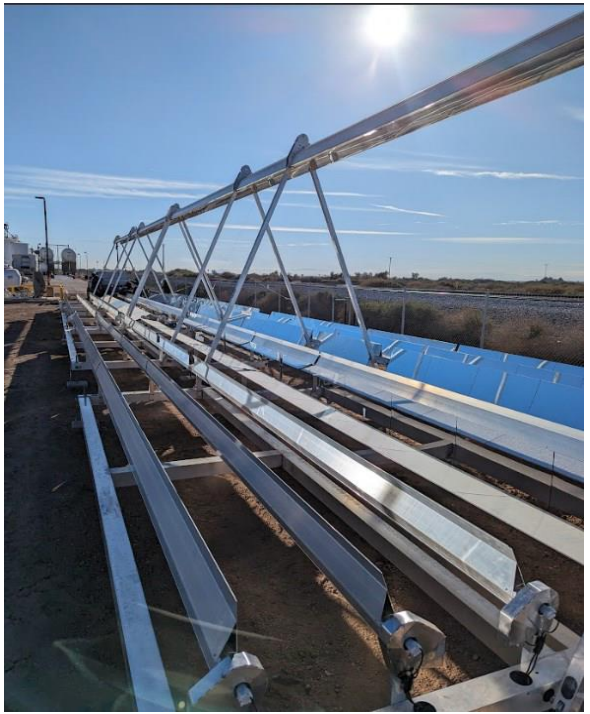

Low Temperature (<400°C) Process Heat

- **Thermally-Driven Industrial Processes**
  Desalination
- Enhanced Oil Recovery, refining
- Agriculture and Food Processing
- Fuel and Chemicals Production
- Iron and Steel
- Cement

# First Steps by CSP Team in IPH Area: Steam for Di-methyl Ether from Ethanol



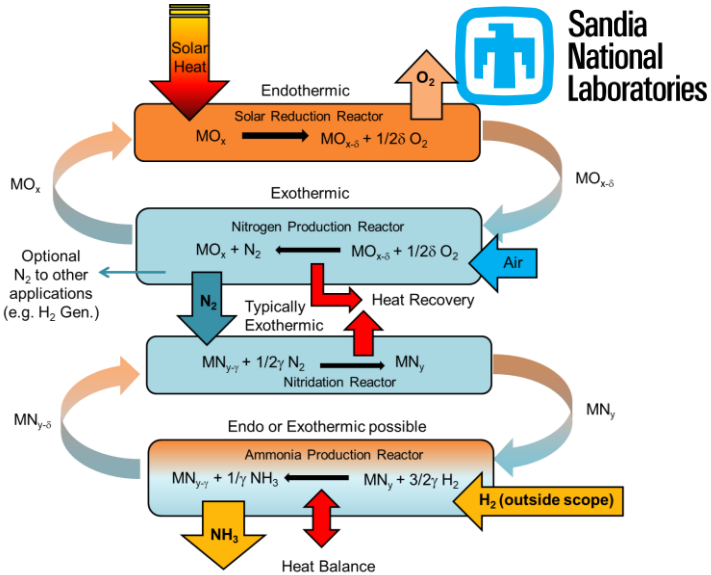

- Sunvapor's solar steam customer and site host Oberon Fuels produces DME from methanol at the site
- Line Focussing Collectors produce solar steam with a steam accumulator as TES



# Solar Desalination – 2017

- Natural Energy Laboratory of Hawaii Authority (NEHLA) Hawaii Ocean Science and Technology Park
- "Hawaii Solar Desalination Project"
- 2 MW Trough Solar Field Coupled with Forward Osmosis
- Capstone Demonstration Testing Ongoing

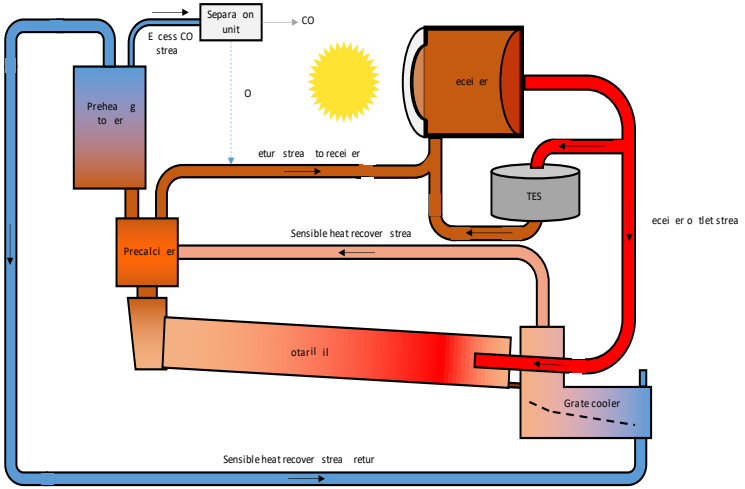
# Novel Process Chemistries – High Temperature




**Solar Thermochemical Ammonia Production (STAP)**

PI: Andrea Ambrosini


Bush, H. E., Nguyen, N. P., Farr, T., Loutzenhiser, P. G., & Ambrosini, A. (2021). Air separation via a two-step solar thermochemical cycle based on (Ba, La) xSr1-xFeO3-δ: Thermodynamic analysis. *Solid State Ionics*, *368*, 115692.

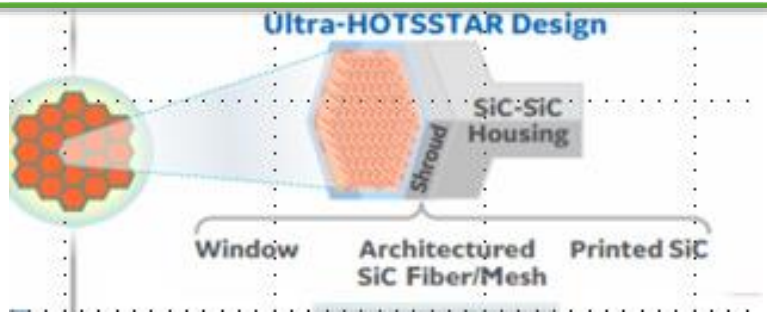




**Solar-Thermal Mixed-Media Enhancement and Decarbonization of Clinker Formation (Solar MEAD)**

PI: Nathan Schroeder

Sandia National Laboratories · Synhelion · CEMEX

# High T Component Research – Material R&D, Prototyping, On-Sun Testing





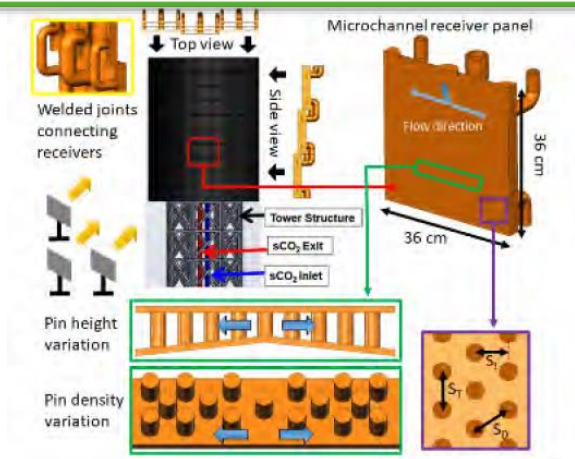
Volumetric air receiver > 750C
Design, Fabrication and Testing

**Ultra-High Operating Temperature SiC-matrix Solar Thermal Receivers (HOTSSTAR) Enabled by Additive Manufacturing**

PI: Reza Sarrafi-nour

GE Research

Sandia National Laboratories




**Enabling Micro-pin Array Receivers For Power Generation and High-temperature Process Heating Using Metal Additive Manufacturing**

UCDAVIS Energy and Efficiency Institute 15 YEARS

PI: Vinod Narayanan

Sandia National Laboratories

MRL MATERIALS RESOURCES, LLC Made in Dayton

NextManufacturing

Carnegie Mellon University

PennState

University of Michigan

STATE

SUNVAPOR

# Funding Opportunities with Decarbonization Focus

| | | |
|---|---|---|
| SETO FY 2021 PV/CSP FOA | Solar Receivers and Reactors (Component development for SIPH) | High temperature materials for reactors and receivers |
| CSP FY22 RD&D | Concentrating Solar Thermal for Industrial Decarbonization – Production of Hydrogen, Cement, Steel, Chemicals | High temperature industrial processes (cement, chemicals) |
| Solar-thermal Fuels and Thermal Energy Storage (FY23) | Solar Thermal Fuels – Hydrogen, Ammonia, Methanol, Liquid Fuels (kerosine, jet fuels, …) | Proposals under review, focused on CST for fuel production, novel chemistries |
| FY 2025 – 2027 National Lab Call | CST – Sector Specific Analysis, Engineering Design & Case Studies | Proposals under review |

SETO is continuously addressing the decarbonization goals that includes process heat applications along with electrification

# QUESTIONS?