U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

SOLAR ENERGY TECHNOLOGIES OFFICE

Concentrating Solar-thermal Power R&D

2022 sCO_2 Symposium

February 23, 2022

Avi Shultz, Program Manager

Applications of Solar-Thermal Energy

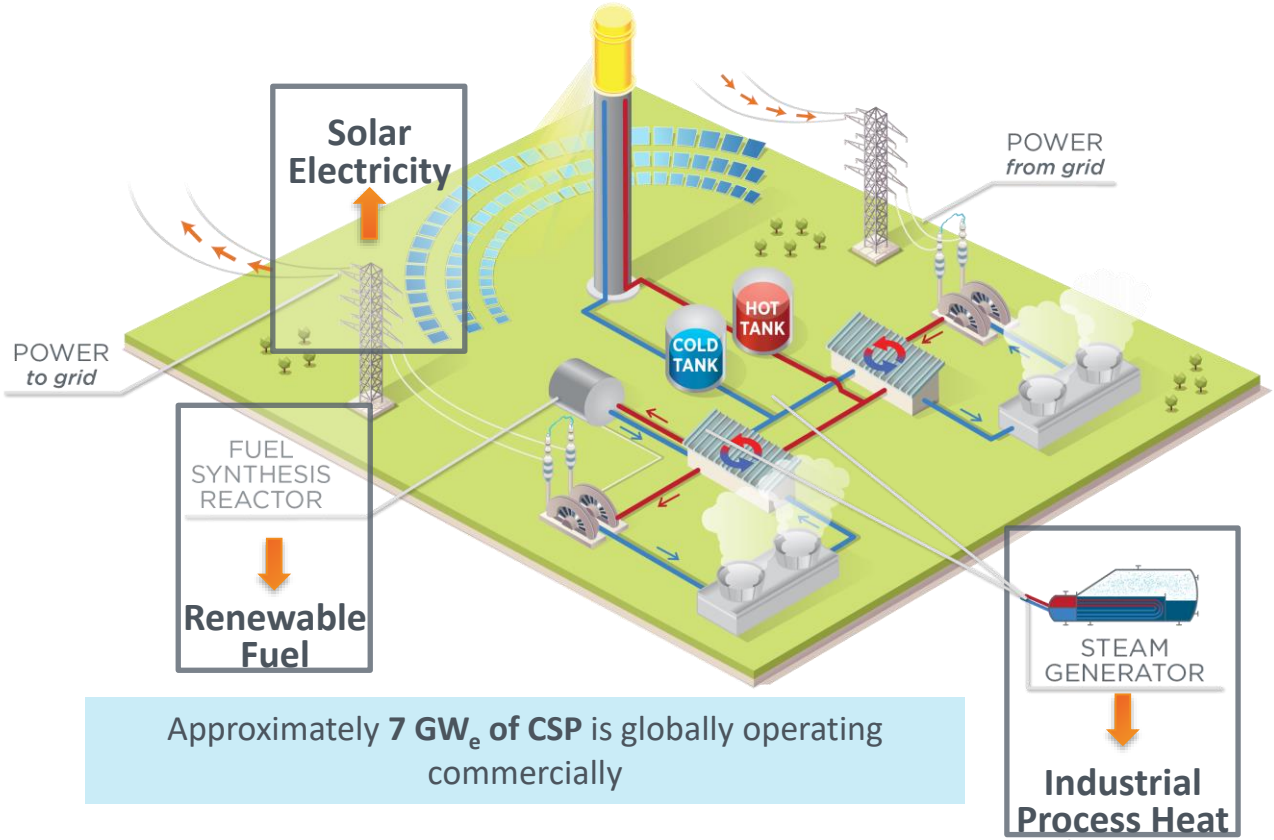
Oil-Based Troughs with steam rankine cycle (390 °C)

↓

Molten Salt Towers with steam rankine cycle (565 °C)

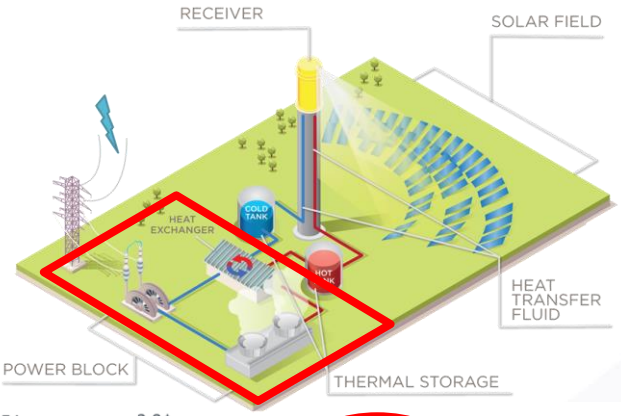
↓

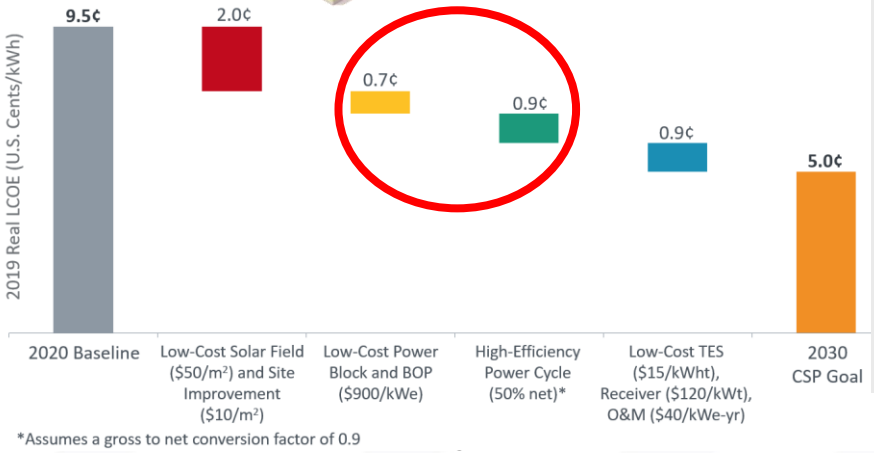
'Gen 3 CSP': Novel Heat Transfer Media with advanced power cycle (>700 °C)



Approximately **7 GW_e of CSP** is globally operating commercially

Advanced Power Cycles





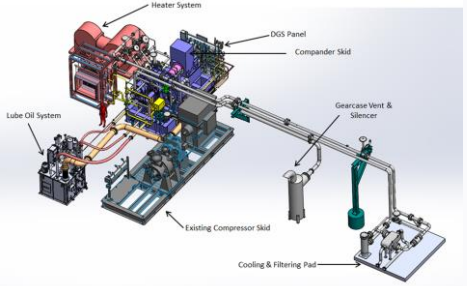
*Assumes a gross to net conversion factor of 0.9

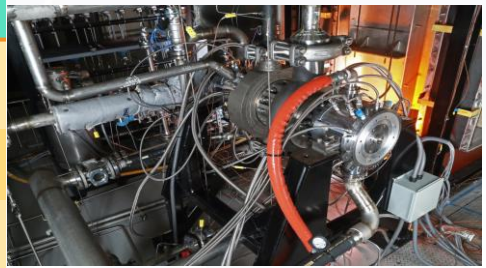
Programmatic Objectives

- Develop and demonstrate supercritical CO_2 power blocks consistent with > 50% net thermal-to-electric efficiency, including:
  - **Turbomachinery**
  - **Recuperators**
  - **Air cooling capability**
  - **Primary heat exchangers integrated with TES**
- Validate turbomachinery at MW_e scale ✓
- Support R&D on materials and manufacturing to **reduce cost to < $900 kW_e** for systems with **turbine inlet temperature > 700 ° C**
- Demonstrate commercially-relevant systems – with existing materials – at turbine inlet temperature approx. 600°C

sCO_2 Power Cycles – Completed and Ongoing Research

Component	Organization(s)	Status
Expander	Southwest Research Institute, GE Research	Successfully tested at 1 MW_e, 715°C for several hours
Compressor / Expander	Southwest Research Institute, Hanwha Power Systems	Successfully tested compressor and expander, at 1 MW_e to 715 °C; compressor inlet temperature to 36-37°C
Compressor	GE Research, Southwest Research Institute	Successfully tested compressor to inlet temperature 35°C
Seals	Southwest Research Institute, Eagle Burgmann	550-700°C dry gas seals being developed and tested
Bearings	GE Research	Gas bearing testing at large size
Air Cooler	Southwest Research Institute, Vacuum Process Engineering	Testing of MW_{th} sized air cooler

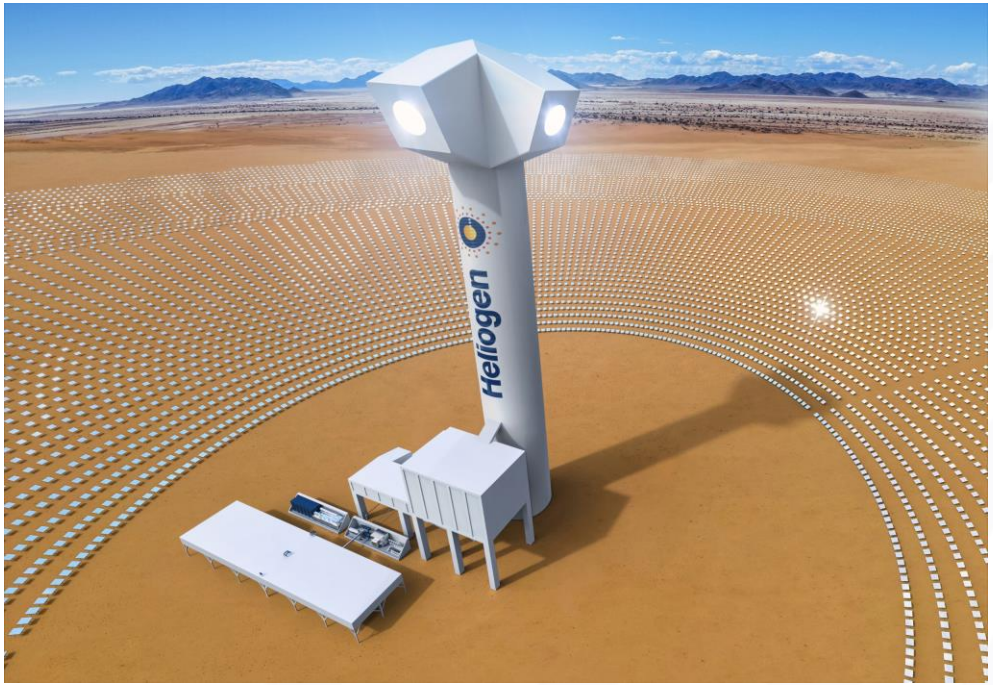




Remaining R&D challenges for power cycles > 700 °C :

- Low-cost manufacturing and fabrication for casing, recuperators, valves, air coolers
- Improved performance of seals and bearings to meet efficiency targets

Integrated TESTBED (*T*hermal *E*nergy *St*orage and *B*rayton Cycle *E*quipment *D*emonstration)



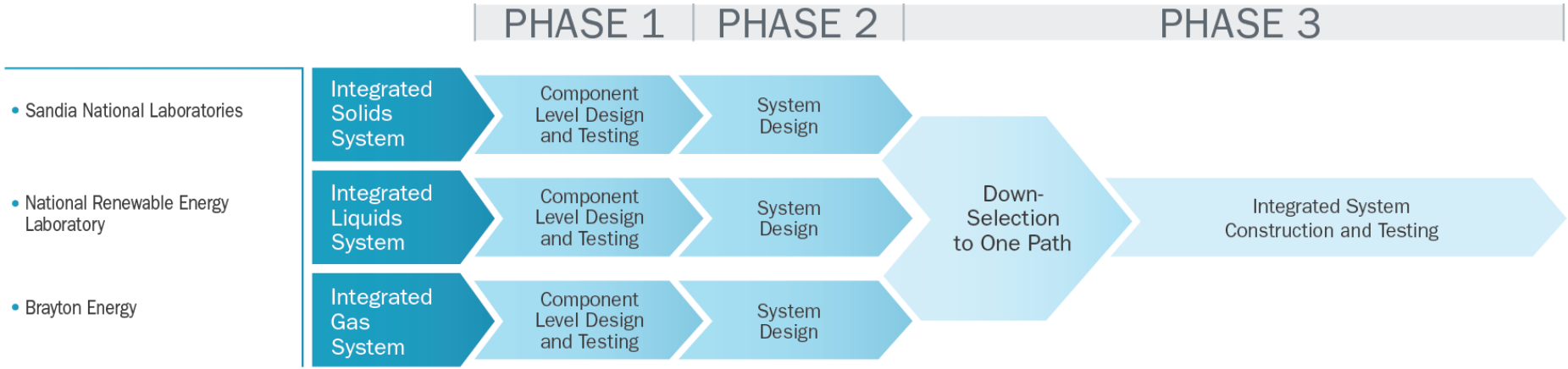
TESTBED

- **$39 million DOE funding** to develop a First-of-a-Kind sCO_2 facility integrated with TES
- 5 MW_e sCO_2 cycle at ca. 600°C turbine inlet
- Heat input up to 48 MW_{th} from Heliogen's solar field
- >200 MWh_{th} solid particle TES

TESTING CAPABILITY

- Recompression Brayton Cycle (RCBC) operation, targeting > 39% efficiency, with mostly stainless steel construction
- RCBC control and integration with TES
- Turbomachinery durability and operation
- FOAK TES and heat exchanger

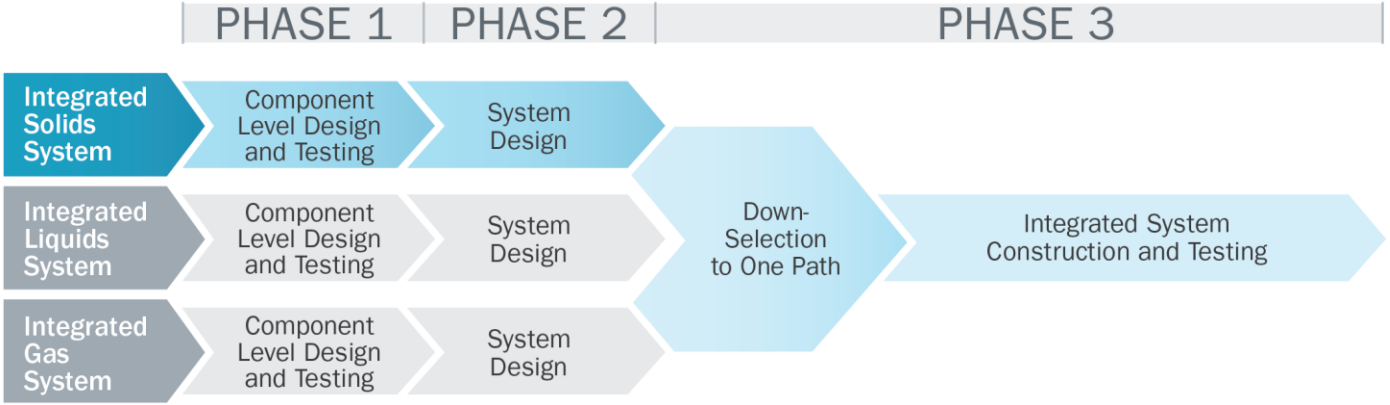
Gen3 CSP: Pathway Selection

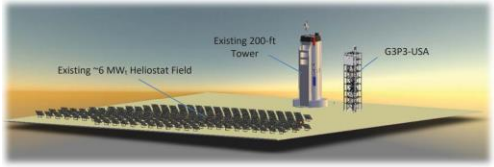


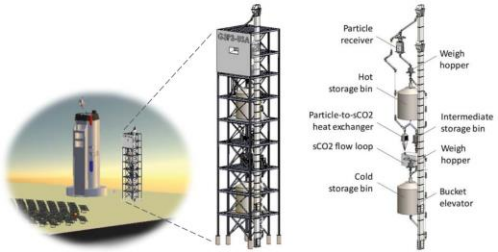
In March 2021, SETO announced that Sandia would receive $25 million to construct a MW-scale test facility at the National Solar Thermal Test Facility in Albuquerque, NM

Gen3 CSP: Pathway Selection

- Sandia National Laboratories





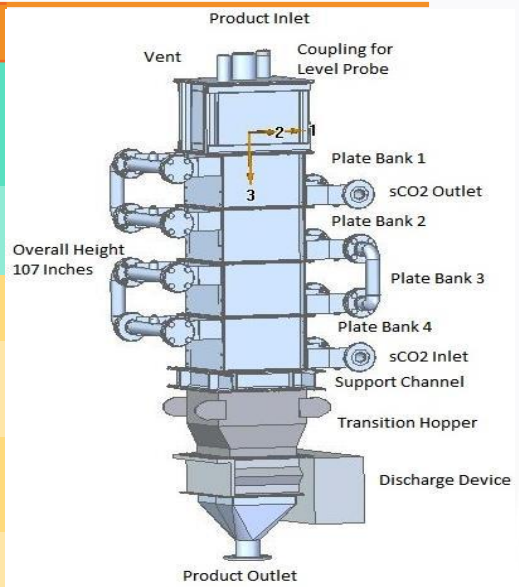


- **Strengths:**
  - System simplicity for construction, operation, and reliability
  - Wide operating range and opportunity for further temperature increases
  - Potential relevance to other solar thermal applications

- **Remaining Gaps:**
  - Receiver optimization (also for controlled environments)
  - Particle cost
  - Demonstrations of flow control and particle handling at scale
  - **Increasing system ΔT**

Primary Heat Exchanger – Completed and Ongoing Research

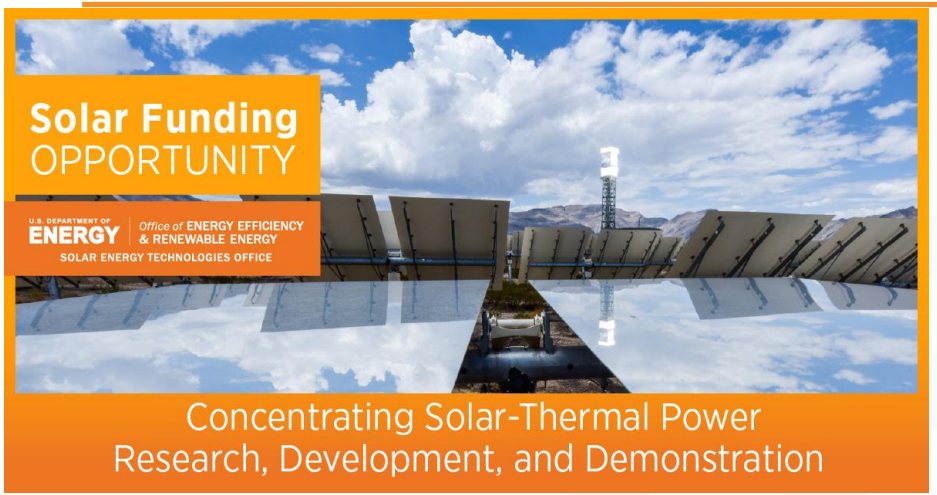
Description	Organizations	Status
100 kW_{th} Moving Bed	Sandia, Solex, VPE	Tested at 550-715°C for several hours; design improvements identified to overcome low heat transfer coefficients measured
20 kW_{th} Moving Bed	Sandia, Solex, VPE	Successfully tested stainless steel heat exchanger at 500°C to 200 W/m^2-K
≤50 kW_{th} Moving bed	Sandia, Solex, VPE	High alloy heat exchanger procured for testing
100 kW_{th} Fluidized bed	Sandia, Babcock & Wilcox, TU-Wien	Build and test heat exchanger at SNL 100 kW_{th} facility
≤20 kW_{th} Moving Bed	Argonne, Sandia, Ex-one	SiC heat exchanger being built for 500-700°C application
14 MW_{th} Moving bed	Solex	Scaleup of large size stainless steel heat exchanger



Remaining R&D challenges for primary heat exchangers > 700 °C :

- Nickel alloy PHE cost exceeds 300 \$/kW_{th}; 200-400 W/m^2-K heat transfer coeff. unproven
- No molten salt-sCO_2 heat exchanger design yet demonstrated in operational environment

New Funding Opportunities



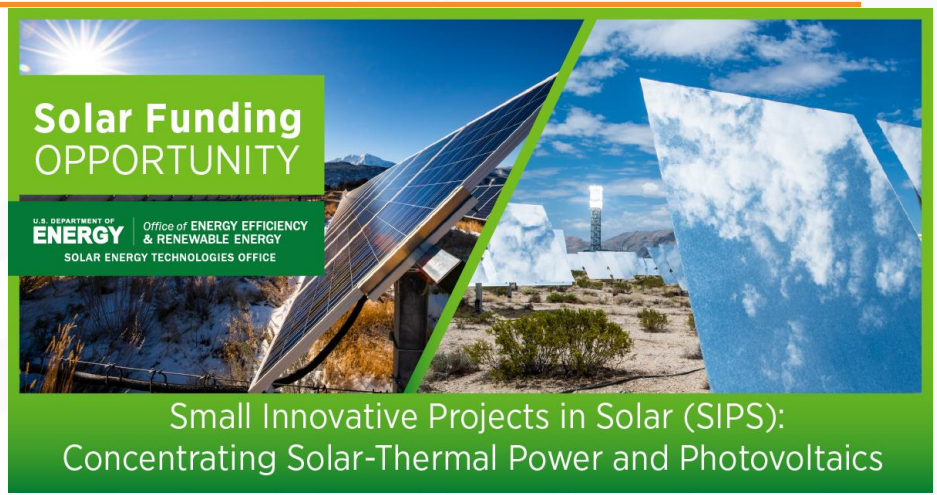
Concentrating Solar-Thermal Power
Research, Development, and Demonstration

$25M for 8-15 projects that develop:

- CSP for carbon-free industrial processes
- Solid-particle-based CSP plant designs and components

Concept paper deadline: March 16, 5:00 p.m. ET

Info webinar: February 24, 2:00 p.m. ET



Small Innovative Projects in Solar (SIPS):
Concentrating Solar-Thermal Power and Photovoltaics

$5M for 15-23 seedling projects in photovoltaics and concentrating solar-thermal power that accelerate large-scale development and deployment of solar technology

Letter of intent deadline: February 28, 5:00 p.m. ET

Thank You!

The SETO newsletter highlights the key activities, events, funding opportunities, and publications that the solar office has funded.

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