Sandia National Laboratories' National Solar Thermal Test Facility (NSTTF)

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Exceptional service in the national interest

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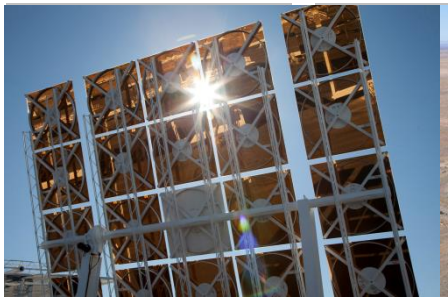

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Concentrating Solar Power

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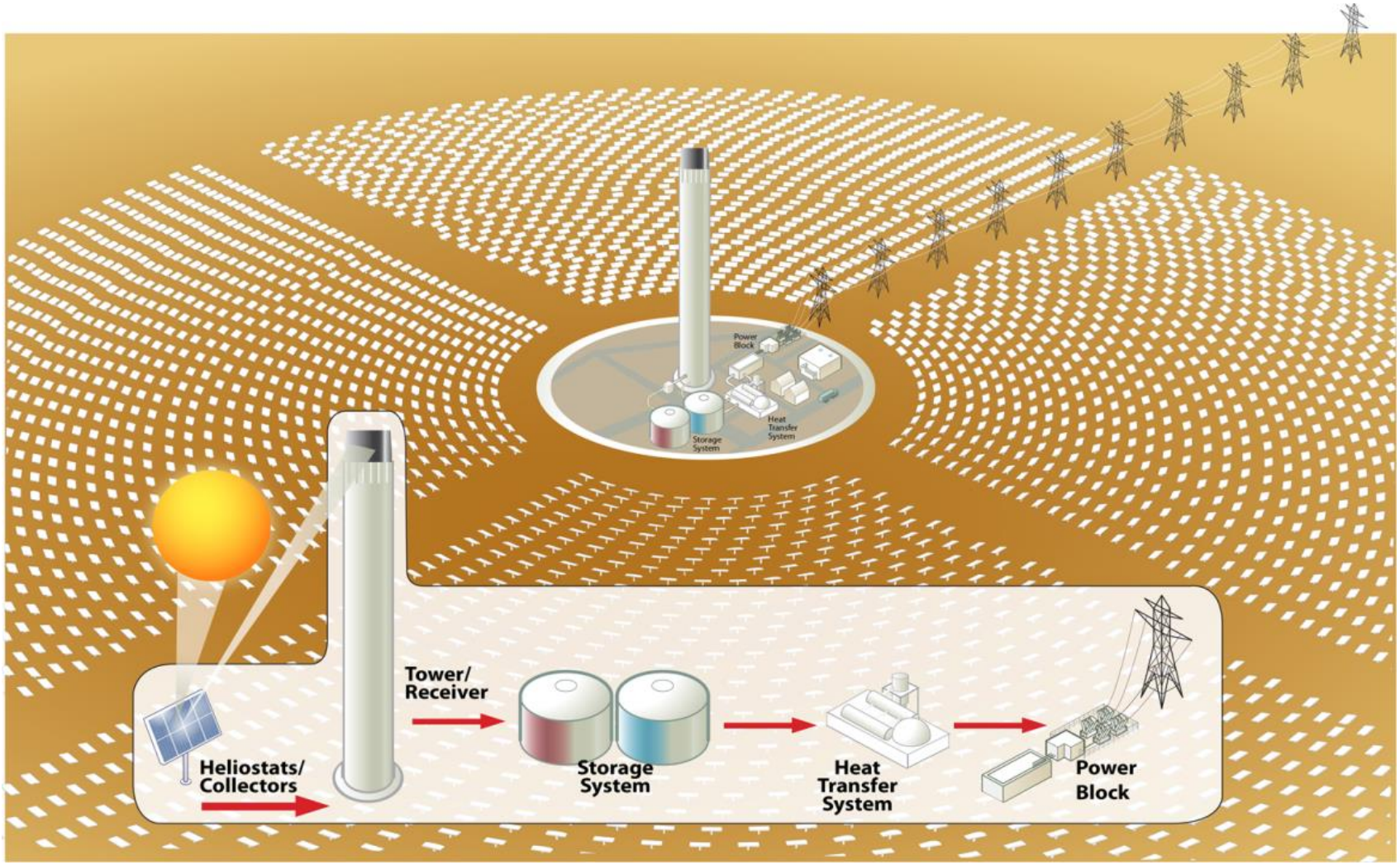

Sandia NSTTF Lineage

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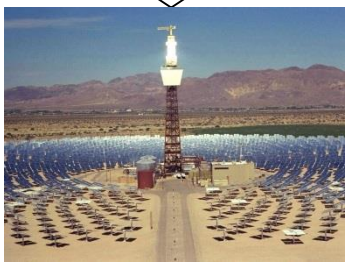
NSTTF Started
1MW$_t$

Circa 1970

Solar One (Steam)
10MW

1980-1990



Solar Two
(Salt) 10MW

1980-1990

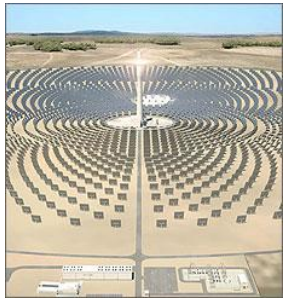
PS10/PS20
11/20 MW

2000's

eSolar Sierra
5MW

Late 2000

Gemasolar
2011
1st Salt
Storage



Ivanpah
2013-2014

3 Towers
120 MW

Direct Steam

Tonopah
2014 110
MW

Salt storage

Test Facility Towers

- PSA (2)
- CSIRO (1)
- KSU (1)
- Beijing (1+1)
- Julich (1)
- Weizmann (1)

1970	1980	1990	2000	2010	2011	2013	2014

National Solar Thermal Test Facility (NSTTF)

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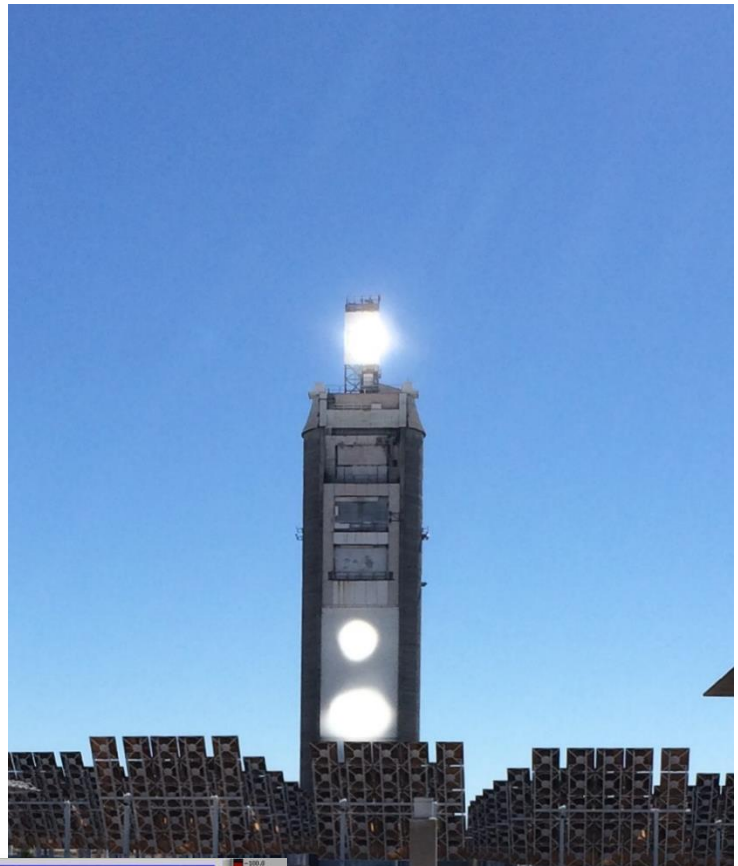
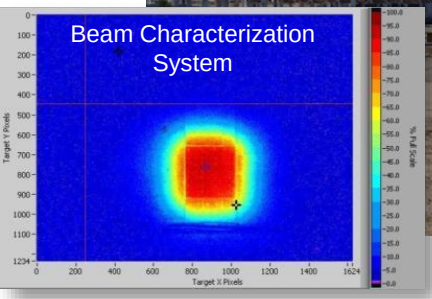
- Optical modeling, measurement and characterization
- Low-cost, high efficiency collector design and characterization
- Advanced reflective materials and coatings
- Receiver materials, design and analysis
- Thermal energy storage
- Solar fuels (e.g. hydrogen)
- System and component modeling and analysis
- Higher efficiency power cycle

Heliostat Field

- The heliostat field has 218 individual heliostats.
- This field can provide flux levels of greater than 300W/cm2 and total power in excess of 6 MWt.
- Each heliostat has two motors and two drives (one azimuth and one elevation),one 480V power box, one electronics box, and one control box and associated cabling. The total reflective area on each heliostat is 37m2.
- The reflectivity on the recently replaced facets 96%.
- Additional foundations, electrical supply, and controls wiring are in place to support prototype heliostat installations.

Central Tower and Heliostat Field





Capability

Testing receivers, materials and systems under high solar flux conditions
(6.2 MW_{th} incident power and 350 W/cm^2 peak irradiance)

Heliostat field

218 heliostats, each providing 37 m^2 reflective area

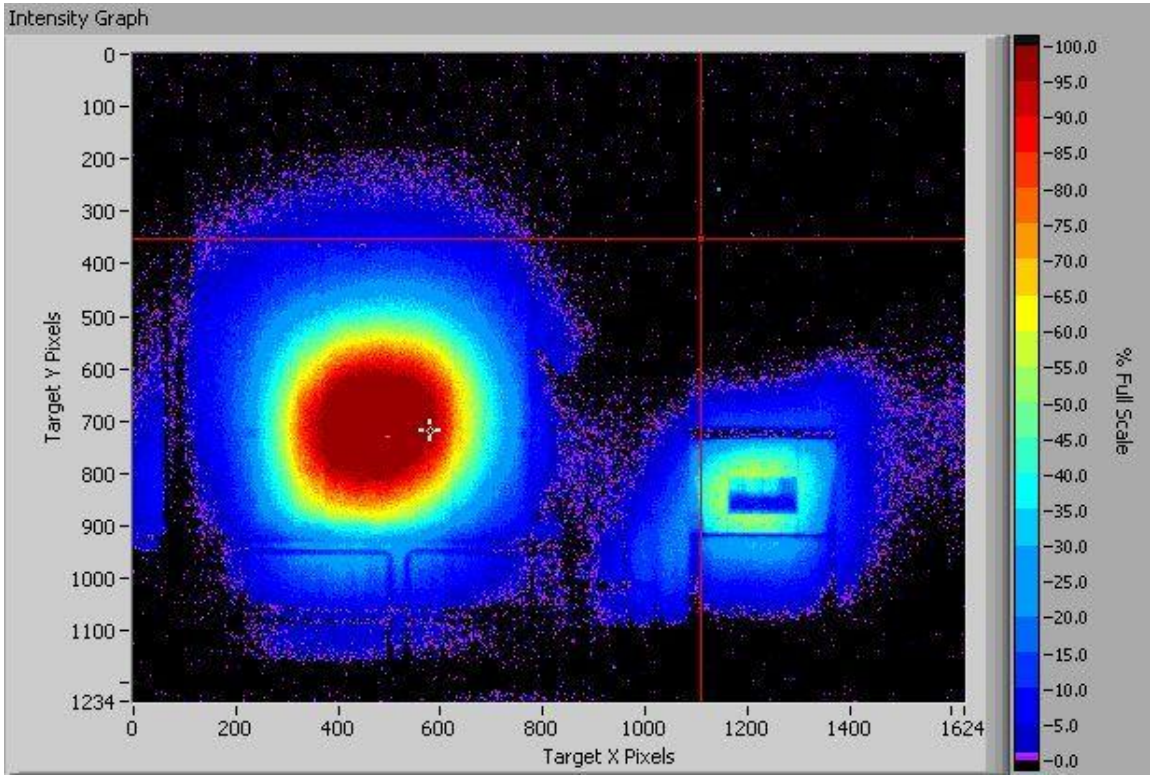
> 95% solar-weighted reflectivity

Central tower

200 ft. tall with three bays, and rooftop for testing
100 ton capacity elevating module
Beam characterization system

Heliostat test-bed

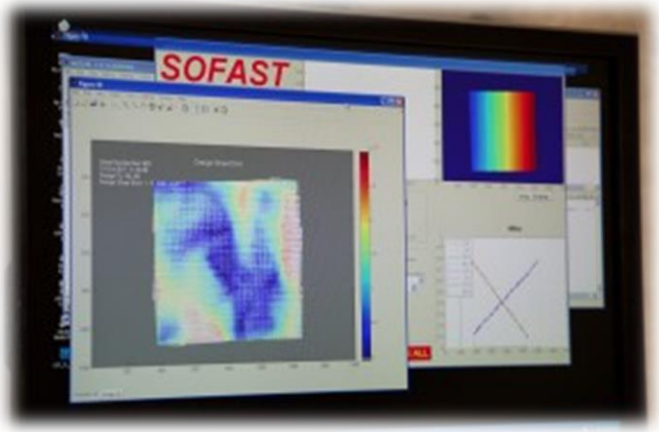
Beam Characterization System (BCS)



- The BCS provides a real -time means for capturing and characterizing the concentrated beam from one or more heliostats onto a flat target area.
- This data is useful for characterizing heliostat performance, calibrating heliostat tracking, and correlating data with models.

Optics Lab

- **Capability**
  - Software & hardware tools to maximize CSP optical systems performance
- **Large Scale Optical Metrology**
  - Advanced optical & system modeling tools
  - Long range heliostat flux mapping (up to 1770 m)



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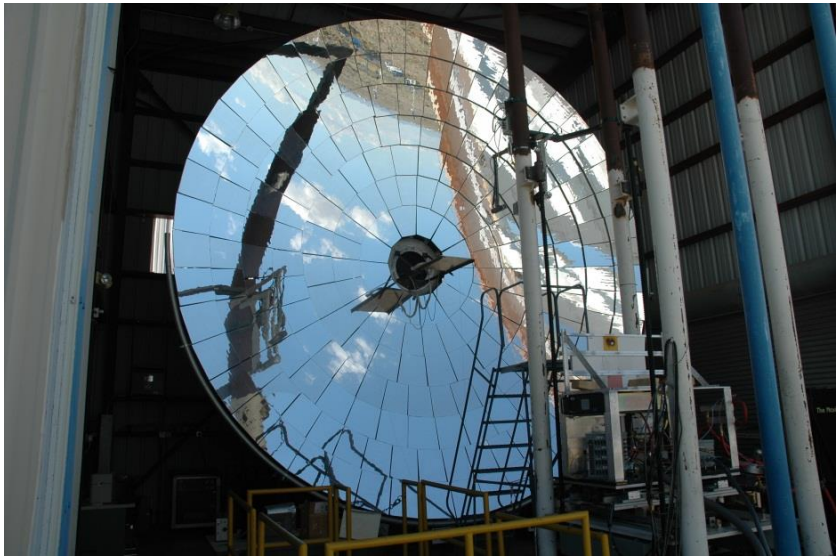
Solar Furnace



16 kW solar furnace comprises:

- Primary heliostat
- A secondary concentrator
- Test table where experiments or calibrations are performed.

Peak flux > 600W/cm2.

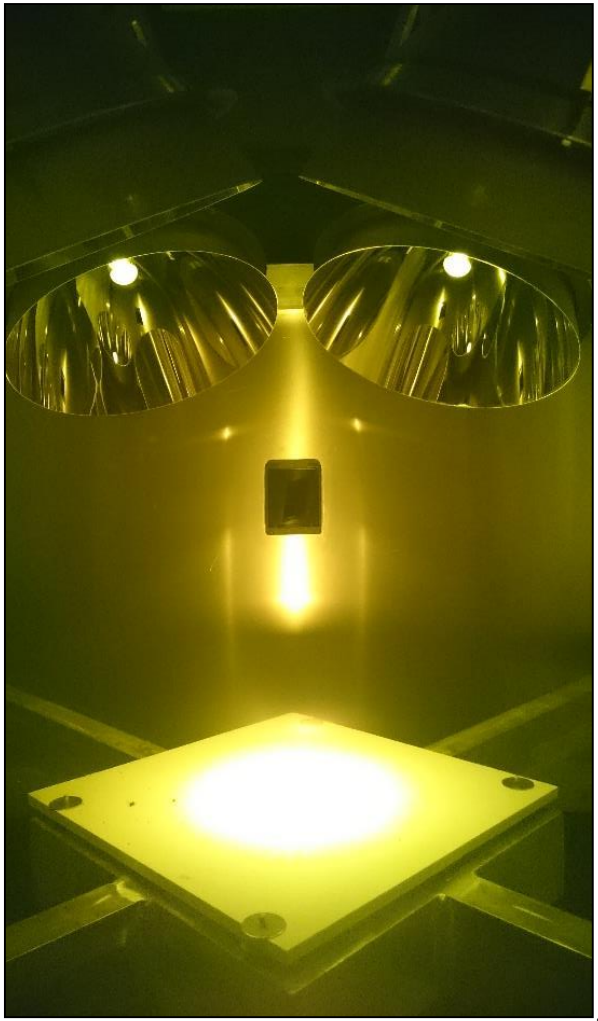
Furnace used to demonstrate the feasibility of the Sunshine-to-Petrol initiative.

Furnace also used for selective absorber testing and material screening.

Only place in the US that provides solar calibration for flux gages.

Solar Simulator

- Solar Simulator provides accelerated testing for materials under high flux conditions
- Peak Irradiance:1.3 MW/m^2
- Average Irradiance: 0.9 MW/m^2
- Spot size: ~4 inches
- Operational: 24/7
- Programmable, robotic sample holder, for multi-sample testing



Solar Glare Hazard Analysis

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Need tools to quantify glare and potential ocular impacts to safely site solar energy systems

Glare Analysis of Ivanpah Solar Towers

- Pilot reports have been received regarding glare from Ivanpah Solar
- Preliminary results from helicopter surveys indicate that glare may be visible when the heliostats are in standby mode
- Initial measurements indicate that heliostat glare may have the potential to cause a temporary after-image
- Analyses are ongoing

Ryan Goerl, NRG

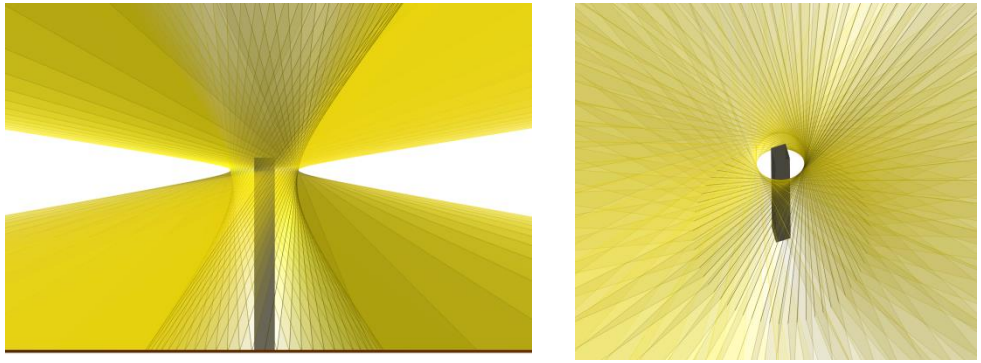
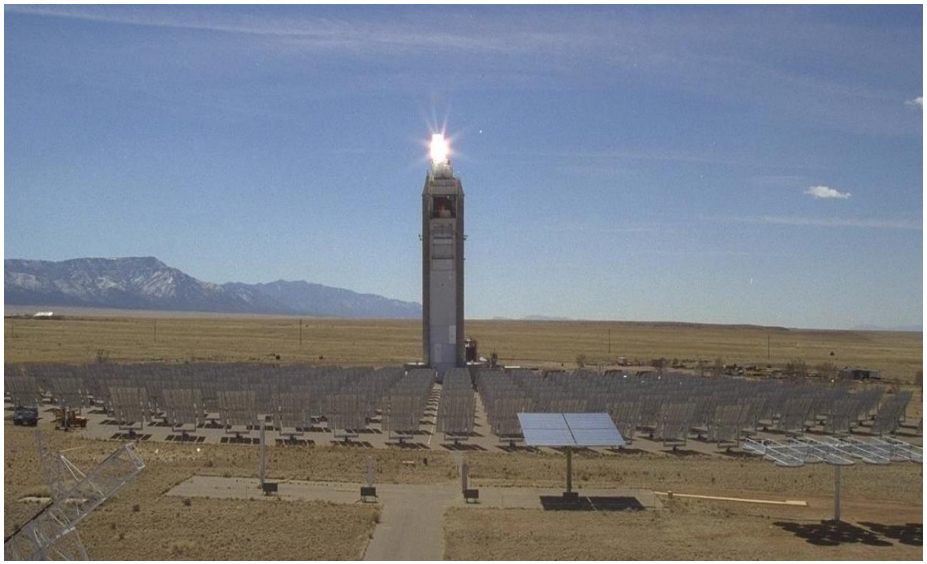


Photo (top) and model (bottom) of reflected light from heliostats in standby mode

High-Temperature Receivers



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- Liquid Based Receivers
- Gas Based Receivers
- Solid Particle Receivers

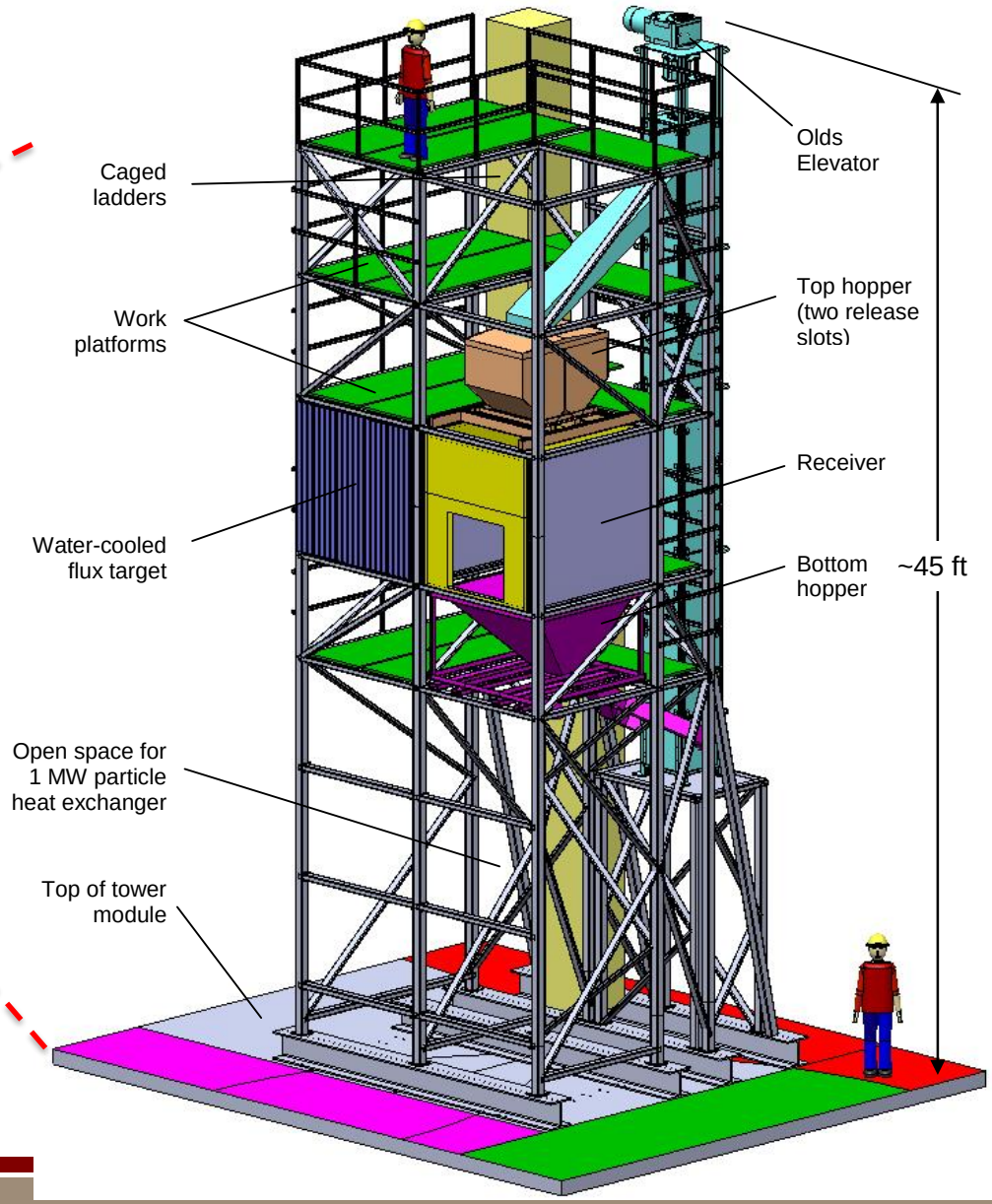
Cavity receiver

External tubular receiver

Falling Particle Receiver Project

- **Falling Particle Receivers**
  - **Benefits**
    - High temperatures (T > 700 °C)
    - Direct energy storage of particles
    - Increased fluxes
  - **Challenges**
    - Particle attrition / wear / conveyance
    - Particle solar absorption
    - Particle/fluid heat exchange
    - Need to increase thermal efficiency (from 50% to 90%)

Prototype System Design



Molten Salt Test Loop

- The molten salt test loop can be utilized to obtain greater collection efficiencies and higher-temperature operation for linear Fresnel and trough systems using molten salt.
- The facility provides a means of performing accelerated lifetime testing on components, thus reducing the risk of the technology.
- Though operating below 600 °C, many of the lessons learned at this facility will be directly applicable to molten salt systems operating range ≥650 °C.

The Brayton Cycle and Supercritical CO_2

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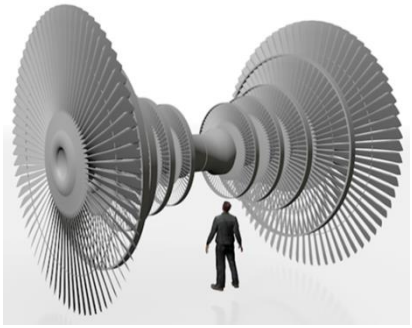
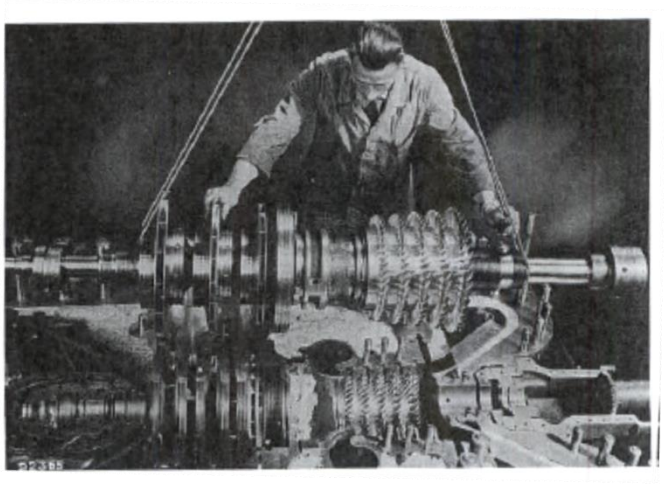
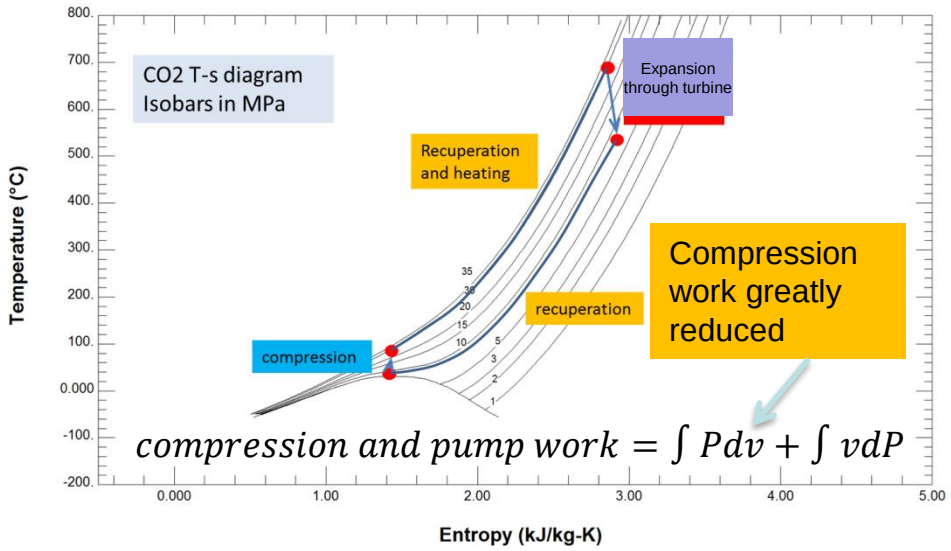
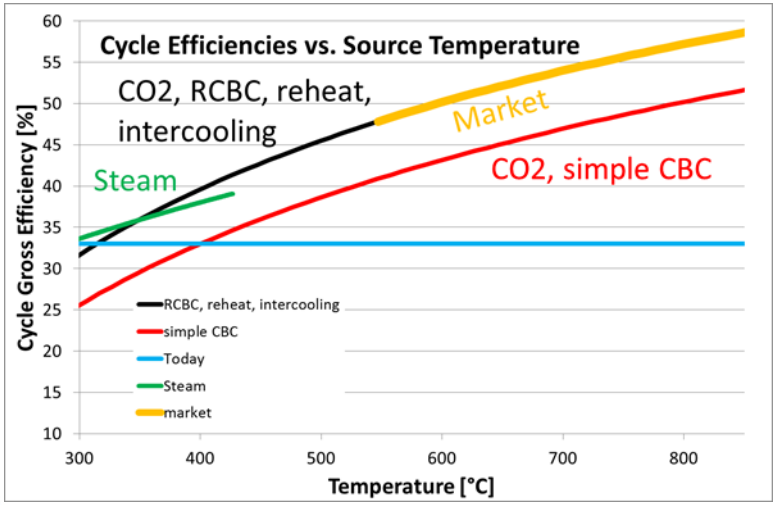
20 meter Steam Turbine (300 MWe)
(Rankine Cycle)





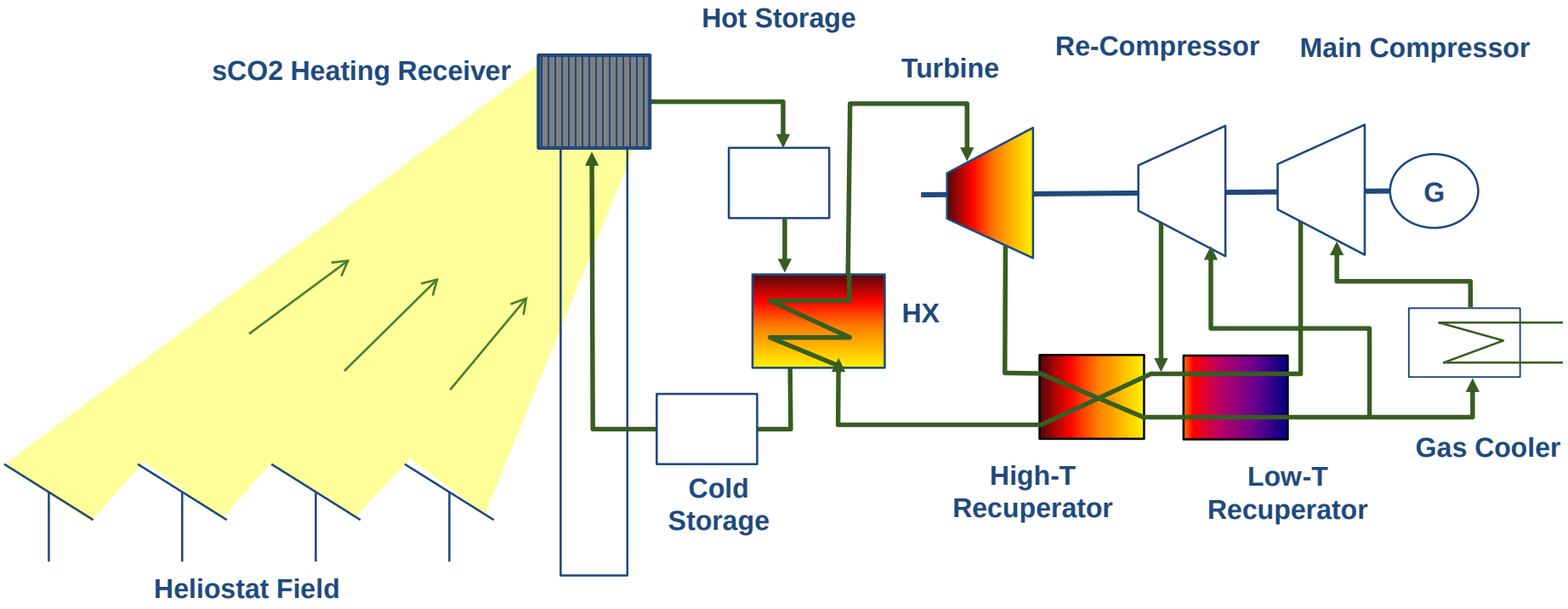
1 meter sCO_2 (300 MWe)
(Brayton Cycle)





CSP Integration with sCO_2 Brayton Cycle

Schematic



CSP SunShot goals of 6 cents/kWh lead to power cycle working temperatures >700°C