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Sandia National Laboratories

Sandia's Concentrating Solar Power Program Overview

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For National Ground Intelligence Center and

National Geospatial Intelligence Agency Visit

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U.S. DEPARTMENT OF ENERGY | NNSA

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Outline

- 10:15 AM Sandia's CSP Program Overview
  - Energy, Climate, and Infrastructure Security
  - Commercial CSP Plants
  - DOE SunShot Goals
  - Sandia's CSP Program
  - NSTTF Facility
- 10:45 AM Tour

Energy, Climate, and Infrastructure Security

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Program Areas

- Infrastructure Security
- Energy Security
- Climate Security
- Enabling Capabilities

Vision

To enhance the nation's security and prosperity through sustainable, transformative approaches to our most challenging energy, climate and infrastructure problems.

Renewable Energy R&D

- Solar
  - Photovoltaics
  - Concentrating Solar Power
  - Solar Fuels
- Wind
- Water
- Geothermal
- Biomass

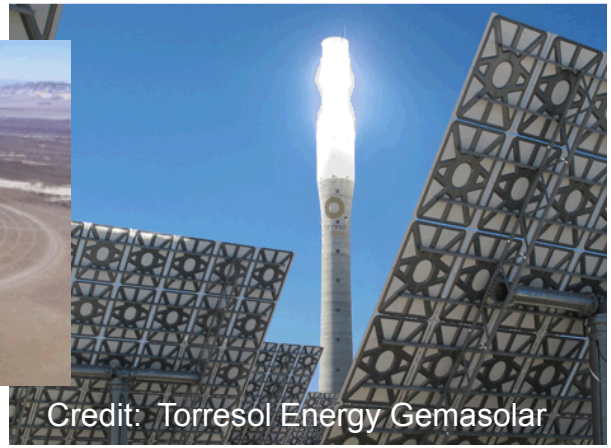
Overview of CSP

- Several CSP plants are in operation around the world
  - 539 MW in the US
  - 1182 MW in Spain
  - 655 MW the rest of the world
  - Gigawatts under construction and planned
- Parabolic trough is the most mature and prevalent.
- Power towers are emerging and the first commercial plants are coming on-line.
- Dish engine systems have higher efficiency and the potential for significant cost reductions.

Commercial Power Tower Plants

- Gemasolar Thermosolar Plant
  - **20 MWe** molten salt power tower
  - Operational in Andalucía, Spain
- BrightSource Ivanpah
  - **390 MWe** direct steam generation
  - Three plants under construction in CA
- Solar Reserve Crescent Dunes
  - **110 MWe** molten salt
  - Under construction in Tonopah, NV
- eSolar Sierra SunTower
  - **5 MWe** direct steam
  - Operational in Lancaster, CA


Credit: SolarReserve

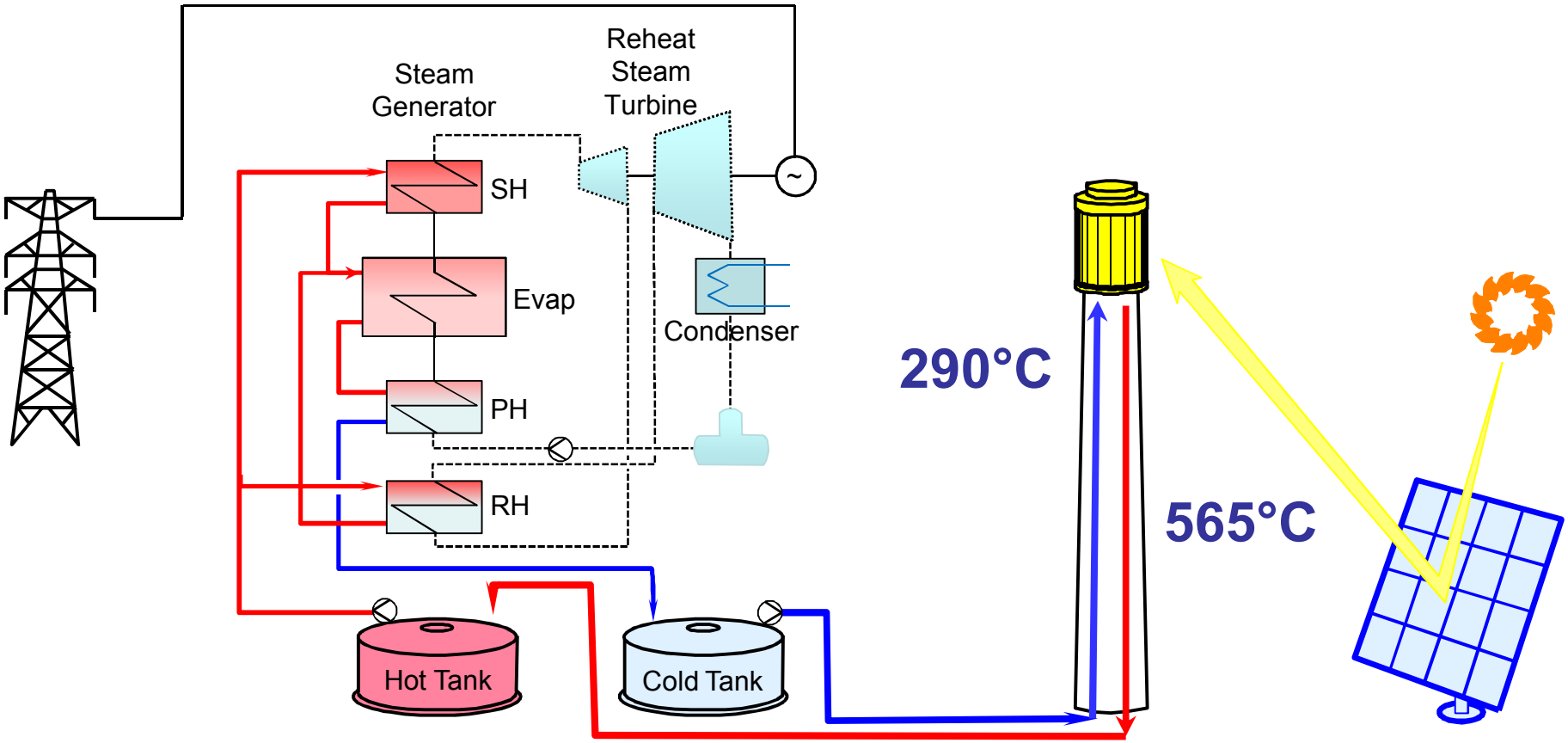

Credit: Torresol Energy Gemasolar


Credit: eSolar


Credit: BrighSource Energy, Inc.

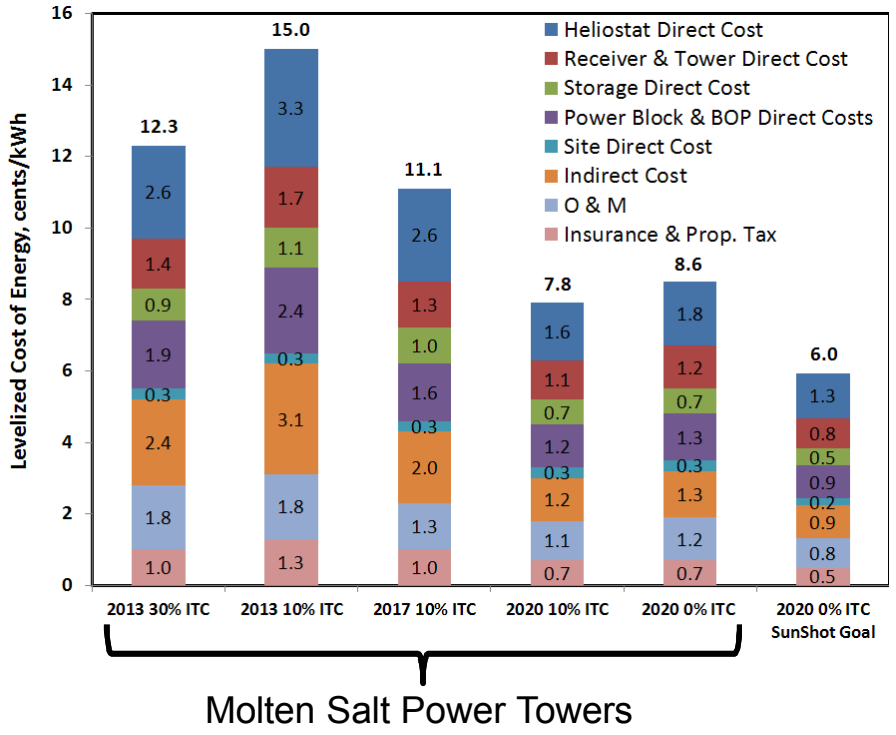

Credit: Torresol Energy Gemasolar

Schematic of Molten Salt Power Tower



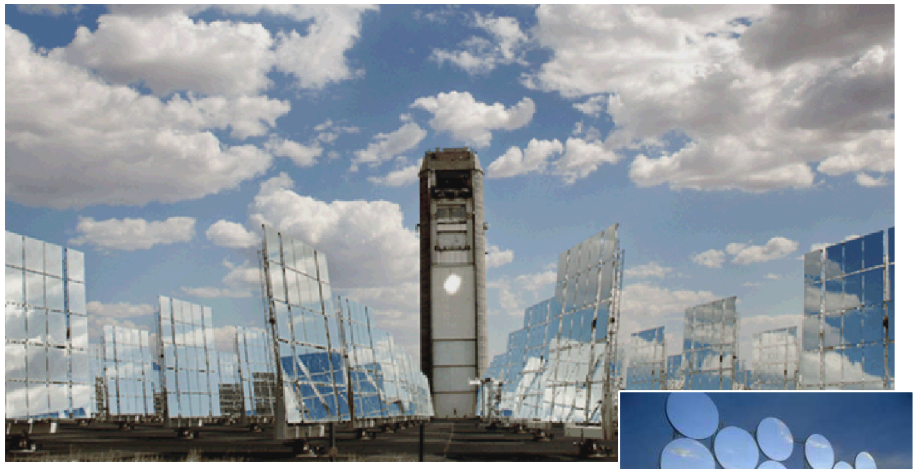
DOE SunShot Goals

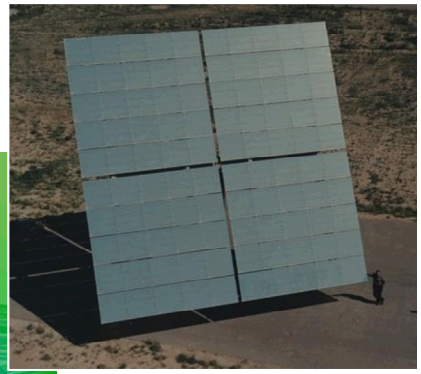
- Reduce the cost of solar-generated electricity to be competitive with fossil fuels (6 cents/kWh) by 2020 without subsidies.
- All major systems in a CSP plant must have improved performance and reduced costs
  - Collector Systems: $75/m^2$
  - Receivers: >650°C operating temperatures, >90% efficiency, <$150/$kW_t$
  - Thermal Storage: <$15/kWh, >95% exergy efficiency
  - Power Cycles: >50% gross-cycle efficiency with dry cooling, >650°C operating temperatures, <$1200/$kW_e$

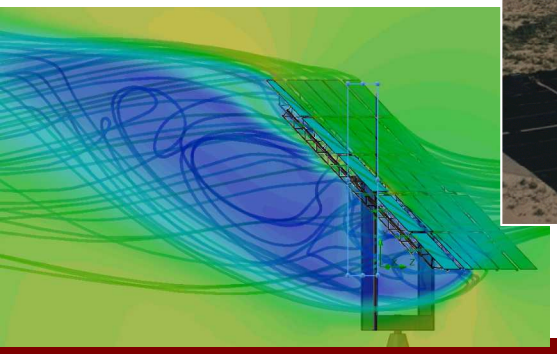


Sandia CSP Program R&D

- Power Tower R&D
- Dish R&D
- Trough R&D
- Thermal Storage R&D
- Systems Analysis
- Optical Materials and Tools
- $7.3M in FY12
- $2.0M in FY13







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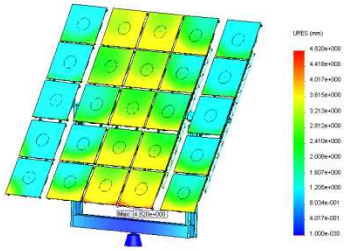
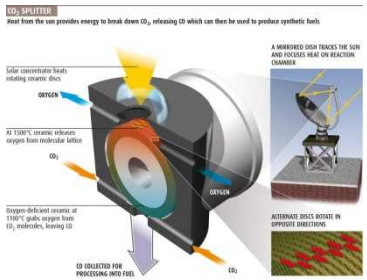
Vision

- Develop the next-generation CSP technologies to provide dispatchable, clean solar-thermal generated electricity at higher conversion efficiencies
- Realize significant reductions in Levelized Cost of Energy (LCOE) by making fundamental advances in power cycles, receivers, thermal storage, and collectors to achieve the intent of the SunShot goals by 2020



Full-scale heliostat modeling and testing at the NSTTF

Molten Salt Test Loop (MSTL)



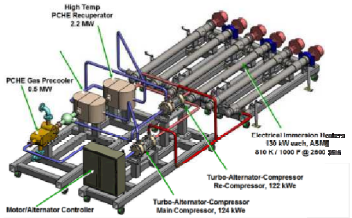
Counter-Rotating-Ring Receiver/Reactor/Recuperator (CR5)

Graphic Credit: Popular Science

Development Areas

- Power Tower R&D – Reduce the cost and improve the performance of high-temperature receivers and novel heliostats
- Thermal Storage R&D - Lower the cost of thermal energy storage through analysis of HTF/material compatibility and performance evaluation of next-generation hardware
- Optical Materials and Tools - Address identified cost and performance impacts in the optical systems
- System Analysis - Develop models and analysis tools that will aid in the evaluation of CSP components and systems
- Dish R&D – Develop thermal storage systems for dish-engine system that use heat pipes and latent thermal storage
- SunShine-To-Petrol (S2P) – Development of a solar chemical process to convert CO_2 and H_2O into hydrocarbon fuels

National Solar Thermal Test Facility at Sandia National Laboratories, Albuquerque, NM



Development of supercritical CO_2 Brayton cycle

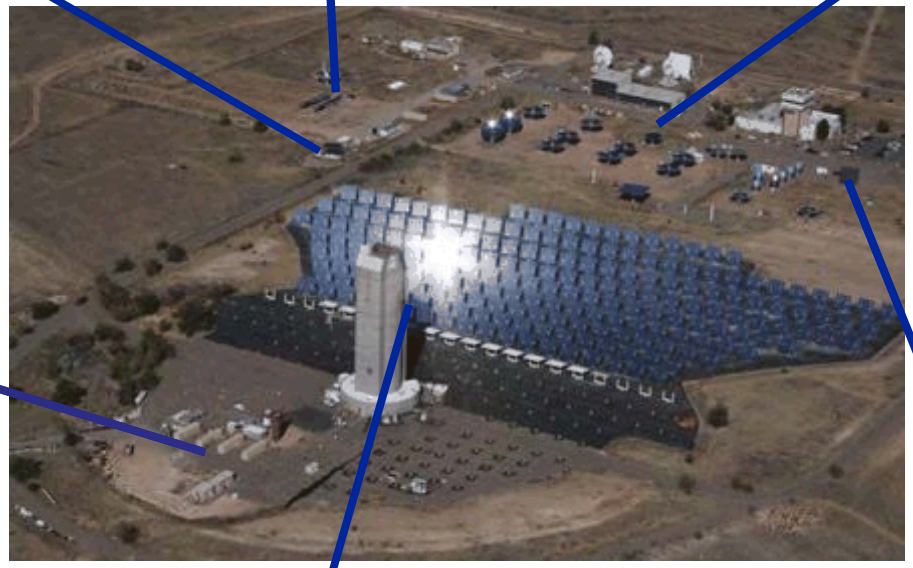
National Solar Thermal Test Facility

Sandia National Laboratories

Parabolic Trough R&D

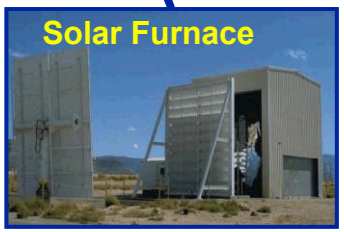
PV System Reliability

Dish Stirling R&D



Thermal Energy Storage R&D

Receivers and Heliostats

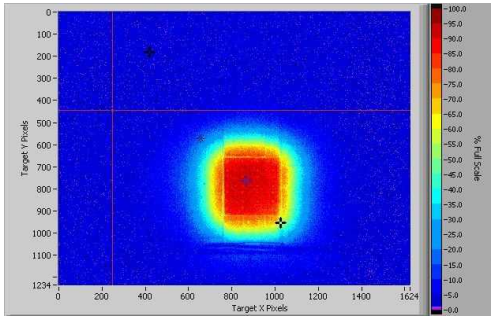


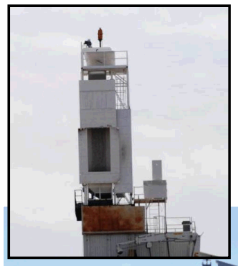
Solar Fuels and Selective Absorbers

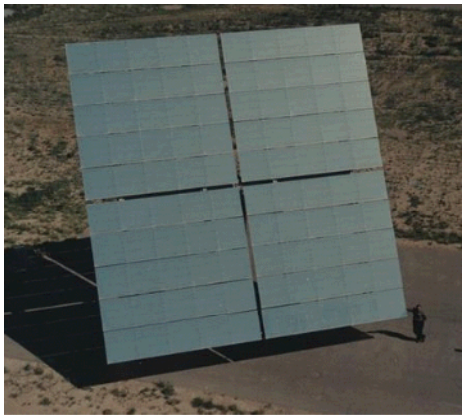
Power Tower & Heliostat Field

- Ability to test large receivers at incident power up to 6.2 MWt
- Heliostat Field
  - 214 heliostats.
  - 37 m2
  - Completely re-mirrored
  - Low-iron, >95% solar-weighted reflectivity
- Tower
  - 200 ft tall tower
  - 100-ton capacity elevating module
  - Three test bays
  - Beam Characterization Target
- Heliostat Test Bed
  - Full-scale heliostats
  - Novel designs
  - High performance reflective film evaluation

Shuttle Tile Testing on top of Solar Tower

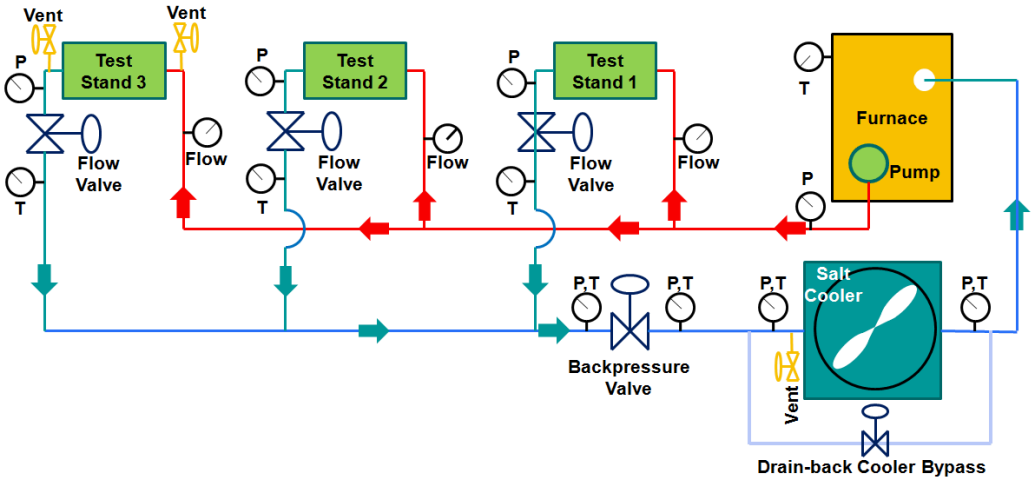






Molten Salt Test Loop

- Purpose:
  - Enables testing of molten salt hardware at high-flow and high-pressure, over a range of temperatures
- Features & Capabilities
  - 3 Test Stands
  - 60% $NaNO_3$ / 40% KNO_3
  - Flow rate: 1.5 m^3/min (400 gal/min)
  - Salt temperature range: 300-585□C (572-1085□F)
  - Maximum salt pressure: 40 bar (580 psi)
  - Remove up to 1.4MW solar thermal input



Dish Test Area

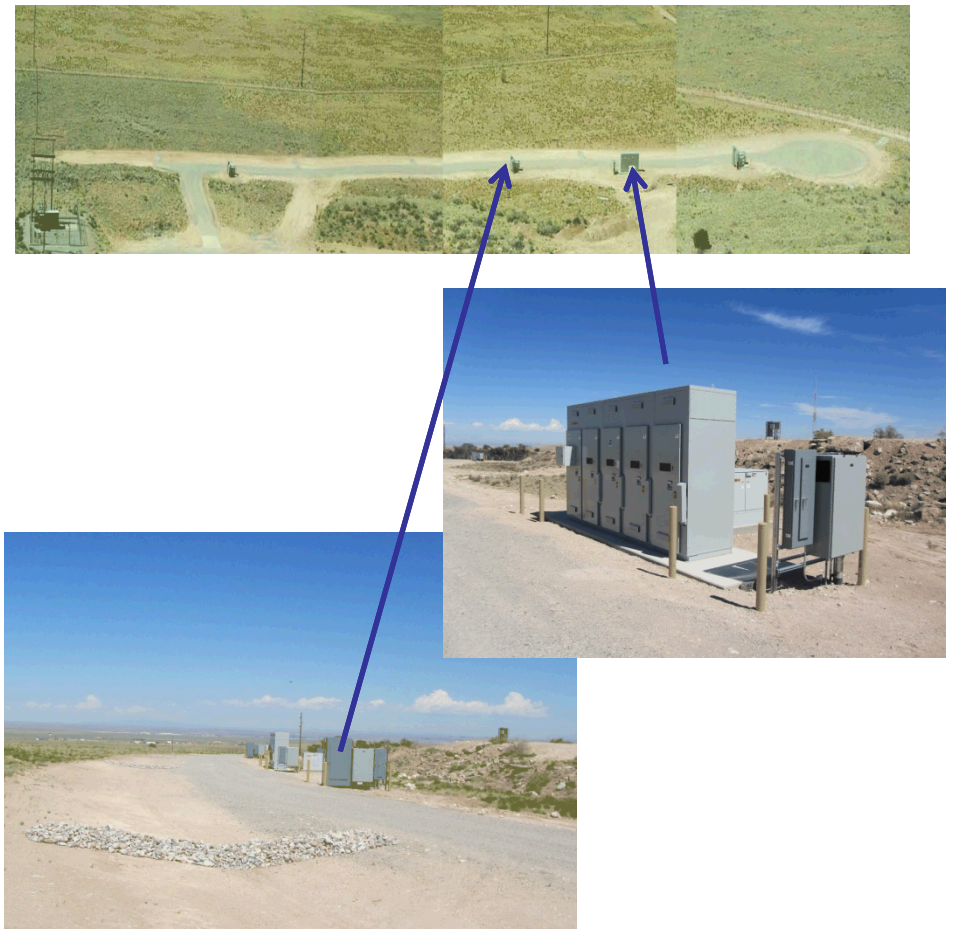
- Allows industry partners to install full-scale solar dishes for long-term reliability testing and evaluation.
- Currently site has ten 30-kW dishes and six 3-kW Infinia dishes at this location.
- The site also includes two SNL-developed solar dishes that are available for research.
- Fully characterize short- and long-term performance

Solar Furnace

- The 16 kW solar furnace comprises:
  - Primary heliostat
  - A secondary concentrator
  - Test table where experiments or calibrations are performed.
- The peak flux provided is greater than 600W/cm2.
- Recently, the furnace has been used to demonstrate the feasibility of the Sunshine-to-Petrol initiative.
- The furnace is also used for selective absorber testing and material screening.
- The solar furnace is the only place in the US that can provide a solar calibration for flux gages.

Regional Test Center

- Purpose: Support US industry in actual field test and validation of US-based PV modules and systems designs to accelerate bankability assessments.
- 1 MWe connectivity to the utility system on eight acres of the NSTTF.
- The second phase, an additional ten acres when complete, will provide an additional 1 MWe.
- One of four RTCs in the country to validate US manufacturers' products at the commercial scale and utility scale in a hot, dry climate.



Concentrating PV

- First demonstration of a utility-size CPV test at SNL.
  - 110 kWe of SunPower's new C7 low-concentration PV systems.
  - SNL is using the systems data to evaluate the reliability of this low-concentration system.
  - SunPower is using the site to test new components in side-by-side comparisons.
- The groups are working together to improve performance models specific to this technology.