



# **A Sea of Mirrors: An Overview on Ivanpah Solar Power Plant**

**Xin Ning and Neil Fromer**

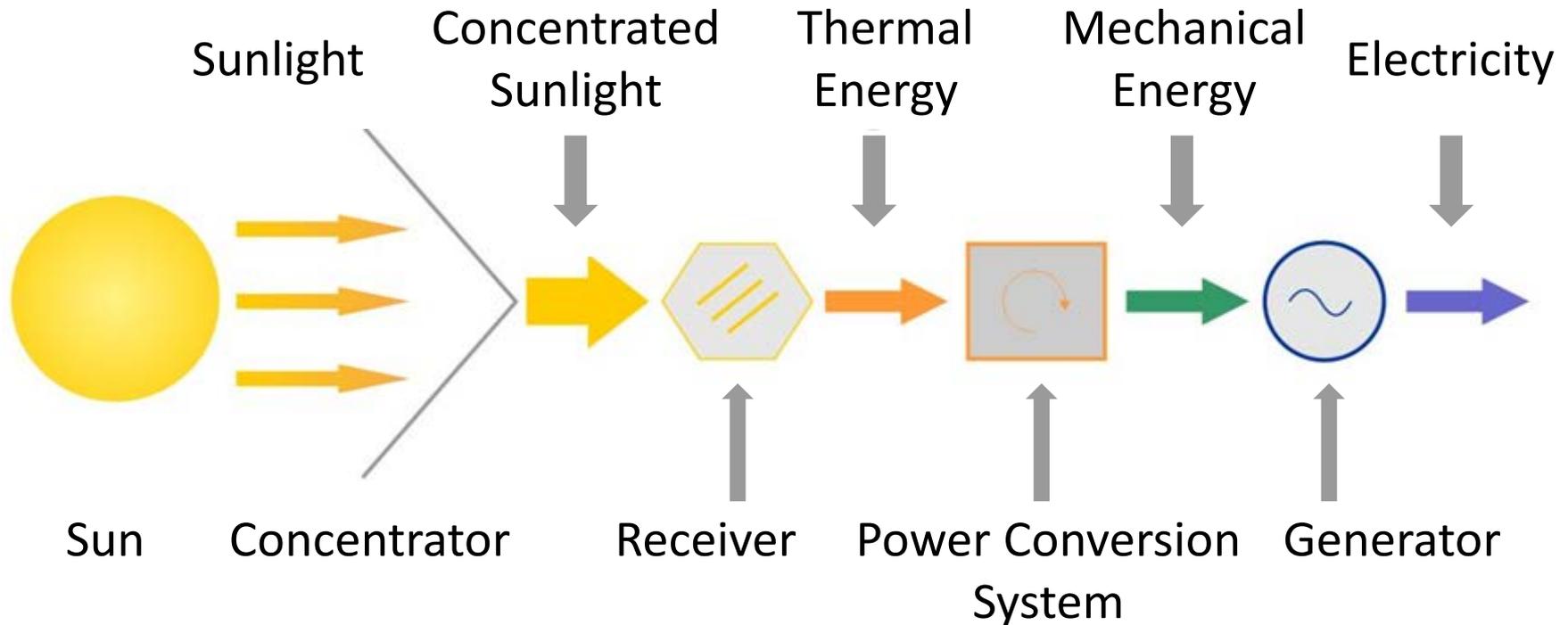
KISS Workshop: Adaptive Multi-Functional Space Structures for Micro-Climate  
Control, Pasadena, CA

Feb. 17th, 2015

# Solar Power

Solar Power:

- Photovoltaic (PV): DC
- Solar thermal: concentrating solar power (CSP) - AC



# CSP Systems

## Point Receiver

Single  
Mirror



Parabolic dish (PSA, Spain)

## Linear Receiver



Parabolic trough (Torresol Energy, Spain)

Multiple  
Mirrors



Power tower (Ivanpah, USA)



Fresnel linear mirror  
(Novatec Solar, German)

# Ivanpah at A Glance

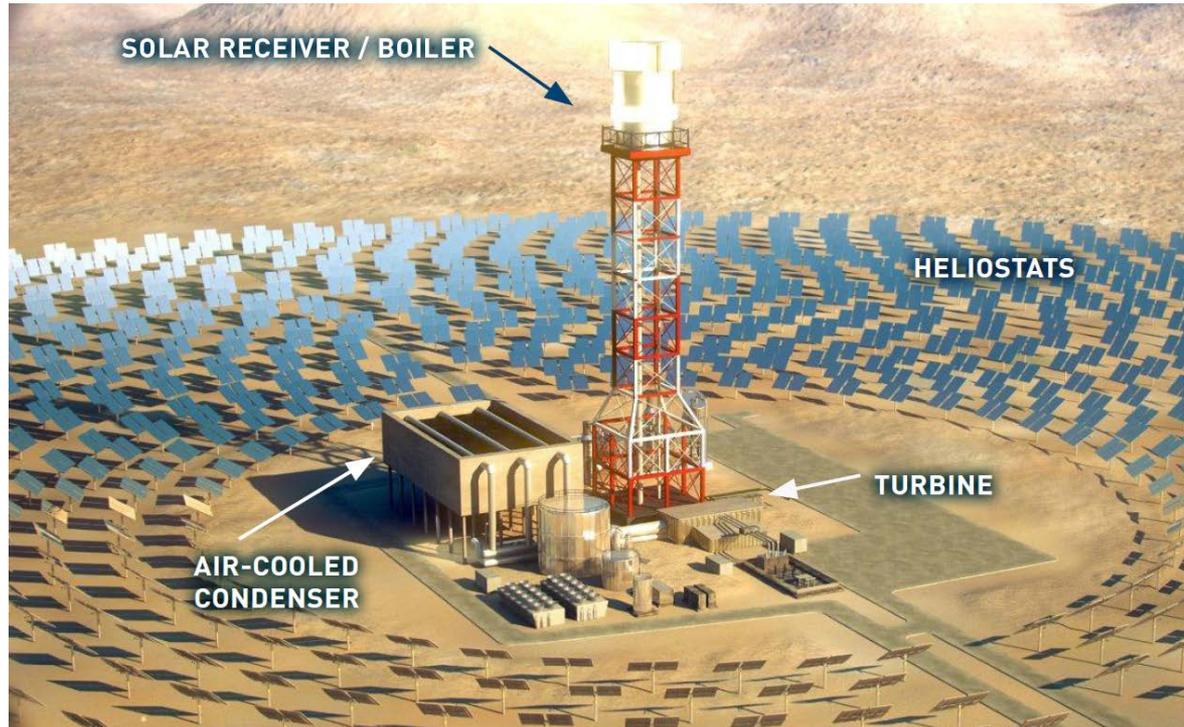
- Location: Ivanpah Dry Lake, CA
- Size: Approx. **3,500 acres** (14.2 km<sup>2</sup>)
- **3** plants
- **173,500** computer-controlled heliostats
  - 2 mirrors on each heliostat
- Cost: **\$2.4 Billion**
  - NRG Energy
  - BrightSource Energy
  - Google
- Power Production: **377 MW**
- Homes Served Annually: **140,000**  
(California, USA)



<http://photo.sf.co.ua/id356>

Ivanpah Project Facts, BrightSource

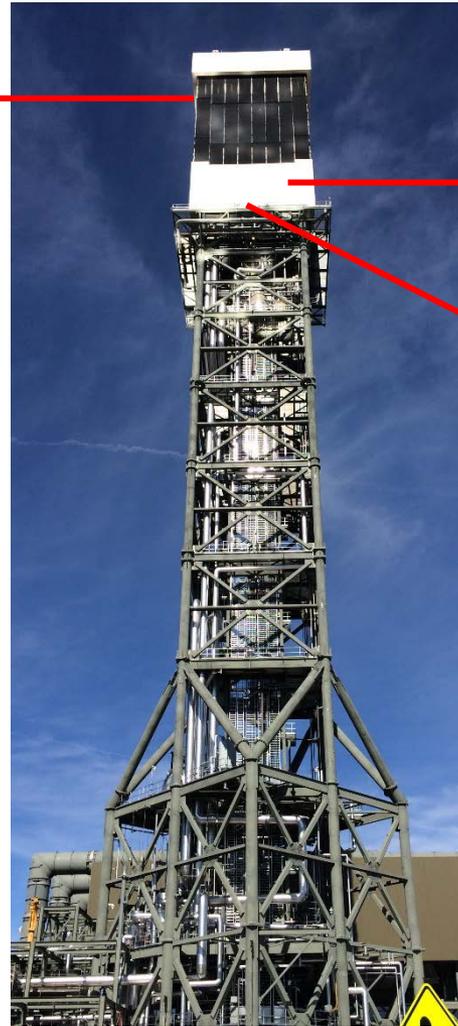
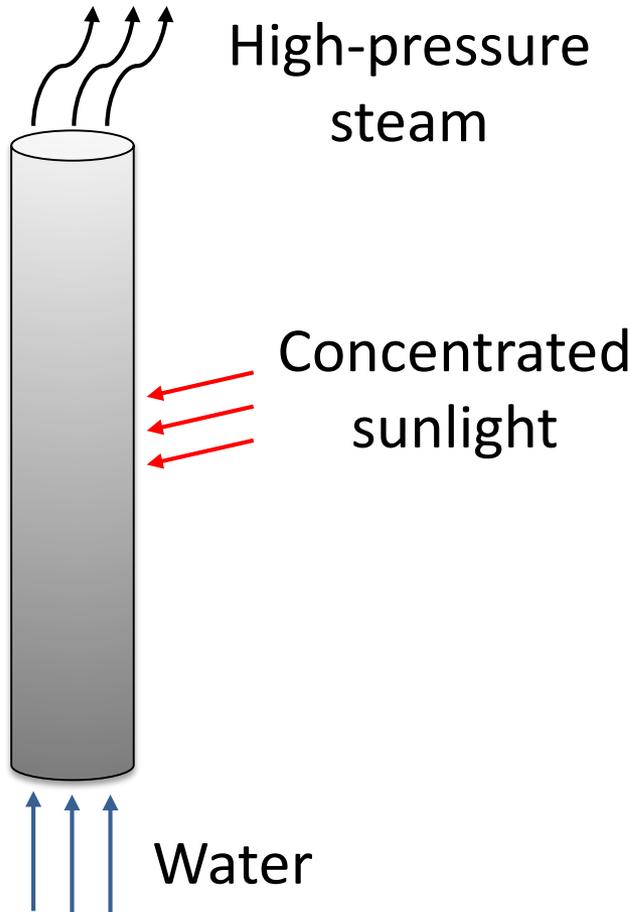
# Ivanpah Solar Thermal System



- Solar receiver/boiler
- Heliostats/mirrors
- Air-cooled condenser
- Turbine

# Solar Receiver/Boiler

Steel hollow tubes with absorptive coating



Insulation material

3 infrared cameras monitoring temperature

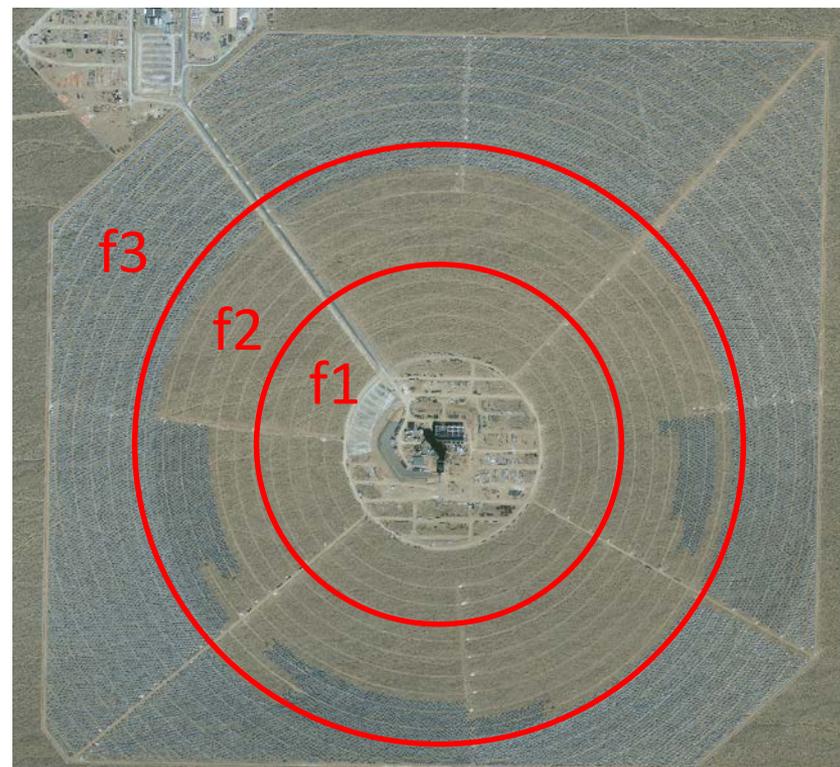
- 460 foot tall
- No thermal storage facility

# Heliostats/Mirrors



- 173,500 heliostats track the sun in two dimensions.
- Controlled by a central server
  - Positions of all heliostats were measured by high-resolution GPS.
  - Angle of each mirror is calculated, distributed, and adjusted by a motor on a **10s period**.
  - No sun-tracking sensors on the heliostats.

# Heliostats/Mirrors



- Mirrors are slightly curved (no actuators)
  - Initially flat
  - Bended when assembled to the supporting frames.
  - Curvature controlled by the length of bolts.
  - Three different focal length
  - Cleaned twice a year.

# Air-Cooled Condenser



An air-cooled condenser housing giant fans



Top view of the condenser

- Dry-cooling system.
- The steam production cycle is a closed-loop system.
- 0.03 Gal/KWh
  - Nuclear: 0.72 Gal/KWh
  - Coal: 0.5 Gal/KWh

<http://photo.sf.co.ua/id356>

<http://www.freerepublic.com/focus/news/3122781/posts>

Ivanpah Project Facts, BrightSource