BrightSource Energy

Ivanpah Solar Electric Generating Facility

Engineering and Construction Contracting Conference, San Antonio Texas

Michael Bobinecz, Vice President
September 7, 2012

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Ivanpah Project Facts

IVANPAH Project Facts

A BRIGHTSOURCE ENERGY CONCENTRATING SOLAR POWER PROJECT

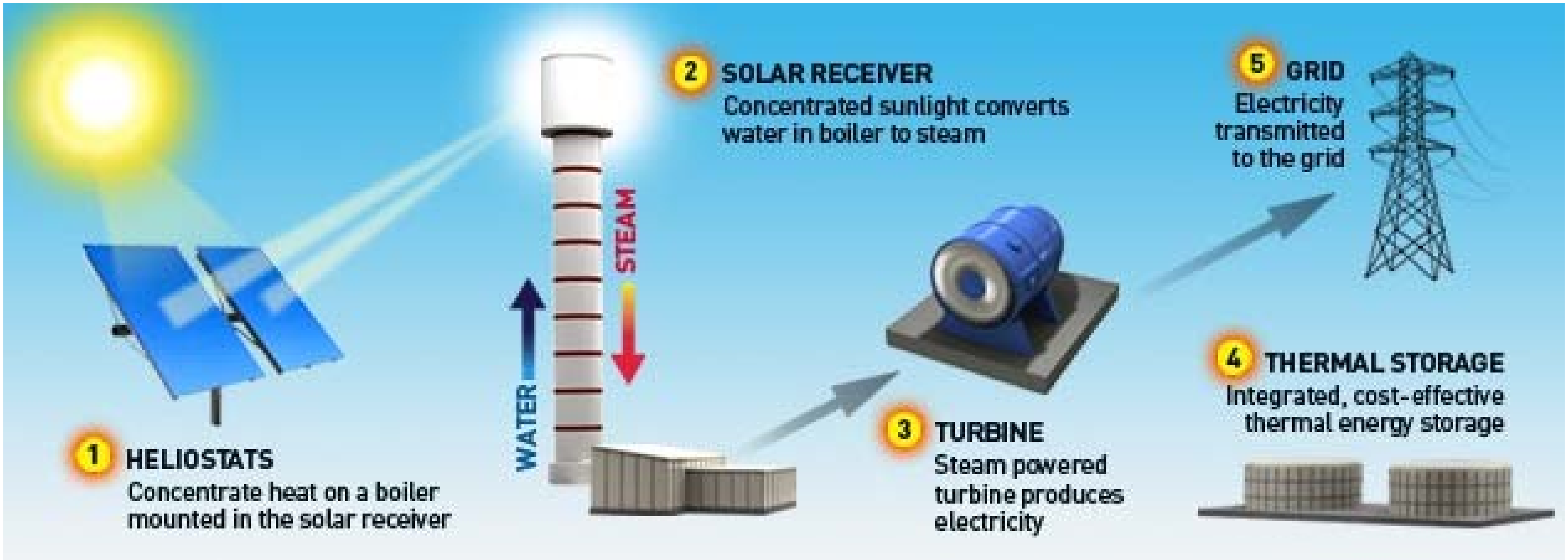
IVANPAH AT A GLANCE

The world's largest solar thermal project

- Size: 3,600 acres
- Power Production: 370 MW (nominal)
- Homes Served Annually: 140,000
- Customers: PG&E and SCE
- Owners: NRG, Google, BrightSource
- DOE Loan Guarantee: $1.6B
- Project Financing: $2.2B

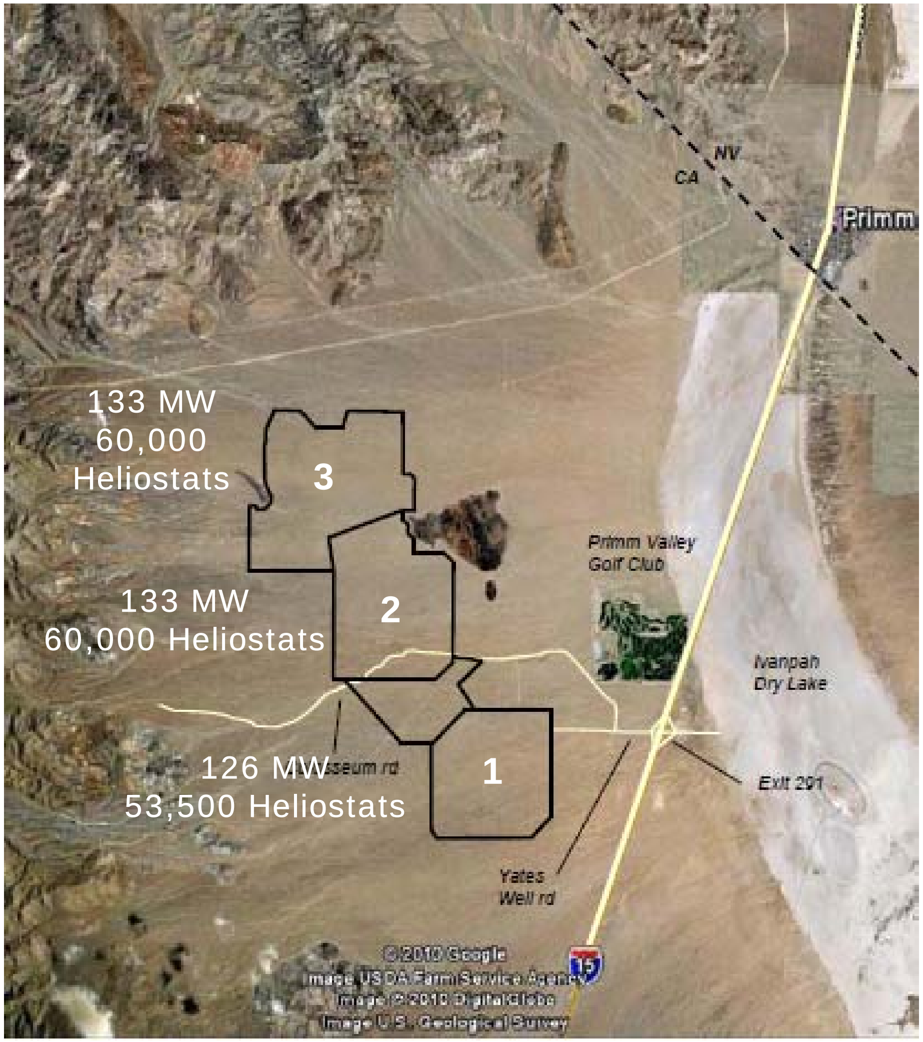
- Construction Commenced: Oct 2010
- Construction Status: 50% + complete
- Construction workers: 2,000
- Expected Completion: 2013 (Q2 – Q4)

Concentrated Solar Power Overview

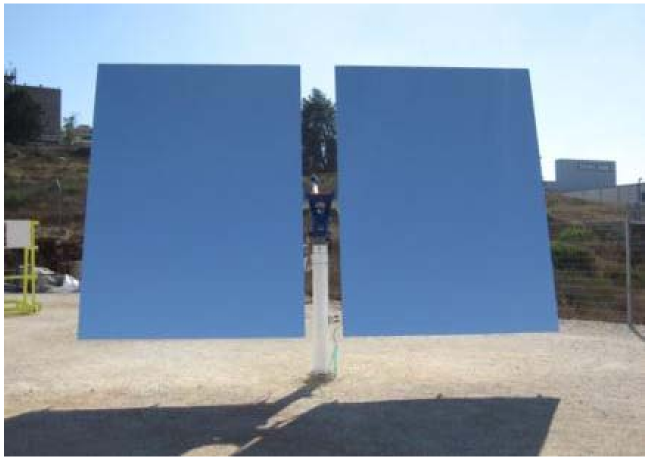


Overview

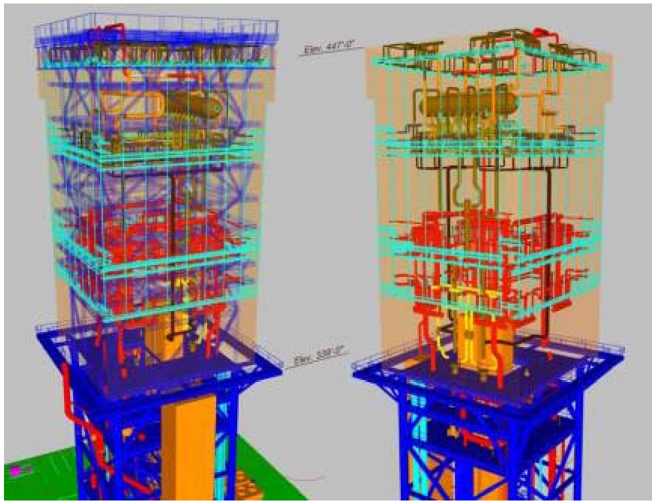
IVANPAH PROJECT SITE



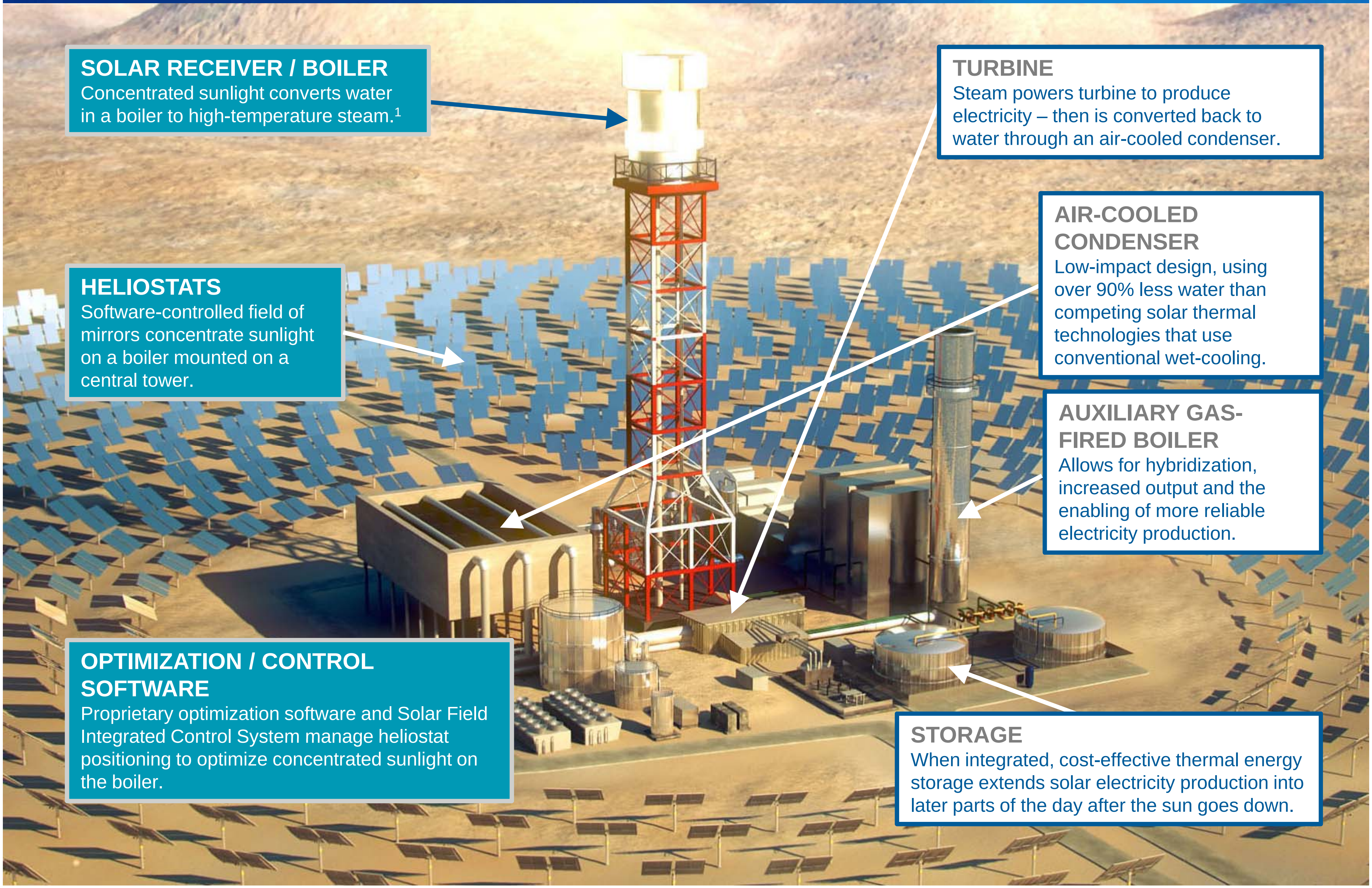
Heliostat



SRSG
(Boiler)



Concentrated Solar Power Main Components



Play “Fly by” of Power Block

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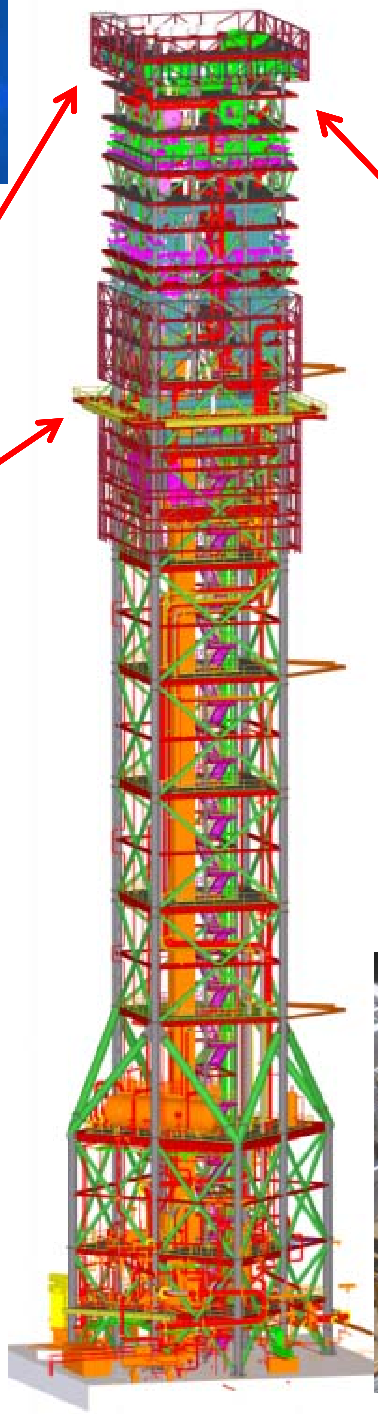
Solar Tower & SRSG

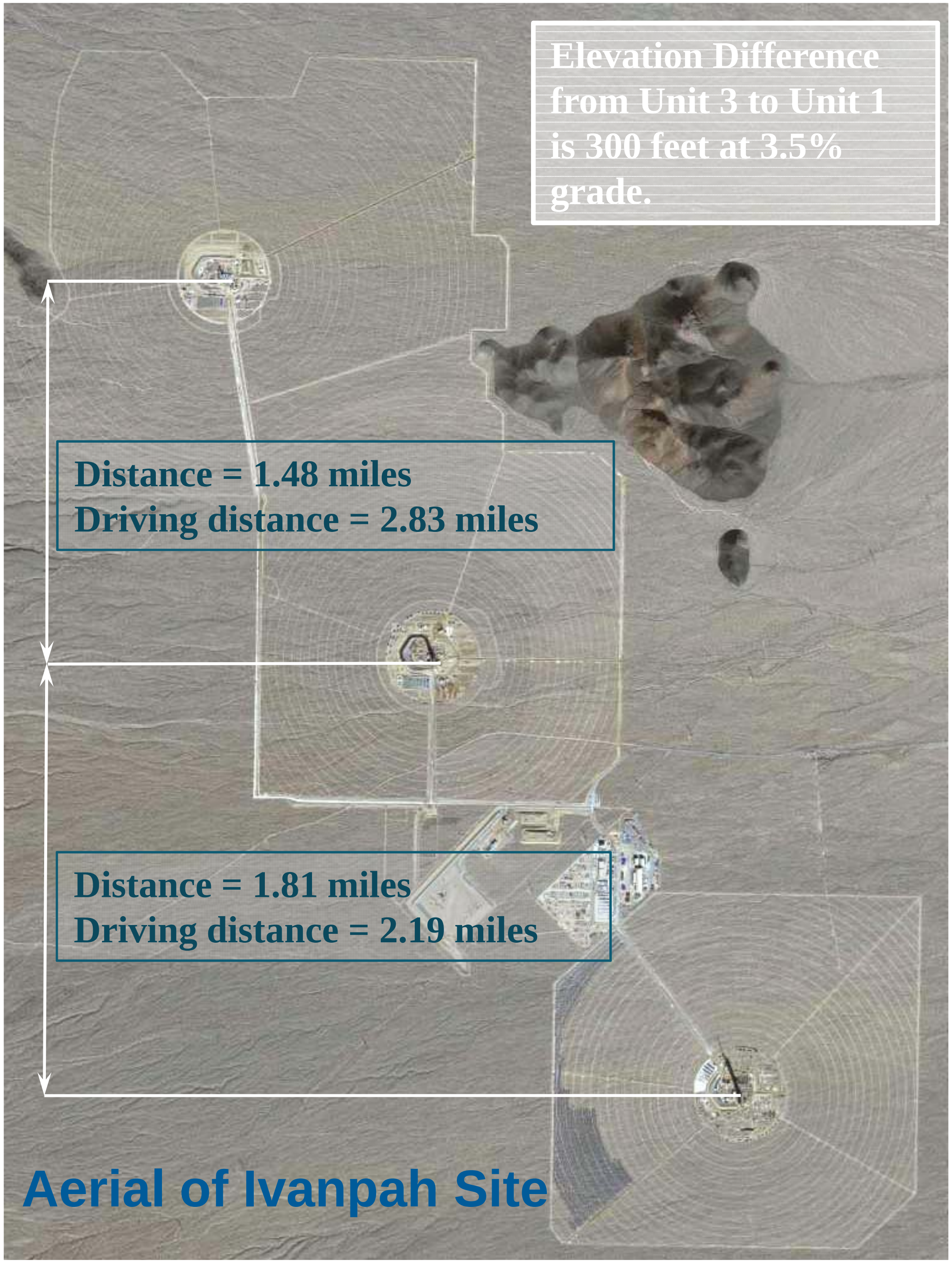
- Top of Solar Receiving Steam Generator (SRSG) = 450 feet
- Top of Steel Structure = 327 feet
- 7,533 tons of steel
- 9 tower tiers
  - Tiers 1 – 4 = Stick built
  - Tiers 5 – 9 = Modularized, including pipe & hangers



Tuned Mass Damper to reduce tower movement = 100 tons

SRSG – Inside out, upside down boiler

- Insulation Panels
- Superheater Section
- Evaporative Steam Generation Section
- Reheater Section
- Insulation Panels

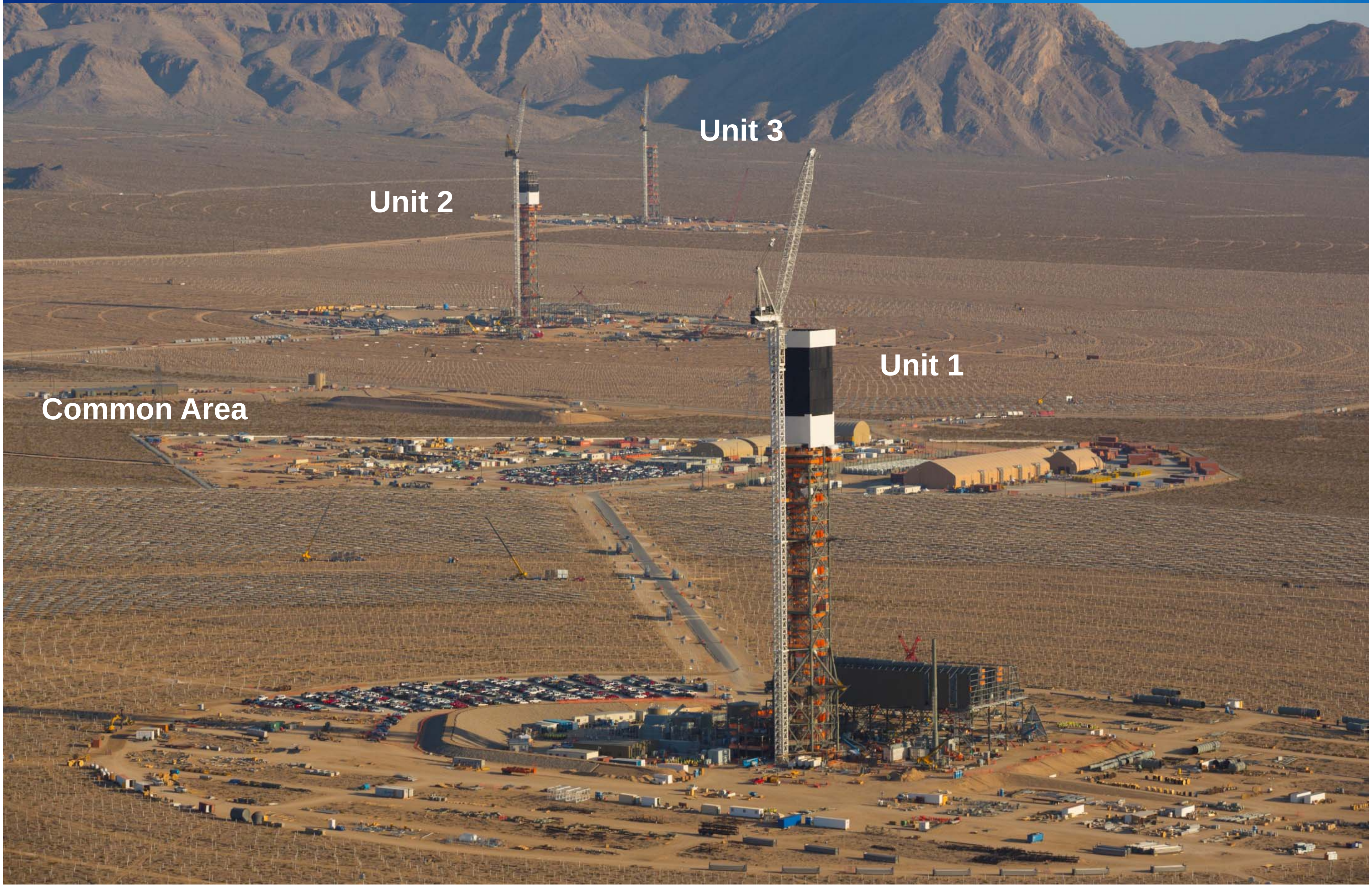

Elevation Difference from Unit 3 to Unit 1 is 300 feet at 3.5% grade.
Distance = 1.48 miles
Driving distance = 2.83 miles
Distance = 1.81 miles
Driving distance = 2.19 miles
Aerial of Ivanpah Site


Unit 3


Unit 2


Unit 1

Receiver/Boiler Progress

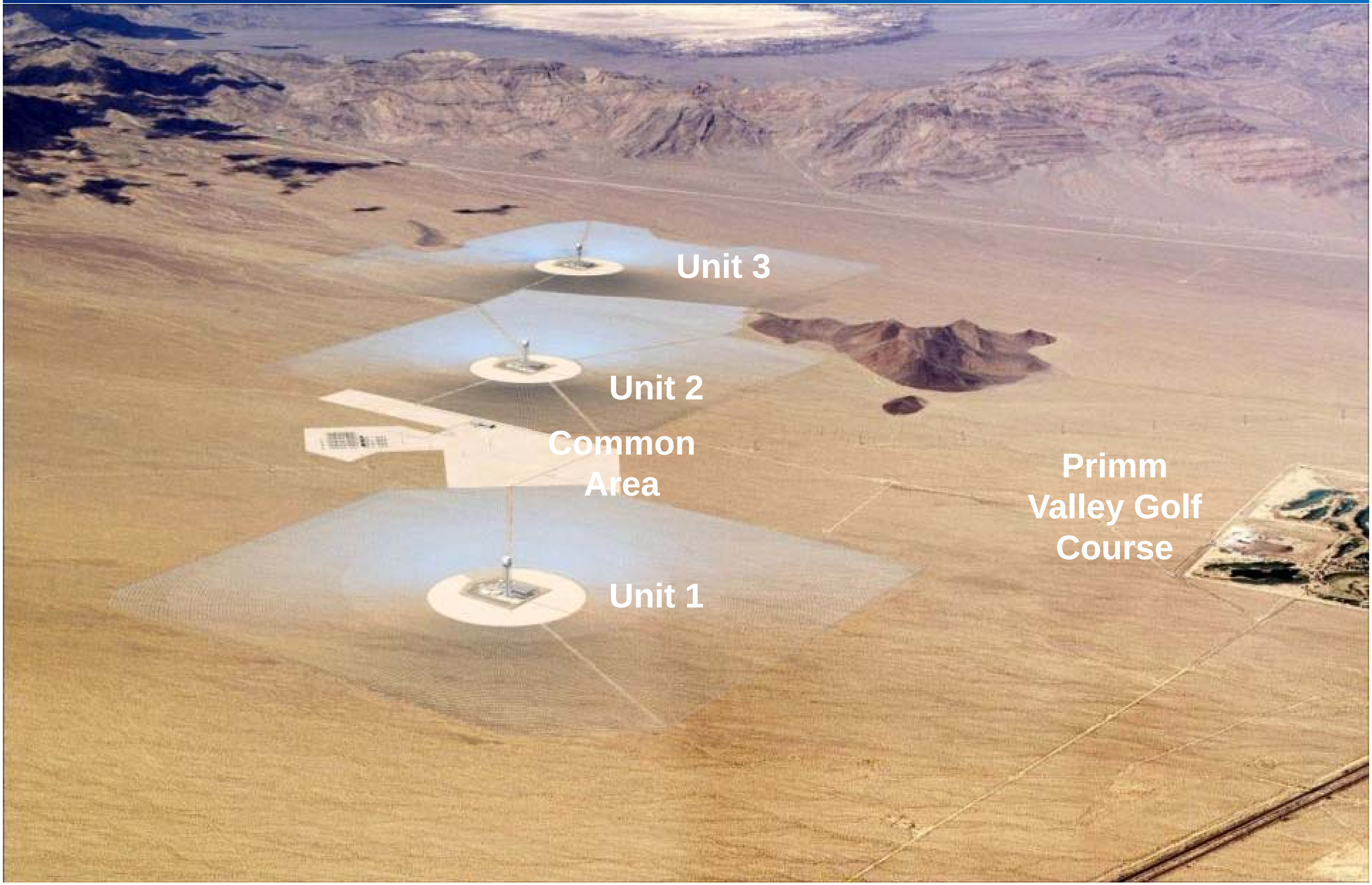


Unit 1 Construction Progress

Construction Progress

	Unit 1	Unit 2	Unit 3
Tower	▪ At final height of 459’ ▪ Receiver / Boiler installation in progress	▪ At final height of 459’ ▪ Receiver / Boiler installation in progress	▪ At final height of 459’ ▪ Receiver / Boiler installation in progress
Power block	▪ Turbine in place ▪ Air Cooled Condenser (ACC) construction ongoing	▪ Turbine in place ▪ Air Cooled Condenser (ACC) construction ongoing	▪ Turbine in place ▪ Air Cooled Condenser (ACC) construction ongoing
Solar field	▪ Pylons: 92% complete ▪ Heliostats: • > 45,000 installed • Installation rate ~ 500 / day • Solar Field Integrated Control System (SFINCS) installed	▪ Pylons: > 35,000 installed ▪ Heliostats: > 1500 installed	▪ Pylons: Installation scheduled to start 6 / 2012
Milestones	▪ 5/14: Main boiler feed-pump	▪ 5/22: SRSG steam drum	▪ 5/23: WSAC foundation placement ▪ 5/31: 1st SRSG boiler lift ▪ 5/31: Auxiliary boiler foundation

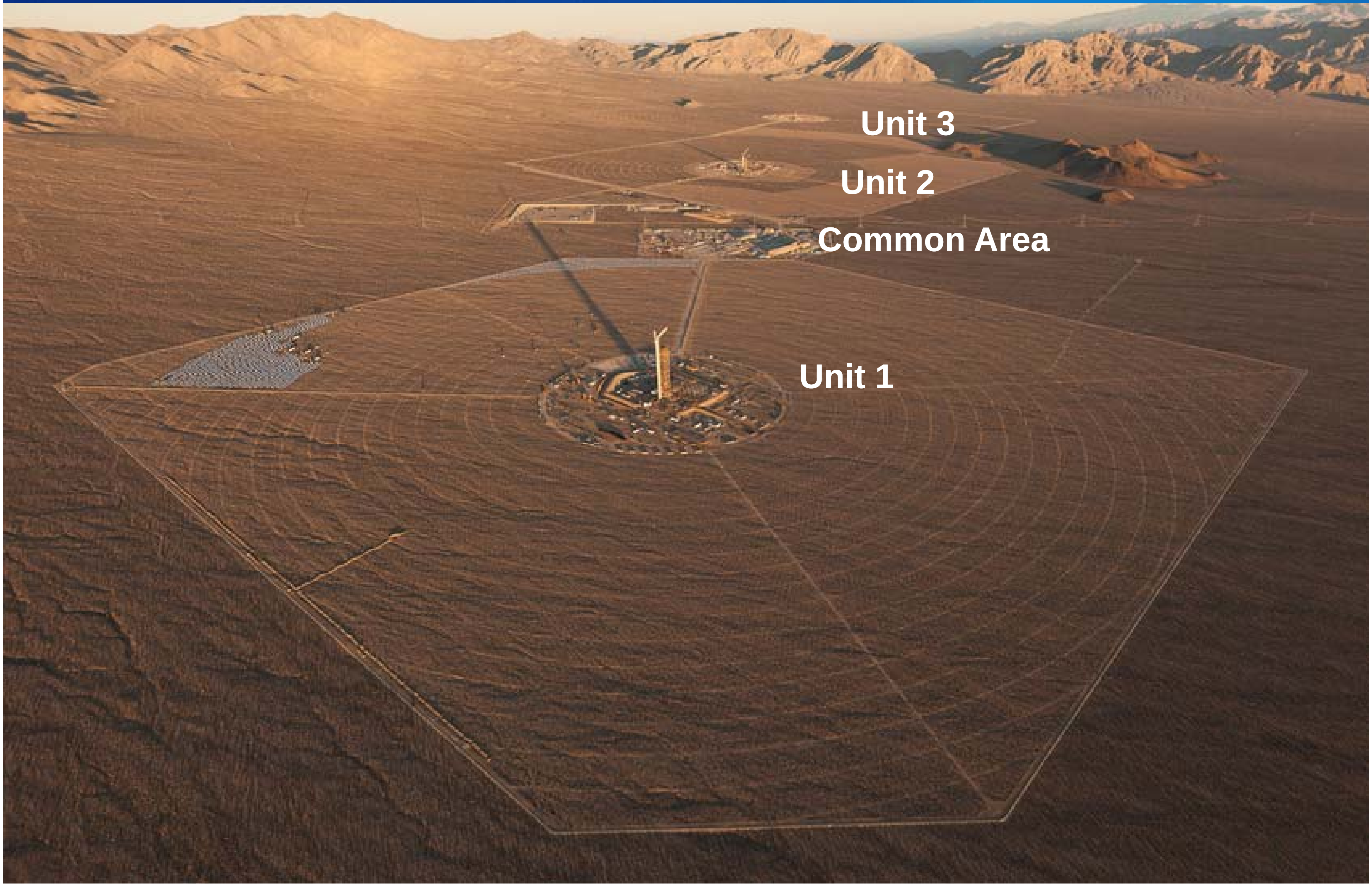
Ivanpah – Original Artist Rendering



Overview - Ivanpah Site as of August 2009

Ivanpah Valley Pre-Construction

Overview - Ivanpah Site as of Feb 2012



Overview - Ivanpah Site as of May 2012

Overview - Ivanpah Site as of May 2012

Overview – Ivanpah Site as of July 2012

Heliostat

Pads

Mirrors

Torque Tube

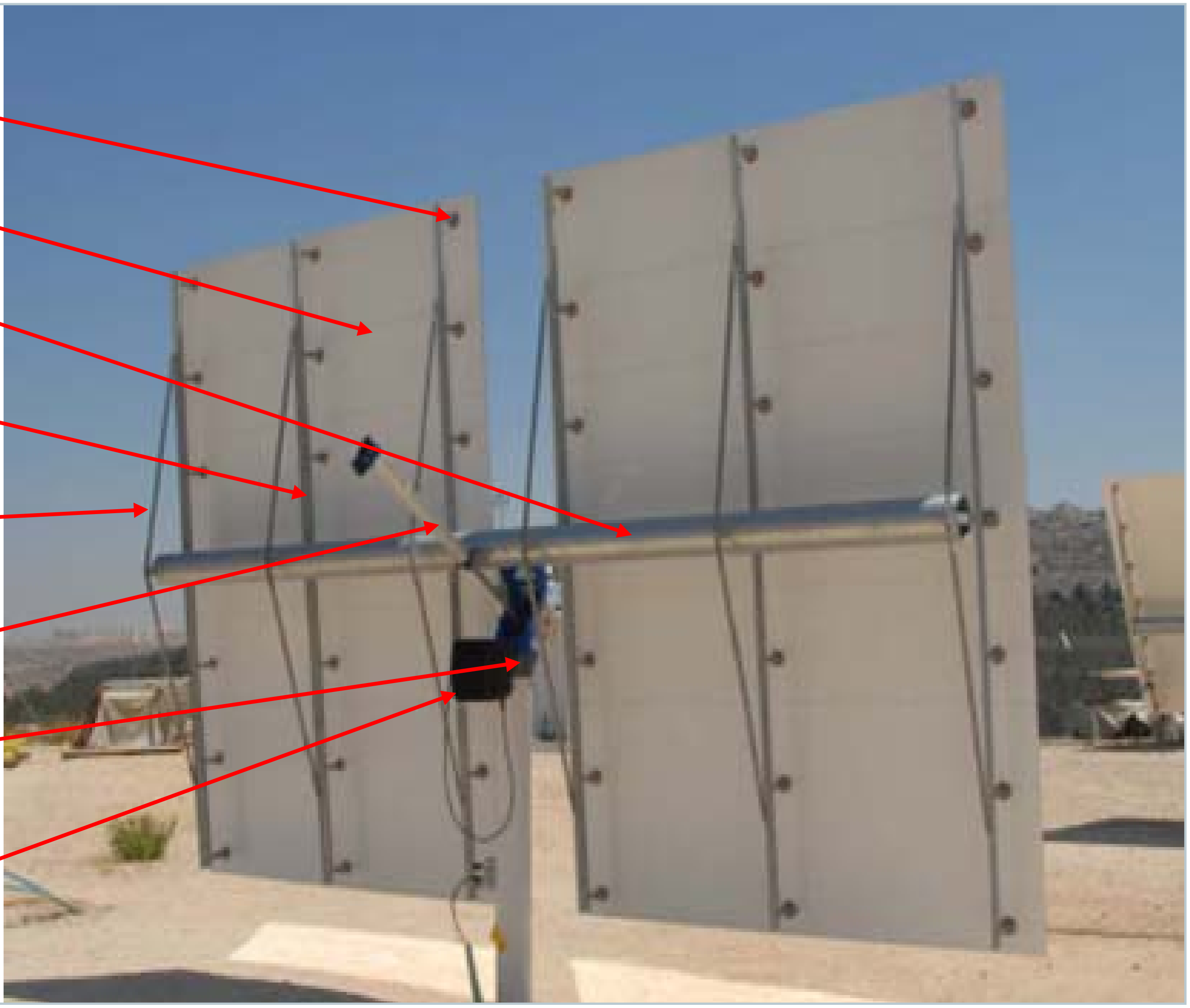
Support Arms

Diagonals

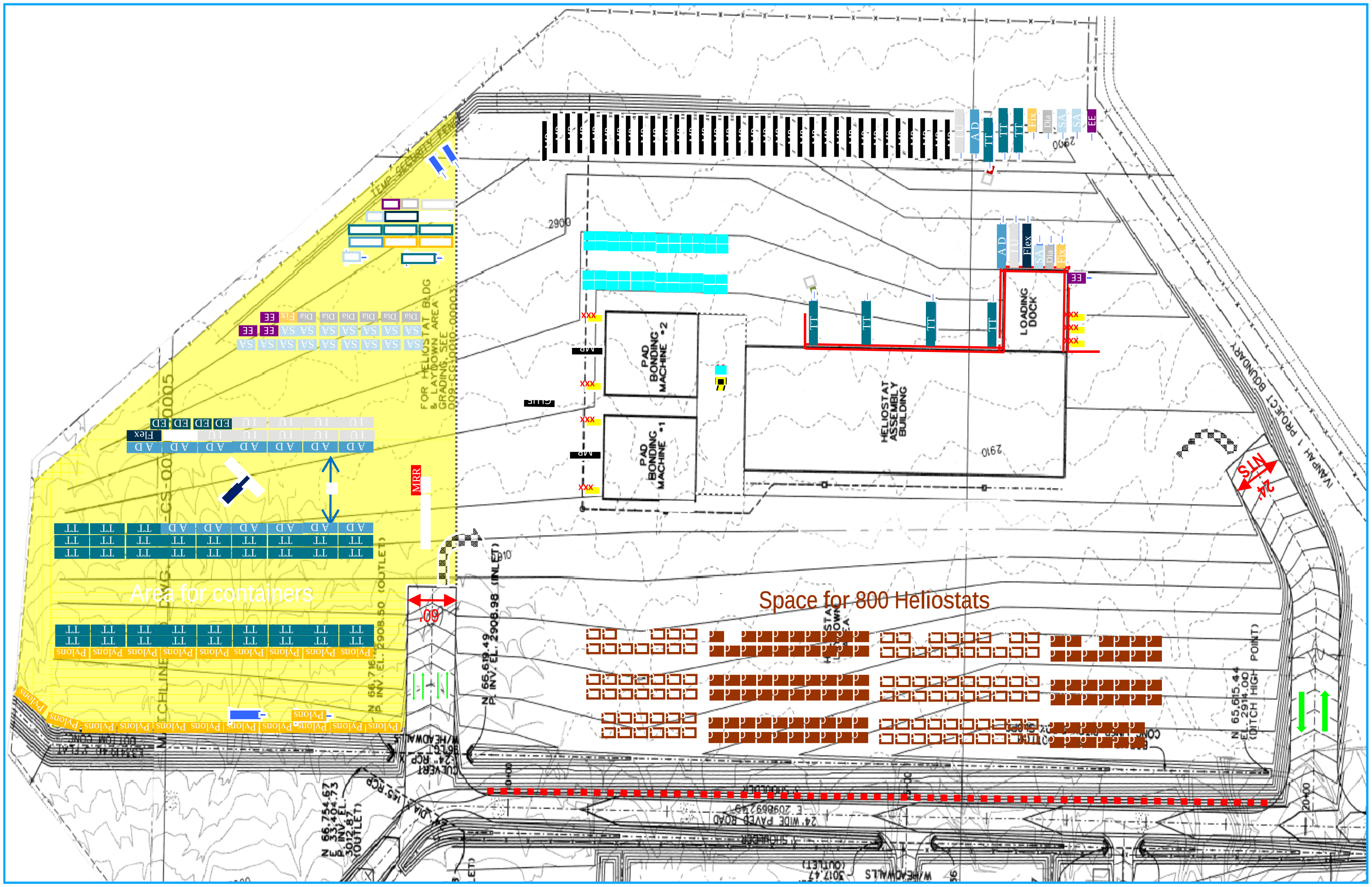
Elevation Drive

Azimuth Drive

Electronic Enclosure



Integration of supply and assembly at site



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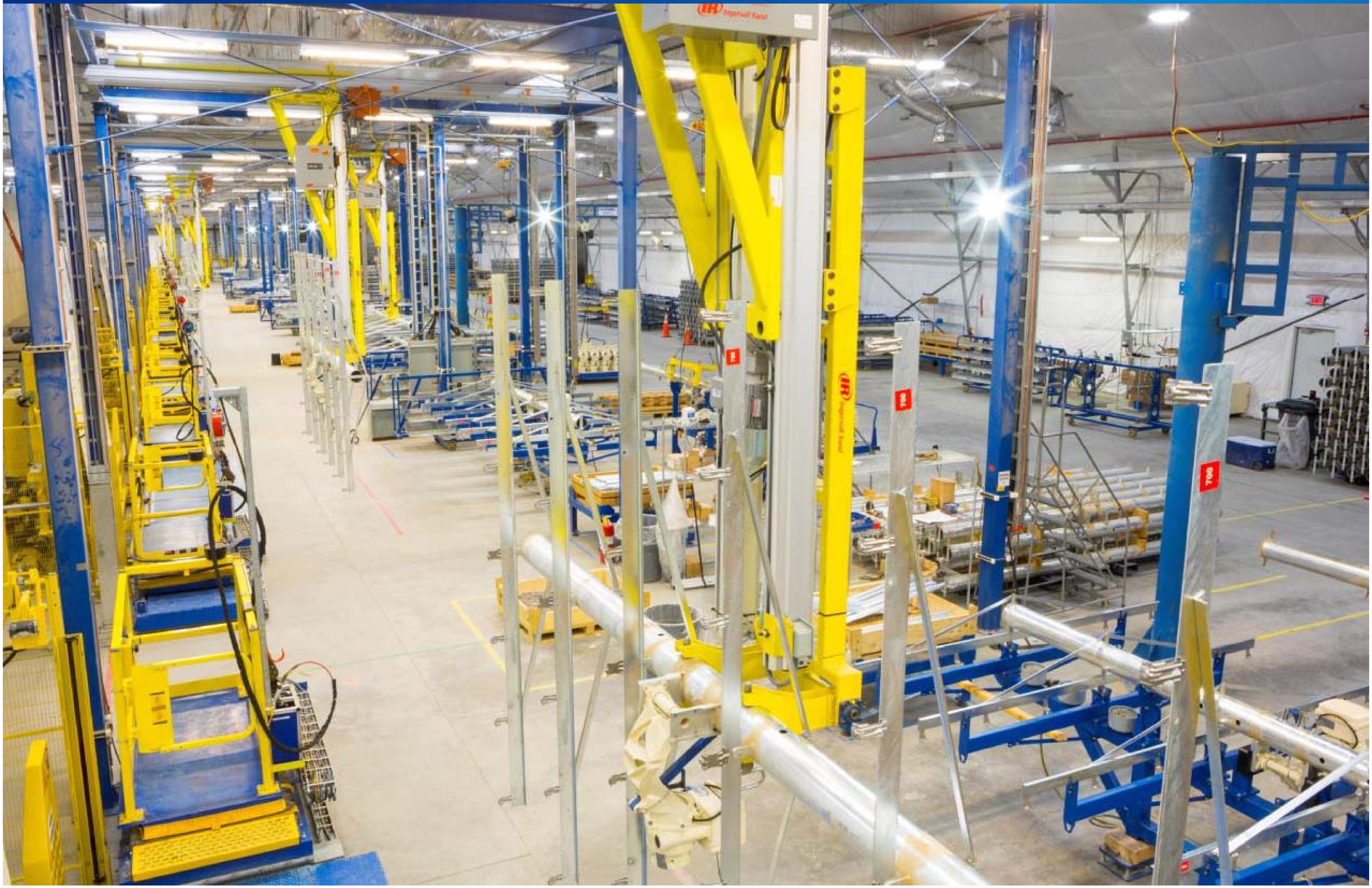
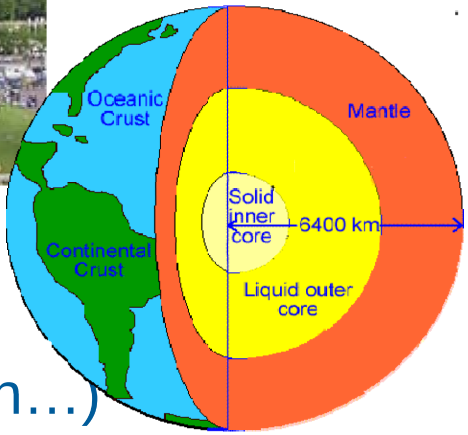


BrightSource Supply Chain Key Figures

- 22,000,000 key Heliostat components
- 30,000 Ton of Heliostat support structural steel (~3 X the total metal in Eiffel Tower)
- 2,000 Km of cables (~1/6 of Earth's diameter)
- 4,000 truck loads; average of 55 per week
- Over 7,000 schedule tasks
- Import/Export via ~10 ports (Haifa, Shanghai, Ningbo, Hamburg, Bremen…)



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Pylon Insertion Machine

Transportation of Heliostats to Solar Field

Installation of heliostats; 500/day

Unit 1 Solar Field looking at Unit 2 & Unit 3

Ivanpah – Current Status

- Construction is half-way complete
- Installed 27 miles of plant piping
- Assembled and installed about 100,000 pylon supports and 50,000 heliostats
- Installed 3,000 heliostats a week in the last three weeks "one-a–minute"
- Solar towers for Units 1, 2, 3 are erected
- SRSG for Units 1 and 2 are erected; Unit 3 tops out next month
- Unit 1 to enter testing and commissioning phase

Solutions for First of a Kind Challenges

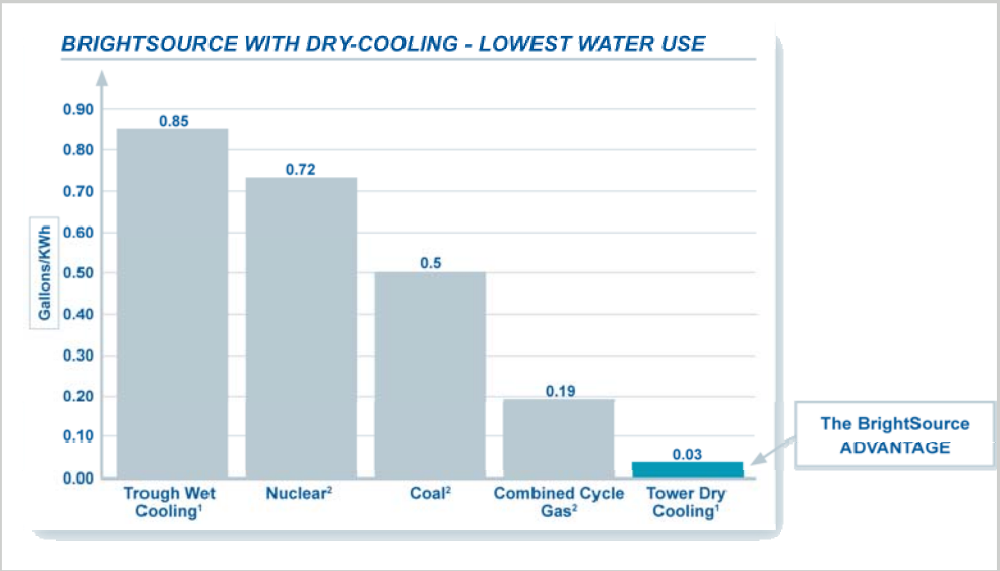
- Logistics in assembling and transporting 173,000 heliostats across 3,600-acre project site
- Operation and use of 3 tower cranes at 450 feet tall
- Only 22 of these cranes in world
- Lifting 90-ton modules to a height of over 300 feet

Labor and Equipment

- Peak construction workers = over 2,000
- Project supports additional jobs throughout supply chain
- Local building trades staffing project
- More than 50% of ocean freight is shipped aboard US-flagged vessels
- Pay prevailing wages
- Construction equipment selection minimizes environmental impact

Low Impact Development

- Highly land efficient; 1/3 less land per MWh
- Provides for heliostat placement and flexible plant design to work within natural land contours
- Avoids impacts and costs of extensive land grading and concrete pads



Key design parameters:

- Water Use: dry-cooling, conservation and closed-loop recycling
  - Uses air instead of water to condense steam
  - Uses over 90% less water than CSP using traditional wet-cooling

A “Cool Project” – World’s Largest CSP

Environmental Benefits	
1,000,000	▪ **MWh of electricity per year** ▪ **~300 average sunny days**
140,000	▪ Typical U.S. homes powered per year
70,000	▪ Cars off the road, per year (avoided emissions equivalent)
12,300,00	▪ Metric tonnes of avoided CO_2 over 30-year life-cycle (363,000 MT/yr)
123,350 (100 AF)	▪ Cubic meters of water used per year (less than 300 U.S. homes)
Less than 1%	▪ Concrete surface impacted. None used with pylons. Low impact construction design.

“Ivanpah is an iconic infrastructure project that will set the course for the future of renewable energy in the US and around the world,” said John Woolard, President & CEO, BrightSource Energy.

Enough reflective area to cover approximately 600 football fields…enough mirrors to replace all the windows of the Empire State building…54 times

Solar Thermal Power Tower Technology

Solar To Steam

Yasser Dib

San Antonio

Sep 7th, 2012

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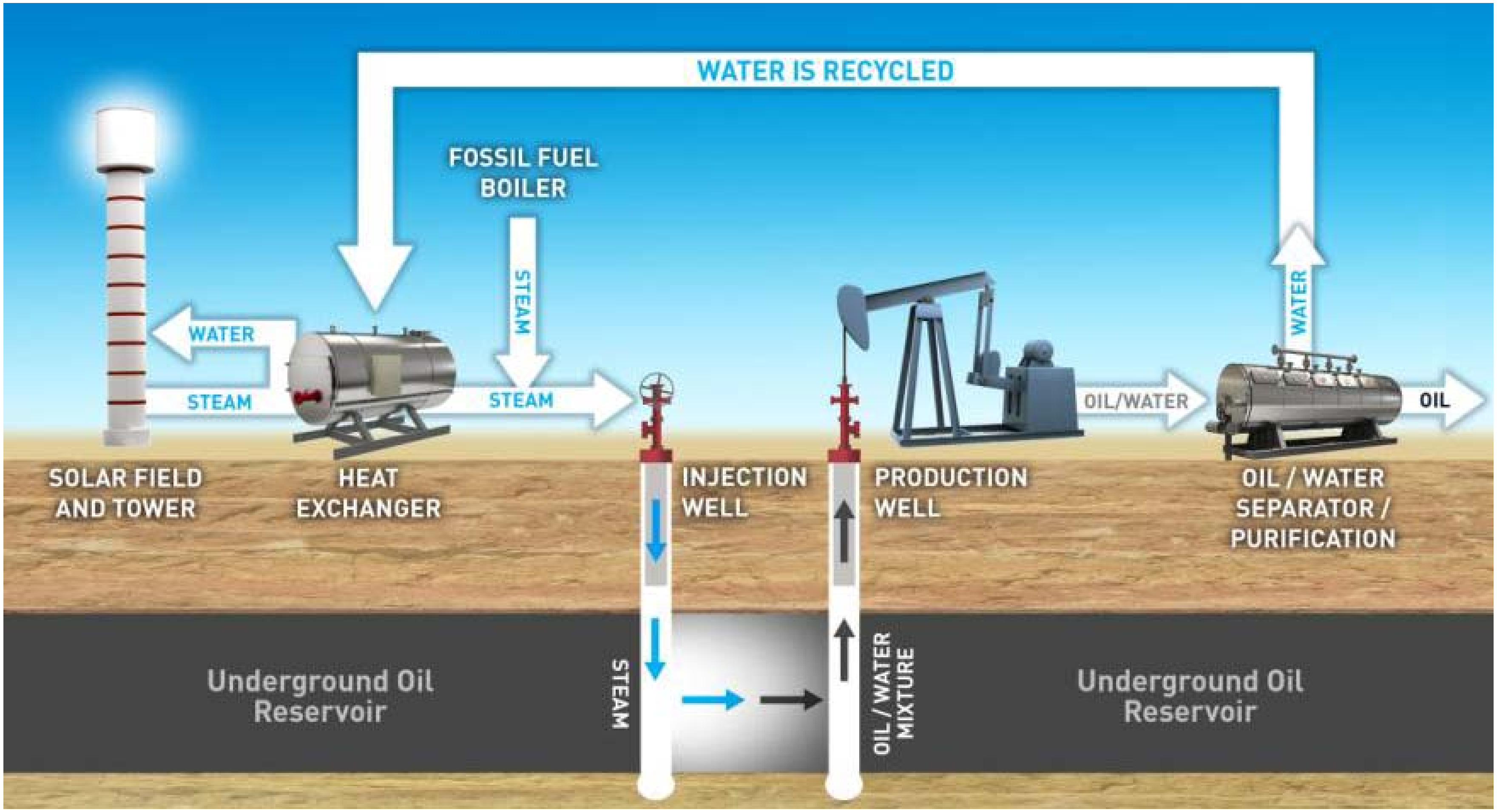
Introduction

BrightSource Energy designs, develops and deploys concentrating solar thermal technology to produce high-value steam for electric power, petroleum and industrial-process markets worldwide.

Chevron's Coalinga Project - Solar-to-Steam for Thermal Enhanced Oil Recovery

Coalinga Solar-to-Steam Flow Diagram



Coalinga Solar-to-Steam EOR Project

Key Design Parameters:

- 29MWth for Enhanced Oil Recovery (EOR)
- 100 acres
- 98.5 meter receiver tower with boiler
- 20.5 meter boiler
- 3,822 heliostats (55,000 m^2 reflecting area)
- Mechanical completion / testing complete

Selected Technology Features:

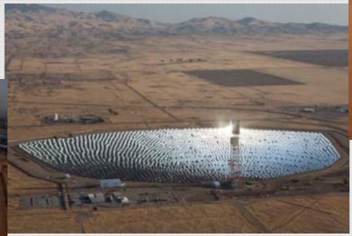
- Saturated steam
- Heat exchanger
- Closed loop boiler water feed
- Ties into existing steam injection system

Chevron's Coalinga Project - Solar-to-Steam for Thermal Enhanced Oil Recovery

Power vs. EOR Application Differences

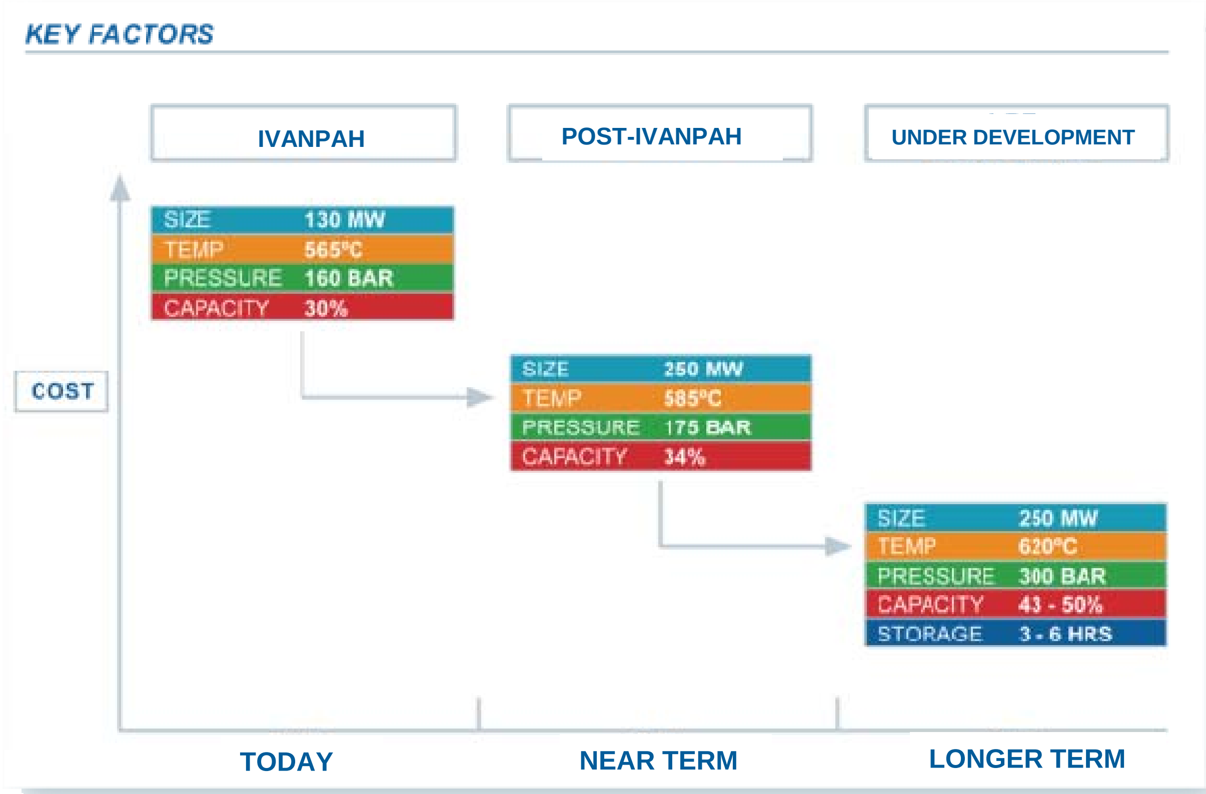
	Power	EOR
Power Block	Power Block	No Power Block
Receiver	Evaporated + Superheated + Re-heater	Evaporator
Steam	Temperature: 560+ °C Injected into the Turbine	Saturated Steam 300+ °C Injected down the reservoir
Pressure	160 + Bar	60-70 Bar
Heat Exchanger	No Heat Exchanger	Heat exchanger between clean water / dirty water loops
Solar Field + Tower	same	same

Technology Scale-Up

Solar Energy Development Center (6 MWth) Operating	Chevron Coalinga Solar Thermal EOR Plant (29 MWth) Commissioned	Ivanpah Solar Electric Generating System (377 MW) Under Construction	Rio Mesa Solar Electric Generating Facility (500 MW) Permitting

Industry-Leading Technology Roadmap

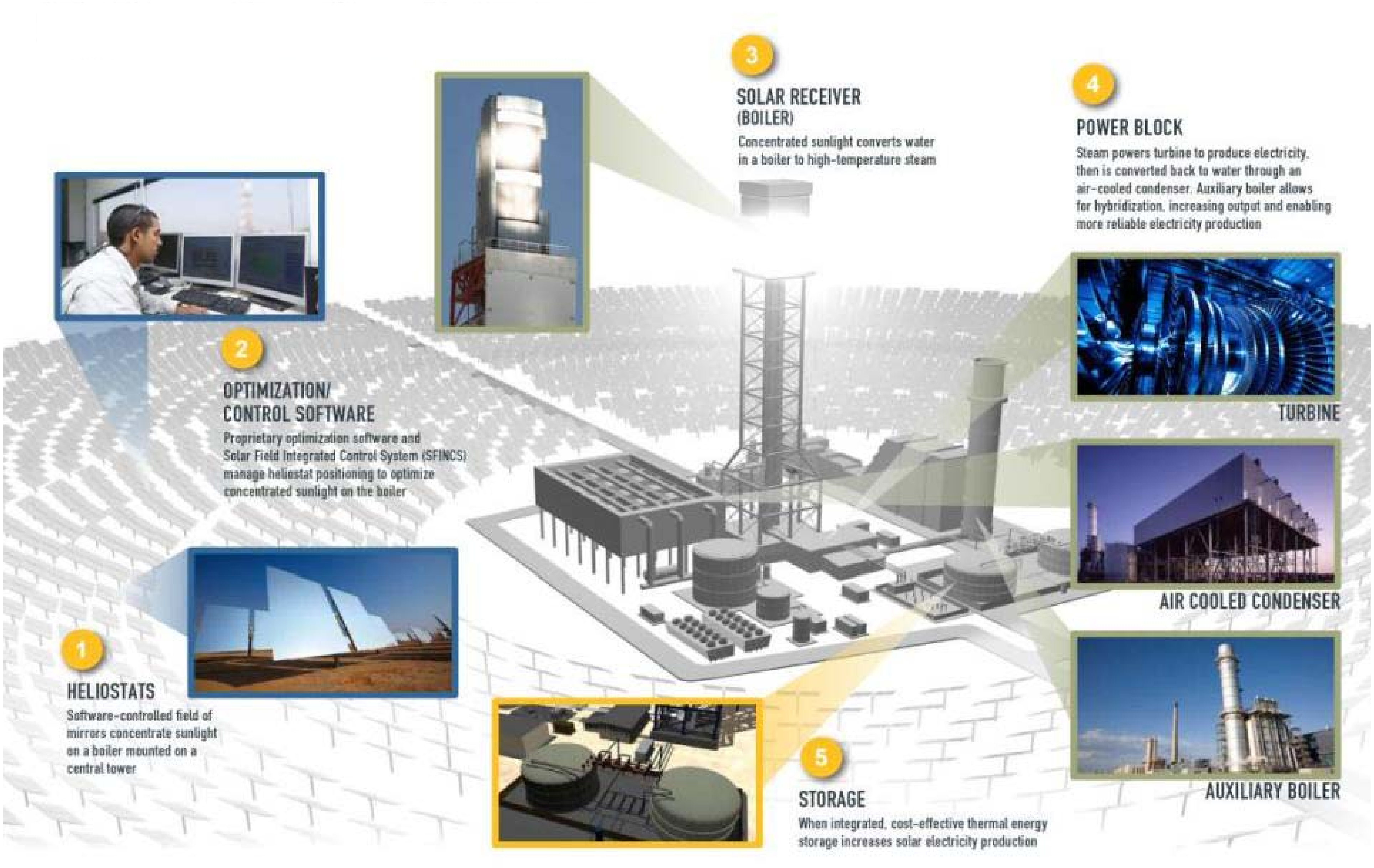


MW Increased size drives power block cost effectiveness

°C BAR High temperature and increased pressure drive turbine efficiency and lower costs

% HRS Additional capacity and storage yield higher efficiency and increased asset utilization

BrightSource Power Tower Components



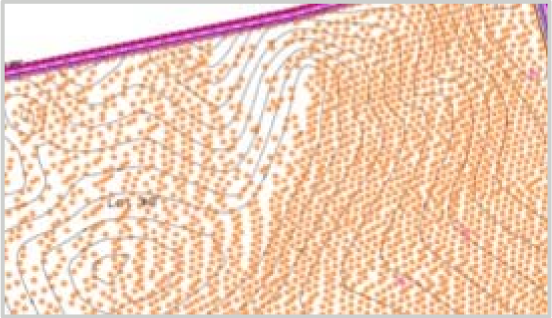
Heliostats Overview

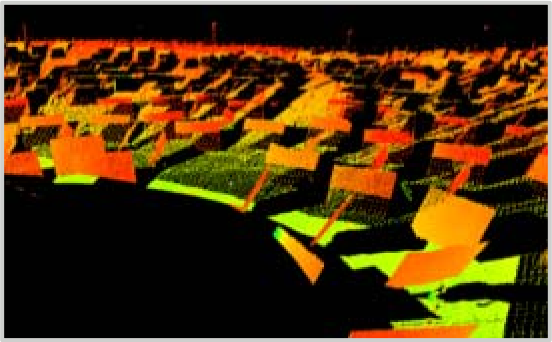
Two flat glass mirrors (2.3m x 3.3m) mounted on a single pylon equipped with a computer-controlled drive system

- Heliostat individually positioned to optimize annual plant output and revenue
- Dual-axis tracking significantly increases plant output, particularly in winter months and late afternoon hours of the day
- Low-impact design avoids costly extensive land grading and concrete pads

Proprietary Optimization Control Software Overview

Solar Field Integration and Control System (SFINCS)

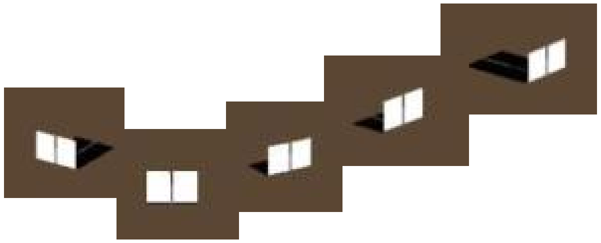


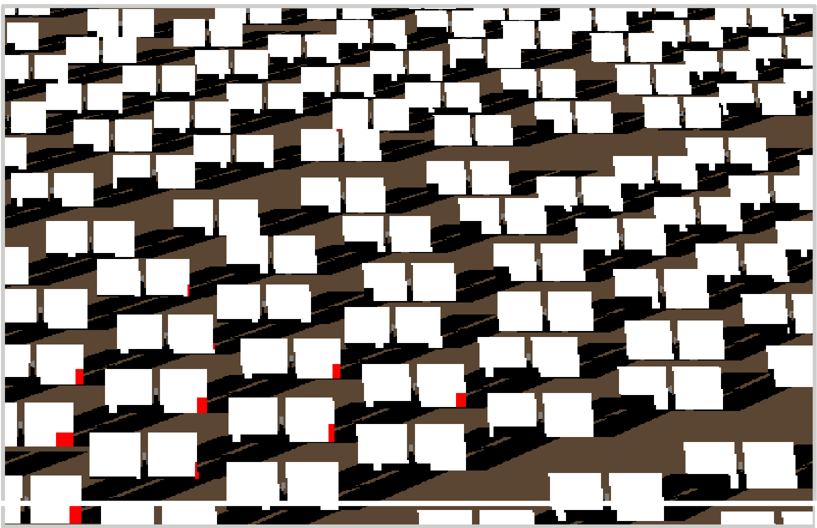


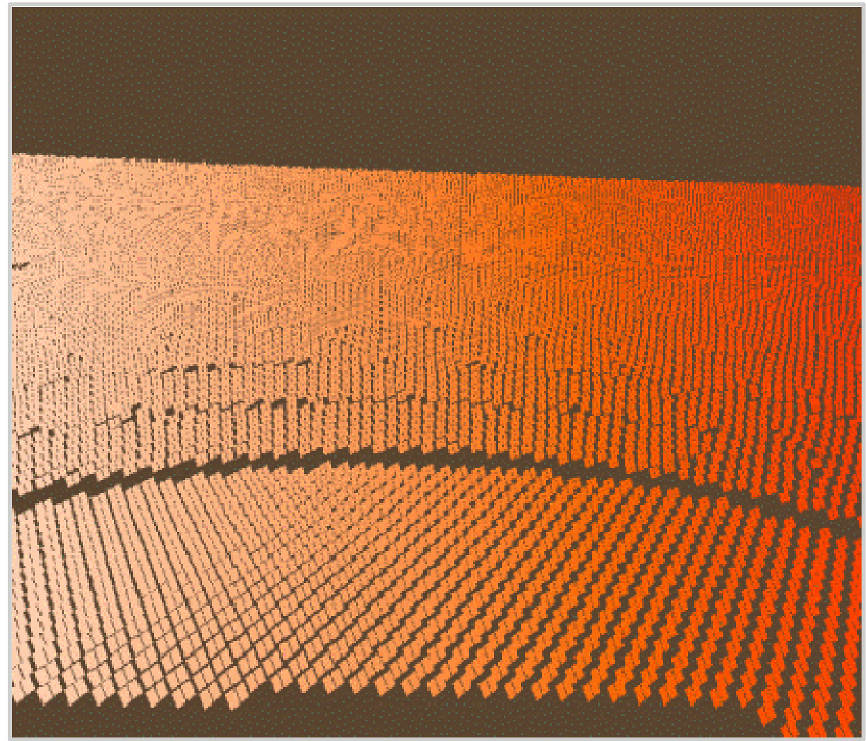
Infrared Camera System

- Algorithmic software determines the optimal position of each heliostat accounting for the unique conditions of each project site
- The SFINCS control system manages distribution of energy across the solar receiver using real-time heliostat-aiming and closed-loop feedback
- On-site weather systems, and visual and infrared cameras provide real-time feedback into advanced algorithms for solar field management
- Proprietary optimization and control software maximizes project performance and power production efficiencies

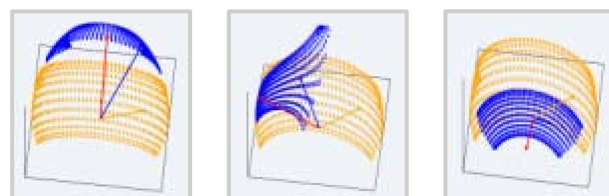
Solar Field Optimization







Field layout simulation calculates optimal heliostat positioning to minimize shading, and maximize heat concentration on solar receiver

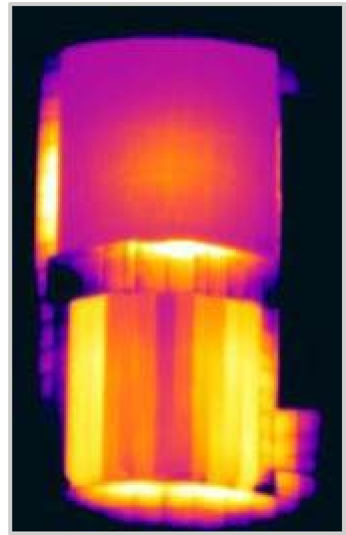


Coordinated field of heliostats enables system to achieve industry-leading steam temperature and pressure levels

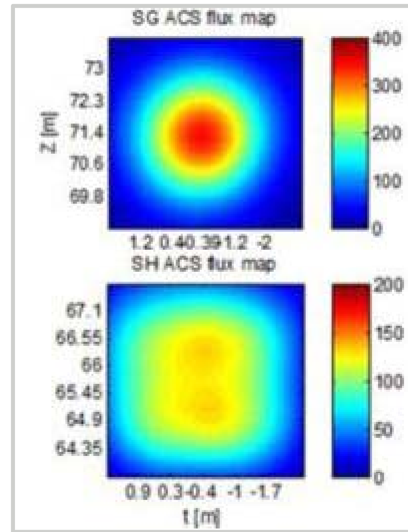
Solar Receiver Overview

Solar Receiver Steam Generator (SRSG)

SRSG Infrared Image



SBMS Temperature Measurement



Solar Receiver

Superheater

SOLAR RECEIVER STEAM GENERATOR (SRSG)

- Utility-scale “inside out” boiler heated by reflected solar radiation
- Proprietary coatings for maximum solar energy absorption

SOLAR BOILER MANAGEMENT SYSTEM (SBMS)

- Matches steam output to load demand
- Camera and sensors transmit real-time heat levels to heliostat control system
- Flexibility to respond rapidly to cloud cover & weather changes

CSP Technology: Areas of Focus

- Solar Field
  - Wireless communication and control
  - Solar PV powered drives
  - Mirror reflectivity, cleaning and anti-fouling
  - Heliostat control and accuracy
  - Improved measurement devices (flux, tracking)
  - Real-time attenuation measurement and cloud coverage
  - Weather forecasting, day ahead, hours and immediate
- Receiver
  - Advanced “selective” coatings
  - Alternative heat transfer fluids
  - Secondary reflectors
- Supercritical steam conditions and turbine efficiencies
- High Efficiency Storage Integration

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