Ivanpah Solar Thermal Plant Tour

Nevada Chapter of Association of Energy Engineers (AEE)

April 18, 2019 at 1:30pm

On April 18, 2019, twenty-one members and guests of the Association of Energy Engineers (AEE) Nevada Chapter visited the **world's largest solar thermal facility** just beyond the southern state line near Primm, Nevada. The $2.3 Billion Ivanpah Solar Thermal Plant consists of three power towers and **3,600 acres** of mirrors. The ownership of the site included our host company NRG, Google, and Bright Source. The power generated is used in California.

After crossing the state line between Nevada and California, we climbed the hill where three **459' power towers** were glowing obelisks against the western sky. Thousands of acres of ground mounted mirrors shimmered across the apron of the Clark mountain range to the north, welcoming us with signs of the renewable resource equipment that is part of this industrial energy system.

What We Learned in 2015

At 392 MW, this plant is the largest concentrating solar facility on the planet. It's not hard to reference the solar system in the scale of this plant because it has teamed up with the sun to do what no other plant has done on this scale or location.

After an hour or so briefing, the group dressed in head, eye, hand and foot protection before driving over to the center mirror field and tower.

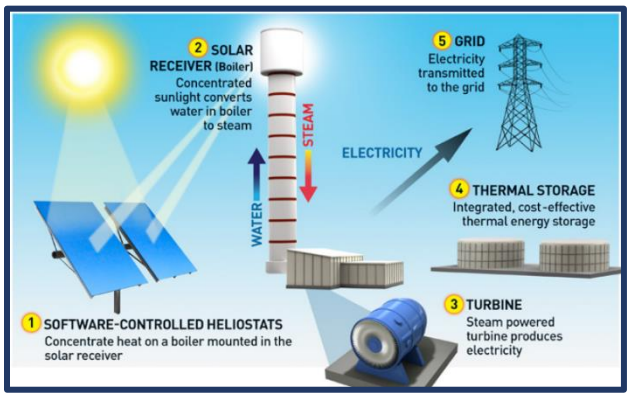
The mirror (**heliostat**) field is made up of four concentric rings of mirrors that vary in curvature and represent four increasing levels of efficient reflection as you move from the outermost to innermost mirrors.

Approximately **375,000** glass mirrors in total are aimed at the three power towers on site. The mirror fields are arranged in concentric circles around the power towers. The mirrors have a slightly concave shape to them, to concentrate reflected light on the boiler. The degree of concavity that the mirrors have is a function of distance from the tower and there is a precise formula for this curvature so that the focal position of the energy being bounced to the tower does not become optimized in front or behind of the tower, but rather, precisely on the boiler surface. The most effective mirrors are the ones closest to the tower.

To calibrate the direction and angle of each mirror calibration is a continuous effort as it takes a couple of weeks to calibrate the entire field, but every mirror may not need constant adjustment, rather only a few that fall out of position or have been recently repaired. Mirrors along the perimeter of the field are sometimes used in position to shield mirrors located on the interior of the field from wind events.

One of the technologies used to optimize energy production is a series of thermal cameras mounted atop the towers. These cameras collect a thermal signature of the tower that reflects mirror subfields – like a sunflower which follows the suns trajectory during the day. In real time, management can observe through a visual gradation of the heat spectrum if the collective sections of the entire mirror field are behaving as planned.

When the plant was commissioned in 2015, a single **airplane contrail** (white exhaust) in the sky could take the plant offline. Why? Because the contrail would mimic cloud cover hampering the mirror tracking of the sun's rays/heat. But now, contrails no longer affect the plant to that extent. It's only when there are so many contrails that it emulates a cloudy sky is when we are impacted, but not enough to trip it offline. The impact will be a drop in load that is recoverable within a few minutes.



The power towers are located 4 miles apart, and each have three distinct sections at the tower tops. The uppermost section is the superheater that can withstand temperatures as high as **1,150 degrees**. The mid-section of the tower top is the evaporator where steam is produced and transported at pressures in excess of **2,400 PSI**. The lower section of the tower top is the reheater which takes exhaust steam from the high-pressure (HP) turbine and raises the temperature before re-entering the intermediate pressure (IP) turbine.

What We Learned in 2019

Lessons learned from the Ivanpah operations crew (and AEE) over the past 4 years since the plant's inception:

- **A Boiler In The Desert Needs Love Too** - By Install heating blankets on the steam turbines in each tower, the operational performance was significantly improved by preventing a cold start, every day. This can be compared to a supercar getting its tires warmed up for optimal performance before hitting the track and leaving the competition in the rearview mirror. Wear and tear on the equipment is something that can be predicted and responded to, but temperature extremes in the desert can be severe too. (Atmospherically, a 125 degrees range Fahrenheit annually, and sometimes, a 50 degree swing in 24 hours.) By adjusting the ramp-up to full production using this pre-heating technique, the operators see better resiliency and dependable production. By way of the racing analogy, this car has to run at 100% every day, as well.

- **Vulcan Logic at Work** - Boiler plate control logic has been drastically changed from the initial design and commissioning to specific field conditions was not surprising, but very necessary. When there is only one of these plants of this size in existence, the options for operational response involve expert engineering, digesting operational historical statistics, managerial ingenuity and basic intuition. That's a fancy way of saying pay attention to the nuances of your site weather, equipment performance and make calculated adjustments to account for the continual variations in output.

- **The Shopping Never Ends** - Valve replacement (steam, water, etc.) is an ongoing effort due to the unusual and sometimes, unrealized field conditions. In the desert, plants and animals adjust for the extremes, but this plant has to do its best work when the conditions are harsh and unforgiving. Even by conditioning the water to be higher performance, the equipment it serves, needs to have compatibility, durability and a life cycle that also does not disappoint. Excess temperature, gentle wind and even UV rays take an effect on systems and equipment that has sensitivity to fluctuations in production. When staff monitors the plant from on-site and distant locations, it begins to seem more like energy production was a globally scaled, carefully monitored, production test that has to last a mere 25 years.

- **Controlling the Controls** - Over 400 control modifications have taken place since Day 1. Google has few answers for tricky questions on the operations of the largest solar field on the planet. The skilled mechanics and analytics provided, along with superior instrumentation and automation, have still required "boots on the ground" problem solving skills. Having a seasoned group of professionals on site supported by corporate analysts and outside consultants has resulted in many improvements that include planned capital outlays as well as short term response or emergency repairs.

Fun Facts

One particularly aggressive hail storm shattered 1200 mirrors.	The site is allotted 100 acre feet of water each year from local wells, but only uses about 50 acre feet.	Mirrors are sometimes adjusted every 10 seconds with motor controls to track the sun.
China and Dubai want to construct similarly scaled plants.	The three power towers are named "RedBull, Monster and Rockstar"*	* Not true, but we are talking energy here and it would be cool if they were.

In Closing

The phone cameras carried by our group were put to use and everyone came home with dozens of shots that showed the best side of this complex and the equipment it takes to produce energy at world-class levels.

For questions, contact Shawn Breker at sbreker@nvenergy.com