Project briefing

SOLAR STAR: INSIDE THE WORLD'S BIGGEST SOLAR PLANT

Project name: Solar Star
Location: Kern and Los Angeles counties, California
Project capacity: 579MW
Site 1,295 hectares

Covering a 1,295-hectare estate mostly of fallow farmland, the world's largest solar plant sits in the Antelope Valley straddling two counties of California. The Solar Star project has been supplying its full 579MW of capacity to the grid since May this year and it will be announced as officially complete before the end of 2015. *PV Tech Power* explored the designs behind this mammoth installation near Rosamond, California, to investigate what key factors had to be considered when creating a solar plant that can supply electricity to more than a quarter of a million homes.

BHE Renewables, a subsidiary of Berkshire Hathaway Energy (BHE), previously known as MidAmerican Energy, owns the project, which was developed, constructed and maintained by PV developer SunPower. Construction began less than three years ago and was completed around six months ahead of schedule. Meanwhile two 20-year power purchase agreements (PPAs) were signed with the utility Southern California Edison back in January 2011.

No development of this scale could be accomplished without overcoming a range of environmental and local community issues. Strangely, in this case, one of the biggest barriers stemmed from previous attempts by PV developers to build projects in the same valley, some without success.

Bryan Whitcomb, general manager, Solar Star project, BHE Renewables, tells *PV Tech Power* that other projects in the valley had had to grade much of the land to make it level enough to install solar modules, but this had created a lot of "fugitive" dust, which concerned locals. However, SunPower's Oasis Power Plant technology, with its 'light on land' approach, minimised the amount of grading required for the Solar Star, because the panels could be installed above the ground to alleviate problems with curvature of the land including hills and bumps.

"Our goal was not to touch the ground as much as possible because of our experiences with other solar sites in the valley," Whitcomb says.

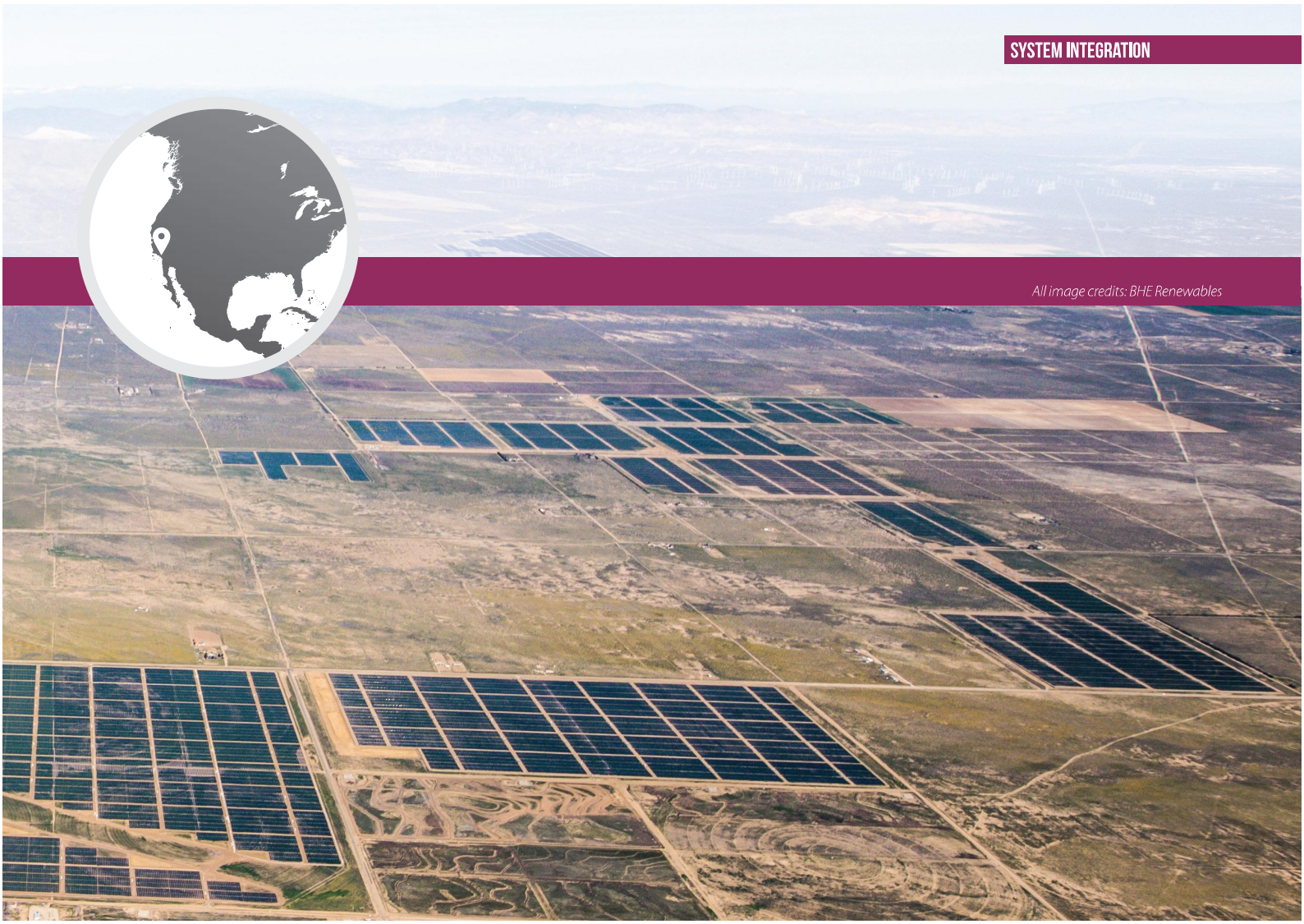
This off-the-ground approach is also cost-effective because it requires less heavy equipment on site, Whitcomb adds. The location is subject to strong winds, evidenced by the fact that it neighbours the largest wind farm in America, the 1,320MW Alta Wind Energy Center. These winds can exacerbate any dust issues.

The construction team pre-seeded the ground before installing so there was plant growth ahead of the build. Meanwhile ground was only graded in order to build roads for access to the plant inverters.

Looking from an aerial perspective, various segments of the plant appear oddly spread out. Whitcomb says this split came down to availability of land issues, because other PV projects in the middle of the site had never come to fruition. "One of the biggest challenges was splitting the design within the land we had and then getting the power to the grid," he says.

There were a few landowners with more than 100 acres and others owning five acres, which meant BHE Renewables had to buy several separate plots of land. This also contributed to the site not appearing as one continuous installation and being split up across the valley.

"The neighbours were still upset about what happened at other solar projects in



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the valley where they created a lot of dust. We spent a lot of time convincing them that we were going to do it the right way and we did – so we really have a good relationship with all of our neighbours and the local community," Whitcomb says.

The hardware

In terms of solar technicalities, the project team picked up publicly available data about the site's irradiance levels from Federal Emergency Management Agency (FEMA) flood maps and topographic maps, before installing metrology stations to verify the data.

The project uses approximately 1.72 million SunPower modules, which BHE regards as being able to deliver up to 75% more energy over 25 years than conventional panels. The panels use SunPower Maxeon cells, which have a copper foundation to make them stronger and more durable and to minimise corrosion. Cells with a weaker foundation are susceptible to cracks and can lose power when exposed to temperature swings, claims BHE.

SunPower also offered a 25-year combined power and product warranty, with a degradation rate of 0.4% a year after the first five years. The result is an 87% power level at the end of 25 years.

SunPower's Oasis technology installs the modules in high-density, cost-optimised power blocks. Using these standardised 1.5MW blocks, a kind of 'cookie-cutter' approach, allows a developer to use one template and multiply it to install a plant as large or small as required, but with a minimal time of construction. This also reduces field wiring and costs of labour, SunPower claims.

The Solar Star projects also use SunPower's C1 Trackers, which can produce up to 25% more energy than fixed-tilt systems by using GPS to follow the sun, according to BHE. Solar Star's panels are not tilted to the south so at high noon it experiences a dip in energy production compared to fixed-tilt systems. Nevertheless due to its tracking of the sun throughout the day, Whitcomb says it picks up energy far earlier in the morning and later in the evening, and maintains that level for some time. This gives a smoother energy input to the grid. The late-afternoon energy is also particularly valued because there is a strong load on the grid at that time of day as a result of demand for air conditioning within California.

The Oasis system also uses a mix of smart inverters from ABB and some from SMA, which feature voltage ride-through, curtailment control and solar reactive power, which enhance the plant's grid interoperability.

Whitcomb says that as technology has improved and interconnection requirements have increased, the plant has the capability to supply reactive load to the grid although it cannot do this at the same level as a giant thermal power plant or nuclear plant. Recently, inverter companies have had to meet several interconnection requirements put forward by the Federal Energy Regulatory Commission (FERC) and this is reflected in the plant's new capabilities.

"We can do voltage control. We can ramp up and down from zero to max output, and if voltage varies on the grid and dips we can actually ride through that. In other words the inverters won't shut down. They will just keep on putting power down and keeping up with it," he explains.

The Solar Star inverters are also assisted with larger capacitor banks, allowing the operators to switch capacitor banks as necessary when power factor requirements change.

The SunPower Tracking Monitoring and Control System (TMAC) is used to anticipate storm conditions and protect the array. The operators also use a supervisory control and data acquisition (SCADA) system to visualise the plant's operation, with rapid commissioning and historical data reports. This also helps the plant meet the requirements of the grid.

Back in 2011, when Southern California Edison signed up for the two PPAs relating to the Solar Star the utility remarked that it was advances in technology and economies of scale that would enable such a large solar project to be cost competitive. Furthermore the location within Kern County, which is recognised for its leadership in permitting solar energy deployments and the project's proximity to the major Southern California Edison substation, were also factored into the utility's evaluation of the levelised cost of energy (LCOE) offered by the plant.

Whitcomb says that it was easy to set up in Kern County which is a "very strong energy county" with plenty of oil and gas exploration alongside its renewable energy developments. Furthermore, Los Angeles County also has a large proportion of pro-solar locals. For example, it is illegal to build a new house in the nearby Lancaster area unless it includes solar panels on the rooftop. "That is the atmosphere of the environment we are working in here," Whitcomb says.

Grid connection

In terms of power evacuation, the Solar Star projects were located just four miles from a large substation, which is critical for a plant of this size. The Whirlwind 230/500 kV substation ties directly into the grid that supplies power to Los Angeles.

Whitcomb says: "That is what made it realisable because you cannot just put a project like this anywhere. You have to have good access to a large grid network."

The team minimised the amount of overhead lines being used by sharing poles with other local projects already in operation. There are several wind projects to the north of the site for the solar plant to share poles with, along with one other solar plant. Future projects located nearby will also share in this way. Whitcomb says putting up such giant poles is very difficult and using ones already installed alleviates a potential bottleneck.

In terms of grid connection, the project's distribution system is underground within the arrays. Medium voltage cables transition from underground to above ground poles with air switches. Overhead lines then carry the collected energy at 34.5kV to one of the three substations where the electricity is stepped up to 230kV on three separate lines, which connect the Solar Star projects to the Whirlwind Substation.

There are nearly 400 inverters of 1.5MW used at the Solar Star, hence the requirement of the significant medium-voltage (34.5kV) distribution network to transfer the energy to the three substations with minimal loss.

It is clearly a significant operation, but one made easier by strong local support for renewables. For the community at large, BHE Renewables says it is possible to be a good neighbour by being active in the community and supporting local events, serving on local boards, and hiring local workers who have the necessary skills.

There were around 650 construction jobs created during the three-year period, and several BHE staff will remain on site now that it is connected. It is also estimated to bring in around US$500 million for the regional economy.

The company already owns what was previously the world's joint-largest solar plant, the Topaz solar project in the San Luis Obispo County of California, developed by First Solar and which stands at 550MW. Another First Solar-developed project, Desert Sunlight, in Riverside County also stands at 550MW. BHE is also a minority owner of the 290MW Agua Caliente solar plant in Arizona, again developed by First Solar. Now the Solar Star site is yet another unprecedented project in terms of scale and it begs the question of just how big solar can go.

With the investment tax credit (ITC) for large-scale solar projects in the US currently scheduled to fall from 30% to 10% at the end of 2016, there are a lot of projects around the 100-200MW ranges that are rushing to get finished but there are no projects larger than the Solar Star visible on the horizon.

Neither Topaz nor Desert Sunlight were able to hold onto their crowns for longer than seven months, but for the moment Solar Star will remain firmly the world's largest solar farm. ■