Are Solar Power Towers Doomed in California?

Chris Clarke, KCET (Los Angeles television), 9-26-15

It used to be the future of solar. From the time the 10-megawatt Solar One project rose east of Barstow in 1981, renewable energy advocates imagined that California's solar future would look a lot like Solar One, a tower with a bright white boiler on top, illuminated by sunlight reflected from more than 1,700 large mirrors arranged in concentric circles around the tower's base.

Now, California generates more solar electricity than at any point in its history. With a new mandate that the state get half its electrical power from renewables by the end of 2030, solar's role in California is only going to get bigger. And yet solar power tower technology seems to be languishing. Of 11,535 megawatts of solar generating capacity installed in the state by the end of last year, solar power towers account for just 397 megawatts: about three percent of the state's solar.

Things have turned so sour for solar power tower technology that in August, the company behind the only power tower project being proposed for the state of California announced it wants to build the plant using a different technology. That means there are no new solar tower plants on the drawing board for California. How did this once-popular technology fall on such hard times?

Solar One has been dismantled for some years. California now has two operational solar power tower projects online: the 392-megawatt Ivanpah Solar Electric Generating System in San Bernardino County near the Mojave National Preserve, and eSolar's Sierra Sun Tower, a five-megawatt demonstration project in Lancaster. Solar Reserve's Rice Solar Energy Project, a 150-megawatt project slated for the desert east of Joshua Tree National Park, has been approved by regulators, but was subsequently postponed indefinitely by its owners and may never be built.

Outside California, Solar Reserve's 110-megawatt Crescent Dunes Solar Energy Project is built but still offline near Tonopah, Nevada, its formal launch delayed by a number of technical issues.

In the meantime, solar generating capacity using other technologies has been burgeoning in California, with more than 4,300 megawatts worth of both photovoltaic and parabolic trough technology installed in the state in 2014 alone: more than 10 times the total amount of solar power tower capacity in California.

That's quite a fall for solar power towers. Over the last few years solar power tower projects have been proposed for more than 90,000 acres of sun-drenched land in California, with at least 3,800 megawatts' worth of generating capacity making it at least as far as the developers' whiteboards.

Some of those proposed solar power towers, like an 800-megawatt plant BrightSource Energy once proposed for the Johnson Valley area in San Bernardino County, likely wouldn't have made it to the serious planning stages even if power tower development was proceeding full steam ahead. Others, such as the 500-megawatt Palen Solar Electric Generating System in Riverside County -- which current owner Abengoa announced in August it would instead build using parabolic trough tech -- came within a few months of breaking ground.

And now? The Rice Solar Project, which has all its state and federal government approvals obtained, remains a patch of open desert. *Really* open: SolarReserve has even taken down the tortoise fencing that surrounded the site. Ivanpah, after about a year of slow starting, seems to be delivering much of the power it promised to the state's grid -- though it burns enough natural gas each year to stay warm to generate as much as 16 or 17 percent of its total output if that gas were burned in a conventional gas-fired power plant.

Meanwhile, installation of photovoltaic solar systems continues at a breakneck pace, with new PV solar installed in California in 2014 alone dwarfing the state's power tower capacity. As of the end of 2014, the state had 10 gigawatts of installed solar capacity -- ten thousand megawatts -- which means power towers' contribute less than four percent of the solar electricity generated in the state.

This might have been a little surprising for a 2007 solar expert granted a glimpse at the near future. But three things got in the way of solar power towers in the state, and at this point it would be equally surprising if the technology recovered from any of those three blows.

Other solar technologies are cheaper

Solar power towers have two main technological competitors: photovoltaic cells and parabolic trough solar thermal. Of the three kinds of technology, PV panels -- the same kind of solar panels you or your neighbors might have on your roof -- have become the overwhelmingly dominant way in which Californians turn sunlight into electrical power.

There are a few reasons for this dominance. A big reason is that PV scales: you can generate 1,000 megawatts of energy in a few fenced-off square miles, or 100 watts on the roof of your 20-year-old van, and the technology is about the same either way. PV is also modular in a way power towers and solar trough aren't: You can build a 500-megawatt photovoltaic power plant by adding a single 100-watt solar panel every day for 13 and a half years, if you really wanted to, and your setup would begin generating power on day one.

Once it's installed, PV has a minimum of moving parts. Some sophisticated systems mount their solar panels on pivots to follow the sun either from east to west each day, or from low in the sky in winter to higher during summer, or both. That increases the amount of power the panels can create by increasing the intensity with which sunlight hits the solar cells. (And the motors that move the panels use a bit of that extra energy.)

Or you can just mount the panels in a fixed position with no moving parts, and they'll generate power anyway. Contrast that with solar power towers, which require servos to aim thousands or mirrors at the tower-top boilers, and the multitude of moving parts required to regulate temperature and move steam, and then the large turbines that are spun by that steam, and that's potentially hundreds of thousands of moving parts in a single power tower plant. If a single one stops moving, that's expensive downtime and repair costs.

So PV is by its nature less expensive to operate once installed than solar power tower plants, or, for that matter, just about any other form of power generation, renewable or otherwise. That's half the picture. The other half is upfront costs, the costs of materials and installation. And PV's gotten a lot cheaper to install over the last decade, while the cost of almost everything else has gone up. According to the National Renewable Energy Laboratory, the typical cost per watt of PV panels has dropped an average of 6-7 percent per year between 1998 and 2012, and the price has dropped more quickly since then. In 2013, the feds projected that utility-scale PV power plants would be paying about $1.80 per watt for PV systems.

Meanwhile, the Ivanpah Solar Electric Generating System's total building costs, with an initial capital outlay of about $2.2 billion, work out to just under $6 per watt, according to reporter Eric Wesoff at Greentech Media.

BrightSource Energy's former CEO John Woolard told Wesoff in that 2011 article that he expected BrightSource's technology would compete with PV on a straight cost basis, but not until the company built its second round of improved, more efficient power plants. Four years later, none of those improved power tower plants are in the works in California.

Even if they had been built, BrightSource's new and improved power towers might not have been all that much cheaper. Higher costs of both construction and operation mean higher energy costs, and the projected cost of electrical power from proposed BrightSource power tower plants at Rio Mesa and Sonoran West caused the California Public Utilities Commission to deny proposed Power Purchase Agreements between BrightSource and California utilities for power produced by those projects, effectively killing them.

Solar power towers do have a couple of technical advantages over PV. The most important is power storage: by harnessing the sun's heat rather than converting light directly into electrical power as PV panels do, solar thermal plants such as power towers and parabolic trough plants can store some of that heat by raising the temperature of a substance such as saltpeter, then use that stored heat to generate power after the sun sets -- or during short bouts of cloudy weather. That's important because most renewable energy is intermittent: the sun sets and the wind dies down, and without a way to store power for later use, the grid could run short on electrical power on calm evenings when people are firing up their washing machines and turning on lights.

At least on paper, power towers should be able to offer more efficient designs for energy storage because all the heating is done in a central location, as opposed to parabolic trough plants where the material being heated by reflected sunlight has to snake through hundreds of yards of conduit. Crescent Dunes has the capacity to store heat in a bank of molten salt, and Solar Reserve says that the plant should be able to generate power until midnight.

But even that theoretical advantage of solar power towers over PV may become less important, due to ongoing advances in battery storage that could work with PV power. from Tesla's much-hyped Powerwall to the growing number of electric cars plugged into the grid, the storage world seems poised to make the same kind of advances that PV has in the last decade, rendering one of the last remaining advantages of power towers moot.

Danger to wildlife

All construction projects pose some danger to wildlife. Building a project on undeveloped land deprives wildlife of habitat, and once the project is built, it may pose further hazards to animals because of the way it's built. And all large solar plants, whether PV, trough, or tower, pose a hazard to wildlife, especially birds. All three types of power plants have shiny surfaces that can resemble lakes, luring birds to land with fatal collisions resulting. Collisions with power lines and other structures, electrocution, and exposure to toxic substances are other hazards solar facilities pose to wildlife.

But solar power tower plants offer a unique threat to birds, along with bats and other flying wildlife such as insects: concentrated solar energy in the vicinity of the towers, or "solar flux."

Solar flux injuries to birds were first noted when Solar One was in operation, and a peer-reviewed study published in 1986 documented some of those injuries. Almost as soon as a new tranche of solar tower projects was proposed in the late 2000s, wildlife protection advocates and agency scientists expressed concern over the likelihood that the new projects, with solar flux intensities much higher than those found at Solar One, would pose a threat to wild birds and bats.

Those fears were borne out when the BrightSource-designed Ivanpah Solar Electric Generating System started aiming its mirrored heliostats at its three boilers in 2013, and accounts of bird injuries and deaths started coming in to wildlife agencies. KCET started reporting on the issue in mid-2012, and the rest of the world caught up in early 2014.

Solar power tower advocates were forced onto a defensive PR tack, claiming that bird deaths were

exaggerated or pointing out that other things such as plate glass windows or feral cats were far riskier for birds than solar facilities. At that point, the public relations battle was officially lost for solar power tower promoters. No more minds were likely to be changed.

Advocates could still make claims that the numbers reported by solar companies were the only reliable metric of bird deaths, ignoring complications such as "scavenger bias:" simply stated, the possibility that birds injured at solar power tower plants get eaten before they're counted. Multiple biologists working at the Ivanpah site have reported to KCET that the site has a high population of desert kit foxes, protected by the site's fences from larger predators such as coyotes, and subsidized to some degree by bird carcasses on the site.

Biologists now conduct surveys of the Ivanpah site at 30-day intervals looking for bird carcasses. The same biologists estimate the average length of time a bird carcass remains in place at around three days, before a kit fox (or raven, or snake, or hawk) gets it. Wildlife advocates have been able to do that math even if industry representatives haven't always been.

In January 2015, a solar flux test at the Crescent Dunes Solar Energy Project showed that bird mortality issues weren't limited to BrightSource designs: during a daylong test of the plant's "standby mode" in which solar flux was generated in an area well above the tower, at least 130 birds were apparently injured during a six-hour period. Project operators were later able to create a standby mode in which no highly concentrated areas of solar flux exist, and tested it with no reported bird injuries.

However, despite the claims of some in the trade press that this "fixed" the problem of solar flux injuries to wildlife, it merely reduces the danger during standby mode. When a majority of a power tower's heliostats are focused on the boiler, that creates a field of solar flux that becomes more dangerous the closer you get to the tower.

That bright white line at left is a face of the power tower's boiler component, and a number of so-called "streamers" erupt in white steam and smoke to the right. The smaller ones may be large insects such as dragonflies or hawkmoths: at least one of the larger plumes is recognizably produced by a bird.

Other solar facilities may cause injuries to wildlife and there are tradeoffs to be made in any development project, but incinerating birds in mid-air would seem to be just beyond the pale... at least for most people.

Power towers are obtrusive.

As potentially destructive to wildlife habitat as any large-scale solar development might be, there's something just... *in your face* about solar power towers. Even the five-megawatt Sierra SunTower in Lancaster has been described as an eyesore, and it can definitely offer a blinding distraction for drivers on local streets. And the Sierra SunTower is tiny. Glare from Ivanpah's taller towers has prompted a lot of comment, and some complaint, from drivers on I-15 south of Las Vegas. Glint from its mirrored heliostats has annoyed pilots. The plant's visual prominence has significantly altered views from wilderness areas in and around the Mojave National Preserve. Its mere visual presence has hindered traditional Native cultural uses of the Ivanpah Valley and the mountains around it.

Having Ivanpah as a striking visual example of power tower technology actually in operation almost certainly hurt the chances of other projects being built. Being able to see how Ivanpah visually dominated the landscape, and then hearing that (for instance) the Palen project's towers would be almost 300 feet taller might have given random Californians pause. Ivanpah certainly became a benchmark for agencies examining

the proposal to build larger solar power towers at Hidden Hills, Rio Mesa, and Palen. And the plant's problems may well have scared investors away from other projects like Rice.

Ivanpah was supposed to be a proof-of-concept for the industry. Now it seems more like an albatross hung around solar's neck. Say what you will about the problems with utility-scale PV and parabolic trough solar plants: at least you can hide them behind a chain link fence.

For the record: An earlier version of this piece implied that some of Ivanpah's electrical power output is derived from burning natural gas. That was an oversimplification. The plant can legally use more than 1.5 billion cubic feet of natural gas per year to keep its boiler fluid warm enough to operate efficiently, a significant increase over the amount the plant's designers had originally projected. That's enough natural gas to operate a gas-fired power plant approximately Ivanpah's size for about 20 days non-stop, and since Ivanpah produces power about 30 percent of the time, that would work out to about two months' worth of Ivanpah's power output, more or less.

But though that gas does get burned, and its CO_2 does end up in the atmosphere, and though according to its owners the power plant needs to burn that gas in order to function, none of the gas burned goes directly to generate power. We regret the error.