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Solar Heat Challenges Photovoltaics as Power Source

Concentrated solar power may surpass photovoltaics as the solar technology of choice because the sun's heat is more easily stored

By Umair Irfan and ClimateWire | Monday, January 14, 2013 | 1 comments

Along with the sun's light, our closest star's heat is an ample source of renewable energy, which generators can harness in ways that overcome one of solar energy's biggest shortcomings.

SOLAR HEAT: Solar thermal technology offers the ability to store energy as well as turn sunlight into electricity. Pictured: Rendering of BrightSource's Ivanpah Solar Power Complex. *Image: Flickr/pgegreenenergy*

Using mirrors, developers can focus the sun's rays to produce industrial heat or generate electricity, often using materials that can store the energy, as well. In theory, it is a very simple idea and certainly is not a new one. Legend has it that Archimedes used large, polished mirrors to torch Roman ships during the Second Punic War.

In the United States, concentrated solar power (CSP) manifested in the 1980s as nine power plants in Southern California using trough-shaped mirrors to concentrate energy on a circulating heat transfer fluid. The fluid, often a synthetic oil, then heats up a molten salt to as high as 350 degrees Celsius, which then boils water to drive a turbine.

Interest in CSP waned and development largely idled for more than a decade as low-cost fossil fuels, wind energy and photovoltaics came online. However, in recent years, the demand for renewable energy and solar thermal technology caught up with each other as utilities sought clean and constant power. Now developers in the United States and abroad are building new CSP facilities, spurring research into new methods to make these systems more efficient.

"CSP today offers functionality that [photovoltaic technology] doesn't have, which is dispatchability," said Philip Gleckman, the chief technology officer at Areva Solar.

The liquid salt compound in solar thermal plants can stay hot for several hours, allowing the operator to generate electricity as needed, he explained. This means a CSP plant can produce a steady electron flow as clouds pass overhead and even after the sun sets, unlike photovoltaic panels that only produce electricity when the sun shines.

As a result, CSP stands out among intermittent renewable energy sources as an attractive choice for developers looking for steady power. The National Renewable Energy Laboratory (NREL) released a study last week that showed this flexibility from CSP gives utilities $35.80 per megawatt in value when one-third of their electricity comes from photovoltaics and wind turbines.

"I think the market has spoken very clearly it wants [energy] storage," Gleckman said.

Putting solar thermal through the wringer

Areva Solar is working with Sandia National Laboratories at the National Solar Thermal Test Facility to develop a CSP system that uses molten salt to replace oil in receiver tubes, serving as both the heat transfer fluid and the working fluid, thereby reducing costs and increasing efficiency. The facility was built in 1976 but received $17.8 million under the American Recovery and Reinvestment Act for upgrades.

Gleckman explained that developers need to test solar thermal systems extensively at scale before building a full-size plant, more so than photovoltaic panels.

"It's a pretty hostile environment," he said. "It's not something you just want to convince yourself will work on paper." In a solar thermal system, components can face temperatures higher than 600 degrees Celsius, hot enough to melt glass, along with solar energy swings up to 100 suns in intensity.

At the test site, a 100-yard-by-100-yard patch of parabolic mirrors focuses light on receiver tubes suspended 100 feet above in a design known as a compact linear Fresnel reflector. "This is pretty much a segment of a full-size plant," said Cheryl Ghanbari, a test engineer at the National Solar Test Facility.

Researchers would monitor how well the salt flows, how efficiently the tubes absorb heat and how temperatures change at this site, coupled with Sandia's Molten Salt Test Loop, Ghanbari said. She expects the facility to be up and running by April.

Other solar thermal designs, like solar towers, are also gaining traction. This is where sun-tracking mirrors, called heliostats, focus light on a central tower. "Troughs are a tried and true technology, but you also have these new central receiver plants that achieve higher temperatures and, in theory, lower costs," said Mark Mehos the CSP program manager at NREL.

The Ivanpah Solar Electric Generating Station near the California-Nevada border is one such design. The 377-megawatt plant will use 170,000 heliostats and power 140,000 homes. When it comes online in October, it will double solar thermal production capacity in the United States. The project received a $1.6 billion loan guarantee from DOE.

Spain, Italy and Saudi Arabia gearing up

Compared to photovoltaic plants, CSP generators require sunshine that is more reliable, so they are limited geographically to sun-soaked locales. Photovoltaic panels are also modular, so developers can construct plants faster. However, mirrors are more durable than panels and do not degrade over time. As these plants get larger, power variability becomes a greater concern with photovoltaics but not with CSP.

On the back end, solar thermal plants have more in common with coal- and gas-fired generators than with photovoltaic farms. Thermal plants, both renewable and fossil-fueled, generally use the Rankine Cycle to produce electricity. This is where a heat source heats steam in a closed loop that spins a turbine to generate electricity. The steam then condenses and recirculates.

However, solar thermal systems, because of their high temperatures, could also use a power block driven by supercritical carbon dioxide, according to Gleckman. These turbines use a Brayton Cycle, which is similar to how jet engines work, except the turbines use a hot liquid -- in this case, carbon dioxide -- instead of air. This power block would use 30 times less space than Rankine turbines, substantially cutting materials and maintenance costs.

"If you could use a different way of producing the electricity that is less expensive, then you have a potentially disruptive approach," Gleckman said. "It's very challenging to come to cost parity [with fossil fuels] without doing things on the power block cycle."

Despite their steady performance, Mehos said, solar thermal plants would likely serve on the grid to absorb demand surges rather than provide baseload power. "In today's market, my belief is, really, there is no market for baseload CSP systems. The value of that energy in non-peak or shoulder times is low," he said. Part of the reason is that grid operators do not generally price energy storage, but CSP developers are trying to change that.

Many other countries are also developing CSP plants. Spain leads the way, with more than three dozen running or under construction.

"The two biggest markets are expected to be India and Saudi Arabia," said Gleckman, pointing out that Saudi Arabia wants to move away from burning oil for electricity so it can sell the oil instead, while India wants low-carbon energy to power its development.

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