Research Continues on Solar with Molten Salt Storage

Stephanie Hobby, Sandia National Laboratory

June 16, 2014 | 16 Comments

A soaring structure on the south side of the Department of Energy's National Solar Thermal Test Facility (NSTTF) combines two cutting-edge technologies in concentrating solar energy: Compact Linear Fresnel Reflectors and molten salt thermal storage. Using them together is a pioneering concept.

Today's Compact Linear Fresnel systems use water or oil as the thermal fluid to capture heat from solar collectors. The hot fluid heats water and converts it into superheated steam to drive a turbine connected to a generator that produces electricity.

Collaboration Promotes Exploration of New Technology

With significant input from Sandia researchers, AREVA Solar designed the 100-foot-tall A-frame structure and Compact Linear Fresnel Reflectors, which are mirrors arranged in rows at ground level. The goal is to explore a different

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technology to collect and store heat generated by the reflectors in molten salt. If the system proves to be efficient and effective, AREVA will consider the technology for its solar plants around the world.

A team of Sandia National Laboratories and AREVA engineers examine the focal point of the sunlight reflected from the rows of mirrors on the ground. Credit: Randy Montoya.

"Our goal is to demonstrate the viability and performance of a Linear Fresnel system that uses molten salt as a working fluid, thus allowing us to offer steam at higher temperatures (up to 585 degrees Celsius, or 1,085 degrees Fahrenheit) and also deliver a cost-competitive storage solution for concentrating solar power projects," said Robert Gamble, general manager, North America at AREVA Solar.

AREVA Solar approached Sandia because of its unique Molten Salt Test Loop and Sandia researchers' accompanying expertise. The $10 million Molten Salt Test Loop, known as MSTL, was completed in late 2012 and is the only test facility in the nation that can provide real concentrating solar power plant conditions and collect data to help companies make commercial decisions. Sandia researchers have been testing components for external customers and have developed the expertise to help design and conduct experiments.

"A customer can come to us with an idea, and we have the knowledge to help them shape that idea into a working test," said Sandia engineer Bill Kolb. "In the world of molten salt, this is where you come for expertise."

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Compact Linear Fresnel Reflectors are attractive because they can generate a large amount of heat cost-effectively, using a comparatively small land area. The mirrors are aligned to focus the sun's reflected light at the top of the structure, which houses stainless steel receiver tubes through which the molten salt is pumped and then returned to a hot tank of salt, which can be used later to produce electricity. The receiver tubes are at the focal point of the series of mirrors, and an additional set of mirrors across the top of the tubes captures and refocuses any sunlight that does not directly hit the tubes, taking advantage of all available sunlight.

"This really is based on an industry need for thermal storage, so what we have here is a proof-of-concept demonstration project, aimed at an industry need. The idea is all the feedback and lessons we learn will be fed into our optimized design for the power industry," said AREVA's lead project engineer Antoine Bera.

Steve Sellers of AREVA Solar stands amid the Compact Linear Fresnel Reflectors, the mirrors that focus sunlight to the top of the structure where molten salt is flowing. The resulting heat is stored and used later when the sun is not shining. Credit: Randy Montoya.

In the early days of concentrating solar power, the industry was focused on generating steam to turn turbines, and there was not much demand for thermal storage. Today, as the technology evolves, more companies are incorporating thermal storage into their designs. Molten salt is increasingly the medium of choice because it is affordable and abundant and stores thermal energy for long periods of time, providing greater flexibility for the electric grid.


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"This is enabling technology and is providing a path to the DOE's SunShot goals. Essentially, molten salt allows dispatchable electrical energy and reduces the levelized cost of energy, which is the advantage of using molten salt technology," said Subhash L. Shinde, manager of Sandia's Concentrating Solar Technology department. The DOE SunShot Initiative is a national collaborative effort to make solar energy cost-competitive with other forms of electricity by the end of the decade.

Turning to Sandia was an easy choice, Gamble said. "Sandia's first-of-a-kind Molten Salt Test Loop, along with leading molten salt expertise, made it an obvious choice. Shared lessons learned and expert reviews from Sandia's molten salt experience in the fields of circulating molten salt, testing valves, instruments, and freeze/thaw cycles have helped drive decisions in AREVA's research and design for molten salt and have proved the great value of this partnership," he said.

The construction portion of the project was led by Sandia Facilities Project Manager Scott Rowland and his team. "This was a big undertaking, from a technical and contractual standpoint," Rowland said. "The customer, AREVA, was also the design team for the project. Our goal was to take molten salt from the facility and create a piping system 100 feet in the air with a football field of mirrors below to heat it even further. AREVA's previous installations had been done with water and steam so this was a design modification to their system."

The construction, commissioning, start-up and initial testing have been completed, with further testing scheduled to begin soon.

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16 COMMENTS

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MICHAEL HERTEL
July 13, 2014

We need to look to combined technologies. If a solar power up slope tower can be built so that the slope faces the sun then the reflectors if placed under the greenhouse structure and supported by it can be less rigid since they will not need to stand up to weather and the waste heat will still contribute to the operation of the solar powered updraft.

The combined use of technology is always going to be better

than any individual use in my opinion.

In hot very sunny,dry, climes build solar up draft slopes with ordinary and focused solar mixed in with ordinary agriculture and biofuels production while also producing distilled water from sea water.

I have located places in Egypt, Greece, Mexico and many other countries where this should be tried.
Alas I have no funding to get anything going.
If able to help or interested in more information email me at mghertel(@) execp.com
Note, you need to fix the address, otherwise the scammers find it and I get too much junk.

ROGER BEDELL
June 26, 2014

CSP with molten salt is potentially far more cost effective as energy storage than the equivalent PV with batteries. And directly heating the salt instead of via an oil heat exchanger reduces costs further while at the same time increasing working temperatures. High working temperatures mean greater thermal efficiency.

All in all, these CSP plants can provide replacements for fossil fuel plants for dispatchable, baseload power which is the Achilles heel of PV and wind. Throw in a backup system to heat the salt with gas during long cloudy weather events, and it should be pretty solid, and much cheaper to build and run than an equivalent nuclear plant.

BRIAN DONOVAN
June 19, 2014

Greg: "backup power", using--what else?--carbon sources are what we need to get rid of"

Carbon fuels are NOT the problem, fossils fuels are.

It's the massive excess of carbon from fossils fuels that has overwhelmed the biosphere.

Waste to fuels is at worst carbon neutral in which case the earth will reduce the carbon level. Or if the waste is biochar'ed and the char used for enhancing poor soils, it's massively carbon negative, the ONLY tech we have that id profitable, energy positive and carbon negative.

DON QUIXOTE
June 18, 2014

There is a common public perception in the US that solar-thermal is low-tech or "old" technology; this perception is unfortunate, and based primarily on ignorance of the more subtle issues and physics involved..

Meanwhile, Germany and China continue dominating the spending in the ST area. Germany is now mass-producing low-emissivity ST absorber technology for greatly boosting ST efficiency, and has done very well, shipping square kilometers of it to China, where there are presently many GW's worth installed, and where this low-temp ST promises to remain a high-growth industry.

On other hand, high-temperature solar-thermal, such as that using molten salts, is, despite misconceptions, very much still a fledgling technology. As with almost any hardware technology these days, the bottlenecks are in the materials development.

However, unlike widely recognized PV materials/efficiency limitations, the materials issues of molten salt systems leave a great amount of room for improvement in realizing higher temperatures , higher efficiency's, and new applications. Given the storage density, applications flexibility, and DG possibilities, the unrealized potential is vast. Unlike PV, the technical materials development and food-chain development for high-temp solar processing is barely begun.

There's a good upward vector here; think I'll bank on a bright future for molten salt solar-thermal.

J D
June 18, 2014

To GREG MORGAN what started as a source of "OLD" information which offered some "Layman" technique insights from thousands of years ago, to learn from, became a source of banter for the naysayers. I am directly involved with a very large number of projects based on "Disruptive Technologies" one of them in them on a Caribbean Island is one such technology that updates a twist to the archaic kiln concept to make the Salt method much better than the approach used by the article.

GREG MORGAN
June 18, 2014

JD, I don't understand the points of any of your posts. This article adds news to my knowledge base of what's happening in the area of energy storage--an area that (despite the suggestion of one other contributor) must be developed as an ajunct to a highly efficient transmission grid, considering that localized variations of wind and solar imput DO vary considerably over the short term, and that "backup power", using--what else?--carbon sources are what we need to get rid of. Of course, technologies for using molten salts have been around for thousands of years! How does this impact the production of energy through their use?

BRIAN DONOVAN
June 17, 2014

Storage is the fossils and nuclear pr folks solar and wind red herring. When are folks going to realize that?

Solar and wind in aggregate are HIGHLY predictable, they don't need storage battery or salt because it's easy to plan backup power to take care of it. We already have reserve generators to deal with expected generation shortages.

The real problem is unexpected demand changes, which force

nuclear and coal to buy expensive pumped hydro storage so they don't have to damages their power plants by throttling. They end up paying people to take their electricity causing negative pricing. Yet all that get's blamed on solar and wind if you have been reading up.
Solar mostly coincides with peak electrical demand. Wind tends to blow when solar doesn't.
What's funny is that these thermal storage advantages are purely a result of rooftop/parking lot solar eliminating the big afternoon peak, leaving only a little evening peak to deal with.

OF course nuclear and cal plants can't adjust at all, and that's the problem: they call it "baseload" as if it were a feature.

J D
June 17, 2014

To DON QUIXOTE based on your comment I can see you are stuck with certain "STUBBORN" limitations..... HEE HAW!

But as for your comment about referencing peer-reviewed technical work... This is usually done for self-promotion in the world of academia. Although I am from that world, started lecturing while a sophomore. However, when I became a physicist-humanitarian and philanthropist I found it more useful to simply build the technologies than to talk about them. But to satisfy your need for apparent legitimacy issues, I am directly associated with a major US University, and a number of other International ones, with new R&D Centers being planned for. The misgivings you have are limiting on your part for presently in negotiation with the first 13 countries out of a list of 33 on a waiting list, for their country-wide licensing and use of these NON-peer reviewed technologies. Philanthropy is about making change for the betterment of those who need it first, and then the rest, without the need for self-promotion along the way.

J D
June 17, 2014

To CHRISTOPHE MABIE.... The best I can do in this forum at

this exact time is to say that I one needs to look beyond the limits of human neural perception, i.e. Heat(IR) and visible light. Look at the full spectrum and energy levels at all frequencies....the "Whole Sun". There is so much more energy to be "Harvested" from the Sun's radiation than our meager focus.... You may find my response to DON QUIXOTE of further interest.

DON QUIXOTE
June 17, 2014

Wait - did I just flip channels to "HEE HAW"? I thought I was at Renewable Energy World.

JD - if you have a reference to a peer-reviewed technical work, then please reference it. If you don't, then submitting one for review might be a useful exercise. In the mean time, talk is cheap; especially when there are no numbers involved.

CHRISTOPHE MABIE
June 17, 2014

JD, with all due respect, you side stepped the question. I agreed that a paradigm shift would be most beneficial. You gave a general discussion topic "...USE THE WHOLE SUN, hint." However you gave no suggestion on how to use "THE WHOLE SUN" for a better more efficient and applicable way of producing electrical and thermal energy for the man's use.

Please, if you have some better way of getting the most out of solar energy, this might be the best forum to discuss it.

J D
June 17, 2014

To CHRISTOPHE MABIE in response... I will give you a couple answers to your response, 1st is the need to understand a new way to approach a problem, You could call it a paradigm shift....

It's called the Accepted Disadvantage Paradigm(c) in essence look at the worst of a technology, it's greatest inefficiency, and take advantage of it. (Sorry I don't have time for giving the lecture here, but take heed to the few words stated. Now to apply this ADP concept.... 1) A fuel is a consumable resource and will be a resource of energy until it is used up. So we flip the View about fuel for a moment, what would happen if it were close to 100% RECYCLABLE, the paradigm changes because you get energy out and you use energy to recycle it BUT.. since it is recycled, there is no limit to producing the excess energy needed to always have the usable supply available by recycling--Perpetual---KINDA, but there is a indisputable fact that you can keep recycling what you need is what counts. 2) the other point to be made is don't limit yourself to an archaic past just because you feel HEAT from the Sun.... The fact that the heat is only a small part of the energy being used is the point to be taken to "HEART" . When you have a canteen sure you can take a sip, but you don't empty it after a sip just because it is not being used at the time. USE THE WHOLE SUN, Hint!

J D

June 17, 2014

In response to ANONYMOUS... I am not actually going to far when a point is to be made when it has to do with learning from the past. 1st to get rid of a few tech issues to respond to the statement about reaching to far. The salt glaze process used at the time in the kilns was a dipping process originally however, glazing changed and became optimized by the Chinese much later. The dipping process required constant heating, containment, and re-circulation. As for the reflectors they were of the Bronze Age and late copper, as for the temperature it was concluded from the VITRIFIED bricks and blocks from the kiln liners. I don't disagree with your "Engineering is exciting etc. etc. etc." However, there seems to be an issue in your comment that is missing a major point. There is a difference between INNOVATION & INVENTIVENESS. "Invention is the pragmatic solution to a problem, Innovation is improving the effectiveness of the solution (c)" By taking off the Engineering "Blinders" as in HORSE Blinders, there is much to be learned from the past to NOT REINVENT the WHEEL.

Of course "extending the useful hours of solar energy in a day is of tremendous value. To give Einstein Credit..."We can't solve problems by using the same kind of thinking we used when we created them." Molten Salt at this test site is not offering any new information from the ORNL 2006 study or even the Kilns referenced.

As for you trying to inflate your questionable intellect. You are right, it didn't work for you.

ANONYMOUS
June 17, 2014

Usually I am content to view and not comment, but JD has reached too far. To equate a salt glaze in a pottery kiln with a molten salt heat transfer and storage system is ludicrous. Plus, I'd like to see the reference for a thousand year old solar kiln/oven operating at 2800F outside The Kingdom of the Crystal Skull. Science is fun. Engineering is exciting because that's when we apply the science to practical application. Even if this was "old" technology, bringing it into commercial viability would be a significant engineering and commercial achievement. Finding practical means of extending the useful hours of solar energy in a day is of tremendous value. Your comments appear to be intended to do nothing more than inflate a questionable intellect. It didn't work.

CHRISTOPHE MABIE
June 17, 2014

So, JD, what is your suggestion for the direction of new research?? Please be specific by not giving a general topic of discussion, but a specific NEW direction that energy research should look to for immediate, or at least short term integration and application.

Most of today's research is about improving the output efficiency and reliability of the process over a broad input range. Your new direction might help create a different approach to energy research by creating an entirely new process.

J D
June 17, 2014

YAWN! as usual, just another waste of Money.... It is not to say the idea is bad, my comment here is based on the fact that this is adding nothing more to what is already known and what has been studied before..... We continue to read stories about the archaic, and the "Reinvention of the wheel" Molten salt glazing on pottery has been done for thousands years using solar ovens where the temperatures were in excess of 2,800 F.... and they didn't have anything more than stone and brick ovens and primitive reflectors... LEARN FROM THE PAST!!!! before getting the Tax Payers funding to line pockets.

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