How to make solar power 24/7

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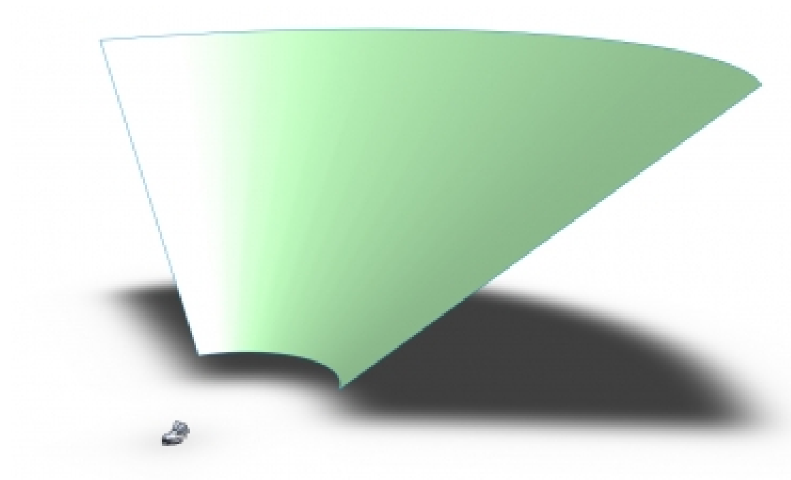

Diagram shows the idealized arrangement of a vat of molten salt used to store solar heat, located at the base of a gently-sloping hillside that could be covered with an array of steerable mirrors all guided to focus sunlight down onto the vat. Image: Courtesy of Alexander Slocum et al.

The biggest hurdle to widespread implementation of solar power is the fact that the sun doesn't shine constantly in any given place, so backup power systems are needed for nights and cloudy days. But a novel system designed by researchers at MIT could finally overcome that problem, delivering steady power 24/7.

The basic concept is one that has been the subject of much research: using a large array of mirrors to focus sunlight on a central tower. This approach delivers high temperatures to heat a substance such as molten salt, which could then heat water and turn a generating turbine. But such tower-based concentrated solar power (CSP) systems require expensive pumps and plumbing to transport molten salt and transfer heat, making them difficult to successfully commercialize — and they generally only work when the sun is shining.

Instead, Alexander Slocum and a team of researchers at MIT have created a system that combines heating and storage in a single tank, which would be mounted on the ground instead of in a tower. The heavily insulated tank would admit concentrated sunlight through a narrow opening at its top, and would feature a movable horizontal plate to separate the heated salt on top from the colder salt below. (Salts are generally used in such systems because of their high capacity for absorbing heat and their wide range of useful operating temperatures.) As the salt heated over the course of a sunny day, this barrier would gradually move lower in the tank, accommodating the increasing volume of hot salt. Water circulating around the tank would get heated by the salt, turning to steam to drive a turbine whenever the power is needed.

The plan, detailed in a paper published in the journal *Solar Energy*, would use an array of mirrors spread across a hillside, aimed to focus sunlight on the top of the tank of salt below. The system could be "cheap, with a minimum number of parts," says Slocum, the Pappalardo Professor of Mechanical Engineering at MIT and lead author of the paper. Reflecting the system's 24/7 power capability, it is called CSPonD (for Concentrated Solar Power on Demand).

The new system could also be more durable than existing CSP systems whose heat-absorbing receivers cool down at night or on cloudy days. "It's the swings in temperature that cause [metal] fatigue and failure," Slocum says. The traditional way to address temperature swings, he says: "You have to way oversize" the system's components. "That adds cost and reduces efficiency."

The team analyzed two potential sites for CSPonD on hillsides near White Sands, N.M., and China Lake, Calif. By beaming concentrated sunlight toward large tanks of sodium-potassium nitrate salt — each measuring 25 meters across and five meters deep — two installations could each provide 20 megawatts of electricity 24/7, which is enough to supply about 20,000 homes. The systems could store enough heat, accumulated over 10 sunny days, to continue generating power through one full cloudy day.

While exact costs are difficult to estimate at this early stage of research, an analysis using standard software developed by the U.S. Department of Energy suggests costs between seven and 33 cents per kilowatt-hour. At the lower end, that rate could be competitive with conventional power sources.

The team has carried out small-scale tests of CSPonD's performance, but its members say larger tests will be needed to refine the engineering design for a full-scale powerplant. They hope to produce a 20- to 100-kilowatt demonstration system to test the performance of their tank, which in operation would reach temperatures in excess of 500 degrees Celsius.

The biggest challenge, Slocum says, is that "it's going to take a company with long-term vision to say, 'Let's try something really different and fundamentally simple that really could make a difference.'"

Most of the individual elements of the proposed system — with the exception of mirror arrays positioned on hillsides — have been suggested or tested before, Slocum says. What this team has done is essentially an "assemblage and simplification of known elements," Slocum says. "We did not have to invent any new physics, and we're not using anything that's not already proven" in other applications.

Gershon Grossman, who holds the Sherman-Gilbert Chair in Energy at the Technion-Israel Institute of Technology, says this approach "includes several innovative CSP concepts." But, he adds, "the main advantage of this system is its ability to deliver power continuously, unlike other CSP systems, which are affected by clouds. This work is innovative and is expected to make a significant contribution" to the industry, he says.

Slocum emphasizes that this approach is not intended to replace other ways of harvesting solar energy, but rather to provide another alternative that may be best in certain situations and locations. Playing on the familiar saying about rising tides, he adds, "A rising sun can illuminate all energy harvesters."

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