U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

Solar Research Spotlight: Concentrating Solar-Thermal Power

The Crescent Dunes concentrating solar power plant in Nevada uses molten salt technology to store heat and generate electricity and can provide power to 75,000 homes during peak operations. *Photo courtesy of SolarReserve.*

The concentrating solar-thermal power (CSP) subprogram within the U.S. Department of Energy (DOE) Solar Energy Technologies Office supports early-stage research and development to de-risk and lower the cost of CSP technologies that can provide solar power on demand. Projects in the CSP portfolio focus on novel technologies that will integrate thermal storage, increase efficiency, improve reliability, and lower the cost compared to current state-of-the-art technologies. This includes the exploration of new designs and innovations for the collector, receiver, thermal storage, heat transfer fluids, and power block subsystems, as well as plant operations. These innovations can enable the solar industry to reach the office's 2030 cost targets for CSP: 5 cents per kilowatt-hour for a baseload plant with 12 or more hours of storage and 10 cents per kilowatt-hour for a peaker plant with six or fewer hours of storage.

The CSP subprogram also funds transformative solutions that reimagine the ways solar-thermal energy can be used through new system designs and smaller, more modular configurations. Because CSP can easily decouple solar energy collection from electricity generation through the use of thermal energy storage, plants can be designed to minimize capital costs, while meeting changing energy demands, helping to provide the best value to the grid. Solar-thermal technologies can also be used to generate heat for applications beyond electricity, such as water desalination, thermochemistry, and other industrial thermal needs like food processing.

Solar Energy Technologies Office

The U.S. Department of Energy Solar Energy Technologies Office (SETO) supports early-stage research and development to improve the affordability, reliability, and performance of solar technologies on the grid. The office invests in innovative research efforts that securely integrate more solar energy into the grid, enhance the use and storage of solar energy, and lower solar electricity costs.

CSP 101

CSP technologies use mirrors to reflect and concentrate sunlight onto receivers that collect the light energy and convert it to thermal energy—heat. This thermal energy can then be used for industrial heat applications or to deliver heat to a turbine or heat engine that can drive a generator and produce electricity. Thermal energy can also be inexpensively stored which enables the plant to generate electricity even when the sun isn't shining. Thermal energy storage increases CSP flexibility and enables these plants to be used as peaker plants that supply electricity when there's high demand, or as a baseload source of electricity that can meet electricity demands around the clock.

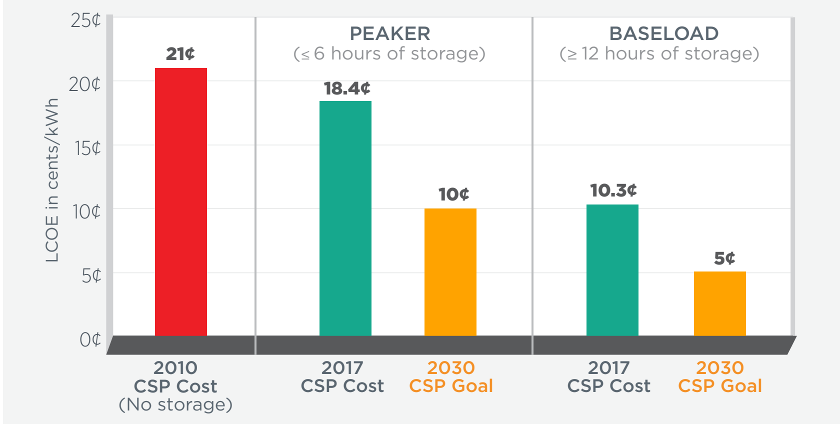
The Path to Commercialization

CSP deployment is growing in sunny regions around the world due to the value of dispatchable thermal energy storage and significant cost reductions that the industry has been able to achieve. However, to enable widespread deployment in the United States, further cost reductions are necessary. In addition, current molten salt technology is limited in efficiency due to the temperature limitation of today's molten salts (565 °C). DOE is targeting the development of technologies that can raise the temperature of the heat delivered to a power cycle in a CSP plant to approximately 720 °C, helping to increase the efficiency of the plant and reduce costs. Advancements have been made at the subsystem and component levels, but there are three material pathways for the heat transport system—using gas, liquid, or solid particles—that all show promise for commercialization but face significant technological and economic barriers.

Each of these pathways feature thermal energy storage and a field of mirrors that concentrate sunlight onto a receiver that then heats either a liquid, gas, or solid particles, which can be used to heat the working fluid of a turbine and produce electricity.

- **Gas** – Supercritical carbon dioxide is a dense, gas-like fluid that can be circulated to generate heat and then transferred to another medium for thermal storage. Projects focus on improving receiver efficiency and integrating an indirect thermal storage system.
- **Liquid** – Molten salt can be used as both the heat transfer fluid and storage medium. It circulates through the tower to collect solar-thermal energy and can be easily stored in large tanks. Research focuses on creating heat exchanger, pump, valve, and storage tank designs that are resistant to corrosion at high temperatures and can operate efficiently in molten salt environments between 400 and 750 °C.
- **Solid Particle** – In this pathway, falling ceramic particles are heated by concentrated sunlight, are stored hot, and used to provide heat for electricity generation, before being circulated back to the top of the tower. Research focuses on reducing heat losses and characterizing the flow and heat transfer of particulates in order to optimize operations and improve efficiency.

Concentrating Solar-Thermal Power Progress and Goals



Current Funding Programs

The CSP subprogram manages several funding efforts to advance and lower the cost of CSP technologies. Current active funding programs include:

Research engineer Stefan Cich is pictured with a novel, high-efficiency heat exchanger for supercritical carbon dioxide power cycles that was developed at Southwest Research Institute for a Solar Energy Technologies Office project. *Photo courtesy of Southwest Research Institute.*

- **Solar Desalination** – Projects aim to develop low-cost, novel technologies or concepts that use solar-thermal energy to generate freshwater from otherwise unusable waters.
- **Generation 3 Concentrating Solar Power Systems (Gen3 CSP)** – This funding program focuses on de-risking the next generation of CSP technologies by advancing high-temperature components and developing integrated assembly designs with thermal energy storage that can reach high operating temperatures (>700 °C). Three teams will work to advance a gas, liquid, or solid particle thermal transport system design and one will be chosen to build a test facility for further evaluation.
- **Concentrating Optics for Lower Levelized Energy Costs (CSP: COLLECTS)** – Projects target improvements to the design and manufacture of novel solar collectors, the costliest part of a CSP plant.
- **CSP: Advanced Projects Offering Low LCOE Opportunities (CSP: APOLLO)** – Projects address challenges in each technical system of a CSP plant, including solar collectors, receivers and heat transfer fluids, thermal energy storage, power cycles, as well as operations and maintenance
- **Solar Energy Technologies Office Laboratory Support FY19-21 (SETO Lab Call)** – This program supports research and development into CSP technologies that have the potential for lower cost, higher efficiency, and more reliable performance than existing CSP systems.

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