Sun♦Lab
SnapShot

Concentrating Solar Power Program Overview

Advancing solar power into the 21st century.

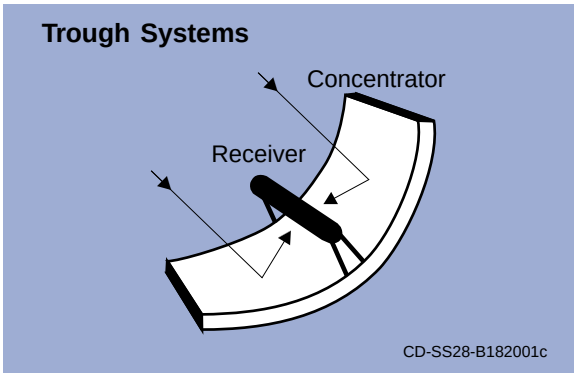
Over the last decade, the U.S. solar thermal industry has established a track record in the power industry by building and operating utility-scale power plants with a combined rated capacity of 354 megawatts (MW). The technology used in these power plants is based on years of research and development (R&D), much of it sponsored by the U.S. Department of Energy (DOE).

DOE's Concentrating Solar Power (CSP) Program is collaborating with its partners in the private sector to develop two new solar technologies — power towers and dish/engines — to meet the huge commercial potential for solar power.

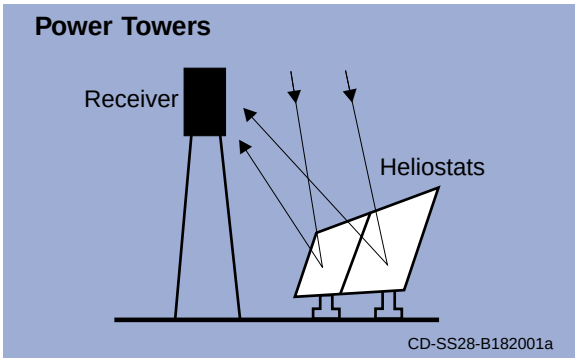
What Is Concentrating Solar Power?

Concentrating solar power plants produce electric power by first converting the sun's energy into heat, and then to electricity in a conventional generator. The plants consist of two parts, one that collects solar energy and converts it to heat and another that converts heat energy to electricity. Systems are usually classified by how they collect solar energy:

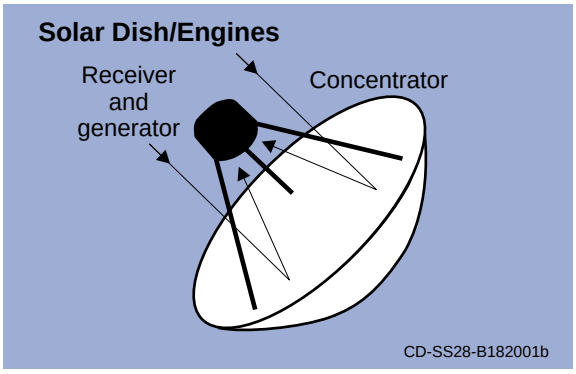
- **troughs** — concentrate the sun's energy onto a receiver pipe located along the focal line of a parabolically curved trough-shaped reflector. Oil flowing through the pipes is heated to about 400°C (752°F), and the heat energy is then used to generate electricity in a conventional steam generator. These are utility-scale power plants, such as those operating in California, with capacities that range from 30 to 80 MW each.
- **power towers** — include a field of heliostats that reflect the sun's rays to a receiver located on top of a tall tower. The energy is absorbed by a molten-salt working fluid and stored for up to several hours at 565°C (1050°F) in large tanks located at the base



The sun's energy is concentrated on an oil-filled tube running along the focal line of the parabolically shaped trough.



Large sun-tracking mirrors, called heliostats, focus the sun's energy on a receiver located atop a tall tower.



The sun's energy is concentrated on a receiver and generator located at the focal point of the parabolically shaped dish.

Concentrating Solar Power Program

of the tower. The energy is then used to generate electricity in a steam-turbine when needed. Eventually power towers will range in size from 100 to 200 MW.

- **dish/engines** — focus the sun's energy at the focal point of a parabolically shaped dish at a temperature of about 800°C (1452°F), where an engine/generator converts the heat energy to electricity. Individual units will range from 5 to 50 kilowatts (kW) in size. Larger power plants will be assembled by connecting many dishes together.

Why Concentrating Solar?

Concentrating solar power systems have many advantages over competing power sources, because they:

- **use components available today**, such as mirrors, heat-collection systems, and engine/generators.
- **have higher efficiencies** than other solar electric technologies.
- **are environmentally benign.** There are virtually no harmful emissions from solar power plants.
- **rely on a secure, domestic, and inexhaustible source of energy.** Like an investor who profits from a diversified investment portfolio, our nation benefits from an electricity system that has multiple supplies, including solar supplies that cannot be interrupted.
- **can join with fossil technologies in hybrid power plants,** which increases flexibility. In fact, combining solar operation with conventional technologies based on combustion of fossil fuels gains the advantages of both. Solar technologies yield superior environmental performance and predictable costs in the long run, and conventional technologies provide lower costs in the short run and power production on demand.
- **provide jobs and promote local economic development**, such as construction and manufacturing. Furthermore, concentrating solar power plants also provide more income to state and local treasuries through withholding, sales, and real property taxes than do conventional technologies.
- **are popular with consumers.** As demonstrated in numerous market surveys and recently confirmed in utility programs experimenting with customer choice, consumers repeatedly show their preference for clean energy, with solar power consistently collecting high marks.

What Is DOE Doing?

As concentrating solar power technologies enter the early stages of commercial viability, DOE's CSP Program partners with industry to help the technology become available for near-term markets, advance it toward its technical potential, and foster its acceptance and utilization by the U.S. power industry.

Cost-Shared Development

In all of its activities, the program leverages its R&D investment by combining with investment from industry

Warren Gretz, NREL/PIX02385

Solar Two is a $50 million project, cost-shared 50/50 between DOE and industry partners.

partners through pilot projects, joint ventures, cooperative research and development agreements (CRADAs), and subcontracts. By the start of FY 1997, the program had eight major cost-shared projects underway and another planned. These projects, worth a total of $100 million of public and private investment, include:

- **Solar Two**, this country's newest power tower and the first to use heat storage to produce electricity for up to 3 hours after dark. The storage allows this pilot plant to operate during utility peak periods when electricity production is the most valuable. Solar Two is demonstrating that all of the subsystems of molten-salt power towers are technically defined, function well together on a pilot scale (10 MW), and are ready for commercial development. The plant is built and operated by a consortium of utilities, industries, and government agencies, including DOE, and led by the Southern California Edison Company in Irwindale, California.
- **Joint ventures** to develop solar dish/engine systems. The first industry team, consisting of Science Applications International Corporation in Golden, Colorado, and Stirling Thermal Motors in Ann Arbor, Michigan, will build and deploy up to six dish/engine systems over the next 2 years. In February 1997, Arizona Public Service Company in Tempe, Arizona, agreed to join the venture and test three to five of the dishes after the systems are built.

  The second industry team will be determined later in 1997 through a request for quotation issued by Sun•Lab. Unlike the first joint venture, this new request will focus on establishing the performance of the engine and the receiver before an entire system is built.
- **A CRADA** with a solar manufacturer, Energy Laboratories, Inc. in Jacksonville, Florida, to develop and commercialize a new, low-cost absorber coating for parabolic troughs. Made of a unique nickel compound, the coating absorbs the sun's energy efficiently. Under a CRADA, the manufacturer pays for and directs much of the research at DOE facilities but retains the rights to commercialize the product resulting from the research, while DOE provides technical guidance and support.
- **Subcontracts** to lower the cost of component manufacturing. Through SolMaT, manufacturers are decreasing their costs in the short-term to allow sales of small quantities so large cost reductions can be achieved in the long-term through economies of scale.

  — Science Applications International Corporation (SAIC) in Golden, Colorado, is developing and manufacturing heliostats, the component of power towers that currently represents almost half of the plant's total cost. By modifying the design to allow production of heliostat facets at a factory, rather than in the field, SAIC believes it can reduce heliostat costs by 40%.

Warren Gretz, NREL/PIX02333

These dish concentrators power Stirling engine/generators to produce electricity for utility and village applications.

— Solar Kinetics, Inc. in Dallas, Texas, has also redesigned heliostats to increase their manufacturability.

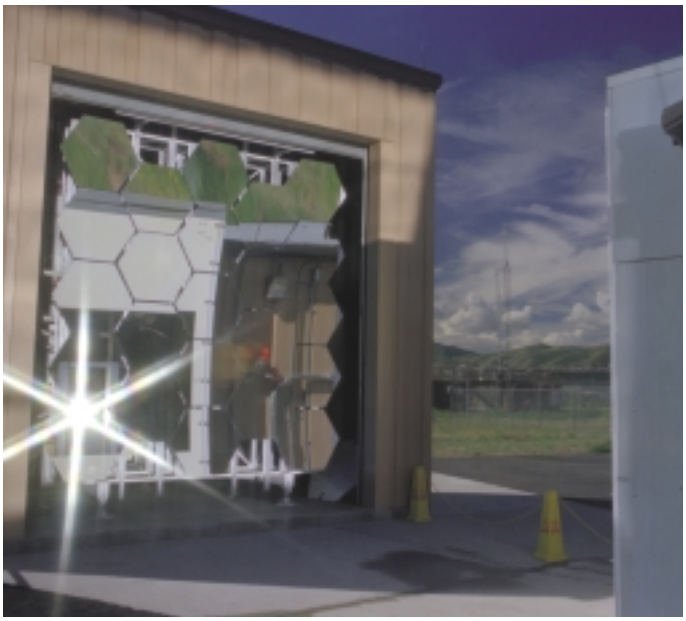
— Rocketdyne Division of Boeing North American in Canoga Park, California, is using what they learned constructing the receiver on Solar Two to reduce the costs of future commercial molten-salt receivers. After only 1 year of work, engineers found a way to reduce the cost of building the receiver of a commercial-scale power tower by more than $1 million and the yearly cost of operating the plant by almost $250,000. Such work increases confidence in projected costs of commercial power towers.

— McDonnell Douglas Astronautics in Huntsville, Alabama, is assessing the feasibility of improving the manufacturability of dish concentrators by using composite materials.

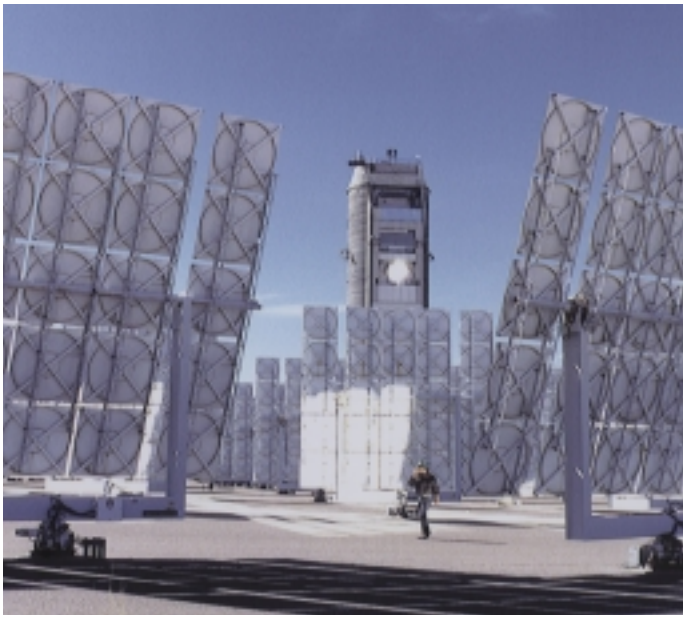
Future Potential

The CSP Program sponsors a number of R&D activities to develop and prove the viability of CSP technology to potential investors, users, and consumers in a way that targets short-term markets. Because many of these markets are overseas, program researchers are supporting the World Bank and industry in assessing market potential. These activities include:

- **Resource assessment** to improve our knowledge of the worldwide distribution of direct normal solar radiation, like that used by CSP systems. Program researchers are using cloud cover data obtained from satellites to



Warren Gretz, NREL/PIX00292



Sandia National Laboratories/PIX03778

Research at the National Renewable Energy Laboratory's high-flux furnace (left) and Sandia National Laboratories' National Solar Thermal Test Facility (right) is key to the success of the CSP Program.

complete distribution maps for promising geographic areas worldwide.

- **Market assessment**, including developing software for evaluating the commercial prospects for providing solar power to more than a third of the world's population that is currently without electricity, many of whom live in remote villages in sunny locations. Sun♦Lab is also providing analysis support to Bechtel Corporation in San Francisco, California, in developing a business plan for commercializing power towers in overseas markets, such as India.
- **Advanced scientific research** for use by industry in developing new, low-cost reflective materials, receivers, and engines for tomorrow's concentrating solar power applications.

What Is Sun♦Lab?

DOE administers the CSP Program through two of its national laboratories — Sandia National Laboratories in Albuquerque, New Mexico, and the National Renewable Energy Laboratory in Golden, Colorado. To increase the administrative efficiency of the program and leverage the respective technical expertise of each of the labs, DOE has "combined" the concentrating solar departments of each into a "single business unit" called Sun♦Lab.

Sun♦Lab is a "virtual" laboratory obtained through cooperation, communication, and teamwork. A single management team consisting of managers from both labs provides day-to-day direction of program activities. Together with DOE management, they formulate a long-term vision, develop yearly operating plans, and negotiate cooperative agreements with the program's industrial partners.

For More Information

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For on-line information about the U.S. Department of Energy's Concentrating Solar Power Program, please visit its web site: **http://www.eren.doe.gov/sunlab**

For more information on renewable energy or for additional copies of this brochure, contact the Energy Efficiency and Renewable Energy Clearinghouse (EREC): **1-800-DOE-EREC (363-3732)**

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