Concentrating Solar Power

Utility-Scale Solutions for Pollution-Free Electricity

Overview

Concentrating solar power (CSP) plants use mirrors or lenses to concentrate the energy from the sun, creating high enough temperatures to drive traditional steam turbines or engines that create electricity. The most cost-effective size of CSP plants is hundreds of megawatts (MW), making them attractive as wholesale energy suppliers to utilities. Today, over 400 MW of CSP plants operate in the United States, and projects totaling more than 8,000 MW are currently under development.[1]

CSP Technologies

Parabolic Trough

Source: Abengoa Solar

Parabolic trough systems use curved mirrors to focus the sun's energy onto a receiver tube that runs down the center of a trough. In the receiver tube, a high-temperature heat transfer fluid (e.g., synthetic oil) absorbs the sun's energy, reaching temperatures of around 700° F, and passes through a heat exchanger to heat water and produce steam. The steam drives a conventional Rankine steam turbine power system to generate electricity. A typical solar collector field contains hundreds of parallel rows of troughs connected as a series of loops. These loops are placed on a north-south axis so the troughs can track the sun from east to west. Individual collector modules are typically 15-20 feet tall and between 300 and 450 feet long. The Luz LS-3 collectors used in the 80 MW SEGS IX plant in California are each 325 feet long and 11 feet wide.[2]

Source: Ausra

Compact Linear Fresnel Reflector (CLFR)

To reduce some of the up-front capital costs of plant construction, CLFR developers rely on the principles of curved-mirror trough systems, but use long parallel rows of lower-cost flat mirrors. These modular reflectors focus the sun's energy onto elevated receivers, which consist of a system of tubes through which water flows. The concentrated sunlight boils the water, generating high-pressure steam for direct use in power generation and industrial steam applications. Ausra operates its 5 MW Kimberlina plant in Bakersfield, Calif., the first CLFR facility in North America.[3]

Power Tower

Seeking higher operating temperatures for greater efficiencies, other plant designers opt for a central receiver system. Computer-controlled flat mirrors (called heliostats) track the sun along two axes and focus solar energy on a receiver at the top of a high tower. The focused energy is used to heat a transfer fluid (800° F to 1,000° F) to produce steam and run a central power generator. At Abengoa's PS20, a 20 MW plant in Seville, Spain (see photo), 1,255 heliostats surround a tower standing 531 feet tall.[4]

Source: Abengoa Solar

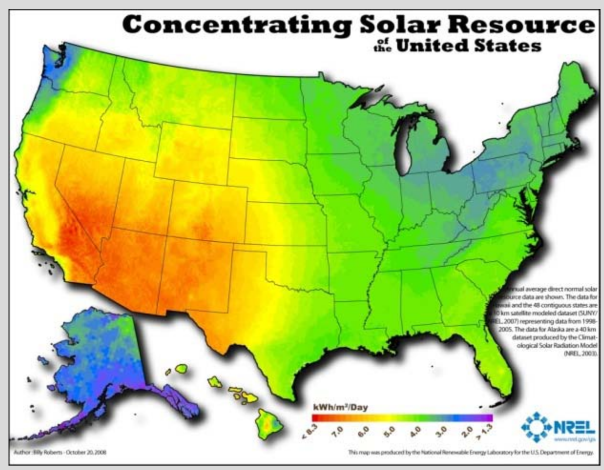
Source: Stirling Energy Systems

Dish-Engine

Mirrors are distributed over a parabolic dish surface to concentrate sunlight on a receiver fixed at the focal point. In contrast to other CSP technologies that employ steam to create electricity via a turbine, a dish-engine system uses a working fluid such as hydrogen that is heated up to temperatures of approximately 1,200° F in the receiver to drive an engine such as the Stirling engine. Each dish rotates along two axes to track the sun. A dish will generate 5-30 kilowatts of electricity depending on the system. Stirling Energy Systems' 25 kW SunCatcher™ is 38 feet tall and 40 feet wide.

Key Requirements

Nine CSP plants, totaling over 350 MW, have been in daily operation near Kramer Junction, Calif., for over 20 years. Over the last four years, new CSP plants have come online in Arizona, Nevada, and California. The plants' locations reflect the important conditions required for CSP projects. CSP plants need:



Areas of high direct normal solar radiation – In order to concentrate the sun's energy, it must not be too diffuse. This feature is captured by measuring the direct normal intensity of the sun's energy, called DNI. Potential CSP production in the U.S. Southwest stands apart from the rest of the U.S. (see NREL map, right[5]), totaling almost 7,000 GW, or over 16 million GWh per year.[6]

Contiguous parcels of dry, flat land with limited cloud cover – A CSP plant operates most efficiently, and thus most cost-effectively, when built in sizes of 100 MW and higher. While land needs will vary by system type, a typical trough plant, for example, requires approximately 5 to 10 acres of land per MW of capacity.[7] The larger acreage is usually associated with thermal energy storage. Most reflector systems that track the sun are best situated on relatively flat lands.[8]

Access to water resources – Like other thermal power plants, such as natural gas, coal and nuclear, some CSP systems require access to water for cooling. All require small amounts of water to wash collection and mirror surfaces. CSP plants can utilize wet, dry, and hybrid cooling techniques to maximize efficiency in electricity generation and water conservation.

Important Features of Concentrating Solar Power

- CSP plants can produce electricity when it is needed most, because high sunlight periods create both peak electricity demand and peak production.
- Components for CSP plants consist mainly of traditional materials like steel, glass and concrete, which are available worldwide.
- CSP systems can be incorporated into fossil fuel-burning plants for cleaner baseload power.[9]
- Recent advances in thermal energy storage allow many CSP plants to operate even when the sun is not shining. Just as a thermos keeps coffee warm, substances like molten salt (sodium and potassium nitrate) have been developed to hold excess heat in large storage tanks during the day for power generation at night.[10]

About the Solar Energy Industries Association

Established in 1974, the Solar Energy Industries Association® is the national trade association of the U.S. solar energy industry. Through advocacy and education, SEIA and its 1,000 member companies are building a strong solar industry to power America. As the voice of the industry, SEIA works to make solar a mainstream and significant energy source by expanding markets, removing market barriers, strengthening the industry and educating the public on the benefits of solar energy.

For a referenced version of this factsheet and more information, please visit www.seia.org.

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[10] See Andasol CSP plants: "The parabolic trough power plants Andasol 1 to 3." Solar Millennium AG. Accessed online 24 July 2009. http://www.solarmillennium.de/upload/Download/Technologie/eng/Andasol1-3engl.pdf. For more on the science behind thermal storage, see NREL's "Parabolic Trough Thermal Energy Storage Technology." Accessed online 24 July 2009. http://www.nrel.gov/csp/troughnet/thermal_energy_storage.html