2.3.4 CONCENTRATING SOLAR POWER

Technology Description

Concentrating Solar Power (CSP) systems concentrate solar energy 50 to 5,000 times to produce high-temperature thermal energy, which is used to produce electricity for distributed or bulk generation process applications.

Luz Trough Power Plant

System Concepts

- In CSP systems, highly reflective sun-tracking mirrors produce temperatures of 400°C to 800°C in the working fluid of a receiver; this heat is used in conventional heat engines (steam or gas turbines or Stirling engines) to produce electricity at solar-to-electric efficiencies for the system of up to 30%. Systems using advanced photovoltaics (PV) cells may achieve efficiencies of 33%.
- CSP technologies provide firm, nonintermittent electricity generation (peaking or intermediate load capacity) when coupled with storage.
- Because solar-thermal technologies can yield extremely high temperatures, the technologies could some day be used for direct conversion (rather than indirect conversion through electrochemical reactions) of natural gas or water into hydrogen for future hydrogen-based economies.

Representative Technologies

- A parabolic trough system focuses solar energy on a linear oil-filled receiver to collect heat to generate steam to power a steam turbine. When the sun is not shining, steam can be generated with a fossil fuel to meet utility needs. Plant sizes can range from 1.0 to 100 MW_e.
- A power tower system uses many large heliostats to focus the solar energy onto a tower-mounted central receiver filled with a molten-salt working fluid that produces steam. The hot salt can be stored extremely efficiently to allow power production to match utility demand, even when the sun is not shining. Plant size can range from 30 to 200 MW_e.
- A dish/engine system uses a dish-shaped reflector to power a small Stirling or Brayton engine/generator or a high-concentrator PV module mounted at the focus of the dish. Dishes are 2-25 kW in size and can be used individually or in small groups for distributed, remote, or village power; or in larger (1-10 MW_e) clusters for utility-scale applications, including end-of-line support. They are easily hybridized with fossil fuel.

Technology Status/Applications

- Nine parabolic trough plants, with a rated capacity of 354 MW_e, have been operating in California since the 1980s. Trough system electricity costs of about 12¢-14¢/kWh have been demonstrated commercially.
- Solar Two, a 10-MW_e pilot power tower with three hours of storage, provided all the information needed to scale up to a 30-100 MW commercial plant, the first of which is now being planned in Spain.
- A number of prototype dish/Stirling systems are currently operating in Nevada, Arizona, Colorado, and Spain. High levels of performance have been established; durability remains to be proven, although some systems have operated for more than 10,000 hours.

Current Research, Development, and Deployment

RD&D Goals

- RD&D goals are to reduce costs of CSP systems to 5¢-8¢/kWh with moderate production levels within five years and below 4¢/kWh at high production levels in the long term.

RD&D Challenges

- RD&D efforts are targeted to improve performance and lifetime, reduce manufacturing costs with improved designs, provide advanced designs for long-term competitiveness, and address barriers to market entry.
- Improved manufacturing technologies are needed to reduce the cost of key components, especially for first-plant applications where economies of scale are not yet available.
- Demonstration of Stirling engine performance and reliability in the field are critical to the success of dish/engine systems.

RD&D Activities

- Key DOE program activities are targeted to support the next commercial opportunities for these technologies, demonstrate improved performance and reliability of components and systems, reduce energy costs, and develop advanced systems and applications.
- Several European countries and Israel have programs comparable in size to the United States.
- DOE support of RD&D has been required because of the specialized technology development and the need for reducing costs and for reducing barriers to market penetration. The Federal CSP program provides expert technical support, as well as serving as a catalyst and facilitator for participation of utilities and manufacturers to assist in driving down system costs.

Recent Progress

- New commercial plants are being considered for California, Nevada, and Arizona.
- The 10-MW Solar Two pilot power tower plant operated successfully near Barstow, California, leading to the first commercial plant being planned in Spain.
- Operations and maintenance costs have been reduced through technology improvements at the commercial parabolic trough plants in California by 40%, saving plant operators $50 million.

Commercialization and Deployment Activities

- Parabolic troughs have been commercialized and nine plants (354 MW total) have operated in California since the 1980s.
- The state of Nevada announced plans to build a 50-MW parabolic trough plant near Boulder City. Nevada Power and Sierra Pacific Power will purchase the power to comply with the solar portion of Nevada's renewable portfolio standard.
- Successful operation of Solar Two has provided the basis for a partnership to provide the first 30-100 MW power tower plant.
- The World Bank's Solar Initiative is pursuing CSP technologies for less-developed countries. The World Bank considers CSP to be a primary candidate for Global Environment Facility funding, which could total $1-$2 billion for projects during the next two years.

Market Context

- There is currently 350 MW of CSP generation in the United States, all of it in Southern California's Mojave Desert.
- Power purchase agreements have been signed for 150 MW of new CSP capacity (50 MW in Nevada and 100 MW in Spain). The plants are anticipated to come on-line within the next two to three years. Significant domestic and international interest will likely result in additional projects.
- According to a recent study commissioned by the Department of Energy, CSP technologies can achieve significantly lower costs (below 4¢/kWh) at modest production volumes.
- Congress asked DOE to scope out what would be required to deploy 1,000MW of CSP in the Southwest United States. DOE is actively engaged with the western Governors to map a strategy to deploy 1-5 GW of CSP in the Southwest by 2015.
- A near-term to mid-term opportunity exists to build production capacity in the United States for both domestic use and international exports.