

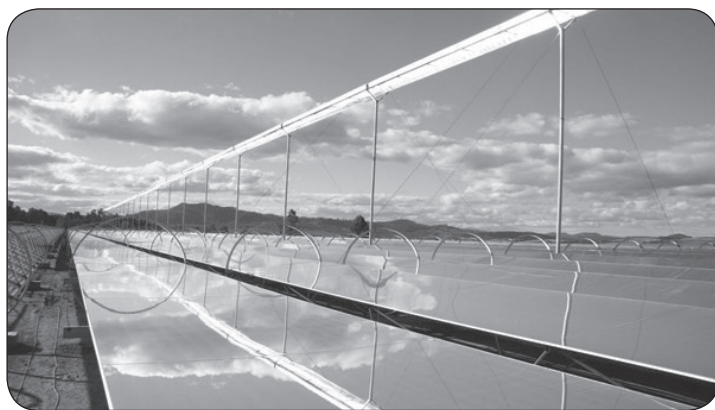
## Concentrating Solar Power Systems

**Concentrating solar power (CSP) systems** also use solar energy to make electricity, but instead of only panels, they also use a turbine system. Since the solar radiation that reaches the Earth is so spread out, it must be concentrated to produce the high temperatures required to generate electricity using a steam turbine. There are several types of systems that use mirrors or other reflecting surfaces to concentrate the sun's energy, increasing its intensity.

**Linear concentrating systems** use mirrors to concentrate sunlight onto receivers located just above the mirrors. The receivers are long tubes that carry either water that is directly converted to steam or fluid that transfers energy in a **heat exchanger**, which produces steam. The steam drives a turbine that turns a generator to make electricity. Linear concentrating systems are either parabolic trough systems, or linear Fresnel reflector systems.

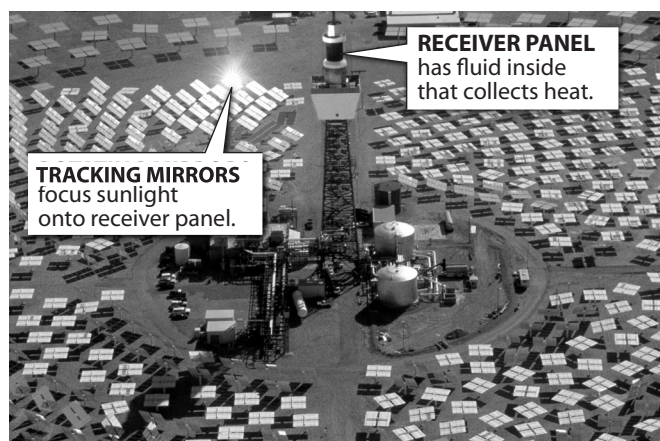
**Parabolic trough systems** use long, curved mirrors in troughs that focus the sunlight onto a pipe located at the focal line. A fluid circulating inside the pipe collects the energy and transfers it to a heat exchanger, producing steam to drive a conventional turbine. The world's largest parabolic trough system is located in the Mojave Desert in California. The SEGS facility consists of several sites that together have a total generating capacity of 354 megawatts. Five to ten acres of parabolic troughs are needed to produce one megawatt of electricity. Arizona houses another one of the world's largest facilities of this type. The Solana plant near Phoenix can generate 280 megawatts.

### LINEAR FRESNEL REFLECTORS



Photos courtesy of National Renewable Energy Laboratory

## Solar Power Tower



### DISH/ENGINE SYSTEM



**Linear Fresnel reflector systems** use several flat mirrors in groups to concentrate the sun onto a tube receiver above them. This arrangement allows the mirrors to better track the sun's position for maximum reflection. The first linear Fresnel reflector system in the U.S. generates 5 megawatts of electricity in Bakersfield, CA.

While parabolic trough systems are the most common in the United States, there are advantages and disadvantages to both systems. Parabolic trough systems are proven and have excellent performance. However, the parabolic mirrors are expensive to manufacture and the power plants require large amounts of land. Linear Fresnel reflector systems use mirrors that are easier and cheaper to manufacture. However, the performance of linear Fresnel reflector systems does not yet match that of parabolic troughs.

A **solar power tower** consists of a large field of sun-tracking mirrors, called **heliostats**, that focus solar energy on a receiver at the top of a centrally located tower. The enormous amount of energy in the sun's rays focused at one point on the tower can produce temperatures over 500 degrees Celsius. The thermal energy is used for heating water or molten salt that saves the energy for later use. In a heat exchanger, the hot water or molten salt heats the water and changes it to steam that is used to move the turbine generator. The largest solar power tower system in the world is found in California. The Ivanpah Solar Electric Generation System uses three towers with over 170,000 heliostats and has a generating capacity of over 390 megawatts.

**Dish/engine systems** are like satellite dishes that concentrate sunlight rather than signals, with a heat engine located at the focal point to generate electricity. These generators can be small, mobile units that can be operated individually or in clusters, in urban and remote locations.