Concentrating Solar Power Technology

Another way that solar energy can be used to generate electricity is with concentrating solar power technology, or CSP for short. CSP Power Plants are usually very large, or "centralized", power plants. CSP technology uses large mirrors to first concentrate solar energy to create very intense heat, which is then used to generate electricity. Some CSP technologies do this by using the concentrated light to create steam or hot air, which is then used to drive a generator (turbine):

SOLAR ENERGY ⇨ HEAT ⇨ STEAM/HOT AIR ⇨ TURBINE ⇨ ELECTRICITY

Solar Troughs

The photo at right shows what one type of CSP Power Plant looks like. This kind of CSP technology is called a "Solar Trough" (pronounced "trof"), because the (cylindrical parabolic) shape of the mirrors is trough shaped. The light is focused into the narrow pipes at the focus of the troughs, which contains synthetic oil, or water, that is used to carry the heat away to make steam.

This CSP Plant is located in California, and provides enough peak power for 340,000 homes! It has operated well for over 15 years. Another plant like this is fully operational in Nevada.

Power Towers

The photo at right shows another type of CSP Technology. This type of CSP Power Plant is called a "Power Tower" because many separate mirrors are used to reflect light into a central receiver that is located at the top of a tall tower. This (test) CSP Power Plant, called "Solar II" was tested in California, but its technology was first invented and tested in New Mexico, at a National Laboratory in Albuquerque (Sandia National Labs). Solar II could actually store the solar heat using "molten salt", which was used to smooth out the output of the plant, and keep it going when clouds passed by. The tanks of molten salt can be seen in the photo on either side of the base of the tower.

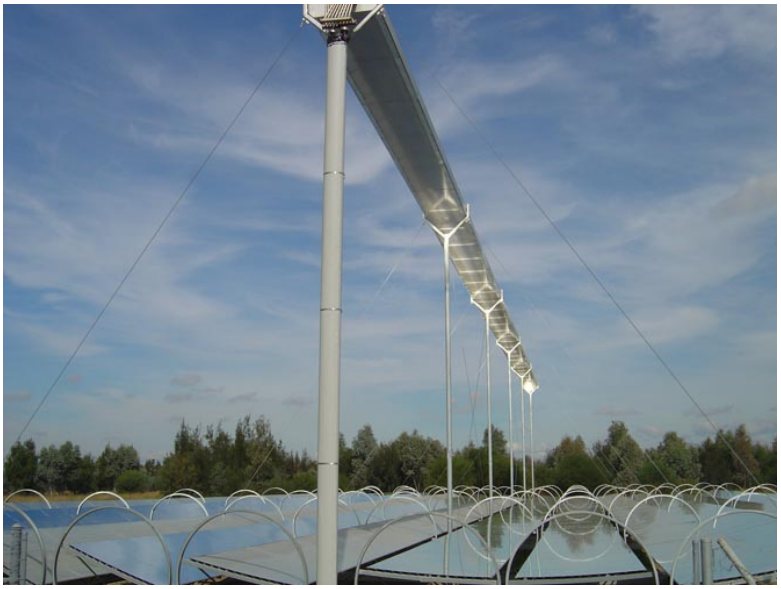
Solar Dishes

The photo at right shows another type of CSP technology, called a "Solar Dish" because the (circular parabolic shape) mirrors resemble a giant dish.

Solar dishes focus light into a small receiver to create very hot air, which then drives a special hot air turbine called a "Stirling Engine". These engines require no water to operate.

Some very large power plants using solar dishes are currently under development in California.

Concentrating Linear Fresnel Reflector CSP



The image at right shows a newer type of CSP technology, which is called Concentrating Linear Fresnel Reflector CSP, or "CLFR" CSP. These systems have many long mirrors near the ground, each with a slightly different tilt, so that they make what people call a giant "fresnel lens" (pronounced "frnel"), named after the German scientist who first invented lens that use glass with many small grooves to concentrate light, instead of a curved lens. These mirrors reflect light into a single long narrow receiver about 30 feet above the ground. This type of CSP is under development in Australia and Spain. This CSP technology may prove to be quite cheap, because the mirrors are only curved slightly (they are easy to make by just bending regular flat mirrors a little bit). The receiver tube is also simpler than that typically used on a solar trough system (it does not require a vacuum, unlike a trough system).

One can think of CLFR CSP as roughly *intermediate* between solar troughs and power towers: Imagine starting with a solar trough, and moving the receiver tube away from the curved mirror gradually, while slowly flattening out the mirror. Then add more mirrors (each with its own correct tilt). This gives you a CLFR system! If one were now to further collapse the receiver tube along the long axis into a small central receiver, and break up the mirrors into many small mirrors, one would get a power tower! We can see that it may be the case that the cheapest system is one that lies in the middle between solar troughs and power towers.

Concentrating PV Technology

A final type of CSP technology are the "concentrating PV" CSP technologies. Concentrating PV uses mirrors to concentrate sunlight on PV cells, so that not as many PV cells are needed to produce the same amount of power. There is a price to pay, because the PV cells get very hot, so they have to be specially engineered either to withstand the heat, or to have the heat removed rapidly.

Because very little PV is used, however, this type of CSP technology may be a strong competitor for the other CSP technologies above. A new version of concentrating PV CSP, called "micro-concentrating" PV, gets around the heat problem by simply using thousands of very small mirrors and extremely tiny PV cells, which dissipate the heat quickly because they are so small. This technology may be able to lower the cost of PV technologies dramatically.

Towers, Troughs, and CLFR Systems can *store energy*

A major advantage of CSP technologies that produce solar heat over both solar dishes and photovoltaics is that they can *store* energy for cloudy times, or nighttime, by simply storing heat. The heat that they generate can be stored in various ways, for example, by melting a special kind of salt, in a technique called "molten salt thermal storage" (mentioned in the power tower example above), or by just storing steam in very large underground chambers. Because they can store energy, power towers and solar troughs are better able to maintain their electricity output even while clouds pass by, and to provide electricity into the evening, when people still need it.

Solar Dishes and PV use no water and are very efficient

On the other hand, solar dishes are extremely efficient (up to 29%, which is almost twice what troughs and towers have achieved so far). And because solar dishes create hot air instead of steam, this type of CSP technology, along with concentrating PV, does not use water. Troughs, towers, and CLFR CSP *can* avoid using large amounts of water, but only if they use special "dry cooling" technology, which makes them more expensive and less efficient.

Observe: Different kinds of CSP technologies have different advantages. Which one is best for a given place depends on things such as whether water is available, cost, whether energy storage is needed, and other factors. We also don't know yet which ones will work best in the long run!