Solar tech

There are many different ways to harness solar energy. Light can be converted into heat, electricity and fuels. The two options for electricity generation are photovoltaic (PV) solar energy conversion and concentrating solar power (CSP). In the future these technologies may also be used to generate sustainable fuel, especially hydrogen.

Solar thermal energy (STE)

STE is a technology that uses the sun's energy to generate heat. The technology used to heat water is fairly simple: thermal collectors move the heat from the collector to its point of use, where it can then serve a variety of purposes, such as heating swimming pools or creating hot water for residential and commercial use. The best known application is the millions of rooftop solar water-heating systems installed around the world. The most powerful STE systems superheat water and convert it to steam, which then powers turbines to generate electricity.

China is the world leader in the deployment of solar heating systems, with over 70 GW installed. Israel and Cyprus are the per capita leaders, with over 90% of households using solar hot-water systems.

Solar photovoltaic (PV)

PV is the state-of-the-art in solar electricity generation. PV solar cells convert sunlight directly into electricity. The first PV panels were produced in the US in 1956, and PV cells have been used for decades for satellite applications. Presently, billions of dollars go into building factories, and generally scaling up solar PV production, while vast amounts are also spent on R&D to improve cell efficiency and make them cost effective.

How does PV work? The first step is the absorption of light on a semiconducting material, which has a built-in electric field that pushes/pulls negatively charged electrons to one side and positively charged 'missing' electrons (called holes) to the other side. This leads to a build-up of negative and positive charges on either side of the interface, and as a result a voltage builds up. When the two sides are contacted an electrical circuit is formed and a current can flow. Voltage and current represent electric power. Upon illumination, electrons and holes are generated continuously and the solar cell can thus generate power.

The most commonly used PV panel is made of **crystalline silicon**. Its core material, silicon, is derived from sand (more precisely, from SiO_2, quartz). Production costs of silicon panels are coming down each year. According to Steve O'Rourke, managing director of Deutsche Bank Securities, this technology, which has dominated the solar PV industry since its inception, 'will likely maintain a commanding presence for the foreseeable future'.

However, **thin-film technology** emerged as a competitor in 2008. Thin-film technologies can use silicon but also non-silicon materials (copper, indium, gallium and selenium) to create PV cells. They are much cheaper to make and can be printed onto glass, metal or other construction materials, opening the way to new, large-scale applications. Thin-films are not as efficient as their silicon counterparts.

First Solar, Inc., which has factories in the US, Malaysia and Germany, applies cadmium telluride on glass and offers the first product in the history of the industry that is cost competitive with conventional electricity generation. The company has shown that the module cost/watt of this thin-film technology can be roughly half that of crystalline silicon.

R&D also focuses on **organic-based PV cells**, which have a low-cost fabrication potential and offer the possibility for manufacturing flexible cells for new applications, such as on textiles and clothes.

Concentrating solar power (CSP)

CSP systems use lenses or mirrors to focus an area of sunlight. This significantly increases the light's intensity, in the same way a magnifying glass can burn a hole in a piece of paper. The sun's energy can be concentrated onto PV cells, or onto boilers to create steam. Solar trackers built into these systems follow the sun to guarantee the highest output possible at any moment of the day. CSP systems – which have an overall higher efficiency than non-concentrating systems – are more complicated to build, manage and maintain.

An example of a large industrial application of CSP is the Luz Power Tower in California built by BrightSource Energy. The system uses thousands of small mirrors to concentrate sunlight onto a boiler atop a tower. The high-temperature steam produced (550°C) is then piped to a turbine that generates electricity, which is carried by transmission cables to homes and businesses. In February 2009, BrightSource Energy (which is backed by Google.org) signed an agreement with Southern California Edison (SCE) for a series of projects which together should produce 1300 MW of solar thermal power, enough to serve nearly 845,000 homes. 'This landmark agreement illustrates the increasing demand for solar thermal energy as a reliable source of utility-scale renewable power', said John Woolard, CEO of BrightSource Energy. A similar landmark construction, Europe's first commercial CSP tower, is located near the sunny Spanish city of Seville. ■

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