SOLAR ENERGY

The sun is the source of nearly all (99.97%) renewable energy on Earth. Not only solar energy directly – wind, hydroelectric, biomass, and all other renewable energies except geothermal get their energy from the sun. The total solar energy absorbed by the Earth in one hour is more energy than the world uses in one year. The amount of solar energy reaching the surface of the planet in one year is about twice as much as will ever be obtained from all of the Earth's non-renewable resources of coal, oil, natural gas, and mined uranium combined.

About 30% of the solar radiation received by the Earth is reflected back to space by the upper atmosphere. The rest is absorbed by clouds, oceans and land masses, heating them. Warm air containing evaporated water rises, driving atmospheric circulation (*wind*). This air cools when it reaches a high altitude, and the water vapor condenses into clouds, which rain onto the earth's surface, completing the *water cycle*. The conversion of solar energy into chemical energy by *photosynthesis* produces food, wood, and the *biomass* from which *fossil fuels* are derived.

Since ancient times, solar energy has been used by humans in many ways. There are two basic types of solar technologies: passive and active. *Passive* solar techniques are architectural. Using materials that can absorb heat is a passive solar technique. Spaces are designed to circulate air naturally. Buildings are positioned to the sun in a way that minimizes energy requirements for heating or cooling. Clotheslines, which dry clothes through evaporation by wind and sunlight without consuming electricity or gas, are another example of passive solar technology. *Active* solar techniques convert sunlight into electricity or other useful power. Active solar technologies generate energy, while passive solar technologies reduce the need for energy.

Solar thermal technologies can be used for water heating, space heating or cooling, and process heat generation. *Solar hot water systems* use sunlight to heat water. *Solar cookers* use sunlight for cooking, drying and pasteurization. *Solar concentrating technologies*, such as parabolic dishes and other reflectors, can provide process heat for commercial and industrial applications, such as providing power for factories.

Sunlight can be converted into electricity using *photovoltaics* (PV), *concentrating solar power*, and various experimental technologies. PV have mainly been used to power small and medium-sized applications, from a calculator powered by a single solar cell to homes powered by a photovoltaic array, but there is a trend toward larger PV power stations in the US and Europe.

A *solar cell*, or *photovoltaic cell*, converts light into direct current using the photoelectric effect. They were first made in the 1880s. The earliest significant use of solar cells was as a power source for satellites, where they are still used today. The high cost of solar cells limited their use on Earth until the early 1970s, when prices fell to levels that made PV generation more competitive. The 1973 oil crisis also caused a rapid rise in the production of PV during the 1970s and early 1980s. The price of PV fell during this time, from $100/watt in 1971 to $7/watt in 1985. Cheaper oil from the early 1980s, however, slowed growth of the PV industry to about 15% per year from 1984 through 1996.

Some experts believe photovoltaics could cover all the world energy demand. Photovoltaics are 85 times as efficient as growing corn for ethanol. A one-hectare plot of

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land can produce enough ethanol in one year to drive a car 30,000 miles. Covering the same land with photo cells can produce enough electricity to drive it 2,500,000 miles.

One experimental idea is the *solar updraft tower* (also known as a solar chimney or solar tower), a large greenhouse that funnels into a central tower. As sunlight shines on the greenhouse, the air inside is heated, and expands. The expanding air flows up the central tower, past a turbine that converts the air flow into electricity.

Space solar power systems, another experimental idea, would use a large solar array in geosynchronous orbit to collect sunlight and beam this energy in the form of microwave radiation to Earth for distribution. In theory, these systems could deliver power about 96% of the time, an advantage over other solar energy sources.

Developing a *solar-powered car* has been an engineering goal since the 1980s. The World Solar Challenge is a solar-powered car race, where teams compete to cross central Australia. In 1987, when it started, the winner's average speed was 42 mph. By 2007, the winner's average speed had improved to 56.46 mph. International interest in the development of other solar-powered vehicles is also growing. *Solar boats* have sailed across the Pacific and Atlantic oceans, and in 1974, the unmanned *Sunrise II* plane made the first *solar flight*. On April 29, 1979, the *Solar Riser* made the first flight in a solar-powered, fully controlled, manned flying machine.

Storage is an important issue in the development of solar energy. Solar energy is available only when the sun shines, not at night or in inclement weather, so storage or back-up power systems must be used. One method of storing solar power is to use *thermal mass* systems. Thermal mass systems store solar energy in the form of heat at domestically useful temperatures for daily or seasonal durations. Thermal storage systems generally use common materials with high specific heat capacities such as water, earth and stone. Such systems can lower peak demand, shift time-of-use to off-peak hours and reduce overall heating and cooling requirements.

Solar energy can also be stored at high temperatures using *molten salts*. Salts are an effective storage medium because they are low-cost, have a high specific heat capacity, and can deliver heat at temperatures compatible with conventional power systems.

Some PV systems often use *rechargeable batteries* to store excess electricity. A *photogalvanic device* is a type of battery in which the cell solution forms energy-rich chemical intermediates when illuminated, and can store and produce electricity.

Pumped-storage hydroelectricity stores energy in the form of water pumped when energy is available from a lower elevation reservoir to a higher elevation one. The energy is recovered when demand is high by releasing the water to run through a hydroelectric power generator.

It would seem that solar power could supply all of our energy needs, but there are some drawbacks. As with wind power, solar power is an intermittent resource. Time will tell if ways can be found to solve these problems and enable us to use these abundant energy sources on a large scale.

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