Solar Energy Industries Association®

Solar Thermal

Overview

Solar thermal technologies harness the energy of the sun to provide thermal energy for solar water heating, solar pool heating, solar space heating and cooling, and industrial process pre-heating. The umbrella term "solar thermal"[*] represents solar thermal technologies used for a variety of point-of-use applications. The amount of solar radiation that the U.S. receives is significant enough for solar thermal technologies to be an integral part of a clean energy future in any region. Solar thermal systems are composed of three main elements: solar collector(s), insulated heat transport piping, and heat storage. Some systems also employ the use of electronic controls, and in colder climates, a freeze protection strategy.

Example of Flat Plate Collectors

Source: Entech Solar, Inc.

Solar Thermal Collectors

Solar thermal collectors produce heat, and are different from photovoltaic (PV) modules, which produce electricity.[1] There are several types of thermal collectors: flat plate, evacuated tube, Integral Collector Storage (ICS), Thermosiphon, and Concentrating. Flat plate collectors are the most common type of collector in the US; typically copper pipes are affixed to an "absorber plate" contained in an insulated "box" covered with a tempered glass[2] or polymer "coverplate."

Evacuated tube collectors consist of rows of parallel, transparent glass tubes. Each tube encloses an "absorber" assembly, and the entire tube is "evacuated" of air, leaving a vacuum; this vacuum acts as a highly efficient insulator, since air is required to transmit heat from the absorber to the glass. A fluid transfers the heat from the solar collector to a storage tank, where it is distributed for water or space heating purposes. Evacuated tube systems are generally used when higher temperatures or higher volumes of water are needed as well as for process heating and solar air conditioning systems.

Solar Water Heating[3]

The solar collector(s) converts solar radiation into heat and transfers the heat to potable water[4]. This heated water flows out of the collector to a water tank, and is used as necessary. A conventional water heater (using electricity, natural gas, oil, or propane) can provide additional heating if needed.[5] In a colder climate where temperatures can drop to 32°F or below, an antifreeze solution, such as non-toxic propylene glycol, is heated in the solar collector. The heated antifreeze is circulated from the solar collector through a heat exchanger connected to a storage tank. The potable water in the storage tank is warmed by the hot, antifreeze-filled heat exchanger, and the heated water can then be used as necessary, while the cooled glycol is piped back to the solar collector to be heated again. Another common type of solar water heating system design for cold climates is called "drainback." This type of solar thermal system typically uses regular water as a heat transfer fluid, and is designed to allow all of the water in the solar collector to "drain back" to a holding tank in a heated portion of the building it is used on. [For more information, see the SEIA fact sheet on solar water heating].

Solar Pool Heating

The most widely used application for solar thermal energy in the U.S. today is for heating both commercial and residential swimming pools. The existing pool filtration system is used to pump water through solar collectors where the heat is collected and transferred directly to the water. Solar pool heating systems typically operate at a slightly warmer temperature than the surrounding air and normally use unglazed, low temperature collectors made from polymers. Solar heaters can stand alone or work in conjunction with an existing fossil fuel heater to make a "hybrid" system.

[*] This should not be confused with concentrating solar power technologies that are often referred to as solar thermal electric.

Solar Space Heating

Solar space heating systems are similar to solar water heating systems[6], except that they have larger collector areas and larger storage units, and a more sophisticated design. These heating systems use either non-toxic liquid, water, or air as the heat-transfer medium in the solar energy collector. The heated liquid or air is then circulated throughout the building or home.[7] New technologies use transpired solar collectors along a building's outer wall: perforations in these collectors allow for air to pass through and to become heated. This solar-heated air then either enters the building's ventilation system or not, depending on the season.

Solar Cooling

There are two kinds of active solar cooling systems:[8] absorption chiller and desiccant systems. In contrast to a regular air conditioner that uses a compressor, an absorption chiller uses solar heat to evaporate a fluid that removes heat, creating a cooling effect. Chillers are in common use today for large buildings but solar energy is underutilized as a heat source. In a desiccant system, air is passed over a common desiccant such as silica gel to draw moisture from the air and make the air more comfortable. The desiccant is regenerated by using solar thermal energy to dry it out.

Typical Evacuated Tube Water System- Sunda Seido 2 Collectors Shown

Photo courtesy of SEIA.

Industrial Process Pre-Heating

Similar to residential solar water heating, industrial process solar thermal systems heat water or other fluids, but for use in manufacturing processes. These systems may use high-temperature solar collectors, which can concentrate sunlight to achieve temperatures up to 800°C. In some cases, heat at 480°F (250°C) is required for steam generation, washing, drying, distillation, and many other processes - making solar industrial process pre-heating an optimal technology for such applications.[9] Many process water heating applications require very large volumes of relatively low temperature water, making flat plate solar collectors a good choice in these circumstances. It takes almost the same amount of energy to heat water from 100°F to 101°F as it does to heat the same amount of water from 180°F to 181°F, making any fluid heating application a good candidate for solar thermal.

Other Facts

- Solar thermal systems (collector) can last anywhere between 15-40 years with proper maintenance.
- Some solar thermal projects can be completed in as little as one day.
- Solar water heating systems range in price from $2,000-$8,000, depending on the size and complexity of the system. The return on investment can be as little as 3-6 years, the lowest of any solar technology.
- The potential for solar thermal systems is huge! China and the U.S. have similar solar resources, and yet China makes up 66.7 percent of existing global solar heating capacity, while the U.S. makes up 1.3 percent. From another perspective, Austria, with a population of just over 8 million, and a climate almost identical to Chicago, installed 350,000 m^2 of water heating type solar thermal collectors (3.7 million ft^2), compared with just 180,000m^2 of installations in the U.S. (1.9 million ft^2).[10] The U.S. population is over 307 million.
- Water heating, space heating, and space cooling accounted for 47.1 percent of the energy used in residential buildings in the U.S. - representing a huge market potential for solar thermal technologies![11]

About the Solar Energy Industries Association

Established in 1974, SEIA is the national trade association of the solar energy industry. As the voice of the industry, SEIA works to make solar a mainstream and significant energy source by expanding markets, removing market barriers, strengthening the industry and educating the public on the benefits of solar energy.

For a footnoted version of this factsheet and more information, please visit www.seia.org.

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[1] Regarding energy metrics: The energy from solar water heating technologies is generally measured in British Thermal Units (BTU), which can be converted to kWh through an industry accepted conversion factor. The Solar Rating and Certification Corporation (SRCC) rates each collector in terms of kWh.

[2] Efficiencies range between 30-60% for flat plate collectors.

[3] For more information on solar water heating, see separate SEIA fact sheet on solar water heating.

[4] This describes an active, direct system. There are also passive systems, which rely on gravity and thermodynamic properties to circulate water, as well as indirect systems, in which the heat is transferred to a storage tank via a "heat exchanger," and from there to the potable water for household or business use.

[5] New storage technologies are being developed that would significantly reduce the need for back-up conventional heating.

[6] Active solar space heating systems are similar to indirect solar water heating systems. Lower delivery temperatures to systems such as radiant floors allow the solar thermal system to participate more often in the heating of homes or businesses.

[7] Liquid based systems heat water or an antifreeze solution and circulate this heated liquid through a heat exchanger connected to a storage tank. The heat from the storage tank is then transferred to the home or building. Air-based systems heat air in a solar air collector and use electric fans to distribute the heated air. Some solar heating systems also use energy-storage to provide heat at night or when the sun is not shining, and can be used in combination with solar water heating systems as well. For more information, see separate SEIA fact sheet on solar space heating and cooling.

[8] Solar cooling can provide 30-60% of building cooling requirements; this figure is continually improving.

[9] For example, high heat temperatures are critical to the food, paper, textile, and chemical industries.

[10] http://www.estif.org/fileadmin/estif/content/market_data/downloads/2008%20Solar_Thermal_Markets_in_Europe_2008.pdf

[11] http://buildingsdatabook.eren.doe.gov/TableView.aspx?table=1.1.4