Lecture #6 Solar Collectors

Now that we have learned about the amount of solar energy flux and solar energy available for different times of year for different locations on earth, we need to look at the types of solar collectors used to harvest this solar radiation and convert it into thermal energy, that is, into heat.

Several types of collectors are used. A good sample of the types used is illustrated in Figure 2.21, page 59 of the text. These may be classified as:

1) Flat plate collectors. These are the most common type. Usually, the fluid heated is water, though sometimes air is heated. The temperature rise of the fluid heated is relatively small -- no more than about 100°C.

2) Concentrating collectors that focus the sun's rays onto a line, i.e. onto a pipe carrying fluid.

The text shows water flowing through the pipe and receiving a temperature rise of 50 - 150 °C.

In point of fact, although water can be used, an intermediate fluid, such as a special oil, may flow through the pipe. This carries the heat collected to a heat exchanger, where the heat is transferred to water, which is boiled to steam. We have made a steam-electric power plant.

The temperature obtained may be as much as about 300°C.

The "line-focus" collector is also called a "trough" collector.

3) Concentrating collectors that focus the sun's rays onto a point. The fluid collects the heat at the focus point. These collectors have the potential to impart very high temperatures to the fluid. They are used in conjunction with a heat engine to produce electricity. Note, although the text shows water flowing into and out of the collector, in point of fact, intermediate fluids are used to receive the heat. The "point focus" collectors are also called "dish" collectors.

Flat plate collectors

Some flat plate collector systems for hot water are illustrated on page 43 of the text. Figure 2.2 shows a common type with a pump. The mechanical pump moves the water between the collector and the hot water storage tank. The pump is run off of line (grid) electricity, or off of electricity protoelectrically generated from the sun. This would be a two collector system: Solar-thermal collector (to create the hot water) and a solar photovoltaic (PV) collector to generate the electricity.

Note the main components of the system, as shown in Fig 2.2:

1) Flat-plate solar collector. This is where the solar radiation is converted into thermal energy (i.e., the heat of the water).

2) Primary piping system that carries the water between the collector and the storage tank.

3) Pump.

4) Heat exchanger coils in the hot water storage tank. These permit the heat to be transferred from the primary water loop -- i.e. the water flowing through to collector -- to the secondary water.

The secondary water is the water heated in the tank and used by the homeowner. There are at least two reasons for using two water systems:

A) The primary water is probably contaminated with chemicals -- for example, antifreeze to inhibit corrosion and prevent freezing.

B) The mass of water flowing through the collector should be relatively small, to avoid as much water damage as possible to the building should a leak develop.

5) Hot water storage tank.
6) Temperature sensors and pump controller. For example, the primary loop should shut down in the evening and night, otherwise there will probably be a reverse flow of energy from the hot water to the night sky.

The solar hot water system illustrated in Figure 2.3 is somewhat different. Note the differences:

1) There is no pump!
2) There are two tanks. There is a solar storage tank located above the collector, that is, at a higher elevation than the collector. And there is the hot water storage tank located at ground level.

This is a thermosyphon solar hot water system.

It relies on the buoyancy of hot water relative to cool water. That is, the heating of the water in the collector causes the water to naturally flow from the collector "uphill" into the solar storage tank. The primary loop water is cooled in the solar storage tank by heat transfer to the cooler secondary water.

"Rules" for designing the thermosyphon system, that is, determining the elevation changes, may be found on p 101 - 104 of the book by Twidell and Weir "Renewable Energy Resources", ISBN 0419120106, Routledge Press.