Chapter 6

Solar thermal desalination and solar water heating

"Solar power is the last energy resource that
isn't owned yet – nobody taxes the sun yet."

Bonnie Raitt, American blues singer and songwriter.

"It's time for the human race to enter the solar system."

Dan Quayle, Vice President of the United States 1989–1993.

It is not necessary always to use electric power to produce clean water. Solar distillation is described in 6.1 as a complement to other water supply methods. Heating water has been done with solar thermal collectors for a long time. In 6.2 it is shown to be a complement to using electric power for heating and cooking.

6.1 SOLAR STILL DISTILLATION FOR CLEANING WATER

Solar still distillation (SSD) is simply a natural evaporation-condensation process. This is a practical and simple technique to clean water in remote arid areas and does not require any electric power, only the heat from the sun. The advantages of an SSD system include low investment costs, low maintenance and low energy requirements.

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low investment costs, low maintenance and low energy requirements. It is certainly environmentally friendly. However, an SSD system has low productivity; but for small-scale water demands, those of a small village or a household, SSD is a viable option due to the high cost of water transportation. It also offers a complement to electric power-driven water supply so that the available electric power can be used for other purposes.

The key function of an SSD system can be illustrated by a typical greenhouse. A constant volume of brackish or saline water is enclosed in a basin with a dark bottom. The basin can be constructed of concrete or some fibre-reinforced plastic. The roof is a transparent material like glass or plastic. The brackish or saline water is fed to the basin. The distillate is collected at the lower end of the roof. As the sunrays pass through the glass roof they are absorbed by the blackened bottom and will heat the water. The vapour pressure will increase and the water vapour is condensed on the underside of the roof. It will run down into troughs that conduct the distilled water to a storage basin. The process is a direct application of the greenhouse effect. Furthermore, the roof encloses all the vapour, prevents its loss and keeps the wind from reaching and cooling the contaminated water.

As the saline water is distilled there will be increasingly higher salt concentrations in the basin. Therefore, the systems need flushing, which preferably should be done during the night. There are several designs of SSD systems and some of the more popular designs are described and reviewed by Kalogirou (2005) and Al-Karaghouli and Kazmerski (2011). A typical still production is about 3–4 l/m^2 per day (Daniels, 1977), but 8–10 l/m^2 per day has been reported in simple and practical designs.

The real advantage of the SSD system is its simplicity and low cost. Since it is less efficient it needs much more space than the desalination methods described in 5.3 to produce a given volume of water.

6.2 SOLAR WATER HEATING

Solar thermal collectors or solar water heating (SWH) have been used for a long time as heating sources for water. The technology is simple and extensively proven. For cooking this may remain the backbone of water heating, even if electrification of the heating process is possible. Solar thermal collectors can be installed on roofs and work well in climate zones all over the world. In sunny regions in Africa and Asia they will naturally be an important complement to solar PV systems.

Active solar heating systems use a *collector* and a fluid that absorbs solar radiation. Fans or pumps circulate air or heat-absorbing liquids through collectors and then transfer the heated fluid directly to a room or to a heat storage system. Active water heating systems usually have a tank for storing solar heated water.

Solar systems for heating water or air usually have non-concentrating collectors. This means that the collector area (the area that intercepts the solar radiation) is the same as the absorber area (the area absorbing the radiation). *Flat-plate collectors* are the most common type of non-concentrating collectors and can produce water with a temperature of more than 90°C.

The surface of the absorber determines the efficiency of solar water heaters. It has to combine high absorbance (percentage of incoming energy that a material can absorb) and low emittance (percentage of energy that a material radiates away) of the solar radiation. At the top and bottom of the metal absorbing plate, thicker copper pipes, known as headers, assist in the removal of heated water and the arrival of colder water to be heated.

The principles of operation for flat-plate collectors are fairly consistent, but significant improvements in the design of systems, particularly absorber plates, have occurred. The major types of thermal collectors are:

- *Evacuated tube solar thermal system*: this is one of the most popular solar thermal systems in operation. The collector itself is made up of rows of insulated glass tubes that contain copper pipes at their core. Water is heated in the collector and is then sent through the pipes to the water tank. This type of collector is the most efficient, but also the most expensive.
- *Flat-plate solar thermal system*: this is a type of device that has been in use since the 1950s. The main components of a flat-plate panel are a dark coloured flat-plate absorber with an insulated cover, a heat-transferring liquid to transfer heat from the absorber to the water tank and an insulated backing. The flat-plate feature

of the solar panel increases the surface area for heat absorption. The heat-transfer liquid is circulated through copper or silicon tubes contained within the flat surface plate. The flat-plate design is slightly less compact and less efficient when compared with an evacuated tube system, but the cost is lower. A flat-plate SWH can work well in all climates and can have a life expectancy of over 25 years.

An SWH system contains a storage tank. In a close-coupled system the storage tank is mounted with the collector on the roof. The tank is located above the collectors to take advantage of the principle of thermo-siphoning. This principle utilises collectors to heat the water, which rises to the storage tank. Cold, denser water flows through the collector, is heated up and is then returned to the tank. As the heated water is less dense, it rises to the top of the tank. Roof-mounted flat-plate collectors that utilise thermo-siphoning are extremely popular.

Since the system has no moving parts it is easy to maintain and reliability is very high. How about electricity requirement? Yes, electricity may be needed to (1) lift the cold water to a level where it can flow into the storage tank and (2) make sure that the system does not overheat. If the storage tank is filled with hot water, it may overheat and a valve may be closed so that no more hot water is fed into the tank until more cold water is fed into the system.

6.3 FURTHER READING

Several practical SSD solutions are demonstrated on www.youtube.com (search for "solar: still distillation"). Kalogirou (2004) presents a survey of the various types of solar thermal collectors and applications.

Practical demonstrations as well as academic lectures on solar thermal systems can also be found on www.youtube.com (search for "solar thermal").