

# Solar Water Heaters

Solar water heaters—also called solar domestic hot water systems—can be a cost-effective way to generate hot water for your home. They can be used in any climate, and the fuel they use—sunshine—is free.

## How They Work

Solar water heating systems include storage tanks and solar collectors. There are two types of solar water heating systems: active, which have circulating pumps and controls, and passive, which don't.

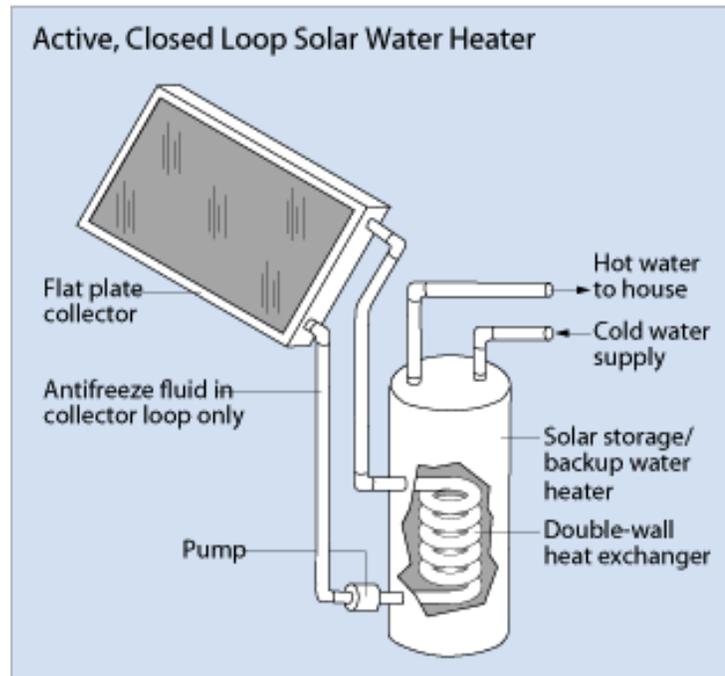
Most solar water heaters require a well-insulated storage tank. Solar storage tanks have an additional outlet and inlet connected to and from the collector. In two-tank systems, the solar water heater preheats water before it enters the conventional water heater. In one-tank systems, the back-up heater is combined with the solar storage in one tank.

Three types of solar collectors are used for residential applications:

### ❖ Flat-plate collector

Glazed flat-plate collectors are insulated, weatherproofed boxes that contain a dark absorber plate under one or more glass or plastic (polymer) covers.

Unglazed flat-plate collectors—typically used for solar pool heating—have a dark absorber plate, made of metal or polymer, without a cover or enclosure.



## ❖ Integral collector-storage systems

Also known as ICS or batch systems, they feature one or more black tanks or tubes in an insulated, glazed box. Cold water first passes through the solar collector, which preheats the water. The water then continues on to the conventional backup water heater, providing a reliable source of hot water. They should be installed only in mild-freeze climates because the outdoor pipes could freeze in severe, cold weather.

## ❖ Evacuated-tube solar collectors

They feature parallel rows of transparent glass tubes. Each tube contains a glass outer tube and metal absorber tube attached to a fin. The fin's coating absorbs solar energy but inhibits radiative heat loss. These collectors are used more frequently for U.S. commercial applications.

There are two types of active solar water heating systems:

### ❖ Direct circulation systems

Pumps circulate household water through the collectors and into the home. They work well in climates where it rarely freezes.

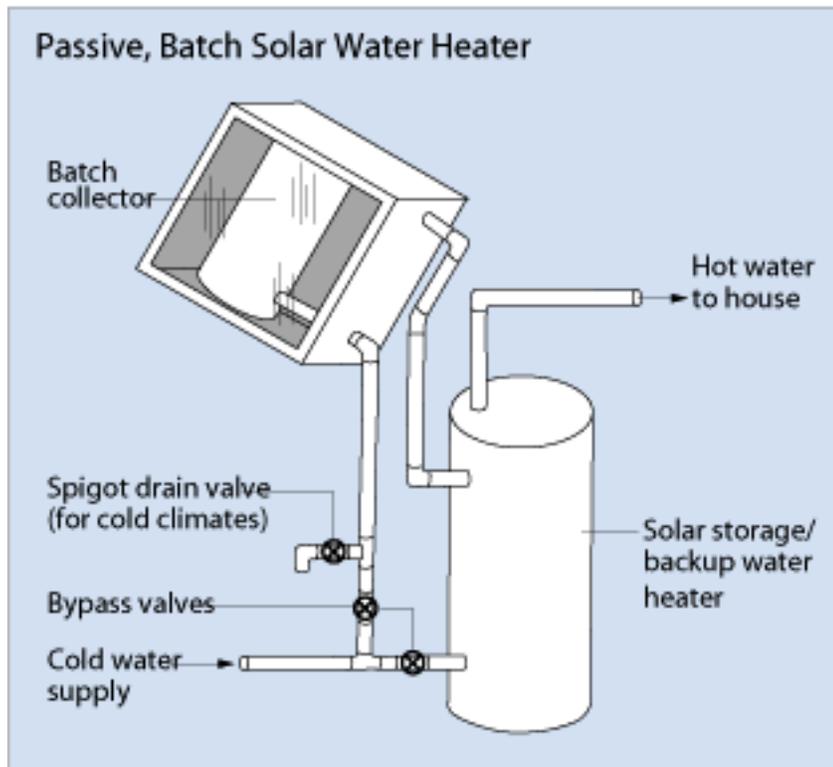
### ❖ Indirect circulation systems

Pumps circulate a non-freezing, heat-transfer fluid through the collectors and a heat exchanger. This heats the water that then flows into the home. They are popular in climates prone to freezing temperatures.

Passive solar water heating systems are typically less expensive than active systems, but they're usually not as efficient. However, passive systems can be more reliable and may last longer. There are two basic types of passive systems:

### ❖ Integral collector-storage passive systems

These work best in areas where temperatures rarely fall below freezing. They also work well in households with significant daytime and evening hot-water needs.



## ❖ Thermosyphon systems

Water flows through the system when warm water rises as cooler water sinks. The collector must be installed below the storage tank so that warm water will rise into the tank. These systems are reliable, but contractors must pay careful attention to the roof design because of the heavy storage tank. They are usually more expensive than integral collector-storage passive systems.

Solar water heating systems almost always require a backup system for cloudy days and times of increased demand. Conventional storage water heaters usually provide backup and may already be part of the solar system package. A backup system may also be part of the solar collector, such as rooftop tanks with thermosyphon systems. Since an integral-collector storage system already stores hot water in addition to collecting solar heat, it may be packaged with a demand (tankless or instantaneous) water heater for backup.

Before you purchase and install a solar water heating system, you want to do the following:

- ❖ Consider the economics of a solar water heating system
- ❖ Evaluate your site's solar resource
- ❖ Determine the correct system size
- ❖ Determine the system's energy efficiency
- ❖ Estimate and compare system costs
- ❖ Investigate local codes, covenants, and regulations.

## The Economics of a Solar Water Heater

Solar water heating systems usually cost more to purchase and install than conventional water heating systems. However, a solar water heater can usually save you money in the long run.

How much money you save depends on the following:

- ❖ The amount of hot water you use
- ❖ Your system's performance
- ❖ Your geographic location and solar resource
- ❖ Available financing and incentives
- ❖ The cost of conventional fuels (natural gas, oil, and electricity)
- ❖ The cost of the fuel you use for your backup water heating system, if you have one.

On average, if you install a solar water heater, your water heating bills should drop 50%–80%. Also, because the sun is free, you're protected from future fuel shortages and price hikes.

If you're building a new home or refinancing, the economics are even more attractive. Including the price of a solar water heater in a new 30-year mortgage usually amounts to between \$13 and \$20 per month. The federal income tax deduction for mortgage interest attributable to the solar system reduces that by about \$3–\$5 per month. So if your fuel savings are more than \$15 per month, the solar investment is profitable immediately. On a monthly basis, you're saving more than you're paying.

## Estimating a Solar Water Heater System's Cost

Before purchasing a solar water heating system, you can estimate its annual operating cost and compare it with other more and/or less efficient systems. This will help you determine the energy savings and payback period of investing in a more energy-efficient system, which will probably have a higher purchase price. Before you can choose and compare the costs of various systems, you need to know the system size required for your home.

## Installing and Maintaining the System

The proper installation of solar water heaters depends on many factors. These factors include solar resource, climate, local building code requirements, and safety issues; therefore, it's best to have a qualified, solar thermal systems contractor install your system.

After installation, properly maintaining your system will keep it running smoothly. Passive systems don't require much maintenance. For active systems, discuss the maintenance requirements with your system provider, and consult the system's owner's manual. Plumbing and other conventional water heating components require the same maintenance as conventional systems. Glazing may need to be cleaned in dry climates where rainwater doesn't provide a natural rinse.

Regular maintenance on simple systems can be as infrequent as every 3–5 years, preferably by a solar contractor. Systems with electrical components usually require a replacement part after or two after 10 years

# Improving Energy Efficiency

After your water heater is properly installed and maintained, try some additional energy-saving strategies to help lower your water heating bills, especially if you require a back-up system. Some energy-saving devices and systems are more cost-effective to install with the water heater.

## Other Water Heater Options

- \* Conventional storage water heaters
- \* Demand water heaters
- \* Heat pump water heaters
- \* Tankless coil and indirect water heaters

## Heat Exchangers for Solar Water Heating Systems

Solar water heating systems use heat exchangers to transfer solar energy absorbed in solar collectors to the liquid or air used to heat water or a space.

Heat exchangers can be made of steel, copper, bronze, stainless steel, aluminum, or cast iron. Solar heating systems usually use copper, because it is a good thermal conductor and has greater resistance to corrosion.

## Types of Heat Exchangers

Solar water heating systems use three types of heat exchangers:

### ❖ Liquid-to-liquid

This heat exchanger uses a heat-transfer fluid that circulates through the solar collector, absorbs heat, and then flows through a heat exchanger to transfer its heat to water in a storage tank. Heat-transfer fluids, such as antifreeze, protect the solar collector from freezing in cold weather. Liquid-to-liquid heat exchangers have either one or two barriers (single wall or double wall) between the heat-transfer fluid and the domestic water supply.

A single-wall heat exchanger is a pipe or tube surrounded by a fluid. Either the fluid passing through the tubing or the fluid surrounding the tubing can be the heat-transfer fluid, while the other fluid is the potable water.

Double-wall heat exchangers have two walls between the two fluids. Two walls are often used when the heat-transfer fluid is toxic, such as ethylene glycol (antifreeze). Double walls are often required as a safety measure in case of leaks, helping ensure that the antifreeze does not mix with the potable water supply. An example of a double-wall, liquid-to-liquid heat exchanger is the "wrap-around heat exchanger," in which a tube is wrapped around and bonded to the outside of a hot water tank. The tube must be adequately insulated to reduce heat losses.

While double-wall heat exchangers increase safety, they are less efficient because heat must transfer through two surfaces rather than one. To transfer the same amount of heat, a double-wall heat exchanger must be larger than a single-wall exchanger.

## ❖ Air-to-liquid

Solar heating systems with air heater collectors usually do not need a heat exchanger between the solar collector and the air distribution system. Those systems with air heater collectors that heat water use air-to-liquid heat exchangers, which are similar to liquid-to-air heat exchangers.

## Heat Exchanger Designs

There are many heat exchanger designs. Here are some common ones:

### ❖ Coil-in-tank

The heat exchanger is a coil of tubing in the storage tank. It can be a single tube (single-wall heat exchanger) or the thickness of two tubes (double-wall heat exchanger). A less efficient alternative is to place the coil on the outside of the collector tank with a cover of insulation.

### ❖ Shell-and-tube

The heat exchanger is separate from (external to) the storage tank. It has two separate fluid loops inside a case or shell. The fluids flow in opposite directions to each other through the heat exchanger, maximizing heat transfer. In one loop, the fluid to be heated (such as potable water) circulates through the inner tubes. In the second loop, the heat-transfer fluid flows between the shell and the tubes of water. The tubes and shell should be made of the same material. When the collector or heat-transfer fluid is toxic, double-wall tubes are used, and a non-toxic intermediary transfer fluid is placed between the outer and inner walls of the tubes.

### ❖ Tube-in-tube

In this very efficient design, the tubes of water and the heat-transfer fluid are in direct thermal contact with each other. The water and the heat-transfer fluid flow in opposite directions to each other. This type of heat exchanger has two loops similar to those described in the shell-and-tube heat exchanger.

## Sizing

A heat exchanger must be sized correctly to be effective. There are many factors to consider for proper sizing, including the following:

- ❖ Type of heat exchanger
- ❖ Characteristics of the heat-transfer fluid (specific heat, viscosity, and density)
- ❖ Flow rate
- ❖ Inlet and outlet temperatures for each fluid.

Usually, manufacturers will supply heat transfer ratings for their heat exchangers (in Btu/hour) for various fluid temperatures and flow rates. Also, the size of a heat exchanger's surface area affects its speed and efficiency: a large surface area transfers heat faster and more efficiently.

## Installation

For the best performance, always follow the manufacturer's installation recommendations for the heat exchanger. Be sure to choose a heat-transfer fluid that is compatible with the type of heat exchanger you will be using. If you want to build your own heat exchanger, be aware that using different metals in heat exchanger construction may cause corrosion. Also, because dissimilar metals have different thermal expansion and contraction characteristics, leaks or cracks may develop. Either of these conditions may reduce the life span of your heat exchanger.

### **Plan/Diagrams for Solar Hot Water Systems**

<http://www.networkearth.org/naturalbuilding/heater.html>