5

Introduction to Thermal Solar Hot Water

Do It Yourself (DIY) Instructions

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Table of Contents

Section 5

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Introduction to Solar Water Heating

Congratulations! If you're reading this guide, then you have taken the first step toward getting our world's most abundant energy source working for you. Did you know that solar water heating is perhaps the most effective ways to harness the sun's energy for personal benefit?

At a fraction of the cost of solar electric systems, solar water heating systems pay for themselves quickly and provide reliable hot water for the lifetime of the system.

This guide will provide you with everything you need to know to begin enjoying the benefits of solar hot water heating. Included in this guide are:

- an overview of solar water heating
- plans to build your own solar hot water system
- instructions for siting your system for optimal performance
- installation guide to integrate the system into your home's existing plumbing
- maintenance measures to protect your system as climate conditions change

In the first section of this guide, you will learn the basics of solar water heating as well as the unique types of systems and distinctive features of each. Then, the plans will walk you through the construction of your own batch solar water heater.

After construction, you will learn how to site your system for optimal performance and install the system to work with the existing plumbing in your home. Finally, you will learn to maintain your solar water heating system through adverse climate conditions to increase the life of the system and improve its operating efficiency.

Overview

Solar Energy and Solar Water Heating

The sun is our planets greatest energy source. On the most fundamental level, it provides plants the energy they need to grow, which in turn feeds animals higher on the food chain. Plants' capacity to use the sun's energy for growth enables the survival of living organisms.

Through science, people have recreated the natural process seen in plants. We, too, are able to convert the sun's energy to a useable form. Further, the energy we get from the sun is not only abundant, but also clean and free. People harness solar energy in two forms: We either convert it to electricity with photovoltaic cells, or we harness the thermal energy from the sun's rays.

Solar water heating, as you probably expect, uses the thermal energy from the sun to provide a common luxury of everyday life: hot water. Solar hot water systems produce hot water without polluting the atmosphere, and they do so with impressive efficiency. Whenever energy changes forms (e.g. when an electric heater changes electricity to heat) a significant amount of the energy is lost in the conversion. With solar water heating, the energy does not change forms. Thermal energy from the sun is collected and stored as thermal energy in the water, a very efficient process.

But the collection of thermal energy by water is only the basic principal of solar water heating; the countless designs of solar water systems today reflect a multitude of variables, geographic location, local climate conditions, end use demand parameters, and economic considerations. The result has been a number of different systems of varying efficiency, strategy, complexity, and cost. Before diving into your own solar water heater project, we hope you will review this overview of different types of solar hot water systems.

Basic Components of Solar Hot Water Systems

- *Solar Collector* – The visible, outdoor array that collects the solar energy.
- *Controls* – The components that regulate the system as it operates.
- *Storage Tank* – The tank which holds solar heated water until it is used or cools.
- *Heat Exchanger* – Only found in indirect systems, the heat exchanger transfers heat from the heat transfer fluid to the water that will be consumed at end use.

System Classifications

Active and Passive Classifications: The broadest classification of solar hot water systems is active or passive. The distinction refers to the way water is moved through the solar collector. Active systems use pumps to move the water to the solar collector and back to the house for use. Passive systems rely on water pressure or thermosiphon to move the water. In this section, we will review a number of both types of systems.

Direct and Indirect Classifications: The second classification for solar hot water systems is direct or indirect. This distinction refers to the transfer of heat from the sun's rays to the end use hot water that is consumed. In direct systems, the water that is eventually consumed is directly heated by the sun. In indirect systems, there is a heat transfer fluid that is heated by the sun and then, in turn, heats the water that is consumed. Every solar hot water system is classified as passive or active, and direct or indirect.

System Types

Active Direct Systems: Active direct systems are systems in which water pumps circulate potable water to the solar collector where it is heated directly by the sun. These systems require controls to turn the pump on and off. There are several different strategies for determining when the pump should be on, and this distinction is the basis of the different types of active direct systems.

1. **Differential Controlled** – Differential controlled systems continuously measure differences in water temperature at distinct places in the system to determine when the pump should circulate water. Usually, two temperature readings are taken, one at the hottest point in the system – the top of the solar collector – and the other at the coldest place in the system – the bottom of the storage tank. When the temperature difference between these two points becomes great enough (set on system control), the pump turns on to circulate water and increase the temperature of the water in the storage tank.
2. **PV Controlled** – Photovoltaic (PV) controlled systems circulates water whenever there is enough light to activate a solar PV powered circulating pump. In other words, the pump stays on during the day circulating water when the sun is out. At night, the PV panel does not collect enough light energy to power the pump. Thus, water does not circulate over night when there's no solar thermal energy to heat the water anyway.
3. **Timer Controlled** – Timer controlled systems use timers to activate and deactivate the system's pump. Usually, timer controlled systems are active during the same times as PV controlled systems. The timer controlled system is good for areas with very consistent high temperatures and solar availability, such as the tropics. The advantage to the timer controlled system is that the timer controlled is cheaper than the PV

alternative. The disadvantages are 1) that the timer and the pump use energy to run, diminishing the net saved energy of the system, and 2) that the timer controller will signal the pump to circulate water, even when conditions are bad.

Active Indirect Systems: Active indirect systems use circulating pumps to move a heat transfer liquid. The liquid enter the solar collector, absorbs heat energy, moves to the heat exchanger where it transfers heat to the potable water, and then returns to the collector to start to process over. These systems are good in areas with high freeze risks and with water with high mineral content, because heat transfer liquids may contain antifreeze solutions and are not at risk for buildups of mineral deposit.

1. **Drainback** – Drainback systems offer freeze protection by draining the water in the system when the pump shuts off. When the pump is on, the circulating water – regardless of temperature – prevents freezing. When the pump deactivates, the fluid drains out of the system plumbing into a reservoir tank shielded from the elements. This system requires careful installation of components so that the pipes will drain via gravity, and they require properly sized pumps to overcome gravity when the pumps start back up.

Passive Direct Systems: Passive direct systems are conceptually the simplest form of solar water heater. Water flows into the collector, is warmed by the sun, and flows back into the house when required for use. These systems employ no pumps or controllers. Instead, water pressure and convection – a type of heat transfer in fluids – move the water through the system.

1. **Thermosiphon** – Direct thermosiphon systems function according to the rule that warm water will rise and cold water will sink. Thus, in a thermosiphon system the storage tank is located above the collector. Cold water flows into the collector, heats

up, and eventually rises out of the collector to the storage tank above. From the storage tank, the water either flows into the house for end use or cools and flows back into the collector to be reheated.

2. **Integral Collector Storage Systems** – Integral collector storage (ICS) systems are unique in that the collector and storage tank are the same. In these units, water flows into the collector where it is warmed by the sun. Then, instead of flowing out of the collector and into the storage tank after being warmed, it stays in the collector until being demanded for use.
3. **Batch Collector System** – Batch systems are like ICS systems because they combine collector and storage into one function. The difference is that in the ICS system, the collector is doubling as storage, but in the batch system, the storage doubles as collector.
4. The batch system is comprised of storage tanks painted black and set out in the sun. There they hold water until it is drawn for use in the residence or to replace water drawn from the home's conventional water heater tank.

Passive Indirect Systems: Passive indirect systems employ no pump and controllers but do employ heat transfer fluid and heat exchangers. These types of systems are not very common.

1. **Thermosiphon** – Indirect thermosiphon systems work exactly the same as direct thermosiphon systems except they employ a heat transfer liquid and heat exchanger. Thus it is the heat transfer liquid that travels from collector to storage tank and then back to the collector once it transfers all its thermal energy and cools.

Plumbing Components

In addition to the different types of solar hot water systems, it is important to understand the water transfer system and components that move the water, monitor and protect the system, improve performance, and ensure safety.

Systems employ a variety of plumbing components, each with a unique purpose. In a well-designed system, risk of damage to the system can be minimized and performance maximized by installing the right set of meters, gauges, and valves.

Some common plumbing components include:

1. *Check Valve* – Only allows fluid to flow in one direction. Important component in most systems. Prevents reverse or unwanted thermosiphon.
2. *Isolation Valve* – Used to manually control water flow to specific pipes by blocking water flow at specific locations in the plumbing.
3. *Pressure Relief Valve* – Monitors pressure. Relieves system when pressure is too great.
4. *Temperature and Pressure Relief Valve* – Monitors temperature and pressure and relieves system when temperature or pressure are too great.
5. *Air Vent* – Admits and releases air from system when draining and filling.
6. *Vacuum Breaker* – Admits atmospheric pressure into the system when draining to ensure proper drainage.
7. *Drain Valve* – Used to drain the system. Most systems employ multiple drain valves for full drainage.
8. *Freeze Protection Valve* – Set to open at near freezing temperature, these valves bleed water through the lines to prevent freezing. The valve should be installed just before hot water line from collector passes inside the home envelope.

9. *Temperature Gauge* – Monitors system operating temperatures. Good to monitor solar collector performance based on output water temperature.
10. *Pressure Gauge* – Monitors pressure in the system. Can help identify leaks if system is leaking or if pressure is building.
11. *Flow Meter* – Monitors flow of water. Usually installed on active systems and allows reader to determine if pump is functioning.
12. *Mixing or Temping Valve* – Mixes cold water into hot water to reach desired temperature if water is too hot. Meant to be used as a comfort control, not a safety device.
13. *Anti-scald Valve* – Mixescoldwaterintohotwatertoreachdesiredtemperatureifwater is too hot. Designed to be used as a safety device.

Not all systems will employ all these components. Check system design specifications for a list of necessary components.