

# ENERGY DEPARTMENT



## Solar Domestic Water Heating

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### Does solar domestic water heating make sense in the Pacific Northwest?

Should I buy a house that has a solar hot water system installed? Is installing one on an older home a smart investment? Is it cost effective to install a solar system as part of the construction on a new home?

This factsheet can help you decide whether solar hot water heating makes sense for a particular household. It won't teach you how to design, build, or install a solar water heater, but it will help familiarize you with some of the terms and concepts common to the solar water heating industry. (Although it is not necessary, professional installation is generally recommended for optimum performance and satisfaction.)

### Solar Hot Water in the Northwest?

It is a common misconception that it is too cloudy in the Northwest for solar water heating to work. Even in cloudy conditions, usable amounts of solar radiation reach the earth. Over the past 15 years successful installations both east and west of the Cascades have demonstrated that a properly designed solar hot water heating system can meet between 25% to 60% of a household's annual water needs.

### Is It Cost-Effective?

It's technically possible to get a useful amount of water from a solar system in the Northwest, but will it be economical? The answer to this question depends on the design chosen, its cost, your local electric rates, how much hot water you use, and type of financing. It also matters whether it's an existing system or not or whether it's part of new construction or an addition to a home you already own. A properly installed and maintained solar hot water system already serving a house you plan to purchase is especially economical. It will help reduce the cost of living in the house and provide insurance against increasing energy expenses. Installing a system on a house you are building can also be cost effective.

There are two basic economic methods available to determine cost effectiveness. The first is simple payback, useful for quick analysis and low cost investments. The other is life-cycle costing, more complicated, but necessary to evaluate major investments and financing arrangements.

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Electric utility rates have a dramatic effect on the savings potential of solar hot water systems. The same solar hot water system installed in two different utility companies service territories can vary dramatically in cost effectiveness. For example, if the rate in one territory is double what it is in another, savings produced by reducing electric needs will be double as well. (Call your local utility to determine your rate.)

### **How Will it Affect the Looks of the House?**

The aesthetic impact of a solar hot water system also needs to be considered. Will the collector array detract from the appearance of the house? Does it blend with the architectural style? Will reflection from the collector cause a glare problem for the neighbors?

### **Typical Costs**

The cost of a solar hot water heating system ranges from a low of about \$100 dollars for a simple system made from recycled materials to over \$5,000 for a contractor-installed multiple-collector, automated, freeze-protected system. Factory-built systems usually range between \$1,200 to \$3,500 for material costs, with contractor installation costing about one third more.

### **Choosing a System**

There are many different types of domestic solar hot water heaters on the market. Choosing between them will involve many of the considerations outlined in the first part of this factsheet. The best system for a particular application depends on local weather, the household's site, its location on the lot, the structure of the house, the household's hot water requirements, the technical abilities of the homeowner, and the amount of money the homeowner chooses to spend.

### **Types of Systems**

Most solar water heating systems classify as either active or passive. Active systems use mechanical pumping systems, whereas passive systems do not. Another way to categorize solar hot water systems is by the method used to collect solar energy. The two most common collecting methods are the batch and flat plate design. The basic principles of both these designs are the same. They use a glazing system, an absorber system, insulation, and a protective box. Infrared radiation enters through the glazing, strikes the interior, and causes it to heat up. Some of the heat radiates back through the glazing and the insulated box and some is transferred to the fluid inside the absorbing surface. In the batch system, the hot water is stored in the collector itself. Flat plate collectors have a system of risers and headers that transfer the heated water to a remote storage tank.

The glazing in a collector should be tempered glass or high temperature plastic. Plate glass will break if there is a high temperature difference between the back and front side of the glazing. The absorber system is painted flat black in color. In better quality solar collectors, this paint is usually a selective surface coating that is highly efficient at retaining

radiation in the infrared spectrum. The collector box is insulated wherever possible to reduce heat loss to the surrounding air. The insulation should be either a high temperature foam or low binder fiberglass. Residential-grade fiberglass contains binders that will outgas and condense on the collector's glazing. Ideally, the protective box that encloses the absorber system will be made of a durable material such as aluminum, especially if the collector has a high efficiency absorber. Wood components in flat plate collectors have spontaneously ignited during malfunction. Wood is safer in low efficiency collectors.

## **Batch Collectors**

Batch collectors use a hot water storage tank as the solar energy absorber. A black bucket is a simple version of a batch collector. Change the bucket to a water tank, add an insulated box with glass on the south side and you have a typical batch solar hot water heater. This type of heater is often called a "breadbox heater" because of its appearance. Sometimes they are built with an insulated door that closes over the glass to prevent heat loss at night. The door usually has a reflective surface to increase heat gains by reflecting additional light into the box.

The primary advantages of this type of system is simplicity of design and low cost. They are slow to heat up and heat losses are rather high since the system is usually installed out of doors. Because they are usually very heavy when filled with water, siting can be a challenge.

## **Flat Plate Collector Systems**

There are several types of flat plate collector systems, including closed loop, drawdown, drainback, and passive heat exchange. The system types vary according to the way they deal with freeze protection.

### **Closed Loop**

Antifreeze is a very effective method of freeze protecting flatplate collector systems. A glycol or silicon fluid is circulated through the flatplate collector to a heat exchanger installed next to or in the storage tank, where the heat is transferred to the domestic water stored in the tank. Most building codes require the heat exchanger be double walled and/or a non-toxic antifreeze solution be used. Many local jurisdictions also require that any antifreeze system have a back flow preventer installed on the city supply line to prevent accidental contamination of the city water supply with antifreeze. There are efficiency losses associated with a heat exchangers and antifreeze itself is not as good a heat exchange fluid as water. Antifreeze can become acidic when exposed to high temperatures and must be checked annually.

### **Draindown**

Draindown control systems employ a set of electrically activated valves to empty flat plate collectors whenever a near freezing condition is sensed by the controller. A vacuum relief valve on the roof allows air to enter the top of the system while one valve isolates the collector piping from the storage tank and another valve system drains the water in the system. A single slide valve can be used in place of two valves. This system eliminates the

inefficiencies of antifreeze by pumping domestic water through the collectors. An air release valve should be adjacent to the vacuum relief valve. This allows air to exit the system when filling at startup times. Special care must be taken to make certain water cannot become trapped in the plumbing when the system drains down. Hard water can also clog these valves. Drain down systems may require multiple freeze sensors on the plumbing runs. In the winter of 1984, many draindown systems in the Puget Sound area were damaged by a period of subfreezing weather. The causes were varied, but generally the valves failed, a freezing condition was not accurately sensed by the sensors or water was trapped in the plumbing runs.

## **Drainback**

Drainback systems are similar to drain down in that they are designed for active systems, but rather than utilizing solenoid valves to empty the collector, the pump shuts off to drain the system. Whenever the pump shuts off, air enters through a vacuum relief valve and the system drains back into a separate tank. Drainback systems can have the same problems with trapped water as the draindown. Similar to antifreeze systems, the collector fluid is separate from the domestic supply and a heat exchanger is used in the drainback tank.

## **Passive Heat Exchange**

This system is designed to "thermosyphon" and uses an antifreeze or alcohol solution to prevent freezing in the collectors. There are no pumps, controls, or valves. Thermosyphoning occurs when the heated fluid in the collector provides the energy to circulate to and from the exchanger. The heat exchanger in the storage tank transfers the heat to water and the fluid circulates back to the collector. This type of system offers the advantage of both freeze protection and minimal maintenance.

## **Installation Considerations**

Before installing a solar hot water system, a careful site analysis should be undertaken. Potential problems such as shading and building code restrictions should be considered. In a residential neighborhood, the effects of new construction are important considerations. Is it possible that a neighbor could build a second story addition that would shade your solar collector? Lastly, the weight of the system should be considered. Is a ground location more suitable than a roof location?

## **Orientation**

Historically, people have been told solar collectors must be pointed within 15° of true south and the collector's tilt should be within 10° of the site's latitude. Both performance and research have shown collectors can be oriented 90° off true south and tilt can range from 15° to 65° without significantly impacting performance. A tilt of 45° or more may be worth considering in an area with significant snowfall.

## **Sizing**

To size a solar hot water heating system, first determine the amount of hot water the household uses. A good rule of thumb is about 20 gallons per

day per person. A three member household will want about 60 gallons of storage. One square foot of collector will produce about one to one-and one-half gallons per day per person. Therefore, the three person household will need between 45 to 60 sq. ft. of collector area. It may be difficult to locate an integral water heater with this amount of absorber surface. One solution is to install multiple breadboxes in series, another is to consider a flatplate system.

## **Mounting**

### **Ground Mount**

Ground mounting a solar collector can eliminate a number of problems. If the system being installed is an integral design, ground mounting can prevent damage caused by overloading the roof. It can also simplify plumbing runs. But ground mounted systems are subject to possible shading problems.

### **Roof Mount**

Roof mounting can overcome shading, but can lead to plumbing and rack design problems. Usually they require roof penetrations for attaching the collector and installing the plumbing. These penetrations need to be carefully sealed. Racks should be built from either metal or treated wood. The system support rack needs to be carefully designed to resist wind damage to both the system and the roof.

## **Freeze Protection**

Several system types have been developed to provide freeze protection for solar hot water systems. Each have advantages and disadvantages. The best freeze protection systems are those that do not use water in the collector loop.

For all systems, the outside plumbing runs should be insulated. This will not only help protect them from freezing, it will also reduce heat loss. Most pipe insulation can be painted to prevent deterioration from sunlight. Seasonal use and mass can also protect systems from freezing.

## **Seasonal Use**

The simplest way of protecting a solar hot water system against freezing is seasonal use. When the system is drained for the season, it is important to make certain there is no residual water in the collector or outside plumbing runs. Seasonal systems operate at reduced efficiency since they cannot utilize solar energy available throughout the colder months of the year. There is also a danger of freezing during an unexpected fall or spring cold snap. Water in a flatplate collector can freeze on a cold clear night even though ambient air temperature never drops to 32°F. On clear nights enough heat can be lost to the night sky to cause collector temperatures to drop well below freezing. In moderate climates, batch collectors can survive occasional freezing periods because of their large internal mass. Shutters or insulated doors will help. Special attention must be given to protecting the plumbing runs. Heat tape and insulation have been used for this successfully. Some attempts have been made to provide freeze

protection by locating batch heaters in sunspaces with mixed results.

## **How Long Can You Expect the System to Last?**

The plumbing components of your solar hot water system will last as long as a regular system might. This can vary depending on water characteristics, such as hardness, or acidity. The tank is prone to the same problems of corrosion as conventional hot water tanks - - they develop pin hole leaks. You can expect 10 to 12 years from a hot water tank, although stone-lined tanks (more expensive) generally outlast glass-lined tanks. This assumes regular maintenance of your system.

The mechanical and electrical components of the system will need replacement at varying rates. Most systems need a pump replacement or some mechanical/electrical repair by the time the system is 10 years old.

## **Installing Your System**

Once you have decided to install a solar hot water system, you need to determine the best way to go about installing it. The options are to do the job yourself or contract the installation.

If you decide to do it yourself, carefully assess your carpentry, plumbing, and electrical wiring skills. Do you have the necessary tools for the job? Will you damage the roof while doing the installation yourself? You need to consider local building codes and how long the installation will take. A breadbox system or a simple thermosyphon flatplate will take a couple of full weekends, a flat plate collector with an antifreeze loop may take a month of weekends.

Hiring a contractor is the logical choice for anyone lacking the time, ability, or tools required. Make sure the installer is knowledgeable about and experienced with the product. Has he or she been in business long? Can the contractor provide references from people previously worked for? What sort of warranty does the contractor provide? Ask for product and labor warranties. Both should be available. Is the contractor bonded?

## **Safety and Maintenance**

Proper maintenance ensures the system will last its full life expectancy. All solar collectors will require cleaning the glazing. Collector plumbing runs should be labeled as either an outflow or return line. Any pipes carrying other than potable water should be labeled as such. All faucet handles should be removed from the collector loop valves to prevent accidental drainage of the collector loop. Passive systems are fairly maintenance free, requiring only annual emptying for freeze protection and sediment removal. Occasional inspection of pipe insulation is a good idea. Depending on its original finish material, the collector housing may need to be painted now and then. For a more complex active system, the way to begin a proper maintenance program is by reading the owner's manual and following the manufacturer's instructions.

## **Other Publications**

**Homeowner's Handbook of Solar Water Heating Systems,**

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Curtis, Gary, June 1985. Solar Water and Pool Heating Installation and Operation, Chandra, et al., Florida Solar Energy Center, 1979.

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