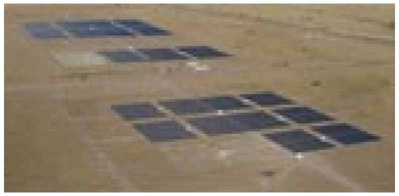
HOT WATER FROM THE SUN

Hot water - it is a regular part of our daily lives - it is used to clean our clothes, wash our dishes, and to bathe and relax us. It is used to heat our buildings and even extends use of our swimming pools into the winter months. But then, hot water doesn't come that way naturally.

Water must be heated in order to meet these purposes. In the past, fires heated water for cooking, cleaning and bathing Today we use electricity and/or natural gas to excite water molecules to such a point that it becomes hot. Electricity is generated at some distant point source location such as a river whose force spins turbines, or near a coal resource to fire up generators, or even at isolated and highly security conscious nuclear plants. Natural gas is captured and piped distances to the end user where it is then burned, creating heat for maintaining comfort, or for transfer to another medium - like food, or water.

The remote site generation of electricity and/or capturing of gas both require transfer to get the product to the consumer. This transfer requires a sophisticated and complex network to assure both quality and quantity needs are met. Transport of energy always has some losses of product and efficiencies along the way but most arrives ready for use.

In the recent past, serious issues and questions have arisen regarding environmental impacts, resource access, energy distribution, and energy cost and today there are concerns regarding energy resource stability and security.



Today, some utility companies are incorporating renewable energy systems of wind and sun and biomass into their energy generation palette. Although these renewable energy farms continue the approach of centralized collection, generation, and complex distribution system, the llocations are much closer to the consumer, often within the boundaries of communities they serve. In Arizona communities of Tucson, Springerville, Prescott, Phoenix and Yuma, utility solar plants are springing up, due in part to Arizona's mandated Energy Portfolio Standard which designates that Arizona utility companies must derive a prescribed amount of their energy from solar and renewable energy resources.

The use of the sun to meet people's needs isn't restricted to the actions of large utility companies. More energy, in the form of sunlight, falls upon the roof of a typical house than the entire house uses! Solar energy is the most democratic of energy sources - available to everyone and it doesn't require a sophisticated and complex system of extraction, conversion, and transport for people to use. Best of all it is free and directly under your control.

Many Arizonans use the sun's energy to meet daily hot water requirements for bathing, washing, pool heating, and heating of buildings, and many more are interested.

BENEFITS

The benefits of using the sun to heat water include:

* Solar water heating reduces the amount of energy required from the utility company thereby reducing monthly energy bills;

* Less energy demand means less use of finite oil and gas resources, and reduction in the infrastructure required to create and deliver energy to users;

*In replacing other energy sources, the use of solar energy will enhance the reduction of pollution, improve air quality, and lessen negative impacts on the environment

* Solar water heating is direct, simple, safe and within the individual's direct control

*Solar water systems can meet all hot water needs if incorporated appropriately.

* Water will be hot, and some even claim it is healthier

* To quote an Arizona utility - "Just a portion of your house's roof receives more solar energy than you need to heat house hot water all year long. To take advantage of that pollution-free energy you need a solar water heating system."

There's nothing mysterious about heating water with the sun - a lot of hot water with simple operation and little maintenance, and monthly energy bills will be reduced - a return on your investment, something a traditional water heating system doesn't provide, and when savings surpass initial investment - it is free!!

What more could you ask for?

SOLAR WATER HEATING SYSTEMS - The Technology

Using sunlight to heat water is simple and has been done by Arizonans for quite some time. A "batch" water heater was discovered on an outbuilding of the historic Tempe Bakery, and Phoenix's historic Ellis - Shackleford house had a Day/Night solar water heating system.

A solar water heater system has a short list of component elements. Basically, there is

* The collector - used to capture the heat in sunlight, and
* the water storage tank which is part of the heat collection system, storage, and distribution when hot water is needed.

In some applications as in pool heating or some radiant floor installations, a tank is not a necessary element.

Additionally there are other elements of a solar water heating system that may be incorporated. These include

* an auxiliary heating system used in periods of additional hot water demand; and.
* a Control system for monitoring and coordinating the operation of all a solar system's components in more sophisticated systems.

A Solar Collector - What Is It?

Simply - a container with a glass cover, that allows sunlight to impact the interior surface which contains pipes or tubes through which water or other heat collecting and transferring liquid travel.

Arizonans are familiar with the direct heating action of sun through windows of an uncovered car in the summer, and even on a sunny winter day. Sunlight impacts the interior surfaces and the resulting heat is prevented from escaping by the glass, and the car interior heats up to quite intolerable levels. This is the same action that occurs with the solar collector in a solar water heating system.

Solar collectors capture the sun's light, converting it into heat, which then heats water, or another heat transfer fluid. This collection of the sun's energy happens at the collector's dark color absorbing surface (absorber), below the glazing. As the absorber heats from exposure to sunlight, water moving through the absorber picks up the heat and carries it to storage or to direct use.

Since the collector glazing reduces heat loss to the outside air, colder climate conditions may warrant multiple glazing to increase heat retention capabilities.

What About Hot Water Storage?

Like typical water heating systems, the storage tank holds heated water. In a solar system, water is heated by continued circulation through the collector and the tank and is always hot. Solar hot water system tanks may be integral to the collector, or separate altogether.

Solar hot water tanks can be a primary hot water storage element, or a preheater, feeding into a regular tank. In all cases, solar tanks are highly efficient, and better insulated than standard tanks and are usually of larger capacity than regular tanks, in order to provide large hot water storage capacity for nighttime use and days of limited sunlight.

Tank Size

Tank size is directly related to the amount of hot water used, and needed for times of no solar access A typical Arizona family use is 20 gallons per day per person. This number, multiplied by the number of days of storage desired, gives a desired tank capacity.

Physical Protections

Super hot water - Solar water heating systems can generate water much hotter than conventional water heaters so a mixing valve is usually incorporated. This protective measure tempers hot water from the tank by adding cool water.

Cold climate impact - Solar equipment, just like any other water system exposed to cold conditions can be susceptible to freezing, but this issue is mitigated in modern solar water heating systems. State requirements mandate that safeguards must be built into all solar systems sold Arizona.

SOLAR WATER HEATING METHODS

A variety of solar hot water approaches are used in Arizona. All have the means of capturing the sun and heating water for use - they vary in the details of solar capture, transport of captured heat, and approach to storage and storage placement. Basically there are 2 fundamental approaches

Direct Heat Exchange - where water to be used is heated directly by the collectors,

Indirect Heat Exchange – where an efficient heat transfer fluid other than water, like propylene glycol a non-toxic antifreeze compound, is run through the collector to pick up heat, then run through a heat exchanger where it transfers its collected heat to the water to be used or stored in the tank.

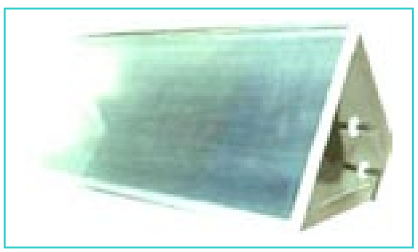
Direct heat transfer is highly effective, and even more so when attention is given to water quality in dealing with scale, which can affect collector performance and useable life. Water treatment, a common installation due to Arizona's hard water, often mitigates the condition, and regular care and maintenance is always a good practice.

Indirect heat transfer solar systems, beside providing higher heating and lower heat loss inherent to the glycol liquid used, have the additional benefit of no scaling at the collector since there is no water at this part of the system.

SOLAR WATER APPLICATIONS

Passive Systems

Batch or Integrated Collector/Storage (ICS) System



The simplest of systems - water in a dark container exposed to the sun. Contents will get hot, and in an Arizona summer, get very hot. This is the basis of an ICS and batch or “breadbox” system, which combines collector and storage into a single unit. Water flow occurs when hot water is drawn off. Direct heating of the tank, or tanks, makes this system compact, simple, and effective. It can be used as a pre-heater to a regular water heater, or as some Arizonans have done, to meet all needs.

These units do not rely on external equipment and/or energy to work. The "batch" approach has been used in Arizona for quite some time, and evolved improvements have enhanced the effectiveness in water heating and storage.

Newer ICS systems incorporate a number of connected small-diameter storage tanks to expose more surface area to the sunlight, thereby heating the water at a faster rate. Improvements in glazings and containers have made the systems more efficient in heat retention and the pure volume of the water mitigates the issue of freezing. Some ICS systems use evacuated glass tubes (like a thermos bottle) around the tanks to keep heat loss to a minimum. As a result, Batch and ICS systems do not usually operate at temperatures high enough for scale build-up to clog the system

In some cases reflectors are integrated, bouncing more of the sun's rays onto the water tank, and when the sun falls, the reflectors, made of highly insulating material, fold over the glazing to provide for better heat retention.

Thermosiphon Systems

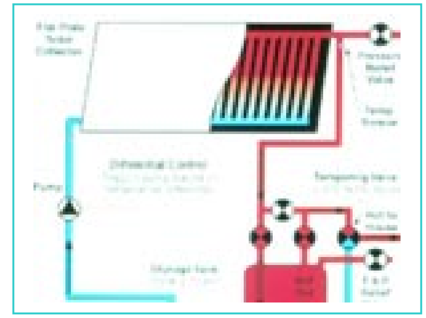
Hot water rises - cold water settles. This is because hot water is less dense than cold water due to its molecular excitement in heating.

A thermosiphon solar hot water heating system incorporates natural convection to move fluid heated by the collector to a storage tank. To do this, the storage tank is located higher than the collector. Cool water from the tank flows to the bottom of the collector where it is heated, becomes less dense, and rises all the way to the top of the storage tank. This continuous convective process occurs whenever there is enough sunlight to warm the liquid in the collector. Since this is a natural process, not needing pumps, the thermosiphon water heater is con-side red a passive system

Active Systems/Forced Circulation Systems

These applications, called active systems because a pump is used to move fluid through the solar collector, allow hot water storage to be placed at any convenient location within the building. Forced circulation systems transfer heat either directly by water circulating through the collector to the tank, or indirectly, by use of a heat transfer fluid at the collector and transferring that collected heat via a heat exchanger to water in the storage tank. Variations of a forced circulation include Open Loop and Closed Loop Systems

Open Loop System



Open loop forced circulation systems transfer heat directly to water to be used. When water in the collector loop is hotter than the water in the storage tank, the pump is activated and water from the tank is circulated through the collector.

NOTE: State requirements stipulate provision of equip-ment to prevent freeze damage, and open loop systems come with recircu-lation and/or drain down con-figurations, as well as with freeze plugs or a “dribble” valve.

* A recirculation system controller activates a pump when collector temperatures near freezing, and circulates storage tank hot water through the collector loop to raise its temperature to prevent freezing.

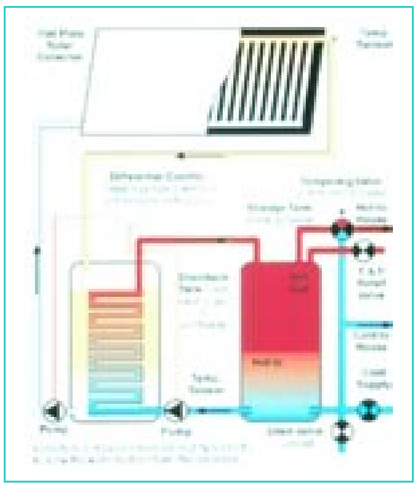
* A drain down system valve opens when the temperature drops near freezing, and all water in the collector is automatically drained from the collector and piping, into the tank.

* A freeze plug is simply a valve that opens when the pressure in the

collector rises above a certain point. As water changes from liquid to ice, it expands which forces the freeze plug to open and relieve that pressure, thereby avoiding freeze damage to the solar collector and piping.

* A "dribble" valve is much like a freeze plug. When it gets cold, the valve opens, allowing water to drain from the collector. Open loop and Closed loop systems also are installed with a check valve, which allow fluid in the collector loop pipe to move in only one direction in the collector in order to prevent undesired reverse siphoning and loss of heat when the sun is not available.

Closed Loop



Closed loop forced circulation systems transfer heat to water to be used in a 2-part operation. Fluid not susceptible to freezing is used in he collector loop. It is heated by the sun and circulated to a heat exchanger which transfers the heat to a second loop containing the water to be used and/or stored, and the collection fluid is circulated back to the collector. There are two separate fluid loops, one for the heat collecting liquid, and the other for the water to be used. Separately, each moves through the heat exchanger that implements the heat transfer process. A system controller turns the circulating pump on when the collector fluid is hotter than the storage tank water.

There are two primary types of closed loop systems:
The drain back system
The non-freeze system.

Drain-back
Forced-circulation systems have an additional tank (drain-back tank) for ensuring protection against freezing. When the pump is off, collector fluid flows into the drain-back tank.

Non-freeze
Forced circulation systems that use an antifreeze mixture in the collector loop. The antifreeze mixture provides protection against very high and low collector operating temperatures. An expansion tank is usually included on these systems to allow the collector loop fluid to expand and contract without damaging the pipes.

PERFORMANCE

Arizona is a great location for solar water heaters because of year around bright sunny, cloud-free days. Some installations, in continuous operation, have provided up to 100% of the daily hot water requirement. Others have realized energy savings ranging from 75-90% with a modicum of back-up. As a general rule, savings depend on the system performance, the amount of hot water demand, and the timing of use.

If large amounts of hot water is needed, or early morning hot water is necessary, inclusion of auxiliary heating may be desirable. The amount of electricity or gas used for the auxiliary is dependent on the capacity of storage, and the amount and timing of demand.

Seasonal conditions also impact upon the effectiveness of a system. Summer has more exposure to the sun than winter. Summer conditions easily provide 100% of the requirement, while winter may necessitate larger storage capacity or ancillary heating and back-up.

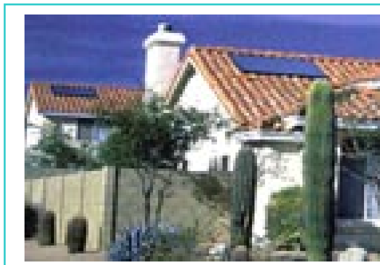
Collector Placement
Collectors are best located in an area where there is unobstructed access to the sun throughout the year. The ideal location, of course, is the roof. If hot water storage is within a building, a collector system should be located to minimize piping runs. This reduces materials, and cost, as well as heat loss in the pipes. Collector placement considerations include:

* A collector facing true south gains equal amounts of sunlight in the morning and the afternoon. If more hot water is desired in the morning, the collector should face somewhat east of true south, and if hot water is more desirable later in the day, the collector should face west of true south.

Collector performance is maximized when tilted perpendicular to the sun. Typically, a solar water collector is placed to operate at its optimum during the winter, with the short days of sunlight, lower sun angles, and colder temperatures. For this reason the upright angle of the collector is important in maximizing solar heating of water during wintertime conditions.

* **NOTE:** Optimum collector angle and angle of a roof may not be compatible. This condition may require an independent support system or integration into the building form. It is said that the difference between an ideal angle and a flush roof angle is about $30 per year in savings.

It is important to also note that some subdivisions have restrictions (CC&R) regarding equipment on rooftops, and although recent Arizona court judgment has decided against Homeowner Association prevention of solar installations at rooftops, there may still be conflicts regarding aesthetics and maintenance of style and impact upon the building and neighborhood "look".



SAVINGS/BENEFITS

* Energy bills will be lower due to less demand of electricity and/or gas. Savings are directly proportional to efficiency of the system, cost of energy, and amount of hot water used.

* Solar energy replacement for heating water reduces supplier provided gas and/or electricity and avoids new, costly generation and transmission systems

* Solar water heating replacement of electricity and gas systems results in avoiding additional pollution created by generating electricity and burning gas - a solar water heater avoids the equivalent pollution of .3 cars/year

* Conventional water heating uses electric energy or gas, at plants or on site, and burning of hydrocarbon based fuels (such as coal, oil, or natural gas) emits oxides of carbon (Cox), nitrogen (Nox) and sulfur (Sox). Use of solar water heaters significantly reduce pollutants and contribute to a more clean and healthy environment.

* Local, county, and state government incentives for incorporation of solar energy equipment. The State has a tax credit, and no sales tax, for the purchase and installation of approved solar water heating systems. The community of Marana waives building permit fees for solar photovoltaic and hot water installations on new and existing buildings

* In response to the Arizona. Corporation Commission Environmental Portfolio Standard requirement that Az. Utilities provide a specific percent-age of their energy from green sources, some utility providers have incentive programs for solar hot water system utilization.

* A solar water heating system is a good investment. Return on investment will be result in reduced energy bills, increased savings and disposable income, and a cleaner environment over the lifetime of the system

CONSUMER PROTECTIONS

*All system components and systems must meet State requirements. Contact the Az. Dept. of Commerce Energy Office for information

*Arizona Registrar of Contractors, the Better Business Bureau and the Az. Solar Energy Industries Association are information sources about solar companies and certified installers.

*Arizona Dept of Revenue and Az. Dept. of Commerce Energy Office are information sources re: approved solar systems and tax benefits

A properly installed, approved system must have the following warranties and certifications for the equipment and installation

* Product meets Az. Dept. of Commerce Energy Office Certifications and Installation Requirements

* Installation meets or exceeds all applicable Codes

* System conforms to the guidelines procedures, and certifications of the Solar Rating & Certification Corp.

* Parts and Labor Warranty for the entire system for a minimum period of two years from the date of installation.

* System has a Warranty against freezing for a minimum of five years.

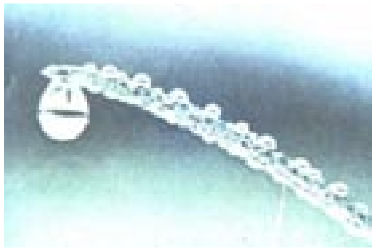
* Installer of system must have a Solar Contractors License

* Work is executed By Certified Solar Technicians (Contact the Az. Solar Energy Industries Association and the AZ. Department of Commerce Energy Office for a list of Certified Installers)

A Solar Water Heater Can Deliver Hot Water All Year Round

In Arizona we have fewer cloudy and cool days than almost anywhere else in the country, so solar energy can carry much of the load.

We have an inexhaustible resource all year around
We have the technology
We have a stable industry
We have consumer protections
We have the capability to provide for our own energy stability and security and at the same time improve environmental conditions.



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