A Guide to Selecting and Installing a Solar Hot Water Heater

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Introduction

There has been a lot of press lately about the growth of renewable energies and the need for energy independence. There have been articles written about Solar Electric (PV), wind, ethanol, bio-diesel, and hydroelectric. Being at heart a pragmatist I have researched each of the technologies in turn and been disappointed to find that for whatever reason these technologies have little to offer me at the current time. I thought solar electric offered a lot of promise until I researched the cost –vs.- the savings. It takes 20+ years (with government incentives) to pay back the cost of the investment. While the economics of wind are very attractive, the fact is I live in a state (North Carolina) where wind is only viable (according to the government energy office) along a tiny sliver of the coast and a tiny sliver along the ridgelines of the mountains. Unfortunately, I don't live in the 1% of the state that has adequate wind speed to generate electricity. It was at this point in my investigation that my job took me south way south.

Brazil is a developing economy. Since it is a developing country, the Brazilian government maintains a very high import tariff on items that are/can be manufactured in the country. They do this to protect the jobs of the workers in the country. It has the added effect of increasing the cost for many goods since foreign competition is virtually eliminated as a result of the high tariffs. In 2004 Brazilian per capita income was 1/5th of the United States. Because of lack of development in the financial markets, in Brazil it is uncommon for people to take out a mortgage to buy a house. Rather, they build their home and pay for it out of their earnings (remember they are making 1/5th of what we make in the U.S.). Finally, as I visited various friends and co-workers that were building houses in Brazil I noticed that they were all installing solar hot water systems. In a country where the wage rate is relatively low, financing is virtually non-existent, and many goods are priced more than in the U.S. how can this be happening? I asked a friend and he said, "Because it makes economic sense." Clearly, I had to get more information.

When I returned home I researched solar hot water systems and found that he was correct. Where solar electric systems take 20+ years to get a payback solar thermal systems payback in 5-7 years. If you consider the added value to the home ($4000 - $5000 according to a recent study by the American Institute of Architects, Washington Post-August 6th, 2006) the payback can be instantaneous. If you roll in the federal (and many state) tax credits available you end up with an investment that increases the value of your home, pays you 30-50% back on your next tax bill and pays you back with lower energy bills each year. I can think of no other investment that comes even close. So why haven't people jumped on the bandwagon?

Unfortunately there are many reasons. First, there is lack of familiarity with the technology. When many people think of solar they are interested in powering their microwave or refrigerator.

Up to 30% of a home's energy bill is used for generating hot water. I would attribute the confusion over solar to the amount of press that has gone into covering the more sexy Solar electric industry.

Second, they think the collectors look ugly on the roof. I have included a number of pictures of installed solar collectors in this book and will let you decide. In a country where we didn't think it too ugly to run power lines everywhere or didn't think television antennae or satellites were too ugly or roof penetrations for vent pipes weren't too ugly, I find the inconsistency in this argument to be challenging. I will address one approach to make them more cosmetically appealing in the section on siting of collectors.

Third, people don't know where to go to get one installed. This is a very real concern. There are two websites www.findsolar.com and www.sourceguides.com that will point people in the direction of solar installers in the area. All contractors that are actively installing solar systems should have their name connected with each of these web sites. The number of people doing installations is relatively low. The number of people advertising that they do installations is even lower. This shortage of installers drives the cost and aggravation up. Part of the motivation for writing this book is to help eliminate this concern. I am hoping to do that in two ways. For those of you that are interested in joining the solar crusade and installing solar hot water system(s), I am hoping that I will provide the details and encouragement to go out there and do it. I applaud you and want to be here to support you as you help to change the world.

Finally, there are people that will claim they want to install one but can't because of zoning rules. Many states have solar access laws where the ability to install a solar hot water system is written in to state law trumping any local zoning regulations. If your state doesn't have solar access laws I encourage you to contact your state representative to make sure it gets addressed during the next session.

Section 1:

Selecting a Solar Hot Water System

Chapter 1: What is Solar Thermal?

There are many people that are confused about what solar thermal is. It is exactly what its name implies, heat from the sun. From our youngest days we learn that the sun makes things hot. Many of us have tried to walk across black top with bare feet in the summer time and realize how hot the ground actually is. Some have concentrated the sunlight through a magnifying glass to burn a leaf. These are experiences that most people can relate to. Solar thermal seeks to take the heat that the sun naturally provides and tries to channel it in ways that make it useful for our day-to-day energy needs. In the discussion in this book I am not going to give you instructions on how to paint a water tank black and stick it in a box so you can be amazed at how hot it gets. I will walk you through what you need to know to select and install a modern, state of the art solar hot water system. A quality system today will provide 40-80% of the homes hot water needs for free. Don't worry the other 20-60% will be supplied with a back-up source of energy so the homeowner won't ever have to experience cold showers.

Solar hot water is also called solar thermal or Solar DHW (domestic hot water). It is the process where the sun heats water and then you store the heated water in a storage tank. Almost everybody has had the experience where they have gone to take a drink from a hose in the yard in the summer time and they got very hot water coming out of the hose at first. That is all solar thermal is but with a little more attention at trying to collect that heat.

Like the magnifying glass for burning the leaf, the solar collectors manufactured today are finely tuned to capture, and store that energy so you don't have to think about it. A properly installed system should be totally unnoticeable to the hot water users in the house with a few exceptions. First, we generally use larger tanks for storage than an average 40-gallon tank for a home. An 80 gallon tank is pretty standard. The larger tank means we have more hot water available before we run out. That's right the home will have more hot water with a solar hot water system than with a conventional hot water heater. Second, the utility bill will be noticeably smaller. Third, you will start to notice how many other people have solar hot water panels on their homes or businesses. There are 1.5 million homes/businesses in the United States that use solar hot water. Of those over 94% say that it was a good investment.

There is not a renewable technology available today that provides a better combination of environmental and financial benefits than investing in a solar hot water system.

> News Flash: The federal government provides 30% tax credit, up to $2,000, for solar hot water systems that are installed on primary residences before the end of 2008. In addition, a number of states provide either tax credits or rebates for a solar hot water system. A standard SolarH2Ot system will pay for itself in 5 to 7 years depending on usage.

Chapter 2: Siting of collectors

It is all about the sun. In the solar electric world they have developed many complicated schemes to insure that the solar collectors are always pointed as directly at the sun as they can be. They do this because the efficiency (the amount of energy striking the surface that turns into usable energy) of solar electric panels is in the teens. That's right their ability to convert sunlight to electricity is generally around 17% efficient. With a panel that is only 17% efficient you need to make sure it is maximizing the direct sunlight. A solar thermal panel can be as high as 80% efficient at transmitting direct sunlight into usable energy. Because of the much higher efficiency, siting is not as critical, although it is still important.

You want to install your solar panels in a spot that receives direct sunlight from 9 a.m. to 5 p.m. on December 21st. Ideally, you would also like to install your collectors facing directly south angled to match the latitude of your site. It is at this point that many people get discouraged. Some of the common problems with this ideal location are; wrong tilt, wrong angle and shading. I will address each in turn.

Issue #1 wrong tilt: Many solar collectors installed in the past sought to get the perfect angle for solar collection by using special mounting hardware to incline the collectors at the "perfect" angle. This is almost entirely unnecessary. While it is true that if you tilt the collectors at exactly the same angle as your site's latitude you will maximize the solar radiation on the collector, the difference between perfect and not perfect is virtually immeasurable. Running the numbers in a simulation I found that for Raleigh North Carolina (latitude 35.7^0) if you mounted the collectors between 0^0 and 60^0 the worst performance was only 9% off of optimal. While the ideal angle for my solar collectors is 35.7^0, I installed my solar collectors flush to the 12/12 pitch roof with roughly the same annual performance I would have achieved had I mounted them at the "ideal" angle.

The general rule states that if your collectors are mounted at an angle less than your latitude you will receive more heat in the summer and less in the winter. If your collectors are mounted at an angle greater than your latitude your winter heat gain will be higher and your summer lower. That is the rule but as you see from the previous example the actual difference is small.

Issue #2 wrong direction; The house sits on the lot so the section of roof that I want to install the collectors on point south-east or south-west or due east or due west. While it is true that due south is the optimal orientation, a solar thermal system is pretty forgiving in this regard as well. Collectors can be pointed within 45^0 of south and not see more than a 3.5% reduction in their output. If you get much beyond 45^0 off of south I would recommend increasing the area of your collectors first before I would recommend angling your collectors perfectly toward the sun. If you don't have a compass handy I would suggest downloading a copy of Google Earth™ free from the Internet. With this software you can get a satellite image of the home that includes the compass rose. Using this snapshot you will know the exact orientation of the home.

Picture 1:

This is a snapshot from Google Earth™ that shows a street address and how that building sits relative to South. As you can see from the picture the street is almost due south from the building so any collectors would need to be facing the street. (Please note that Google Earth does not yet cover all parts of the U.S.).

If you want to know the exact impact of the tilt and direction on the performance of the system you can go to www.retscreen.net and go through their solar calculator. They have weather data from every weather station in North America as well as a database of most solar collectors available today. You simply enter the weather station that is most appropriate for your location; indicate the tilt of the collector as well as the orientation (azimuth) and the software will spit out the overall energy produced. You compare that with the perfect orientation and you can see what impact your siting decision has on the overall output of the system. Feel free to play around with this database. It provides a wealth of information. Don't be discouraged if you can't figure out all of the other inputs because they are not pertinent to the question of what impact your siting has on the performance of the system.

Note: Later in the book we will discuss sizing of the collector area. The rules of thumb that we go over are based on collectors being pointed south and angled to match the latitude of the site.

If you need to use an angle and pitch that significantly reduces the solar gain of the collectors (as measured by the Retscreen database) I recommend adding collector area to get back to the same quantity of energy collected.

Issue #3 shading; If you mount the collectors in a location so they are shaded during a portion of the solar day or are shaded during a portion of the year you will reduce the output of the system. There are no exceptions to this rule. While you can increase the number of collectors to increase your heat gain while the sun is shining, a shaded solar collector won't collect any heat. Now you are torn. You want to do the right thing for the environment by going with solar energy but it seems like you are moving in the wrong direction if you have to cut down trees to get there. I can help with this a little. Go to the BP solar website at http://www.bp.com/solarsavings.do?categoryId=4323 and enter in a 3 KW system (a DHW system with 2 chrome plated 4x8 panels is equivalent to a 3KW PV system). This will show you the environmental benefits of installing a system equal the impact of planting 1 acre of trees. So, unless you live in the forest the environmental benefit of adding a solar hot water system is greater than the harm of removing a few trees. We removed 2 trees from our site (1 pine and 1 walnut) and it broke my heart to do it but I knew pollution wise we would be better in the end. Removing the pine tree didn't bother me too much but taking out the walnut hurt. Although, by removing those two trees our yard and smaller trees in it have flourished.

Chapter 3: Sizing of System

In this chapter we will only cover sizing of systems for Domestic Hot Water. We will size a system for typical domestic hot water usage. While these same principles and systems work well for space heating, we will focus on Domestic Hot Water systems since that is where the bulk of the initial applications lie.

Sizing a system for typical Domestic Hot Water Usage

There are a couple of rules of thumb that are useful for sizing solar hot water systems. Granted, these rules of thumb apply for the average person/families water usage. If a person doesn't bathe but once a month and washes all of their dishes in the creek these rules of thumb will provide more hot water than they need. If the family has all teenagers that participate in sports and like to take multiple 30-minute hot showers per day the sizing generated by the rules of thumb will provide a smaller fraction of their hot water. Depending on the location, size of the system, and usage patterns you should expect a solar hot water system to provide between 40-80% of your hot water needs. This is also a rule of thumb. Personally, we have turned off the back-up elements in our hot water tank so the sun is providing 100% of our hot water. This may lead to a few showers that aren't quite as hot as my wife would like but the environmental and financial benefits are worth it for us. (note: I can't handle a shower as hot as my wife prefers)

> The SolarH2Ot Advantage: SolarH2Ot systems are very scalable. It is easy to add additional collectors to the system. It's just as easy to use a larger hot water tank or put two standard tanks together in case you decide that you need additional hot water storage.

Sizing the collector area: The maximum energy you can get out of the system is controlled by a few things and the square footage of collectors on the roof (or in the yard) is one of them. The more square footage of collectors you have the more potential you have for collecting solar energy. The rule of thumb (for the southern half of the country) for how much collector area you should have says that you should have 20 sq. ft. of collector area for the first two people in the household and 8 sq. ft. of collector area for each person after the first two. For example; if you are sizing the system for a family of 6 you would need

This rule of thumb doesn't take into consideration the quality of the solar collector that you use. It is possible to have a solar collector that produces 2/3rd of the energy because the absorber is painted black –vs.- using a selective coating or because it uses lower quality glass that doesn't allow as much light to pass through. The rule of thumb that I just mentioned is appropriate for high quality solar collectors. I am defining a high quality solar collector as having either black chrome plated absorber or having some form of selective surface. Also, the glazing (glass) on the collector needs to be high transmission tempered glass. Avoid plastic glazed collectors since the clarity of the plastic will degrade quickly over time and ruin the value of your investment.

> The SolarH2Ot Advantage: SolarH2Ot gold and platinum series collectors use selectively coated all copper absorbers with high transmission solar glass. Flat plate collectors will perform well while laying flat on most rooftops and are considered by many to be far more aesthetically attractive when compared with evacuated tube collectors.

Another thing that impacts this rule of thumb is where you are located in the U.S. The truth is the farther north the installation is the less sunlight you receive and the colder the groundwater is (therefore the more heating you need to get it to 120^0F). If the home is in the northern U.S. you would want to install 20 sq. ft. of collector area for the first two people and 14 sq. ft. per person for additional people. The previous example would look like this if you live in these colder areas.

There are three things that interact to impact the overall performance of the system. First, there is the amount of energy absorbed by the collectors. This is controlled by the collector area as well as the efficiency of the collectors at absorbing the solar energy. Second, the size of the storage tank controls how much of the heat that is absorbed in from the collectors that you can keep. If you have a storage tank that is too small for the collector area you will heat the water up very quickly and then the system will either need to dump the heat (in a glycol system) or just sit there. If the storage is too small (40 gallons) you will rapidly deplete the heat you have stored and then switch over to auxiliary heat. Because a solar hot water system is just that – a system – if you cut corners on a single piece of the system you are impacting the overall performance of the system. An 80-gallon water heater is only a little more than a 40-gallon water heater so no need to put thousands into an installation and only get 50% of what you could have gotten had you put in a tiny fraction of additional cost in materials. Third is how efficiently the heat from the collectors is transmitted to the storage tank.

Similar to the collectors the size of the storage tank is dictated by where you are located in the country. If you are located in the Sunbelt you should have 2 gallons of storage for every 1 sq. ft. of collector. If you are located in the north of the country (New England to Idaho) you should

	People	Square Feet/Person	Total square feet
Parents	2	20	40
Kids	4	8	32
			72

have 1 gallon of storage for every sq. ft. of collector. In the middle of the country you should have 1.5 gallons of storage for every sq. ft. of collector. Using the first example from above, assuming 1.5 gallons per sq. ft. of collector, we have

> The SolarH2Ot Advantage: SolarH2Ot integrates hot water tanks of several capacities from a leading manufacturer into the solar system. This creates a scalable, economical solution for the hot water storage needs. These tanks come with built-in electric heating elements for those days when the system needs auxiliary heat to meet the hot water needs.

We have covered the sizing of the collectors as well as the sizing of the tank. The truth is these are guidelines. There are a couple of overriding considerations that should be given when trying to size an installation. It will take the same pumps, controls, piping, pipe insulation, and valves for a small system that it will take for a large system. It doesn't make a whole lot of sense in my mind to size a system for the minimum when for a relatively small increase you can produce more hot water and have a larger environmental impact.

> Example: A North Carolina couple decides they want to do their part and install a solar hot water system. Based on the calculations they need a 4x10 (40 sq. ft.) of collector area and a 60-gallon tank. To cover a larger % of their hot water load and to take into consideration future family growth or sale of the home to a larger family I would recommend installing 64 sq. ft. of collector and 90 or 100 gallons of storage. The incremental cost would be slight

	People	Square Feet/Person	Total square feet
Parents	2	20	40
Kids	4	14	56
			96

> (since you still have the same piping, controls, pumps, insulation, etc..) but the additional usability of the system would be much greater.

Don't be penny wise and pound-foolish. Another consideration is sizes of collectors and storage tanks. 4x8 and 4x10 collectors are commonly available. Smaller size collectors are less available (3x7, 3.5x7.5). Tanks also come readily available in 40, 50 and 80 gallons. The tanks can be combined to make storage systems of whatever configuration you want, i.e. 2 – 50s to make 100 gallons of storage. When you start going with oddball size components the cost (particularly the cost per KW) of your system rises pretty quickly. I have found on hot water tanks it is significantly cheaper to use an 80-gallon tank in series with a 40-gallon tank rather than use a special 120-gallon tank. So, for the earlier example that called for 72 sq. ft. of collector area, I would use 2-4x10 collectors for a total area of 80 sq. ft. and an 80-gallon storage tank plumbed with a 40-gallon tank.

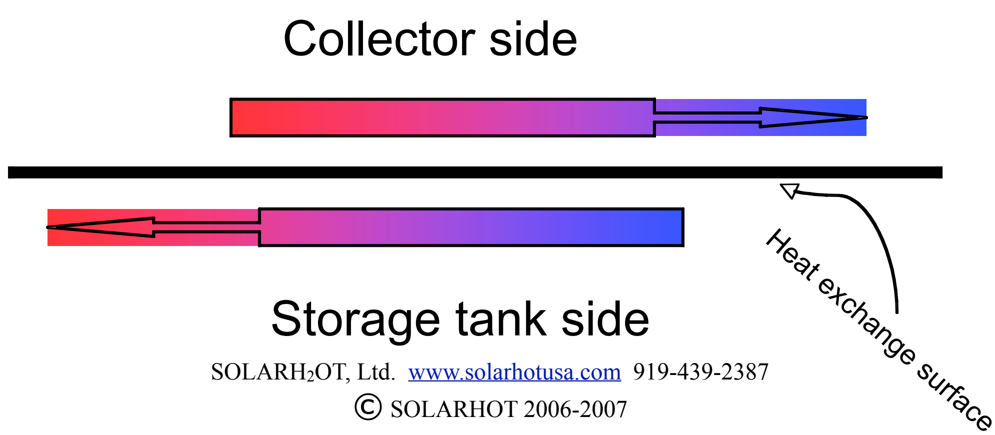
Sizing the heat exchanger. There are several different types of heat exchangers available on the market today. You can purchase hot water tanks that have integral heat exchangers built in. While these tanks are expensive, they can eliminate the need for a separate pump required for a two-pump heat exchanger. You can also purchase shell and tube heat exchangers, brazed plate heat exchangers, or just use a section of copper pipe curled in the bottom of a tank of water. Each one of these methods works by moving the cold storage tank water past the heat exchanger before being deposited back into the storage tank. At the same time the hot water from the

Total square feet	Gallons per square foot	Total gallons of storage
72	1.5	108

collector loop is pumped on the other side of the heat exchange surface and then back up to the collectors. A system with a properly designed heat exchanger will transmit the heat from the collector loop to the storage tank quickly. Generally speaking, the larger the surface area the better the heat transfers. If you undersize the heat exchanger your pumps will run longer to extract the heat from the collectors reducing the energy saved on the system. The larger the heat exchanger the more it will cost. But you will want a larger heat exchanger surface area. I recommend a 5”x12”-10 plate brazed plate heat exchanger for up to 200 sq. ft. of collector area.

> The SolarH2Ot Advantage: SolarH2Ot has uniquely created the SolVelox package which pre-assembles and integrates an oversized stainless steel heat exchanger along with the pumps and valves necessary to drive a two-loop solar system. The heat exchanger and pumps are sized to meet the heat output of up to 6 solar flat panel solar collectors so one SolVelox appliance provides an economical solution as you scale the solar system to meet your particular needs. Also, the Solvelox is externally mounted in order to reduce maintenance issues.

Heat Exchange principle: Diagram 1



Chapter 4: Choosing a system

The first question you have to answer before you can accurately choose a system is to determine whether it freezes in your location. To determine if it freezes in your location go to http://www.ncdc.noaa.gov/oa/climate/online/ccd/lowtmp.txt. This website covers the lowest temperature on record for all of the government's major weather stations throughout the country. If it never freezes then the best system to install is an open loop system. An open loop system has no heat exchanger between the storage tank and the collector. Based on a sensor mounted on the collectors and a sensor mounted on the bottom of the storage tank it detects when there is more heat in the collectors and activates a pump to capture that heat. Circulating water from the bottom (which is colder than the top) of the storage tank through the collectors to pick up the heat and then back to the storage tank. Once the collectors are close to the same temperature as the storage tank bottom the pump automatically turns off.

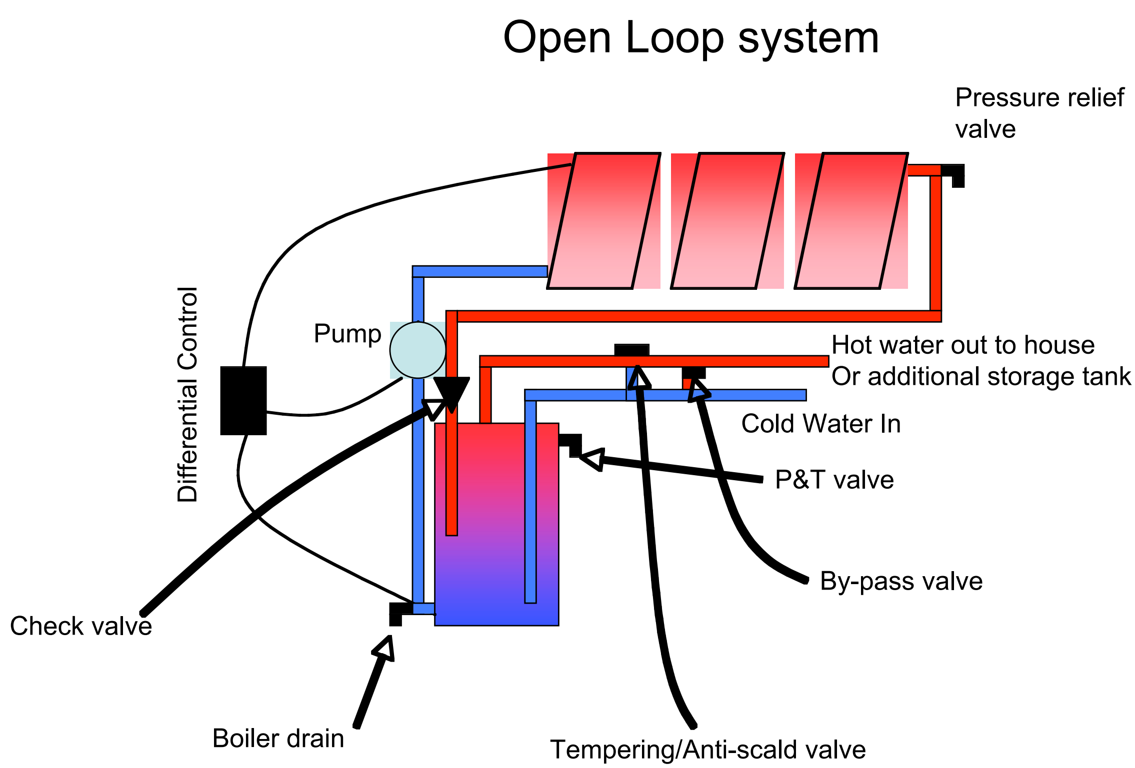


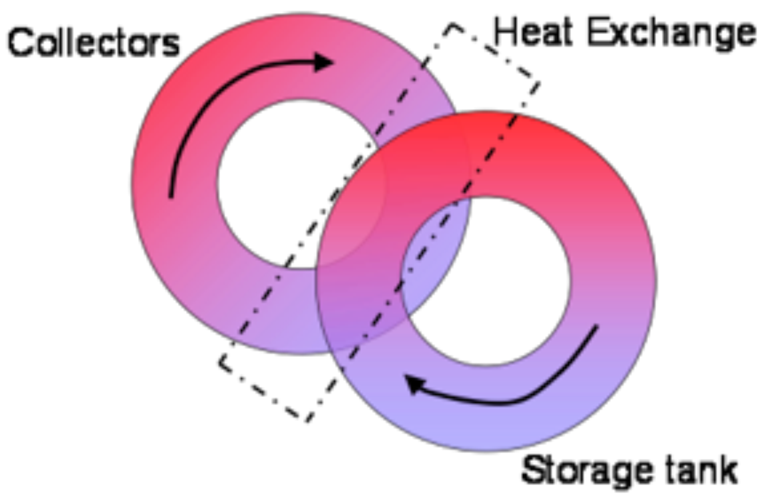
Diagram 2

If the site sees freezing conditions, even if it is only once every 5 years, I recommend installing a freeze protected system to eliminate the concerns of having pipes or collector freeze up during a "freak" cold snap that catches the system owner off guard. There are two basic types of freeze-protected systems; Drainback and Glycol. The chart below covers some of the points of difference between them.

	Drainback (double pumped)	**Glycol**
Heat transfer fluid	Water	Propylene glycol*
High limiting	Has it	Doesn't
Fluid life	Forever	5 years
Pump energy requirements	Higher	Less
Heat exchange performance	Best	Worse
Initial cost	about $100 higher	
Location limitations	Requires gravity draining	Can be mounted anywhere

* Note: Use only buffered propylene glycol for your heat transfer fluid
Never use toxic ethylene glycol.

A freeze protected system works by having two loops. The first loop circulates the heat transfer fluid through the collectors and then to one side of a heat exchanger. The second loop circulates,



either by forced circulation with a pump or by passive circulation through convection, the potable water on the other side of the heat exchanger.

Basically you are trying to maximize the amount of heat that you take from the collectors and put in the storage tank.

With that being the objective, I would recommend a double pumped drainback system. First, water is a better heat transfer medium than a water/glycol mix. Second, a double pumped heat exchange is 20-60% more efficient than a single pumped heat exchange. On both points drainback wins. In addition, Drainback has the added feature of allowing the system to shut off once it has put as much heat as you want in the storage tank. The differential control will automatically shut the pumps off once the system has reached the high limit on the control. If you did this with a glycol system the pressure would spike (opening the pressure relief valve) and the additives in the glycol would be destroyed requiring it to be replaced.

A drainback system works by using a reservoir (drainback tank) that is filled with water. That reservoir is located below the collectors. When the differential control says there is heat to be harvested in the collectors the pump(s) turn on and force the water from the reservoir through the heat exchanger and up to the collectors. Once the water reaches the highest point on the collectors the water then falls back to the reservoir where it starts it's journey all over again. Since water finds it's own level, when the pumps turn off, if all the piping is angled from the collectors towards the storage tank, the water will drain out of the collectors and drain back to the drainback tank (hence the name).

> The SolarH2Ot Advantage: The SolarH2Ot system uses a double-pumped efficient design as mentioned above. It comes with the two closed loops already pre-assembled and attached to the hot water tank. This will reduce both your installation effort and assembly issues as you install the SolarH2Ot system. As a result, this should reduce the overall cost of the system.

Caution: The primary design principle behind a drainback system is that the water in the collectors is able to drain back when the differential control turns the pumps off. In order to accomplish this the collectors must be inclined 1/16" per foot towards the inlet line. In addition all the piping must also be angled to facilitate the flow of water towards the drainback reservoir. If you violate this principle you jeopardize rupturing the pipes to/from the collector or the absorber in the collector itself should it freeze with water still in it.

There are several different styles of drainback systems out there. Double pumped external heat exchange, double pumped with an integral heat exchange in the drainback reservoir, and single pumped with an integral heat exchanger in the storage tank. The argument for the last is generally that the pump requirements of that system are the lowest so the parasitic losses of running the pumps are minimized. This is not necessarily the case. Of the two pumps in a drainback system the larger one is the one that runs the water through the collectors. That pump will run as long as it takes to bring the temperature differential between the storage tank bottom and the collectors within a preset limit. If you make the heat exchange between the storage loop and the collector loop worse you will require the large pump to run for a longer period of time to put the heat in storage. So the argument that you have less pump horsepower is correct although you may be significantly increasing the running time of the pump and thereby eliminating or even reversing the “benefit” of having only one pump. While having a single pump system will reduce pump maintenance, the added cost for the special heat exchange tank and maintenance on that make a single pump drainback system a worse approach than a double pump system.

Comparison of 3 different drainback approaches

	Drainback (double pumped - external HX)	Drainback (double pumped - integral DB/HX reservoir)	Drainback (single pump - integral HX/storage tank)
Heat transfer	Best	Best	Fair
Pump cost	Moderate	Moderate	Low
Tank cost	Low	Medium	High
Maintainabilty*	Good	Fair	Poor
Scalability**	Great	Poor	Poor
Availability	Good	Fair	Fair

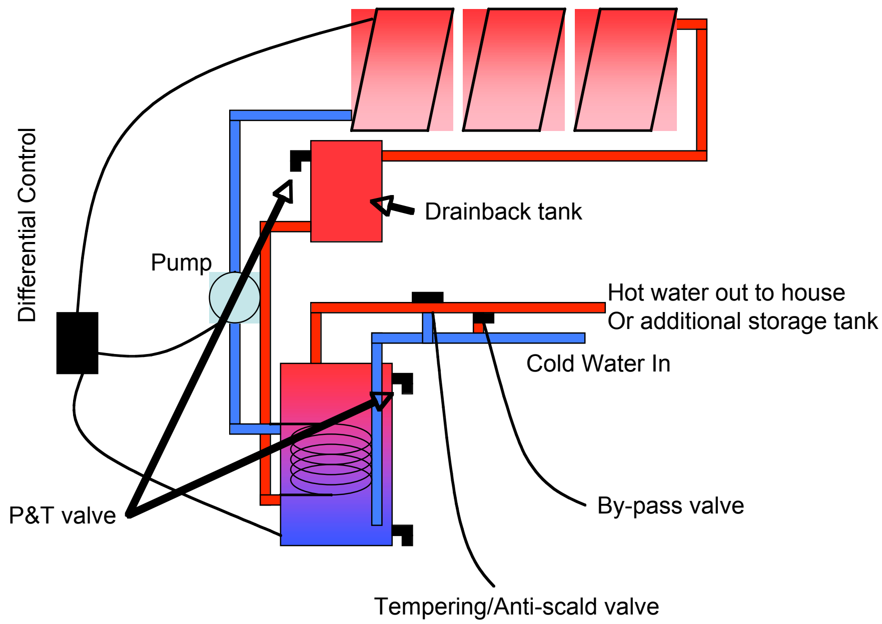
* This is a measure of how easily the heat exchanger can be cleaned if need be or the anode rod can be changed.

** This measures how easily you can change your heat exchanger requirements to match a smaller or larger storage requirements.

I recommend an externally mounted heat exchanger. Either shell and tube or brazed plate heat exchangers work well with their own unique advantages. I prefer the brazed plate heat exchanger because of it’s cost to performance ratio as well as its compact size. A 5”x12” heat exchanger can mount on the side of a standard 80 gallon tank and all of the piping be run from there. With a profile of only 3” off the tank (for a 10 plate heat exchanger) that makes it ideal for tight spaces as well.

The SolarH2Ot Advantage: Complete SolarH2Ot systems include an oversized external heat exchanger which will come already mounted on the exterior of an unmodified standard hot water tank. The hot water tank contains electric elements which will provide additional hot water for those times when solar alone will not meet all of the hot water needs. The package eliminates the costs and lead times associated with custom tanks. The external positioning of the heat exchanger reduces maintenance difficulties down the road. The SolarH2Ot system is characterized by the attractive attributes shown in the column above, titled “Drainback (double pumped –external HX”

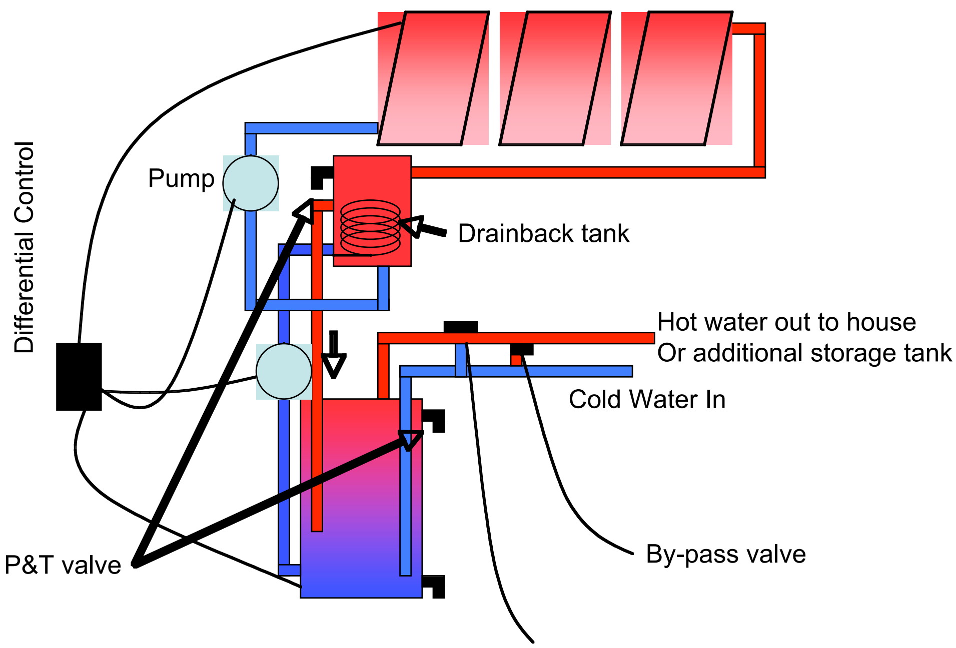
Drain-back system
(single pump w/ HX in storage tank)



Note: All drainback systems require that all piping to and from the storage tank be inclined at least 10 degrees toward the storage tank to insure proper draining.

A standard 8-20 gallon hot water tank can be used for the drainback reservoir in this configuration.

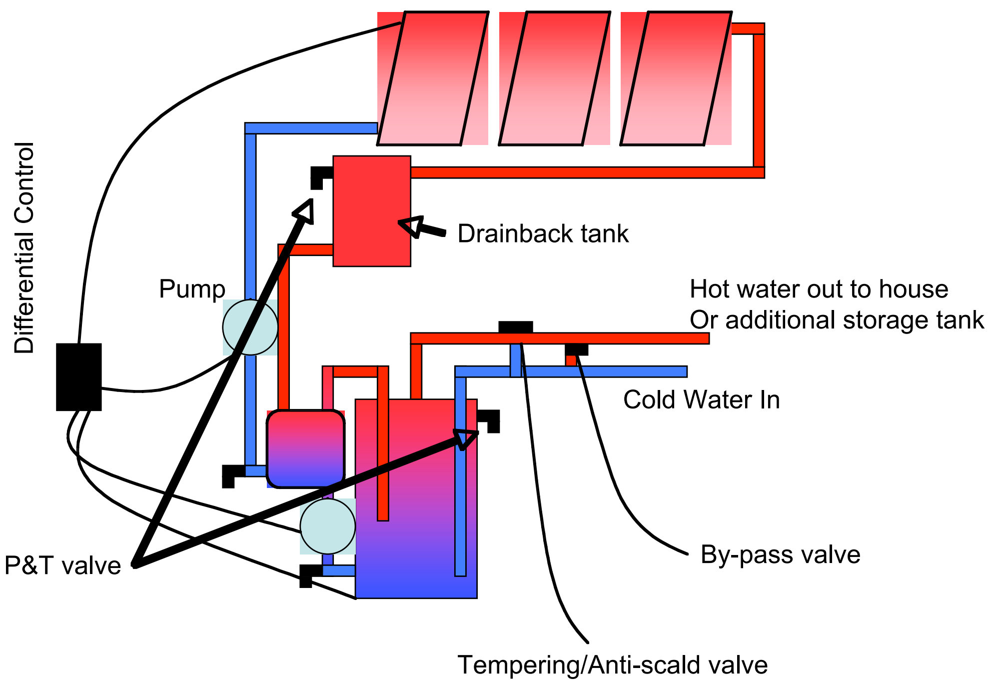
Drain-back system
(Double pump w/ HX in DB tank)



Note: All drainback systems require that all piping to and from the storage tank be inclined at least 10 degrees toward the storage tank to insure proper draining.

A standard hot water tank can be used as the storage tank in this configuration.

Drain-back system - recommended (double pump w/ external heat exchange)



Note: All drainback systems require that all piping to and from the storage tank be inclined at least 10 degrees toward the storage tank to insure proper draining.

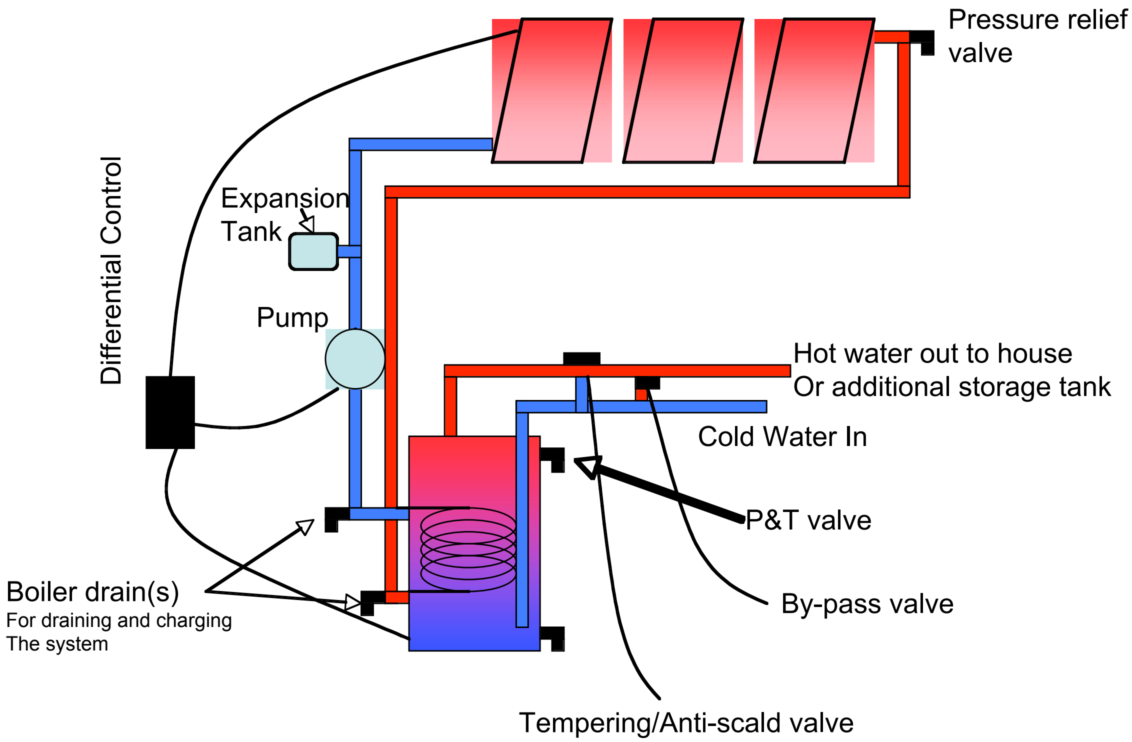
A standard 8-20 gallon hot water tank can be used as the drainback reservoir in this configuration as well as using a standard electric water heater for the storage tank/back-up.

Glycol systems:
If the site requires that you install a glycol system you need to consider a number of the options presented in the section on drainback systems. You can go with a single pump heat exchange system or a multi-pump external heat exchanger. The same relative advantages apply as listed on page 13. The only option that is not available for a glycol system is a system where the heat exchanger is integrated with the drainback tank (there is no drainback tank).

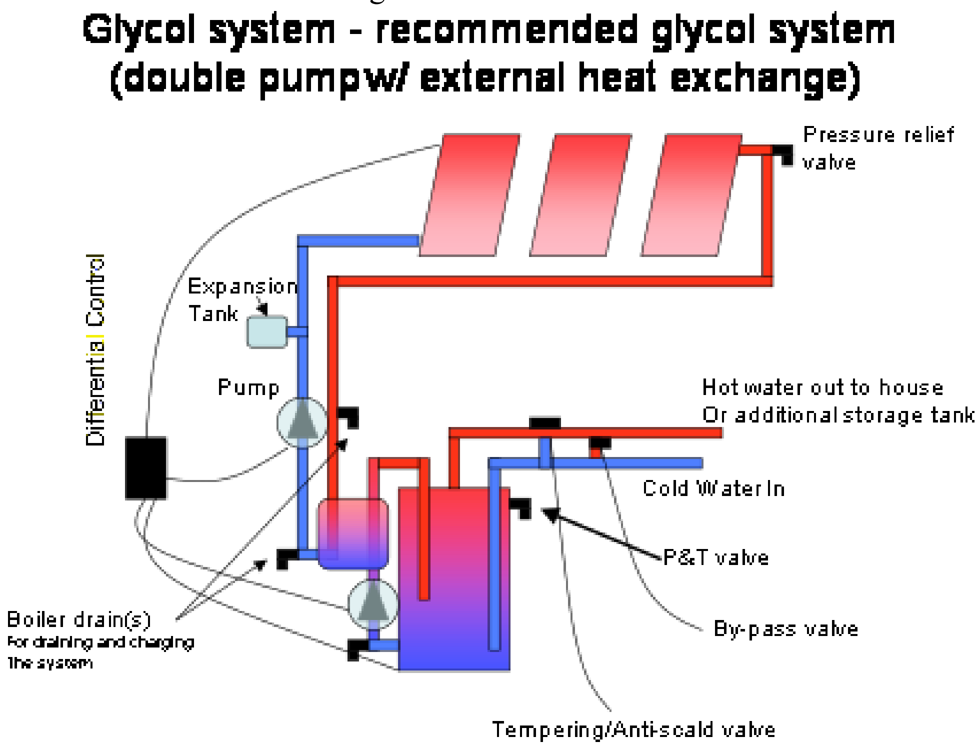
There are a few things you need to be aware of when it comes to installing a glycol system. First, the size requirements of the pump for the collector loop are lower than the same pump on a drainback system. Second, copper is the only piping material suitable for a glycol system although you can use ½" pipe rather than ¾". Third, you cannot use the high limit function of the differential controller. The high limit function of the control turns the differential control off once the storage tank reaches a certain pre-determined set point. Finally, you need to change the heat transfer fluid every 5 years to keep it from turning acidic.

A drainback tank is not required in this system but an expansion tank is. The expansion tank should be sized to the overall volume of the piping and collectors. See: http://www.amtrol.com/thermxtrol.htm for proper sizing of the expansion tank. The expansion tank that you use should be mounted below or beside the connection to the piping. Never mount it above it's connection to the pipe. Polypropylene lined expansion tanks are preferred for longevity. A pressure relief valve should also be installed on the system. The pressure relief valve can be mounted on the roof or in the boiler room or anyplace in between but make sure there are no isolating valves between the collector and the pressure relief valve. Violate this principle and you are creating a potential safety hazard.

Glycol system
(single pump w/ HX in storage tank)



This picture shows the heat exchanger in the tank but a wrap-around heat exchanger would be connected in the same manner.



Heat exchangers;

Many companies will tout their individual product whether it is the best performing product or not (no fault there). You should understand a few concepts before you decide which heat exchanger makes the most sense for your application. The more surface area, the shorter the heat transfer path and the more flow (on each side of the heat exchanger) the better the performance. There are systems on the market today that take advantage of individual pieces of this equation trying to convince the buyer that their way is better, e.g. aftermarket submerged heat exchangers. The claim is that you can feed a spiral tube into the port of an existing tank to provide the heat exchange. This product takes advantage of a short heat transfer path (being immersed in the storage tank) but isn't able to get around the limitation of surface area (you can only get so much surface area on a tube installed through the existing, small, port on the top of the tank). These rules can be applied to any heat exchange process that someone tries to sell.

While there are no exceptions to the heat exchanger rules given above there are some other considerations that might be worth noting. There are tanks on the market today that have ceramic-coated heat exchanger coils immersed in the tank. These tanks eliminate the need to clean the heat exchanger since scale won't adhere to the ceramic coating. The same can be said for the heat exchange tanks that are wrapped with a coil to provide the heat exchange. Both of these methods eliminate the maintenance that may (not necessarily) be required on heat exchangers that don't protect the heat exchanger from scale. Understand, by selecting a lower maintenance option you will be sacrificing performance.

Choosing a collector

Caveat Emptor – Buyer beware. There are (as in all industries) people selling their product that make claims about the performance of the product that aren't backed up with any data. In the solar market there is a single independent rating agency that rates the performance and durability of collectors the SRCC, Solar Rating and Certification Corporation. They are co-housed with FSEC, Florida Solar Energy Corporation. Don't believe the sales hype believe the numbers. There are several high quality collectors on the market today as well as a number of lower quality options. The SRCC provides a minimum requirement for the quality of solar collectors sold today. You can find the list of collectors and collector manufacturers that meet this threshold at http://www.solar-rating.org/.

A few points to consider in selecting a solar collector: You should choose a solar collector that has a selectively coated surface to maximize the heat that the panel collects. Most manufacturers produce both a black painted absorber model as well as a selectively plated absorber model (generally black chrome). The supplier will generally charge \$50-\$100 more per collector for the selectively plated model since it produces as much as 20% more energy. This is money well spent. If you look at the overall cost of materials for the system plus the time and money to install it this incremental investment is a small price to pay for a significant improvement in energy savings. Among the choices you make on the system this one is a no-brainer.

There are manufacturers that produce collectors that have plastic glazing (covers) rather than tempered high transmission glass. Don't even think about it. While plastic has come a long way (copper pipes being replaced with PEX), the plastic glazing isn't ready for prime time yet. The glazing looses its clarity over time compromising the performance of the system.

Each collector manufactured on the market today has different mounting hardware. If you want the collector to have a cosmetically appealing look on the roof I would suggest choosing a collector and mounting hardware that are either black anodized or black painted but that is a matter of taste. There are collectors supplied today that have a mill aluminum finish with mill aluminum mounting feet. If the homeowner prefers that look then so be it. I prefer the collectors to look unobtrusive on the roof rather than having them as a stylistic feature.

> The SolarH2Ot Advantage: The SolarH2Ot collectors come in an extruded black aluminum casing which provides an attractive look on the roof that is similar to a low-profile skylight. The collector glass is patterned to minimize sunlight reflection and is tempered to maximize strength. The absorber plate is selectively plated over copper for maximum heat absorption. Layered insulation within the collector minimizes heat loss. The result is that the collectors are top performing flat plate collectors as measured by the SRCC.

Section 2:

Installing a Solar Hot Water System

Chapter 5: Piping

Depending on whether you are installing a glycol system or a drainback/open loop system you may have two choices for piping.

Option 1 – run your entire pipe in ¾" copper.

Advantages;

- This option has the advantage of being time tested. Most systems installed throughout the country (approximately 1.5 million systems) are piped this way.
- With copper you don't have to worry about the extremely high pressure and temperature you might get from that first surge of water going through the collector after it has been sitting in the sun.

Option 2 (only available for Drainback and open loop systems) – run the lines from the drainback tank to the heat exchanger and from the heat exchanger to just before you penetrate the roof in ¾" Pex (cross-linked polyethylene) and then run the roof penetrations, collector connections, and collector-drainback leg in copper.

Advantages:

- The cost of Pex is roughly ¼ of the cost of copper.
- Pex is easier to work with than copper.
- Since Pex is plastic it is naturally more thermally insulating than copper (assuming the same amount of insulation you should loose less heat with Pex along the pipe run).

Disadvantages:

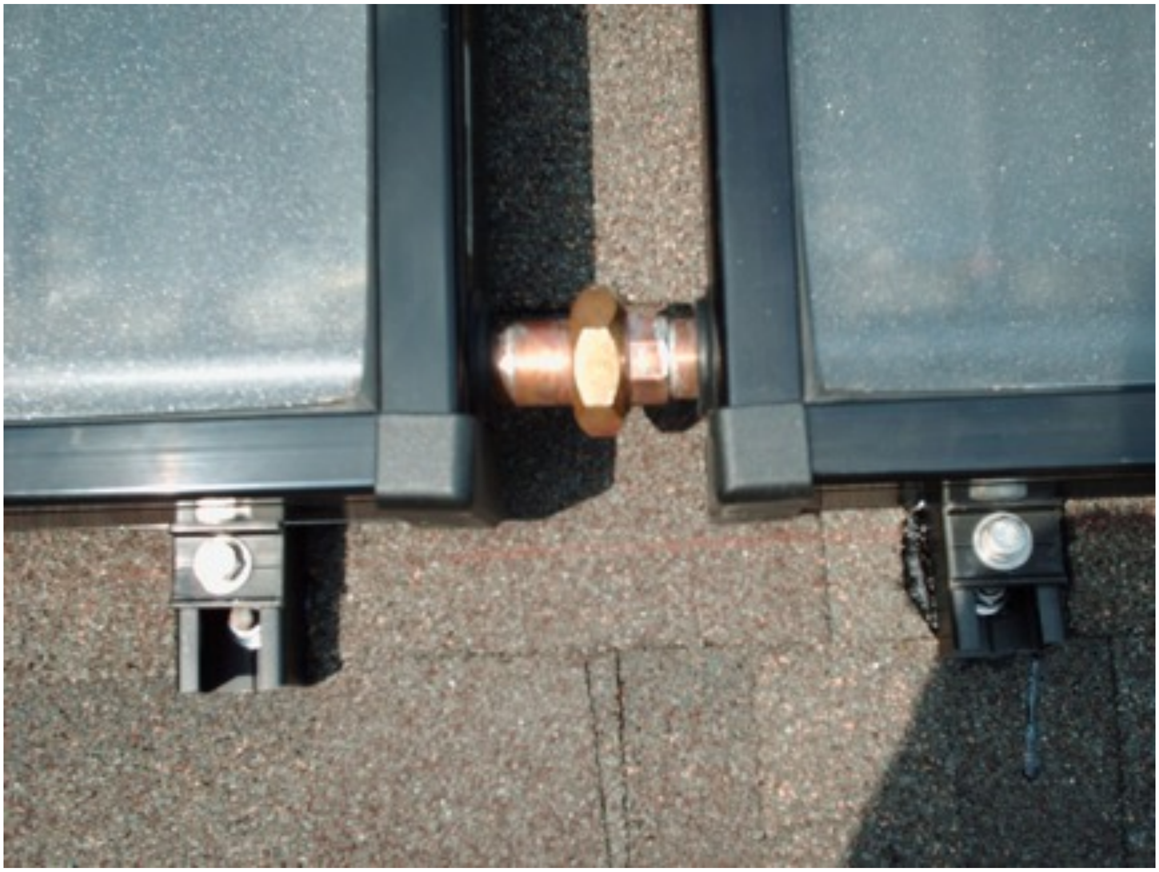
- Pex can't handle the pressure or the temperature that copper can. High limiting the system at 160^0F can circumvent this difference.
- If you use Pex that doesn't have an oxygen barrier in it you will need to use a bronze pump on the collector side to keep the pump from corroding.

Whether you plan to upscale the system and go with copper or stick with Pex be sure to use ¾" I.D. pipe for all of the runs to and from the collector for a drainback system to insure good drainage when the pumps are off. Referring back to the basic design principle of a drainback system, make sure that all of the pipe runs are sloped to allow gravity flow of water from the highest point in the system (the top of the collectors) to the lowest point in the system (the storage tank). If you have to run the pipe through an attic or crawlspace where a long sloped run is required be sure to support the piping to insure that it doesn't sag (and thereby violate the drainback design principle). It is pointless to install a high quality system only to have it fail two years after installation because the pipes weren't supported and started to sag over time.

If you are installing a glycol system you need to use copper for all of the piping runs. Although with glycol you only need to use ½" I.D. copper.

You want to give special consideration to how you flash the copper piping as you penetrate the roof. Use copper pipe flashing (see photo). Use roofing tar underneath the copper base and on top of the base underneath the shingle. Once you have placed the ¾" pipe through the receiver pipe and ring you will sweat the ring to the pipe to eliminate any chance of leaking.

You should determine what method to use to join the collectors while they are still on the ground. If you are using collectors that have straight stub out connections you can either sweat a union on the collectors prior to mounting on the roof or you can sweat a coupling on the collector prior to placing on the roof. If you have a steep roof that you are working on, the unions are far easier to line up when you are on the roof than the couplings.



Copper Union: sweat on the ground prior to mounting.

In order to keep all of your connections consistent, use only lead free solder and flux for all of your soldering requirements. My preference is to use acid based flux to eliminate the need to clean each connection prior to soldering. If you use acid based flux be sure to clean, neutralize or flush the area to stop the acid from continuing to attack the copper.

Chapter 6: Insulation

By installing a solar water heater you are trying to reduce the homes energy requirements. Whether the motivation to install the solar hot water system is to reduce the homes energy cost or to reduce the home's pollution burden on the planet the objective is the same. The last thing you want to do is spend a few thousand dollars installing a solar hot water system only to have the energy that you have harnessed squandered as it reradiates the collected heat back through un-insulated pipes or storage tanks. There are a few considerations when it comes to how much insulation; more is better but to a diminishing amount, more insulation will cost more, and the physical limitations to how much insulation you can have. Any pipe runs outside I would recommend insulating them to the greatest thickness that you can find and will fit. Any pipes running through interior walls will be limited by how much insulation can be installed (generally not more than ½" wall insulation on a ¾" pipe). Any pipes not running through walls should have 1" wall thickness insulation.

If you are installing a glycol system or a drainback/open loop system with a relatively high limit on the storage tank (170^0 F+) you will need to use rubberized insulation for insulating the pipes. The more common polyethylene insulation can't handle the high heat and will melt. If you use a lower high limit on your tank you can use the less expensive insulation. If you use a 150^0F high limit on your open loop or drainback system you can save money by using Pex piping and polyethylene insulation. When the insulation is exposed to the sunlight you need to provide jacketing for the insulation. Visit your local HVAC supply house and ask what size and styles of jacketing they have for their insulation. If the exterior insulation is not protected from U.V. it will disintegrate over time.

It is also a good idea to make sure that you have extra insulation on the storage tank(s) as well. You can purchase an inexpensive water heater blanket from the hardware. I would also recommend that you insulate about 4 feet of the cold line coming in to the storage tank. By taking these extra precautions, you will insure that you keep as much of the solar energy as possible.

Chapter 7: Temperature sensors and Control wires

All solar hot water systems should have a differential control to turn the pumps on and off. A differential control uses a temperature sensor mounted on the collector as well as a temperature sensor mounted on the bottom of the tank. The control detects when the collectors are hotter than the storage tank and turns the pumps on to circulate the heat transfer fluid through the collectors to harness the heat that has been gained. When the storage tank temperature matches (sic) or is greater than the collector temperature the pumps are turned off. The differential control is the brains of the solar hot water system.

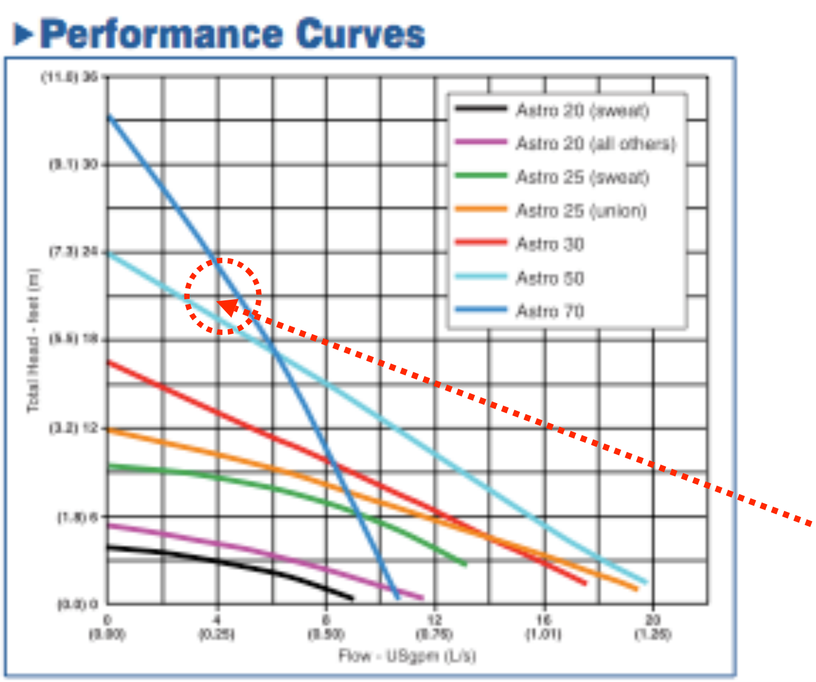
In order for a differential control to work it has two sensors wired to the control. The first sensor (the collector sensor) should be attached to the pipe leading out of the top of the collector array. Use a strap clamp to secure the sensor to the pipe. Be sure to provide adequate insulation around the sensor and pipe to allow an accurate reading of the temperature in the collectors. The second sensor should be stuffed under the insulation at the base of the tank. If you are using a standard 80 gallon two element electric water heater as your storage tank/back-up heater, then the tank bottom sensor can be mounted under the insulation under the lower element tucked between the insulation and the tank wall.

You should use 18/2-shielded wire with a high temperature jacket for running the sensor wire to the differential controller. Never run control wire within 12” and parallel or in the same wire way as power wires. If you have to pass power wires, run the control wire perpendicular to the power wire as you cross their paths. By following this rule you should avoid intermittent problems with the control temperatures sensed.

Chapter 8: Pumps

Pumps circulate the heat transfer fluid through the collectors and the heat exchanger. Depending on whether you install a single pump or dual pump system you will require a small amount of knowledge about pumps to make an appropriate selection. First, since we are discussing domestic hot water systems centrifugal pumps are the only style that should be considered. They are significantly more energy efficient than piston style pumps and are suitable for this application. Second, if your pump is exposed to a supply of air you should use bronze pumps rather than cast iron. Note: if your pump is on the storage tank side of the loop it will be regularly exposed to air entrained in the water coming from the city or your well. If your pump is on the collector side of a freeze protected system you can use a cast iron pump (and flanges). Bronze pumps are not necessary if the pump is not regularly exposed to air although you may desire one for overall pump body longevity. Third, the pump that you require is based on the head requirements of your system.

Two things; head and flow rate a pump. The head represents how high the pump can lift a column of water. They measure flow by how much water (gallons or liters) a pump can push at a given head. A pump head/flow curve for the Armstrong Astro series pumps looks like this.



This graph shows that an Astro 70 would push 4 GPM at 23 feet of head.

Pump requirements for 5 different systems

	Two pump drainback system	Two pump glycol system	Single pump drainback system	Open loop system	Single pump glycol system
Storage Tank Side	Astro 25B	Astro 25B			
Collector side	Astro 70	Astro 30	Astro 70B	Astro 30B	Astro 30

* All models are for Armstrong pumps.

** A pump that ends with a B-denotes that the pump must be a bronze model.

See the chart below to find which pumps are appropriate for which application. Different manufacturers pumps can be cross-referenced with this list or the above head/flow graph.

The SolarH2Ot Advantage: The pumps for both loops come already packaged into the Solvelox assembly. This gives you confidence that your customer will have the right pumps at the time of installation.

Chapter 9: Placing the collectors

Warning: All work more than 5' above the ground should be conducted with the appropriate fall protection equipment.

We have already covered the proper siting and sizing of the solar collectors now we will delve into the proper placement. The collectors (assuming roof mounted) should be located at least 18" below the ridge and 18" in from the edge of the roof. This is a guideline to prevent the collector from seeing abnormal uplift during high winds. See picture.

The tops of the collectors are 18" down from the ridge.

Once you have identified the general area where the collectors will be mounted use a chalk line to mark the upper and lower edge of the collector. These lines should be parallel and spaced apart the same distance as the collector length. The collectors must be mounted with the headers parallel to the ridge line for a drainback installation (see picture).

> Note: You want to make sure that these chalk lines are inclined down the slope at least 1/16" per foot to insure drainage in a drainback installation.

The next step will be to identify where the rafters are under the shingles. You can do this using several different methods.

If you have access to the attic underneath

1. Find an existing roof protrusion and measure the distance from that protrusion to the nearest rafter from underneath. Return to the roof and make a chalk line perpendicular to the roof slope that goes through that point.
2. If you have no roof protrusion drill a hole through the roofing into the attic space. With the drill through the roofing measure the distance from the end of the drill to the nearest rafter from underneath. Return to the roof and make a chalk line perpendicular to the roof slope that goes through that point. Be sure to fill the drilled hole with roofing tar when you are finished.

If you do not have access to the attic from underneath

1. Peal back the shingles from the edge of the roof to determine where the roof decking sheets are joined. Make a chalk line perpendicular to the roof slope that goes through that point.

1. Now that you have identified a single rafter you should snap chalk lines parallel to your perpendicular line (spaced to coincide with the rafters underneath) until you have all of the rafters marked underneath the area where you will be placing the collectors.
2. Using your mounting feet placed over the intersection of your chalk lines, mark where you will drill your holes. Drill a ¼” 2” deep where you have for each of the mounting feet.

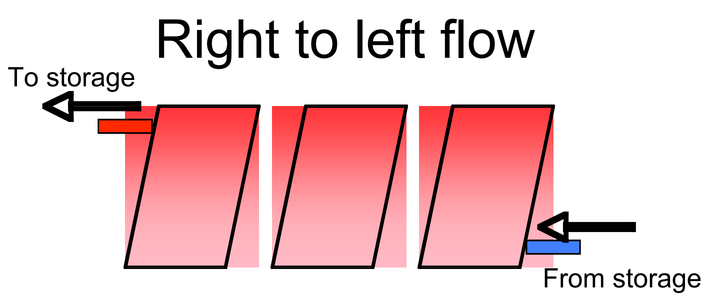
   Note: You want to maximize the space that you have between your feet on the upper and lower edge of the collector. Depending on your rafter spacing you will be placing the mounting feet either 32” apart under the collector or 24” apart under the collector. Between the collectors use a single rafter as the spacing between mounting feet.
3. Once you have drilled for you mounting feet inject roofing tar into each one of the drilled holes.
4. Using the mounting foot and 3/8-16 x 2.5” stainless steel lag screws, stainless steel flat washers and stainless steel lock washers place the foot over the pre-drilled holes.
5. Inject roofing tar underneath the flat washers and screw the foot assembly through the roofing material to the rafter. You should see roofing tar ooze out from underneath the mounting foot. Repeat this process for all of the mounting feet.

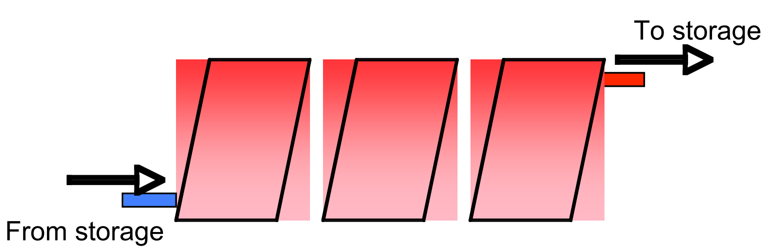
Placing the collectors;

Prior to bringing the collectors to the roof you should sweat the following items on the collectors while they are still on the ground;

- 2 – 1" couplings or unions to the side(s) between the collectors
- 1 – 1" pipe cap on the upper right header pipe of the collector to be mounted on the right (for a right to left flow)
- 1 – 1" pipe cap on the lower left header pipe of the collector to be mounted on the left (for a right to left flow)
- 1"- ¾" elbow (elbow pointed straight down) lower right header (for a right to left flow)
- 1"- ¾" elbow (elbow pointed straight down) on the upper left header (for a right to left flow)

6. With the mounting feet in place, place the collectors over the mounting feet securing the bottom of the collectors with the mounting feet. Slide the collectors together so the unions are touching. With the 1"x3/4" elbows, mark where the piping should penetrate the roof. Move the collectors and drill the roof penetrations for both the incoming and outgoing copper pipe.





Left to Right flow

Chapter 10: Charging the system

I recommend that prior to filling the system that you pressurize the system with compressed air to 60 p.s.i. to check for leaks. The system should be able to hold pressure for 15 minutes without pressure loss. Once you have insured that the system doesn't leak you are ready to fill the system.

Drainback:

1. If you have used a standard hot water tank for your drainback tank, with the use of a funnel (if there is a top mounted port) or the use of an inverted boiler drain, pour distilled water into the drainback reservoir until the reservoir is filled.
2. If you are using a top mounted port for filling, use a dipstick to determine when the water is close to the top of the drainback tank.
3. Once the drainback tank is filled, insert the brass plug or Pressure/Temperature valve prior to turning the system on.
4. Turn the system on and let it run for a few minutes.
5. Listen for the fall of water into the drainback tank to insure that the system is working. Once you are sure the system is working turn the pumps off.
6. Wait a few minutes. Check to make sure that the water returned to the same level that it was when you filled the tank. If it doesn't you need to double check to make sure you have enough slope on all of your components to allow proper drainage.

Glycol:

1. Using the shraeder valve on the bottom of the expansion tank release the pressure until the pressure is 30 lbs.
2. Open both boiler drains on the collector side of the loop.
3. Using a high head style piston pump, connect the outlet side of the pump with a washer hose to a boiler drain on the system.
4. Connect a flexible hose from the inlet side of the pump to a 5-gallon pail that contains a pre-mixed solution of inhibited propylene glycol and water. The maximum freeze temperature of your site determines the concentration of the mixture. Reference http://www.raypak.com/afreeze.htm and the NOAA weather data to determine the correct concentration.
5. Connect a hose from the other boiler drainback to the 5-gallon pail.
6. Turn the pump on and start charging the system. As the pump runs you should see air come out of the hose into the bucket. The air should quickly change to air mixed with glycol. If you keep the pump running you should see over time the amount of air coming out of the system reducing. Ultimately, you should not see any more air bubbles coming through the system.
7. Once the air bubbles have stopped close the exiting boiler drain valve.
8. Continue charging the system until the pressure (as measured by the pressure/temperature gauge on the system) reaches 15 psi + 2 psi for every foot of head.

Appendix A:
Destratification

One of the real concerns that people should consider when installing a solar hot water system is what to do about destratification. Your hot water heater (or any body of water) naturally has the hot water rise to the top. This is useful in a hot water heater since it allows the homeowner to enjoy the hottest water the tank has to offer since the hot out to the house comes from the top of the tank. In a solar hot water system where you use a single tank with a back-up element or where you have a pump circulating the water in the storage tank you have a chance to stir up the tank by over-pumping. This stirred up water can cause two problems; 1) by moving the colder bottom water around in the tank it can cause your element to fire (using energy) when you don't really need it, 2) by moving the colder water to the top the owner who thinks they are taking a hot shower gets water that is colder than they would like.

How do we handle destratification;

1. Use a special solar dip tube on the return of any heated water back into the tank. This dip tube has a closed end and multiple perforations down the length. This allows the return water to seep out rather than gush. See picture

2. Use a storage tank prior to feeding the pre-heated water into a tank with the back-up elements. This is a great solution for a retrofit since it allows you to hook up the solar system without taking out the existing hot water tank. (Be sure if you do this to turn off the lower element of the existing tank and turn back the upper element to maximize your solar gain)
3. Pump the water really slowly on the tank side of any two-pump system. I think this idea stinks!!! Remember the rules of how a heat exchanger works, speed is good. If you slow down to a crawl the storage tank side of the equation you are destroying your heat exchange through your heat exchanger.

   The SolarH2Ot Advantage: The SolarH2Ot Solvelox integrated packaged comes pre-assembled with a special dip tube already installed to prevent destratification. The system is also designed to pull the coldest water from the bottom of the tank or (if water is coming into the tank) the cold incoming water thus improving the overall efficiency of the system.

Appendix B:
Evacuated Tube collectors

Many times I have been asked, "what about evacuated tube collectors?"

Evacuated tube collectors are long cylindrical glass vacuum tubes that have a copper filament that extends down the length of them. A collection of these is connected to a separate header. The collection fluid flows through the header, which is coupled to each of the vacuum tubes.

The theory behind an evacuated tube is that since it is a vacuum it will resist shedding its gained heat back to the atmosphere. The argument is that it is much more efficient than flat plate collectors because of the vacuum. There is some truth to that claim.

SRCC has tested and certified a number of evacuated tube collectors. In the rating process they perform much better than flat plate collectors when the difference between the water's temperature going into the collector and the outside air is very high (144^0 F) and when that temperature differential is very high and the weather is cloudy. When the difference between the outside temperature and the water going into the collectors is not that great evacuated tube collectors perform much worse than flat plate collectors. Those are the published facts of the testing.

Studies have been run on the performance of evacuated tube collectors in Germany and the tests have shown that because of the superior vacuum that they possess they don't slough frost or snow well at all.

When you combine these published test results you end up with a conundrum. Evacuated tube collectors outperform flat plate collectors during the same conditions when evacuated tube collectors are likely to not perform at all. Huh? That's right. They perform best on the coldest of winter days, which happens to be the time when they are likely to be covered in frost and not perform at all. Even if they didn't have frost on them think about it this way. With a temperature differential of 144^0 F between the outside air and the water inlet temperature (generally around 120^0 F) the outside temperature would have to be -24^0 F for evacuated tube collectors to outperform flat plate collectors. Don't forget that that would need to be the temperature when the sun is shining. No solar collector collects any heat at night. Based on the reality of when it is coldest (at night) plus the problems with frost, I can't see evacuated tube collectors outperforming flat plate collectors.

Therefore, I can't recommend them for anybody using them for hot water or space heat. If somebody is interested in using them to power an adsorption chiller then they might be a good selection.

Appendix C:
Resource links

www.solarH2Ot.com - A full service solar thermal manufacturer and distributor. They carry pumps, controls, heat exchangers, valves, collectors, as well as manufacturing systems to ease installation. They provide engineering services for larger installations as well.

www.ases.org - A national organization dedicated to advancing solar energy.

http://www.azsolarcenter.com/technology/solarh20.html - A basic overview of solar hot water systems.

www.dsireusa.org - a website that provides all of the current state and federal tax credits as well as current utility incentives for renewable energy.

http://www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=12850 - Government website that provides a basic overview of solar hot water systems

http://www.estif.org/ - European solar thermal industry federation. Dedicated to promoting solar thermal use in Europe.

http://www.fsec.ucf.edu/solar/ - Florida solar energy corporation. Dedicated to testing of solar thermal systems

http://www.ncsc.ncsu.edu/ - North Carolina Solar Center. Dedicated to research and promotion of solar energy.

www.noaa.gov - The National Oceanic and Atmospheric Administration. A government agency that tracks weather across the country.

http://www.nrel.gov/ - The National Renewable Energy Laboratory. This is a government funded piece of the DOE focusing on testing and supporting all forms of renewable energy.

www.retscreen.net - A Canadian government sponsored website that gives estimated environmental and savings impact of renewable energy projects.

www.seia.org - The solar energy industry association website

Appendix D:
Environmental Impact

These numbers represent the environmental impact of installing 2 35,000 BTU per hour 4x8 black chrome collectors.

Per year this system will eliminate the production of

8,496 lbs of CO_2
20.4 NOX
34.8 SO_4

Over it's 20 year lifetime this system will eliminate the production of

169,920 lbs of CO_2
408.0 NOX
696.0 SO_4

Appendix E:
Pictures of installations

A Guide to Selecting &
Installing a Solar Hot Water Heater

Appendix F:

SOLARHOT Collector Specification Sheet

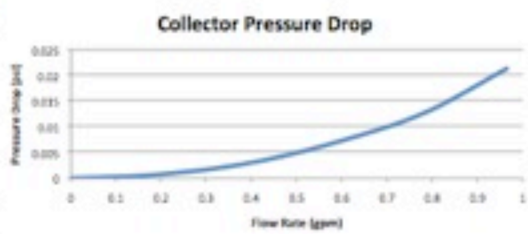
Platinum

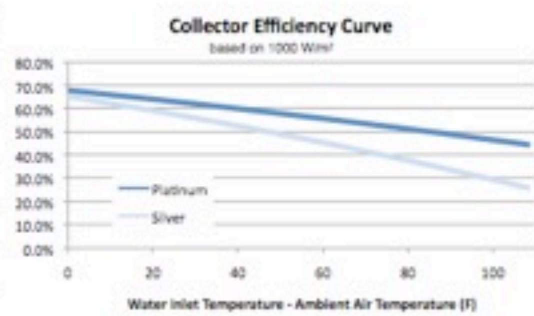
Category (Ti - Ta)	Clear 2000 Btu/ft^2•day			Mildly Cloudy 1500 Btu/ft^2•day			Cloudy 1000 Btu/ft^2•day		
	S-SC-126P26	S-SC-126P32	S-SC-126P40	S-SC-126P26	S-SC-126P32	S-SC-126P40	S-SC-126P26	S-SC-126P32	S-SC-126P40
T inlet fluid - T ambient air	Thousands of BTU per Panel per Day								
A (-9°F)	33	40	50	25	30	38	17	21	25
B (9°F)	30	37	45	22	27	33	14	17	21
C (36°F)	26	31	38	18	21	26	10	12	14
D (90°)	17	21	25	10	12	14	3	3	4
E (144°F)	9	11	14	3	4	4			

Silver

Category (Ti - Ta)	Clear 2000 Btu/ft^2•day			Mildly Cloudy 1500 Btu/ft^2•day			Cloudy 1000 Btu/ft^2•day		
	S-SC-126S26	S-SC-126S32	S-SC-126S40	S-SC-126S26	S-SC-126S32	S-SC-126S40	S-SC-126S26	S-SC-126S32	S-SC-126S40
T inlet fluid - T ambient air	Thousands of BTU per Panel per Day								
A (-9°F)	33	40		25	31		17	21	
B (9°F)	28	35		20	25		6	15	
C (36°F)	21	26		14	17		3	8	
D (90°)	9	10		3	3				
E (144°F)									

	S-SC-126P26 S-SC-126S26	S-SC-126P32 S-SC-126S32	S-SC-126P40 S-SC-126S40
Length	80.3 in	96 in	120 in
Width	47.2 in	47.2 in	47.2 in
Depth	3.7 in	3.7 in	3.7 in
Dry Weight Platinum Silver	98 lbs 89 lbs	121 lbs 110 lbs	137 lbs 137 lbs
Fill Weight Platinum Silver	106 lbs 97 lbs	130 lbs 119 lbs	147 lbs 147 lbs
Fluid Capacity	1 gal	1.1 gal	1.2 gal
Recommended Flow Rate	0.8-4.5 gpm		
Max Operating Pressure	80 psi		
Test Pressure	232 psi		
Nominal Header Diameter	1 in		
Header Center to Center	75 - 3/4 in	92 - 1/2 in	116 - 1/2 in
Frame	black anodized aluminum		
Absorber	Platinum - SunSelect Tinox coating on copper fins Silver- Selective black paint on copper fins		
Absorptivity / Emissivity	Platinum - 95% / 5% Silver - 90% / 25%		
Light Transmission	91%		





SOLARHOT
200-D East Johnson St
Cary, NC 27513
919.439.2387
www.solarhotusa.com

A Guide to Selecting &
Installing a Solar Hot Water Heater

SolVelox by solarH2Ot

The Solar Thermal package which converts any existing water heating system into a solar water heating system using our Patent Pending appliance.

- Available in Drainback and Glycol models.
- Pre-assembled system eliminates the hassle and cost of putting the components together on the job.
- No cast iron components in the system eliminates corrosion concerns.
- Mounts directly to the side of a standard 80 gallon hot water tank.
- Eliminates expensive closed loop storage tanks.
- Use on locally available hot water tanks.
- 50% more surface area for heat transfer than other brands.
- Comes with state of the art digital control.
- One SolVelox can heat storage tanks of any size.
- One SolVelox can heat multiple tanks.
- Our highly efficient heat exchange process means the pumps run less saving you even more money.
- Ideally suited for retrofits. Heat an existing water heater without adding a solar storage tank.
- Convenient ports for ease of descaling and an engineered particulate filter to prevent heat exchanger clogging (a requirement for any heat exchanger to insure optimum performance).

Making Solar Make Sense

solarH2Ot ltd 116 Vicksburg Dr. Cary, NC 27513 Tel: 919 656 9810 Fax: 919 573 0791

Submittal Data Information
SolVelox DB

Features

- All-in-one Heat Exchanger, Dual-sided circulators and electronic control package
- Brazed Plate Heat Exchanger
  - Stainless steel
  - Counter-flow design
  - Engineered particulate filter
- Only 4 pipe Connections required
- Solid State Microprocessor design
- Greatly Decreases Installation Time
- Substantial space savings
- Line cord included, Hard wire option
- Bronze casing on both pumps for corrosion resistance
- Replaceable cartridge design
- Maintenance free wet rotor circulators
- Large Back lit LCD Display
- Storage tank temperature limit
- Animated representation of solar

Application

The Solvelox is a complete solar pump package with everything you need to connect your solar panels to your storage tank. Integral to the unit are two high-efficiency bronze circulators, a brazed plate, counterflow heat exchanger and the electronics to drive it all. The Solvelox can be purchased to run either drainback or glycol based systems. This unparalleled flexibility within a single unit creates a pumping, heat exchange and control package that can be used in systems utilizing standard hot water tanks. Whether you are installing a solar domestic hot water system or a solar radiant heating system this package has it all. With just 4 piping connections needed, the Solvelox greatly reduces the time and space required for installation.

The features of the Solvelox make it easy and cost effective to include a solar hot water system in any new home or home remodeling project. The Solvelox makes the perfect companion for solar supported radiant heating systems as well. No need to work in confined spaces to make all the connections needed. All of the connections are done for you.

Operation

Cold water from the storage tank enters the Solvelox at port (A1) and exits at port (A2). The high-efficiency bronze circulator has been "flow-matched" to the unique requirements of your solar application. "Flow-matching" insures that the flow rate between the Solvelox's heat exchanger and the storage tank maximizes the heat exchange while minimizing the de-stratification of your storage tank. The heat exchanger is a counterflow style, so hot water from the solar panels, or drainback tank, enters at port (B1) and exits at port (B2). A high efficiency bronze circulator moves the water around the B (collector) side.

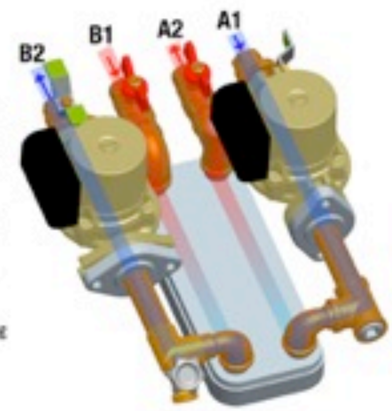
Performance Data

Collector Side – Drainback model
Flow Range: 0 – 11 GPM
Head Range: 0 – 33 Feet
Collector Side – Glycol model
Flow Range: 0 – 18 GPM
Head Range: 0 – 16.5 Feet
Storage Side – (both models)
Flow Range: 0 – 12 GPM
Head Range: 0 – 5.5 Feet
Minimum Fluid Temperature: 32°F (0°C)
Maximum Working Pressure: 125 psi
Connection Sizes: ¾" NPT

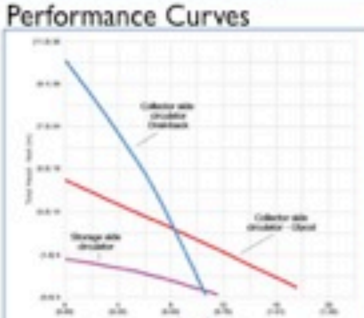
FOR INDOOR USE ONLY

Sizing and Piping

The Solvelox can handle transfer loads in excess of 240,000 BTUs per solar day making it suitable for larger hybrid space heating/domestic hot water systems. Your current method of piping virtually remains the same; yet standard storage tanks are used saving you time and aggravation. The glycol system comes complete with check valve, additional fill port, pressure relief valve, polypropylene lined expansion tank, line cord, and 2 sensors. Everything you need for fast, plug n' play connections.



Performance Curves



Model	Volts	Hz	Ph	Amps	HP	Ship Wt.
SolVelox Glycol	120	60	1	1.18	2@1/25	
SolVelox Drainback	120	60	1	1.48	1@1/25 1@1/20	

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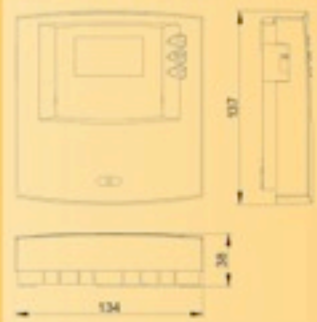
Solar Thermal Technology. Made by Steca.



3 Inputs | 1 Output

Steca TR 0301

Temperature Difference Controller

The controller TA 0301 was the first controller on the market to be equipped with a graphic display, on which an animated solar circuit of a solar energy system fully indicates the operating mode of the system. The consistent use of pictograms on the clearly arranged display ensures easy operation. The controller was jointly designed with an internationally renowned design centre. The controller is used for monitoring and controlling of solar thermal energy systems having a collector array and a storage tank. In addition, the controller also has important system monitoring and safety functions to ensure safe and durable operation of the entire system. The numerous additional functions of the bus-capable TR 0301 also include the option of limiting the storage tank temperature, a tube collector function, an anti-freeze function, a holiday and storage recool function as well as a choice of temperature indications in either degrees Celsius (°C) or Fahrenheit (F°). The operational safety of the system is also supported by a sophisticated fault diagnosis system. The multi-coloured LCD-backlighting ensures the swift and safe detection of errors and allows faults to be quickly rectified.

Features

- Backlight LCD display
- Animated representation of solar system functions
- Compact, 3 piece designer case
- Steca IS bus
- Output protected against overload / short circuit
- Tube collector function
- Holiday (storage recool) function
- Limitation of storage tank temperature
- Temperature display °C / °F

Temperature Difference Controller	TR 0301
System voltage	230 V (± 15 %), 50 Hz (optional 115 V (± 15 %), 60 Hz)
Max. self consumption	≤ 1 W
Inputs	3 3 x temperature determination (Pt1000)
Output	1 1 x switch output relay, max. 800 W (230 V)
Turn-on temperature difference	8 K
Turn-off temperature difference	4 K
Operation temperature range	0 °C...+45 °C
Animated LCD-Display	2 colour backlight
Protection class	IP 20 / DIN 40050
Weight	250 g
Dimensions l x w x h	137 x 134 x 38 mm

System examples

System with 1 storage tank

System with 1 storage tank and 3 temperature sensors

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About the author:

Dan Gretsch is a register Professional Engineer. He received his Bachelors and Masters Degrees in Engineering from the Georgia Institute of Technology. He has been a facilities engineer, Engineering Supervisor, Engineering Manager and Division Engineering Manager. He was responsible for improving the efficiency in the Cooper Hand Tools worldwide operations. In this role he was responsible for improving the efficiency and driving out waste in their 14 manufacturing locations worldwide. He has experience with renewable energy and efficiency improvement in North, South and Central America as well as Europe, Australia and Asia. He currently works as Vice President of Engineering for solarH_2Ot a renewable energy manufacturing company committed to making solar make sense. He lives in Cary, North Carolina with his wife and 4 children.