A Renewable Energy Section for
Plumbing, HVAC, Mechanical
and Related Industries

January-February
2012

Green Perspective™

Is solar hot water cost effective in Wisconsin?

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Photos courtesy of
Cardinal Heating &
Air Conditioning

"Are there enough sunny days in Wisconsin to make solar hot water heating cost effective? Should we be worried about pipes and solar collectors freezing in our environment?" These questions are common among building owners and trades people. They voice real concerns about the viability of solar thermal technology in the subfreezing temperatures we experience in the Midwest.

So, is there enough sun in Wisconsin? Absolutely. The number of sunny days per year in Milwaukee falls just 5% under the total number of sunny days in Daytona Beach, Fla. This information comes from the National Oceanic and Atmospheric Administration (NOAA), the result of compiling and averaging more than 50 years of weather data. Looking at it another way, Wisconsin sees more sunlight than Germany every year, and they are currently a world leader in solar thermal energy production.

The more critical concern is the potential for damage caused by freezing water in solar thermal collectors and pipes. However, there are hundreds of solar hot water systems in Wisconsin that have been producing free energy successfully for decades. The bottom line? Proper system design and installation along with quality components and basic maintenance make all the difference.

There are a few basic system designs that prevent freezing. One design approach drains the heat transfer fluid from the solar collector and any piping that could be exposed to freezing conditions. This can be accomplished two ways, either a drain-back or drain-down design.

Another design is generally referred to as a pressurized system. In a pressurized system the solar fluid remains

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exposed to outside temperatures but a large percentage of food-grade antifreeze (propylene glycol) is added to the water that flows in the solar closed loop.

In any case, the solar thermal systems installed in the Midwest are typically closed-loop—utilizing internal or external heat exchangers. Customers need to be assured that with proper components and installation, potable water will never come in direct contact with the heat-transfer fluid and that the potable water will never get circulated through the collectors.

DRAIN SYSTEMS

The Drain-back system is growing in popularity because it offers additional protection from freezing and overheating. When the system shuts off, all of the heat-transfer fluid drains back to a reservoir located in a temperature-controlled area of the building. Gravity never fails!

Here's how it works: A differential controller continuously monitors the collector temperature and compares it to stored water temperature. When the temperature of the collectors is 12-15° warmer than the water in the solar storage tank, the control sends a signal to activate the circulation pump. This circulation continues until the differential is somewhere around 3-5°. When that happens, the pump shuts off, and all the heat-transfer fluid drains back to the drain-back reservoir. One potential negative point in this design is that in order for these systems to operate properly, all the piping must be pitched back toward the drain-back tank. Code requires a ¼ inch drop in slope per foot. This is an important design element that must not be overlooked.

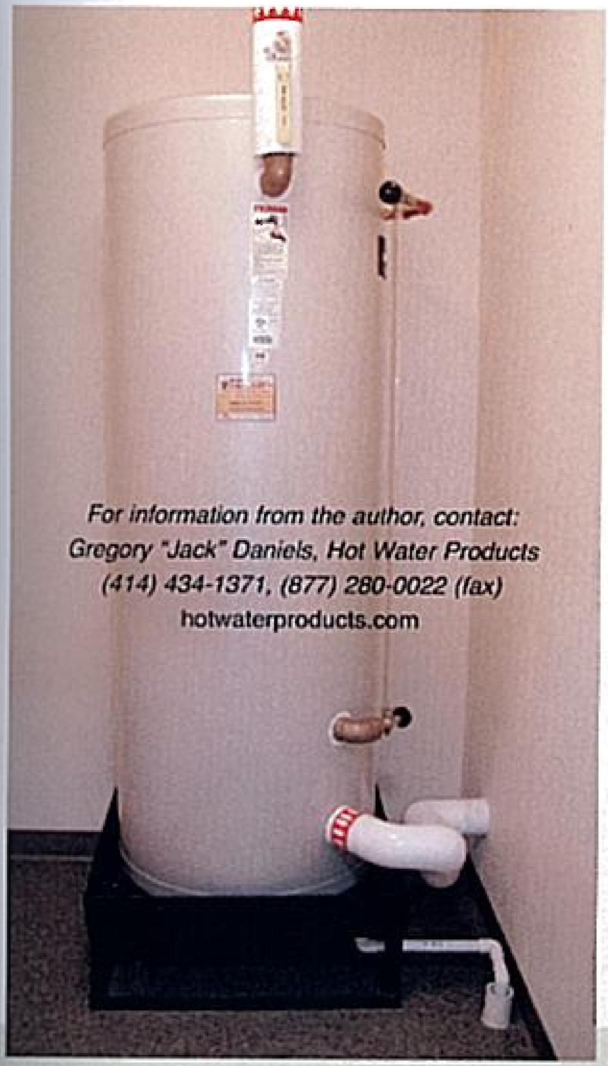
These systems will always contain a small amount of air, which some believe could cause the system to become air locked and cause the system to stop flowing. What actually happens is that when the flow of the fluid reaches the high point in the collector array and begins to fall back down the return piping, it entraps air and drags it down to the drain-back tank. Now, since the return piping is filled with fluid, it acts as a siphon. The siphoning action makes the system act like a pressurized system, which allows full circulation to continue until the differential on the controller is met or the tank is satisfied and the system shuts down again.

There are a few additional considerations with a drain-back system. Sometimes the total feet of vertical head from the drain-back tank to the top of the panel array is very high. This will require accurate sizing of the lift pump or a dual pump design. Another common concern is how well the solar collectors will hold up under high temperatures when the system is shut off if there is still a small amount of propylene glycol left in the collectors. If you use high-quality collectors there is really no need for concern. Some collector manufacturers even carry a 30-year warranty on the heat exchanger in the collector. Currently, drain-back systems can be used only with flat-panel solar collectors that do not have the serpentine absorber plate design. To quote an industry veteran, Tom Lane, "A drain-back system is the best system to install *anywhere*, when properly designed."

Another potential approach with a drain-back design is to forego using propylene glycol completely. If the system is designed properly, then all of the water should drain from the panels and piping that is exposed to external temperatures. That means that there is no need for antifreeze to be mixed with the water. Water is the best fluid for achieving maximum heat-transfer efficiency between the solar system and potable water system. This saves the customer money both in supplies and maintenance.

DRAIN-DOWN

Drain-down systems also use draining as the method of freeze protection. Drain-down systems work well in theory, but are abysmal in practice wherever there are freezing temperatures. The concept of the drain-down system goes like this—if a sensor on the panels detects near-freezing temperatures, a control will close solenoid valves to isolate the tank and open another solenoid valve to drain the collectors and exposed piping. There is a vacuum breaker at the top of the collectors to aid in drainage. Problems exist if one of the valves fails to open or close or if the sensor does not read the proper temperature. The other concern is that after the system drains and is refilled, the system is now filled with fresh water, which can lead to corrosion. The general consensus in the industry is to forego the use of this design. In fact, in Wisconsin, drain-down systems will not qualify Focus on Energy incentive rewards.



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PRESSURIZED ANTIFREEZE SYSTEM

In a pressurized solar thermal system the only thing that prevents freezing is a percentage of propylene glycol. In these applications the heat transfer fluid completely fills the closed-loop solar side of the solar thermal system. When the heat transfer fluid is exposed to freezing conditions it will can "gel-up" or become slushy, but it will not expand like water does when it freezes. This expansion could cause pipes to burst and equipment to be damaged. The downside to having antifreeze in your system is that it lowers the heat-transfer capabilities of the heat-transfer fluid. For example, a 50% mixture of propylene glycol lowers the Btu output by 30%. Glycol-based solutions are also more difficult to pump because they are more viscous. A 50% mixture of propylene glycol increases the head by 40-50%, so pumps have to be sized larger, which makes the system less energy efficient and typically more expensive.

One of the biggest concerns with antifreeze systems is stagnation. When the temperature of the stored water in an antifreeze system becomes satisfied, the pump shuts off and the circulation of the heat-transfer fluid stops. At this point the fluid will sit in the collector exposed to the sun. If the system is shut down for long enough in very high temperatures, the glycol could reach 350°. Glycol at these temperatures may become acidic and no longer be considered "food grade." Also, this acidic mixture is very corrosive to copper piping and heat exchangers. It may cause the pipes to wear away or worse, to develop a leak in the heat exchanger, causing cross contamination between the acidic glycol and the potable water. Not only is the situation expensive to repair, it is potentially dangerous. Stagnation can also occur if a power outage occurs on a sunny day and there is no backup power supply. This stagnation could cause the heat-transfer fluid to build up pressure, which will have to be relieved at a blow-off pressure relief valve. This leads to the loss of glycol, which can be expensive to replace. To prevent glycol from stagnating, the system has to be designed with ample storage or often a heat dump option is necessary. The heat dump could be a pool, a piece of finned radiator, a loop into the earth, or some other means to dissipate heat from the system. These provisions are costly and make the system much more complex.

In every case, a solar thermal system must be designed to meet the particular needs of each location and use. It is important to be aware of the benefits and pitfalls of all types of system design. Consulting with a qualified contractor or instructor will ensure that the solar thermal systems you install or purchase will typically go on producing energy for 30 to 40 years. ●