Shedding some light on adding more efficiency to radiant hydronics

By Eric Skiba

SOLAR Supplementation

Individuals nationwide are becoming more aware of their impact on the environment, and with fuel prices increasing a larger market segment is looking to save money and lessen their environmental impact at the same time. In recent years, solar thermal has risen again as a viable and cost-effective way to achieve both of these goals. By using solar for domestic hot water and space heating, a high-efficiency system that uses the sun's energy to supplement heating loads can be installed.

Solar thermal collectors convert energy from the sun directly into heat. Since this conversion is more efficient than converting electricity to heat, a solar thermal collector will capture more energy per square foot. A typical installation for domestic hot water consists of one or two glazed-type collectors which heat up a storage tank throughout the day to provide the home with between 50- and 80 percent of its hot water requirements.

However, there is a trend in the market toward installing larger systems—known as combination systems—that also contribute to a homes space heating demand.

For a large portion of the country, heating demands are one of the highest energy consumers for a residence, so offsetting some of this cost with renewable energy makes sense. Radiant heating systems are a perfect candidate for solar integration since the systems' operating temperature can be much lower than other systems. These temperatures are much easier to reach with solar in the winter than say, a baseboard heating system that operates at 180 degrees Fahrenheit. This is especially true in the "shoulder" months of winter when there is still plenty of available sunlight and the heating loads are relatively small.

Solar can only supplement a system. There will be times when even the largest solar array can't meet the heating load of a system, so there is still a need to install a traditional backup heating source that can be used on days where solar can't meet all of the demand. The solar system will integrate into radiant hydronic heating and hot water installations to provide solar energy when possible.

Contractors who are able to install these systems will differentiate themselves from others in the field. But the last thing you want to do is to rush out and start plumbing solar collectors into hydronic heating systems. The design and implementation of such systems can be difficult at times, and there are training sessions available to help installers understand how to properly size, design and install a solar combination system. There are a few key design points that will be the starting point for any solar combination system.

Sizing

Since the size and heating load for houses can vary quite a bit depending on the region, there are no "rules of thumb" for sizing the collector field. Most of the time roof space and cost are going to be the limiting factors when sizing a system. If you have more than enough roof space, the best way to size a system is to take the home's annual heating load and size the collector field to match a percentage of that, usually between 20- and 30 percent.

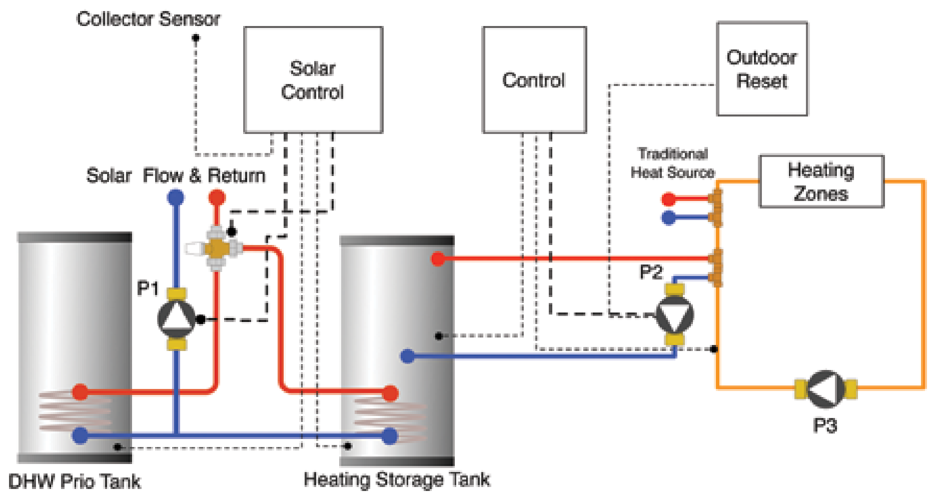
Overheating

A system of this type is going to produce an excess amount of energy in the summertime, a common issue with solar thermal systems. When there is no demand, the circulator will turn off and the collectors will sit hot on the roof, sometimes reaching temperatures exceeding 300 F. Since these combination systems are oversized so there's more energy collected in the winter, it's important that this issue be addressed.

The best way to use this excess energy is to distribute it somewhere that has a high energy demand in the summer time. When the hot water demand is met, pools and hot tubs can be a great place to put excess heat. If there is nowhere to use the extra heat the method of dealing with excess energy, and the issues associated, depend on what type of active solar system is being installed. Since combination systems will be installed in areas with colder temperatures pressurized glycol or drainback can be used.

Types of Systems

Pressurized systems that use antifreeze to keep from bursting during cold weather are very common across North America. In domestic applications antifreeze systems work great since they're sized so the collectors very rarely sit hot on the roof. In a combination system, though, the overheating situation is going to present itself often since the domestic tank will reach its temperature limit very quickly during sunny weather. The main concern in this situation is not the collector being too hot, but the ability of the heat transfer fluid to withstand such temperatures.



Tank priority system with pump injection. [NOTE: these schematics are conceptual and are missing valves, expansion tanks, etc.] Apricus graphic.

Almost all pressurized systems use a mixture of propylene glycol and water as a heat transfer fluid in the solar loop. Normal propylene glycol will begin to break down at temperatures of about 250 F, well below the stagnation temperature of some solar collectors. Over time the heat transfer fluid will degrade, reducing its ability to provide freeze protection and turning the fluid acidic; both of which can result in damage to the system. Since any service call on a solar system is going to reduce the return on investment, having to change the fluid once a year may not be a prudent solution.

High temperature glycols have an operating range that reaches the temperatures seen in a solar system. Certain codes and standards do not approve the use of these fluids with single wall heat exchangers; and in many places, single wall heat exchangers cannot be used regardless of the type of heat transfer fluid used.

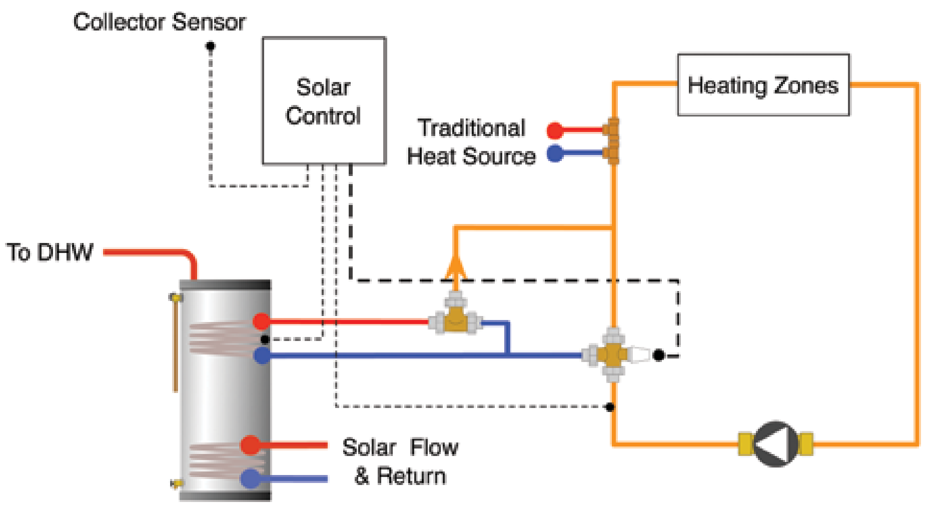
Drainback systems are designed in such a way that when the circulator isn't active the fluid in the solar piping (usually water) drains back to a holding tank leaving empty any piping that's exposed to freezing temperatures. This not only provides excellent freeze protection but overheating protection as well. Since the working fluid is water, whatever trace amounts of fluid are left after draining won't cause degradation after being overheated and the collector will stagnate empty without any damage to itself.

Storage

Collection of solar energy is only a part of how combination systems operate. Once the energy is collected, it must efficiently distribute the energy to the radiant system. Since the energy collected may not be used immediately, storage is important. There are two basic ways to set up a solar-assisted radiant system, one is to use tank priority, and the other is to use a single tank with a heat exchanger for the radiant.

Tank priority is a way of distributing solar energy between two storage tanks, one for domestic water, the other for radiant heat. One benefit of this type of system is there's finer control over where the solar energy is going. Since hotter water is more difficult to achieve in the winter, it may be more efficient to focus most of the solar energy on the heating load. In the case where the homeowner is using expensive electricity for water heating, domestic water may be the priority.

Using a single tank with two heat exchangers is another common method used in solar combination systems. In this type of system, the lower coil is reserved for solar and the top coil is used to pull energy into the heating system. One advan-



Twin-coil system with mixing valve protection. [NOTE: these schematics are conceptual and are missing valves, expansion tanks, etc.] Apricus graphic.

tage of this format is that the system has a smaller footprint. If using a tank priority set up, there may be a solar tank feeding yet another hot water tank, meaning three tanks would be needed. A dual coil tank brings the total count down to two. A disadvantage of a twin coil system is there is less control over where the energy is used. The heating system could remove most of the solar energy before the heated water reaches the domestic system. As long as the solar energy is being used though, it is contributing to savings somewhere.

Controls

A differential control is used to gauge whether it's appropriate to bring the solar energy into the heating system. The controller will measure the return temperature from the radiant system and the temperature from the solar storage tank. The point of measurement on the solar system depends on the type of system being used; for a dual coil system measurement is taken at the heating coil, for a tank priority system measure, the top of the solar storage tank. When there is enough energy from solar, the controller will bring that energy into the heating system.

It's important the connection between the solar heating supply be made as close to the return from the heating system as possible. Solar works best on lower temperatures so energy injection needs to happen before any other heat source raises the temperature in the heating loop. This will ensure the best possible contribution possible from solar. If solar can raise the return temperature enough, the boiler may not need to kick on at all.

Piping

There are two main options to bring the solar energy into the heating system; circulators or valves. The choice between the two will depend on the requirements of the project.

Using a diverting valve may be one of the simplest ways to bring solar into a heating system. When there is enough energy in solar (tank or coil), the valve just diverts the heating loop through the solar heat source. This is very simple and cost-effective but can cause problems by changing the system's flow rate and introducing new heat exchangers, tanks, piping etc. Another issue is, by doing "dumb" diversion, there is the potential of putting water that is too hot through the radiant system. One way to solve this issue is to put a mixing valve after the diverting loop to limit the temperature going back to the heating system. Some newer motorized valves may even be able to integrate outdoor reset into this type of system.

Another option is to use a circulator to bring the energy into the system. This works well since the circulator can be sized properly and primary/secondary piping can be used to ensure proper flow rates throughout the system. Again, consideration needs to be made regarding the potential to inject water into the system that is too hot. Thermostatic mixing valves still can be used to protect the system but a more elegant solution may be to use a variable speed pump operating with a temperature set point control. There are advanced controls now for circulators that will allow the set point to modulate based on outside reset which is crucial if components down the stream are using this. One issue to avoid is having solar injecting too much energy and causing the home to over heat which can happen during the shoulder months of the heating season.

Solutions

There is a lot to consider when putting a system like this together so it is important that products are selected carefully to minimize design errors and inefficient systems. There is a trend towards manufacturers integrating all these components into a pre-engineered package that allows the contractor to spend more time installing rather than designing and/or troubleshooting. Solutions like these are limited at the time but will become more prevalent in the coming years. Several of these systems are currently available in the market and industry trends suggest this is going to be a direction the market will head. Through careful planning and industry innovation more of these highly efficient systems are being installed, saving homeowners' money and fuel, all through the power of the sun. **RJ**

Eric Skiba is a technical engineer with Apricus Inc. and holds a degree in Mechanical Engineering from the University of Vermont. Apricus, a supplier of solar thermal systems with U.S. headquarters in Branford, Conn., will be unveiling its new solar hot water and space heating solution at the AHR show in Las Vegas [Check out the Calendar of Events on pg. 18 for all the details you'll need to register—Ed.] *Once there, come by booth N-3768 to learn more about this new and innovative product or visit* www.apricus.com.