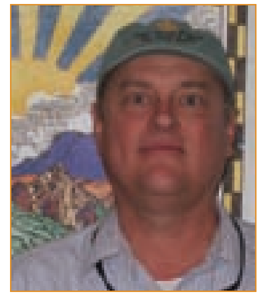
Solar Solutions

Bristol Stickney, technical director, Cedar Mountain Solar Systems, Santa Fe, N.M.



Bristol's six principles of good solar hydronic design

Overheat dissipation control: A brief case study

The need for solar heat dumping

In this series of articles, I have been making the case that the key ingredients for solar/hydronic design and installation can be divided into six categories, listed below, roughly in order of their importance.

1. RELIABILITY
2. EFFECTIVENESS
3. COMPATIBILITY
4. ELEGANCE
5. SERVICEABILITY
6. EFFICIENCY

The success of any solar hydronic home heating installation depends on the often-conflicting balance between any of these six principles. Finding the balance between them defines the art of solar heating design.

In small solar water heaters, using only one or two collectors, overheating may occur rarely, or never at all. But in larger solar heating combi-systems, overheating can be an annual event, occurring intermittently for weeks at a time, typically in the Fall just before the heating season begins. This is because, in the Fall, the sun angle is low enough in the sky to provide ample solar heat to the collectors even though this heat may not be needed in the house on a warm autumn day.

In a combi-system, it is possible to use this solar heat to provide domestic hot water (DHW). But there may be times when there is too much heat to be stored in the DHW tank alone. Some combi-systems may incorporate a pool or spa, or use an extra large water storage system or some other heating job to absorb this extra "free" heat, and this is preferable to dumping it. But, in the simplest solar home heating systems (I call these Combi 101 systems), the most practical solution is often to store as much solar heat as possible in the thermal mass and water tank, and then shed the extra heat in a controlled way during the "swing seasons."

Lets take a look at the details involved in dissipating heat from a Combi 101 solar hydronic system using closed loop glycol and flat plate solar collectors. Please look online to review previous episodes of this column in the *PE* and *Phc News* archives for more details regarding Combi 101 piping, wiring and other factors that make up a complete solar hydronic heating design.

The rules for heat dissipation control

The main reason for solar heat dissipation is to maintain a safe high-limit temperature during normal operation of the solar heat collectors. For lower-temperature propylene glycol (PG) mixtures this is around 225 F, and for PG mixtures formulated for higher temperatures the high limit is around 325 F. The high limit can be found in the manufacturer's specifications or user's manuals. Be sure you know what kind of glycol you have because the specifications change from one type to another.

Normal glycol mixtures are virtually transparent with a pH slightly higher than distilled water (slightly alkaline). When glycol gets too hot, it can "cook," which changes it chemically. Low-temperature glycol will begin to turn brown and will become a thick brown "goo" when cooked for a long time in a solar collector. High-temperature PG holds up much better, but cooking lowers the pH of any glycol, which becomes more acidic — and that can't be good for your plumbing and other metal components. Any glycol that remains in a solar collector for more than about half an hour without normal coolant pump operation may begin to cook. This includes leftover glycol residue inside of collectors that have been drained.

Using the Combi 101 solar heating control system as an example, a large bank of solar heat panels is used to heat a single DHW tank and a number of warm mass floors. The sample controls for this system (as seen in an earlier column) consist of a differential thermostat to heat the DHW tank, and some set point thermostats to control the

Continued on page 32

Continued from page 30

solar heat. Two stage room thermostats allow controlled solar heat banking in the mass floors in each room. The objective for this control system is to make the best use of the solar heat from day to day without exceeding human comfort conditions inside the house, while maintaining safe high-limit temperatures throughout the day.

The Combi 101 control system is designed to dissipate extra heat into a mass floor zone as a last resort to keep the solar collectors from exceeding the normal operational high-limit temperature. The following rules are implemented before solar heat dumping is allowed by this control system:

1. If the solar heat is hotter than the DHW tank, put heat into the tank. (A tempering valve is provided to allow this without danger of scalding at the faucets.)
2. If the DHW tank has reached a safe high limit (e.g. 165-180 F), stop delivering solar heat to the tank.
3. If there is a "stage 1" call for heat from any room (call for solar heat banking) and collectors are hot (e.g. 120-130 F), put solar heat into that mass floor.
4. If "stage 1" high-limit comfort temperature has been reached in the room, stop sending solar heat to that floor (e.g. 72-76 F).
5. If all four of the conditions above have been met and the collectors are still hot, continue pumping coolant around the solar collector loop until the glycol reaches its safe high-limit temperature (e.g. 180-200 F).
6. Turn on one or more mass floor zones to dissipate heat from the glycol until its temperature drops about 10-15 degrees below the safe high-limit temperature.
7. Repeat steps 5-7 until sunset.


Figure 16-1. Rooftop collectors of a combi-system.

If there is any plastic tubing near the solar hot pipes, you may choose to set the safe limit closer to 180 F to provide extra protection for the plastic. (Plastic pipe should never be used directly in the solar collector glycol loop.) All the temperature ranges shown above provide a reasonable starting point, but may need to be adjusted once the response of the house and its occupants have been taken into account.

A recent solar-combi example installation

The photo in Figure 16-1 shows the roof top collectors of a combi-system recently completed by Cedar Mountain Solar, and instrumented with the Beta version of the SLIC control system from SolarLogic (Solar Logic Integrated Control). The SLIC controller allows us to securely monitor this installation in real time from any computer on the internet, capture data from over 200 points in the heating system and change the settings (and the software) remotely if needed.

This installation is a solar heating retrofit to an existing home in Placitas, N.M. (near Albuquerque) with an existing hydronic boiler heating system and all radiant heated rooms using warm mass floors. The house is in a cold winter climate in the mountain foothills at 6,000 feet elevation and 36 degrees north latitude. The solar heating system is installed with a flow center just like a Combi 101, but because of the size of the house, this system now resembles a Combi 101 on steroids.

Instead of a single bank of collectors it has two banks of six panels, each with its own PV (photovoltaic) solar glycol pump, for a total of 12 collectors (4×10 size). You can see the two PV panels in the photo, one for each glycol pump and the collectors mounted the "low way" (landscape orientation) so they can be hidden behind the parapet walls on the roof. There are nine radiant floor heating zones and an 80-gallon solar DHW storage tank. The collectors are mounted at 75 degrees to provide maximum

Continued on page 34

Continued from page 32

heat in winter with ample solar DHW heat all year round.

Sample Temperature Data

Figure 16-2 shows a SLIC Data Graph of what happens at this house over a two-day period this Fall (Oct. 11-12, 2009) when heat is needed on Day 1 but not needed on Day 2 because of fluctuating outdoor air temperatures. Outdoor temperatures are shown on Figure 16-3 for reference, and solar data (not included here) proves that both days were equally clear and sunny. During this entire time the house was in "solar only mode" which prevents the boiler from firing when ever the solar heat supply pipe is hot.

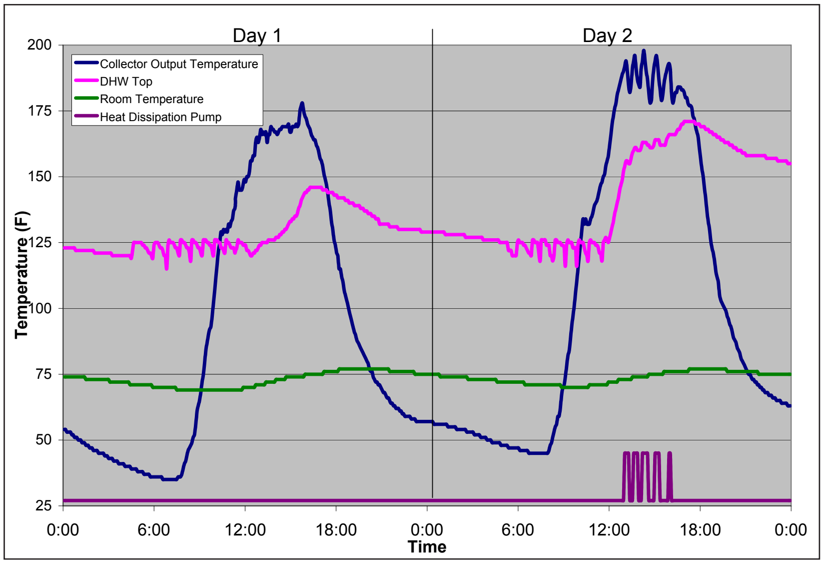


Figure 16-2

Dew point temperature is included to remind us how much cooling is available from these collectors at night if needed. In my experience, cooling can be achieved at night at a temperature about half way between the air temperature and the dew point.

Figure 16-2 shows that on Day 1, the night temperatures were cold enough to allow heat banking in the mass floors as soon as the sun came up. Heat banking continued until around 5 p.m. at which time the collector output temperature spiked as the heating load was turned off. The spike was not big enough to activate the heat dissipation control at the end of Day 1. Because of the "thermal flywheel effect" of the solar heated mass floors, the room continued to warm up and stay warm throughout the night.

On Day 2, the water tank absorbed as much heat as it could, but there was no call for heat banking because the house was a few degrees warmer than the previous morning. Just after high noon, the heat dissipation control took over and cycled on and off every 20 minutes or so to prevent the glycol temperature from reaching 200 F. The DHW tank appeared to reach its operating high limit near 170 F just before sunset.

Safety and comfort

During the sunny part of the day, the solar DHW tank absorbs heat, simultaneously as the floors are warmed by heat banking on Day 1 and also on Day 2 while heat dissipation is going on. The result can be scalding heat storage temperatures in the DHW tank. There is a thermal mixing valve on the outlet of the DHW tank to prevent scalding in the house.

The occupants of this house have an instant hot water circulator pump that is timer controlled and cycles every 15 minutes to provide the comfort and convenience of instant hot water at all the faucets in the house. Much of the continuous heat loss from the water tank and the temperature cycling in the early morning are largely due to this circulator constantly removing tempered hot water from the DHW tank.

Whenever I introduce the idea of heat dissipation to the mass floors, the question always comes up; "Won't this overheat the rooms inside the house"? The data in Figure 16-2 proves that the answer is "No." The glycol can be kept at a safe temperature without affecting human comfort in the house. If the solar heating system is designed and controlled properly there will be no problem. The data shows that the maximum room temperature remains the same during heat banking on Day 1 as it does on Day 2 during heat dissipation. The reason is partly because we

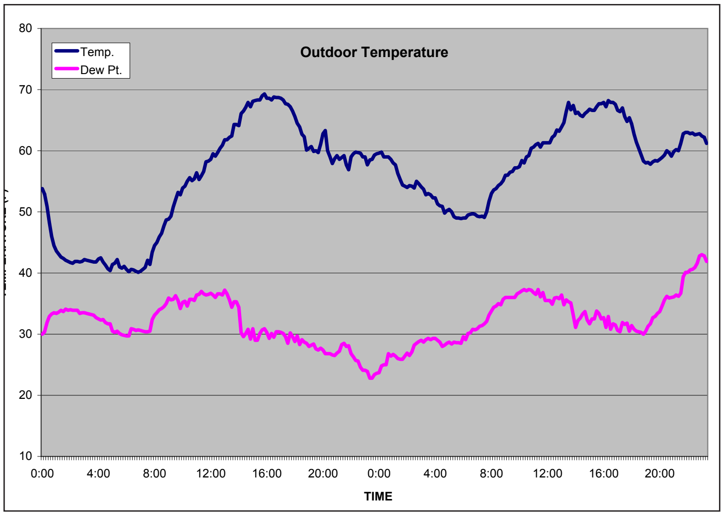


Figure 16-3.

are following the seven rules listed above to control overheating, but also because of the nature of solar collector thermal efficiency. A hot collector is less efficient, and loses a lot more heat to its surroundings than a cool collector. So when we let it heat up, it naturally tends to cool itself thanks to the laws of physics.

Final notes

This example is intended only to illustrate the concepts involved in solar heat and thermal mass when combined for solar space heating and DHW. Results will vary depending on regional and local conditions, as well as control settings. Brand names and manufacturers are mentioned only to provide examples for illustration and do not constitute any recommendation or endorsement. Some data values have been rounded off to simplify the presentation. Special thanks to Fred Milder at SolarLogic for sharing this data with us and to the homeowner in Placitas, Ken Dehoff, for agreeing to be a Beta Test Site for the SLIC. ■

Bristol Stickney*, partner and technical director at Cedar Mountain Solar Systems in Santa Fe, N.M., has been designing, manufacturing, engineering, repairing and installing solar hydronic heating systems for more than 30 years. He holds a Bachelor of Science in Mechanical Engineering and is a licensed Mechanical Contractor in New Mexico. He is the Chief Technical Officer for SolarLogic LLC and is involved in training programs for solar heating professionals (visit www.cedarmountainsolar.com for more training information.)*