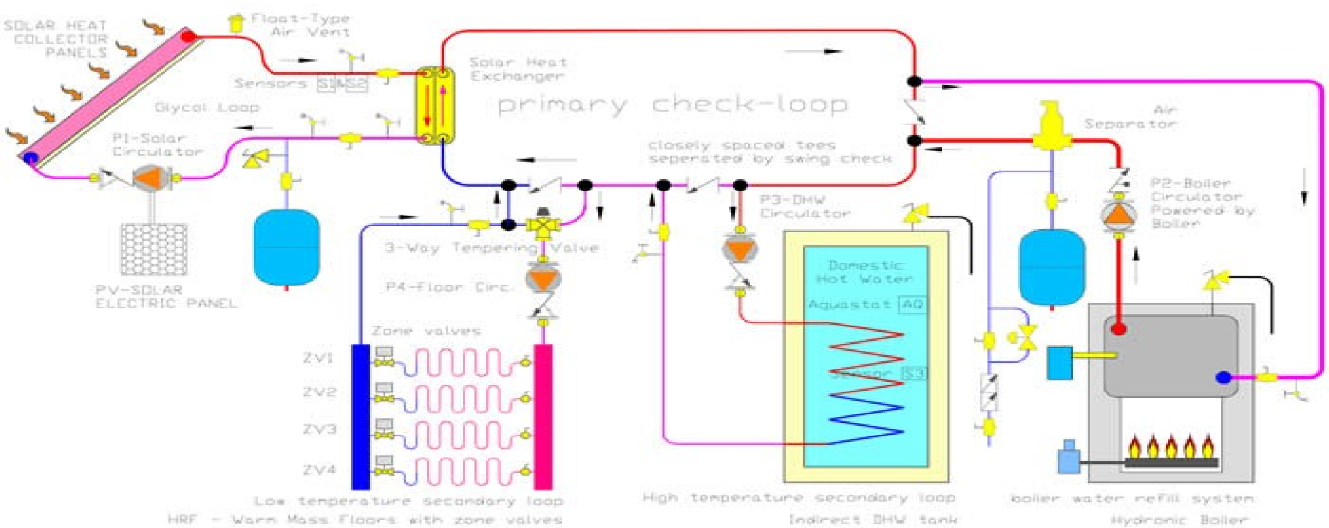
Beyond Solar Combi 101

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

A solar combisystem is a heating system designed to provide heat for both space heating and domestic hot water and includes supplementary (backup) heat, as well. There are many ways to design a combisystem. The International Energy Agency (IEA) has identified more than 20 "generic" versions of the solar combisystem, each requiring a unique piping configuration and different control strategy for collecting, storing and delivering heat. (Most include large water tank solar heat storage systems.) While this is useful and interesting for solar heating specialists, it actually defines the chief obstacle that must be overcome by mechanical contractors and installers. It is a daunting task to learn the finer points of 20 separate plumbing diagrams and their control requirements thoroughly enough to choose the right variation for each new heating application. The mechanical professional who has the time, the skill or the interest to do this successfully is the rare exception in the 'real world' of construction deadlines and budgets.

In an article a few months ago, I introduced a solar heating system I call Combi 101. Figure 20-1 shows the piping diagram for this system which contains the minimum components to qualify as a Solar Combisystem (including a hydronic boiler backup) using a piping configuration that I call the primary check-loop. This piping diagram provides a skeleton for many of the different versions of the generic combisystem, without the need to re-think all the piping connections each time a new variation is required for a building project. (The control wiring diagram originally published with the Combi 101 piping diagram a few months ago also provides a skeleton for the controls needed for all the hydronic equipment.) I have found that in order to include solar heating in many projects, the design time must be kept to a bare minimum. This is especially true in most residential and smaller commercial building projects.



When you reduce all the generic variations down to their basic elements, what you have is a bunch of different heating sources and a bunch of different heating loads. The primary check-loop (which can be assembled at the site or in a shop out of copper parts) provides the "socket" into which any number of sources and loads can be "plugged in." The Combi 101 has only two heat sources and two heat loads and can be duplicated in any small building that has those requirements. Let's take a look at some practical applications that go beyond this minimal solar heating system.

Multiple heat sources

Heat sources can be divided into two major types: Intermittent (alternative) versus On-Demand (conventional) heat sources. The Combi 101 uses two sources, the intermittent solar heat and the on-demand hydronic boiler. But there are many other sources of heat commonly available, and any one of them can be easily added to a primary check loop.

Let's not forget that the basic idea here is to allow easy access to more than one heating "fuel," and to give priority to the least expensive fuels first.

This idea not only works for solar heat, but also for wood- fired boilers, waste heat from gas powered generators or when several boilers are available using different fuels such as the combination of electric, oil, natural gas or propane. A ground source heat pump is another version of a hydronic boiler that runs on electricity. In some rare instances in areas known for their natural hot springs, high temperature geothermal heat is available where the ground temperature can be used as a heat source with or without a heat pump. In the future, fuel cells may become more widely available that generate both electricity and heat. Even a large pile of compost can generate enough heat to useful in some applications.

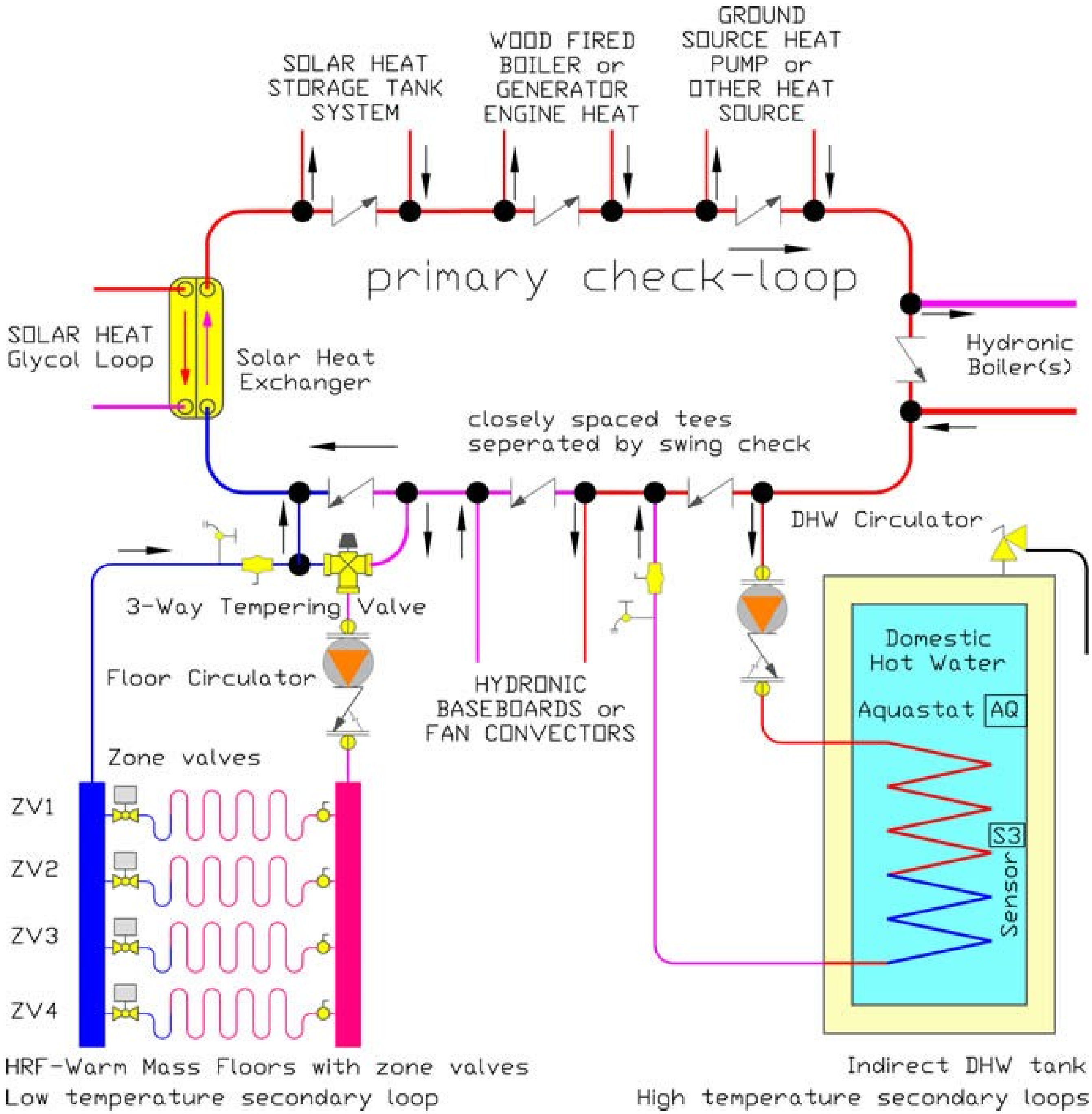
The point is that any one of these heat sources can be plugged into a heating system that is designed with a flow center like the Combi 101, without any major redesign of the piping connections. In Figure 20-2, the top of the primary check-loop shows the suggested piping locations of some of these heat sources. As you can see, each new heat source requires two tees and a swing check valve added to the primary pipe. The on-demand sources can be controlled much like the original boiler. The intermittent heat sources (which tend to be the cheaper fuels) can be controlled much like the solar heat is controlled. The cheaper fuels can be controlled (when available) to lock out the more expensive fuels, and also to provide pre-heat for them. Pre-heating is easily accomplished by connecting the on-demand sources down-stream from the intermittent sources.

Multiple heat loads

In the world of solar combisystems, we need to differentiate between several categories of heating loads. For our purposes, heat loads come in three types: Non-Mass, Mass and Reversible Heat Storage. Each of these types may require higher temperatures or lower temperatures depending upon the application. (The term "Mass" in this context refers to "Thermal Mass," which is the capability of a heavy substance like concrete or water to store heat due to its density and specific heat capacity.)

Non mass loads

Hot water baseboards, fan coils and non-mass hydronic warm floors (e.g. wood floors) are the most common non-mass heating loads. Heat is delivered to the air or light density materials so that heat storage is not possible. The most common baseboards and fan coils require higher temperatures than radiant warm floors. Because of this, the sample pipe connections shown in Figure 20-2 shows the baseboard supply tees installed up-stream of the supply to the warm floors. In solar hydronic heating systems, it is common practice to specify 'low temperature' baseboards or panels (e.g. Runtal, Myson) to make better use of lower temperature solar heat when it is available.



Mass heating loads

Domestic hot water (DHW) tanks, warm floors with mass (e.g. concrete, brick), pools and spas are the most common heating loads with high thermal mass. This allows heat to be stored in the concrete or water by raising its temperature within reasonable limits, as described in an earlier article. Since DHW tanks often require fast recovery during times of high DHW consumption, the DHW tank in Figure 20-2 is first in line to receive the hottest fluid from any of the heat sources. Since warm floors require lower temperatures, they are connected down-stream from the high temperature loads and controlled with a thermal mixing valve for finer control over the temperature response of the floors. Additional secondary loops for more floors or pool heating can be added down-stream, as well.

Reversible heat storage

Large Heat storage water tanks act like a mass heating load and can be controlled just like DHW water tanks when heat is being stored. But when the heating function is reversed and the stored heat is removed from the tanks, they act more like solar collectors and so must be controlled like an intermittent heat source. The heat storage supply tees in Figure 20-2 are located directly down-stream from the solar heat exchanger so that solar heat can be stored immediately as it arrives if it is not needed by the other heating loads. The same tees or the next pair down stream can be used for heat delivery from the tanks. This allows both the direct solar and the stored solar heat to provide pre-heat to all the other heat sources as well as heat to all the loads.

Flow center

I have designed and installed scores of combisystems using the primary check-loop configuration. The swing check allows any secondary pump to induce flow around the primary loop in the right direction without using a primary pump, which simplifies the control system. Secondary pumps with different flow rates simply mix their flows together as they go around the check-loop, just like in any hydraulic separator. The primary check-loop can be expanded to include more heat sources and more heat loads simply by adding tees and a swing check in the right location on the loop. In some retrofit applications, I have stretched the primary loop piping to extend across a building to connect several boiler rooms together so that all the equipment becomes part of one big solar heating system.

The same concept can be achieved using hydraulic flow separators, manifolds and pump modules that are available prefabricated from several hydronic equipment suppliers. In recent solar home heating designs we have adapted this type of equipment from Caleffi, PAW and PHP to perform the same functions as the check-loop flow center system. While the prefabricated component cost is usually not less expensive than the site-built components, the time and labor to install the heating system can be considerably faster.

For more information about generic solar combisystems, see the authoritative book from the IEA, Solar Heating Systems for Houses -- A Design Handbook for Solar Combisystems, edited by Werner Weiss, and printed in 2003. Brand names, organizations and manufacturers are mentioned in these articles only to provide examples for illustration and discussion and do not constitute any recommendation or endorsement. Most of the heating system details presented here are based on solar heating systems installed in recent years in northern New Mexico, mostly in residential sized buildings. The examples shown here have certain technical limitations of temperature control and flow rate and may not be appropriate in every installation.

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 information.