Solar Solutions

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Bristol's six principles of good solar hydronic design

10 Years of Solar Hydronic Evolution

Solar Heating Then and Now

Solar hydronic heating systems have been around for several decades in their present form and many different approaches have been tried with varying success. It is always useful to learn from the past, so that we are not always "reinventing the wheel" as solar heating systems are being installed in ever increasing numbers.

I have seen some successful innovations and trends over the last 10 years that are worthy of notice; some are innovations that I have tried or proven for myself, some are due to advances in new components and some are driven by what the clients are asking for.

Ten years ago, many of our clients were motivated by their concern about "Y2K," and their desire to become more self-reliant. Today people are concerned about the environment and the unstable cost of conventional energy, which can fluctuate wildly from year to year. Let's take a look at the ways that common solar hydronic installations have evolved over the past 10 years with a review of common practices "Then" and "Now."

Collector Mounting

Collector Tilt Then: Solar hydronic collectors were virtually always connected directly to water tank heat storage systems, and commonly still are to this day. Since water heaters work well year round with the tilt ranging from latitude to latitude plus 15 degrees from horizontal, this was the tilt most commonly assumed. This tilt is fine for waters heaters under constant heating load all year round.

Collector Tilt Now: Solar heating systems known as Combi systems have been increasingly popular because the same collectors can be used for multiple heating loads. The Combi systems in our region are now designed with minimal water storage and maximum direct solar heating using other types of heat storage such as radiant mass floors, pools, spa tubs, ice melt and anything else that needs heat at any time of the year. The tilt of the multipurpose collectors is designed differently to provide the right amount of heat to these various loads, during the seasons when the heat is needed. A warm mass floor using solar direct heat requires a more vertical tilt, while a heated pool used only in summer requires a more horizontal tilt. The final tilt chosen depends on the size of the collectors and the seasonal mixture of heating loads.

Higher Profiles Then: The majority of flat plate solar collectors manufactured in the past promoted high profile mounting. In other words, mounting them the "tall" way (or in "portrait" orientation). In most cases, the easiest, most economical way to install the collectors and the piping was to mount the collectors side by side with the long dimension standing up tall. If you wanted to mount them the "Low" way or "landscape" orientation, you had to add external copper headers extra elbows and sometimes extra pipe supports to keep the collector tube plate from sliding down hill inside the collector.

Lower Profiles Now: Some collector manufacturers now make low-mount collectors that are designed with internal headers that plug together side by side just like the tall versions do. These collectors are much easier to hide on a flat roof or a ground mount. They can be screened by low parapets, or low landscape elements much easier than tall collectors. Because of this, architects and homeowners alike tend to prefer them, especially when dealing with uncooperative neighbors or historical zoning districts with strict architectural restrictions. For aesthetic reasons, people seem to prefer flush mounting on walls and pitched roofs and low profiles if the collectors can not be flush.

Water Tank Heat Storage

Solar Domestic Hot Water Tanks Then: Glass-lined insulated preheat tanks with external "add-on" heat exchanger, circulator and piping were common. Stone-lined and stainless steel were less often used but readily available. In-tank heat exchangers were less common although available mostly as boiler side-arm tanks. In-tank heat exchanger with internal backup heat was harder to find but also available.

Solar Domestic Hot Water Tanks Now: An external heat exchanger uses more electrical pumping power, involves more heat loss, and is more likely to foul or clog with minerals when used on open potable water systems. I have found that internal heat exchanger tanks are more reliable, result in a higher solar thermal efficiency and require less maintenance. For these reasons more solar DHW installations make use of internal heat exchangers in water tanks these days. Also, there are more stainless steel tanks with internal heat exchanger to choose from (e.g. Amtrol, Triangle Tube, Oventrop). Because of the long life, higher thermal efficiency and lower maintenance costs, a higher initial cost for this equipment can be justified.

Atmospheric Heat Storage Tanks Then and Now: When storing large amounts of solar heat in a large water tank, the use of unpressurized insulated water containers has been a widespread common practice. Unpressurized containers are less expensive than tanks that can be pressurized. They are open to the atmosphere and so tend to loose water by evaporation. Since hydronic boiler fluid and potable hot water are both pressurized, they require heat exchangers, circulators and controls to extract the heat from the unpressurized water tank. So, the use of a low cost tank results in increased maintenance, increased electrical consumption and decreased thermal efficiency.

Continued on page 36

Continued from page 32

For these reasons, I have been using pressurized tanks almost exclusively in recent years.

Radiant Heated Floors

Solar heat storage in Warm Mass Floors Then and Now: Radiant heated mass (concrete) floors always have been used as an effective and comfortable distribution method for hydronic solar heat, even in some of the earliest installations. But, about 10 years ago we started thinking of them as "thermal mass" that can be used as solar heat storage. This idea was already fully implemented in well-designed passive solar houses of that era, designed to use interior mass walls and sunlit masonry floors to store solar heat gain through large south facing windows.

The passive solar heating effect can be duplicated using active solar hydronic collectors feeding heat into the mass floors directly. When it is controlled right, the floors warm up by day and discharge heat by night all within the comfort-temperature range thereby delaying or preventing the backup boiler from firing. When this heat storage is taken into account, insulated and controlled properly, the need for additional large water storage tanks can be eliminated.

This idea can also be carried over into concrete swimming pools and spa tubs. When radiant heat tubing is embedded in the floors and walls of a concrete pool, solar heat can be delivered in a controlled way, independent of the pool filter pump system. I installed my first solar heated swimming pool floor and hot tub floor systems just over ten years ago. Since then I have done a number of them both indoors and outdoors, and they have worked out quite well. Again, the temperature control, especially in the smaller hot tubs can be very important to the owner's satisfaction.

Overheat Prevention

Then: In the past, overheat protection for glycol-filled solar hydronic heat collector systems typically consisted of an oversized expansion tank, a high limit temperature switch and pressure relief valves. The solar collector coolant pump was shut off when things got too hot, and the expansion tank and relief valve were expected to take care of the resulting high temperature stagnation. I have always been in the habit of using photovoltaic powered solar circulators to prevent loss of coolant during daytime power failures and have always used ample expansion tanks, too.

Now: I like to keep the solar coolant pump running any time it is sunny. Systems that are not allowed to stagnate tend to last longer and require fewer repairs. There are more control options available these days that allow this to happen. More attention is being paid to prevent failures due to overheating. Heat dissipation systems, night sky radiant cooling systems and photovoltaic circulator pumps are all part of the mix. Lately we have also been using night sky radiant cooling for comfort-cooling of hydronic mass floors by running the solar floor heating system at night in summer.

Piping and Components

Components Then: Most large solar heating systems were assembled piece by piece and piping could become a confusing puzzle for the installation crew, working from a one-of-a-kind "spaghetti diagram" of piping and wiring. We began using a standard primary/secondary piping design in an attempt to make the mechanical room assembly more modular and repeatable. The modular piping system allowed for the controls to be more easily duplicated as well.

Modular Now: Our modular primary loop systems are slowly being transformed by the ever increasing availability of multi-function components. Circulators with built in check valves, flanges with built in ball valves, charge ports with three valves in one unit. These components are more compact, and not only save space but save labor during installation. There is a much bigger choice of these components available than ever before and there is even a photovoltaic circulator now that includes a check valve, air vent, valve and unions built into the pump body. The next generation of modules has recently arrived from Europe, where modular pump stations and prefabricated pump manifolds and flow separators are used instead of small primary loops. We have been trying this equipment in solar heating installations and intend to keep using it, mostly because of the ease of assembly with this "snap together" approach.

Collectors

Then and Now: Solar heat collector technology has not changed much in the last 10 years. Flat plate absorber surfaces were and still are mostly coated with selective black surfaces, and covered with a single layer of tempered glass that is low iron and high transmission. The frames and insulation are designed to withstand severe weather and "oven" temperatures without failure. Collectors are tested and rated by the SRCC, and when you look at the ratings today, there are many sizes and brands to work with, and collectors with similar construction tend to perform similar to one another. There are many more companies listed now that offer vacuum tube collectors and they may be worth considering in colder, cloudier climates where high temperatures are needed. But, flat plate panels tend cost less and perform well through out most of the country for common water heating jobs. Collector manufacturers now offer more accessories like mounting clamps, union connections and other prefab hardware that can make an installation go quicker.

Regional Results May Vary

This article presents a brief snapshot of solar heating developments in my region. If your situation is much different than ours, you may be seeing different innovations with different kinds of equipment. It is always a good idea to talk to local solar suppliers and solar installers for a reality check before investing heavily in one technology over another. ■

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