Combining Solar HW with Radiant Floor using a Demand Water Heater back-up and a Tempering Tank with a line voltage three-way valve to prevent heating the solar storage with the gas DHW.

A short list of design themes that are guiding the work we are doing with the combination of solar thermal and radiant heat gained from many years of trial and error and a fair bit of study.
Absolutely stop mixing potable water and radiant floor water.

I can’t really lay any incidents of Legionnaires related pneumonia on domestic - radiant loops but the odds just don’t justify the costs, which turn out to be minimal. I’ve had to bleed out potable floor loops at the beginning of the fall to clear air bubbles and the color of the water that comes out after being stagnant in the pipes all summer is concerning. Sediment drops out of the well water into the loops as the concrete absorbs the heat and during the summer this sediment can grow bacteria, not what you want to have spraying on you in the shower. Plus, I’ve had to repair two systems that had leaks in the slab floor loops, with a potable loop these leaks can cause flooding, with a closed loop they just cause pressure drop and air in the pumps.

The primary-secondary pumping scheme discussed in Dave Holohan’s “radiant heating for the non-engineer installer” addresses the overheating problem that some slab systems are prone to by using one small pump to circulate the water in the floor 24 hrs a day while a second pump adds heat when called for by the thermostat. When the warming pump shuts down the spin pump keeps the heat flowing out through the concrete so it doesn’t just stop and go straight up into the room above but spreads out and is released more slowly, the down side is that the spin pump draws about 60 watts 24 hours a day, which I’m working on a solution for involving a clock timer.

Running the floor loop through a flat plate heat exchanger with the spin pump and using the warming pump to add BTUs to that heat exchanger isolates the floor from the house and lets us drop the pressure to about 20 psi and reduce flood risk while also keeping the minerals from building up in the floor loops. Low mass “staple up” type systems don’t have the delayed heating problem we see in slabs so don’t need the spin pump to run 24/7.

I’m partial to flat plate heat exchangers (sit in a sauna for a while and then blow on your hand, heat transfers better with turbulence) but on staple-up type low mass radiant floors we may still use coil-in-tank heat exchangers on a single pump system.
Stick with drain-back solar thermal systems

Drain-back systems tolerate excessive panel area to tank size by draining the panel when the tank bottom sensor reaches 170 degrees in the summer whereas a propylene glycol system will run into problems if the antifreeze is constantly steaming out of the panels in the summer. This limits the size of antifreeze systems to just enough to heat most of your domestic hot water.

Some designers have increased the size of the storage tank to compensate for increasing the panel area for radiant heating and have run into problems with the big (1,500gallon+) tanks. If you have the room for the panels, you can jump the daily heating potential quite a bit by adding panels without increasing the cost of the tank and the rest of the infrastructure.

Locate the drain back tank and heat exchanger as close to the panels as possible, it does not need to be adjacent to the storage tank and it benefits from having the least rise possible from the heat exchanger to the panels.
3 Never heat the solar tank with the radiant floor.

It’s easier to heat cold water than hot. If the solar tank falls below 120 degrees leave that heat in there to feed the domestic hot water needs of the house rather than try to squeeze every last BTU out for the floor and ending up inadvertently using the back-up gas heat to keep the solar storage tank warm.

A motorized three-way valve can be hooked up to a thermostat in the top of the solar storage tank (the one that normally controls the upper electric heating element) so that if water over 130 degrees is available the switch is open (element off) and the water flows from the tempering tank through the solar tank to re-heat the tempering tank when it is chilled by the floor. When the solar tank is below 130 the switch closes (trying to turn the element on) which energizes the three way switch and the reheat loop is diverted through the demand water heater. No power is sent to the three way switch unless the pump is on. All cold water enters the system in the solar tank so any domestic water use advances hot water from the top of the solar tank to the tempering tank. The thermostat at the bottom of the tempering tank controls the re-heat pump when the radiant floor draws heat from that tank which also supplies power to the three way valve if the solar tank is cooler than 130 degrees.

4 Minimize the use of low voltage controllers.

We need to use low-voltage differential temperature controllers to provide the differential temperature controller “brains” for drain-back and propylene glycol systems but they seem to be vulnerable to power surges so the fewer of this type of controllers we can have in the system the more rugged they’ll be in the long run.

Use molded end line sets, cut ends of grounded extension cords, to connect pumps (and even switches if required by your local inspector) so swapping out pumps and tanks won’t require a visit from the electrician.
5 Design around easily available electric water heaters

Units with 1” threaded heating elements give you extra ports for pumps and hot water outlets. The price is usually right for 80 gallon tanks and the sources of supply are generally just around the corner. If you need more storage you can just add more tanks in series.

Coil-in-tank heat exchangers are generally not as efficient, flexible or economical as flat plate heat exchangers. Marathon high performance tanks and rubber tub-style open top tanks are readily available but there is much to be said for grabbing the biggest tank they have in stock locally and working with that.

6 Take control of pipe turbulence.

Pipes are like rivers. When the water flows around an elbow there are eddies. An elbow at the top of the hot water tank starts the flow off with turbulence in it which mixes hot and cold together so you get warm water at the faucet long before you get hot. Gary Klein has done a lot of the research on residential hot water distribution. He advises that we eliminate all elbows and bull head tees in hot water lines to minimize turbulence that minimizes hot and cold in the run of the pipe and delays delivery to the faucet.

However, when water re-enters a tank from a heat exchange loop an elbow close to the tank will add turbulence to help gentle the stirring effect of the water flow entering the tank. In the illustration we are returning the water from the demand water heater to the tempering tank through a 1” pipe nipple screwed into the tank where the electric element has been removed. This would have a 1” brass elbow on it with a 1”x ¾” bushing and a ¾” pex adapter. The water leaves the ¾” pipe with momentum but the combination of the elbow
with the larger pipe diameter gives it a very turbulent and gentle flow into the top of the tank. The problem we were having was that a sudden input of water into the tank could “roll the tank” causing the hot water at the top to roll down to the bottom and bring cold water to the top where it would cool the water leaving the tank towards the owners shower. This was bad.

7 Eliminate check valves.

They just seem to get jammed at half-open position and can be devilish to diagnose, even the expensive 300 psi brass gate checks with the stainless hinge pins seem to be prone to this.

8 Look out for thermo-siphon prone lay-outs.

Locate the radiant floor heat exchanger below the tempering tank to keep it from thermo-siphoning heat out of the tank when the heat is off. Use a heat trap at the out-flow to the house.

9 Look out for un-intended pressure differentials.

When one pipe with a pump on it is connected with a tee to another pipe with a pump on it you run the risk of creating a relative point of high pressure at that tee that could drive water through the idle pump creating flow in a place where flow is not desired. Break pump loops apart rather than rely on check valves to control this. Check valves fail at precisely this sort of low flow situation.

10 Dump the “boards,”

It’s important to let your systems express what they are doing by the way the pipe layouts are visually clear to a future service tech what part controls what process.

Mount the pumps and valves on threaded pipe directly on the tanks and heat exchangers.

Mounting all your components on a piece of plywood and then piping it across the room to the tanks and pumps just makes things more confusing and makes future service more complex. Don’t layer the pipes up into a three dimensional matrix either (boy have I been guilty of this over the years).
Mount pumps in a vertical flow orientation.

Bubbles are the death of pumps. Bubbles want to go up. Let that happen.

Locate air elimination devices at the point of lowest relative pressure.

Bubbles drop out of closed systems between the restriction of the heat exchanger and the intake of the pump which is the place to locate the bleeder valve and the purge valve.

Use counter-sprial radiant pipe lay-out

Starting with a doubled pipe in the middle of the floor and then spiraling out towards the manifold will get the flow to the center of the room quickly and return back so that every other pipe is running in the opposite direction and is inversely distant from the heat source. Starting at one side of the room and running back and forth to the other side means that one side is closer to the heat source than the other.

Use equal length loops within any radiant manifold.

Pipe runs have resistance proportional to their length. If all the runs on a manifold are the same length they will all have similar resistance and share the flow equally. If one of the pipes is shorter than the rest it will have less resistance and get more flow.
15  Break out pipe subassemblies for service.

Let’s face it, it’s a whole lot easier to chase leaks if thoughtfully placed isolation flanges and unions with ball valves allow major components to be serviced or replaced without draining and dismantling the whole system.

16  Lay off the copper

Except where the pipes are likely to get hotter than 130 degrees.

If PEX will get the job done then go ahead and use it. Threaded brass fittings are expensive but they can support the weight of pumps and valves and earn their keep.

17  Don’t pan individual components, pan the whole area.

I’ve used round commercial drain pans do meet code, but what is the point of “meeting code” when you have water on the floor. We make pans out of EPDM roofing or PVC shower membranes and just line the entire area with a two inch drain to daylight with no trap.