SHW RETROFIT

by John Vastyan
photos by Holly Noel

The first of this two-part series focused on the Wenger home's "regreening," including insulation upgrades and a geothermal-to-radiant heating system. In this part, the Wengers are still on the efficiency path—this time integrating solar-thermal equipment for additional space and water heating.

The Oventrop flat-plate collector is installed on the house's roof (the detached garage is in the background).

Few would consider Pennsylvania the "sunshine state." Compared with Florida and the Southwest, it certainly gets less solar radiation—but, surprisingly, it gets more than enough to make solar viable. In most areas of the United States, there's sufficient solar energy to offset a significant portion of your electricity and water-heating bills.

"Give a few solar collectors 6 or 7 hours of southern exposure and amazing things can happen, even in our state," says Dave Yates, president of York, Pennsylvania-based FW Behler, a contracting firm that specializes in energy-efficient mechanical systems.

In 2008, Yates's firm was tapped by Travis and Rachel Wenger to give their 2,400-square-foot, three-bedroom log home a substantial mechanical makeover. As the Wengers embarked on a whole-house remodel—replacing the plumbing, mechanical and electrical systems—Yates's task was to install geothermal systems for radiant heating and air-conditioning (see "Geo to Radiant Retrofit" in *HP134*).

After those mechanical systems were installed, Yates turned his attention to the solar thermal solution. "We saved the best part for last," says Travis. In the fall of 2009, Yates's crew arrived at the Wenger house with a truckload of solar gear that would soon meet a large part of the home's domestic water-heating load. Surplus production would be diverted to the home's geo-to-radiant heat system.

Yates makes the roof penetrations for the thermal lines.

The sweating of the thermal line-sets begins.

Inserting the evacuated tubes into the header.

Clipping the bottom of the tubes into the lower end of the rack.

The Wengers' house on their 16-acre mountainside property is their indoor refuge during the six-month heating season. And, from April through September, when sunshine is at its best, they use the home as base camp for "waves of visitors" who come to hike, bike, and enjoy water sports.

"Having enough hot water for showers, baths, and washing clothes and dishes was going to be a real challenge with eight to 12 people in the house," says Rachel. "When we brought this to Dave Yates's attention, he offered the concept of tying in solar water heating. That struck us as a great idea."

Fortunately, the Wengers and Yates had this conversation early on, when Yates was designing the home's new heating system. Domestic hot water (DHW) sizing was calculated using the solar thermal resource combined with second-stage electric heating elements that would kick on as required to aid in recovery. Yates used his Solar Pathfinder, a solar siting tool, to determine the viability and yearly potential for solar domestic hot water to supplement the home's hot-water supply.

Yates calculated that a 4- by 8-foot flat-plate collector and one 16-tube evacuated-tube collector would exceed the Wengers' domestic water-heating needs during the summer and provide approximately 30% of the DHW load during poorer winter conditions.

"Flat-plate collectors lose some heat (10%) to the surrounding air," says Yates, "and the hotter the fluid, the faster the Btu go airborne. For this system to operate at peak efficiency, the flat-plate collectors handle the first stage, receiving the coolest water first.

"Vacuum tubes lose very little heat to the surrounding air," says Yates, "so we're gaining in efficiency by sending the warmed water from the flat-plate collector to the evacuated-tube collector. [Marrying the two types of collectors] also provides better economy because flat plates cost less than the equivalent number of evacuated tubes. Basically, the Wengers' 'hybrid' two-collector system is equal to three 4-by-8 flat-plate collectors, but will have higher performance. Although it's not done often—in fact, it's seldom tried— the Wengers were good

Tech Specs

Overview

System type: Closed-loop glycol solar hot water

Location: Central Pennsylvania

Solar resource: 4.4 average daily peak sun-hours

Ave. Monthly Production: 820,161 Btu

Hot water produced annually: 83%

Equipment

Collectors: Oventrop OV-5 16-tube collector; Oventrop OVF-32 flat-plate collector

Collector installation: Roof-mounted on south-facing roof at 45° (flat-plate collector) and parallel to roof plane (evacuated-tube collector)

Heat-transfer fluid: Glycol-water mixture

Circulation pump: Regusol 169-80-65

Pump controller: Regusol 130 pumping station

Storage

Tanks: Bradford White, 120 gal.

Heat exchanger: Bradford White

Backup DHW: Bradford White, 80 gal.

System Performance Metering

Thermometer: Regusol 169-80-65

sports and willing to let me experiment, and Oventrop's Peter Biondo was instrumental in getting this design used."

Because the Wengers would be absent from the property for extended times, Yates looked into integrating excess solar heat-energy into the home's radiant heating system once the DHW target-storage temperature was satisfied. Fortunately, there was an off-the-shelf solution. Watts Radiant builds a control panel—the Source-Select—exactly for this purpose. Designed to easily integrate multiple heat sources, typically a renewable source with backup, it was ideal for the Wengers' system. When their water heater reaches a set temperature, the control panel senses the additional heat from the solar thermal system and activates the pumps to redirect the solar-heated water into the home's hydronic radiant heating system.

Sunny Side Specifics

The two solar thermal collectors were mounted on the south-facing roof. When the Oventrop control unit senses the collectors are heating up, it circulates a glycol solution through the collectors. The heat-transfer fluid circulates through insulated lines that run to the basement where it enters the lower heat exchanger in a 120-gallon, twin-coil Bradford White indirect water heater. The separate, upper stainless steel coil is the business end of the unit—where it preheats water coming into the 80-gallon Bradford White electric water heater beside it.

"Bringing incoming ground water up to 120°F is where the lion's share of Btu are consumed in heating domestic water," says Yates. "By preheating it with the sun, everyone wins." The Wengers save energy and, in the long term, money on their utility bills.

Capturing Another Renewable Resource

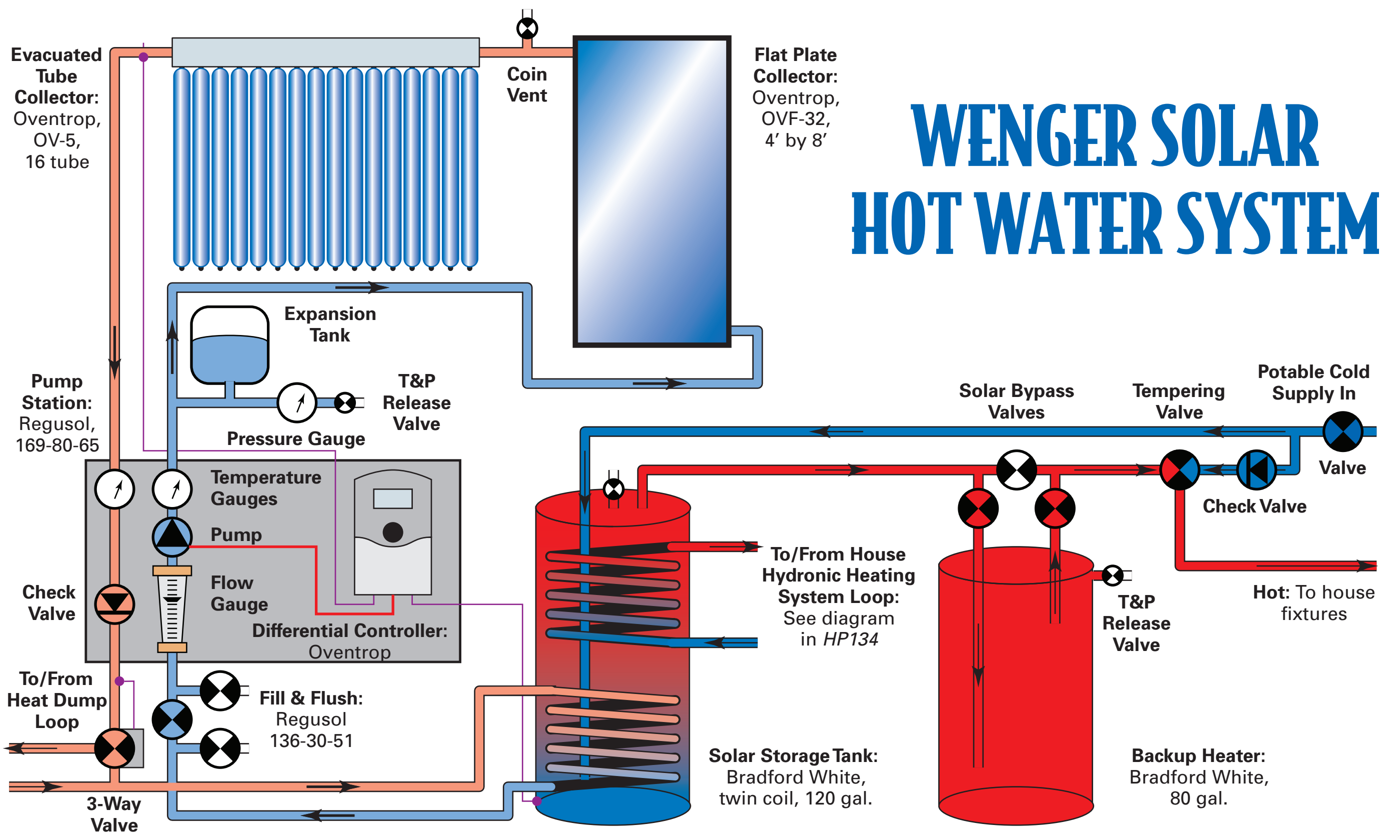
Near the garage, the Wengers sunk a 1,700-gallon rainwater storage tank. Garage downspouts go underground to supply it. Though the water could have been diverted to the toilets for greywater flushing, the Wengers use it all to irrigate the 125 trees they planted.

"It was ideal, because last summer was relatively dry," says Travis Wenger. "We would have put a huge strain on the pump and the well to provide water for all of the trees. But the few heavy rainfalls we had easily filled the catchment tank, giving us all the water we needed to sustain them. In 10 years or so, we'll have our own made-to-order forest."

Getting the tank in the ground was a bigger task than they anticipated, but local excavator Denny Runk made easy sport of it. With a backhoe, Runk dug a 10-foot-wide by 12-foot-deep crater and lowered the tank onto a two-foot bed of sand. He then filled the hole around the tank, while Travis and Rachel tamped sand and stone dust tightly around it with each new bucket load. It took about 30 tons of sand and stone dust to surround the tank with a protective cocoon. Then, the piping and wiring for the submersible pump were dug in.

The tank is now completely underground with only a frost-free faucet above ground. The Wengers simply connect a line or two of hose to the faucet and water with the captured cloudbursts.

Wenger Solar Hot Water System



Storage tanks and pump-stack/controller.

Yates had previously surveyed the location during earlier trips to the Wenger property, noting that the south-facing rooftop received solar radiation from 8 or 9 a.m. until late in the afternoon. The Solar Pathfinder confirmed that the solar window was unobstructed by surrounding woodlands, although a chimney's shadow would need to be avoided.

For enhanced winter production, Yates chose to tilt the flat panel at 45° to favor solar harvesting in winter. The evacuated-tube collector was installed parallel with the roofline—at 25 degrees—for optimal year-round production. Snow melts rapidly in the winter on the Wengers' south-facing roof, so that wasn't a concern and future plans call for tilting both at 39° to further experiment with achieving better performance.

A 60-foot-long coil of thick-walled, soft copper tubing, buried in a large hole behind the house and entombed in well-packed sand, serves as a summer heat sink "To prevent the system from overheating, we needed a dump zone," explains Scott Barnett, a technician at FW Behler. "If the Wengers weren't home and no solar-heated water was being used, especially on a summer day with maximum solar heat, we needed to ensure that excess heat had a place to go. And we thought the best place to divert it was to earth."

Homeowners Travis and Rachel enjoy the great outdoors at their rural retreat.

If the solar tank hits 120°F, and the electric water heater also has met its set-point of 140°F (to control bacteria), a control diverts the heated glycol/water mixture into the heat-dump coil to disburse the excess heat into the sand around it.

Yates says that, even on a cloudy day, Travis and Rachel's system can expect a solar gain between 2,000 and 10,000 Btu. "For maximum, mid-summer gain, the system is estimated to receive 60,000 to 80,000 Btu of solar-heated energy each day—enough to heat 148 gallons from 55°F to 120°F. That's a lot of free energy."

"The Wengers now have one of the best solutions for efficient heating, and will probably see a 60% to 80% drop in energy expenses this year compared to their first year in the home," says Yates. "The carbon footprint got a lot smaller, but they've added tremendously to the size of their comfort zone."

Access

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