A simple solar hot water heater for the tropics

Like most houses in Costa Rica, our casita in Monteverde had no hot water. Our two showers were fitted with electric shower heads. At best, these take a little of the chill off the water. Sometimes it is difficult to know if they are even working, yet they use a great deal of electricity to do even that modest job. Further, having electrical wires attached to the showerhead does not inspire confidence. Solar hot water seemed to present a great opportunity to generate more and hotter water at minimal cost, while being safer and more ecologically sound. Since solar is not commonly used locally, I also wanted to build something that could serve as a model for others, using readily available, inexpensive parts and simple construction. Solar is such an amazing resource in the tropics, but most of the information I have found is oriented to building for cold-weather situations. I hope my experience with this project can be useful to others in warm climates.

Our house sits at 10° N, so there is daylight for about twelve hours and the sun is almost directly overhead all year round. The major limitation on solar potential is cloud cover. The community is within the cloud forest, and gets ~3,000mm of precipitation per year. However, even during the rainy season there are typically several hours of sun in the morning and early afternoon, with torrential rains normally arriving later in the day and overnight.

View from the location of the collector

The collector is located on the roof above the south-facing porch, where there is the most consistent sun and best solar orientation. The house is oriented almost due south. There is a skew of only about 10° to the east. There is a heavily-wooded hill to the north of the house, and a steep drop off to a valley at the south, but at that latitude, this has minimal impact on solar gain. Even in winter, only the northern part of the roof is shaded for any significant portion of the day. A pair of huge rainforest trees to the east provides a bit of shade in the very early morning, but the collector gets full sun for nearly 10 hours each day. Serendipitously, the roof pitch is 10°, as is the latitude, so the collector is installed directly on the roof. This is important because of the extreme wind conditions that the area is subject to, which would otherwise put the collector attachment under a lot of stress.

The collector

The community is quite remote, with a drive of an hour or so from the coast up steep and winding un-paved road. As a result, the design had to be simple and rely on rugged and readily available materials, few tools and my limited plumbing skills.

After some investigation I opted for a thermosyphon system. I initially considered making a simple batch heater. However, the house is within a mile of the continental divide in the Tilaran mountain range. At an elevation of 4700ft it can get rather chilly in the evenings, and rarely reaches much above 80° F during the day, suggesting powerful advantages to using an insulated tank. 50° F is the lowest temperature ever recorded at a weather station that is a short walk from the house, so no freeze protection or heat exchanger is needed.

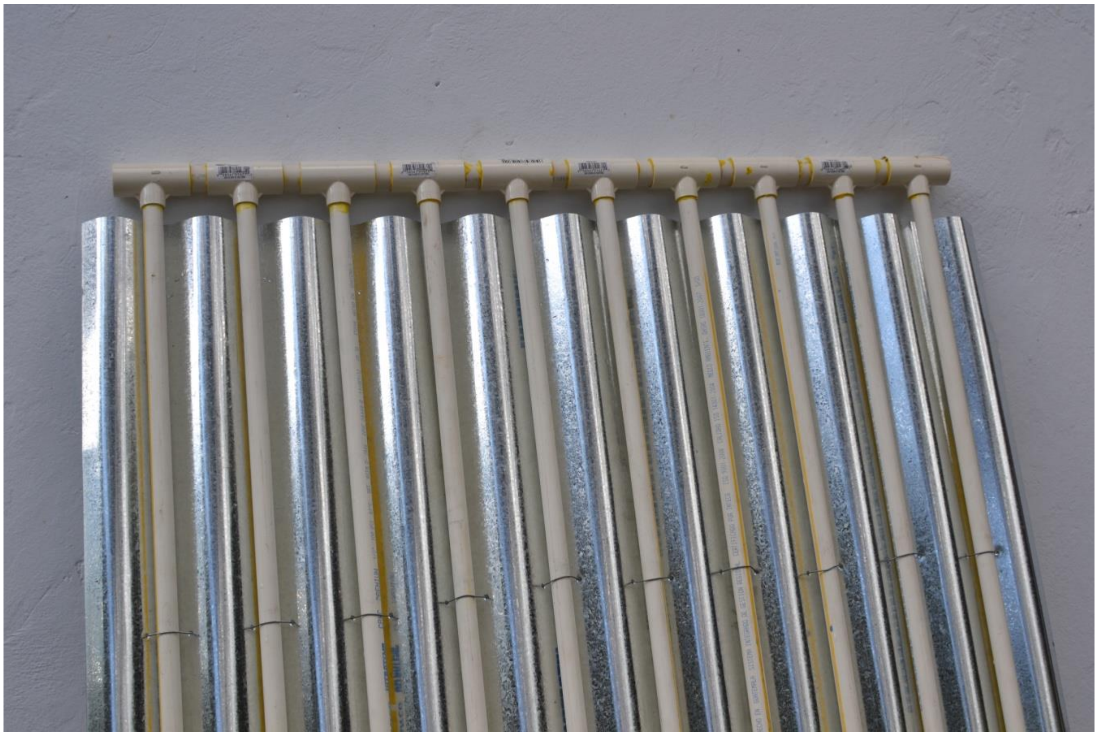
Materials ready to begin

After considerable internal debate and external consultation, I opted to make the collector from cpvc. There was not a great deal of choice really. Copper is available in the local shops only by special order, and is considered a serious luxury item. I have yet to find PEX available in the country.

The design is as simple-minded as possible. Corrugated galvanized steel roofing is one of the most ubiquitous building materials in the tropics, so the collector panels use metal roofing as a heat absorber/reflector. The unit is made up of two five-foot sections of roofing. In future, I would consider mounting the two sheets separately with a minimal gap between rather than having the edge overlap. The risers are ½" pipe. Holes in the roofing allow the risers to be wired down. The header and footer are composed of ½ to ¾ reducing tees and ¾ piping in order to reduce friction. I had to bring the ¾" pipe and fittings from the US, as they were unknown locally, though they could probably be gotten with a trip to San Jose. The risers are cut about an inch longer than the roofing, and the header is wired tight to the roofing at the intake side and the footer is wired tight to the roofing at the outlet side. This way there is a constant, though slight, rise in the header over the span of the collector, minimizing the chances of air accumulating and blocking flow.

Gluing the header

The entire unit is painted with flat black roofing paint. Thermosyphon heaters can operate near or above the thermal rating for cpvc, so I made some modifications to try to minimize the risk that the system would overheat. The collector pipes are held close to the metal roofing that serves as the heat reflector, but there are no fins or other adaptations to increase heat flow to the pipes. While the collector is glazed with clear corrugated roofing, the unit is not sealed at the top and bottom, allowing air flow under the glazing, nor is it insulated (I can hear the high-latitude contingent gasp at the thought).



One unit assembled and wired down

Painted and ready for the roof

The tank is a 20 gallon 3/16" HDPE open-head drum. The tank, while plastic, is rated to 185° F. To my surprise sourcing an appropriate tank ended up being a real headache. Because hot water is not commonly made and stored, containers suitable for it are rare. Readily available plastic containers were mostly light-weight and suitable only for low temperatures (your classic blue barrel). There were some water storage tanks that may have been suitable, but were all of such large capacity that I was not comfortable putting them on the metal roof because of the weight. Metal tanks of any description were almost unheard of. Steel drums could be had, but mostly used and not in the best of condition.

Tank with fittings installed

The tank is mounted on the peak of the roof about 3 feet taller than the top of the collector. It is over a corner of the house, so the weight is supported by two walls. It is currently insulated with a layer of polyethylene foam and a mylar survival blanket. Because of the high winds I lashed it on with twine in addition to lots of duct tape. I plan to add more insulation in future.

As the system is not pressurized, a valve is used to control the water level in the tank. This seemed to be one of the most likely problem areas for the system. After some searching, I found a very simple and (at least apparently) rugged brass float valve, made for livestock tanks. With many dairy farms around the area, I could probably have sourced this locally, but had trouble figuring out what to ask for in Spanish, so I brought it from the US. This was more expensive than many of the alternative valves, but the highly stratified conditions that often occur in the storage tank for thermosyphon systems means that the typical float valves made for toilets and other cold-water applications seem unlikely to survive. Even many of the valves that are listed as being suitable for hot water are only rated to 150° F, while this one is rated at 180° F. One problem is that the float stem for the valve was almost twice as long as would fit in the tank, so I had to cut it in half, leaving the section that attaches to the float not threaded.

The intake valve with line feeding water to bottom of tank

There are four lines to the tank. The top is the cold water intake to the control valve. The valve is plumbed with a pipe going almost the full depth of the tank so that the incoming water is introduced near the bottom. The next line is the return bringing hot water from the collector. At nearly the same level is the line feeding hot water to the house. Finally, the output line feeding cold water to the collector is at the bottom. I used industrial polypropylene bulkhead fittings and EDPM gaskets because I intend to have a solar hot water system for a good while, and I can re-use them as needed if I upgrade to other material for the collector or tank. However, this is not limiting for local adaptations as cheaper alternatives are readily available at the local ferretería. All exposed piping will be painted when I next paint the roof. This will help protect it from UV.

Construction only took a few days, though this was spread over several months as a result of researching and chasing materials. I did not keep careful records of the cost of all materials. Budget was a consideration, but far from the major one. I used all new materials rather than scavenging. None-the-less, I would estimate that the entire unit cost somewhere in the neighborhood of $300 US.

Installed and ready to make hot water

The whole thing assembled and working

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It was a smashing success from the beginning. Remarkably, not a single one of the more than 150 joints leaked. Within minutes of being filled, heated water could be felt coming into the tank from the collector. The first day the insulation was not on, and the top of the tank was open all day for monitoring. Still there was more than enough hot water by evening for two long showers, and they were hotter than the electric ever produces. With the still-modest level of insulation that is now in place it holds some heat overnight. It is early days still, but we look forward to a long and happy relationship with our collector.

Pura Vida.

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