The "$2,000 System" for a Small Apartment Building

This ground-mounted drainback system follows the design and build instructions from Gary's site with a few minor exceptions. The system provides an undetermined percentage of the domestic hot water for a seven-unit apartment building in Southeastern Iowa (41 degrees latitude).

I built this system while on home leave from my job in Kathmandu, Nepal. Kathmandu is a great city for solar junkies. Can you say “thermo syphon”? Kathmandu is full of these beautiful solar water heaters, both domestically produced flat-plat collectors and vacuum-tube collectors imported from China are on almost every roof. PV also proliferates because of “loadshedding” or scheduled rolling blackouts which increase to 16 hours a day during the dry season. Nepal’s electricity is almost exclusively produced by run-of-the-river hydro plants and when flow is low, it’s dark in the city. Many households charge batteries from the grid and top up using PV during the day to avoid excessive discharge.

What’s Different about this system

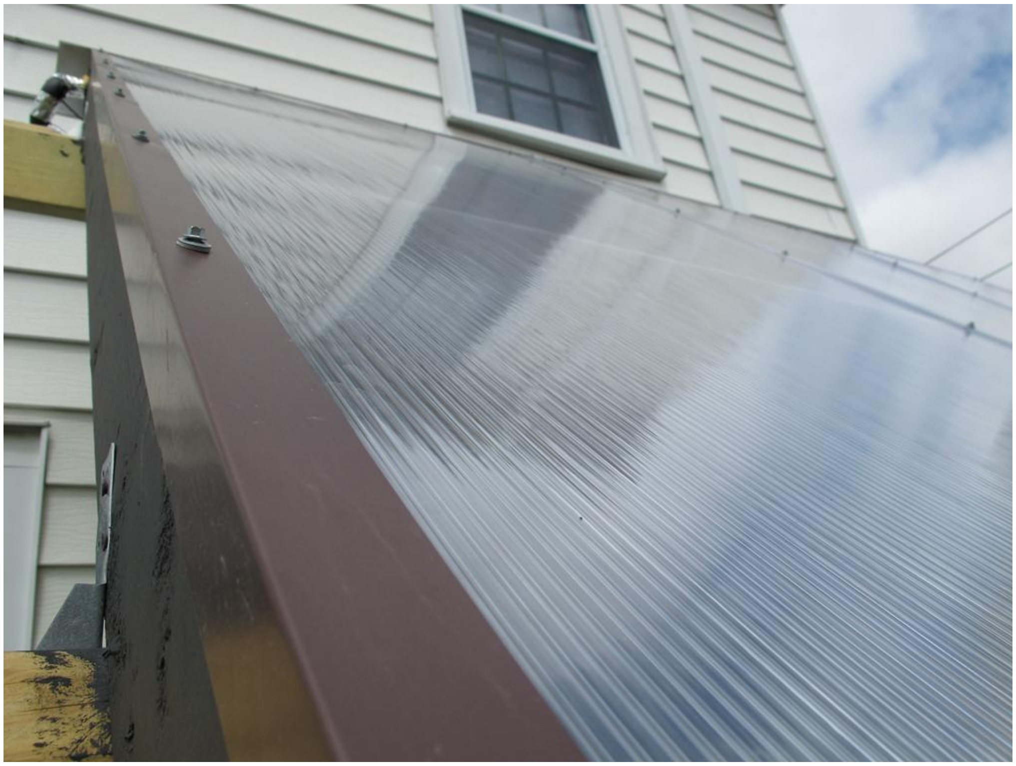
Ground-mounted

The owners of the apartment building (my in-laws) were not excited about the idea of having siding removed from the building or massive collectors hanging off the walls. There is no basement, so we went for this massive ground mounting structure to get the collectors above the tank for drainback capabilities. In hindsight a pressurized collector loop would have been less work, but this turned out really well I think.

If I were to build this ground mount again, I’d make the whole thing a foot taller and you could use it like a little gazebo. Put a picnic table underneath.

Aluminum trim on collectors and use of off-the shelf “joiners” for the glazing.

I joined the 6mm twin-wall polycarbonate sheets using purpose made joiner strips sold right alongside the sheets in Menards. They work nicely because they have a ¼” space perfect for screwing the joiner to the collector frame. The hardest part in using them was getting the sheets into the slot. We ended up needing to use a silicone spray lubricant.



The sides and top of the polycarb sheets are screwed directly into the frames (using screws with rubber washers also sold with the polycarb sheets). Then I bent some aluminum flashing to cover the entire top of the collector and sides halfway down. This gives the collector a more finished look and will protect the wooden collector frame (I also painted this with black deck stain).

45-degree tilt

With a large tank and high demand for hot water from the 7 apartment units, I decided to go with a lower-tilt than most who have built the $2,000 system. The 45-degree tilt angle will give good year-round performance for the 41-degree latitude of southern Iowa. Some performance is sacrificed in the winter when losses will be high anyway due to heat loss from supply and return pipes. With the large tank and high volume of hot water use, 45-degrees is still steep enough to prevent excessive overheating in the summer. I ended up with a higher than planned flow rate with my pump, the high flow rate (~6 gpm) also should help reduce the possibility of overheating.

Construction Fun

Collectors, tank OSB and insulation arrive at the site. Total cost for the system was ~$2,300 with a few 2X4s as the only materials on hand. All other materials were purchased new.

Directly behind this wall is a corner of utility room that was full of junk. We spent hours clearing out old window frames and the like to make room for the tank.

The apartment building has a perfect south-facing orientation with the utility room in the southeast corner of the ground floor.

Collector Frames

I used untreated 4X6s. I cut out a ½” by ½” square from the length of each 4X6. This allowed me to set the plywood into the frame so the back of the collector is flush. I sized the frames based on the dimensions of the polycarbonate glazing. These sheets are the “roof” of the collectors and extend ½” beyond the bottom of the collectors so they shed rain without risk of penetration into the collector.

I soldered the ¾" manifolds parallel to the frame of the collector. To get the needed slope for drainback, the ground mounted rack is sloped ¼" per foot.

If I were to build this collector again, I would change the return pipe so it's located inside the collectors to reduce heat loss.

Hot water return exits the collector at top left. This is a 14' run before the wall penetration. I'm worried about heat loss here and also the lifespan of the pipe insulation. If I get the time I'll re-route this return so that most of it is inside the collector.

Supply and return pipes enter the building with a 2X4 to protect them from climbing kids.

Tank

I made the tank 4’ X 6’ X 4’. If I were to do it over again, I’d make the tank a little smaller in order to leave a little more room to the right side of the tank. Construction was awkward and access to the pump is a squeeze. Two layers of 1” polyisocianurate inside the bottom and sides insulate the tank. Two inches of XPS get the tank up off the floor and add insulation to the tank bottom.

Unique things about my tank and things I would change:

- I made it with Oriented Strand Board (OSB) instead of plywood. I’m a little nervous about how the OSB will hold up to years of humidity. I painted it with the same black deck stain I used on the collector walls and back as a precautionary measure.
- I added a band of 2X4s around the circumference of the tank about 1’ above the bottom. I assumed that this is an area with a lot of pressure on it that could benefit from some extra strength.

- You can see that the Sharkbite elbows on the inlet and outlet pipes for the 1” PEX heat exchanger are in contact with each other. If I get the time I’ll change this so that they enter the tank separately and are thus isolated thermally. Also need to insulate the outlet pipe.
- I threw the heat exchanger (300ft coil of 1” PEX) into the tank with no effort made to coil it neatly or ensure that it is in the upper part of the tank. I assume there is some stratification in this tank once the pump turns off. I’d like to coil the PEX neatly with some spacers to keep pipes apart and then have it all float at the top of the tank to take advantage of the hotter water there.

The buildings 1” copper cold water inlet. Bottom valves, Sharkbite elbows and PEX connect to the heat exchanger in the tank.

The two natural gas water heaters now supplemented with solar heat. An interesting thing I discovered during the construction was that the solar tank alone provides a boost of 10F to the incoming cold water. Water comes from the mains at 55F and leaves the solar tank heat exchanger at 65F with no collectors attached. The utility room stays very warm because of heat given off by a large boiler system that heats the building and the gas water heater flues.

I had very little time to observe the performance of the system before returning to Nepal. The hottest I saw the tank was 81F (see picture). The sensor is located in the very bottom of the tank. My in-laws have seen it go over 100F during their periodic visits to their building.

Tips

Before starting to assemble the collector I read and re-read everything on www.builditsolar.com about the $1 K system and the $2 K system. I also read most, if not all, of the accounts of others who have built these systems. Overall, I'm very satisfied with the appearance and performance of this system. I'm planning to build several more in the near future.