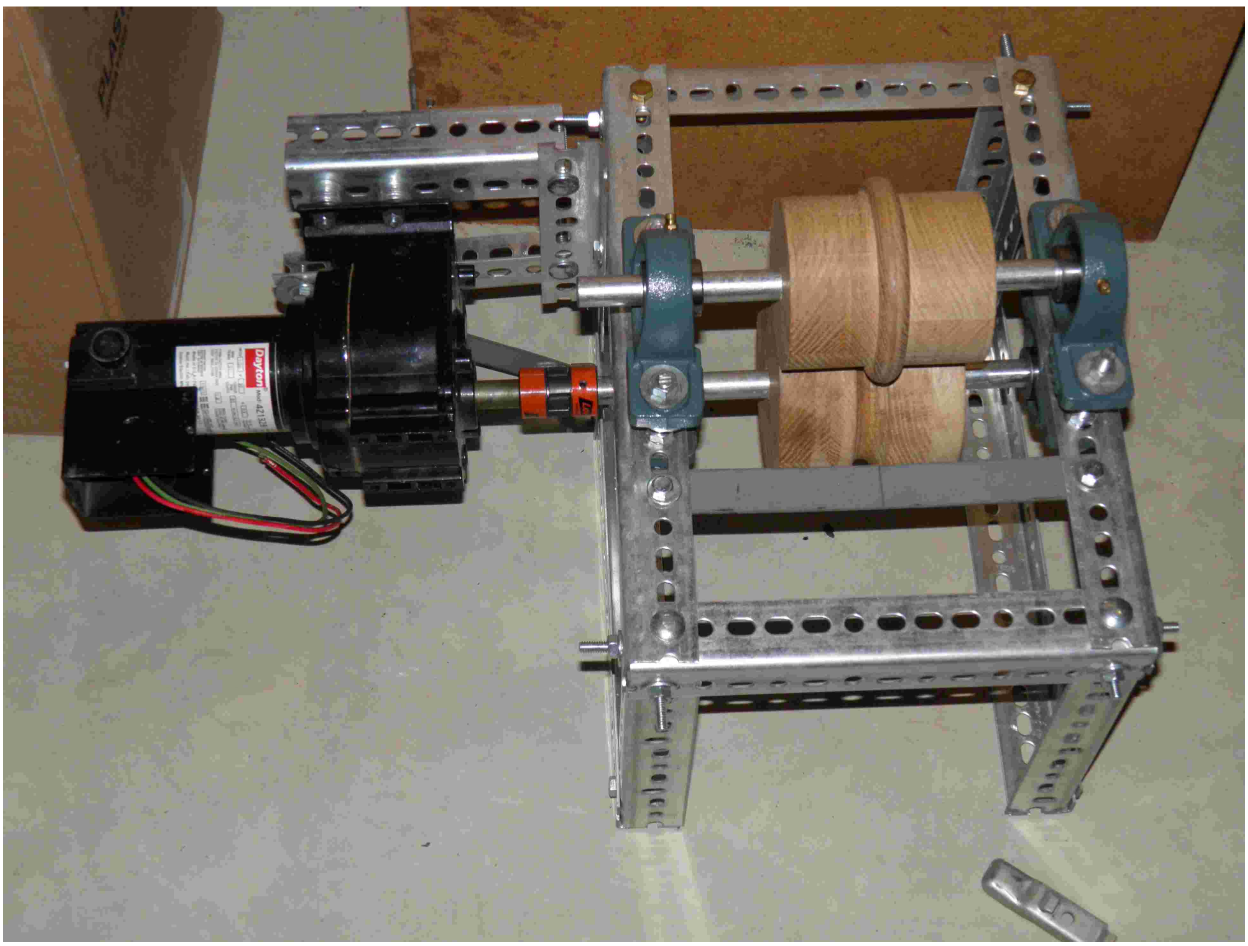
June 29th, 2010

My name is Denver and I live near New London, Ohio. My wife and I built a new home three years ago, and I built it with the thought of putting up a windmill and generating some power. While searching for windmill information, I came across Gary's web site, and decided to digress from the windmill idea for a short time and try the solar water heater. We heat water with Electric here, and I believe that electric is the MOST expensive way to heat water. We use Propane for our home heating source, and with the cost of propane constantly going up, I am also looking for ways to lower our winter heating bill. This is another reason I chose to try the solar heater first.

I read everything I could on Gary's web site, and I think I took ideas from everyone who built the system before me, and used what I thought were the best ideas on my system. The South side of my house has no windows in it, and it is over 30 feet long, so it is a perfect place for solar panels. My current thoughts are to put up 6) 4' X 8' solar panels, and use the residual heat to heat the house in the winter time to supplement the Propane heat. I currently have only one solar panel, but I have a bracket already in place for the second one. The collector in the picture is about 30 square feet as I did not go all the way to the edges with the aluminum sheeting.

The above panel was hung in May of this year. I started working on this about November of 2009, and due to my work schedule, my progress was slow. I started on the collector first, but then moved inside as winter set in, to work on the tank.

Since I had decided to make multiple panels, I decided to make some tooling to form the aluminum heat absorbers. I used Matt's idea, minus the bicycle, and came up with the fixture below which uses a DC gear motor that I picked up from the dumpster at work. I had put the motor up on EBay, but I had no bids on it, so I pulled it off and put it to work. The wood wheels were formed using only a router, and router bits. I glued up some oak table legs that I had salvaged from an old school desk. I rough cut them out round, and drilled a hole in the center for a ¼" pin. I put a pin in a piece of wood clamped on one side to the router table, using the clamped end as a hinge, and slowly brought the part in contact with the router bit. I carefully rotated the wood wheels by hand against the router bit to form them. I of course used the proper concave and convex router bits to get the shape I needed.



I purchased black/white aluminum flashing 24" wide, and cut it into 24X24" squares. I then sliced them into 4) 6" X 24" strips. I found that if I would put a slight crease down the middle the rollers would track better and make the grooves straighter, making it easier to fit the aluminum to the copper tubing. I used a sheet metal shear to cut the aluminum, and a sheet metal brake to put the crease in. I ran the parts through the above rollers twice, and they looked really good. I used Matt's idea and fastened the plates to the copper pipes with small strips of aluminum flashing, and pop rivets. They are not stapled to the OSB backing. I used clear RTV on the joints between the pipe and the aluminum panels. I bought an air operated pop rivet gun from Harbor freight and it made fastening fast and easy.

I used Chad's drawings to form the frame from 2X4's and the top 2X6, using my table saw, and all joints were glued with Gorilla glue and galvanized screws. I brought the return line down the right side, inside of the panel, and exited it out the back. Winters are pretty cold here in this part of Ohio, and I didn't want to loose all of the heat I may get, while the water was returning to the tank. I painted the inside and outside of the frame and the ½" thick OSB backing with paint that I had mixed up to match my house. I even painted the Polyiso insulation on the back. It had a foil back on it, and took paint fairly well. I used 2) stainless steel eye bolts, 3/8" in diameter, mounted on the top 2X6 plate, 40 inches apart, and hung the panel using threaded quick links made of Stainless steel. The 2 X 4 X 10' that is mounted on the house for support was lag bolted on 16" centers to the top wall plates, using plastic spacers so as not to collapse the vinyl siding. The spacers were made with ½" CPVC pipe, cut to about ½" lengths. I drilled 5/8" holes through the siding and pressed the spacers through the holes, and used RTV to seal the spacers around the edges so water would not get behind the siding. The copper heat exchanger was fastened to the inside OSB by copper "U" straps, screwed in place with galvanized sheet metal screws. I fastened a 5K thermistor, a LM34, and a DS18S20 temperature sensor to one of the aluminum panels, and I brought out three, three conductor cables to take the signals into the house. At that time, I was not sure what type of controller I wanted to use. I used copper pipe with insulation over it to get the water to the lower left side of the collector, then used vinyl reinforced hose to run down the side of the support. I have CPVC through the wall with hose clamps securing the hose just outside the wall. The hose has the same insulation over it as the copper pipe.

The picture below is the collector after the plumbing was in and insulated, and the wires were connected. I used two pieces of 1" EMT to mount the bottom, and bring it out to achieve the 45 degree angle. I made "U" shaped brackets from 1/16" aluminum and drilled a hole through the middle of the "U" to lag the bracket to the outer rim plate, using the same spacers as I used on the mounting bracket. The bracket was about 3" long, and I drilled a horizontal hole through the sides, and put a stainless steel bolt, with an elastic stop nut on the end, to go through a hole in the EMT. The other end has a galvanized lag screw through it into the 2X4 side of the collector frame. The collector is tilted to the left inside the frame for good drainage in the winter. Our house is located out in the middle of an old farm field, and near the top of a hill, with the closest tree being ¼ mile away, so we get some pretty high winds here. I am anxious to see how well this holds to the side of the house. I will not elaborate any more on the collector as Gary and many others have written great details on it.

The tank was constructed in a similar fashion to the one Gary made. I had no size restrictions in my basement, so I decided to utilize as much material as I could with minimum waste. The base was 4’ X 4’ X ½” OSB. I salvaged 6) 4’ X 8’sheets from work from some shipment of office walls that the company had ordered, and they were going to throw them out. The frame work was made from standard 2 X 4’s, but I ripped them to 3” width. Half lap joints were used in all frame corners. The bottom 2X3’s were glued and screwed from the bottom up through the 2X3’s with galvanized screws. I put horizontal supports on roughly 16 inch centers. The box is 48-1/2” tall, including the OSB bottom. I constructed the frame work, and used a few galvanized screws from inside the box into the 2X3’s to hold them in their horizontal position. All joints were glued with Gorilla glue, and carriage bolts were used in the half lap joints. Before I put on the top three horizontal frames, I wrapped the box with reflective insulation with the bubbles in the middle. I figured the extra insulation could not hurt. The inside corners have 1-1/2” X 1-1/2” strips screwed and glued in place to support the corners.

That is one continuous piece of bubble wrap reflective insulation with the seam visible on the left side. While traveling in Akron, I stopped at a Habitat for humanity store and found 4’ X 4’ sheets of 3” thick insulation for $4/sheet, so I bought 8 sheets and brought them home to insulate the box. It was a sandy beige color, so I am sure it is not Styrofoam. Maybe it is Polyiso, or maybe it is Polyurethane. I sit the box on a 4’ X 4’ X 3” sheet of foam. I put a piece of the insulation in the bottom first, and then all around the sides. I did not use any canned foam to glue the foam sheets in place. Instead, I cut it a tight fit and slid it in. I had to use my band saw to cut it as my table saw will not cut through 3” thick material. I cut a notch in the corners of the front and back piece of foam to go around the 1-1/2” square corner inside supports. I purchased a 15’ square pond liner online, cut it to 12’ X 12’, and installed it in the box per Gary’s instructions, and with the help of my 12 year old Grand Daughter, who I put inside the box. The weight of water along the sides and bottom should keep the foam from moving. I used the foam scraps to fully insulate the side that I put against the concrete wall. I did use canned foam to lock that side in place plus some 3-1/2” galvanized deck screws. I then used fiberglass bats to insulate the rest of the box on the outside. The lid is made up of EPDM liner against a 3” thick piece of foam insulation with a piece of ½” OSB on the top. The EPDM is stapled to the OSB with Stainless Steel staples, which also hold the EPDM liner to the top of the tank. The lid is silicone sealed to the plastic deck board. The deck board started out as a standard 1” X 5” X16’, and I ripped it to 1” X 3” width and then cut it to 4’ lengths. I cut half lap joints in the corners and I used a good heavy bead of RTV and galvanized deck screws to fasten it down. I left 2 slots on the front side for the 1" PEX to fit through. I fit it really tight, so I knew they would seal good. I have only three holes in the lid, one for the thermal well, one for the return line, and one to check water level and to add water. I split the lid into a front half and a back half, each being 4' X 2'. I chose this size because I had 3' strips of the EPDM left from the 15' square piece. I screwed the lid down with some SPAX PowerLag bolts I picked up from Menards that were ¼" X 6" and they had a big flat head about ¾" diameter with a Torx socket in them. They have very high holding power, and are almost flush with the lid. I set another 3" thick piece of the foam sheet insulation on top of the lid. I will probably seal it across the middle, and around the sides with duct tape, but I haven't done that as yet.

The thermal well was a piece of 3/8" copper tubing, that I smashed on the end, and soldered shut. I put about 2" of oil in it to transfer the temperature, and inserted a thermistor, and a LM34 to monitor temperature. Oil is a good electrical insulator and a good thermal conductor. I sealed the cable end with silicone sealant to stop dirt from getting in, and oil from coming out. In the picture below, the insulated pipe hides the thermal probe, but you can see the cable coming out of it. Here I used a single 4 conductor wire, with the thermister and the LM34 sharing one lead, and one lead each of the leads of the LM34 and the last for the thermister. The thermal well is placed about half way down the tank.

For the suction end of the pump supply, I drilled a 5/8" diameter hole through the 1X3" deck board, and pushed a piece of ½" CPVC through the hole, and put an elbow on it and a pipe down to about 6" from the bottom of the tank. The outside part has a "T" and a shut off valve so I can prime the pump. This way, I did not have to put another hole through the lid, and the pipe is a tight fit in the 5/8" diameter hole as I had to drive it in with a hammer.

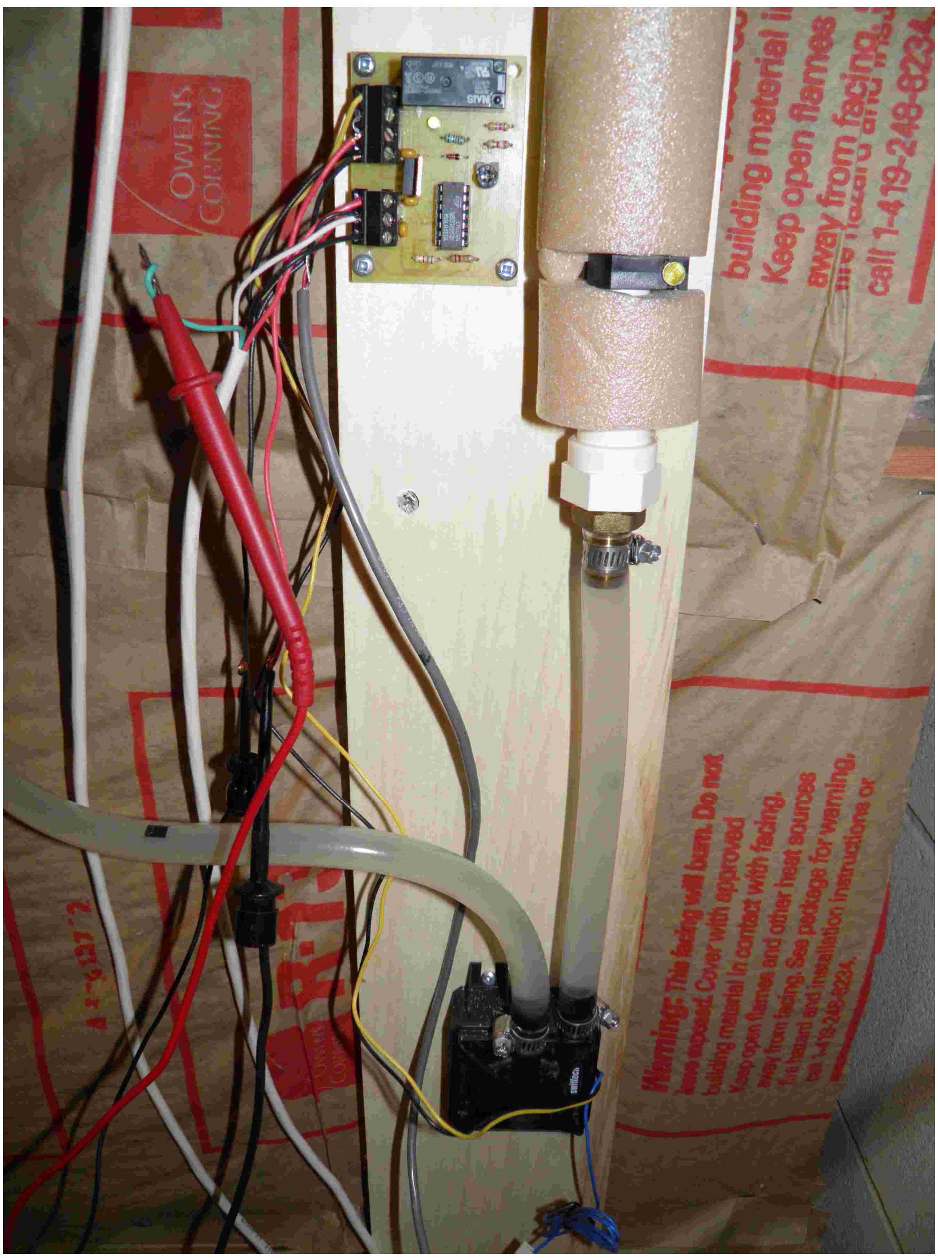
I had to re-plumb the house to accommodate the new solar setup. Fortunately, the house was plumbed with CPVC, so it was easy to cut it down and put up some new. I ran a new run from the hot water tank to the Solar Tank, which is about 25 feet away. I insulated the new run with the slip on pipe insulation that has tape in the slit to hold it together. The original plumbing had the cold water coming in with 3/4" line to the hot water tank, then dropping down to ½" a few feet past the tank. I pulled this all out, and put in ¾" pipe all the way to the solar tank. I installed three valves, one on the inlet to the solar tank, one on the outlet, and one between the two so I can isolate the tank. I ran it this way for over a month until the tank was finish and ready to go online. If you look at the various cans of CPVC glue out there, some of them will cure in 15 minutes, which is what I used. That way I didn't have to have the water off too long. I think my water was off for about 3 hours total. The cold water now comes clear across the basement, to the solar tank, then back to feed the hot water tank. The existing tank is a 50 gallon electric unit that I added a thermal blanket to, and put a layer of reflective insulation on top of that. I still have to insulate the hot water lines coming out of the tank.

As you can see, it is still a work in progress. It just went online June 27th.

The Heat exchanger was a 300’ coil of 1 PEX that I purchased from the source suggested by Gary. I made a ½” CPVC form, 42” high, and wound the pipe around it, fastening each loop on both sides with tie wraps. I did not use any blocks in the bottom of the tank to support the coil, as it kind of floats, and the lid holds it down. The cold water goes in the right side, makes two turns around the outside of the coil to the bottom, then begins its trip up one coil at a time up to the top. Hot water exits from the left side, and into the hot water tank.

In fabricating the coil, I had the coil laying down, as you see it in the picture, but I had an angle iron support slid through the hoop, supported on each end by a saw horse, to allow me to coil the pipe onto the form. I started the loop the same diameter as the inside of the coil was when it arrived, and wound it up keeping this diameter all the way to the top. This should give optimum heat transfer as the pipe is evenly spread out from top to bottom of the tank. I cut the top tie wrap that holds the free end once I got it rotated and inserted in the tank. The lid rests against the plastic form that you see on the left of the picture. I coiled the first layer from bottom to top, then reverse the coil, going down about 9 loops, putting ½" CPVC pipe in to space it out, then I reversed it back up to bring the top coil out. You can see the ½" CPVC spacers adjacent to the form in the picture above. You can also see some of the many tie wraps that I used on the form. Most of them are clear, and don't show up in the photo very well. I ended up trimming each end down about 3" to fit into the shark bite connectors I used to tie into the ¾" CPVC pipe.

The temperature controller was one I copied from http://www.jc-solarhomes.com/. I made a circuit board, and use the LM324 set up as a comparator, and it so far, seems to work great. I am using the 5K thermister for the temperature sensor on both the tank and the collector. Late last year, jc-solarhomes had the schematic posted for the controller, and I downloaded it at that time. I see he no longer has it on his site. Most people would just buy the controller from him anyway as his price is right. I like to experiment, and am an electrical engineer by trade anyway, so I had to make it! It is a simple controller, and simple is usually better. Time will tell. I used the Swiftech MCP355™ pump and I am totally amazed at the water flow from this unit. The top of my collector is 10’ above ground level, and the pump is about 5 foot below ground level so I have a 15’ head. The constant heavy stream of water flows from the ½” CPVC return line. Right now I am using a regulated bench supply, but I am going to switch to a regulated wall wart when I get my hands on one. I also need to run some electric over there, as the only outlet I have in the basement is on the opposite end, and I have an extension cord powering the whole thing up. The pump draws 1-1/2 amps at 12 volts DC. The picture below is of the control and the pump. The test leads allow me to measure tank temperature with a multimeter. I also need to clean the wiring up a bit.



I plan on putting two meters in my hallway upstairs so I can monitor the tank and collector temperature without running to the basement to check it and also see if the pump is on or off. I have the components to do this, but haven't had time to get it done yet.

I have not had the system operational long enough to collect data, but the tank temperature in three days is up to 112 degrees F and it started out at 59 degrees. The tank inside dimensions is 34-1/2" X 34-1/2" X 44-3/4". I have the water level about 3" from the top, so there should be close to 200 gallons of water in the tank.

The picture below shows the plumbing, and you can see the thermal well and the insulation on top of the tank. I took some of the 3" foam, and cut it in half, clamped it back together, and use drill bits to drill it out to fit the brass shark bite connectors that tie the PEX to the CPVC. Gorilla glue was used to glue them back together after fitting of the shark bite. The fittings were very warm when the water is running and I didn't want to lose the heat!

As far as cost is concerned, I can't say I kept track of my spending very well as it was spread out over a long period of time. I know I bargain shopped for a lot of the stuff, like the foam insulation I mentioned above. The Polyiso foam is one of the more expensive items at $28+ a sheet for 2" thick at Home Depot, but the 3" stuff from Habitat was better and cheaper for a total cost of $33 including tax. I bought all of the RTV from Menards for around $1 a tube when it was on sale and I know I have at least 6 tubes in this project. I bought several cans of foam insulation from Menards for $2 a can, but so far have used only one can. The 2X4's I bought last fall, and they were about $1.79 each. The sheeting I got for free. The copper tubing I bought from Lowes, and it was about $7.10 a stick. I purchased the copper fittings in bags of 10 and 25, because they are much cheaper that way. I believe I have close to $800 in it, but I wouldn't want to be held to that!

Thanks to Gary, and all of the others who have written fine articles on this subject. The information contained on Gary's web site has a wealth of information for those that take the time to read it!

If you have any questions, please feel free to email me at denver@corrick.com. I will answer any question that I can.

7/4/2010 Update: The tank temperature is up to 130®F. I am hoping to get the second collector online within a month. As the summer draws to a close, I don't think the single collector will keep up, but I am real happy now with the current temperature. I am tempted to kill the power to the hot water tank and see how it goes.