# Poor Man's Guide
# to
# Solar Hot Water



The author of this document assumes no responsibility for any mishaps of any kind while following these guidelines. These are just suggestions of things that have worked in the past and should work if all proper safety precautions are followed. You work with scalding hot water AT YOUR OWN RISK!

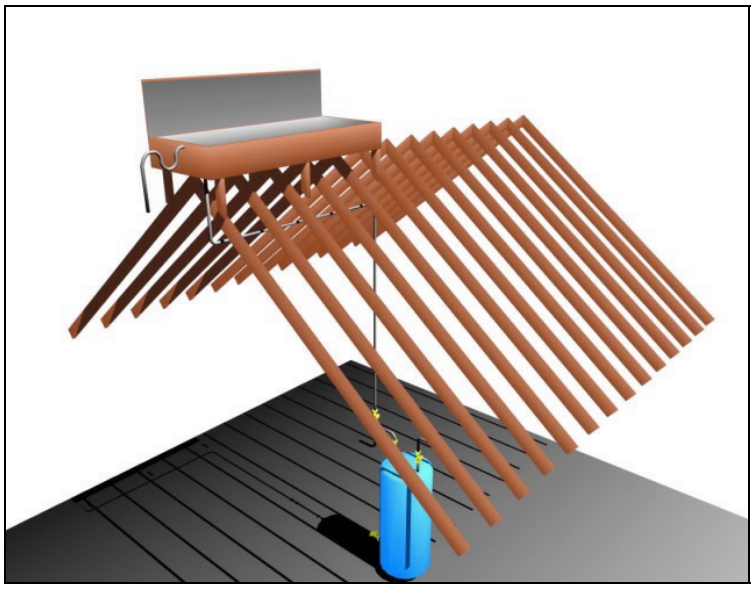
## Table of Contents



## Safety first

- Always wear safety goggles when soldering.
- Soldering gets hot, wear some gloves to protect your hands.
- Be careful when working at heights. Always have someone helping you in case you fall and need medical attention.
- Always use lead-free solder and rosin flux for plumbing projects.
- Always use caution when using a torch near wood. Cover the wood with a piece of sheet metal to prevent direct exposure to the torch flame.
- Read and follow all safety precautions on the propane torch canister.
- This hot water batch heater can produce hot water up to 160° F or more on a hot summer day. Always mix the hot with the cold at the faucet to maintain temperature. And always be aware of kids that could burn themselves.
- If the system can't maintain 140 degrees F for at least 1 hour every few days, in the colder months, the system should be taken off line until the warmer weather returns.

## Introduction



Let's face it, hot water is one of man's greatest achievements. Maybe you don't believe me, but try to go without a water heater for just one day. I don't mean take a shower 2 hours after a power outage. There can still be warm water in the tank for several days after a loss of power. I mean take a shower when the water is as cold as it gets under ground in the pipes. On Vancouver Island that temperature is about 57° F all year round. And that, my friend, is cold! Actually, 70° F water is cold. And 100° F is warm, 105° is a good shower temperature, and 110° is scalding hot. Funny how sensitive humans are to just a few degrees difference in water temperature. Not as bad with air, but with water it is a big deal. It is because conduction works so much better than convection for heat transfer.

In this book I'll discuss how to make a solar hot water system “on the cheap”. (This is a Poor Man's Guide after all) It will be a simple gravity fed setup and will be the cheapest and easiest to make, by far. This system will keep your existing water heater in tact and fully functioning, although, the power going to the water heater will be turned off. Also, the existing water heater will act as a pre-heater for the entire system. Why heat 57° F water when you can start heating with 72° F water? Well, the idle water tank that used to waste about 20% - 30% of your electric bill, can now be used for something different. It just sits in your house, that is probably about 72° F or so. When water sits in that tank for a day or two, it will heat up from its colder temperature to the ambient temperature in your house. It is then fed into your solar system, thus making the whole system more efficient.

## Principles of Solar Heat

Solar heat and the greenhouse principle is actually very simple. The sun puts out about 1300 watts per square meter or 10.8 square feet. Let's assume we have a wooden enclosure with the inside painted flat black and a glass lid on top. The short waves of the sunlight enter in through the glass and hit other objects. Those objects absorb that heat and then emit infrared waves. The darker the color of the object hit, the more efficient this conversion process. Those longer infrared waves try to escape but can't travel through the glass as easily as a shorter wavelength can. Thus, most all of the heat emitted stays within the enclosure.

Conduction of the heat through the glass or the container walls accounts for most of the heat loss. So the trick is to use enough insulation for the container. This includes the glass. But there is a point of diminishing returns. If you had 20 layers of glass, it would be a great insulator, but only a small fraction of the sun light can make it through.

Also, orientation of the solar collector should be toward the sun. In the northern hemisphere, that means that the sun is always to the south. An easy thumbrule is based on your latitude. The angle of the collector should be latitude -10° for summer and latitude plus 10° for winter and, ideally, about 5 degrees to the west.

## Soldering Copper Pipes

In this guide I'll show you how to make a very simple solar batch heater that will hold 45 gallons of water. It can go from 70° F in the morning to about 150° by 3 in the afternoon on a hot summer day. Or it could get up to 110° F by 3pm on a moderately clear but cold day in the 40's.

But, no matter how simplistic this design is, you will still have to solder copper pipe joints if you want to tap into your existing hot water system. So, let's get started.

First, don't get in a hurry. That is a very common mistake. You'll want to make sure that there is no water in the copper pipe you are soldering. Otherwise, it will not work. The water will keep evaporating and taking the heat down to 212° F and the solder will not melt.

Also, make sure that the copper pipe and fittings have been cleaned thoroughly. Otherwise, you will have leaks. Luckily, this system isn't under pressure because it is an open batch system. The only pressure will be where you tap your line into. And even that is only during winter when and if you drain the batch heater and use regular water pressure.

Before you solder, make sure that the pipes fit together properly. It is better to find out at this point than after you start soldering.

### Step 1

Make sure you have all the pipes and tools you are going to need before you start

### Step 2

Cut all the straight pipe to length. Don't forget that some of the pipe will slip into the fittings at both ends. A tube cutter works best but you can use a hacksaw. Just make sure you don't bend the pipe or have nicks that protrude out.

### Step 3

Use the reaming blade on the end of the tube cutter to remove any burrs

### Step 4

Use an emory cloth to thoroughly clean the end of the pipe. This makes for the best solder job.

### Step 5

Use a round wire brush to clean the insides of the fittings.

### Step 6

Make sure the pieces you are about to weld fit together. Cut another piece if you have to, but the two pieces should slide together with a snug fit. Then disassemble and use the flux brush to apply flux to the ends of the pipes and the insides of the fittings. Then assemble everything again.

### Step 7

Get ready to solder. First make sure that you protect all flammable materials near each joint by covering the flammable materials with a piece of sheet metal. Next, take your roll of solder and unwind about 10 inches. Bend the last 2 inches into a 90-degree angle. Light your torch and adjust to a 1-1/2" flame. Heat the area on the fitting where the straight pipe slides into it. You want to use the inner flame tip and move it around slightly so that it heats the whole overlapping area. After heating for about 10 seconds, touch the solder to the joint at its highest point. If it is properly heated, the capillary action should pull solder into the joint. If solder does not pull into the joint, apply more heat and try again. When solder drips out of the bottom, the joint is ready.

### Step 8

Once you have completed soldering all joints, you can turn the water pressure on and watch for any leaks. If you get a leak, you will have to drain water out again from just that section and re-heat and apply solder.

### To disassemble a joint

Heat it up with your torch. While the joint is still hot, quickly grab the pipe and fitting with 2 pairs of pliers. Twist and pull the pipe and fitting apart. **Be careful - they are hot!** Using emery cloth you can clean the pipe and reuse. Do not reuse fittings. They are too difficult to completely clean for a leak-free joint.

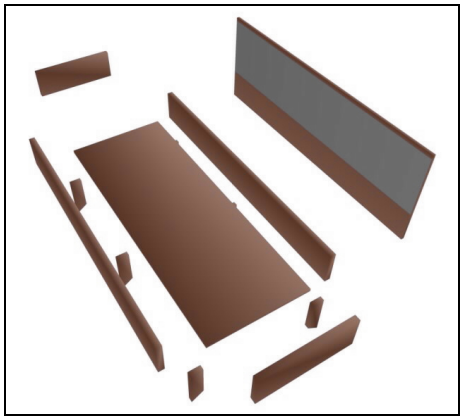
## Batch Heater Gravity Feed Design

## Let's assume that you are making a batch heater that is 27 inches by 77 inches (inside diameter) and that it will be 6 inches deep (inside diameter).

What you will need (estimation):

| Qty | Description | Price (US $) |
|---|---|---|
| 2 | 2x6 boards - 10 feet long | $ 15 |
| 1 | 4x8 plywood 3/4 inch thick | $ 30 |
| 1 | roll of aluminum tape | $ 3 |
| 1 | mylar thermal blanket | $ 1 |
| 1 | double layer tempered safety glass door | $ FREE |
| 1 | section of 4-6 mil black plastic | $ 5 |
| 3 | feet of copper tubing | $ 6 |
| 1 | water valve | $ 3 |
| 2 | “T” connector for copper piping | $ 3 |
| 1 | tube of Aquarium Silicone | $ 5 |
| 5 | copper elbows for loop seal drain pipe | $ 12 |
| 1 | can of spray adhesive | $ 5 |
| 1 | 25 foot rubber industrial hose 3/4 inch - 200° | $ 25 |
| 2 | hose clamps | $ 3 |
| | Total | $ 116 |

First things first, you'll have to get some glass. I prefer the sliding glass doors for three reasons. They are a really good size for a batch heater, they are tempered safety glass and they are double layered for insulation. You can usually get them free just by making some calls to local glass and window shops and asking them. Some places give them away so they don't have to dispose of them and some places charge $10 to $20 for one. You want a cheaper one that doesn't block a lot of the UV radiation. Since it is tempered safety glass, you CAN NOT cut it or drill it AT ALL. If you see any damage at the edges, don't use it.



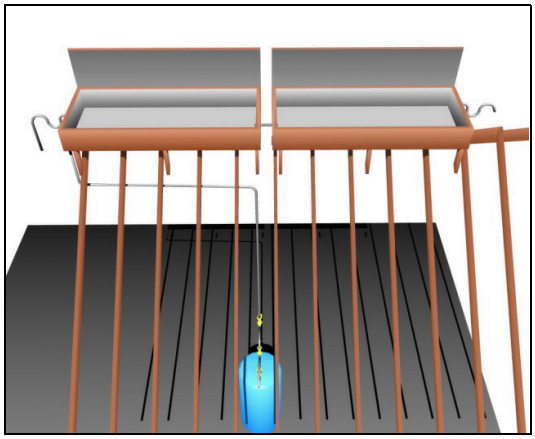
So, once you have the glass door, you will know what size to make your batch heater. A typical door size is about 27 inches by 77 inches. If you make the heater 6 inches deep by using 2 x 6 boards for the walls, and you lose half an inch to the overflow pipe and half an inch to the bottom drain, then that would be 10,395 cubic inches or 45 gallons. You would also have 2,079 square inches available for sunshine. At 1366 watts per square meter, that would be 1830 watts. If the batch heater were 60% efficient, then that would be 1100 watts of heating during the sunny times. The normal electric water heater is about 5,000 watts but it can heat up 50 gallons in a relatively short time. This version would heat up about 3 to 4 times slower than that, but it can easily heat up the 45 gallons to a good shower temperature by noon or so.

Another option is to string two or three of these batch heaters together and only use 2x4s for the walls. That would give about 25 to 30 gallons per heater but with the same surface area as before for each heater. So, with 4 of these heaters, you could heat up about 100 gallons in just an hour or two. But frankly, I don't see the point in that kind of speed. I say just fill up every day. As long as there is some hot water already in there, then it will heat up the new colder water and they will meet someplace in the middle. If you have 20 gallons of 150° F water and you add another 25 gallons of 72° F water, then the resulting temp of the water would be about 105° to 110° F. And that is perfect for the next shower or washing your hands.

*The reason this batch heater should be placed on the roof is because it is a gravity feed system.*

**Base:**

Once you have all the pieces you can start to build. You can build the enclosure on the ground and hoist it and the glass up separately if you have a flat roof. Otherwise, you will want to start with the base plywood mounted to 6 short pieces of 2x4s. This will support the heater on both sides and allow the peak of the roof to support the centerline.



You can use wood screws to mount those legs by drilling through the base plywood straight down into the 2x4 legs. It helps to pre-drill the holes to keep the 2x4s from splitting. You'll have to make sure that the base is level. Then, use wood screws to secure legs to the roof. Use silicone rubber around the base of each leg and around the wood screw's head. This will ensure that your roof doesn't leak when it rains.

Also, if this setup doesn't coincide with the position of the sun, then it can be rotated 90 degrees and mounted so that it is perpendicular to the roof peak.

**Walls:**

Once the base is resting on the roof with the legs attached and is level, you can add the 2x6 wall pieces. The 80 inch

pieces can be attached to the 27 inch pieces via wood screws as well. You should still pre-drill the holes so the wood doesn't split. Then, drill up through the baseboard into the 2x6 walls to secure the two together.

## Black Liner and Piping:

Take a piece of 4 to 6 mil black plastic and lay inside the enclosure with excess you can cut off later. In a corner of the enclosure, most convenient to running feed line to the hot water tank, drill a hole just big enough for the pipe you are using. Just cut a small cross in the plastic at the spot you will drill. The pipe coming from the bottom of the enclosure should just be about 6 inches long and you should screw the flange piece on the end in an inverted fashion so that the flat side is pointed down when the pipe is in the hole. Also, the hole should be just big enough to let the pipe slide through. Then, use the aquarium silicone to seal under the flange around all 4 screw holes and around the pipe hole and screw it down with 4 short wood screws. This type of silicone is safe for potable water.

The flange also ensures that there will always be some water left in the tank (about half an inch) to prevent the black plastic from melting. It also will maintain very hot water that will help to heat up any fresh cold water put into the tank.

## Vent / Loop Seal:

This will suck air in as water drains during use. And, when you fill the tank again, water will reach the top of the tank and overflow through this vent pipe. Since it has a curve like a drain pipe, water will get caught there and keep bugs from getting into the tank. It will also help maintain heat in the tank versus it all venting out to the atmosphere. One more thing it does is ***overflows*** when you fill the tank to the

top. When you see water coming off the roof, you will know that the tank is full. The loop seal should be mounted close to the top of the tank. You can use copper elbows and pipe. Make sure that the top of the loop is at or slightly below the top of the heater's wall height. Otherwise, water will slip between the glass door and the walls when filling.

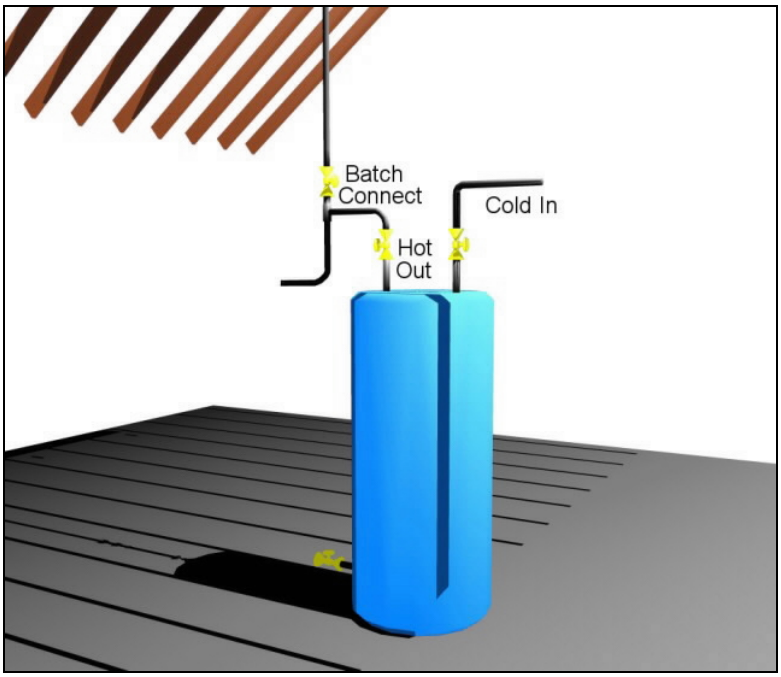
## Top Glass or Glazing:

Place the double layered tempered safety glass door on top of the enclosure. You can even leave the frame molding on as long as it sits flush. That way you don't chance breaking the glass removing the trim. The black plastic liner should be hanging out a foot or so on all sides. When the tank is filled, it will fill in all the gaps and pull the plastic tight. Only then should you cut off the excess plastic. The black plastic will help seal and the weight of the door holds it down. To make sure that it doesn't shift, or the wind blows it off, you can place a few short pieces of 2x4 on each of the edges. You don't need one on the north side, because that is where the reflector is. You can use wood screws to attach these small pieces to the enclosure side.

## Reflector:

Notice that you started with a 4 foot by 8 foot piece of plywood. You used 30 inches of that width for the base which leaves you 18 inches for the reflector. What I like to use is that thermal blanket material called mylar. It can be picked up for cheap in the dollar store. It is by far the most reflective material for the price. Another option is looking for a cheap or free mirror or mirrors. But the mylar is the best bet. Just use spray adhesive on the plywood and, with the help of another person, lay it flat on one end and use a paint roller to work out air bubbles toward the other person as they hold their end up. Cut the excess off the edges with a box cutter. Line the edges of the plywood with aluminum ducting tape. Just mount the reflector to the north side of the

enclosure (if you are in the northern hemisphere). Make sure the wood screws aren't too long and penetrate the plastic liner.




**Hose and Valves:**

Now you can connect the rubber hose to the galvanized drain pipe by cutting off the end connector and fitting with a hose clamp. Run the hose to the water heater. Technically, it doesn't have to tap into where the water heater is. But it makes it more convenient for filling and draining and it also is easy to get to the water heater pipes. If it is difficult to run the hose to your water heater, it is possible to tap into the hot water line somewhere else in the house. But try to avoid that if at all possible.

You should know that normally, garden hoses are dangerous to drink from for a few reasons. Firstly, because they aren't used for long periods and bacteria can be growing in them. And, secondly, because there is lead used in the brass fittings. In this plan, you will remove the end fittings and just use hose clamps. And since it is used in your hot water system, it will be used all the time. Most would drain the system in the winter and then refill in the early spring. The initial flush and the fact that the chlorine water sits in the hose killing any bacteria solves that problem. And, also, the winter isn't conducive to bacteria growth.

You should get some foam pipe insulation for the short galvanized pipe and the few feet of hose that is exposed to the outside. Also, try to make the hose length as short as possible. You should use a 5/8 inch hose as a minimum, but I recommend a 3/4 inch.

The only thing new to your existing system is the hose coming down from the batch heater, the batch connect valve, and the “T” connector at the Hot Out valve to tie it all together.

*Don't forget to paint the enclosure with some good marine paint to help protect it from the elements*

## Operation of Batch Heater

The gravity feed batch solar heater is very simple to use. First, you'll have to fill it up. The “cold in” valve should be in the on position at all times (except when installing the system). The “hot out” valve is normally closed and the “batch connect” valve should stay open at all times, unless you are shutting the system down for the winter. Open the “hot out” valve and let the tank start to fill. It will take probably about 5 - 10 minutes or so to get 45 gallons into the tank. When it does, you will see the water draining off the roof. Then you should shut the “hot out” valve. At this point you are ready for normal gravity fed operation.

Then, whenever you open a hot water valve in your house, such as a sink or shower, then it will gravity feed. You should be careful because the water can get very hot, especially after noon. You can control the temperature like normal by opening the cold water valve at the shower or sink.

In the winter time, you may wish to drain the system. It is really easy. Just open a hot water valve in a sink or shower and let the system drain. When it is all drained, shut the “batch connect” valve and shut the hot water valve in the shower or sink. Then open the “hot out” valve at the electric water heater and turn the breaker on. At this point, your system will be functioning the way it used to.

| | Spring & Fall | 92° start |
|---|---|---|
| Time | Temperature | Heat gain |
| 8 am | 93° | +1 |
| 9 am | 96° | +3 |
| 10 am | 101° | +5 |
| 11 am | 107° | +6 |
| 12 noon | 114° | + 7 |
| 1 pm | 122° | +8 |
| 2 pm | 129° | +7 |
| 3 pm | 135° | +6 |
| 4 pm | 139° | +4 |
| 5 pm | 141° | +2 |
| 6 pm | 141° | +0 |
| 7 pm | 139° | -2 |
| 8 pm | 134° | -5 |

| | Summer | 98° start |
|---|---|---|
| Time | Temperature | Heat gain |
| 8 am | 100° | +2 |
| 9 am | 104° | +4 |
| 10 am | 110° | +6 |
| 11 am | 118° | +8 |
| 12 noon | 128° | + 10 |
| 1 pm | 140° | + 12 |
| 2 pm | 150° | +10 |
| 3 pm | 158° | +8 |
| 4 pm | 165° | +7 |
| 5 pm | 171° | +6 |
| 6 pm | 174° | +3 |
| 7 pm | 175° | +1 |
| 8 pm | 175° | +0 |

Also, if you go away from your house for awhile in the spring to fall, then you should fill up the tank before you leave. It will slowly evaporate through the loop seal. But it lasts a good long time. ***You always want to keep water in the tank in the warmer months. Otherwise, the black plastic can melt very easily. If you go away for longer times, you should drain it and put a cover over the heater like a tarp or some more black plastic.***

## Some Math

In the above example, you have 27 inches by 77 inches of glass exposed to the sun. That is 2,079 square inches. If you divide that by 144, then you get 14.4 square feet. The sun typically adds 250 BTUs per square foot. So this heater applies 3600 BTUs. If 360 BTUs are added to 45 gallons of water for one hour, then it raises temperature by 1° F. So, we should get 10° F per hour in a perfect world and if the

tank is full. But there are a few exceptions. First, the sun slowly rises and the day gets hotter and then it starts going down. Also, the hotter the water gets, the more the heat tries to escape.

The following tables show what you can expect on a typical sunny day from spring to fall. Luckily, the reflector adds some to the efficiency and gives it a bonus on that 10 degree per hour number. If you add some foam to the outside of the enclosure, then you can expect to add roughly 10° - 20° F to the max after a few days.

Also, those charts above show temperature gains after several days or weeks of operation. Each day, the water gets a little hotter, to a point. You may start with 72° water and the next morning after mixing new water in, you may have 78° water and so on.

## Water Pressure

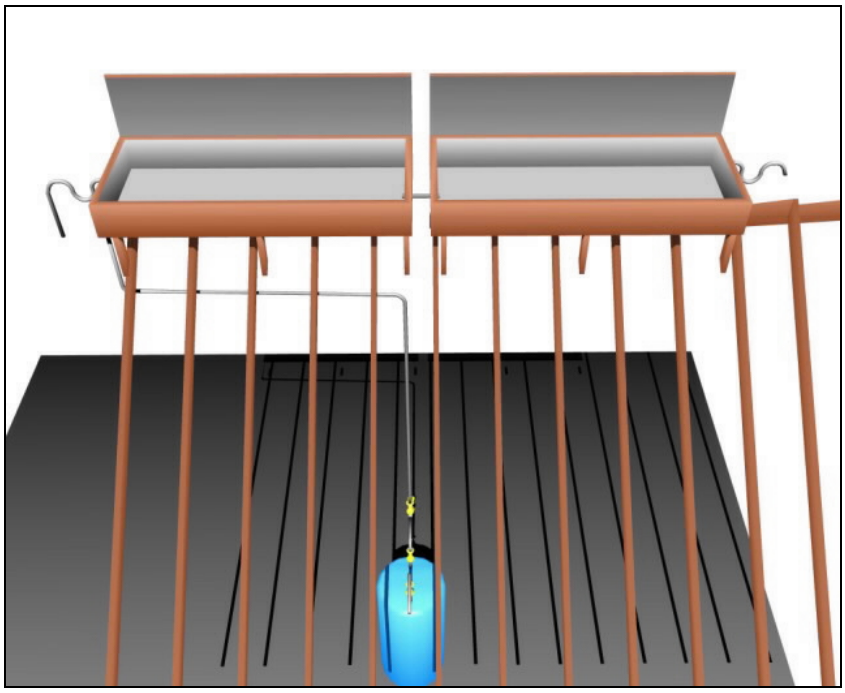
Most people have 120° F to 140° F hot water in their house. And when they shower, they turn on the hot and cold together. Mostly they are both turned on about half and half. A typical house has about 40 to 50 psi water pressure and if you were to turn the hot and cold valves all the way open in the shower, then you would get that full 40 psi (assuming nothing else is running). Most people don't do that though, they turn each up about half way or so. The people that turn theirs all the way up should look into a low flow shower head.

So, typically, you are looking at a total of about 20 to 25 psi during the shower with about 10 psi from both the hot and the cold side.

| height delta in feet | hot water PSI |
|---|---|
| 10 | 4.7 |
| 11 | 5.2 |
| 12 | 5.6 |
| 13 | 6.2 |
| 14 | 6.7 |
| 15 | 7.1 |
| 16 | 7.6 |
| 17 | 8.0 |
| 18 | 8.5 |
| 19 | 9.0 |
| 20 | 9.4 |
| 21 | 9.8 |
| 22 | 10.3 |
| 23 | 10.8 |

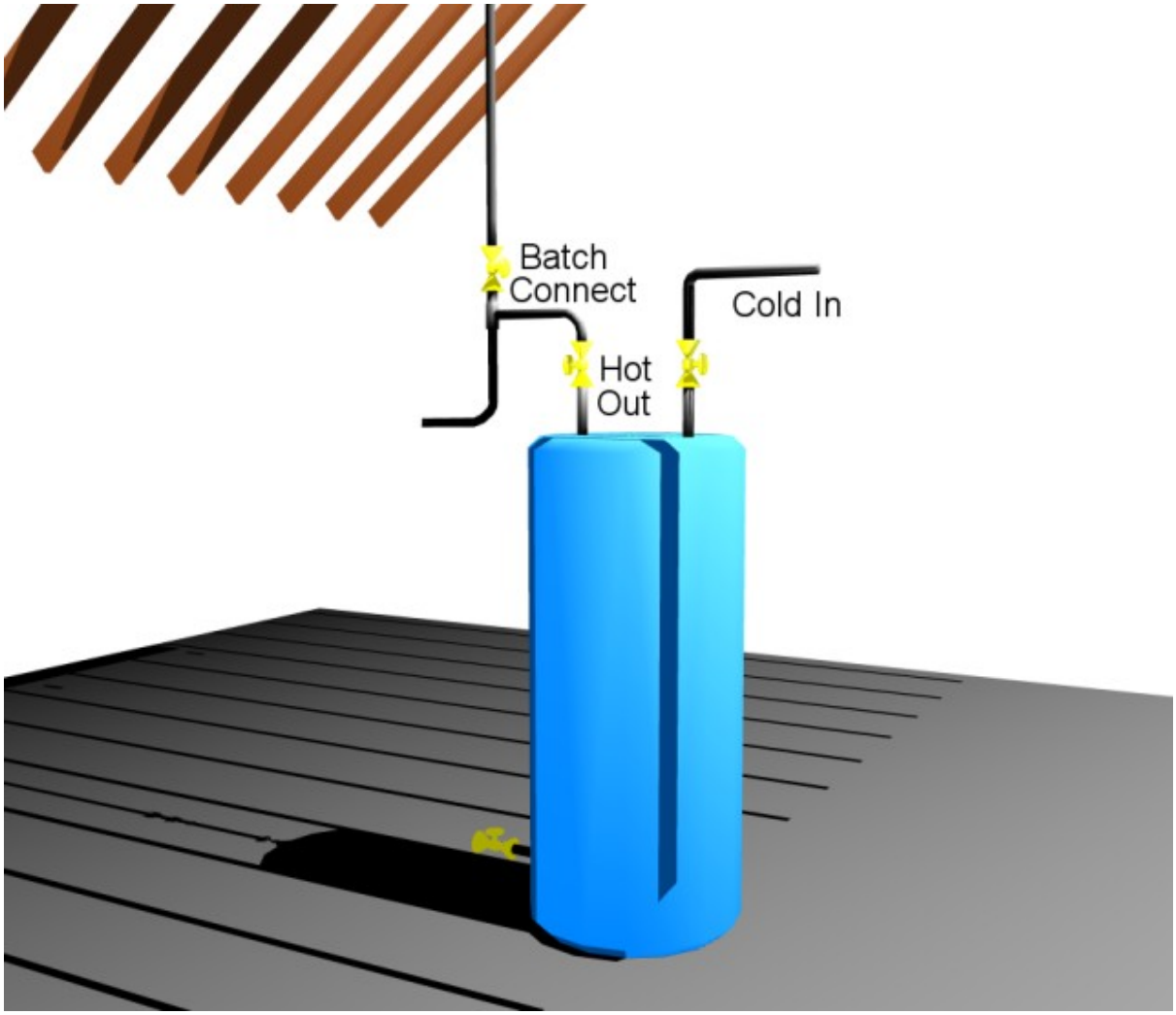
The static water pressure in a gravity-fed system is simply a function of the vertical distance between the opening of the hose and the top of the water level in the tank. The pressure of a column of water is one atmosphere (about 15 psi) for every 32 feet of height. So, if the water level in the tank is 20 feet above the hose nozzle, the water pressure at the nozzle will be about 9.4 psi. So, to take a comfortable shower, and if you needed 30 psi at the shower head, you would use more cold. But to compensate, the hot water temperature would have to be about 140° F instead of 120° F. But remember, with this new configuration, the cold side now has the full 40 to 50 psi, so you shouldn't turn it up as much as you used to. It only takes a few times to get used to the new system.

**Double tank system - 90 gallon**



So, remember some facts to help in your computations:

- height x width x depth gives you cubic inches
- height x width gives you square inches
- sun is typically 250 BTUs per square foot
- square inches divided by 144 gives square feet
- 8 BTUs per gallon of water will raise 1° F per hour
- 32 feet equals 15 psi water pressure
- typical house pressure is 40 to 50 psi
- with this batch heater a typical one story house will see about 5 - 7 psi
- with this batch heater a typical two story house will see about 5 -12 psi (depending on shower location)


Batch
Connect
Cold In
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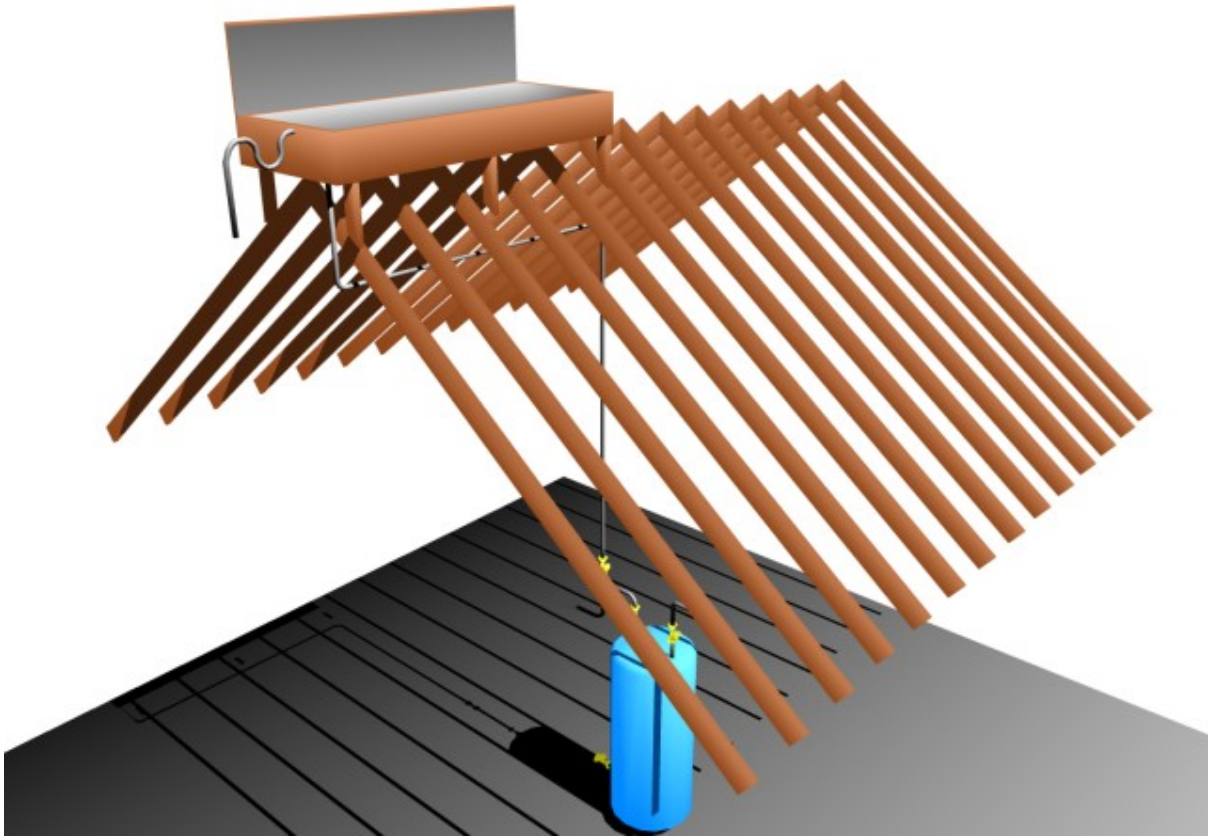

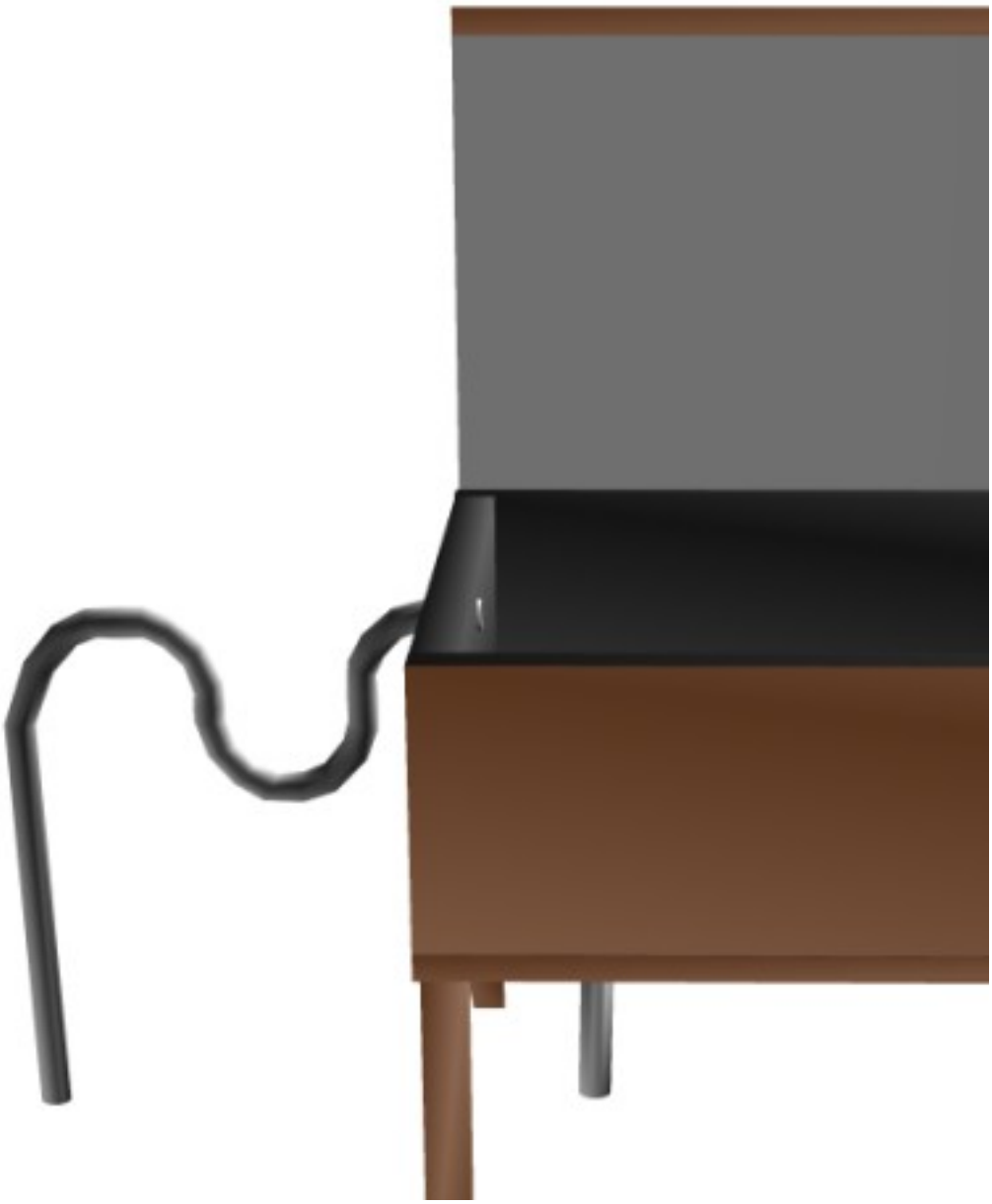

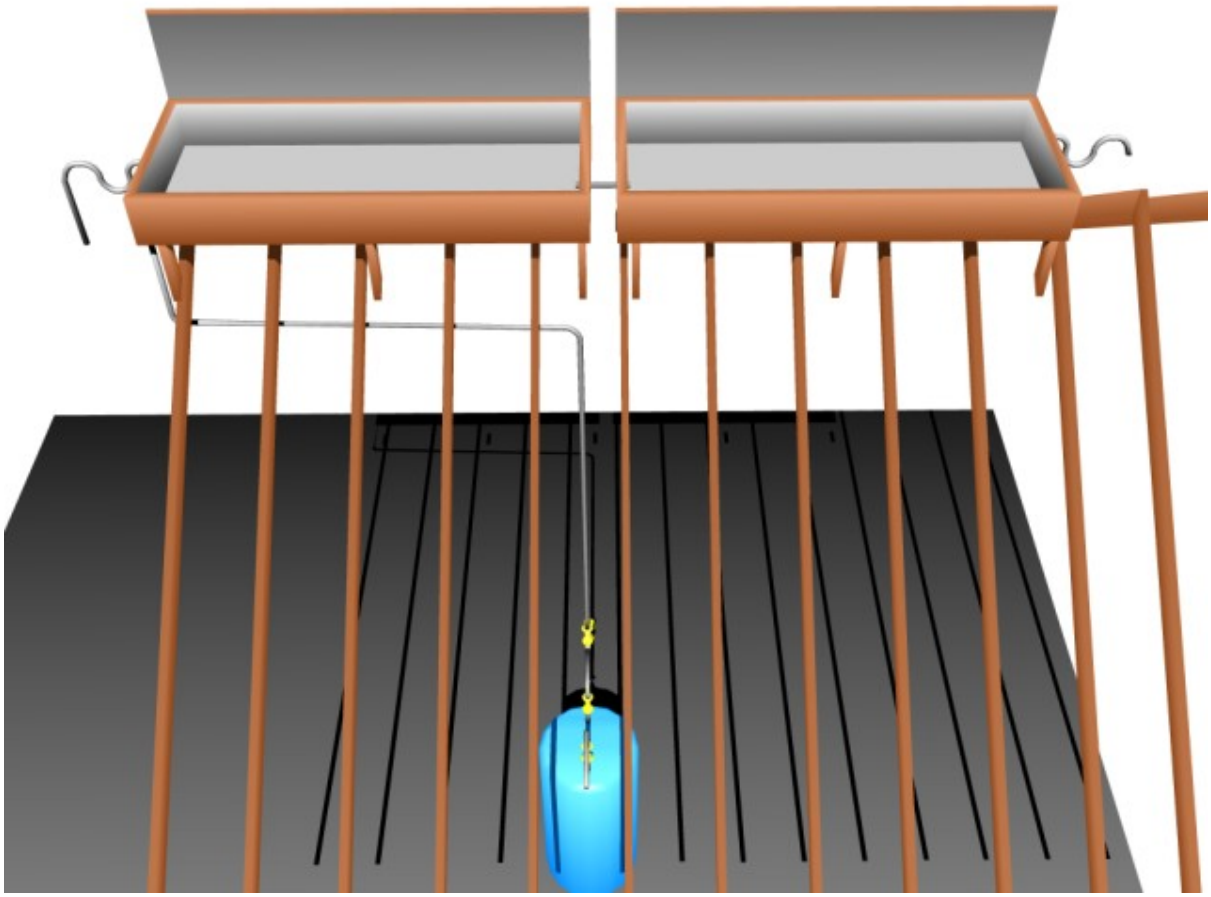

Well, good luck in your new endeavor for energy independence!

***"May your hot water never run dry, may your energy savings always be great, and may you learn something every day for the rest of your life."***

***Richard Lewis***

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