Build your own solar hot tub

By Robert C. Herman

Any homesteader knows that among the many rewards of a self-sufficient lifestyle are a sore back and aching muscles. Recently I realized what I needed to ease the aches and pains after a long day of chopping wood and moving soil: a hot tub.

Not one of those party-size, fancy marble pools with jets and bubbles and surround-sound stereo, but a comfortable place to soak away the knots and contemplate my place in the universe.

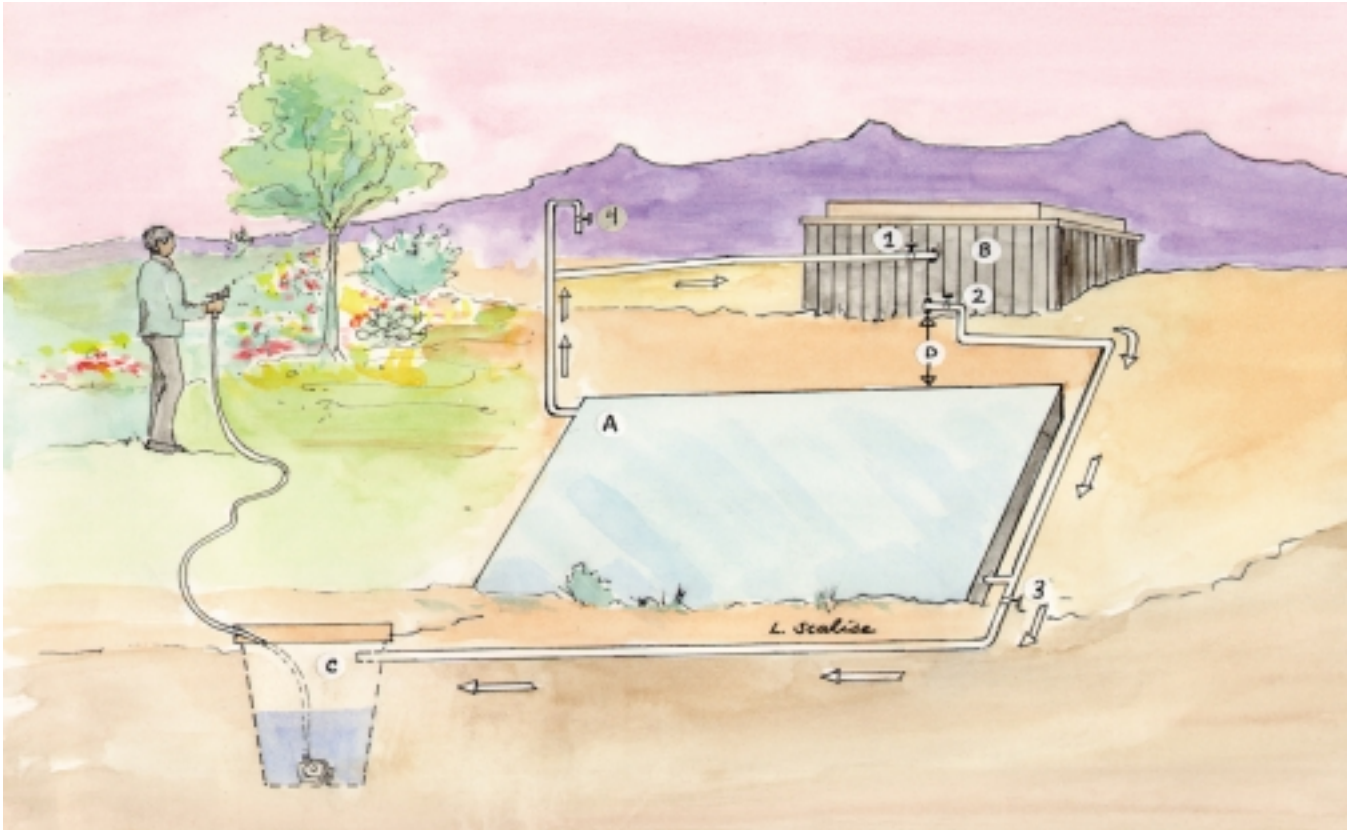
Since I haul my water, generate my electricity, and basically live by my wits, the design criteria for my hot tub were: cheap to build, free to use, and frugal with water.

With about $100, some recycled hardware, and a bit of ingenuity, I built a thermosyphoning, solar heated tub that uses no electricity, no fuel, and less than 60 gallons of water, which is subsequently re-used in the garden.

The principles that make this system work are specific but simple. The skills and tools required to build the tub enclosure, and to plumb the system, are rudimentary. The satisfaction of soaking in my tub as the sun drops over the Rockies is priceless.

Your tub can be made of any suitable container that will hold you and enough water to cover your body. I chose a 100-gallon poly stock tank made by Rubbermaid Agricultural Products and available for about $70 where ranch supplies are sold. This tank is oblong, about 2 1/2 x 4 x 2 feet deep, which is large enough for one person or two very close friends. It is strong and durable, won't rust, and its rounded edges make it comfortable to sit in. Rubbermaid makes these tanks in other sizes. If you are extremely long-legged or plan to share the tub frequently, you might want the 150-gallon size. For my purposes, though, the additional expense and water requirements were not justifiable.

The thermosyphoning water heater is elegantly simple and effective. Basically, it works like this: the solar collector is filled with water and



The thermosyphoning solar hot tub. Water heated in solar collector (A) rises by natural convection and circulates through valve #1 to hot tub (B). Cooler water at bottom of tub circulates through valve #2, back to collector for reheating. Valve #3 allows system to be drained into sunken barrel (C), from which waste water is pumped to irrigate garden. Valve #4 is pressure relief valve. Note: vertical dimension "D" must be at least 12 inches, preferably 24.

pointed at the sun. Sun rays penetrate the glass (or fiberglass) face of the panel, strike the heat-absorbing plate covering the water pipes, and transfer heat to the plate, the pipes, and the water. Since hot water is less dense than cold water, the heated water rises to the top manifold, up into the "hot" pipe and to the tub. At the same time, cooler water from the bottom of the tub drains down via the "cold" pipe and into the collector's lower manifold to replace the hot water that is rising. As long as the water in the collector is being heated and the water in the bottom of the tub is cooler, hot water will circulate to the tub and cooler water will return to the collector. This system works well, with no moving parts, provided that you take a few simple steps to help gravity do its job (see the drawing).

Back in the mid 70s, after OPEC taught us the fragility of our dependence on foreign oil, the federal government offered tax incentives to encourage the development and use of alternative energy technologies. As a result, thousands of solar heating systems were built and installed on houses across the country. Some of these systems worked better than others and when the tax credit program expired, the solar heating fad went the way of the leisure suit.

Depending on where you live, it is very likely that there are abandoned solar collectors nearby, patiently waiting to be rescued from the scrap heap. Ask around, or advertise in your local newspaper that you are looking for used solar collectors and associated hardware. Prices will be negotiable, but I would not expect to pay more than perhaps $20-40 for a good 4 x 10-foot collector (you only need one), and for that price would hope to get a truckload of pipe, valves, and fittings thrown in. Some folks will even give away their collectors and all the associated plumbing and hardware, just to get it out of their barn or off the roof. If you really can't find a free or cheap used collector in your area, you can build your own. My own heating source is a 4 x 10-foot flat plate solar collector from the late seventies. It's what I had around, but a smaller collector would do the job, especially if you insulate the tub well.

The author enjoys the fruits of his labor.

One caveat: make sure the solar collector you rescue has not been damaged by water freezing inside its works. The flat plate collector is made up of a series of parallel, small diameter copper pipes with a larger diameter manifold at each end. If water is allowed to sit in these pipes at subfreezing temperatures, the pipes will burst. You can check for damage either by removing the glazing and visually inspecting the pipes, or by running water through the collector and watching for leaks.

Once you have collected the basic components, you need to site your tub and solar collector. As noted in the drawing, the bottom of the tank must be at least one foot, preferably two, higher than the top of the collector. A level spot at the top of a south-facing slope is ideal; the tub sits on the level, with the collector tucked into the hillside below.

Alternatively, you can site the tub on a platform or deck, with the collector located below. Make sure, though, that the deck is strong enough to carry the weight of the full tub (including 500 pounds of water, plus your own weight).

There are several considerations to address when siting your collector. Ideally, it should face south (within 15 degrees of due south) and have full exposure to the sun between 10 a.m. and 2 p.m. The collector can be oriented on its horizontal or vertical axis, and should be inclined at an angle of at least 15 degrees off horizontal. (30 degrees is better; for year-round use, the optimal angle of inclination should equal your local latitude plus 10 degrees). Finally, the collector should be tilted a few degrees so that the lower corner where the return (cold) pipe attaches is the lowest point in the system and the "hot" pipe comes out at the highest corner. This helps with the thermosyphoning and with draining the system down.

Secure the collector in place by attaching it to posts or rods driven into the ground. The exact method will depend on your circumstances, but

need not be fancy. Just make sure the collector is well supported and stable.

Once you have selected your tub site, level the area and set your tub in place. It is a good idea to raise it off the ground in order to reduce heat loss and moisture problems. I used a hardwood pallet about a foot longer and wider than the tub, and covered it with 3/4-inch plywood. This insulated the tub from the ground and provided a base for framing the enclosure.

Plumbing the tub is relatively simple. I used 3/4-inch copper pipe because I already had it around. If I had to buy new pipe, I might have chosen CPVC (PVC won't take the heat) for reasons of economy. In choosing your pipe, remember that smaller diameter pipe is more restrictive and thus will reduce the performance of your thermosyphon system. I would not use pipe smaller than 3/4-inch diameter.

The stock tank I used already had a fitting near the bottom with a 1 1/2-inch drain plug in it. I simply removed the plug, replaced it with a 1 1/2-inch to 3/4-inch reducing bushing and a 3/4-inch male adaptor (MIP) and I was ready to attach pipe.

For the "hot" (inlet) pipe, I had to cut a hole in the wall of the tank. I located the inlet pipe at a height equal to 2/3 of the minimum water depth of the tub when filled. The inlet must be located low enough to be submerged when the tub is filled, or the thermosyphon will not work. A 1 1/4 to 3/4-inch bushing, silicone caulked and secured on the inside of the tub with a 1 1/4-inch flare nut, formed the hot side inlet.

Actual routing of the pipes connecting the tub with the collector will be specific to your installation. A few general guidelines apply, though:

- Be careful to avoid any high spots in the pipes where air pockets can become trapped.
- Where the "hot" pipe comes out of the collector, route the pipe vertically, then nearly horizontally to the tub, rather than creating a long, steeply diagonal rise to the tub.
- Install a gate or ball valve on both the "hot" and "cold" pipes to control the flow of water.
- Install a safety (pressure relief) valve in the "hot" pipe to avoid dangerous pressure buildup.
- Install a drain valve at the low point in the system.

Keep pipe runs as short as possible. Try to minimize 90-degree turns and other restrictions, and install threaded unions in both pipes near the tub so that the system can be easily assembled and taken apart.

Before building your tub enclosure, test the integrity of your plumbing. Fill the tub and check for leaking joints and fittings. Any leaks at the tub will be easier to correct before it's boxed in; leaking pipes must be fixed before they are insulated. Once you are satisfied that your plumbing is leakproof, you're ready to close everything up and put the tub into use.

Because the tub was intended as a stand-alone stock tank, it needs no structural support, other than a firm, level base. All you really need is some insulation around the sides and a well-insulated lid to keep the heat in. Beyond that, your tub enclosure can take whatever form you choose, based on materials available, your carpentry skills and aesthetic considerations.

My scrap heap was long on weathered 2x4s from an old deck, so that's what I used for my enclosure. The result was a rustic, handsome box that blends well with the landscape and cost next to nothing to build.

I first framed a box around the tub, then insulated the inside of the box with fiberglass batting and wrapped it with 4 mil poly sheeting. Then I sided the box with vertical battens cut from the 2x4s. With scrap pieces of galvanized steel flashing, I covered the top of the box using silicone caulk wherever the pieces overlapped to form a waterproof layer. Finally, again from old 2x4s, I covered the flashing with a deck surface. Using scrap wood I made a two-piece lid, split laterally and hinged in the middle.

Insulating the top of the tub is important. A very efficient way to keep the heat in the water is to cut a slab of styrofoam to fit inside the tub and float it on the surface of the water. More convenient in use, but not quite as effective, is a layer of foam glued to the underside of the lid.

Once you have enclosed your tub, insulate all exposed pipes. Standard

Tub with collector (lower right). Upper collector is for domestic water heating.

foam pipe insulation works well. Pay special attention to the "hot" side pipes, as heat loss on the hot side will reduce thermosyphoning efficiency. But insulate the "cold" side too to maximize heat retention.

Preparing the hot tub for use couldn't be simpler: you put water in it. Open valves 1 and 2 (see drawing) and fill the tub to within 8 inches or so of the top. If you fill the tub during the hot part of the day (and if the sun is out), the collector should immediately begin to heat the water. Within 15 minutes heated water should begin to flow into the tub through the inlet pipe. If not, you may have an air pocket somewhere. The easiest way to flush out an air pocket is to open the drain valve, let two or three gallons run out, then close the valve. Once the heated water is circulating, the water in the tub will gradually warm up.

How long will it take to heat the water? That depends on a number of factors, including the size of the collector, the efficiency of the tub insulation, the pipe diameter, and other aspects of your plumbing, your location, amount of sunshine, etc. On a sunny, mid-summer day in Colorado, if I fill my tub with tepid water at 10 or 11 a.m., the water temperature rises to 110 degrees within two hours.

After the initial heating, the collector only needs to maintain the water temperature. From the second day on, your biggest concern will be how to keep the temperature cool enough for comfort. With a reasonable amount of sunshine and a well-insulated tub, your water temperature can become much too hot—more like a crock pot than a hot tub—and you'll have to cool it down before you can climb in. You'll need to experiment with this, but I have found three low-tech ways to control the heating process:

- Cover the collector surface. I have used bamboo shades to partially cover the collector, thus reducing its solar input and its water heating capacity.
- Uncover the tub. Open the lid and remove the floating insulation to allow heat to escape from the water.
- Partially close the "cold" side valve to reduce the flow rate of heated water.

Of course, you can stop the circulation, thus the heating, by closing both the "cold" and "hot" valves. This will prevent the water in the tub from getting any hotter, but will increase stratification in the tub, with the hottest water near the top and cooler water at the bottom.

IMPORTANT: Whenever the "hot" side valve is closed, the manual safety (pressure release) valve must be open, or an automatic pressure relief valve must be in place. Water + heat + pressure = steam, and that steam must be released. An automatic safety valve, replacing the human element, is better than a manual valve.

A good thermometer is needed to monitor water temperature in the tub. Avoid the standard pool or spa thermometers, which only read up to 120 degrees (If left "full on," my tub can heat up to 150 degrees in two days). I recommend a chef's thermometer (about $5), with a dial that reads from 0 to 200 degrees F. If you use floating insulation in your tub, simply insert the pointed end of the thermometer probe through the styrofoam into the water. Otherwise, make a small raft out of foam, stick the thermometer through it and float it on the water surface.

Ideal water temperature is a matter of individual preference. I find that 102-105 degrees is good for prolonged soaking and meditation, while 110 degrees provides the kind of deep therapeutic heat that turns knotted muscles into putty. Above 110 or so, it's time to throw some carrots and potatoes into the water.

Our household uses untreated spring water, which I haul 300 gallons at a time from a source several miles away. Since I have to truck in every gallon I use, I like to optimize my water use. At the same time, I am disinclined to add pool chemicals to my tub water, nor will I get involved with pH testing or any other slavish rituals. As a result, though I hate to waste water, I have to change the tub water frequently.

My solution to this dilemma is simple. I dug a hole and sunk a barrel in the ground just downhill from the lowest point in the system. Into the barrel I dropped a small centrifugal pump with a float valve. A length of garden hose runs from the collector's drain valve to the barrel.

About once a week, I drain the water out of the system and into the barrel. The pump sends the water to the various garden areas to irrigate vegetables and flowers. Thus the water is used twice. Nothing is wasted and no chemicals are used.

You can extend the useful life of your tub water by fitting a filter of some sort to the cold water outlet in the bottom of your tub. The neck and top section of an appropriate-sized plastic bottle, press-fit into the outlet, will work. Cut a small piece of aluminum or brass window screen material (steel will rust) and mold it into the bottle neck. Back that up with a wad of filter material and you will catch much of the junk that ends up in the water after a few soaks. Be sure to check the filter frequently, and replace it as needed.

There is nothing like relaxing in your tub at the end of a long day of hard work, or soaking for a half hour at midnight under the milky way. The hot water relaxes your muscles, works out the knots, and soothes the soul. A leisurely soak in the tub allows you to slow down and remember why you chose this self-sufficient lifestyle in the first place. Let other people hand thousands of dollars to the Spa Guy. Do it yourself, for peanuts. Δ