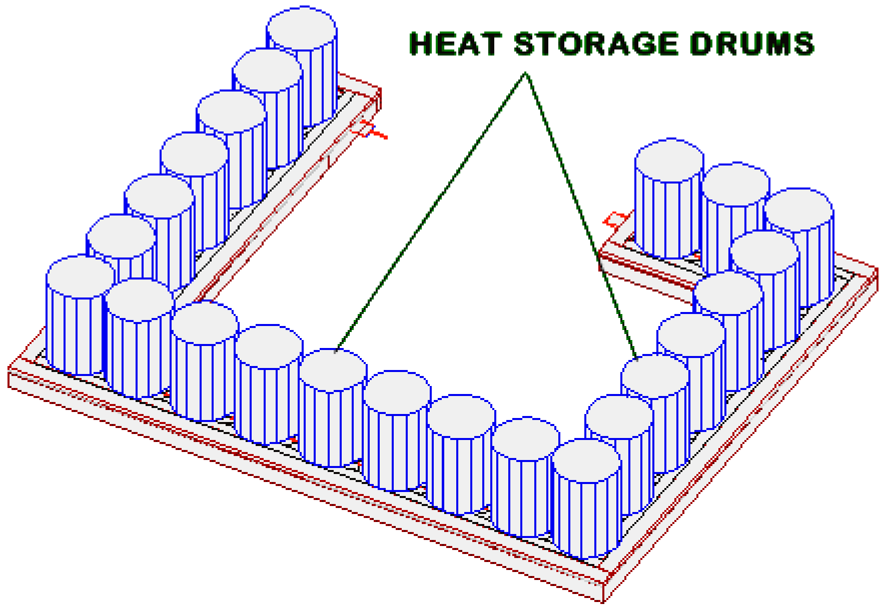
Multi Drum Heat Storage

By
John Canivan

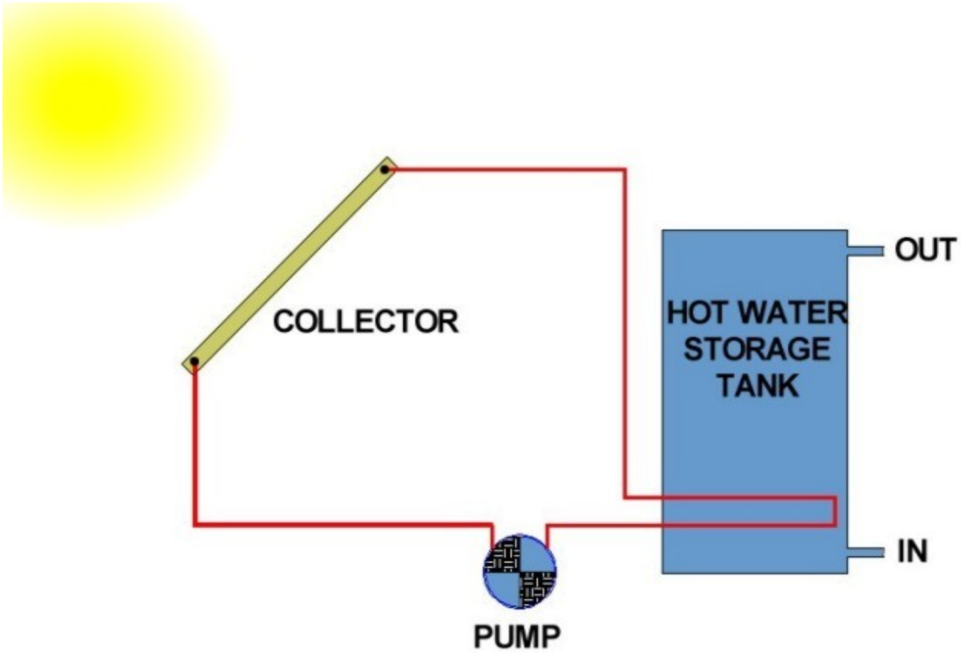


http://www.jc-solarhomes.com/drum.htm

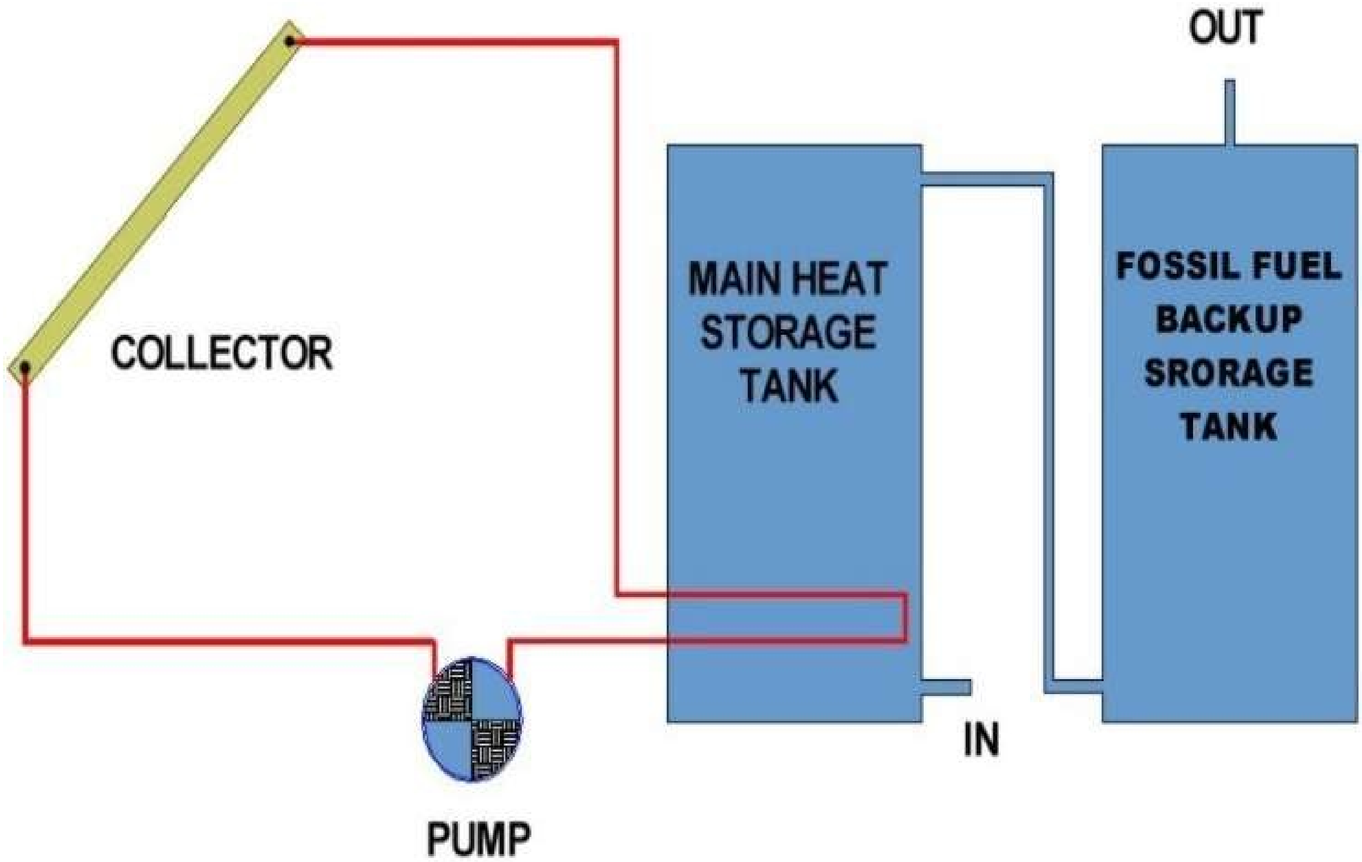
Solar collectors are used to harvest the sun's heat energy from rooftops, but solar collectors are just the tip of the iceberg when it comes to using this renewable resource. Many engineers ague that conserving heat with insulation is more cost effective than alternative energy heating and DHW systems and I must agree that insulation should be a primary concern, but insulation alone will not eliminate the need to burn oil. Too much insulation can actually be counterproductive. Air stagnation inside super insulated homes can pose a health risk.

We need well planed dwellings and well planned retrofits with entire roofs devoted to collecting heat and power from sunlight, AND we also need a place to store energy. Being tied to the General Electric umbilical cord may seem like a comforting and practical alternative to maintaining a charge on a rack of batteries with a photovoltaic system, but storing the sun's heat is another way of storing energy.

The thermal mass of walls, floor and furniture inside a house can be used to moderate temperature swings for short time periods with the use of simple solar hot air circulating systems. HOWEVER, long term heat storage for home heat and DHW systems require more insulated thermal mass and a more versatile means of heat exchange. Let's just say there are advantages and disadvantages to pneumatic and hydronic heat exchange systems, but I'd like to focus on hydronic systems that use multiple heat storing tanks for this article.

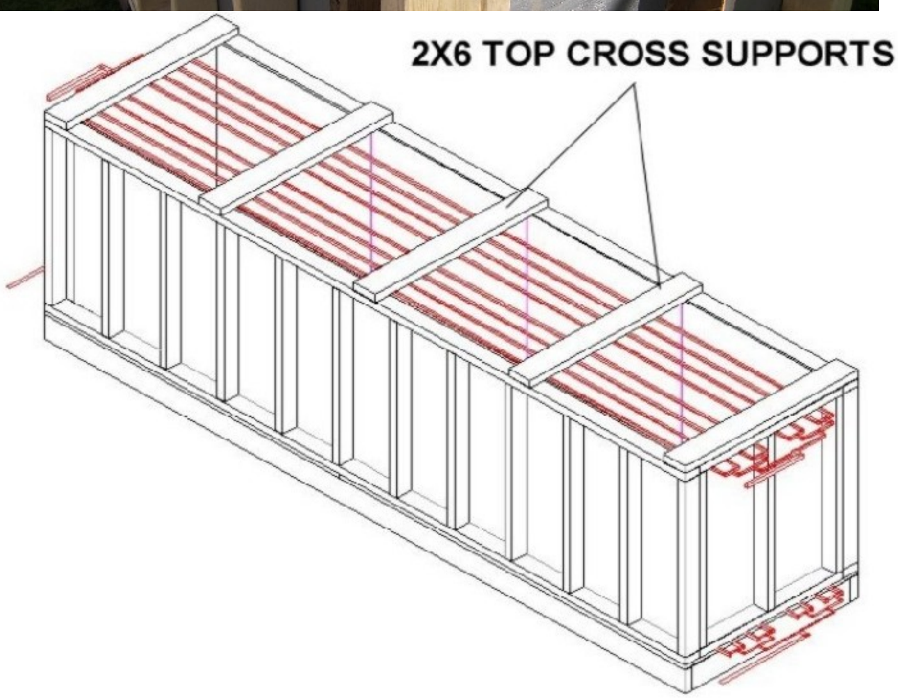


Some very simplistic DHW systems use only one tank for both a fossil fuel and solar DHW system. As you can imagine heating a solar storage tank with oil or gas or electric is counterproductive since heat exchange depends on a difference in temperature. In other words if a fossil fuel DHW tank contains hot water than little or no hot water will be collected from sunlight. This is why most solar hot water systems have at least one tank dedicated to storing heat. In this way cold tap water may be preheated before it enters the fossil fuel heating system.



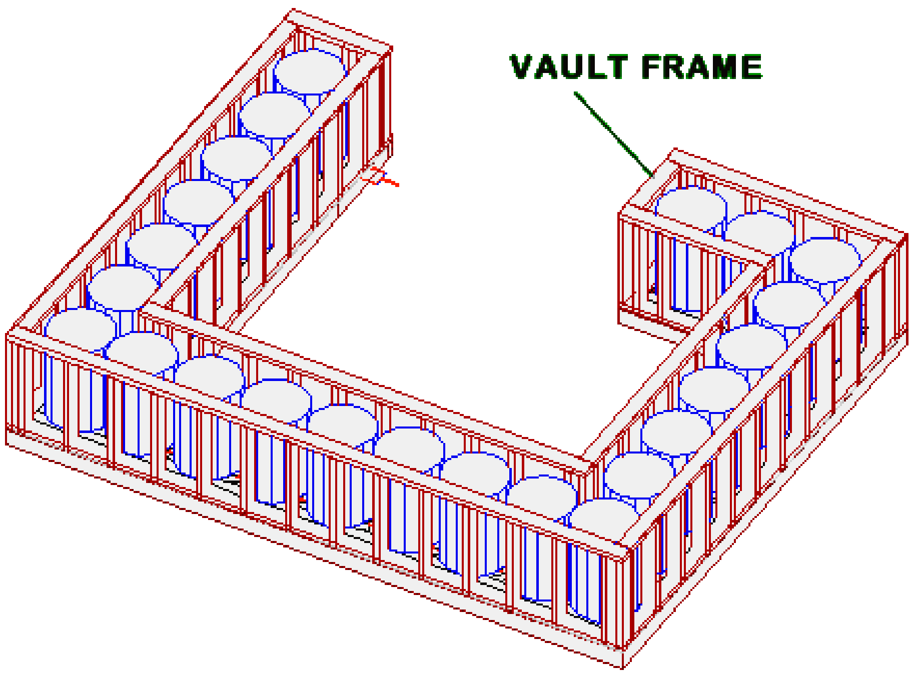
Unfortunately the high cost of conventional DHW systems use expensive storage tanks with internal heat exchange coils. A 100 gallon solar hot water tank may be cost $1000. Now imagine what a serious 500 gallon DHW / home heating system might cost. This is where low cost DIY solar applications come to the rescue.

Large home made open storage containers lined with EDPM, like this one built by Gary Reysa can be a very cost effective. The ones I build are similar except I use an exterior 2x4 frame packed with insulation and I use polyethylene plastic on the inside. As long as the storage tanks remain below 150 F polyethylenes will hold up, however EDPM is easier to work with. Next time I will use EDPM.



CLOSED LOOP HEAT EXCHANGE
The illustrated 600 gallon storage container is divided into four isolated 150 gallon containers that help to stratify heat and increase collector efficiency. A solar heated glycol water mix is circulated through a network of pipes imbedded in a cement slab

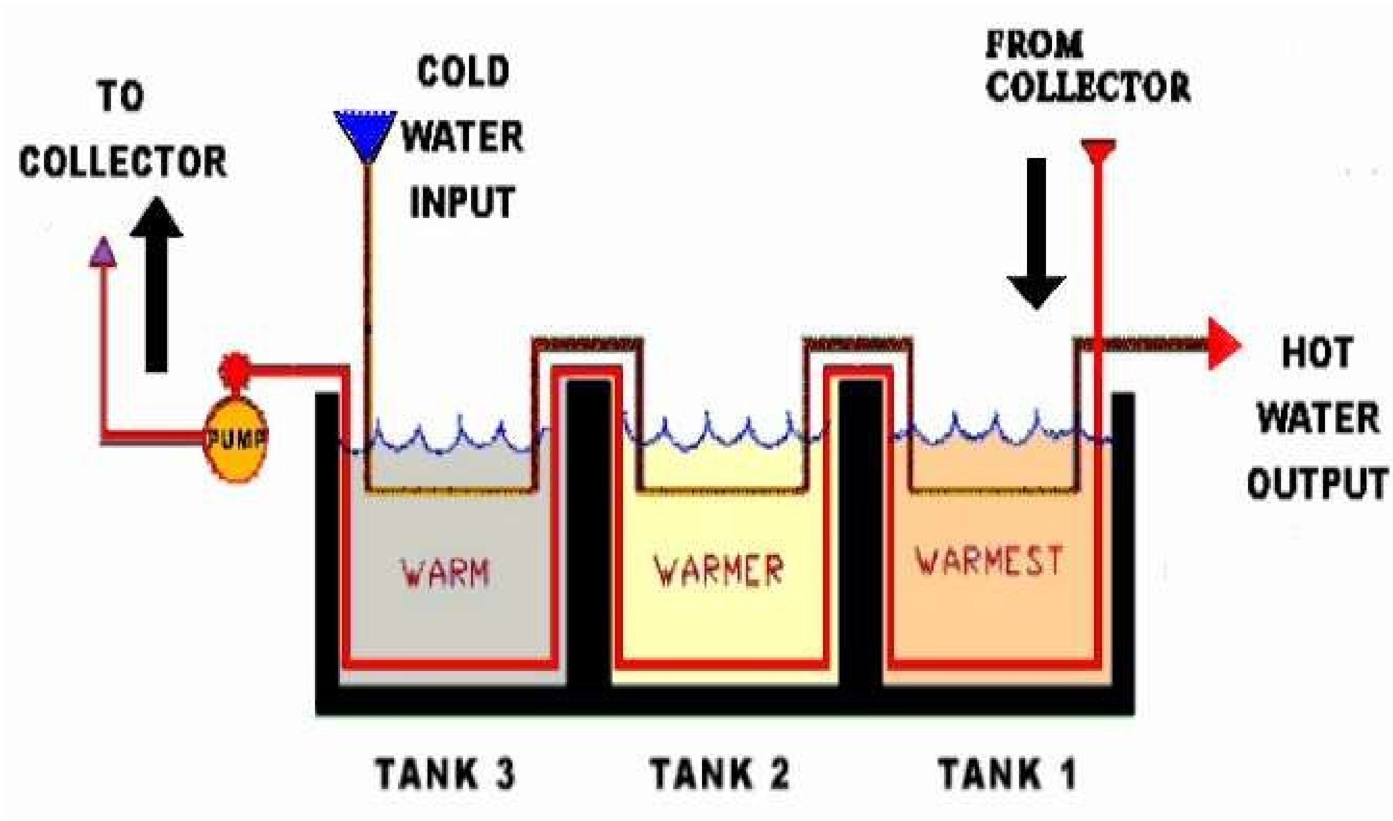
at the bottom of the storage container. This is where collected heat is exchanged into the water storage containers. The network of copper pipes emerged in the top layer of water in the tank are used to extract heat for DHW. This home made storage container is used for closed loop heat exchange. A multi drum heat exchange system based on the same CONCEPT of heat exchange could look like this:



These twenty three drums each have a 55 gallon capacity and hold over 5 tons of water. They rest on a cement platform through which copper pipes have been imbedded. Hot collector fluid (glycol +water) is circulated through the bottom platform to transfer heat into the drums. After the drums are cemented to the bottom platform a top layer of cement and heat exchange tubes are built onto the top lids of the drums. Water will never flow through these drums since they are only used to store and exchange heat.

As you know heat exchange is driven by a difference in temperature. Since the drum bottoms are colder than the drum tops collector heat should enter through the bottom platform and DHW heat should exit through the top platform. The hottest drum will be the first drum to receive collector heat and it will also be the last drum to receive heat for DHW. A simple home heating system may also be implemented with this system by blowing cold household air through the heat storage chamber. Where should air enter the chamber and where should it leave?

A variation of closed loop multi drum heat exchange involves placing heat exchange coils directly inside the drums. This method works best with small DHW systems but it requires a lot of copper for a reasonable heat exchange rate. Let’s now take a close look at a simple three drum closed loop heat exchange system.



HEAT INPUT

Tank 1 is the **warmest** because it's the first tank used to transfer collector heat. Tank 2 is the warmer tank. It will never get as hot as tank 1. Tank 3, the warm tank, is designed to suck the last bit of heat from the already cooled collector fluid. Collector fluid returned to the collector from this tank has a sufficient temperature difference to maintain efficient heat transfer.

HEAT OUTPUT

This series of tanks is designed to preheat water in three successive stages. Tank 3 preheats water for tank 2 and tank 2 preheats water for tank 1. This minimizes heat loss in tank 3 and delivers the hottest possible preheated water. Notice that storage vault water is only used to transfer heat. Vault water never leaves the vault.

CONSIDERATIONS: The above illustrations should only be used as conceptual guidelines in the heat exchange process. Practical close loop systems require a large surface area to exchange heat at a reasonable rate. When copper tubes are imbedded in a cement platform the heat exchange rate is increased because the surface used for heat exchange is increased. Copper is an excellent heat transfer medium but it should be protected with polyurethane before imbedding in cement. PEX can also be used to exchange heat and although the heat exchange rate is slower the cost is less and a protective coating is not needed, but more PEX than copper will be needed for an equivalent exchange.

What are the alternatives to a closed loop heat exchange systems?

Thought you'd never ask… Conventional, open loop, drain back systems have recently become more popular than closed loop systems because they use less copper and less plumbing. HOWEVER, many plumbers are still apprehensive about the freezing problems associated with non glycol based systems. It's true that improperly sloped pipes trap pockets of water that never drain, and sometimes frozen water even accumulates in areas that plumbers expect to drain.

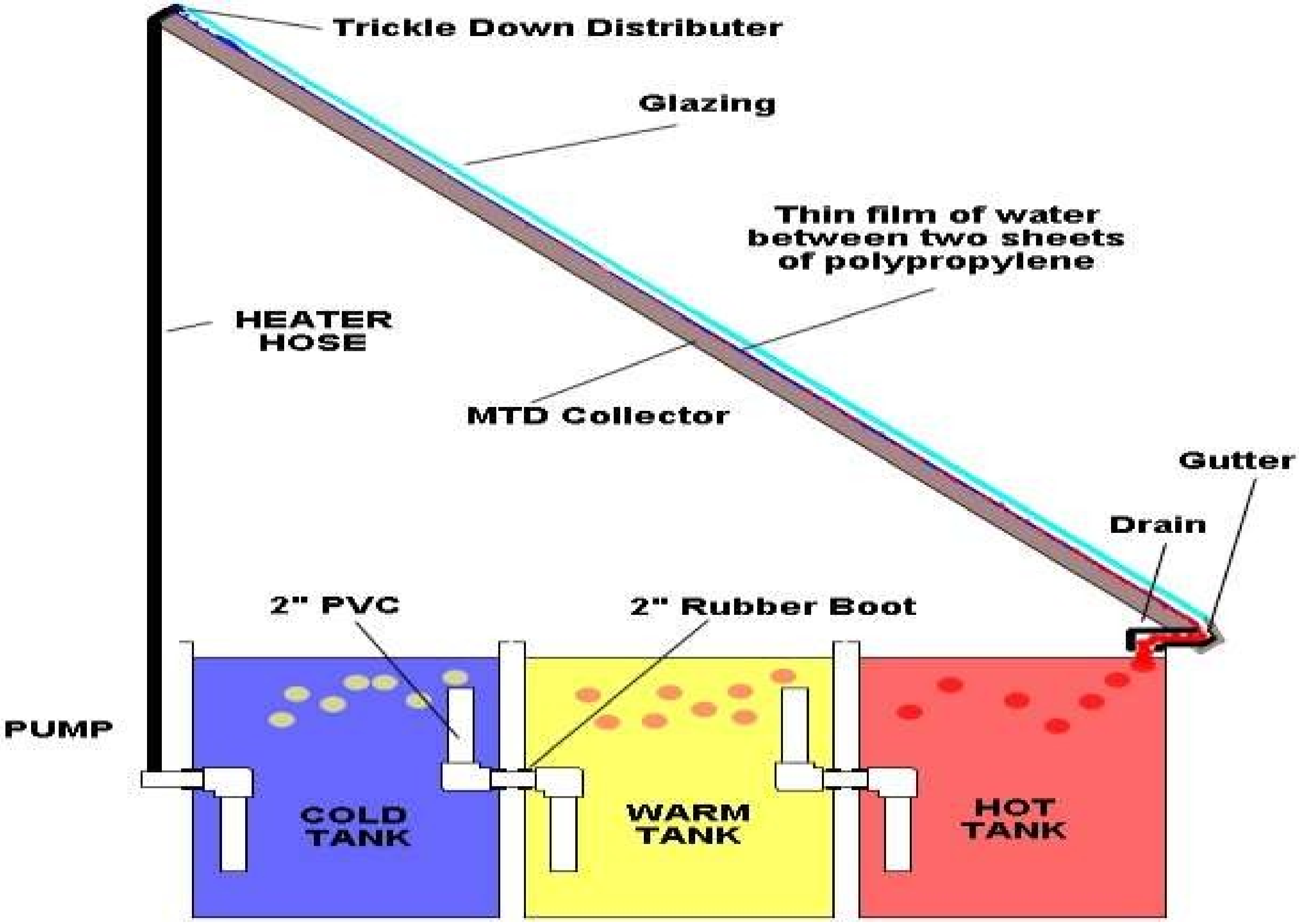
How can we use a drain back system without the worrying about freeze problems?

Well if we could be sure all the water drains from the collector into a nice wide, well sloped pipe, our worries would be over. Unfortunately 2" copper pipes cost about $10/ft.

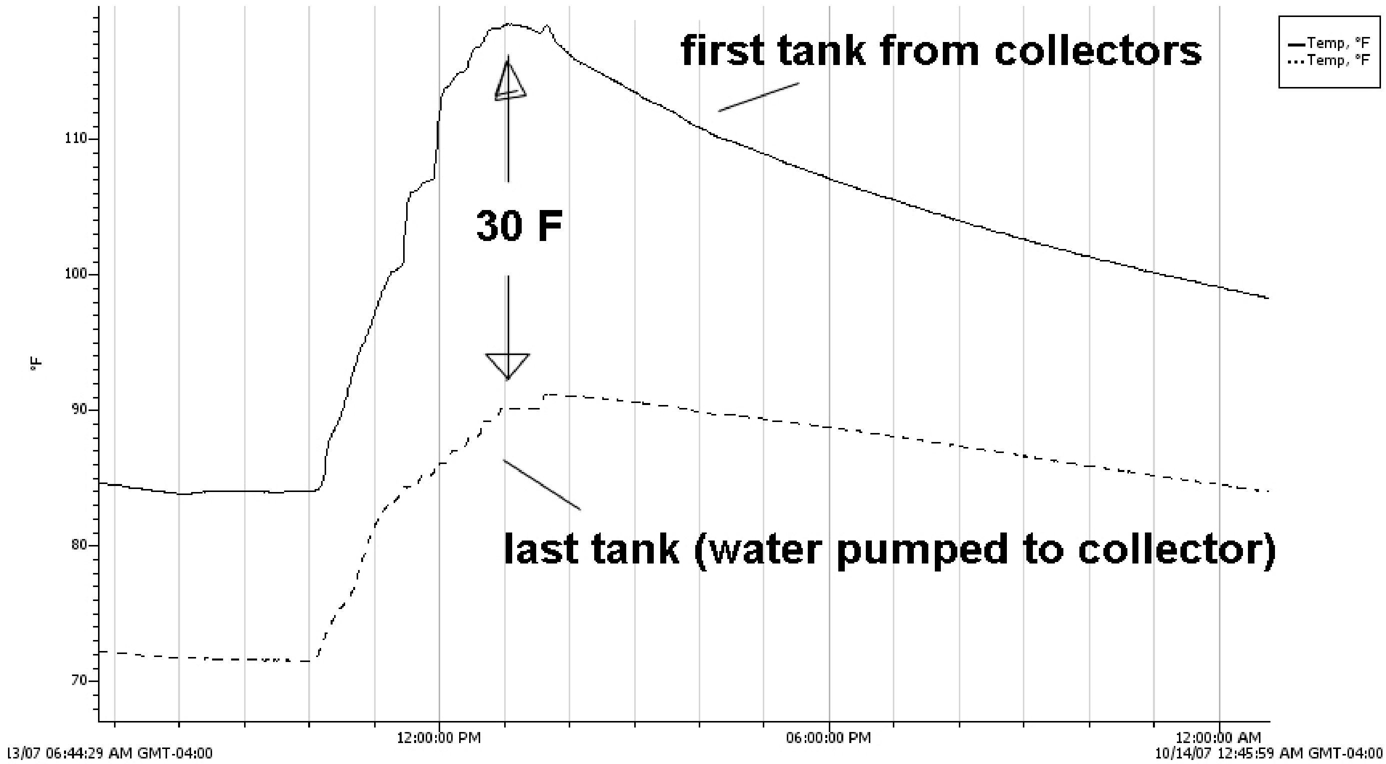
How about 2" PVC pipe?
Not bad for $1/ft but what about the heat, won't it melt?

PVC starts getting soft around 180 F so it's not a good idea to use PVC inside a collector where stagnation temperatures can reach 250 F. However PVC can be used to channel solar heated water from collectors. If the temperature of solar heated water ever exceeds 150 F the heat storage chamber is inadequate small for the surface area of the collectors.

OK we can use a 2" PVC pipe to channel heated water from a drain back collector, but what about the copper inside a collector. Is there some way we could do away with copper inside the collector. Gary came up with a serpentine collector made with PEX pressed into aluminum heat fins. PEX holds together at high temperatures and the heat transfer rate from the aluminum into the water flowing through the PEX is very impressive, but we can also remove the PEX flow tube and channel the heated water into a gutter. This is what Harry E, Thompson did in 1960 with the invention of the "Trickle Down" solar roof. With a few modifications and the help of Richard Heiliger the "Trickle Down" solar roof has been modified into a modular Modified Trickle Down collectors that may be pressed together to form an array. Both Trickle Down and Modified Trickle Down systems use open loop, drain back technology with large gutters to channel solar heated water into open drain back tanks. A basic MTD system might look something like this:



I will not discuss MTD collectors at this time, but will use the above illustration to clarify the concept of open-loop, multi-tank, drain-back heat storage. Notice that no heat transfer tubes are used. Notice also that the basic concept of heat stratification is the same for open loop and closed loop systems with the exception that water is heated directly here without the use of heat transfer tubes. Multiple drums trap heat better than single tanks by doing a better job of separating hot water from cold water. No sense returning hot water to a hot collector. As storage temperature approaches collector temperature the rate of heat transfer begins to slow. Multiple drums delay, storage saturation, improve collector efficiency and generally extend the heat collection process. Here is some graphical evidence that illustrated the heat stratification process. Notice that the first tank to receive solar heated water climbed 30 F higher than the last tank that returns water to the collector.


first tank from collectors
30 F
last tank (water pumped to collector)
Temp, °F
Temp, °F
°F
110
100
90
80
70
13/07 06:44:29 AM GMT-04:00
12:00:00 PM
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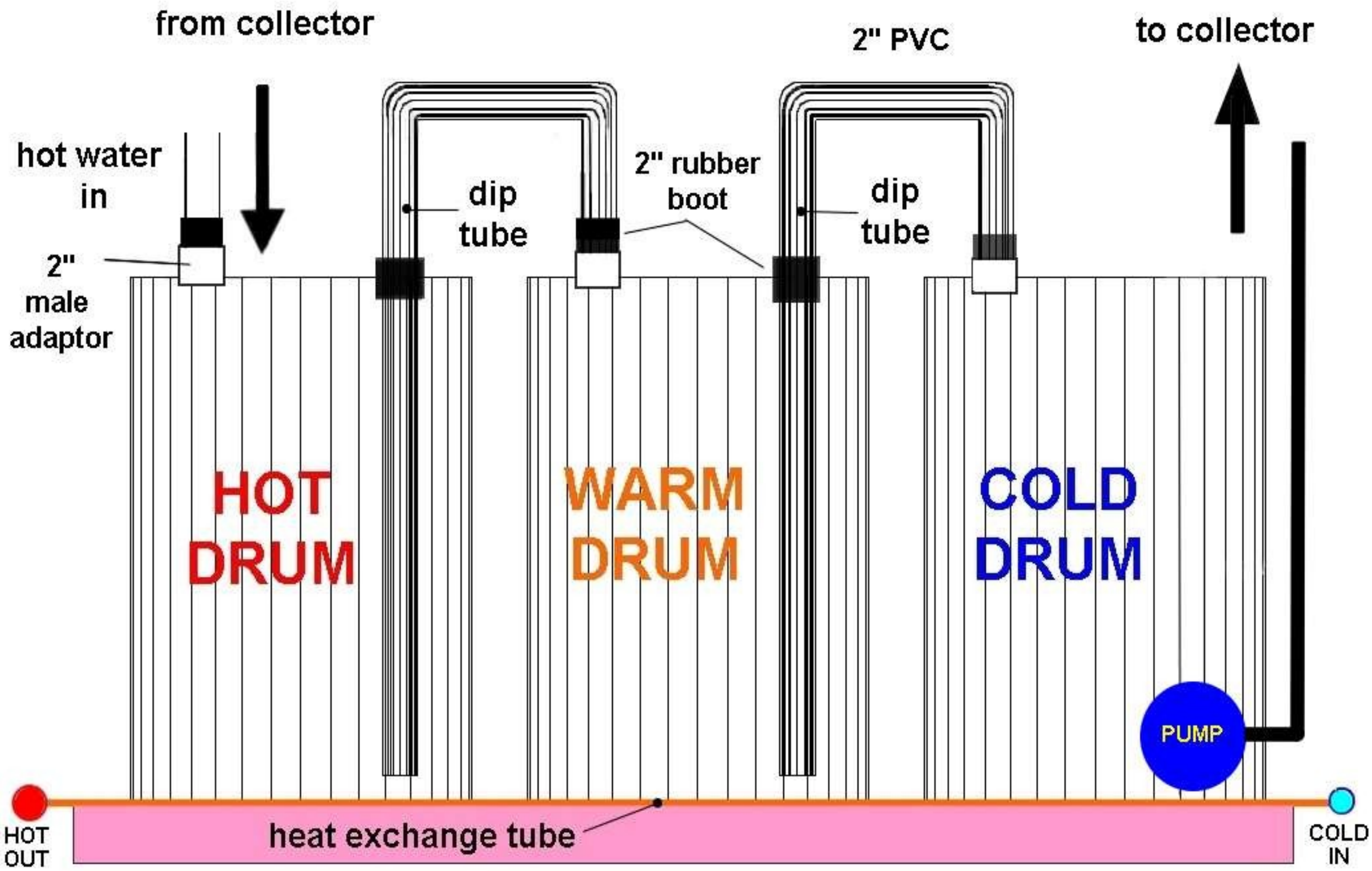


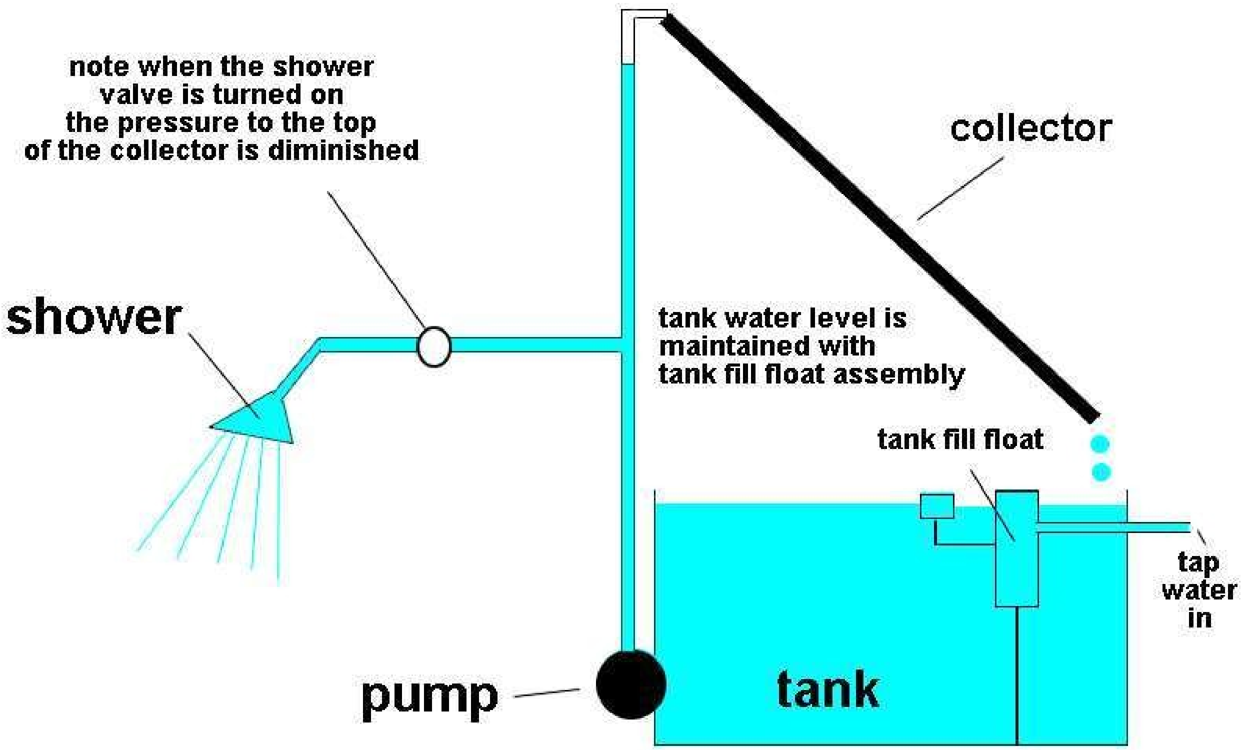
MULTI-DRUM HEAT STORAGE AND HEAT EXCHANGE SYSTEM

As you can see these drums rest on a heat exchange platform that's used extract heat for DHW. A circulator pump installed in the hot tank could be used to circulate hot water through a radiant floor. The water, cooled through the radiant floor would than be returned to the cold tank. In this way the hottest water would always be used up first. Water to the hot drum is preheated by the water from the warm drum which is preheated by water from the cold drum. This three drum system is only being used to illustrate a concept. In reality a minimum of 10 drums would be used for home heating and DHW. Actual drums hooked in series would look something like this:

So now we have a system with no heat exchange tubes in the collector and one set of heat exchange tubes in the bottom slab for DHW. Since the drums are sealed we can use a high reservoir tank to increase the pressure on the pump thereby increasing the flow rate. Now let's see if we can build a practical home heating/DHW system with no flow tubes in the collector, tank or floor. With sufficient drums we should be able to blow cold household air through an insulated storage tank chamber filled with drums of hot water. (Forced hot air)

BUT... What about DHW?

We need pressurized water fed from our water supply….. OR DO WE? If you think everything up to now has been odd hold onto your hat. I'm sure the building department and plumbers union will love this one. just an idea…. needs work… use your imagination. This is just one tank that supplies DHW without a heat exchange tubes of any kind but it should be connected to a multi tank system for all the heat and hot water you would ever need. The tank would always be refilled as needed to give a constant supply of fresh hot water.



Anyhow it has been fun sharing these thoughts with you. Remember alternative energy applications are only limited by our imagination. John Canivan www.jc-solarhomes.com