DIY combination solar water and home heating system

By transforming the north-facing roof of his house into one large solar collector, John Hermans now has a solar space heater and solar water heater. He explains how it works

For many years now I have intended to carry out my plans to build a combined solar domestic hot water system and a solar space heating system. This rather large project has now come to fruition; last winter being its test period. My aim in this article is to explain how such a system might work, at reasonably high efficiency, and discuss some of the variables. As this project involved a long period of design and construction, I found that I had to develop particular skills and methods as I went along.

Although the system I have constructed was for a new building, this style of collector could easily be used to replace all or part of an existing north-facing roof. The primary objective of this solar heating system was to reduce to an absolute minimum the need for any other heat inputs into the house—the goal was 100 per cent solar heating!

John Herman sitting atop his solar collector.

In order to achieve this, you need to appreciate the simple rule 'you only need to generate as much heat within a building as that which is being lost'. Therefore, before going ahead with any home heating project, it is imperative that you do as much as possible to maximise the insulation of the house envelope.

This includes wall and ceiling insulation (R3 and R5 in our case), draught proofing, double glazing (all non-opening windows), curtains (an option we have not taken up, as the double glazing is so effective), minimum south facing windows and keeping the surface area of the house's outer walls to a minimum in relation to its volume.

I might also point out that our house is earth covered to the south and earth bermed around the east, west and part of the north walls—a non-essential part of good design. The use of large quantities of internal thermal mass is also a key factor in designing comfortable solar houses. We have tonnes of thermal mass in the form of a concrete slab, internal mudbrick walls and one concrete wall. Although the 36m² 'active' solar heater on the roof is quite large for a house with a floor area of 200m², this energy input represents only around half of the total input from the sun. Our house also has 30m² of glazing on the north side, which is referred to as 'passive' solar heating (as it uses the direct sun to heat the internal thermal mass).

In a nutshell, the three key principles of functional solar houses are: maximum insulation, maximum internal thermal mass and maximum summer-sheltered north facing glass.

Solar heating system

The hot water generated by the 36m² of solar collectors on the north roof is stored in a 3000 litre steel tank located

Left: Manoeuvring the 3000 litre storage cylinder into its final position, before boxing it in and insulating it. Right: One end of the 3000 litre storage cylinder, showing the access hole with the swimming pool water heat exchangers prior to final positioning.

on top of the garage roof to the south of the house, above the collector area. The heated water from the collectors naturally flows upwards (thermosyphons) into the storage tank above. When this collected heat is required inside the house, an electric pump transfers the hot water to any or all of the seven hydronic plastic pipe loops in the house floor slab. This mode of heating is called 'active solar', as an external energy source is required to transfer the heat to where it is needed.

A similar, and simpler, system could be made by doing away with the storage tank and circulating water directly from the collector to the floor coils, or even to wall-mounted radiators. In our situation the house already gains so much energy via the passive system that it may overheat in the autumn and spring seasons. Being able to store the heat in a large, well-insulated cylinder enables us to direct this heat where and when we want it. The stored heat is also used to heat a courtyard greenhouse and can be used in my workshop office (when I build it). Most importantly for the kids, the system is also used in the warmer months to heat the above-ground 20,000 litre swimming pool.

System sizing

The sizing of the solar water collectors and heat storage cylinder determines just how much stored reserve heat can be carried. In our case, we decided to make the entire north roof of the house into the collector. For every square meter of collector, the recommended volume of water to have in storage is approximately 75 litres, so our tank is 3000 litres. In the coldest season, I have set the thermostat to operate the hydronic heat transfer pump, so that it comes on when the temperature at the top of the storage tank reaches 35°C and turns the pump off at 30°C. On a sunny winter's day, the tank temperature actually continues to rise while the pump takes water from it. By 5pm the entire house slab is noticeably warm, with the air temperature around 21°C. So far, each morning the house temperature has not fallen below 17°C.

Robyn carefully applying heat and home-made solder in order to join the copper riser tubing to the galvanised corrugated iron.

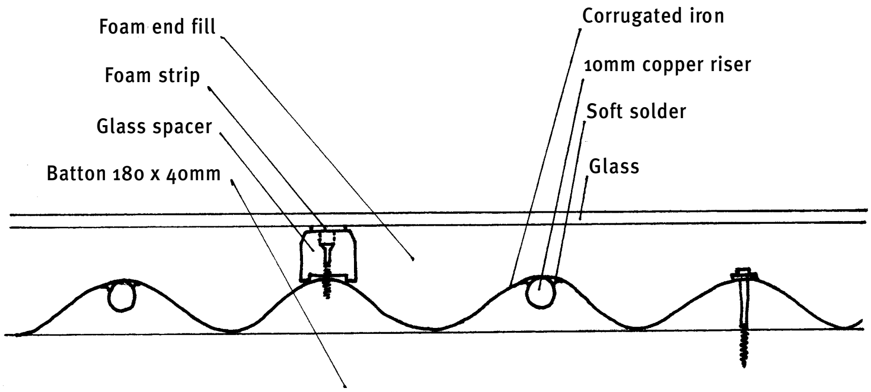

Diagram 1. End of view collector

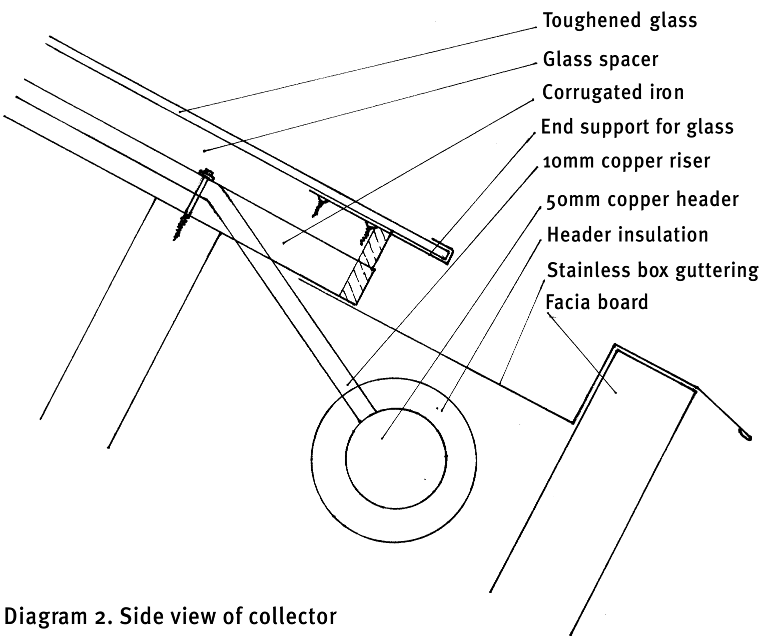

Diagram 2. Side view of collector

As the house has so much built-in heat storage, or thermal mass, the heat is carried through to the next day with minimal temperature drop through the night. There is no provision in the house for any other heating input, despite living on a 40 hectare bush block with abundant firewood. I consider the work we have done in fabricating this home heating system to be less than the effort of gathering, cutting, splitting, stacking, carting, feeding and cleaning an indoor fire place for the rest of our lives. We do burn some wood in a well-insulated AGA stove for cooking and for domestic water heating. There is also provision for heating the water in the 3000 litre storage tank with a large, cast iron water jacket heater for successive days of no sunshine. This stand-by heater resides in the court-yard/glass-house and is used around once a fortnight in winter.

The north facing roof which makes up the solar collector has a physical dimension of 15m x 3.3m. This entire

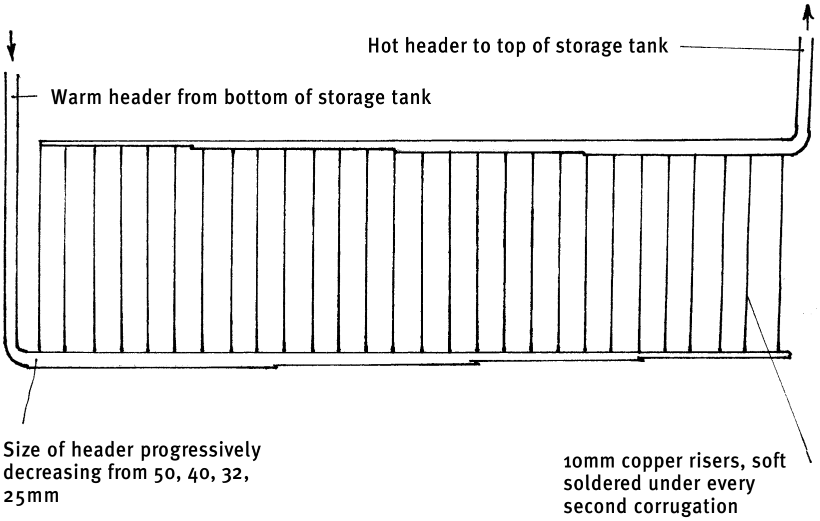

Diagram 3. Pipe layout of solar collector

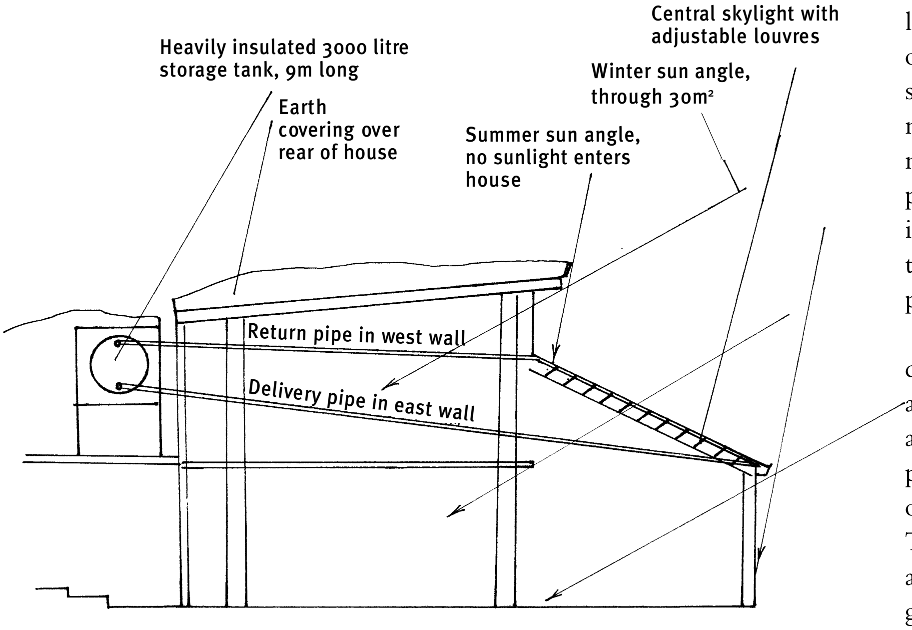

Diagram 4. Showing solar collector, delivery pipes and storage tank replacement.

roof surface is covered with 6mm toughened glass sheets which I acquired cheaply as seconds. The glass is held 20mm above the corrugated galvanised iron by strips of square hardwood, screwed to the top of every sixth hip corrugation (see Diagrams 1 and 2). The glass actually rests on 12mm strips of foam padding. This arrangement forms a very rigid and strong surface that can readily be walked on. The 32 glass sheets were easily handled by myself (1.9m x 0.86m) and none were broken during construction.

Under the large, glass surfaced roof area are three separate solar collectors, the 36m^2 space heater, as discussed, and a smaller 6m^2 domestic water heater at the east end of the roof. In the centre of the roof is a clear skylight, 1.2m wide by the full width of the roof. This skylight has 50mm insulated louvres that can pivot to close, retaining winter heat at night and blocking out summer sunlight. A 12 volt DC motor together with a bicycle chain and sprockets and simple linkages are hidden inside the roof space. Pushing a button switch in the kitchen allows the louvres to be opened and closed. The amount of light it throws into the back of the house in winter is amazing (see Diagram 4).

Construction

I have used galvanised iron for the collectors (not zinc-alume) at a thickness of 0.9mm. It is of minimal extra cost to standard iron at 0.45mm. It has two main benefits: you can jump on it and not bend it, and the extra thickness proportionally increases the capacity of the iron to conduct heat transversely from the iron to the water in the copper riser pipes.

In the fabrication process of these collectors, I used lead/tin soft solder to attach the 81 risers of 3.6 metre length and 10mm diameter, hard drawn copper tube to the underside of every second corrugation in the galvanised iron. This gave the risers a spacing of 15cm and although this distance is slightly greater than what I would have preferred to achieve higher efficiency—that is, a riser soldered in every corrugation—the compromise allowed me to use half as much copper and solder resource. Besides, soldering 280 meters of copper pipe to galvanised iron was quite enough of a challenge! The soft soldering process was simple once the method was established (see the photo with Robyn on the oxy).

The copper pipes that deliver the cold

water to the bottom of the risers and those that take the water away from the top of the risers are termed the headers. This pipework needs to be configured as in Diagram 3 to achieve uniform liquid flow in each of the risers. Uniform flow through all risers is also achieved by using header pipes of large diameter (low pipe friction) and risers of small diameter (high pipe friction). It is most important that the risers and top header maintain a minimum of 20:1 upward slope to facilitate the natural thermosyphon flow and to avoid air and steam traps which will inhibit this flow.

When the floor is being heated, water is taken directly from the top of the 3000 litre storage tank. However, when the pool is being heated the pool water is passed through a heat exchanger mounted along the top of the storage tank. A group of five 20mm diameter and 18 metre long copper tubes (from the scrap yard) are used as the pool heat exchanger. The pool water has chlorine in it, which would accelerate the corrosion of a steel tank. The storage tank's life expectancy is significantly increased by a two per cent solution of a corrosion inhibitor in the form of sodium benzoate. Sacrificial magnesium anodes have been bolted to the inside of the tank to maximise its life span. The steel pipes welded to and passing through the end walls of the storage tank are separated from all copper pipe or fittings by rubber hose or plastic fittings, to avoid corrosion by electrolysis.

The heat distribution pump, which does the work of transferring all this captured solar energy into the house slab is a small 90 watt circulating pump. It circulates around 0.75 litres of the cooler return line water per second and is only needed for a few hours a day. Given that the space heater collector is 36m^2 in area, with a summer radiation level of 1kW per square metre and around half that value in the winter, it is easy to calculate the sort of energy inputs we are receiving from this system. We love it!

Rebate status

In Victoria, the Sustainable Energy Authority (SEAV) administers the solar hot water rebate program as part of the state government's commitment to reducing greenhouse gas emissions. The rebate offers up to $1500 for solar water heaters installed under the regulations of the rebate program. Only system installations that result in reduced greenhouse gas emissions are eligible for a rebate, and the amount of rebate is based on the performance of the system and the hot water delivery of the unit.

Unfortunately for me I am not entitled to any subsidy at all with my home made installation, despite the system's estimated 60 per cent input of our home heating and domestic hot water, and that the newly installed solar collector has displaced the use of burning wood.

My system fails to meet criteria qualification in two ways. First, all systems included in the rebate program must be assessed to Australian Standard AS 4234. This is a performance standard that enables consumers to compare the performance of commercially available units. My system is not a commercially manufactured product and has not gone through the AS 4234 assessment (which is a fairly expensive procedure). Second, the system was not installed by a licensed plumber and therefore did not receive a Certificate of Compliance, as is required by the Plumbing Industry Commission.

More information about the Certificate of Compliance and the regulations governing plumbing work is available from the Plumbing Industry Commission website: www.pic.vic.gov.au. If a plumber had anything to do with this project, it would never have happened! Through scavenging and not including the cost of my own labour, the system cost around $3000. If you consider yourself fairly capable and want something special around the house, go forth and DIY. ✲