

Smart sustainable reno

A pool to tank conversion, plus a solar wall!

With the pool water evaporating each dry, hot summer, and an ineffective northern wall, one homeowner converted both to be water and energy saving assets. Ken Self shares his story with *ReNew*.

Returning to Australia after six years in the UK, we were faced with an energy and water saving challenge, namely our 1950s house in the north-eastern suburbs of Melbourne. It was 2007 in the midst of a drought with tight water restrictions in place. The in-ground swimming pool was losing so much water through evaporation that we couldn't keep the filter pump operating.

Water loss was temporarily fixed by connecting a downpipe diverter to send rainwater to the pool. A 5000 litre water tank was installed so we could keep the garden alive despite water restrictions.

Other small retrofits, such as fixing the dilapidated ceiling insulation and adding reflective foil in the ceiling to deflect the summer sun, helped a little with thermal comfort and efficiency, as did dismantling one of the two hot water systems (the old electric one in favour of the newer gas model).

The tanks filled slowly as there was little rainfall. The pool stayed unused and the summers were still hot and the winters cold. Removing the old electric hot water system halved our electricity usage, but most of that was taken up by gas usage.

Our efforts had been ad-hoc; to really make a difference we needed to invest more wisely.



Photos: Ken Self

The innovative solar wall is essentially a trombe wall, with a wall of glass outside the north-facing brick veneer wall to capture the heat of the winter sun. The addition of solar panels not only provides privacy, they generate some electricity too.

Thoroughly tested

Before launching into renovations we tested the house from high to low to find its thermal weak points.

We estimated the R-value of all the external surfaces of the house such as ceiling, walls, windows, floor, and the area of each, to work out how much energy, in kilowatt-hours, was flowing out of the house per degree of temperature per hour, day or year. We also estimated

how much energy was captured from the sun through windows. We studied passive heating and cooling and were particularly interested in the Passivhaus standard from Europe and the concept of thermal comfort.

Our measurements, using the concept of 'heating degree days' and 'cooling degree days', showed that more energy was going into keeping the house warm in winter. A heating degree day

measures how much heating (in kWh) is needed to maintain a desired temperature, in Melbourne say 20°C.

We found that it took 1926 heating degree days to maintain 20°C, but only 1416 heating degree days to keep the temperature at 18°C, so reducing the heating thermostat by 2°C could cut heating by over 25%.

The modelled results for the house showed the weak points, with 46% of energy lost through the windows, 39% through walls, 7% through the ceiling and 11% through the floor.

Our house had some fundamental issues, such as large areas of single-glazed, aluminium-framed windows, which mainly faced south for the views over the mountains, and there were few north facing windows to capture winter sun. There was no insulation in the brick veneer walls, with a lot of walls due to the shape of the house.

This job was going to take more than just more insulation. We would also need to add some passive heating, more efficient heating systems and some thermal mass, and we had to do something with the pool, which had passed its useful life. Research showed the pool filter accounted for between 25% and 33% of our total electricity usage of around 18kWh a day, peaking at 6kWh a day in summer.

After our attempts to draw up the renovations failed, we engaged Now Architecture to take care of the design. The pool has since been turned into an underground rainwater tank which doubles as a cooling system for the house. A hydronic heating system has been installed, plus a solar wall to improve the thermal efficiency of the poorly performing north face.

From pool to tank

The original design was to convert the pool to a passive cooling system with a 70,000 litre above-ground tank on top. Yet, this would require a 400mm concrete slab to support the 70 tonne tank, which would be expensive and difficult

to blend into the garden.

Plan B saw the pool continue to be used as a passive cooling system and also as a rainwater tank. The pool needs to stay about half full, leaving 35,000 litres available. This would be supplemented with a greywater treatment system to make up for the reduced capacity. The passive cooling system would use the pool water to cool the air being drawn passively into the house but would require some complicated plumbing with

lots of large diameter pipes.

So Plan C replaced the passive system with an active system where a smaller water pipe was used instead, circulating through a heat exchanger, which in turn feeds a couple of fan coil units. The water would always be drawn from near the bottom of the pool where it is coolest. The downside was the need to pump the water rather than relying on a passive system, but it was assumed that the small amount of power needed would be gen-



The disused pool has been converted into a cooling system. Supporting beams and pipework for rainwater and cooling water is placed on top of the pool. A concrete slab is then poured on top and treated with bituminous paint.

erated by the planned solar PV system.

Best of all, we could plant a new permaculture garden on top of the old pool, helping us be more self-sufficient for produce.

How it works

The cooling system comprises two closed loops of water; one is the pool loop and the other the house loop. The pool loop draws water from the pool at 1.1 litres per second and passes it through a plate heat exchanger, which transfers heat from the house loop and returns the warmed water to the pool. The water in the house loop gets cooled to about 16°C and runs through two fan coil units inside the house, which transfer heat from the warm house air to the water, and blow the cooled air through the house.

The key factor that makes the system work is the ability of the water in the pool to stay at around 15°C. Our modelling says that on a 35°C day we require 52kWh of cooling to maintain 25°C inside. The specific heat of the 70,000 litres of pool water comes to 81.2kWh/K. On a 35°C day we would raise the temperature of the pool by 0.6 degrees (52 divided by 81.2). The unknown factor is whether the surrounding earth can draw the heat from the pool quickly enough to counteract this rise. To achieve the same amount of cooling, an evaporative cooler would need to evaporate some 80

litres of water.

The second factor is the capacity of the system to cope with the peak cooling load. The water enters the heat exchanger at 15°C and leaves at about 25°C at a rate of 1.1 litres per second, giving a peak cooling capacity for the system of about 3.5kW. This cooling is achieved with the only electrical input being the pumps for the pool loop, house loop and fan coil units.

This corresponds to the required cooling load when the outside temperature is about 32.5°C. Above that the inside temperature would start to rise and occurs on average 20 times per year for a total of 70 hours. But it does not take into account any lag in the inside temperature due to thermal mass. Even in our former brick tent this lag was some two or three hours.

By our calculations it should work but we'll need to wait until summer to find out for sure. So far we have used the cooling system a couple of times during spring. The water coming from the pool is at 10°C and is returning at 15°C, so has been effective at quickly cooling the house by several degrees.

Large rainwater supply

As far as the rainwater supply goes, the 35,000 litres from the pool is supplemented by a 30,000 litre underground rainwater tank installed at the same

time. This combined 75,000 litres is a good amount to keep us going a few months during future droughts.

The extra tank came about when plans to put in a greywater treatment system were abandoned; with restrictions, only 10 square metres of garden could be watered with it. For just a little more money we could install a 30,000 litre underground rainwater tank made of a matrix of 'milk crates' covered with plastic sheet and geotextile. The water from this tank overflows into the other pool tank. Watching the underground tank being installed was fascinating and exciting with a seriously big hole being dug and then filled in. The hole took most of the day to dig but the crates and plastic liner took less than an hour to install. A Rainbank unit was installed to switch between tank water and mains water and is connected to all the toilets in the house to reduce mains water use.

Hydronics

The hydronic system was a learning experience. The system consists of a ring main connecting all the panels, which also feeds all the hot water taps in the house. In theory, it is supposed to help reduce water consumption by providing pre-circulated hot water to the taps, so there's less water down the drain when showering. One fly in the ointment was that our old electric hot water system was

in the attic and fed the upstairs showers, whereas the ring main is under the floor. So the link from the ring main to the showers has to first go up into the attic to feed the showers; unless we wanted to rip out the shower walls, re-plumb and re-tile. That is for another day.

Innovative solar wall

Our design includes an exciting and innovative feature we call the solar wall. It was originally called the thermal chimney but it looks more like a wall than a chimney, and has more application than just thermal.

The rationale behind the solar wall is that the north face of the house had very little window space, so the amount of heat captured during winter for passive heating was minimal. In addition, the wall itself was not very attractive as it was the 'back' of the house, even though it was the main street frontage.

The solar wall is essentially a trombe wall, with a wall of glass outside the north-facing brick veneer wall to capture the heat of the winter sun. Model-

The construction of the solar wall included the installation of foam insulation on the bricks to prevent hot air heating the house through the brick veneer.



ling estimates that this should capture some 30kWh per day over and above any heat captured through the north facing windows. This in turn reduces the amount of heating energy required for the house on days with enough sun.

The thermal chimney aspect is being tested in the coming months, as the air inside the wall will become very hot in summer. As the air rises it escapes through vents in the roof, which in turn also creates a strong convection current that draws air through the house. The moving air helps to keep you cooler and also draws in cooler air from beneath the house.

A layer of foam insulation on the bricks prevents the hot air from heating the house through the brick veneer wall. This also brings the thermal mass inside the house, similar to a reverse brick veneer construction. The glass wall and the air inside also acts as further insulation in winter.

Some of the panes of glass on the solar wall are substituted with solar panels. These provide a bit of privacy for the rooms behind the wall, are visually stunning and

they generate some electricity. The angle of the wall is such that the solar panels are optimised for winter electricity generation rather than overall annual energy production, important should we ever decide to go off-grid.

With the hot air inside the wall creating a continuous current in summer, the space inside the solar wall provides an excellent environment for drying fruit and vegetables. Our new garden, planted on top of the old pool, will produce more than we can consume over summer so we'll preserve the food for winter. Drying has proven to be the more reliable way to do this and using passive heat is much better than using an electric food dryer. ✨

For more information and photos visit Ken's excellent blog <http://headingoverthepeak.blogspot.com>

Step by step construction of our pool/tank cooling system

1. First the raised edge of the pool and spa bath were removed back to ground level. Not an easy task with 300mm of reinforced concrete.
2. Screw piles were installed around the edge of the pool, then steel beams on top of the screw piles, for strength.
3. The pipework to carry rainwater and cooling water was installed.
4. Dirt and concrete dust that had collected in the bottom of the pool during the demolition was vacuumed.
5. We treated Bondeck panels with bituminous paint to prevent corrosion; these were then laid between the steel beams.
6. Next the concrete slab was poured onto the Bondeck.
7. The slab was treated with bituminous paint for waterproofing.
8. The slab was covered with soil, mulch and raised garden beds.



Left: A 30,000 litre underground rainwater tank made from 'milk crates', a polypropylene liner and geotextile fabric was also installed; Right: The new permaculture garden on top of the old pool, now used as a water storage/household cooling system.

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