Solar Thermal or PV

What is the best use of roof space?

Something we come across time and again when considering low carbon building designs is the use of solar technologies. This should be no surprise given the large amounts of sunshine that Australia gets each year! Solar thermal panels effectively use the sun’s energy to heat water used in the home for general consumption and in some cases for heating. Solar photovoltaic’s (PV) use the sun’s energy to produce DC electricity which when run through an inverter can be used to supply electrical appliances in the home. Both systems are typically roof mounted and work most effectively when they are placed on un-shaded north facing (in Australia) roofs. The question is, when roof space is limited, or indeed costs, which system provides the greatest carbon savings?

Solar Thermal Hot Water (SHW)

Solar thermal panels absorb sunlight and use it to heat water running through copper pipes. They typically convert 40% of the sun’s energy into useful heat energy which is stored in a tank ready for use in the home. The remaining top up heat requirement is usually provided by a gas boiler. Panels are typically sized at 4m$^2$ (2 standard panels) per residence sufficient to supply around 70% of its hot water requirements in Australia. The panels may actually be producing more hot water than is used during summer months but much less during winter months. The tank is typically sized to cover ‘off days’ when there has not been much sunlight. However, if space and cost are not an issue they can also be sized to store several weeks worth of hot water which can be used for space heating or swimming pool heating as well as normal hot water use.

There are two types of solar thermal panel – flat plate and evacuated tubes. Flat plate collectors run the water through copper pipes backed on insulation behind a glass panel and have an efficiency of around 50%. Evacuated tubes also use copper pipes but they run through a vacuum in a glass tube. They are more efficient than flat plates particularly during winter months due to the fact that they are circular and able to absorb sunlight at varying angles as illustrated in Figure 2.
Photovoltaics (PV)

PV panels use doped silicon to convert the sun’s energy into DC (direct current) electricity. When passed through an inverter this electricity can be converted to AC (alternating current) and used in home appliances or exported to the grid. The DC electricity can also be stored in batteries for later use in the home although at present batteries are generally not commercially viable for regular residential situations, but watch this space, prices may become competitive soon. Without batteries, PV cannot be sized to meet a user’s night-time loads due to lack of daylight, however if the system is oversized it effectively offsets the user’s night-time loads by producing more electricity than is required in the daytime as shown in Figure 3.

At present the buy back rate of exported electricity is far lower per unit (8c/unit in WA) than the sale price (22c/unit in WA). The most financially rewarding PV systems are those sized to meet the peak midday load only, with no generated electricity exported at the unfavourable rate.
Comparisons Scenario

Let’s take a standard 3x4 house in Perth that only has 3.5m$^2$ of suitable roof space available - sufficient for 2 solar thermal panels or 0.42kWp of PV. There are a number of different hot water solutions that could be installed alongside the solar technologies. I have considered four of the most common ones currently used across Australia;

1. Solar thermal with electric storage boost (99% efficiency)
2. Solar thermal with gas boiler boost (85% efficiency)
3. 0.48kW PV with gas instantaneous boiler (85% efficiency)
4. 0.48PV with Heat Pump (270% efficiency)

In each case the roof space is fully utilised and hot water is delivered to the residence via either the rooftop panels or the gas and electricity grids. The life cycle carbon and costs associated with the above options are shown in Figure 4

![Figure 4: Carbon and Costs outcomes](image)

Before drawing too many conclusions from the data it should be noted that the Western Australian grid is one of the most carbon intensive grids on the planet with 0.82kg CO$_2$ emitted per kWh of electricity supplied (the gas grid emits nearly a quarter of this as 0.219kg CO$_2$ per kWh). Grids that have more renewable or gas generated power feeding into them are likely to make electric solutions look more attractive in terms of carbon.

In WA at least, it appears that the electric solutions are the most carbon intensive with the solar thermal plus gas solution the outright winner. Interestingly the electric storage plus solar option has the lowest life cycle costs. This is due to both the lower capital cost of the system and its increase in efficiency which together make up for the higher cost of electricity over gas.
How much is too much?

Does that mean we should all go out and cover our roofs in solar thermal panels? No, not really. The benefits of solar thermal are limited by the hot water consumption of the user. If on an annual basis, the user is always consuming less hot water than the overall system is generating then that extra energy produced is wasted. PV on the other hand can feed as much power into the grid as the grid connections can cope with (which is quite a lot in inner city developments). There is a point when the carbon savings from increasing solar thermal stops and the savings from increasing PV continue to fall as shown in Figure 5 below.

![Figure 5: Tipping Point](image)

After the initial jump down for the first 2m² of solar thermal panels there is a very gradual decrease in CO₂ due to adding more panels. Below around 4m² the greatest carbon savings come from SHW panels alone. After 4m² of roof area it is time to stop putting solar hot water panels on the roof and install PV. The carbon savings from a mixed system create a good balance in that they combine to reduce emissions from two different sources of energy - the hot water and the appliances.

Double Counting?

For the above exercise I have assumed the carbon savings associated with the generated electricity from the PV are the same whether it is used in the house or exported. This is somewhat open to debate. In theory when the electricity is exported, it becomes a very small part of a predominantly coal-based cocktail of electricity (although it is most probably going...
straight to the nearest neighbour). The grid operators are likely to claim the credit for all rooftop PV when they do their own carbon accounting. There is a danger of ‘double counting’ the emissions reduction from the PV if it is being used to ‘offset’ the resident’s own emissions as well as emissions associated with grid generation which are used in determining a dwelling carbon footprint.

**Future Grids?**

The carbon benefits of SHW are greatly enhanced by the carbon intensive grid of Western Australia. To meet Kyoto protocols, Australia needs to de-carbonise the grid at a rapid rate. When the carbon intensity of the grid gets to a point closer to that of the natural gas grid, the greatest savings will come from the electric solutions due to their higher efficiencies. Further information on gas vs electricity can be found in Henrique’s post [here](#).

Researched and written by [Pat Hermon](#)

[Watch Pat present his research at a recent industry talk in Perth.](#)

**Research Sources**

1. [http://www.therenewableenergycentre.co.uk/solar-heating/](http://www.therenewableenergycentre.co.uk/solar-heating/)