East West Arrays: are they worth it?

The current cost of rooftop PV means that it can be cheaper to source your electricity from a rooftop solar system than buy it from the grid. A significant problem with this however is that people consume 50%+ of their electricity during the morning and evening when solar systems are not producing, is it possible (or financially viable) to angle a PV array to the east or west to preference supply to these morning or evening loads?

If this is possible, more of the solar energy should be consumed onsite and less exported to the grid. If the end user consumes the solar energy onsite, the value to the end user will be according to the rate at which they purchase energy, that is around ~28c/kWh.

This article considers the advantages and disadvantages of east and west facing arrays and how they compare to north facing arrays. Given that the major driver for installing PV is to reduce energy costs, this analysis has been done on the basis of the financial benefits to the end user.

What is the benefit?

The benefits of east or west arrays are dependent on the consumption profile of any one customer and their tariff structure. Most people have electricity profiles that peak in the morning and evening; during the day they are at work or school and are not available to take advantage of any solar production. However for many people, an east-west array will still not be suitable as their demand will peak before 9am and after 4pm, when there is little solar irradiance regardless of array orientation. If the customer is on a time of use tariff they will also be incurring most of their energy costs in the evening under a peak tariff. Houses that contain school aged children that are home shortly after 3pm (using electrical appliances and turning on air conditioners) might benefit from a west facing array. A family that has a stay at home parent that is able to operate most loads in the morning (such as the dishwasher, washing machine, vacuum cleaner, etc.) might benefit from an array that faces east.

Systems that have strings facing both west and east (in parallel) can also benefit from an undersized inverter. In the morning the east array will be producing at its maximum output, while this will happen in the afternoon for the west array. The inverter can therefore be limited in size to the capacity of the west or east facing array. For example a 2kW array facing east, and a 2kW array facing west may be best matched with a 2kW inverter (opposed to a 4kW inverter). However the amount of energy that is 'spilt' (i.e. DC electricity that is produced by the array but cannot be converted to AC), and the value of this energy must be considered (see the clipped output form the combined east-west array in Figure 3). Furthermore, both arrays will only rarely receive the irradiance of 1000W/m2 as specified by standard test conditions.

Note: it is important when designing a system that has an oversized array to ensure the inverter in questions is capable of this. There are also restrictions on oversizing as stipulated in the CEC design guidelines. For more information on oversizing the array to the inverter see the GSES technical article: Oversizing PV Arrays.

Unshaded PV strings show only small losses when installed in parallel. This is because the maximum power voltage (Vmp) varies only slightly (logarithmically) with irradiance, as shown in Figure 1. A different irradiance across parallel PV strings will greatly affect the Isc and power from the string; however the Vmp will stay (almost) the same across both.

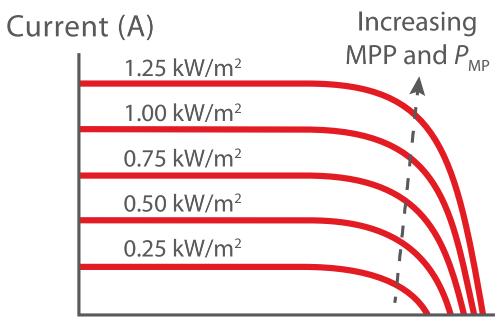

Figure 1: *Changing Vmp with irradiance*

Simulations and Results

Given that the suitability of an east-west array is so dependent on consumption profiles, the only viable way to model such a system is using a program that can accept consumption and weather data, and perform an interval analysis. GSES modelled a variety of systems using the consumption profile shown in Figure 2 (below) using Homer Energy. This profile shows a particularly high energy demand with a peak in the morning and afternoon. The house was modelled in Melbourne, Australia.

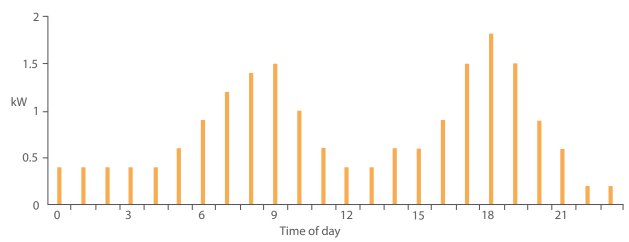

Figure 2: *Daily profile used in modelling*

The following assumptions were made to complete the simulations:

Discount rate	8%
Inflation rate	2%
Project life (life of PV)	25 years
Lifetime of inverters	10 years
Cost of PV (installed)	$1500/kW
Cost on inverters (installed)	$400/kW
FiT	6c/kWh

GSES' simulations show that for both a flat tariff of 28c/kWh and a TOU tariff (peak 33.5c/kWh, shoulder 23.6c/kWh, off peak 14.7c/kWh), a north facing array with an undersized inverter is preferable to any other combination of array (including a single east or west facing). The north facing array is labelled as simulations 2 and 5 in the table below. Simulations 1 and 4 are the business as usual (BAU) case of simply continuing to buy electricity from the grid. It should be noted that the east-west configuration systems in simulations 3 and 6 still have a lower net present cost than the BAU case.

No.	Tariff	PV Array	Inverter	Net Present Cost	Simple Payback	Capital
1	Flat Tariff	(BAU)	(BAU)	$22,455	NA	0
2	Flat Tariff	2kW North	1.5kW	$20,927	9.07 years	$3,600
3	Flat Tariff	1kW East1kW West	1kW	$21,601	10.66 years	$3,400
4	TOU Tariff	(BAU)	(BAU)	$22,455	NA	0
5	TOU Tariff	2kW North	1.5kW	$20,938	9.09 years	$3,600
6	TOU Tariff	1kW East1kW West	1kW	$21,610	10.69 years	$3,400

A north array is preferable because its generation profile is very similar to that of the combined east-west array (Figure 3). As can be seen, an east-west array generates a little more in the morning and evening, however for this given day there is load after 7:30am that the east facing array is not able to supply, as its generation output peaks around 8:30am at ~800W.

In the morning the east array does produce more between 5 – 7:30, but at this point the north facing array ramps up generation; just as the morning consumption peaks. The additional energy supplied to by the north facing array at this point compensates for the lack of energy supplied in the early morning. In the evening, the peak consumption occurs after both of the arrays have stopped generating.

The north facing array also gains a benefit for the energy it can export. The levelised cost of energy

(LCOE) for rooftop PV is around 15c/kWh (LCOE is the cost of the energy that the system produces over its lifetime). Although the FiT is low (6c/kWh – less than the LCOE) it still generates some income. Even with a larger inverter for the east-west array, the generation during the day will be less than the north facing array; providing less power for loads later in the morning, and less energy for export during the middle of the day.

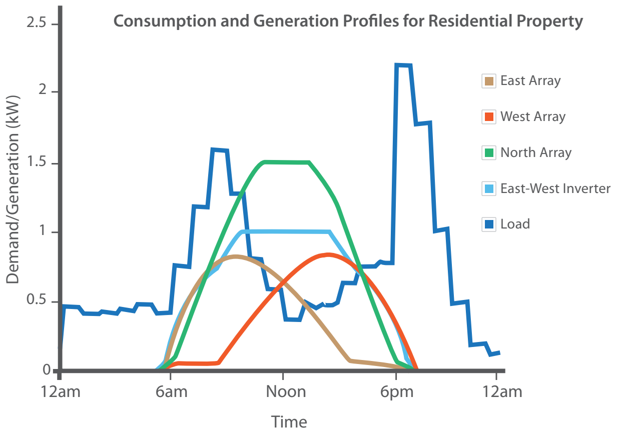

Figure 3: *Demand and generation profiles investigated in simulations*

Comparing the east-west array to the north array: the east-west array is simply not able to produce the same amount of power as an equivalent north facing array, and the difference in generation time is not significant enough to make it financially viable. Interestingly this result is true regardless of consumption profile; the two different profiles are nearly identical in regards to shape (excluding the clipping of the east-west inverter in the above example). If consumption was to peak at 9am in the morning, or 2pm in the afternoon, it may be beneficial to have an east or west oriented array. However, if consumption was to peak at both 9am and 2pm, a north facing array with an undersized inverter would be preferable.

Conclusions

Simulations completed by GSES shows that north facing arrays with undersized inverters perform better than east-west arrays. Designing for either an east or west facing array may be beneficial for very specific consumption profiles, however in the majority of cases morning and evening consumption peaks occur outside of the times of solar generation for an array in any orientation.

These results however do show that there is still significant benefit in installing an array even if it is not possible to install it on a north facing façade. In the above simulations the east-west array design only increased the simple payback time by ~15%. Such systems had a lower Net Present Cost than the BAU case of continuing to purchase from the grid over the 25 year project life. If the load profile can be adjusted to shift more load to when the solar is generating (whether it be a north, east, or west array) this Net Present Cost would obviously reduce further.

GSES welcomes feedback on technical papers and other resources available on www.gses.com.au, please contact GSES by email at info@gses.com.au or by telephone on 1300 265 525.