6.6 Appendix: Full analysis of Regional locations

Table A summarises the general load and simulated PV characteristics of the six regional locations. This analysis includes the use of scatterplots where either the PV output and corresponding load for each half hour period were plotted against each other, or PV output or load for each half hour period was plotted against temperature. Such plots provide a picture of the general relationship between two factors ie. how one varies with respect to the other. Not all of this analysis is of direct relevance to placing a financial value on PV's ability to offset peak load periods but contributes to a more general understanding of the loads and their relationship to PV output.

Table A: General load and PV characteristics of SWIS locations

Characteristic	Description
Annual load profiles	The three Port Hedland substation's daily maxima were about double their baseloads. Both baseloads and daily maxima were about twice as high in summer as in winter, and showed greater variability during the summer months. The Carnarvon baseload was fairly constant throughout the year except for Jan through to March when it increased by 1.5 to 2 fold. The daily maxima were approximately double the baseload in all months and more variable Jan to March. Marble Bar and Meekatharra had a similar load pattern to Carnarvon except that for Marble Bar the period of elevated load extended from Oct 05 to April 06, and for Meekatharra it extended from mid Nov 05 to March 06. Of the Port Hedland substations, only WFD had a weekly pattern (weekends lower than weekdays), although both AST and MDR did to some extent. Carnarvon, Marble Bar and Meekatharra had relatively insignificant weekly patterns. Unlike the SWIS locations, none had extreme load points well above the normal daily maxima – presumably because they represent aggregated load and will not change because of switching from one transformer to another.
Seasonal match	Carnarvon peaked around midday in summer and had a good match to simulated north-facing PV, while Marble Bar and Meekatharra peaked in summer but in mid afternoon and so were better matched to simulated west-facing PV. Of the three Port Hedland substations, all peaked in summer with AST in mid afternoon, MDR slightly later and WFD slightly earlier. As a result, AST and MDR were best matched to simulated west-facing PV while WFD was better suited to simulated north-facing PV.
General correlation between PV output and load	The scatterplots for Carnarvon displayed some correlation to simulated north-facing PV, with the data points generally extending up and to the right. Marble Bar and Meekatharra had limited correlation with the load spread almost into two regions, corresponding to the baseload periods and the daytime peaks. Of the three Port Hedland substations, AST and MDR were again spread into baseload and daytime periods and both were better matched to simulated west-facing PV, while the WFD profile was also spread but was better matched to simulated north-facing PV.
General correlation with temperature	The scatterplots for Carnarvon and Meekatharra displayed a fair correlation between load and temperature, while Marble Bar displayed a good correlation. All three of the Port Hedland locations, AST, MDR and WFD, displayed strong correlation between load and temperature. PV tended to increase at higher temperatures, which would normally occur during the middle of the day – although note there are instances of zero PV output at high temperatures, presumably on hot summer evenings.

CARNARVON

Annual profile

The July 2005 to June 2005 load profile for Carnarvon is shown in Figure 1. It is characterised by a constant baseload around 3MW, with daily maxima almost double the size of the baseload and with both increasing during summer, especially February to March. It also has a minor weekly cycle apparent in winter, with reduced weekend loads – see Figure 2 and Figure 3. There are a number of days of extreme demand peaks, all of which are in summer and which are discussed in more detail below. Figure 4 shows the 500kW simulated north-facing PV output for ACDB site 'Carnarvon', which is highest in spring and early autumn rather than summer as expected.

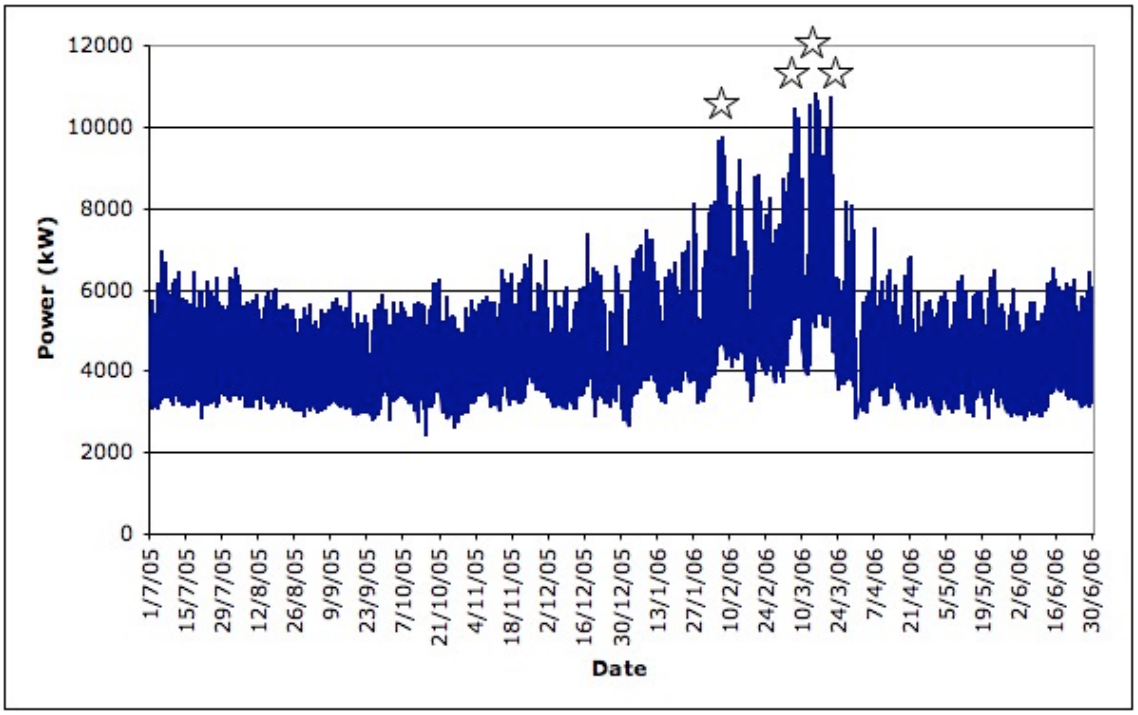

Figure 1: Carnarvon Load
July 2005 to June 2006
(the stars indicate the peak days analysed in detail below)

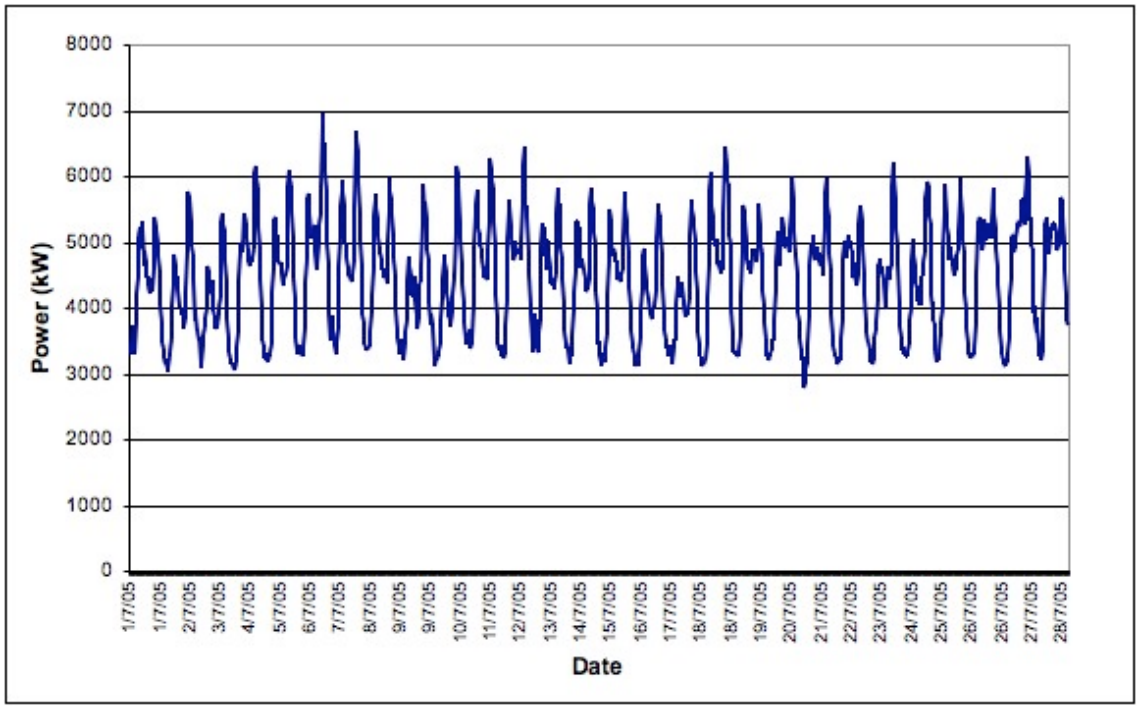

Figure 2: Carnarvon Load - July
The first 28 days of July 2005

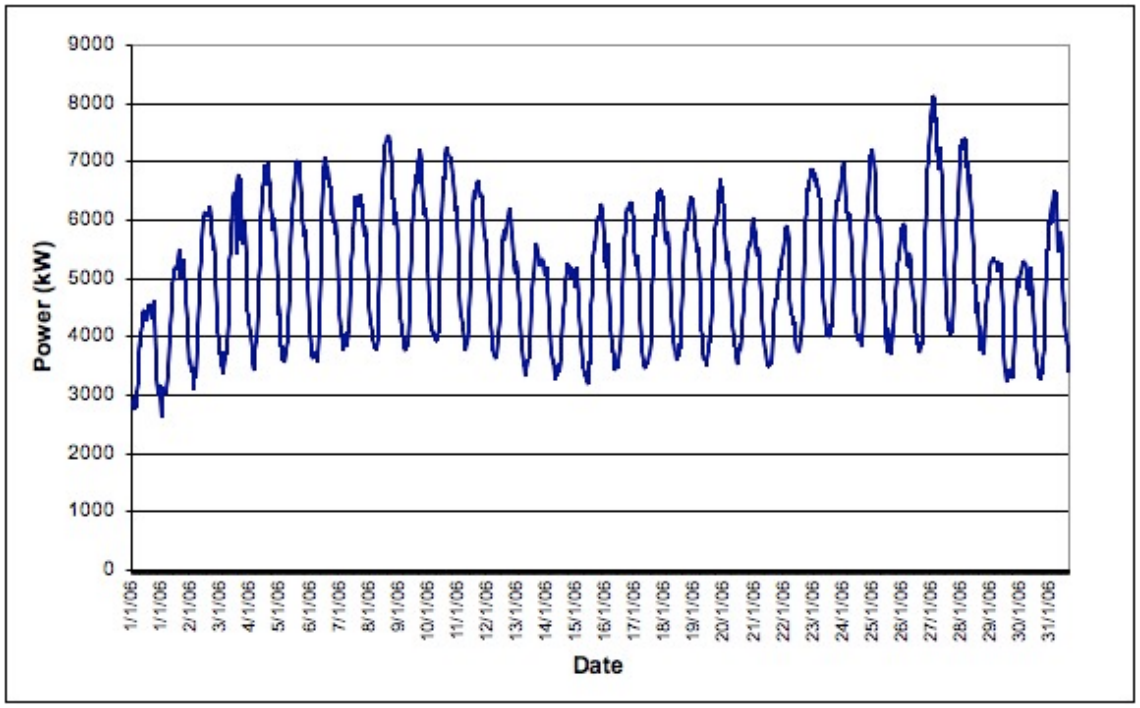

Figure 3: Carnarvon Load - Jan
The first 28 days of Jan 2006

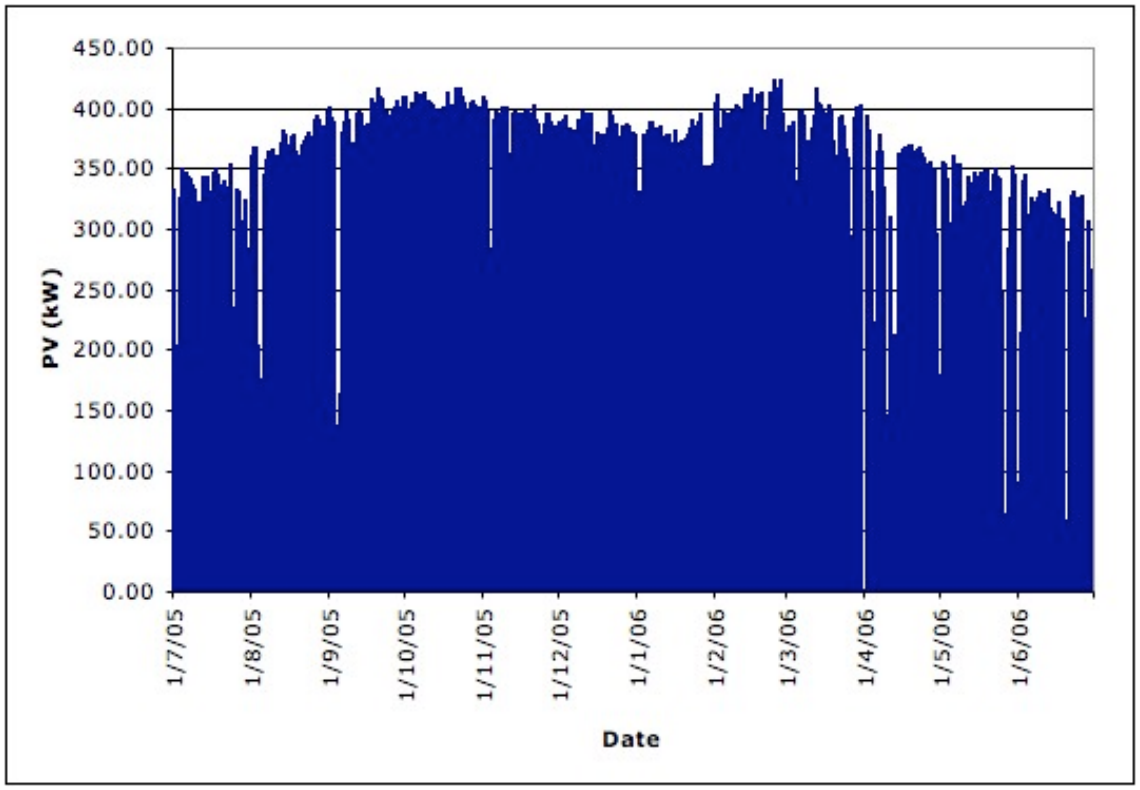

Figure 4: Carnarvon Simulated North-facing PV Output (500kW)
July 2005 to June 2006

Daily profiles

Figure 5 shows the daily annual average load for Carnarvon, the simulated north-facing 500kW PV output, and the net load assuming it is reduced by PV. Both the annual average load and simulated north-facing PV peak at around 12:30pm, however a secondary evening peak is apparent. As can be seen from Figure 6 to Figure 9, the summer and autumn peaks also occur at this time, while the spring peak occurs around 6:30pm and the winter peak occurs around 7:30pm.

The highest seasonal peak occurs in summer and is a good match to simulated north-facing PV. The autumn peak is also reduced by simulated north-facing PV, however because the winter and spring peaks occur so early in the day, they are not – although the reduced summer peak is still the year's highest. The impact of simulated west-facing PV is discussed below.

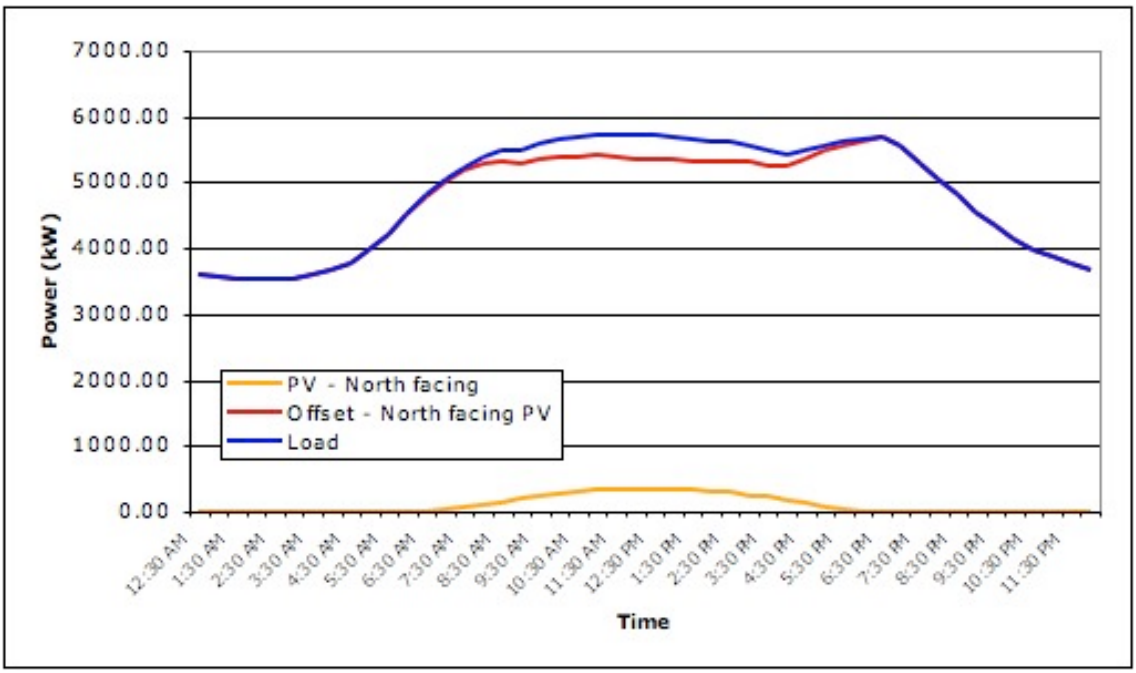

Figure 5: Daily Annual Average
Carnarvon Load, Carnarvon Simulated North-facing PV (500kW) and Net Load after PV Offset
July 2005 to June 2006

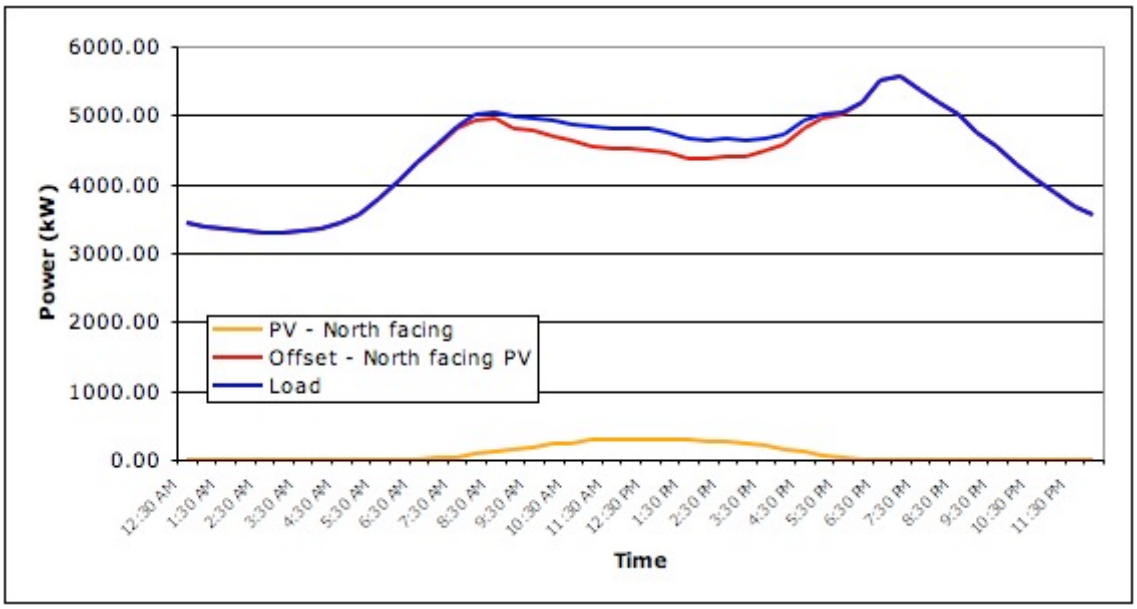

Figure 6: Daily Winter Average
Carnarvon Load, Carnarvon Simulated North-facing PV (500kW) and Net Load after PV Offset
June 2006 and July/Aug 2005

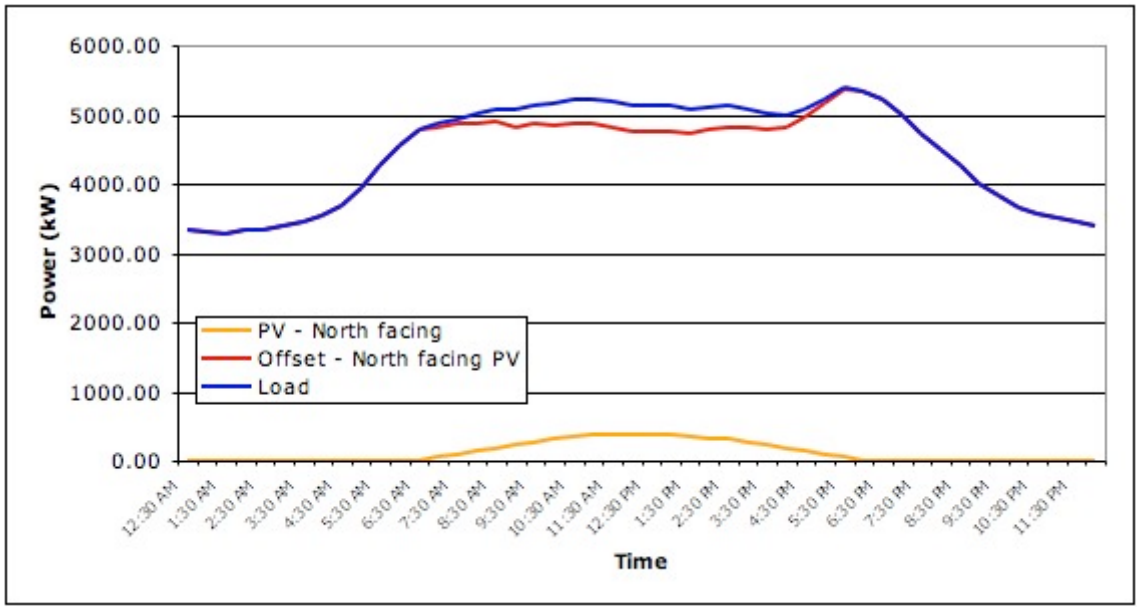

Figure 7: Daily Spring Average
Carnarvon Load, Carnarvon Simulated North-facing PV (500kW) and Net Load after PV Offset
Sept 2005 to Nov 2005

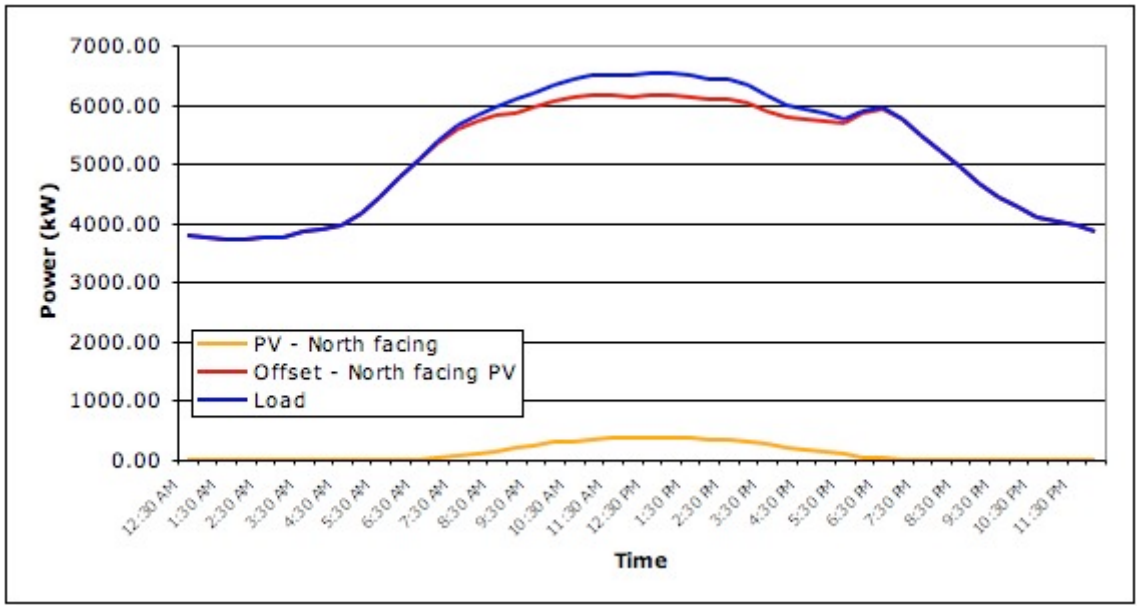

Figure 8: Daily Summer Average
Carnarvon Load, Carnarvon Simulated North-facing PV (500kW) and Net Load after PV Offset
Dec 2005 to Feb 2006

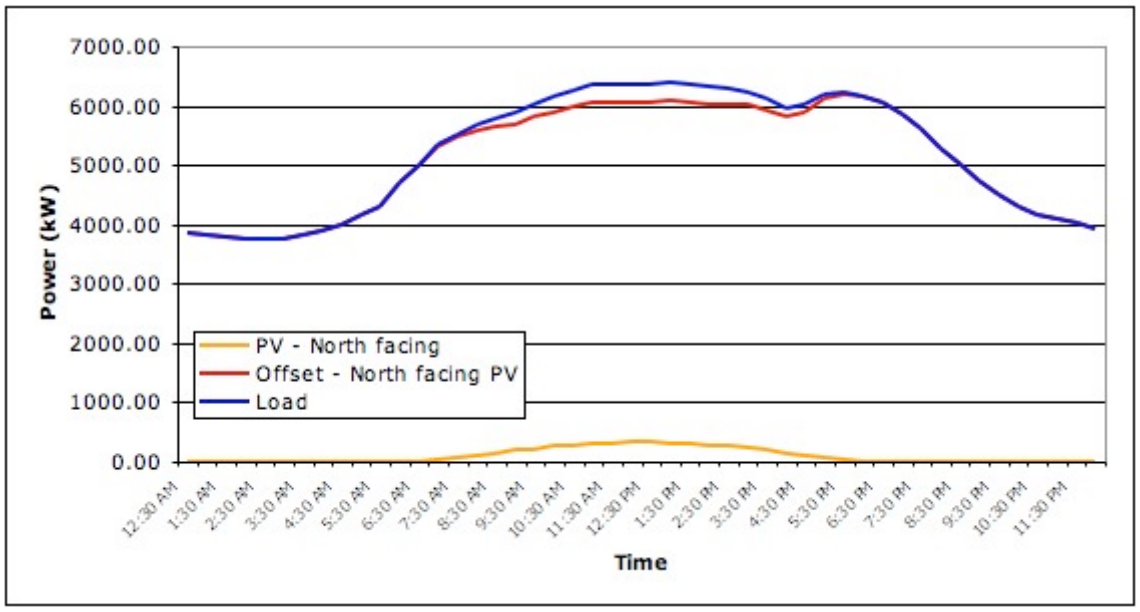

Figure 9: Daily Autumn Average
Carnarvon Load, Carnarvon Simulated North-facing PV (500kW) and Net Load after PV Offset
March 2006 to May 2006

The impact of simulated west-facing PV is illustrated in Figure 10 to Figure 14 and Table 1. Use of simulated west-facing PV with a tilt of 25 degrees shifts the peak PV output by about 1.5 hours later in the day, and a tilt of 45 degrees brings the shift to a total of about 3 hours. However, because the summer load and simulated north-facing PV output match so well, use of simulated west-facing PV has reduced ability to offset load.

Table 1: Annual Energy Output from Simulated 960W PV at Carnarvon

Orientation	Tilt (degrees)	RMY (kWh/yr)
North	25	1,717
North west	25	1,593
West	25	1,424
West	45	1,217
West	90	694

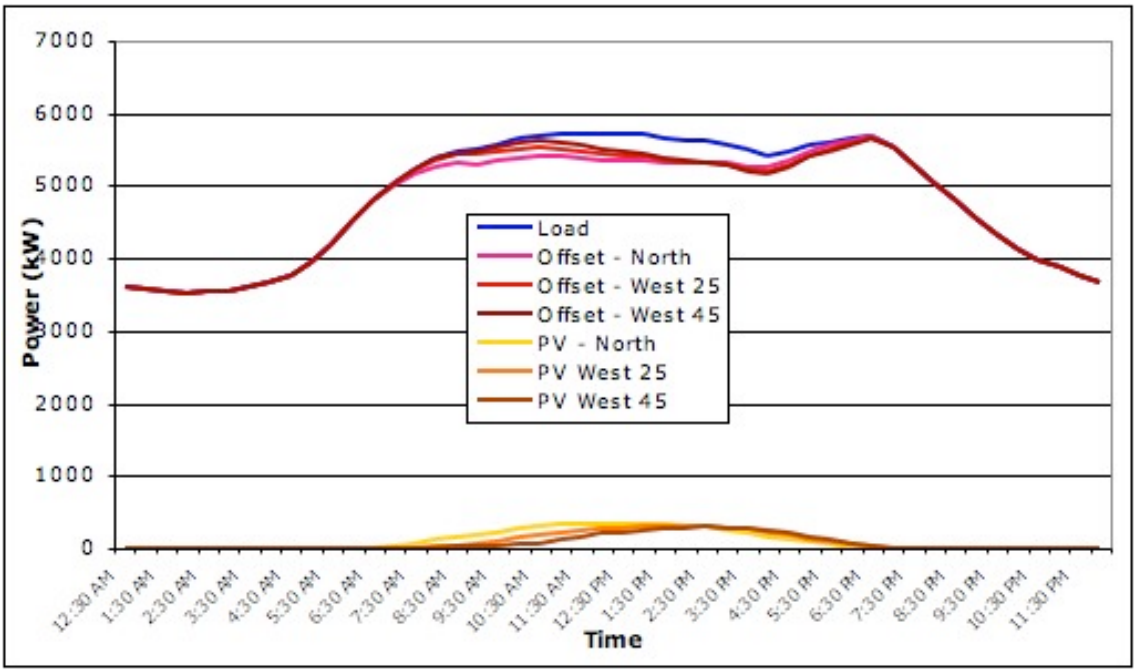

Figure 10: Daily Annual Average
North, and West (25° and 45° inclinations)
Carnarvon Load, Carnarvon PV (500kW) and Net Load after PV Offset
July 2005 to June 2006

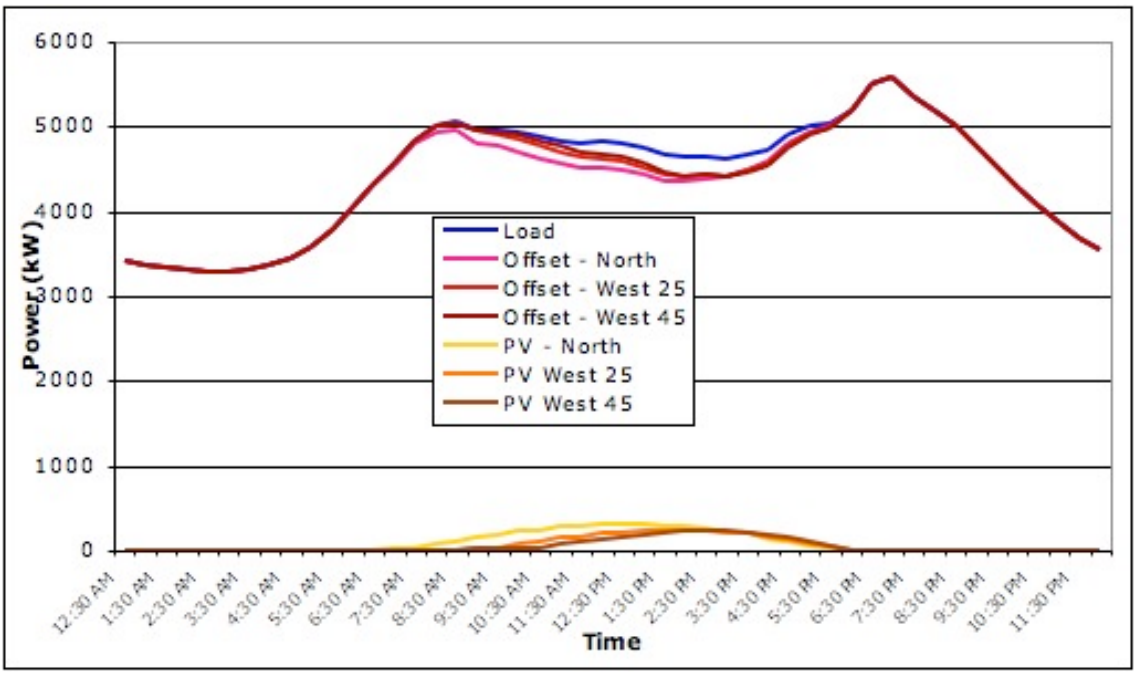

Figure 11: Daily Winter Average
North, and West (25° and 45° inclinations)

Carnarvon Load, Carnarvon PV (500kW) and Net Load after PV Offset
June 2006 and July/Aug 2005

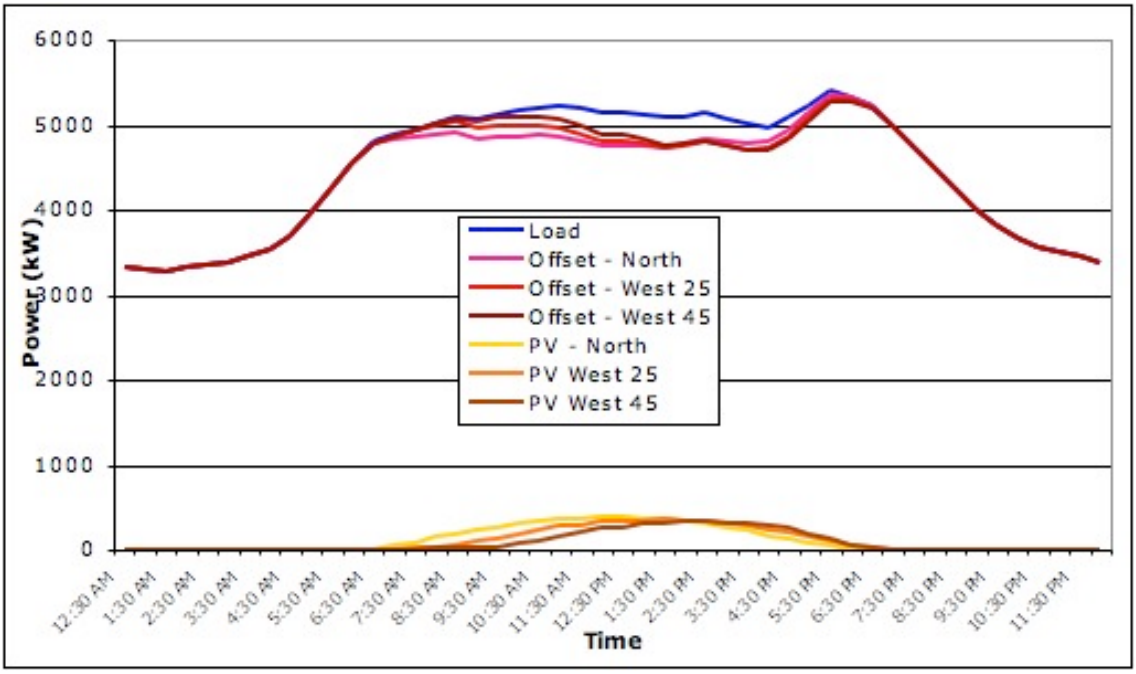

Figure 12: Daily Spring Average
North, and West (25° and 45° inclinations)
Carnarvon Load, Carnarvon PV (500kW) and Net Load after PV Offset
Sept 2005 to Nov 2005

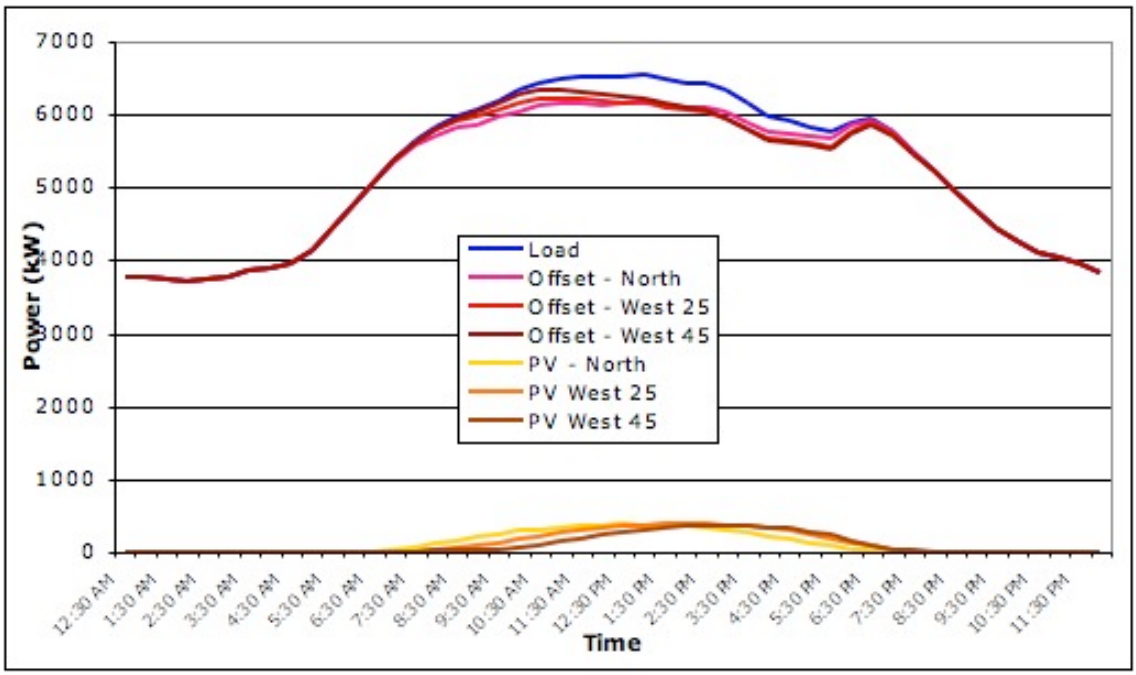

Figure 13: Daily Summer Average
North, and West (25° and 45° inclinations)
Carnarvon Load, Carnarvon PV (500kW) and Net Load after PV Offset
Dec 2005 to Feb 2006

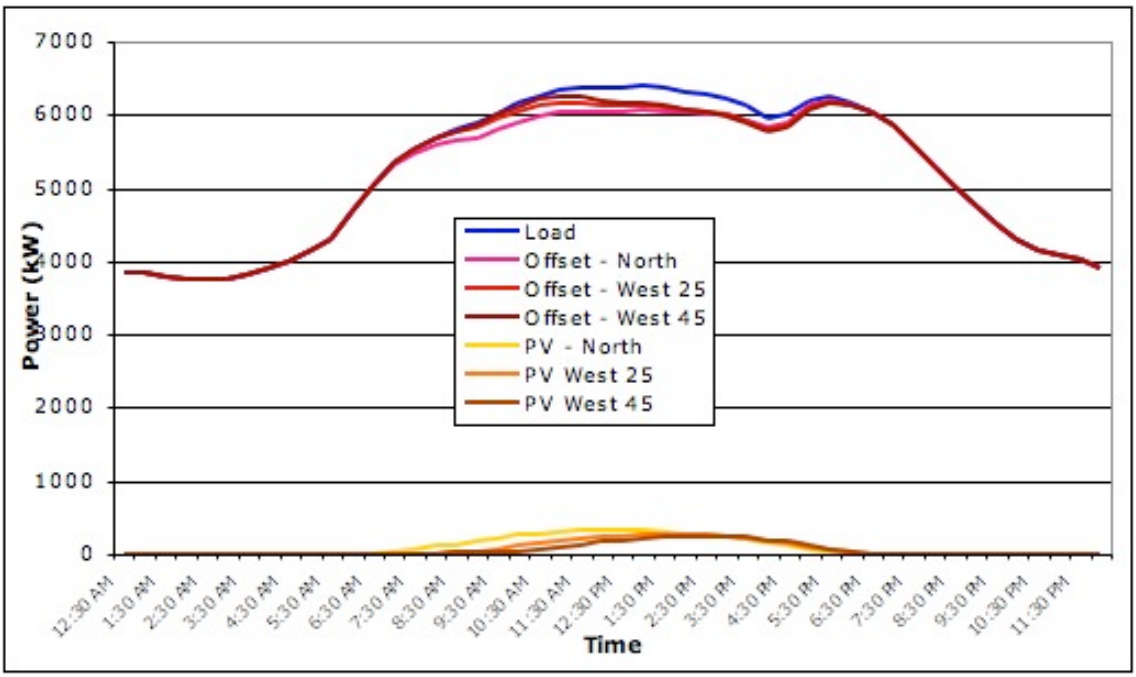

Figure 14: Daily Autumn Average
North, and West (25° and 45° inclinations)
Carnarvon Load, Carnarvon PV (500kW) and Net Load after PV Offset
March 2006 to May 2006

Times of peak demand

The ten top half-hour demand periods at Carnarvon are shown in Table 2. All occur on the 15th, 16th and 21st March 2006, which are illustrated in Figure 17 and Figure 16, and are the ten highest points in the load duration curves in Figure 19 to Figure 21.

The highest peak load day for the study period (15th March 2006; Figure 17) was not particularly hot, reaching around 30°C. It was in a cluster of five days, some of which were slightly hotter and also had high peak loads. The 500kW simulated north-facing PV is a good match for the load on all five days, and, as can be seen from the load duration curves in Figure 20 and Figure 21, reduced the peak half hour periods for those days by between 330 and 400kW.

The second (20th-21st March 2006; Figure 16), third (6th-8th March 2006; Figure 17) and fourth (6th-8th Feb 2006; Figure 18) highest peak load day clusters assessed here were also not particularly hot and again had a good match to simulated north-facing PV.

Table 2: Ten Top Half-hour Demand Peaks at Carnarvon

Demand (kW)	Date	Day	Time
10,845	15-Mar-06	Wed	13:00
10,790	15-Mar-06	Wed	13:30
10,757	15-Mar-06	Wed	14:00
10,747	21-Mar-06	Tues	12:00
10,730	15-Mar-06	Wed	14:30
10,668	15-Mar-06	Wed	12:30
10,650	21-Mar-06	Tues	12:30
10,643	15-Mar-06	Wed	15:00
10,642	16-Mar-06	Thurs	11:30
10,628	16-Mar-06	Thurs	12:30

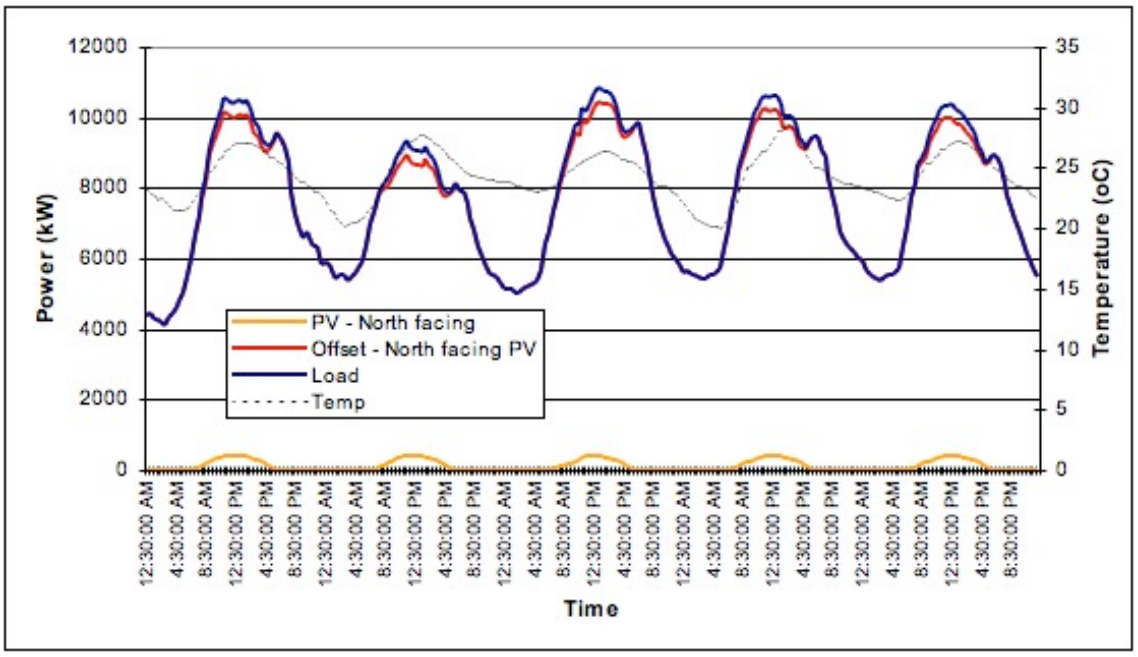

Figure 15: Autumn peak days
13th to 17th March 2006
Carnarvon Load, Carnarvon Simulated North-facing PV (500kW) and Net Load after PV Offset

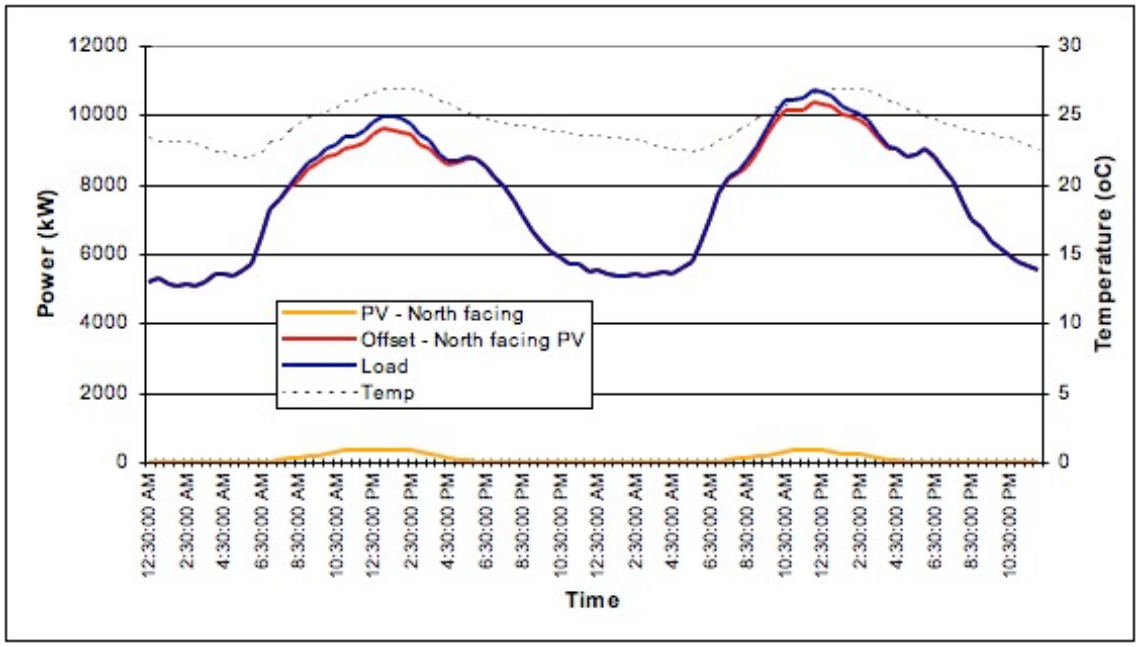

Figure 16: Autumn peak days
20th – 21st March 2006
Carnarvon Load, Carnarvon Simulated North-facing PV (500kW) and Net Load after PV Offset

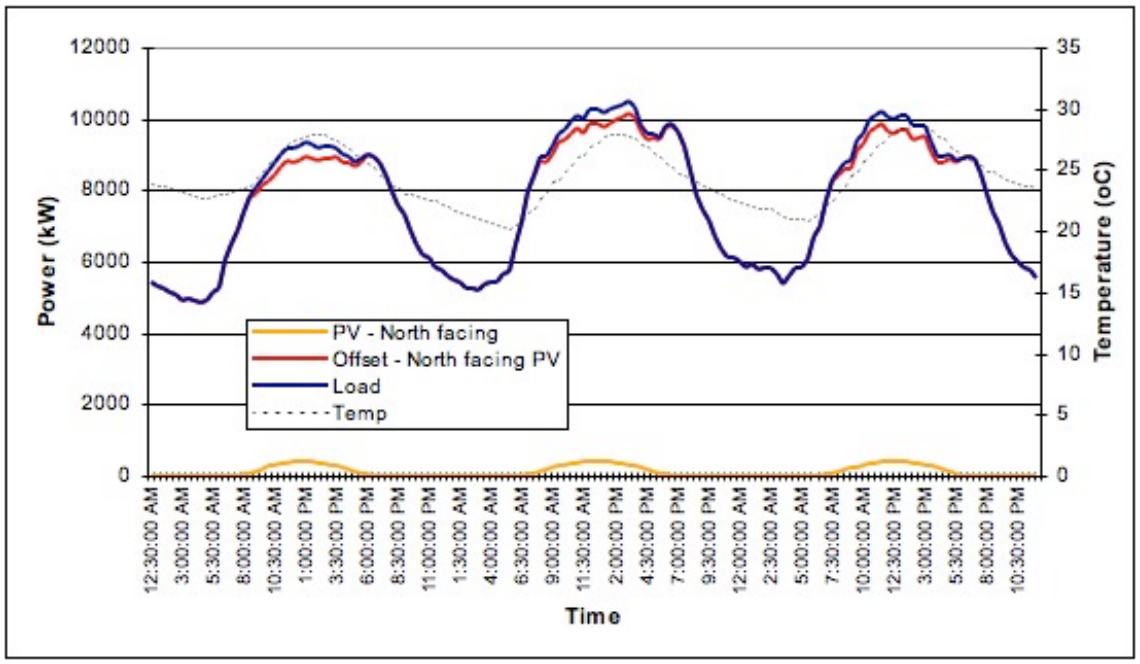

Figure 17: Autumn peak days
6th to 8th March 2006
Carnarvon Load, Carnarvon Simulated North-facing PV (500kW) and Net Load after PV Offset

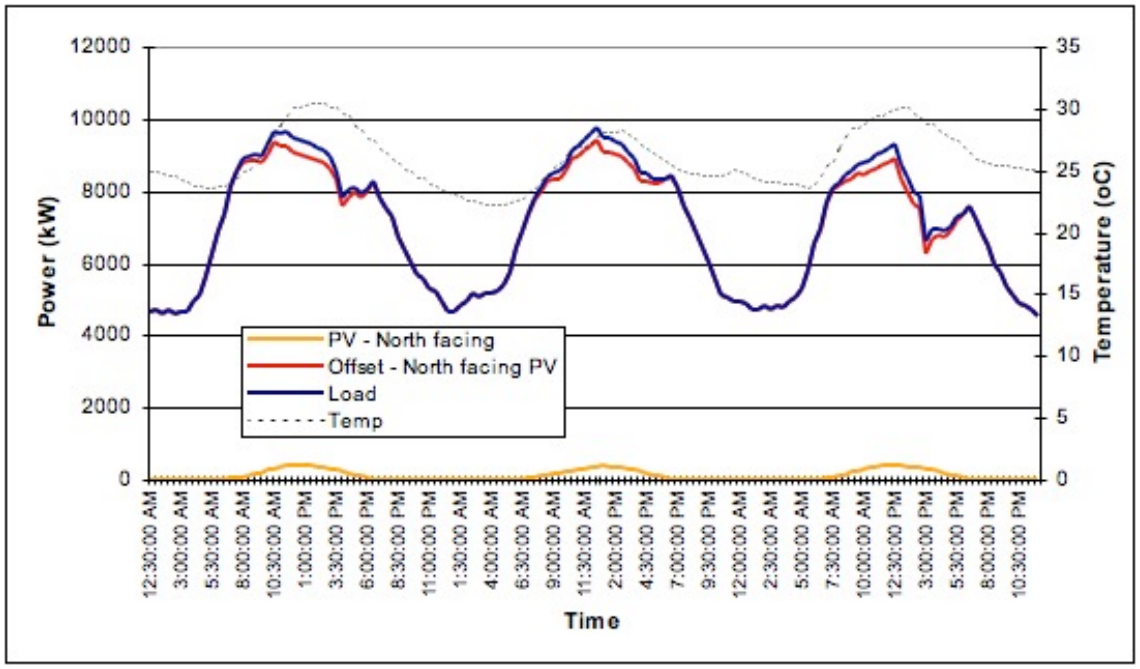

Figure 18: Summer peak days
6th – 8th Feb 2006
Carnarvon Load, Carnarvon Simulated North-facing PV (500kW) and Net Load after PV Offset

Load duration curves

The load duration curve for Carnarvon is in Figure 19. The top 50% of the load occurred for 25% of the study period, while the top 10% occurred for 0.56% of the time.

Figure 20 shows the top 50 half hour load periods, together with the offset load duration curve assuming reduction by north-facing simulated PV or west-facing simulated PV at either of two tilt angles (25° and 45°). It can be seen that the simulated north-facing PV resulted in the lowest offset load duration curve, followed by west-25 then west-45. 500kW of simulated north-facing PV resulted in the highest offset load period being 396kW lower than the highest original load period, and resulted in the top 10 offset load periods being lower by an average of 364kW.

Figure 21 shows the same load duration curves except that the offset periods now correspond to the load periods directly above them on the chart. This shows that during the highest load period, 79% of the simulated north-facing PV would have contributed to load reduction. On average during the 10 highest load periods, 73% the 500kW simulated PV was contributing to reducing peak load.

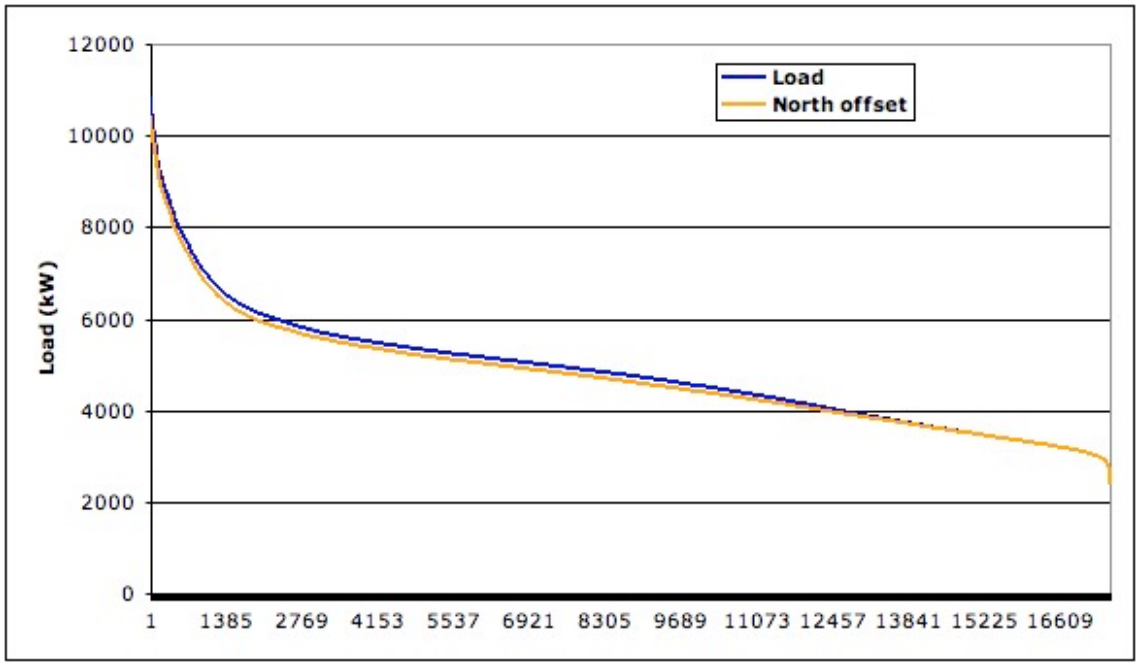

Figure 19: Load Duration Curve - July 2005 to June 2006
Carnarvon Load and Carnarvon Net Load after PV Offset (500kW)

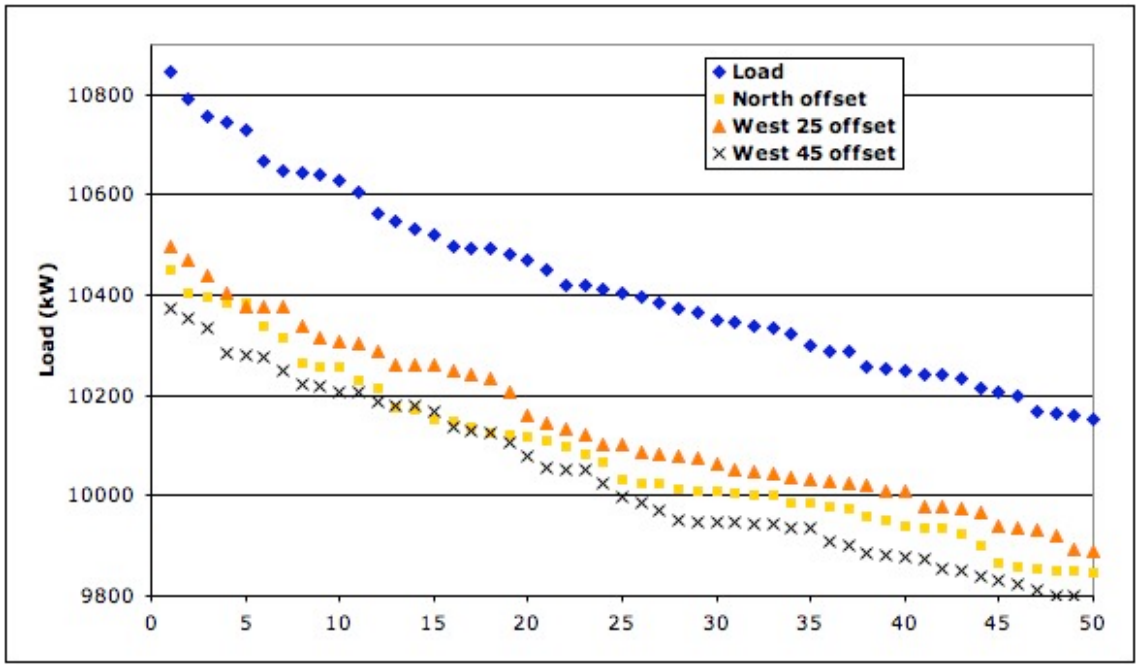

Figure 20: Load Duration Curve - top 50 load periods
North, and West (25° and 45° inclinations)
Carnarvon Load and Carnarvon Net Load after PV Offset (500kW)
July 2005 to June 2006

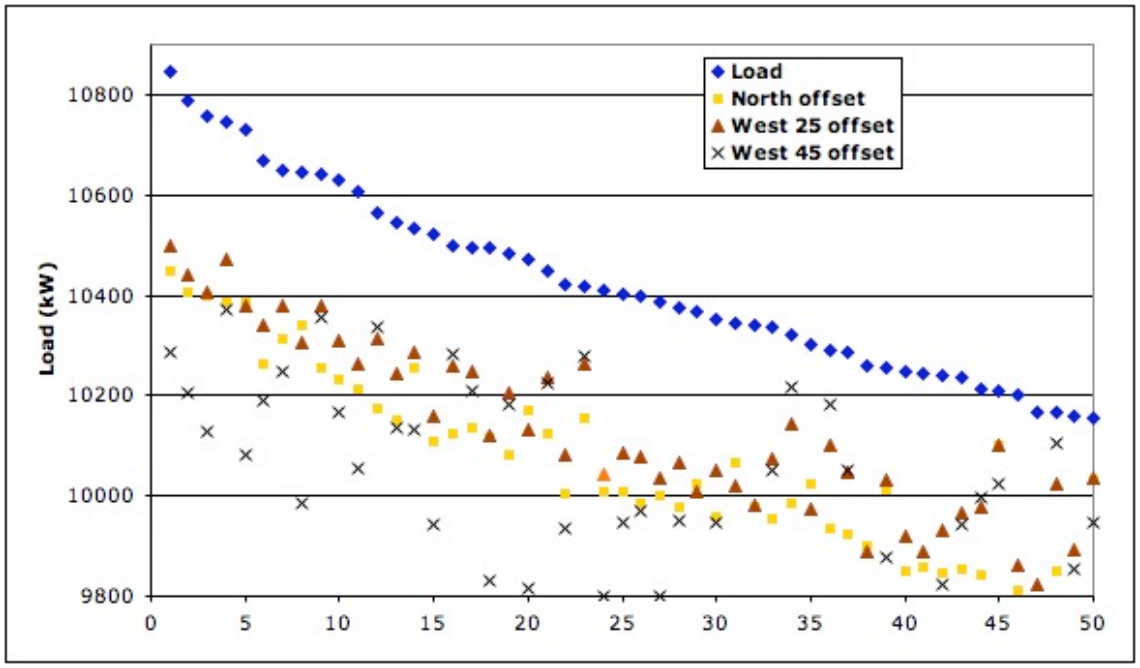

Figure 21: Load Duration Curve - top 50 load periods (linked)
North, and West (25° and 45° inclinations)
Carnarvon Load and Carnarvon Net Load after PV Offset (500kW)
July 2005 to June 2006

General correlation between PV Output and Load

Figure 22 shows the relationship between simulated north-facing PV and the Carnarvon load at any one time, and shows some correlation, with the data points generally extending up and to the right. When the PV output is plotted against the offset load (ie. reduced load because of PV), the PV shifts the load points at the top of the chart, which include the study period's highest load points, to the left – see Figure 23. The load points that occur around 100-150kW PV correspond to early morning and late afternoon loads on days of peak demand.

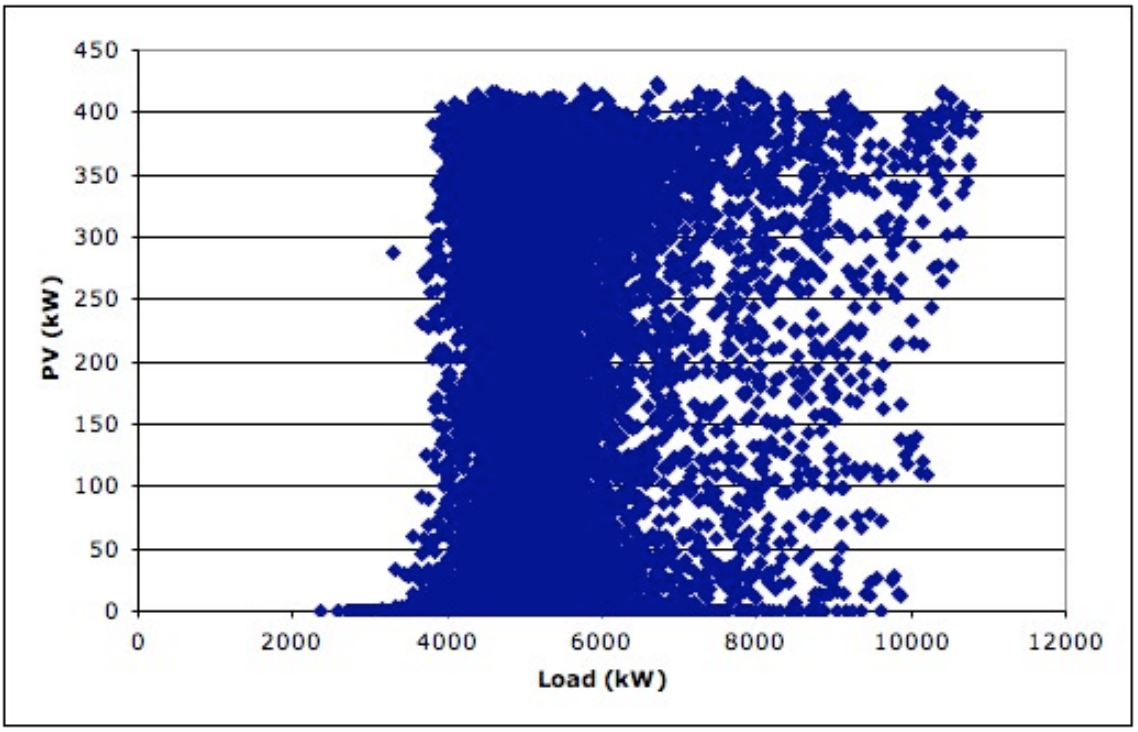

Figure 22: Carnarvon Simulated North-facing PV (500kW) vs Carnarvon Load
July 2005 to June 2006

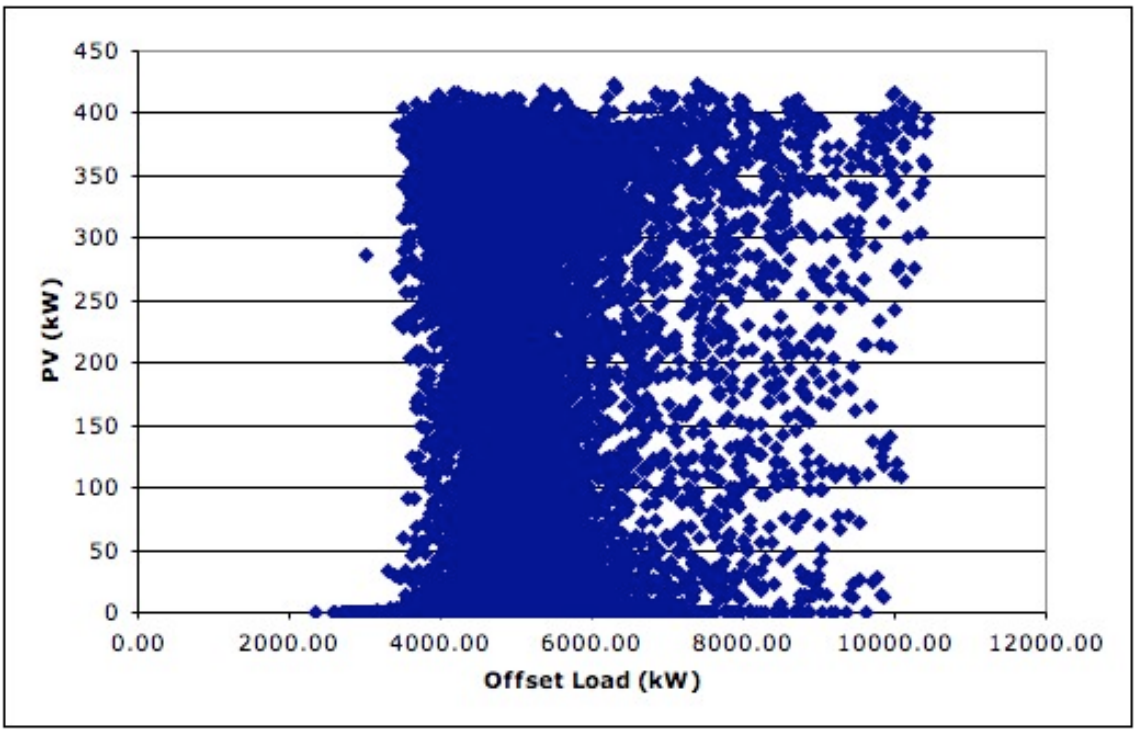

Figure 23: Carnarvon Simulated North-facing PV (500kW) vs Carnarvon Net Load after PV Offset
July 2005 to June 2006

Correlation with temperature

Figure 24 shows the relationship between the Carnarvon load and temperature, and shows fair correlation, with load tending to increase with temperature. Figure 25 shows the relationship between simulated north-facing PV output and temperature, and shows a similar correlation, where PV tends to increase at higher temperatures, which would normally occur during the middle of the day – although note there are instances of zero PV output at high temperatures, presumably on hot summer evenings.

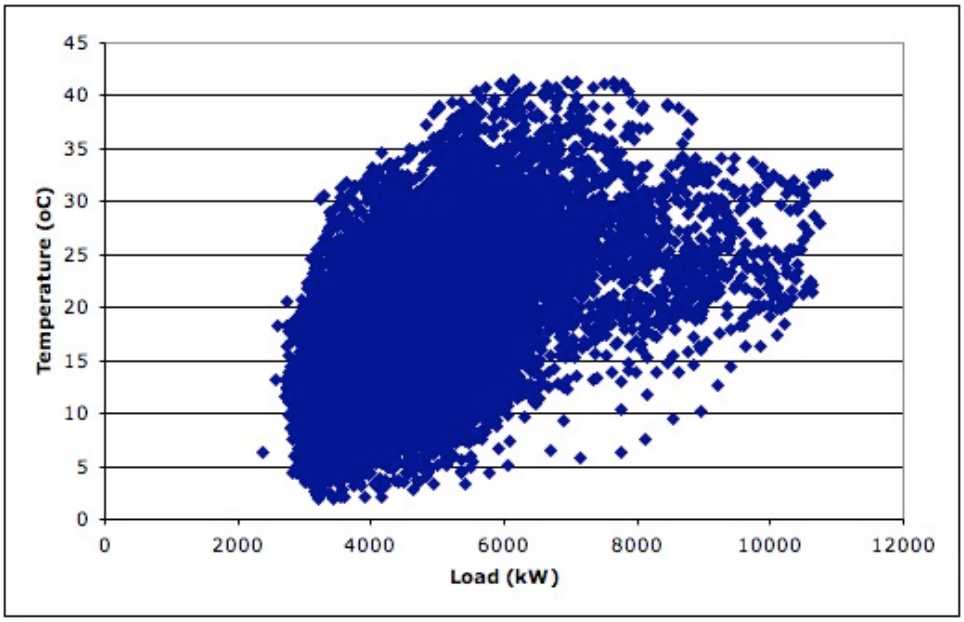

Figure 24: Carnarvon Load vs Temperature
July 2005 to June 2006

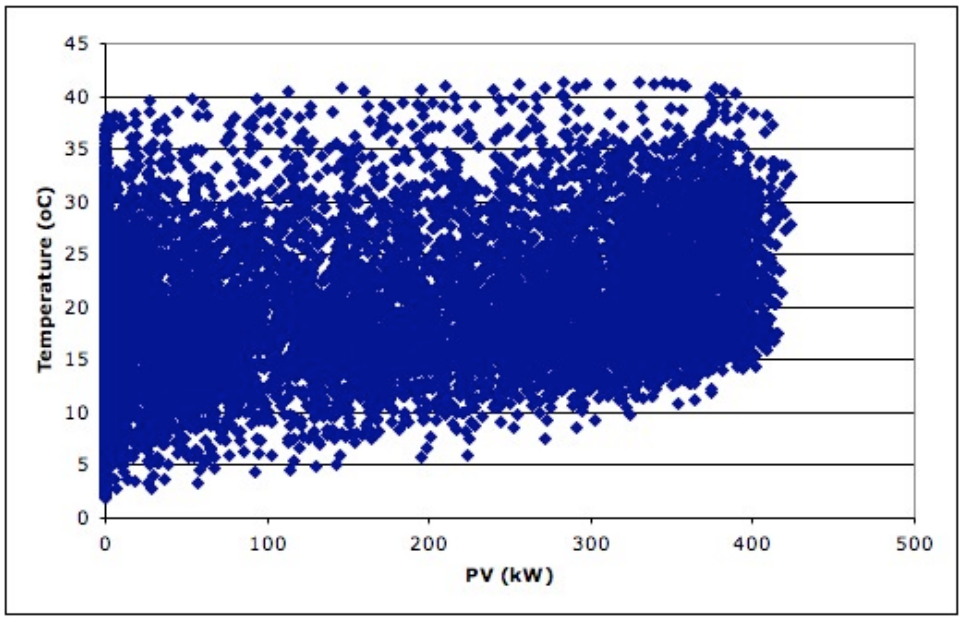

Figure 25: Carnarvon Simulated North-facing PV (500kW) vs Temperature
July 2005 to June 2006