

## 6.5 Appendix: Full analysis of ‘Edge of SWIS’ locations

Table A summarises the general load and simulated PV characteristics of the three ‘Edge of SWIS’ 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	Katanning and Merredin had a fairly constant baseload and daily maxima about double the size of the baseload. Geraldton also had a fairly constant baseload apart from a drop during August/Sept, and its daily maxima were only 30 to 50% above baseload. Katanning had a clear weekly cycle with weekend maxima generally well below weekdays. Merredin had a minor weekly cycle while Geraldton had no clear cycle. There were a relatively small number of very high demand peaks, most commonly in summer but also in winter.
Seasonal match	Merredin peaked in summer at around 4pm and simulated west-facing PV reduces the peak to the point where the evening peak is higher. Geraldton peaked in summer at around 3:30pm and all the simulated PV options reduced it to below both the morning and evening peaks. Katanning peaked in winter at around 7pm – a time where none of the simulated PV options have any impact.
General correlation between PV output and load	The scatterplots for both Geraldton and Merredin displayed a low level of correlaton between PV and load, although Geraldton does display correlation at the highest load points. Katanning displayed no correlation to PV.
General correlation with temperature	The scatterplot for Merredin displayed good correlation between load and temperature but in two distinct regions, with the highest load points showing an increased correlation to temperature. Geraldton load showed some correlation with temperature, while the Katanning load displayed the classic residential profile, where load increases due to high temperatures in summer and low temperatures in winter. 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.

## GERALDTON

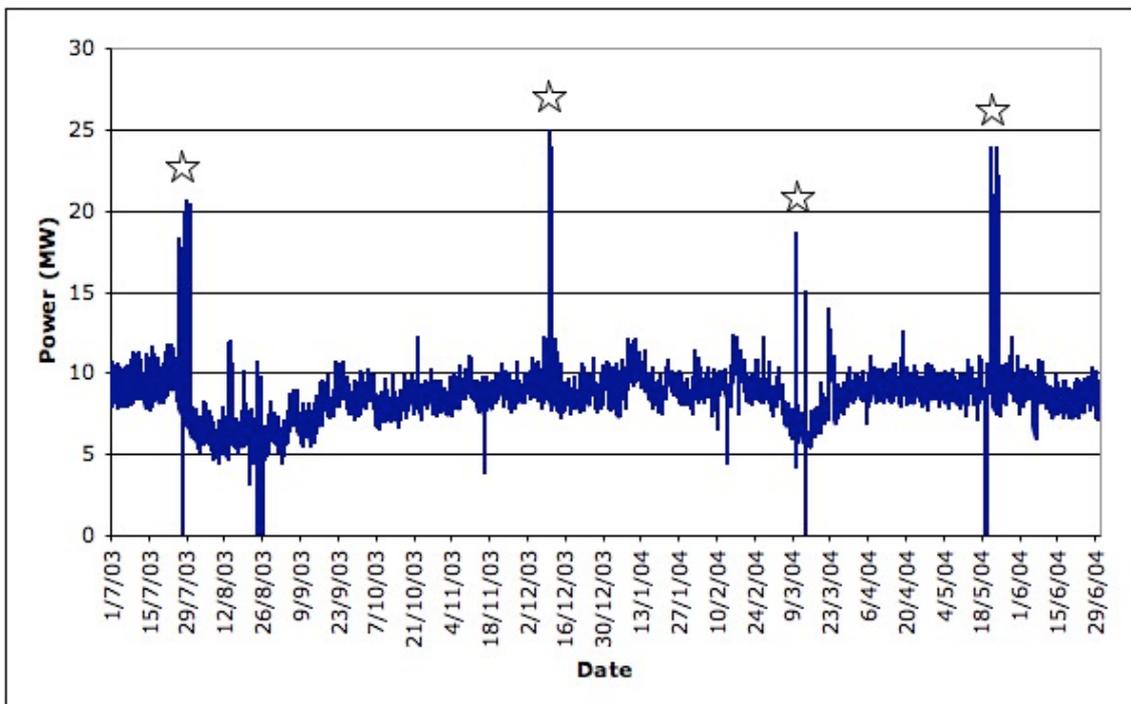
### *Summary of characteristics*

Geraldton substation includes two 132/33 kV transformers with nameplate capacity of 27 MVA and one new T2 132/33 kV transformer with nameplate capacity of 33 MVA. Geraldton substation is supplied via two 132 kV lines from Mungarra. It serves domestic, commercial and industrial customers, the 33/11 kV Durlacher St substation, and as a connection point for GTN GT Frame 5.

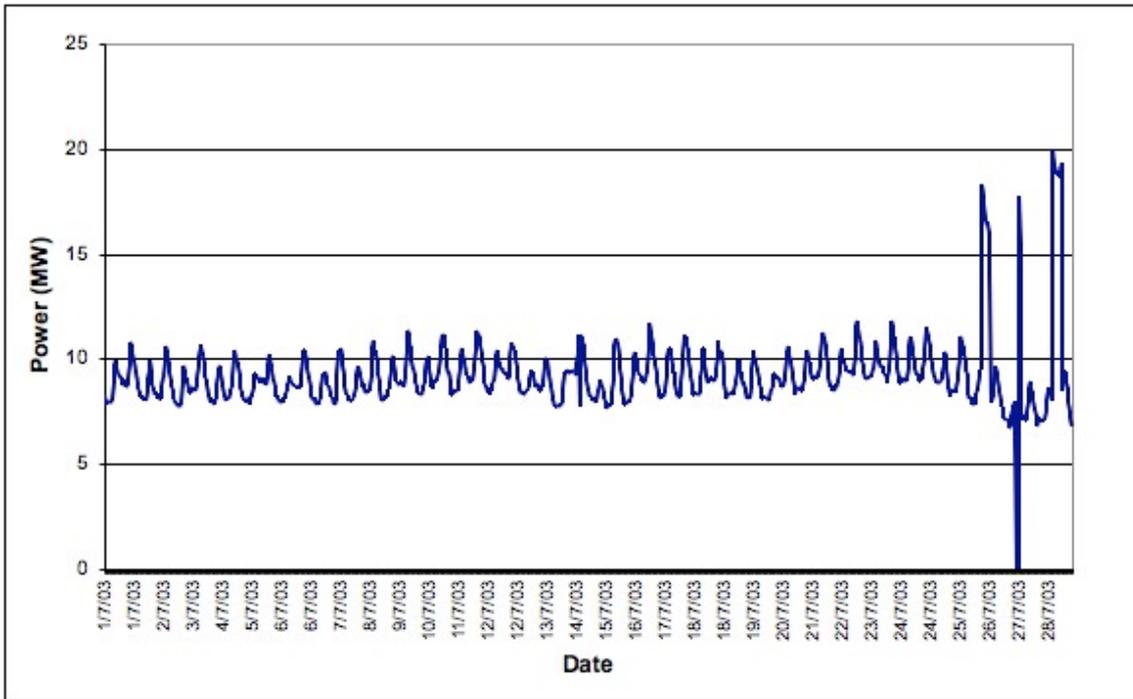
### *Annual profile*

The July 2003 to June 2004 load profile for Geraldton TX1 is shown in Figure 1. It is characterised by a very narrow daily variation and a fairly constant load just under 10MW throughout the year with no clear summer or winter trends. It has no clear weekly cycle – see Figure 2 (which also includes some of the peak load days assessed here) and Figure 3. There are a number of days of extreme demand peaks, which are discussed in more detail below.

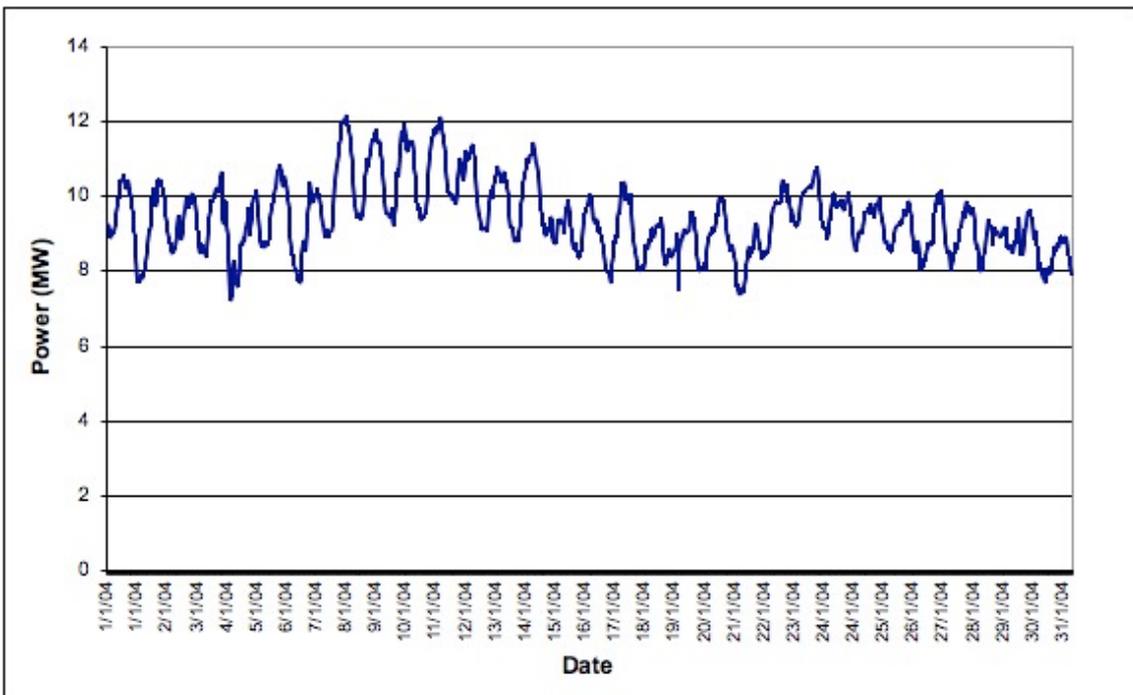
Figure 4 shows the 2MW simulated north-facing PV output for ACDB site ‘Geraldton’, which decreases in winter as expected, but also has a reduced summer peak. This is consistent with the Kalbarri monitored PV output (discussed in the following section) and so likely reflects decreased insolation over this period due to summer cloud cover.



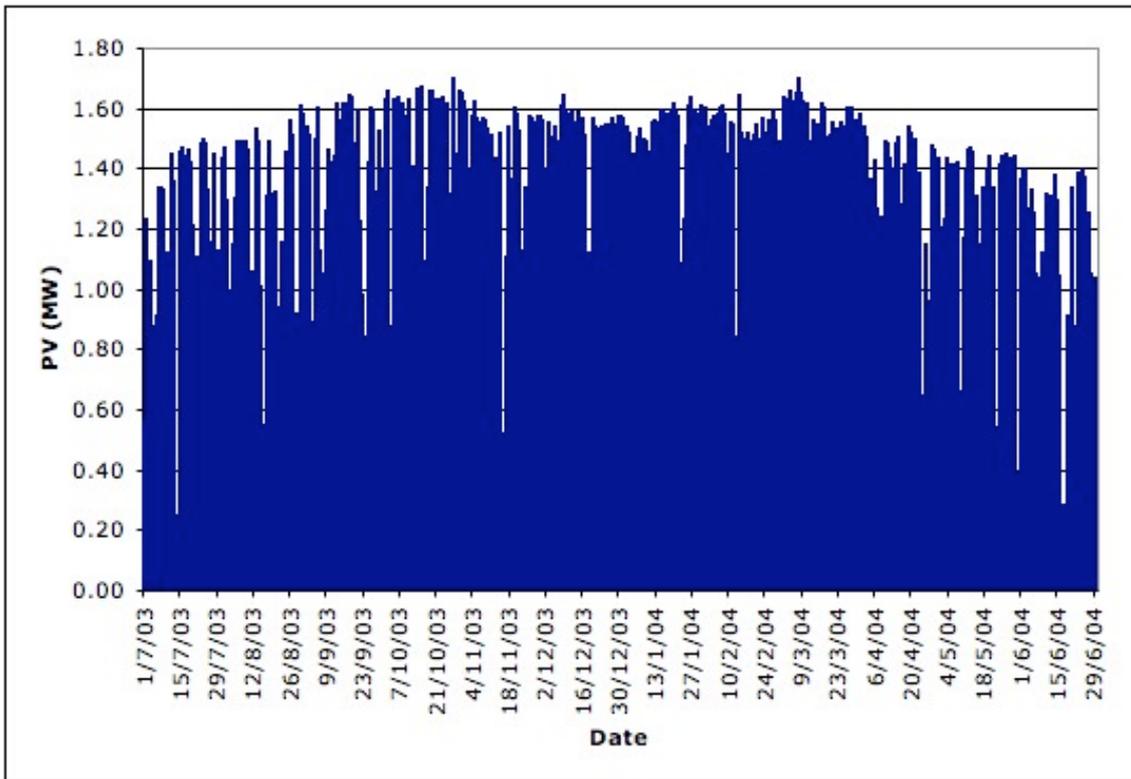
**Figure 1: Geraldton TX1 Load**  
July 2003 to June 2004  
(the stars indicate the peak days analysed in detail below)



**Figure 2: Geraldton TX1 Load - July**  
The first 28 days of July 2003



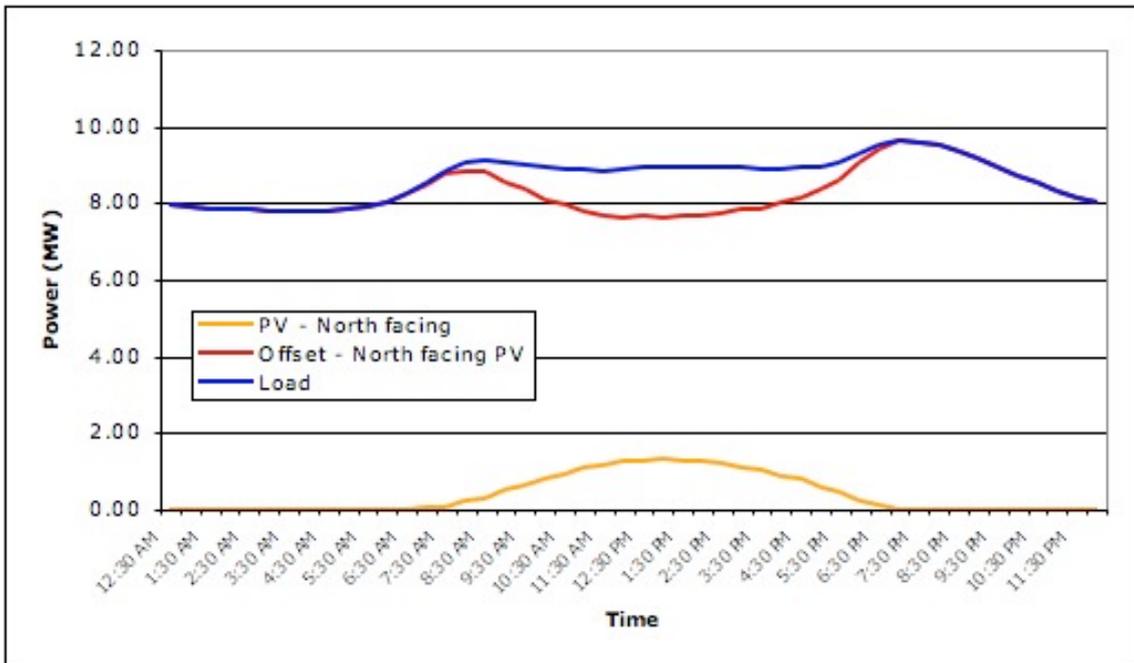
**Figure 3: Geraldton TX1 Load - Jan**  
The first 28 days of Jan 2004



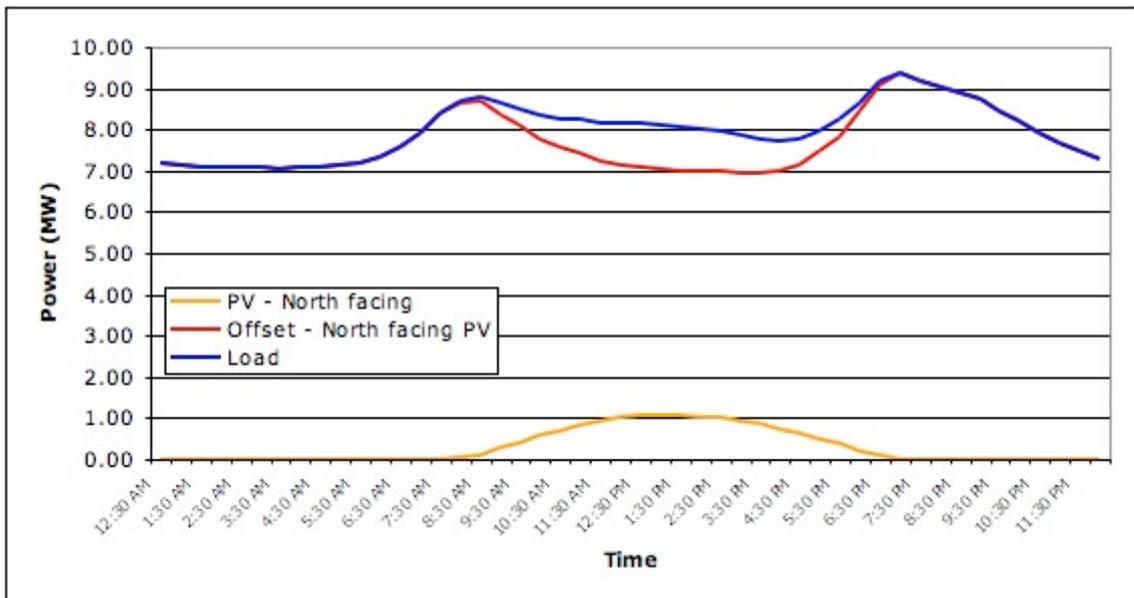
**Figure 4: Geraldton Simulated North-facing PV Output (2MW)  
July 2003 to June 2004**

#### *Daily profiles*

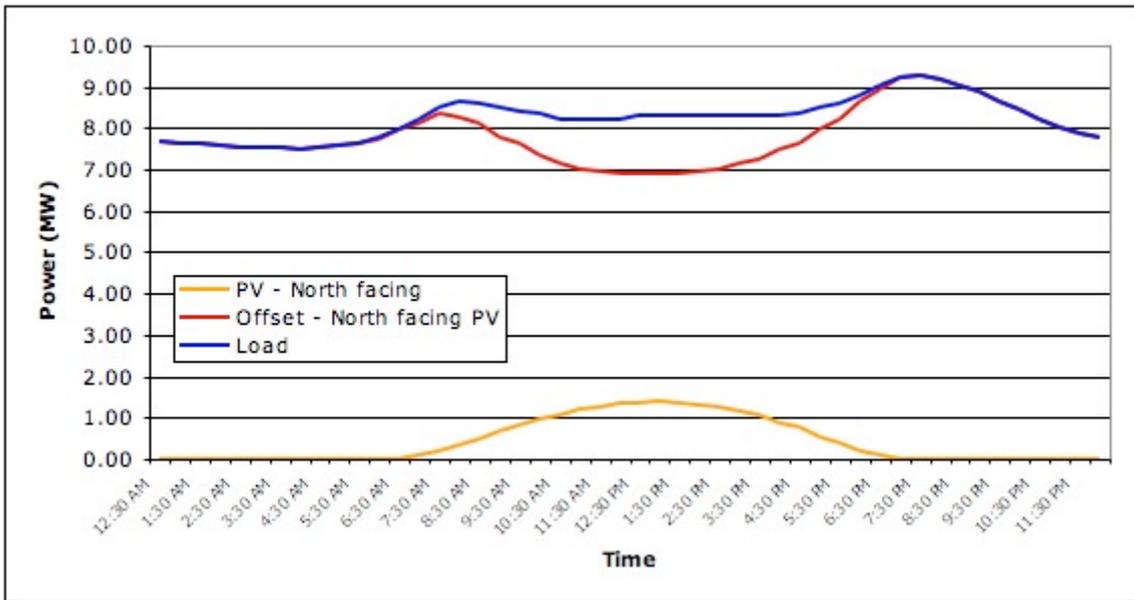
Figure 5 shows the daily annual average load for Geraldton TX1, the simulated north-facing 2MW PV output, and the net load assuming it is reduced by PV. The annual average load peaks occur at around 9am and 8pm and PV makes these peaks more distinct. As can be seen from Figure 6 to Figure 9, these morning and evening peaks are even more distinct in autumn and spring and especially in winter. The highest seasonal peak occurs in summer at around 3:30pm and is reduced by the simulated north-facing PV to well below the summer evening and morning peaks. The impact of simulated west-facing PV is discussed below.



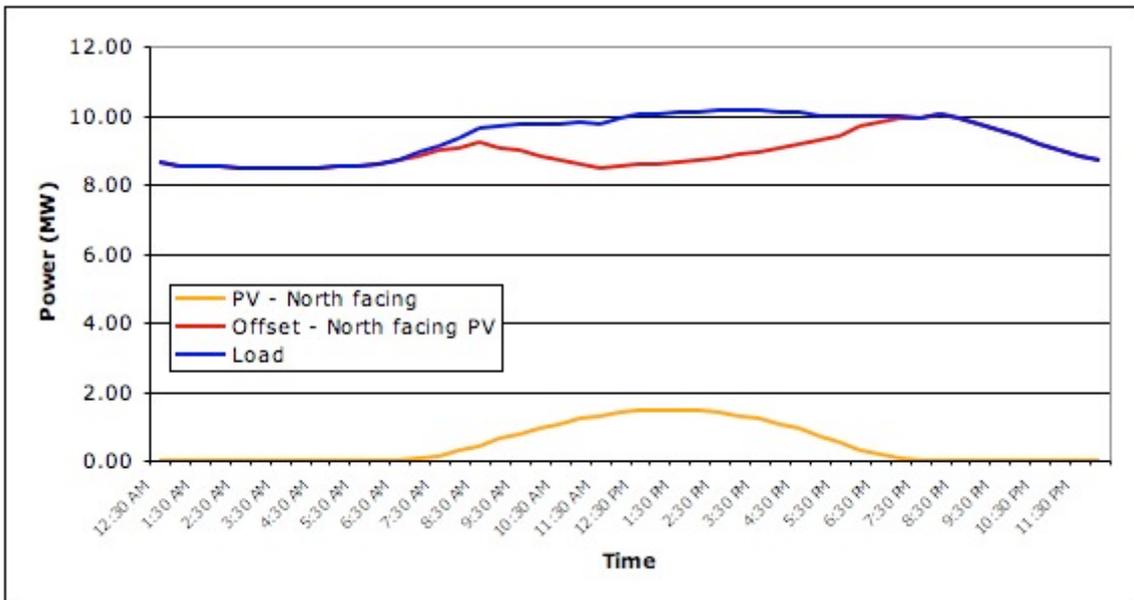
**Figure 5: Daily Annual Average**  
 Geraldton TX1 Load, Geraldton Simulated North-facing PV (2MW) and Net Load after PV Offset  
 July 2003 to June 2004



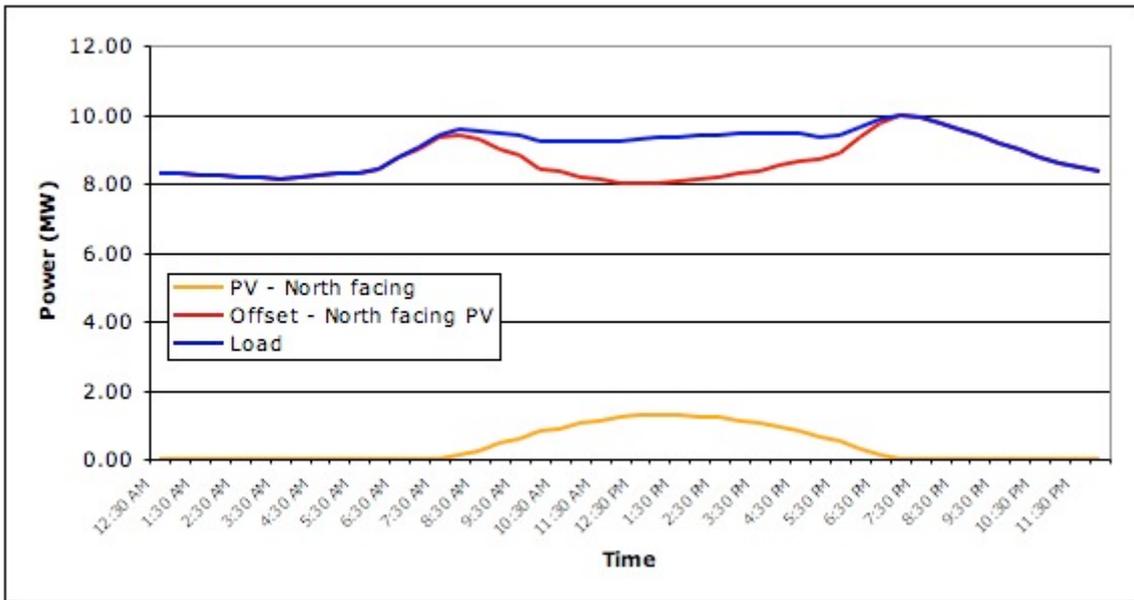
**Figure 6: Daily Winter Average**  
 Geraldton TX1 Load, Geraldton Simulated North-facing PV (2MW) and Net Load after PV Offset  
 June 2004 and July/Aug 2003



**Figure 7: Daily Spring Average**  
 Geraldton TX1 Load, Geraldton Simulated North-facing PV (2MW) and Net Load after PV Offset  
 Sept 2003 to Nov 2003



**Figure 8: Daily Summer Average**  
 Geraldton TX1 Load, Geraldton Simulated North-facing PV (2MW) and Net Load after PV Offset  
 Dec 2003 to Feb 2004

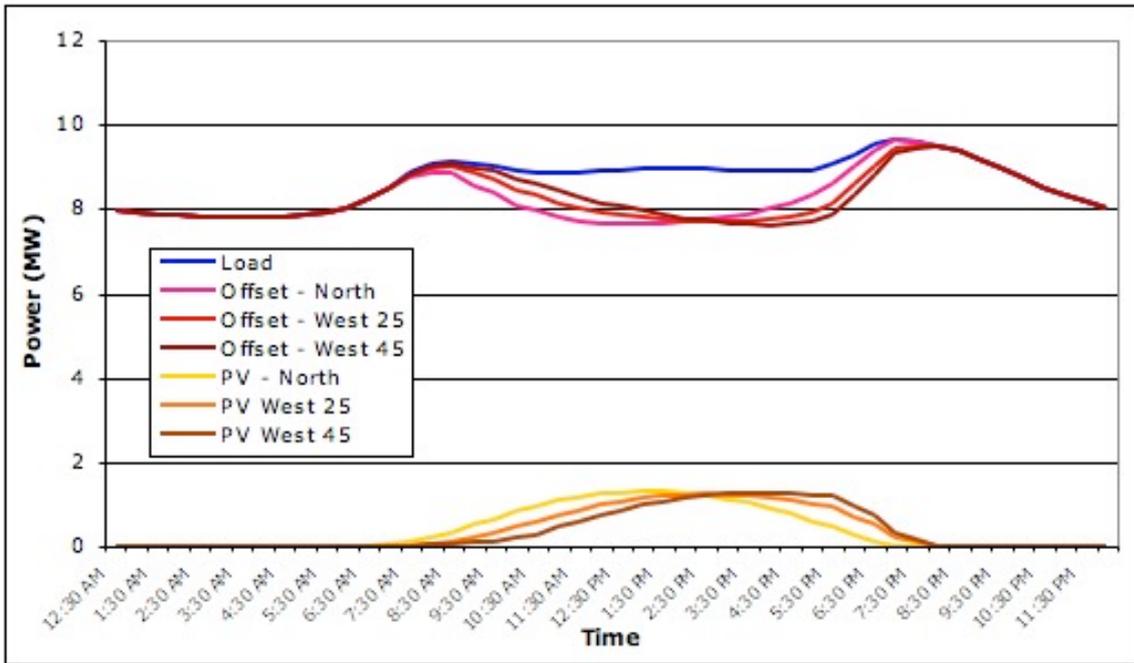


**Figure 9: Daily Autumn Average**  
 Geraldton TX1 Load, Geraldton Simulated North-facing PV (2MW) and Net Load after PV Offset  
 March 2004 to May 2004

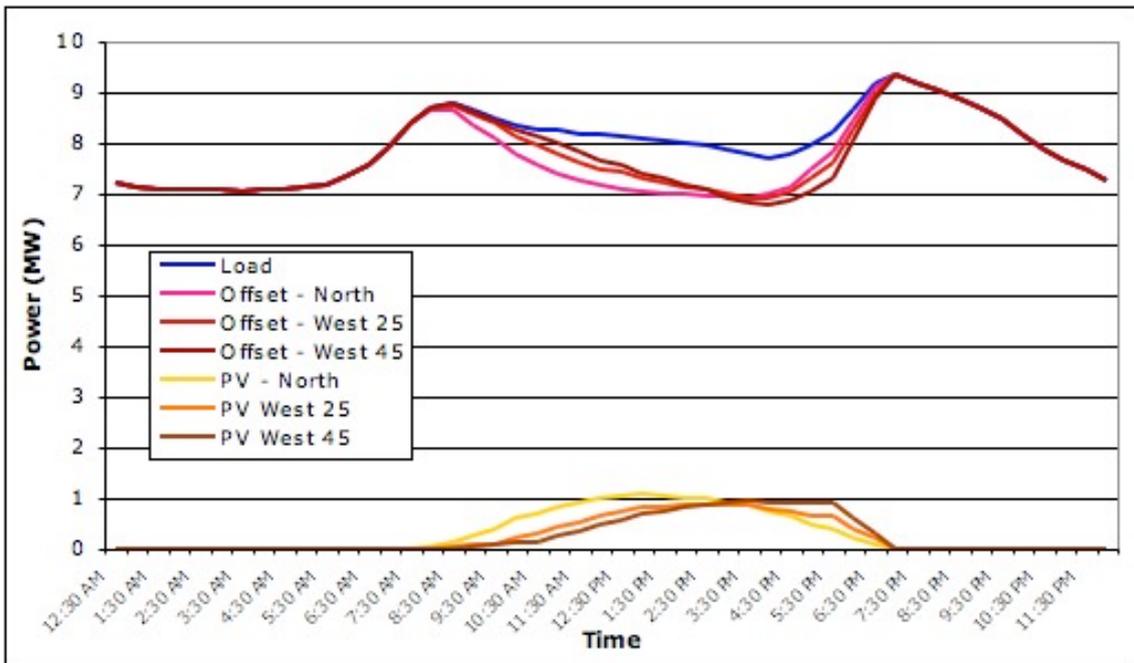
The impact of simulated west-facing PV is illustrated in Figure 10 to Figure 14. Use of simulated west-facing PV with a tilt of 25 degrees shifts the peak PV output by about 1.5 hours later in the day, and a tilt of 45 degrees brings the shift to a total of about 3 hours. However, while this reduces the evening peak marginally, it would have less impact on the morning peak and, given the decrease in energy output (Table 1), it is likely that simulated north-facing or north-west facing PV is the better option.

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

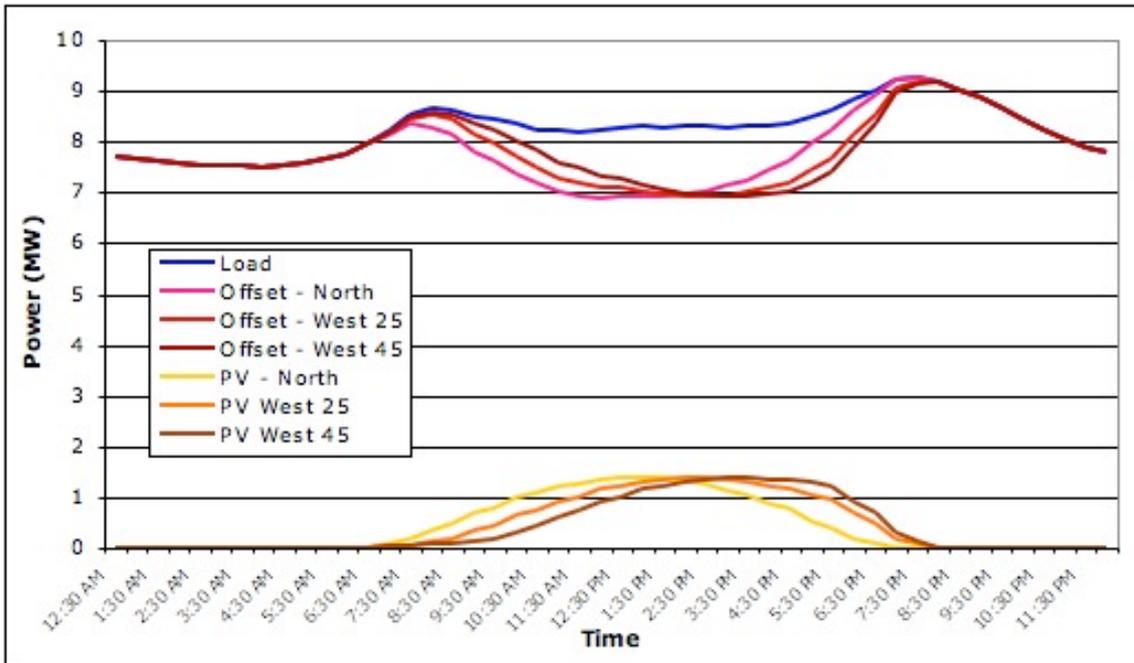
Orientation	Tilt (degrees)	2003 (kWh/yr)	2004 (kWh/yr)
North	25	1,636	1,657
North west	25	1,716	1,744
West	25	1,607	1,633
West	45	1,540	1,568
West	90	1,079	1,098



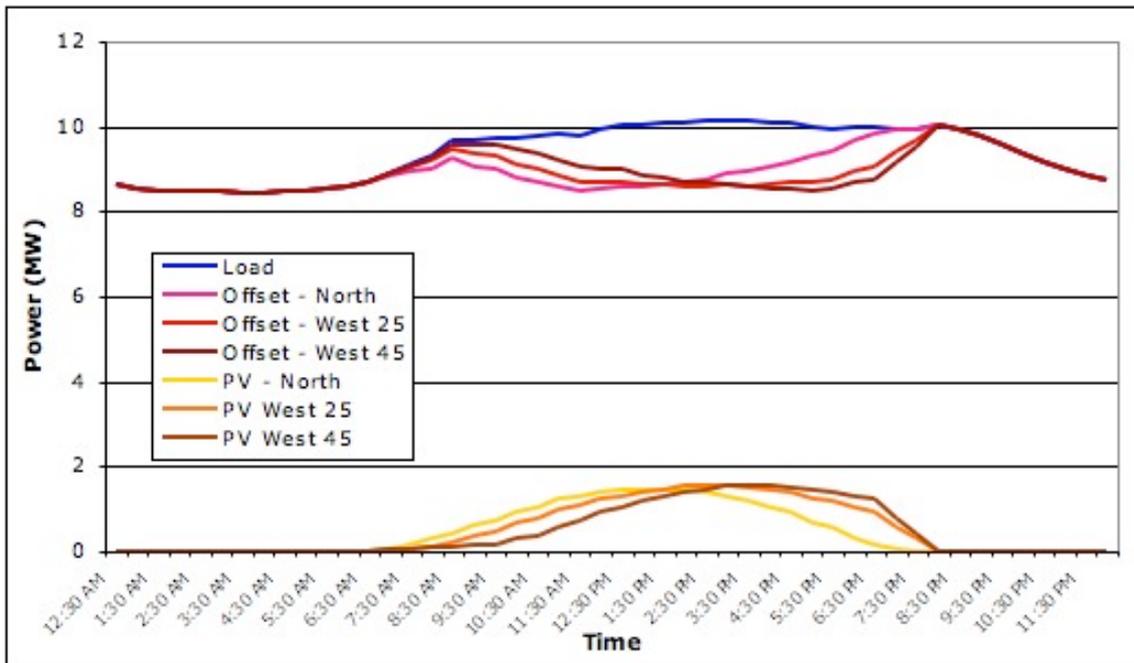
**Figure 10: Daily Annual Average North, and West (25° and 45° inclinations) Geraldton TX1 Load, Geraldton PV (2MW) and Net Load after PV Offset July 2003 to June 2004**



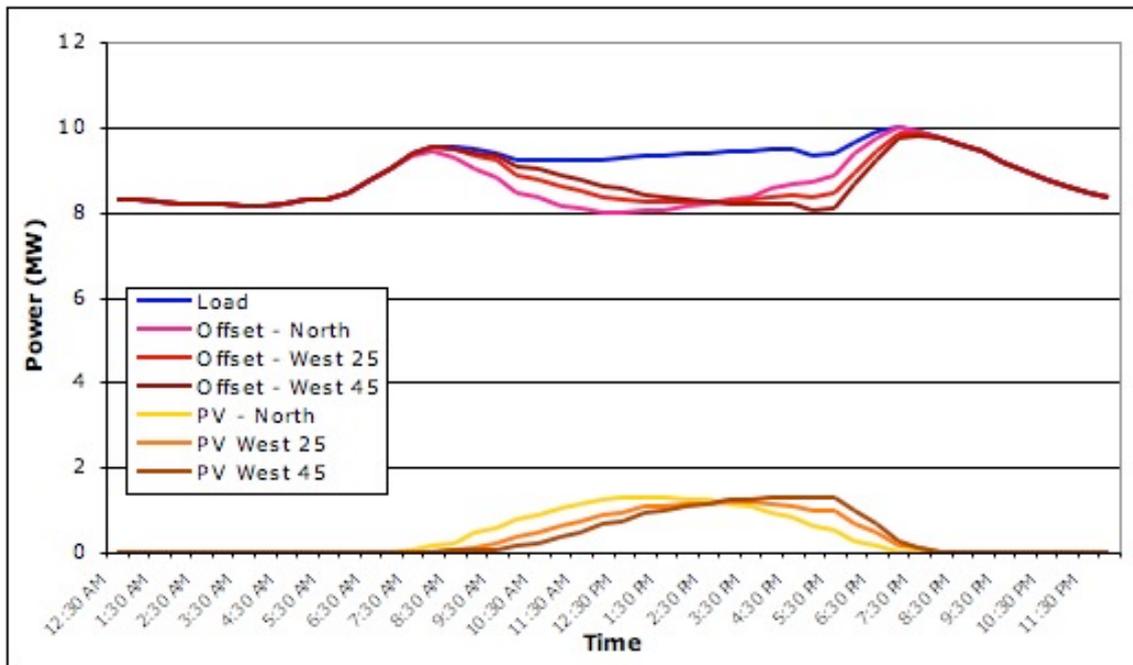
**Figure 11: Daily Winter Average North, and West (25° and 45° inclinations) Geraldton TX1 Load, Geraldton PV (2MW) and Net Load after PV Offset June 2004 and July/Aug 2003**



**Figure 12: Daily Spring Average North, and West (25° and 45° inclinations) Geraldton TX1 Load, Geraldton PV (2MW) and Net Load after PV Offset Sept 2003 to Nov 2003**



**Figure 13: Daily Summer Average North, and West (25° and 45° inclinations) Geraldton TX1 Load, Geraldton PV (2MW) and Net Load after PV Offset Dec 2003 to Feb 2004**



**Figure 14: Daily Autumn Average  
North, and West (25° and 45° inclinations)  
Geraldton TX1 Load, Geraldton PV (2MW) and Net Load after PV Offset  
March 2004 to May 2004**

#### *Times of peak demand*

The ten top half-hour demand peaks at Geraldton TX1 are shown in Table 2. All occur on the 10<sup>th</sup> Dec 2003, which is illustrated in Figure 15, and are the ten highest points in the load duration curves in Figure 19 to Figure 21.

The highest peak load days for the study period (10<sup>th</sup>-11<sup>th</sup> Dec 2003; Figure 15) were not particularly hot days, reaching around 28°C, and it is likely the peak is due to operational changes by Western Power. Simulated north-facing PV was a good match for the load, and, as can be seen from the load duration curves in Figure 20 and Figure 21, reduced the peak half hour periods for the year by between 0.8 and 1.5 MW. The resultant peak period occurs early in the day and so would not be reduced by west-facing PV. The following day has a similar peak, which again has a good match for the simulated PV.

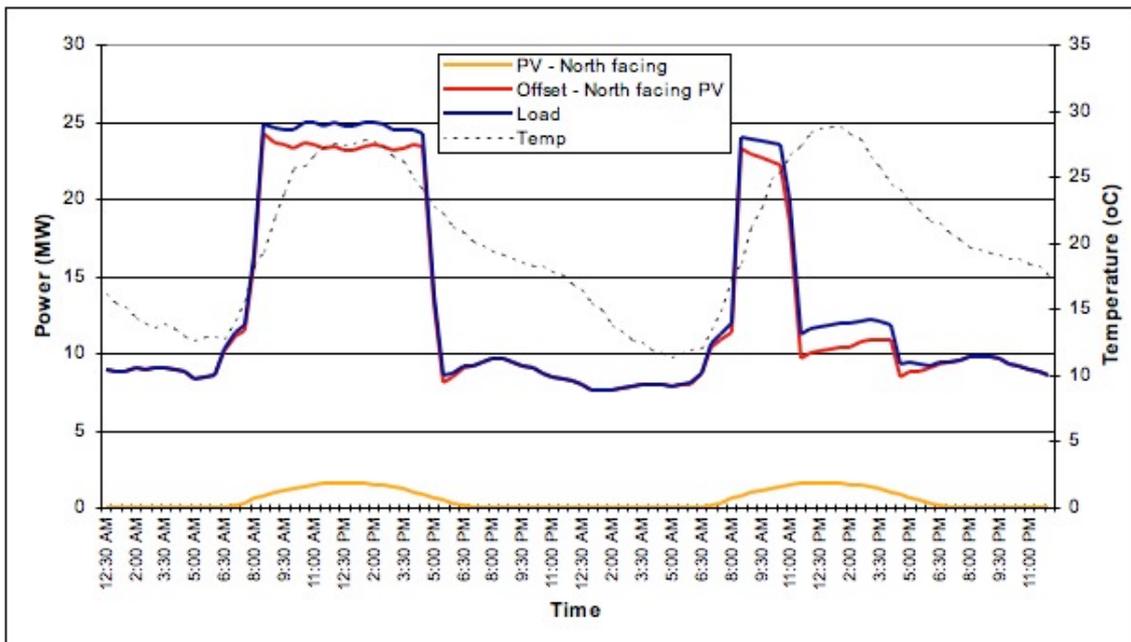
The second highest peak cluster of peak load days assessed here occurred in autumn (21<sup>st</sup>-23<sup>rd</sup> May 2004; Figure 16) and again appear to have been influenced by operational changes. The peaks on the two highest days occur around 6:30pm and so may have benefited from west-facing PV, however PV output was so low on these days that it would have made little difference.

The third highest peak cluster of peak load days assessed here occurred in winter (27<sup>th</sup>-30<sup>th</sup> July 2003; Figure 17), where on a series of days the load rapidly increased from around 8MW to around 20MW, again most probably because of operational changes by Western Power. Simulated north-facing PV matched the load on the 28<sup>th</sup> July quite well but is a poor match on the other days. This is partly because the peaks begin before significant PV output occurs and partly because of poor PV output on those days.

The fourth highest peak cluster of peak load days assessed here occurred in autumn (10<sup>th</sup> March 2004; Figure 18) and was relatively hot (33°C), however the peak occurred very early in the day, well before PV would make any significant contribution. Judging from the shape, it was also the result of operational changes.

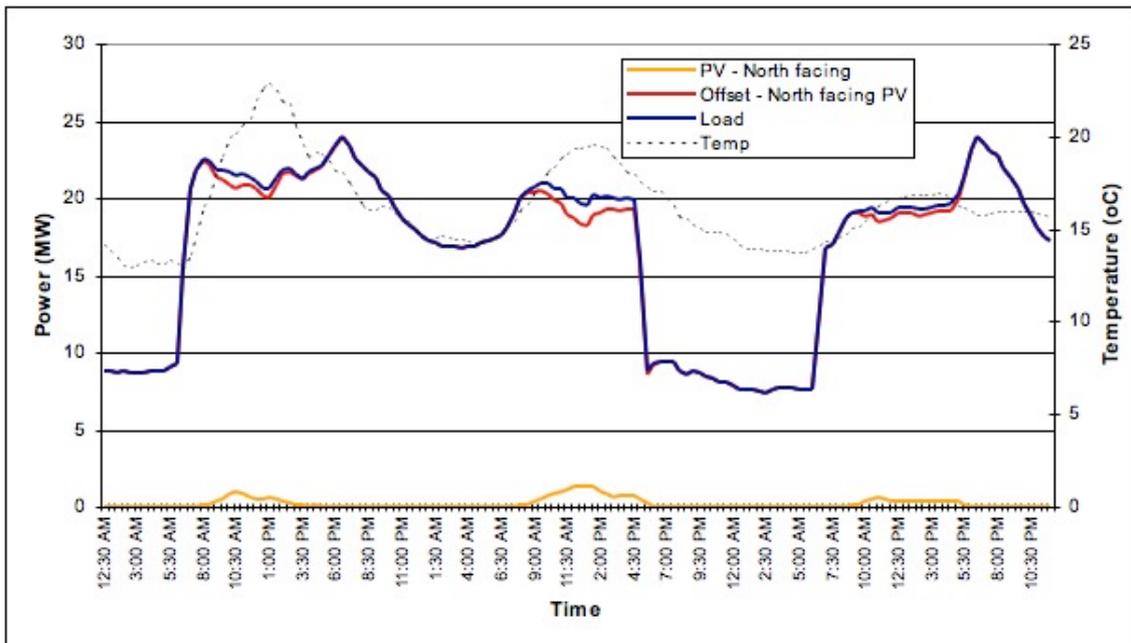
**Table 2: Ten Top Half-hour Demand Peaks at Geraldton TX1**

Demand (MW)	Date	Day	Time
24.98	10-Dec-03	Wed	11:00
24.93	10-Dec-03	Wed	14:00
24.93	10-Dec-03	Wed	12:00
24.92	10-Dec-03	Wed	10:30
24.88	10-Dec-03	Wed	13:30
24.87	10-Dec-03	Wed	8:30
24.82	10-Dec-03	Wed	14:30
24.73	10-Dec-03	Wed	11:30
24.68	10-Dec-03	Wed	13:00
24.67	10-Dec-03	Wed	12:30



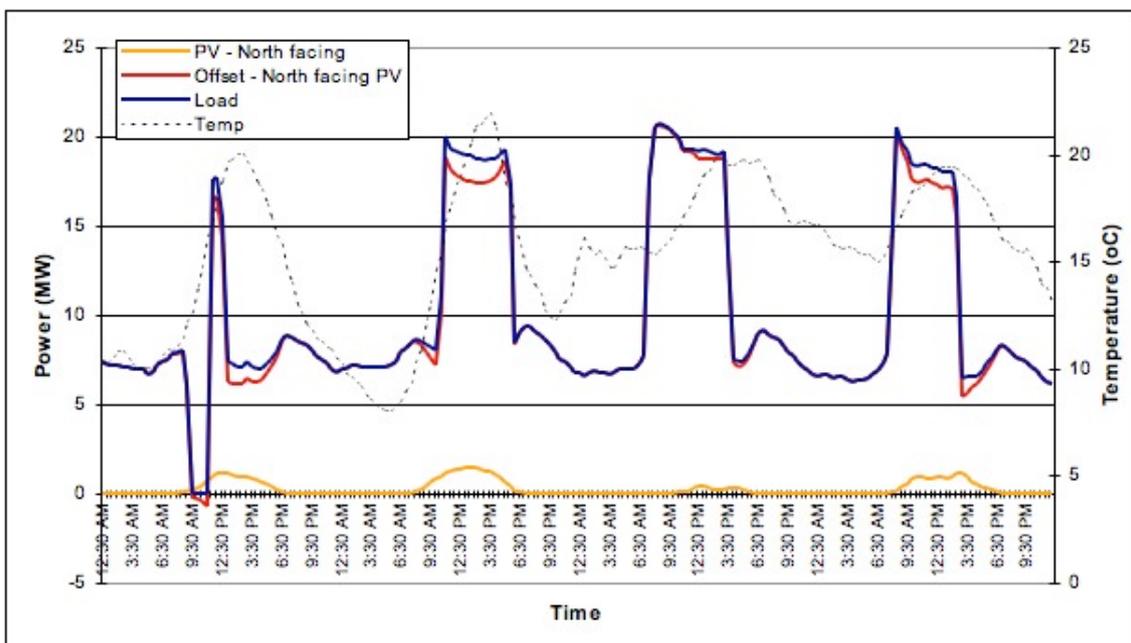
**Figure 15: Summer peak days  
10<sup>th</sup> – 11<sup>th</sup> Dec 2003**

Geraldton TX1 Load, Geraldton Simulated North-facing PV (2MW) and Net Load after PV Offset



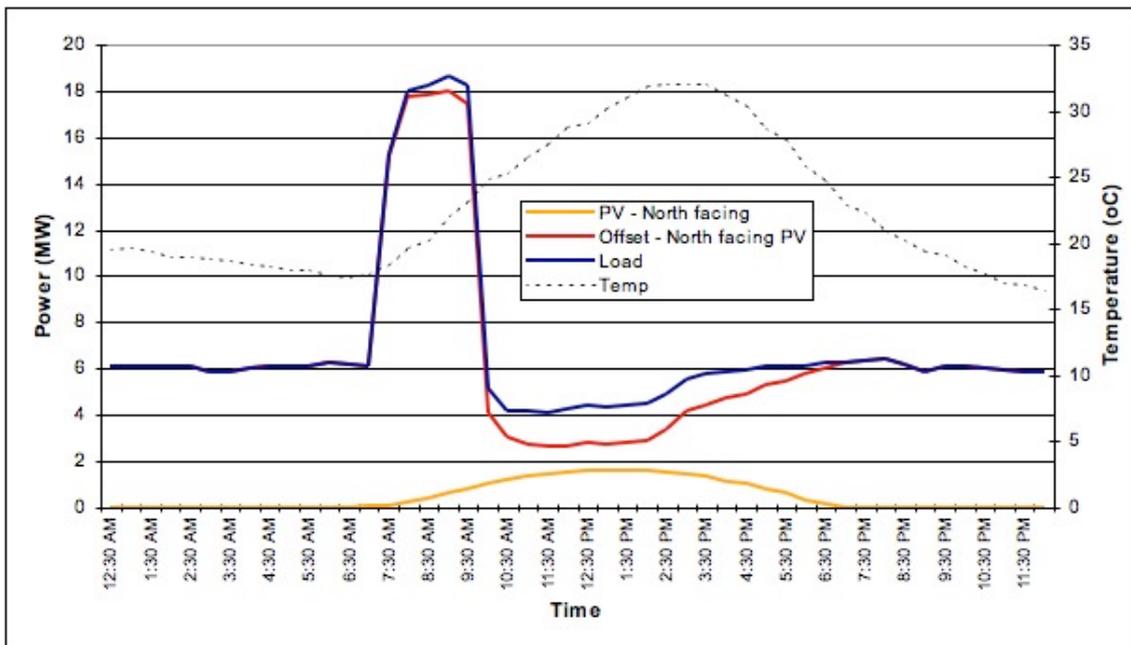
**Figure 16: Autumn peak days  
21<sup>st</sup> - 23<sup>rd</sup> May 2004**

Geraldton TX1 Load, Geraldton Simulated North-facing PV (2MW) and Net Load after PV Offset



**Figure 17: Winter peak days  
27<sup>th</sup> - 30<sup>th</sup> July 2003**

Geraldton TX1 Load, Geraldton Simulated North-facing PV (2MW) and Net Load after PV Offset



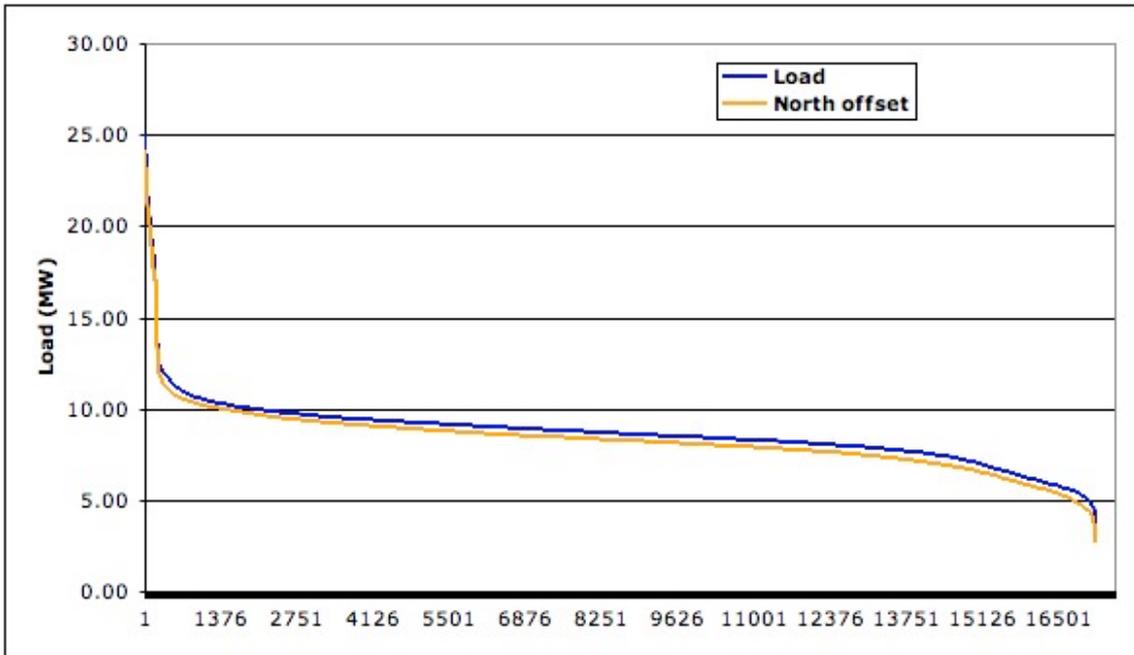
**Figure 18: Autumn peak day  
10<sup>th</sup> March 2004**

Geraldton TX1 Load, Geraldton Simulated North-facing PV (2MW) and Net Load after PV Offset

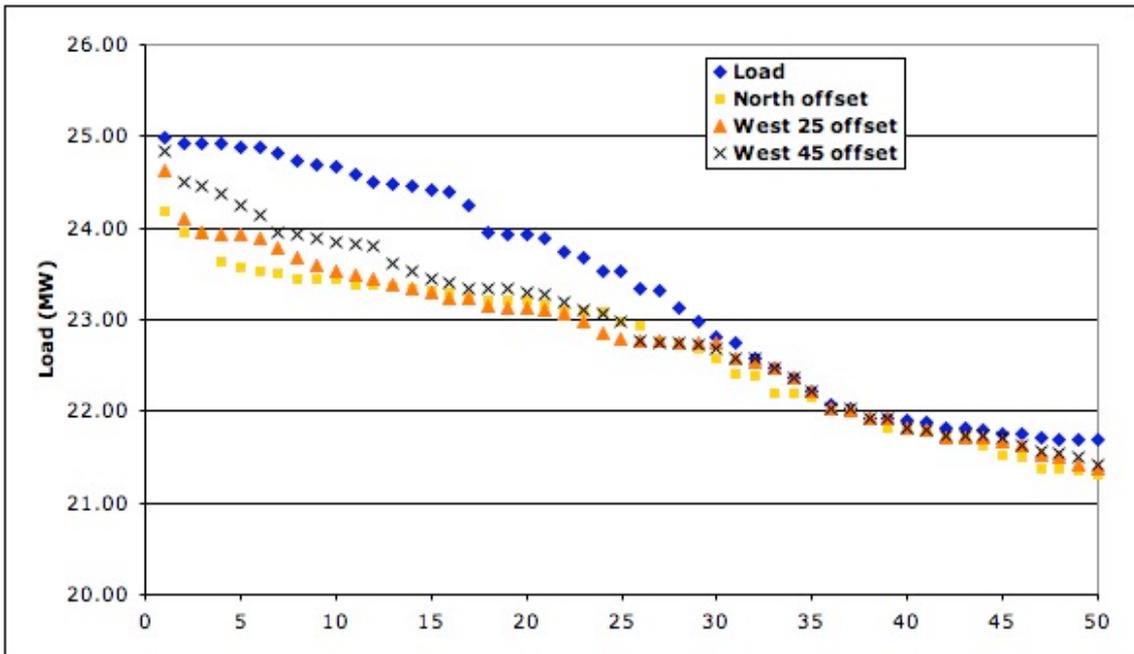
#### *Load duration curves*

The load duration curve for Geraldton TX1 is in Figure 19 and shows that the top 50% of the load occurred for only 1.5% of the study period, while the top 10% occurred for less than 0.2% of the time. Figure 20 shows the top 50 load points, together with the offset load duration curve assuming reduction by simulated north-facing PV or west-facing 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. This occurred only at the highest 30 load period - almost all of which occurred on the 10<sup>th</sup> Dec 2003. 2MW of simulated north-facing PV resulted in the highest offset load period being 0.81MW lower than the highest original load period, and resulted in the top 10 offset load periods being lower by an average of 1.18MW.

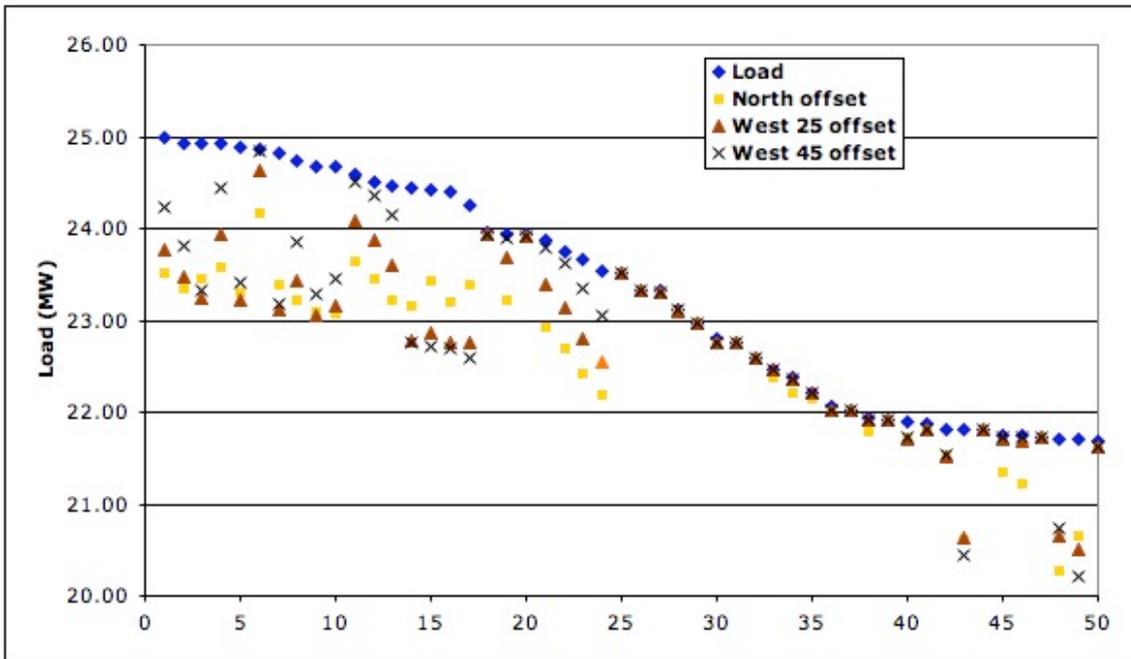
Figure 21 shows the same load duration curves except that the offset periods now correspond to the load periods directly above them on the chart. This shows that during the highest load period, 73.5% of the 2MW simulated PV would have contributed to load reduction, reducing it from 24.98MW to 23.51MW (although note that on the same day, what was originally a lower load period did not correlate as well to PV and so became the day's highest offset load period at 24.17MW). On average during the 10 highest load period, 71.5% the 2MW simulated PV was contributing to reducing peak load.



**Figure 19: Load Duration Curve - July 2003 to June 2004**  
 Geraldton TX1 Load and Geraldton TX1 Net Load after PV Offset (2MW)



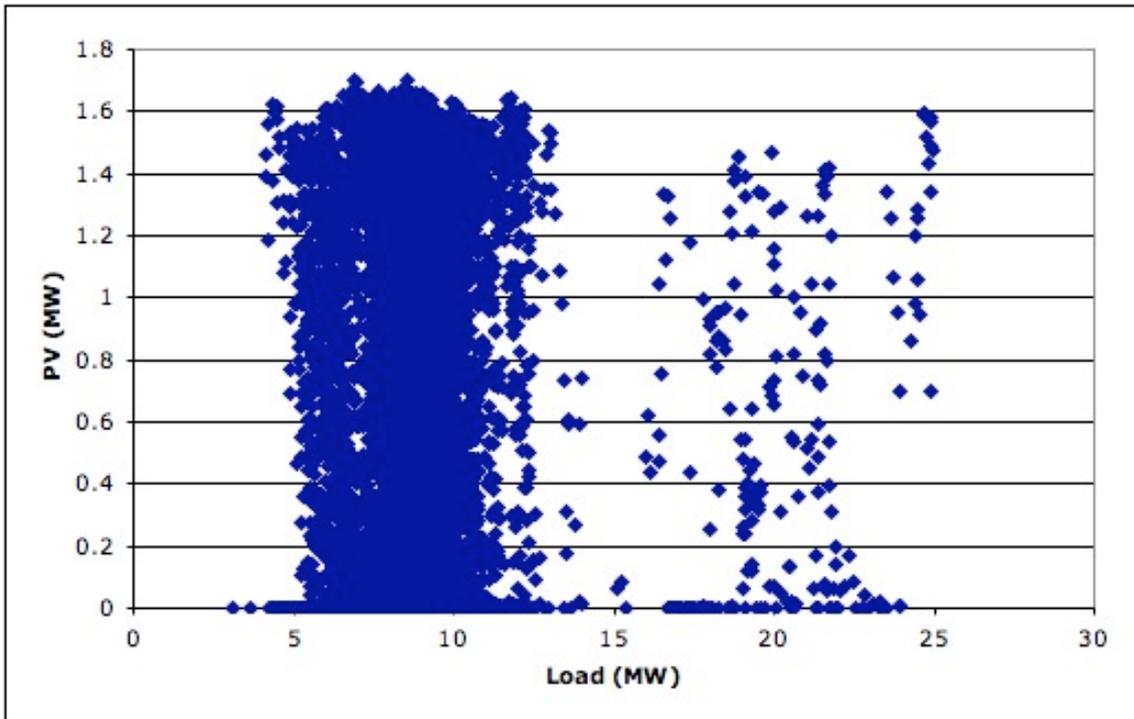
**Figure 20: Load Duration Curve - top 50 load points**  
 North, and West (25° and 45° inclinations)  
 Geraldton TX1 Load and Geraldton TX1 Net Load after PV Offset (2MW)  
 July 2003 to June 2004



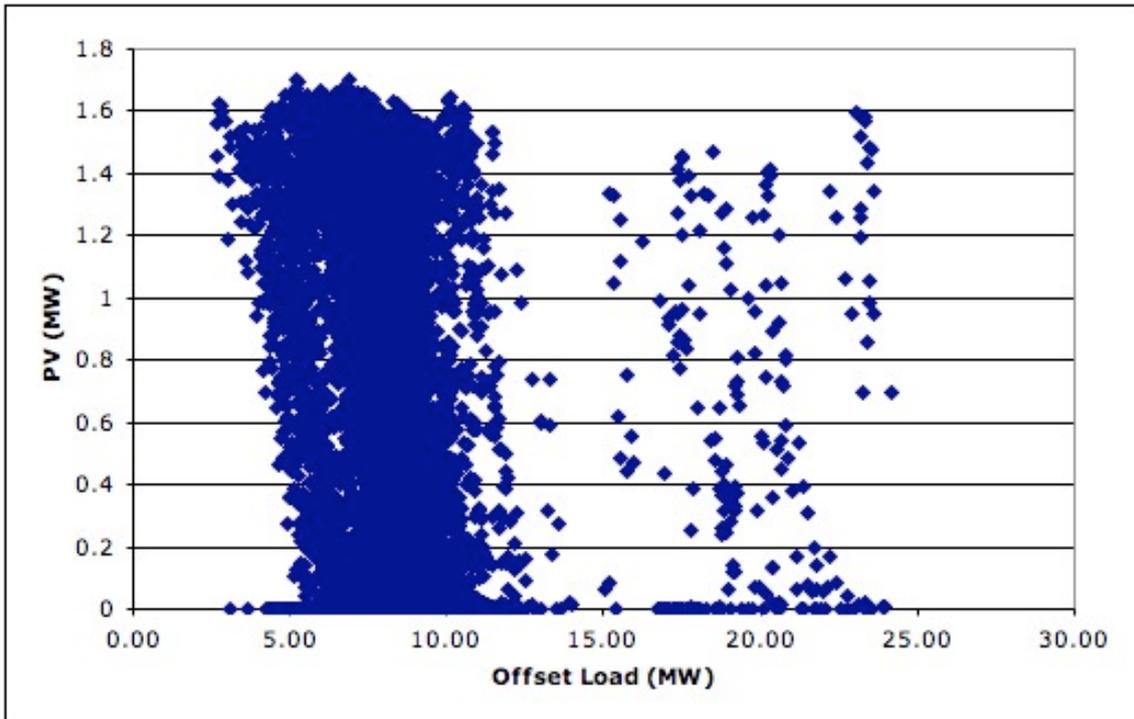
**Figure 21: Load Duration Curve - top 50 load points (linked)**  
 North, and West (25° and 45° inclinations)  
 Geraldton TX1 Load and Geraldton TX1 Net Load after PV Offset (2MW)  
 July 2003 to June 2004

*General correlation between PV Output and Load*

Figure 22 shows the relationship between simulated PV output and the Geraldton TX1 load at any one time, and shows a low level of correlation. There are many times of high demand with zero PV output (evening load peaks), and times of high PV output and relatively low load. The scattered high load points correspond to the unusually high load days started in Figure 1 and discussed above. 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.



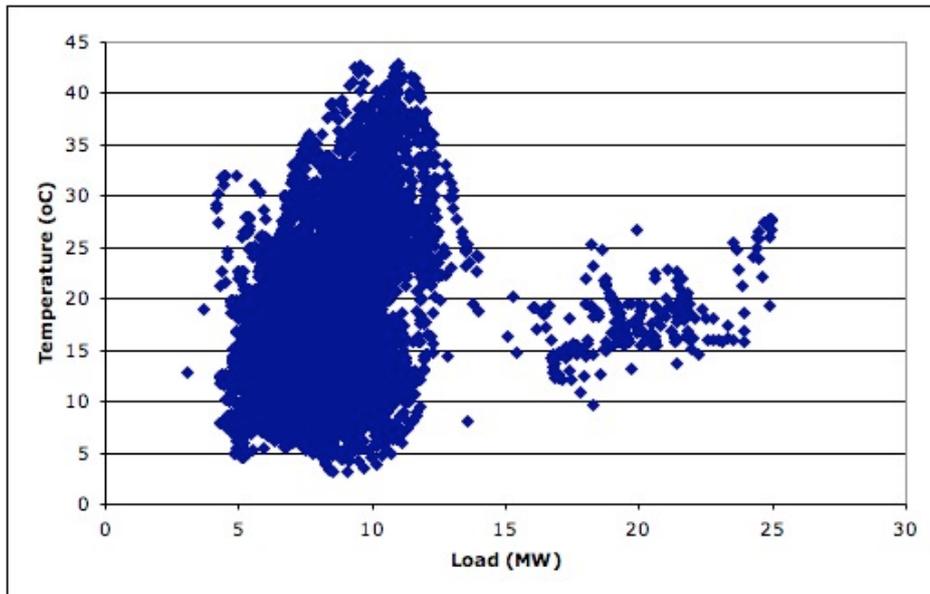
**Figure 22: Geraldton Simulated North-facing PV (2MW) vs Geraldton TX1 Load**  
July 2003 to June 2004



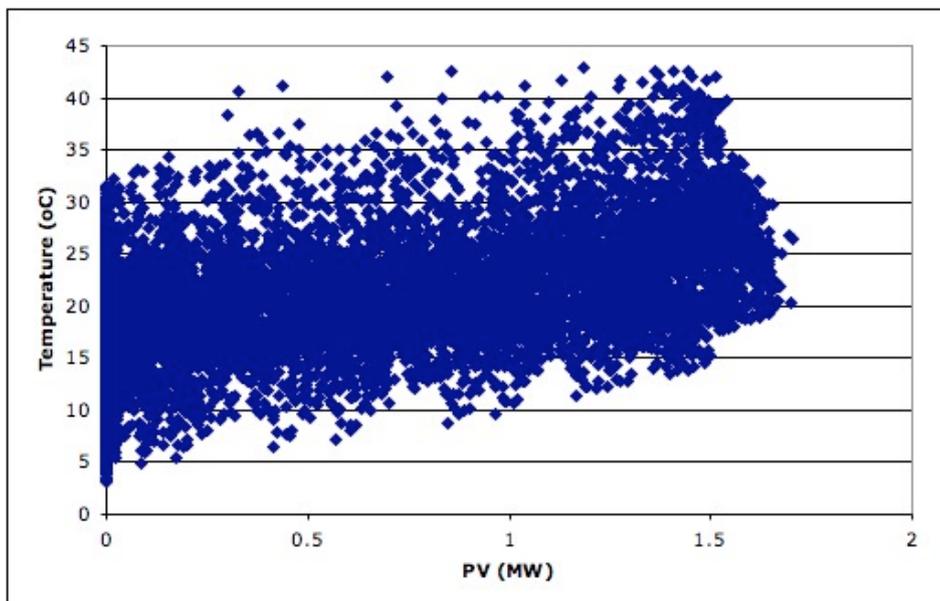
**Figure 23: Geraldton Simulated North-facing PV (2MW) vs Geraldton TX1 Net Load after PV Offset**  
July 2003 to June 2004

### *Correlation with temperature*

Figure 24 shows the relationship between the Geraldton TX1 load and temperature, and shows some 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. The cluster of data points between 15 and 25MW correspond to the load peaks identified in Figure 17 to Figure 16 above.



**Figure 24: Geraldton TX1 Load vs Temperature**  
July 2003 to June 2004



**Figure 25: Geraldton Simulated North-facing PV (2MW) vs Temperature**  
July 2003 to June 2004