MIDLAND JUNCTION

Summary of characteristics

Midland Junction substation has three 132/22kV transformers is a fully developed three transformer substation. It has one 132 kV connection to Darlington substation and another to Guildford Terminal to complete the 132 kV ring. The load type is predominantly commercial with some suburban residential. Works are expected by 2015 and will involve a new one 33MVA 132/22kV transformer zone substation with one section of 22kV switchboard, two 5MVAr capacitor banks and associated works, as well as distribution feeders to offload Midland Junction zone substation. The new substation will be on the site of the Guildford Terminal. Expected cost is approximately $10 million.

Annual profile

The July 2003 to June 2004 load profile for Midland Jnct TX1 is shown in Figure 1. It is characterised by a fairly constant baseload around 6MW in winter and 8 or 9MW in summer, especially February. The daily maxima are about double the size of the baseload and highest over summer, especially Feb. It also has a clear weekly cycle, with reduced weekend loads, especially on Sundays – see Figure 2 and Figure 3. There are a number of days of extreme demand peaks, some of which are discussed in more detail below. Figure 4 shows the 2MW simulated north-facing PV output for ACDB site 'Perth', which increases in summer as expected, particularly late Feb and early March.

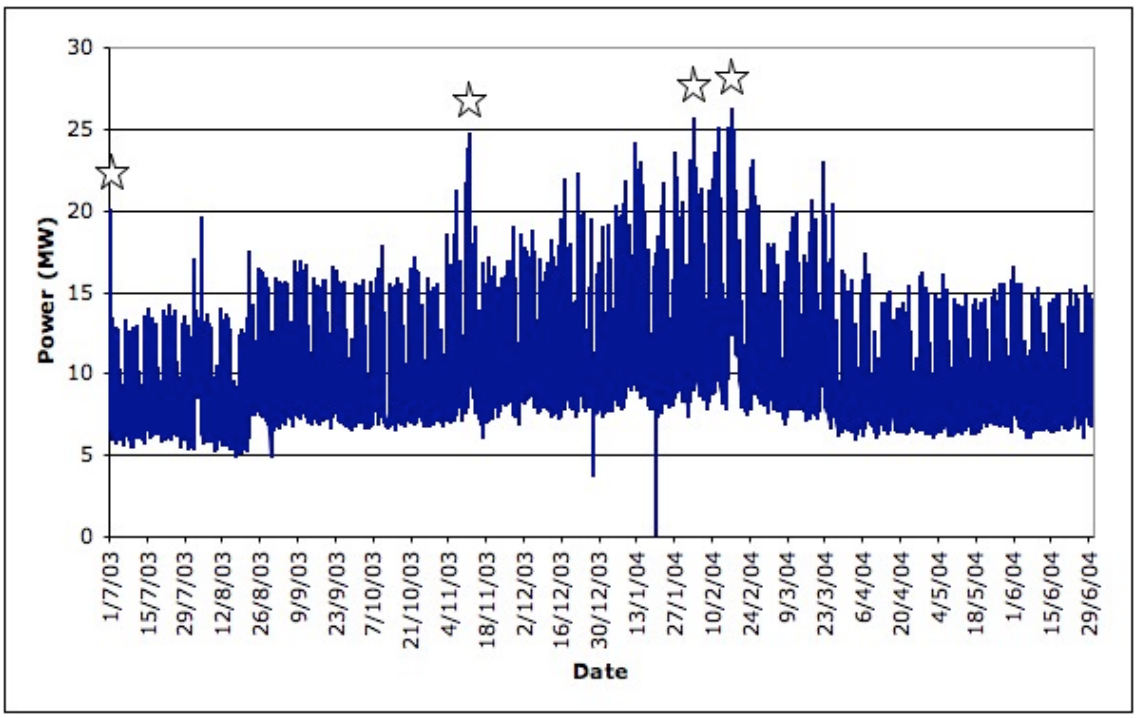

Figure 1: Midland Jnct TX1 Load
July 2003 to June 2004
(the stars indicate the peak days analysed in detail below)

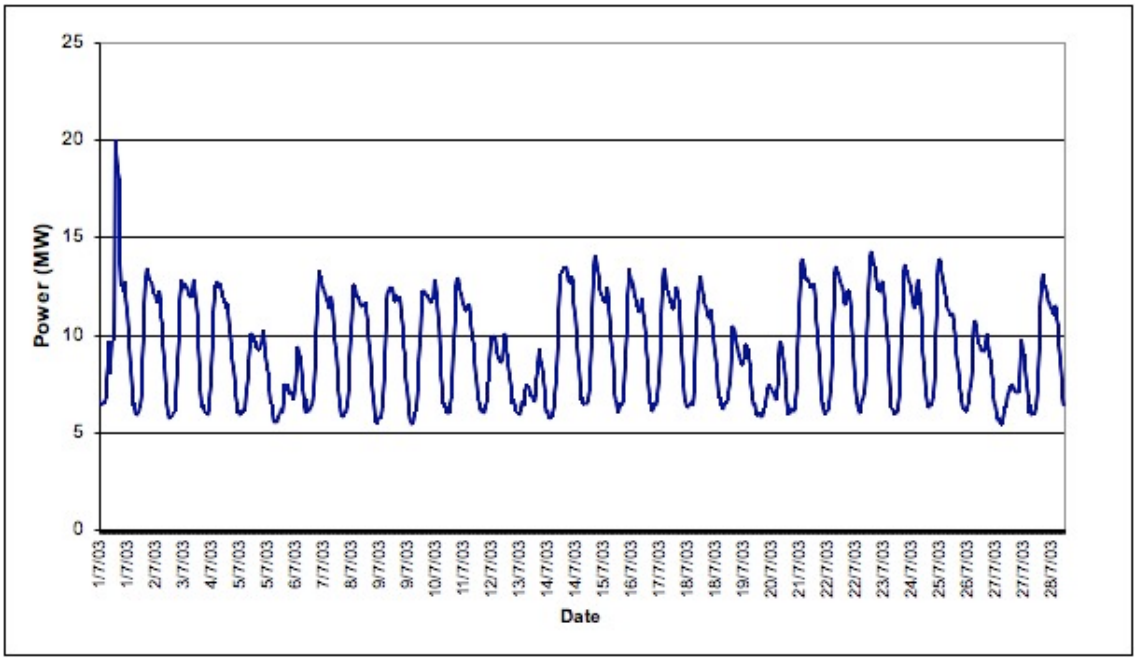

Figure 2: Midland Jnct TX1 Load - July
The first 28 days of July 2003

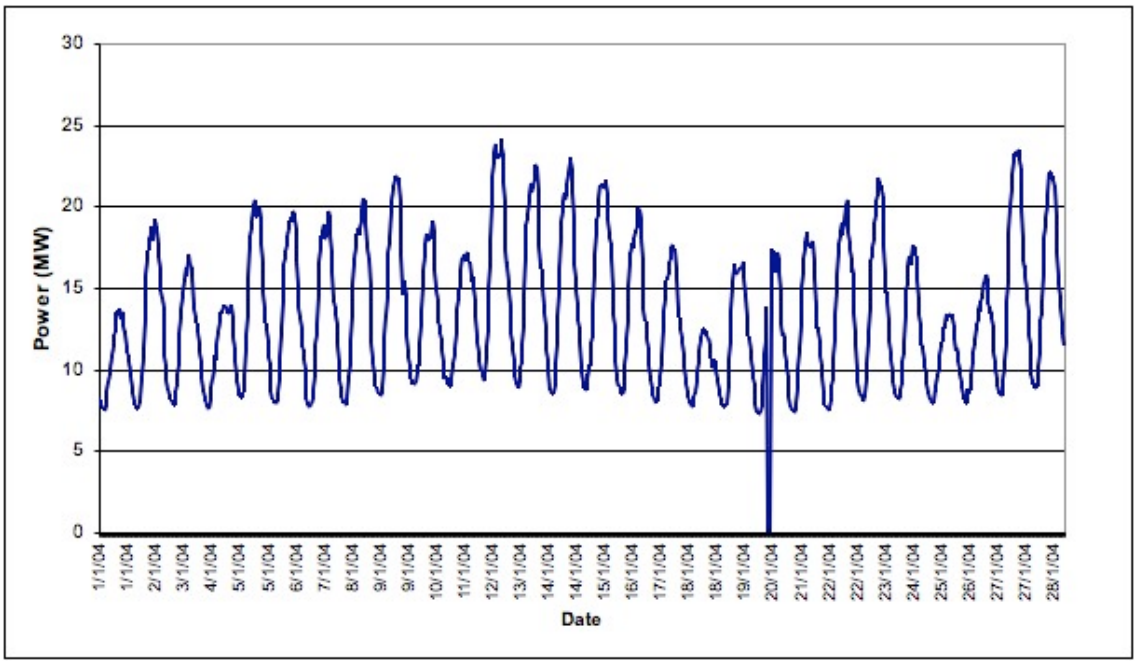

Figure 3: Midland Jnct TX1 Load - Jan
The first 28 days of Jan 2004

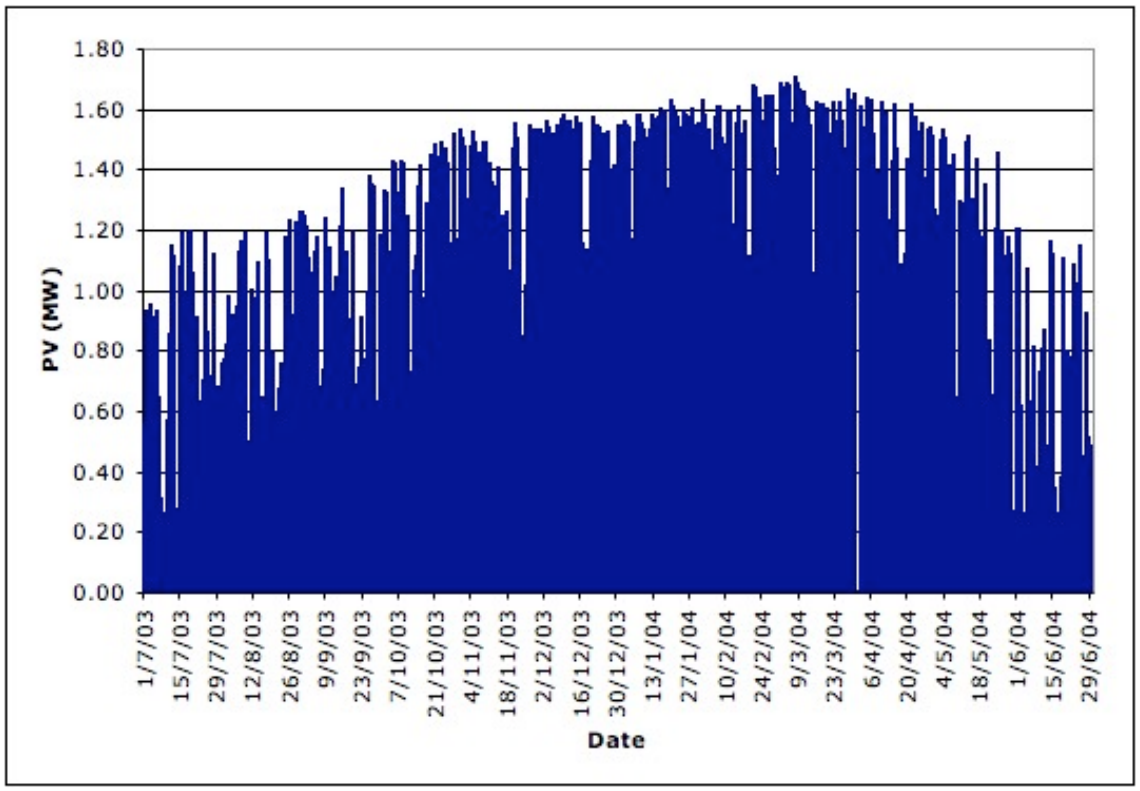

Figure 4: Midland Jnct Simulated North-facing PV Output (2MW)
July 2003 to June 2004

Daily profiles

Figure 5 shows the daily annual average load for Midland Jnct TX1, the simulated north-facing 2MW 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, although the load also has a slightly smaller peak at around 5pm.

As can be seen from Figure 6 to Figure 9, summer has the highest average daily load, which peaks at around 5pm, and so is reduced to some extent by the simulated north-facing PV. Spring and autumn also have two peaks, but closer together, and so match the simulated north-facing PV well. Winter splits into two distinct peaks, at around 9:30am and 6:30pm, neither of which are strongly impacted by the simulated north-facing PV. The impact of simulated west-facing PV is discussed below.

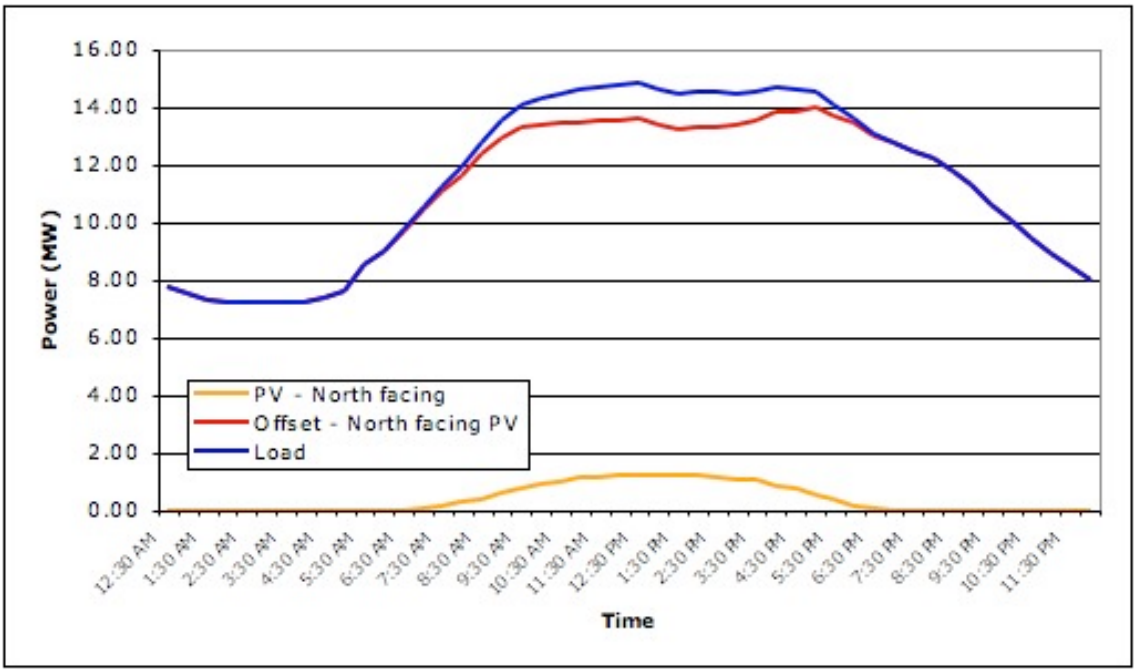

Figure 5: Daily Annual Average
Midland Jnct TX1 Load, Midland Jnct Simulated North-facing PV (2MW) and Net Load after PV Offset
July 2003 to June 2004

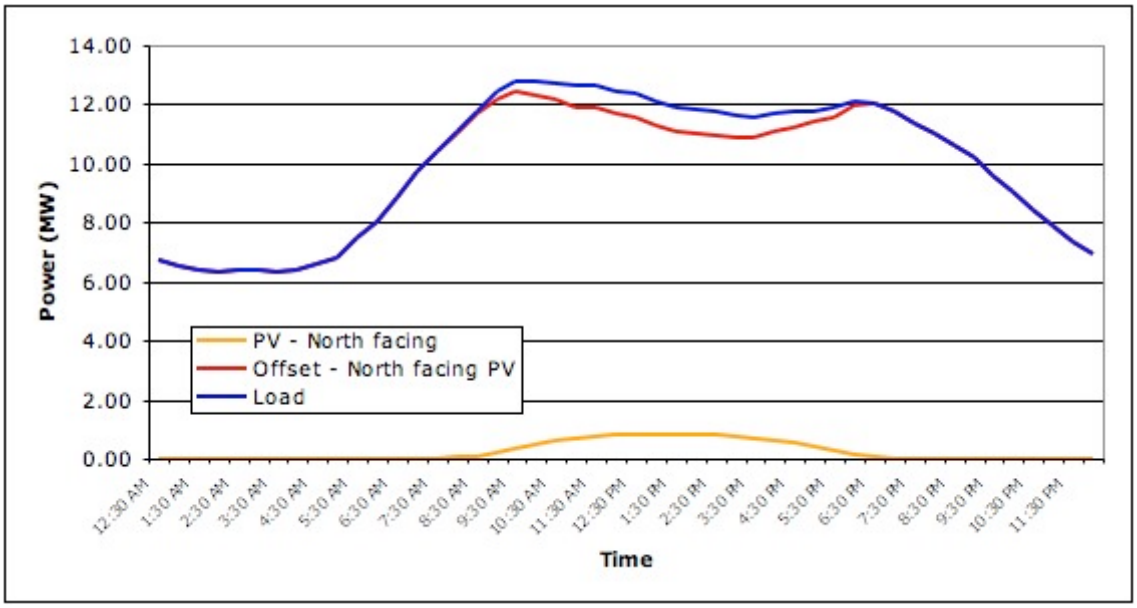

Figure 6: Daily Winter Average
Midland Jnct TX1 Load, Midland Jnct Simulated North-facing PV (2MW) and Net Load after PV Offset
June 2004 and July/Aug 2003

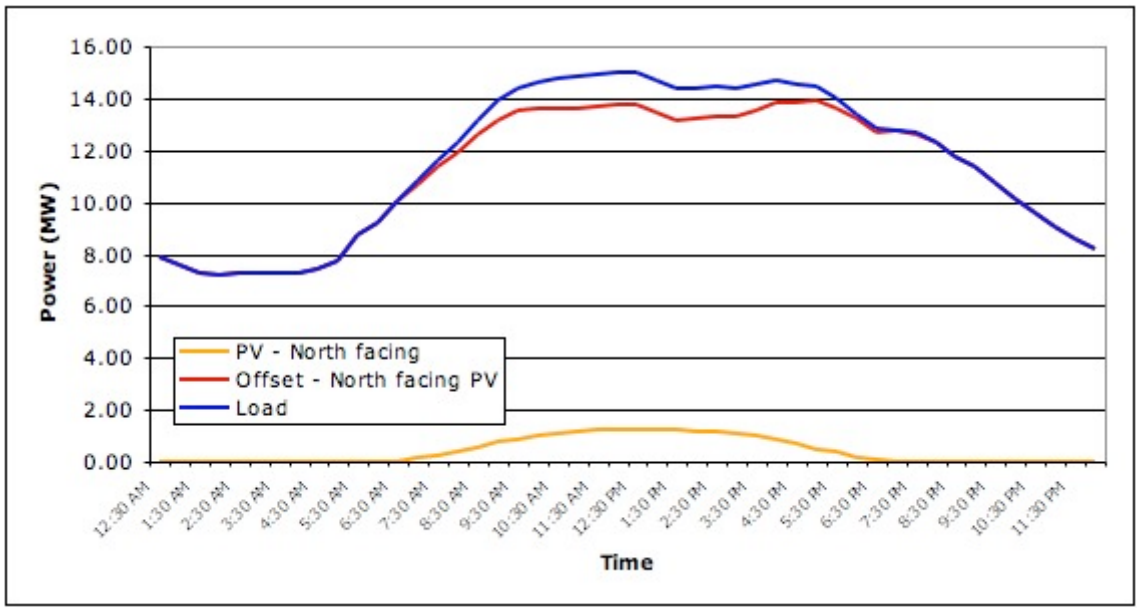

Figure 7: Daily Spring Average
Midland Jnct TX1 Load, Midland Jnct Simulated North-facing PV (2MW) and Net Load after PV Offset
Sept 2003 to Nov 2003

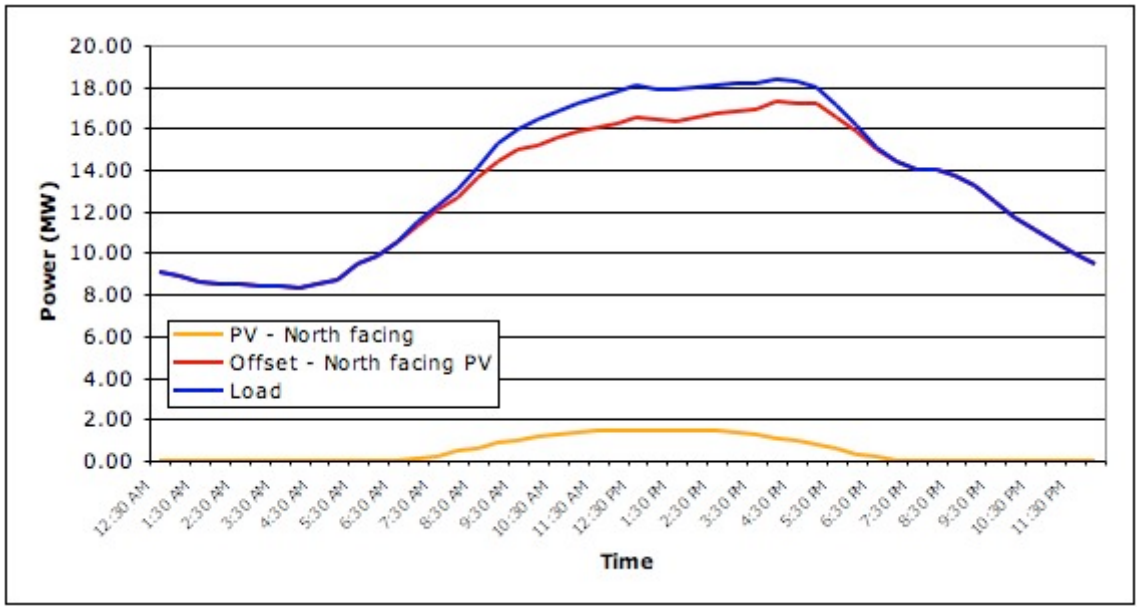

Figure 8: Daily Summer Average
Midland Jnct TX1 Load, Midland Jnct Simulated North-facing PV (2MW) and Net Load after PV Offset
Dec 2003 to Feb 2004

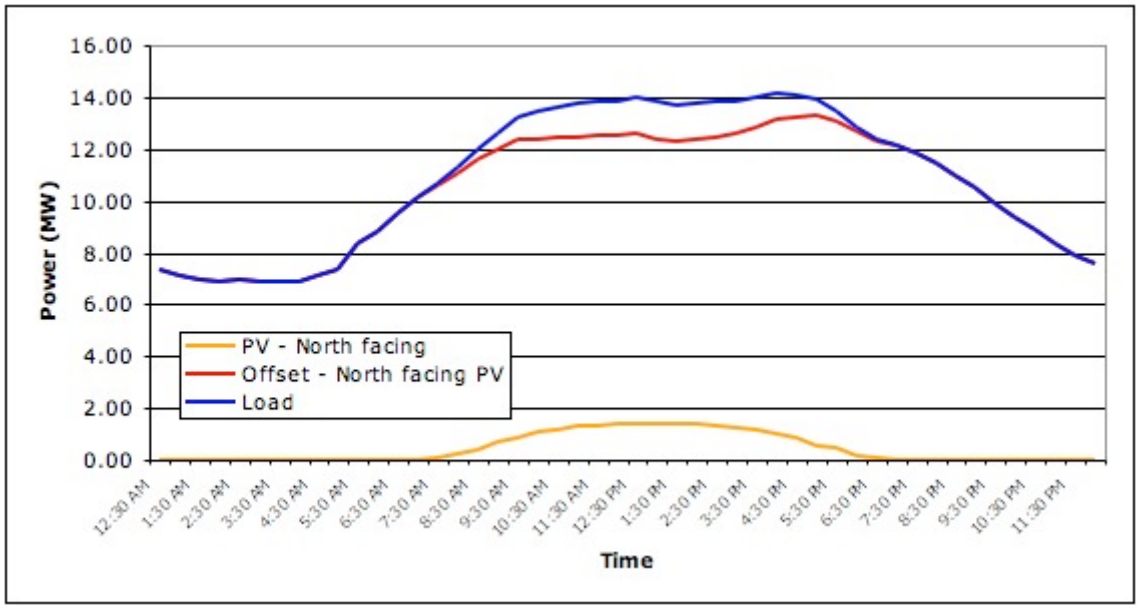

Figure 9: Daily Autumn Average
Midland Jnct TX1 Load, Midland Jnct Simulated North-facing PV (2MW) and Net Load after PV Offset
March 2004 to May 2004

The impact of simulated west-facing PV is illustrated in Figure 10 to Figure 14 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. In summer, the highest load season, the simulated west-facing-25 PV reduces the load to a greater extent than simulated north-facing PV. In all other seasons the simulated north-facing PV is the best match to the load.

Table 1: Annual Energy Output from Simulated 960W PV at Midland Jnct[1]

Orientation	Tilt (degrees)	2003 (kWh/yr)	2004 (kWh/yr)
North	25	1,528	1,695
North west	25	1,585	1,757
West	25	1,476	1,614
West	45	1,409	1,546
West	90	1,015	1,116

[1] Note that these are identical to those for Forrest Ave as they are based on the same ACDB site.

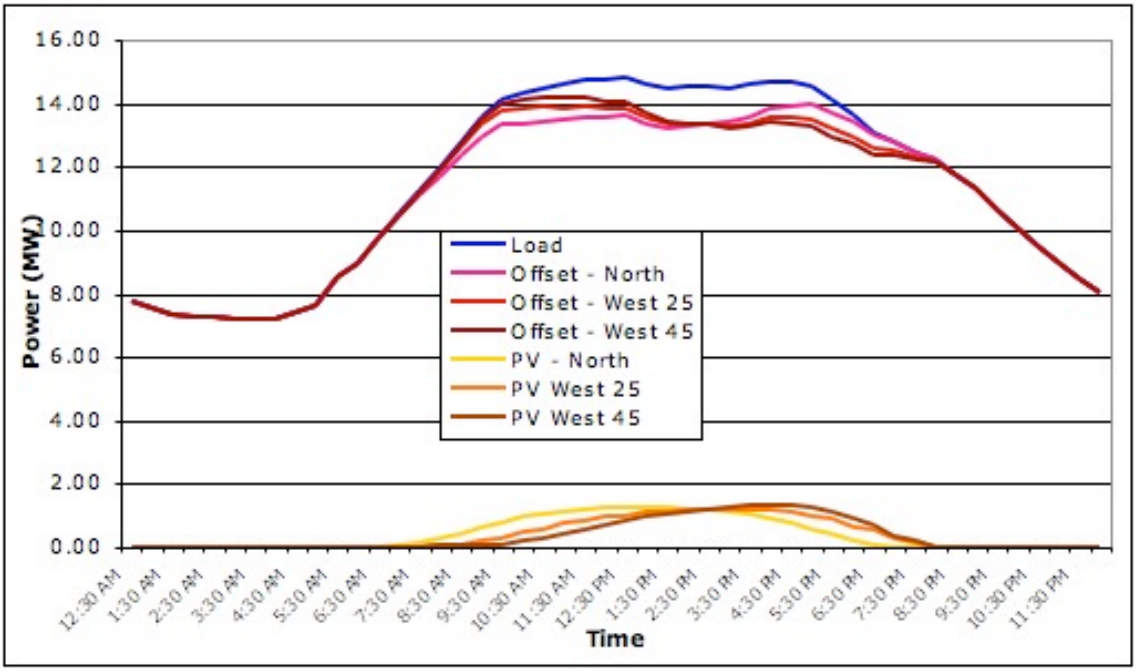

Figure 10: Daily Annual Average
North, and West (25° and 45° inclinations)
Midland Jnct TX1 Load, Midland Jnct PV (2MW) and Net Load after PV Offset
July 2003 to June 2004

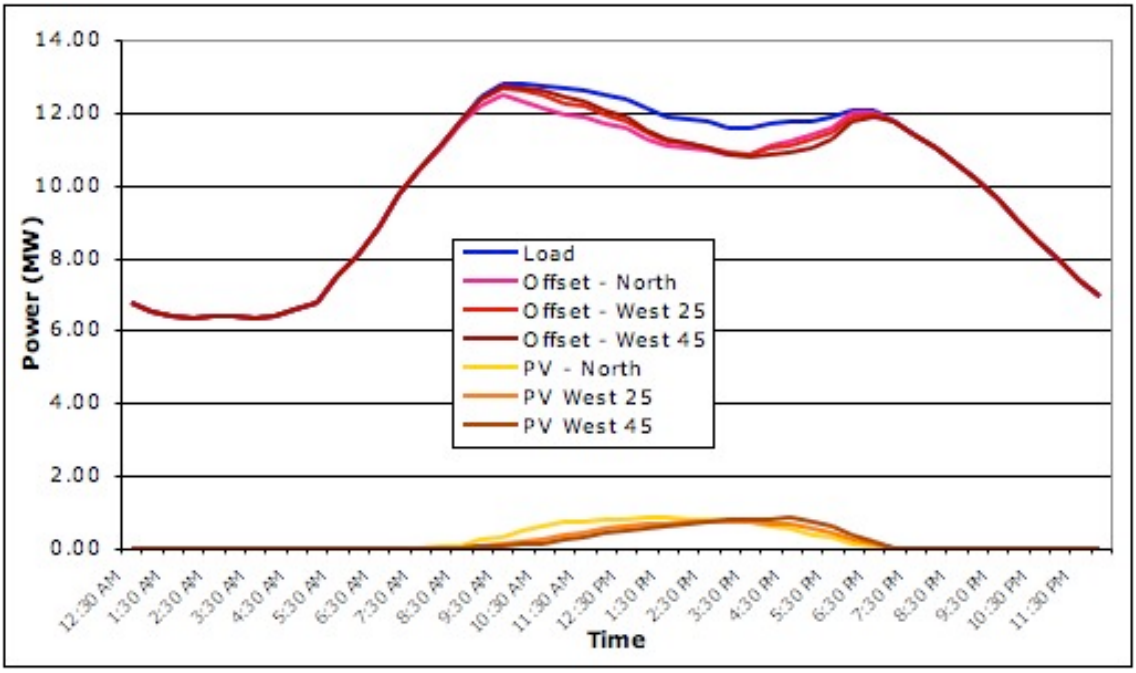

Figure 11: Daily Winter Average
North, and West (25° and 45° inclinations)
Midland Jnct TX1 Load, Midland Jnct PV (2MW) and Net Load after PV Offset
June 2004 and July/Aug 2003

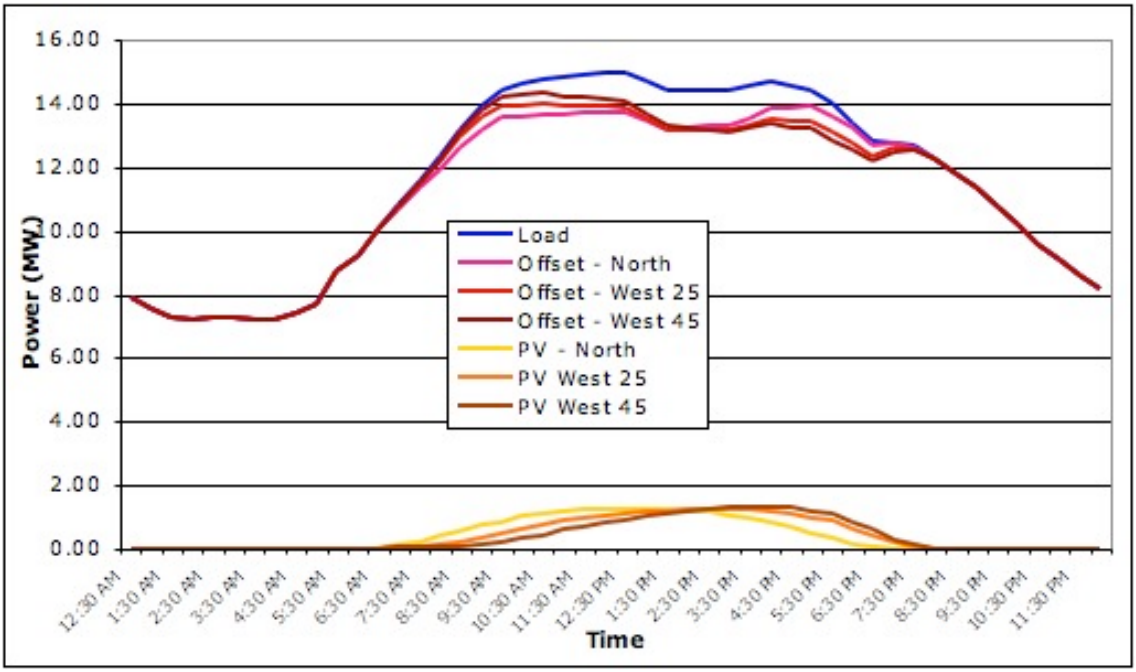

Figure 12: Daily Spring Average
North, and West (25° and 45° inclinations)
Midland Jnct TX1 Load, Midland Jnct PV (2MW) and Net Load after PV Offset
Sept 2003 to Nov 2003

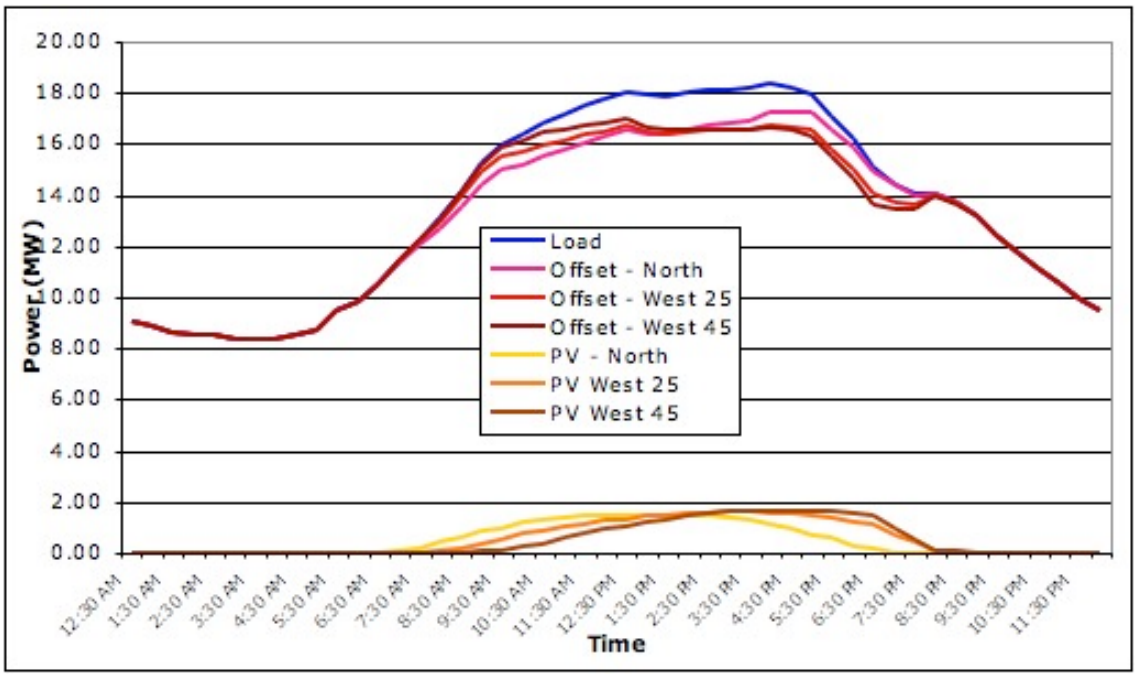

Figure 13: Daily Summer Average
North, and West (25° and 45° inclinations)
Midland Jnct TX1 Load, Midland Jnct PV (2MW) and Net Load after PV Offset
Dec 2003 to Feb 2004

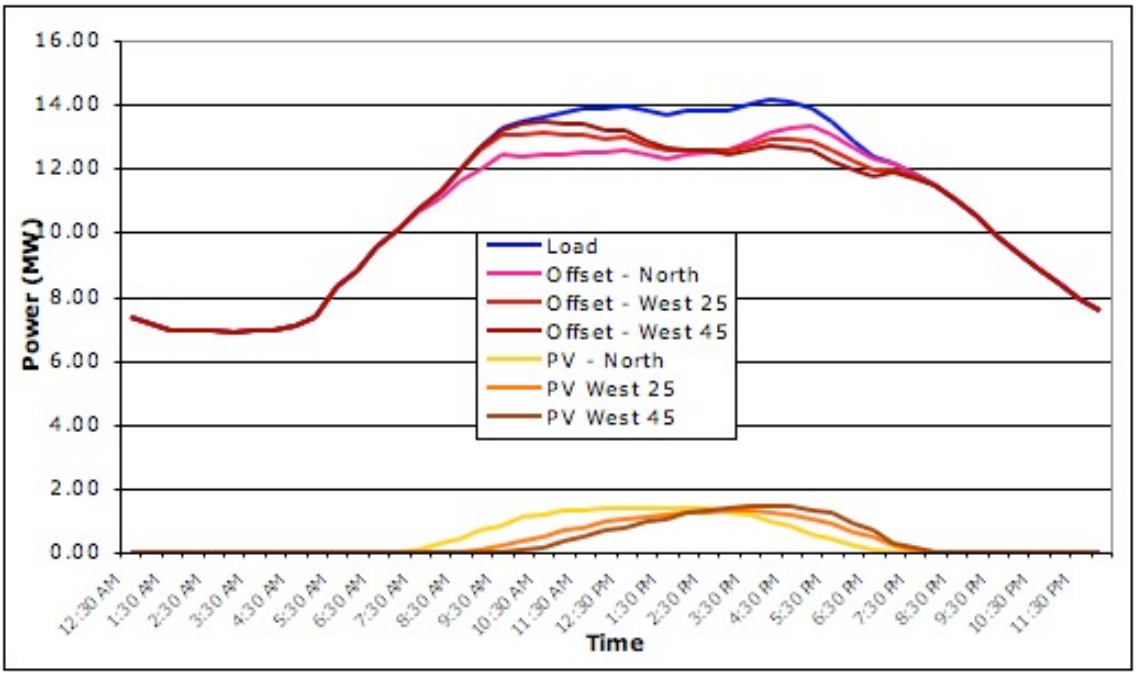

Figure 14: Daily Autumn Average
North, and West (25° and 45° inclinations)
Midland Jnct TX1 Load, Midland Jnct PV (2MW) and Net Load after PV Offset
March 2004 to May 2004

Times of peak demand

The ten top half-hour demand periods at Midland Jnct TX1 are shown in Table 2. All occur on the 17th Feb 2004, which is illustrated in Figure 15, except for the tenth highest point, which occurred on the 3rd Feb 2004 (Figure 17). These are also the ten highest points in the load duration curves in Figure 21 to Figure 23.

The highest peak load day occurred on the 17th Feb 2004 (Figure 15), was quite hot reaching over 40°C, with a broad load peak from 9am to 6pm, and highest at around 2pm. The simulated north-facing PV was able to make a good contribution over most of this time, and, as can be seen from the load duration curves in Figure 22 and Figure 23, reduced this day's half hour peak periods by between 1 and 1.2MW. The impact of using simulated west-facing PV at 25 degree tilt is shown in Figure 16. It can be seen that the highest peak points are slightly reduced compared to simulated north-facing PV. This is born out by the load duration curves, where simulated west-facing-25 PV reduced this day's peak load points by about 1.25MW.

The second highest cluster of peak load days assessed here (2nd-4th Feb 2004, Figure 17) was quite hot, reaching over 40°C, with the peak occurring at 4pm on the 3rd Feb, when the simulated north-facing PV was producing 60% of rated PV output. Simulated west-facing-25 PV reduced the peak by 82% of rated PV output – see Figure 18.

The third highest cluster of peak load days assessed here (10th-12th Nov 2003; Figure 19) peaked at around 12:30pm, which was a good match to simulated north-facing PV.

The highest winter peak load day assessed here (1st July 2003; Figure 20), and involved a sudden increase from 10 to 20MW, peaking at around 11:30am, possibly because of operational changes by Western Power. The simulated north-facing PV output at this time is quite low, resulting in only minimal load reduction.

Table 2: Ten Top Half-hour Demand Peaks at Midland Jnct TX1

Demand (MW)	Date	Day	Time
26.23	17-Feb-04	Sat	14:30
26.18	17-Feb-04	Sat	14:00
26.18	17-Feb-04	Sat	13:30
26.08	17-Feb-04	Sat	16:00
25.92	17-Feb-04	Sat	16:30
25.85	17-Feb-04	Sat	15:30
25.82	17-Feb-04	Sat	12:30
25.70	17-Feb-04	Sat	13:00
25.67	17-Feb-04	Sat	15:00
25.63	3- Feb-04	Sat	16:00

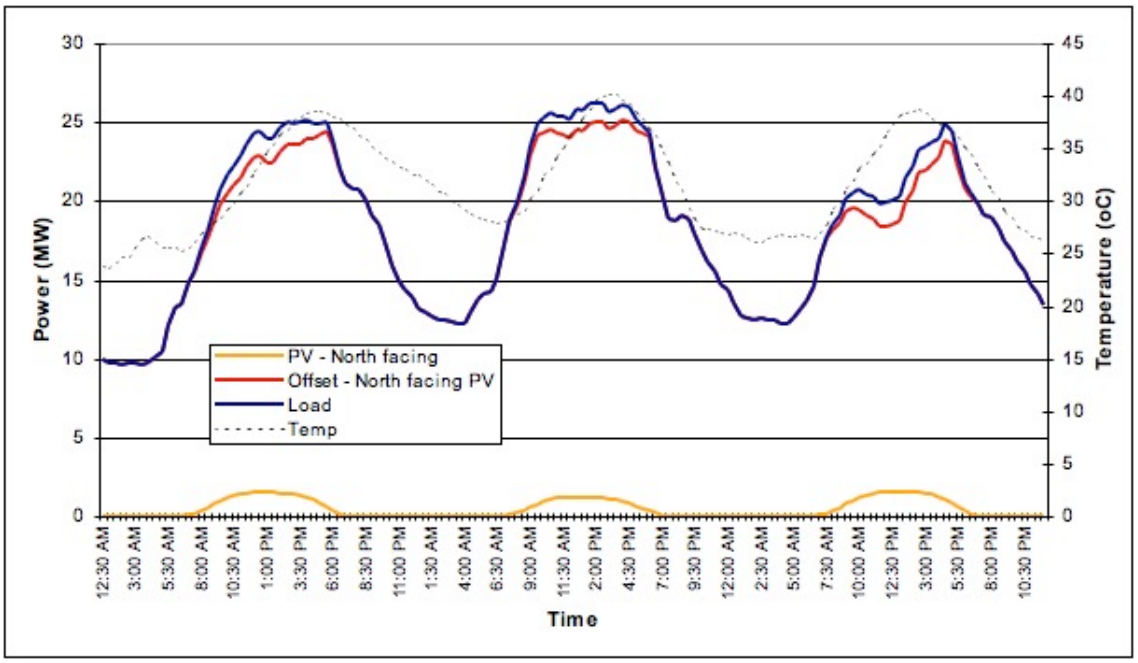

Figure 15: Summer peak day (north-facing PV)
16th-18th Feb 2004
Midland Jnct TX1 Load, Midland Jnct Simulated North-facing PV (2MW) and Net Load after PV Offset

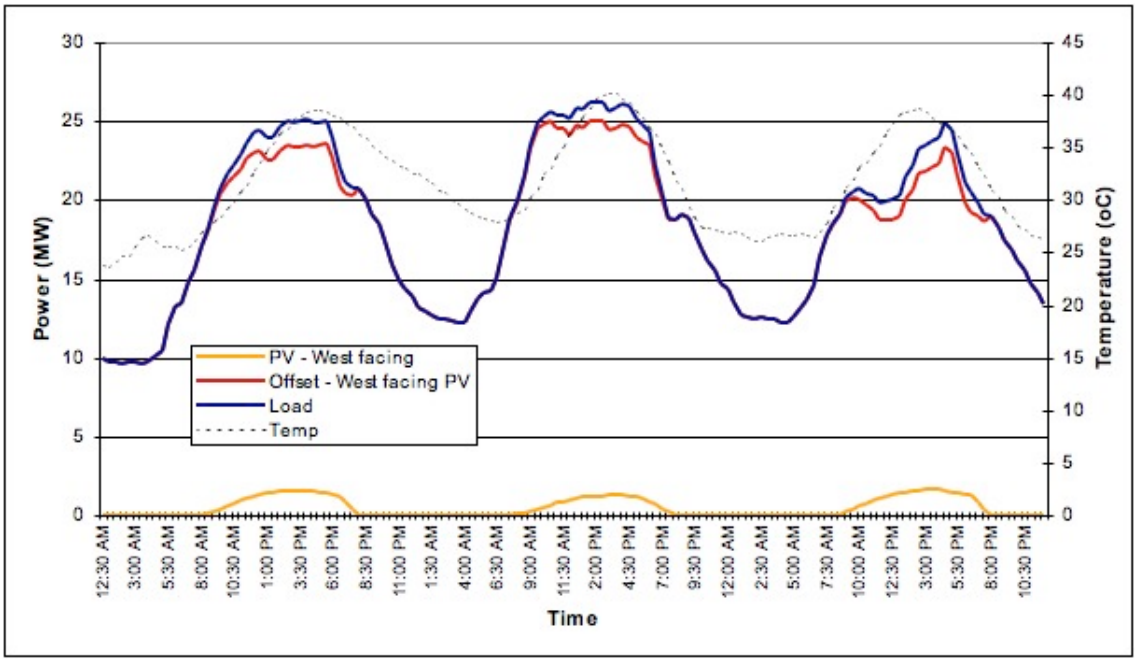

Figure 16: Summer peak day (west-facing-25 PV)
16th-18th Feb 2004
Midland Jnct TX1 Load, Midland Jnct Simulated West-facing-25 PV (2MW) and Net Load after PV Offset

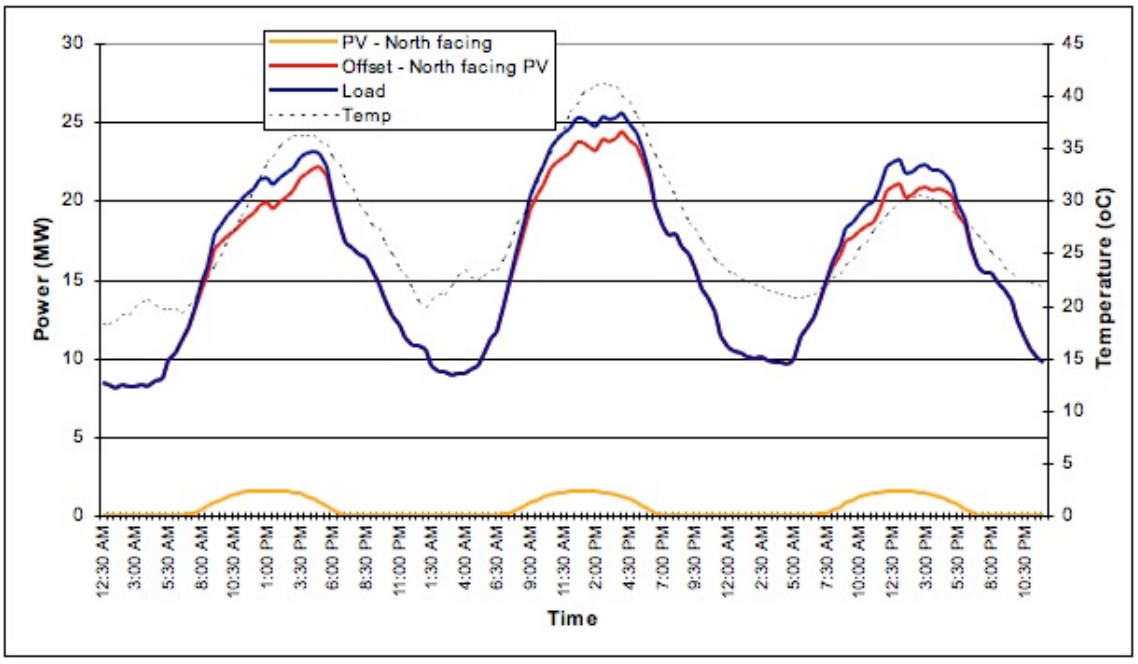

Figure 17: Summer peak day (north-facing PV)
2nd-4th Feb 2004
Midland Jnct TX1 Load, Midland Jnct Simulated North-facing PV (2MW) and Net Load after PV Offset

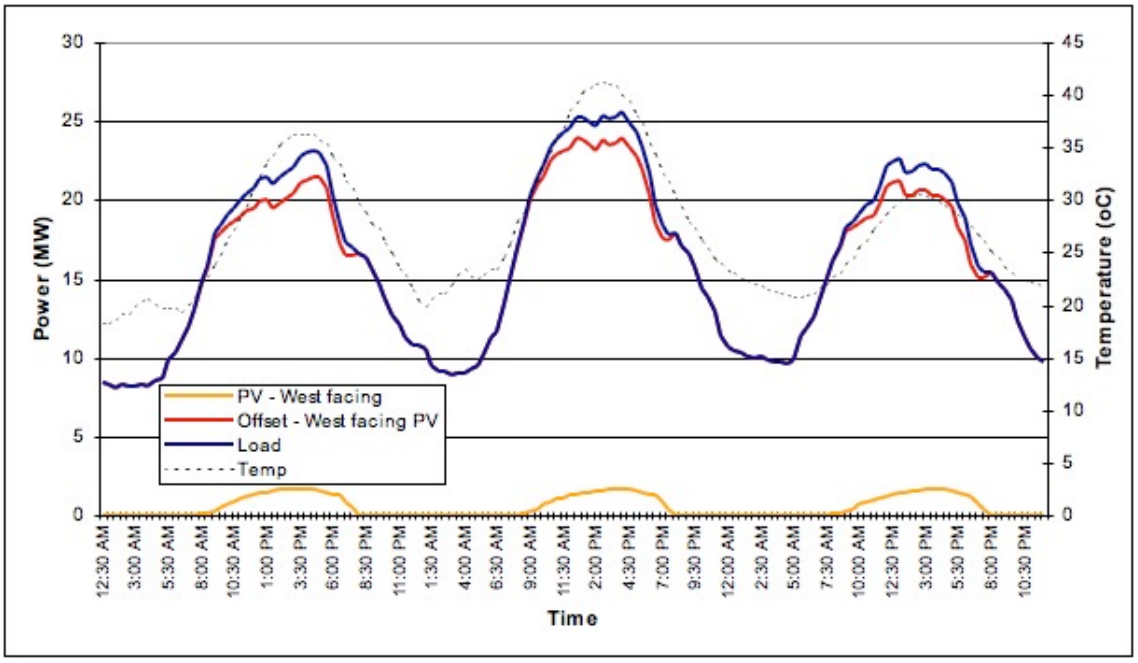

Figure 18: Summer peak day (west-facing-25 PV)
2nd-4th Feb 2004
Midland Jnct TX1 Load, Midland Jnct Simulated West-facing-25 PV (2MW) and Net Load after PV Offset

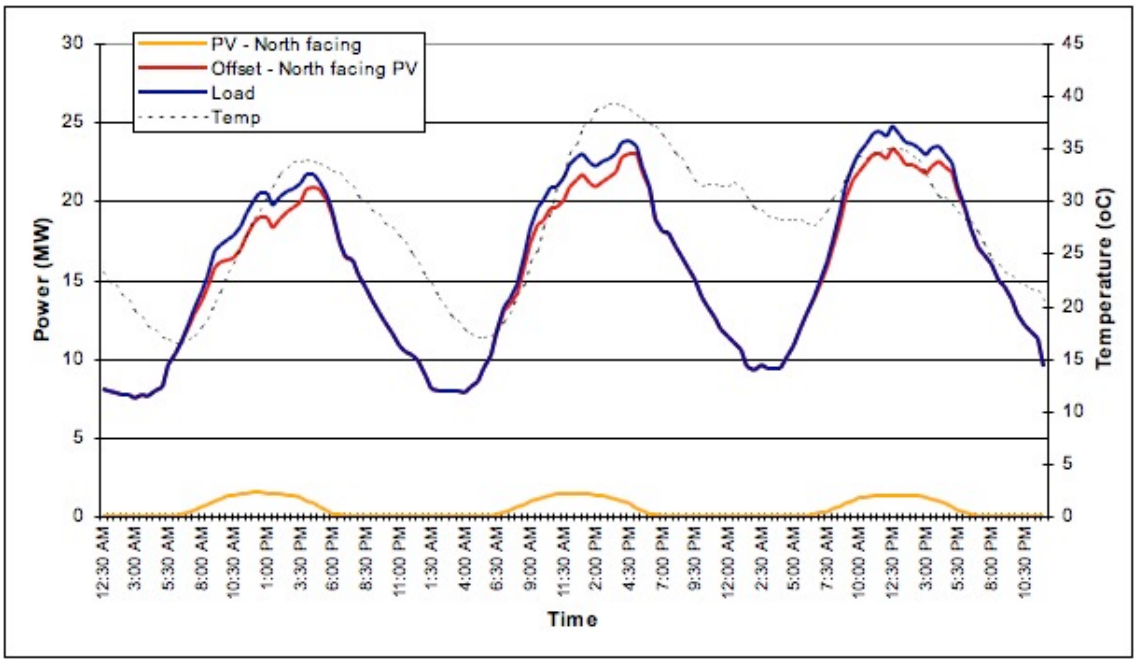

Figure 19: Spring peak day
10th-12th Nov 2003
Midland Jnct TX1 Load, Midland Jnct Simulated North-facing PV (2MW) and Net Load after PV Offset

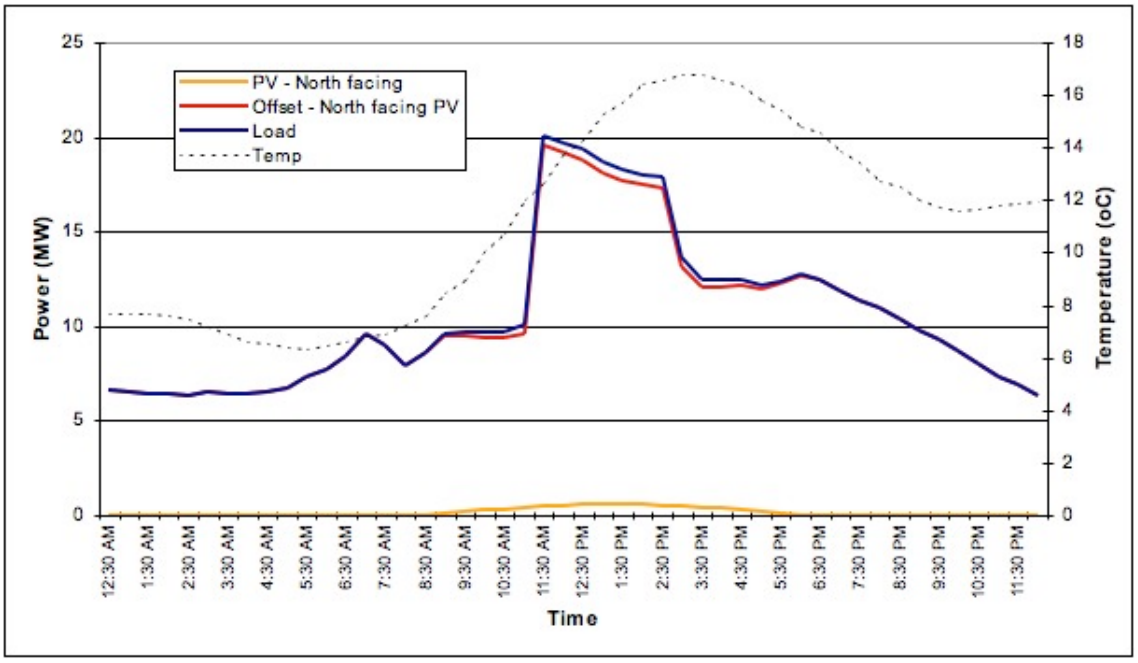

Figure 20: Winter peak day
1st July 2003
Midland Jnct TX1 Load, Midland Jnct Simulated North-facing PV (2MW) and Net Load after PV Offset

Load duration curves

The load duration curve for Midland Jnct TX1 is in Figure 21 and shows that the top 50% of the load occurred for just over 30% of the study period, while the top 10% occurred for 0.4% of the time.

Figure 22 shows the top 50 half hour load periods, 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 west-facing-25 PV resulted in the lowest offset load duration curve, followed by north-facing then west-45. 2MW of simulated west-facing-25 PV resulted in the highest offset load period being 1.2MW (60% of PV rating) lower than the highest original load period, and the top 10 offset load periods being lower by an average of 1.1MW or 55% of PV rating.

Figure 23 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, 61.5% of the simulated west-facing-25 2MW PV contributed to load reduction, reducing it from 26.23MW to 25.00MW (although note that what was originally a lower load period did not correlate as well to PV and so became the study period's highest offset load period at 25.02MW). On average during the 10 highest load periods, 62.5% the simulated west-facing-25 2MW PV was contributing to reducing peak load.

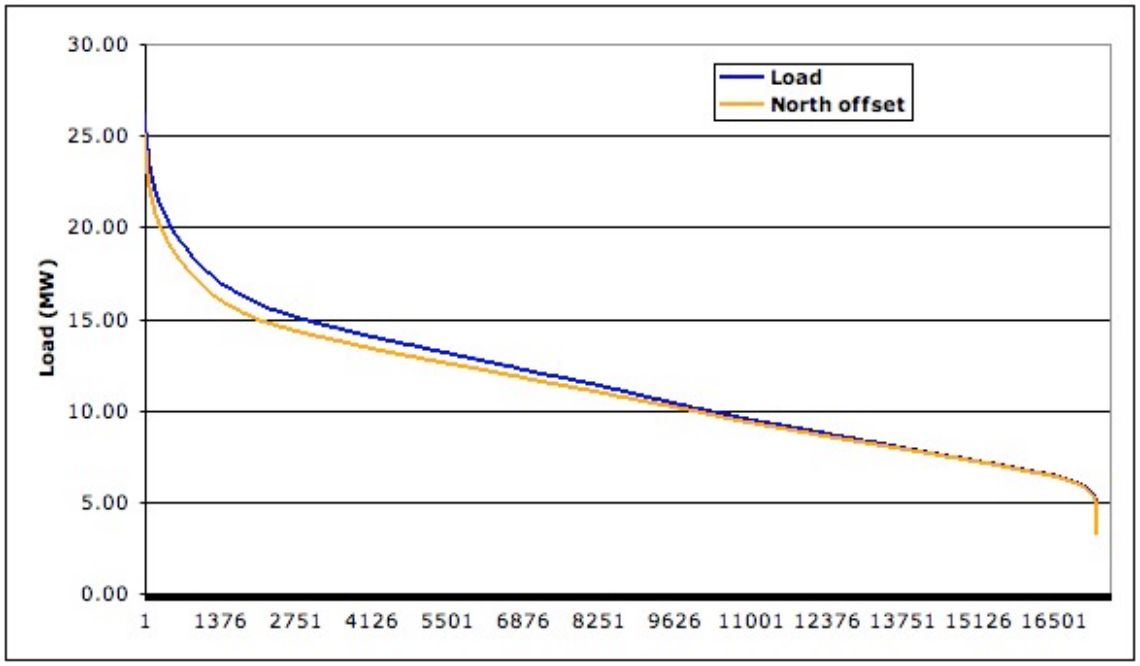

Figure 21: Load Duration Curve - July 2003 to June 2004
Midland Jnct TX1 Load and Midland Jnct TX1 Net Load after PV Offset (2MW)

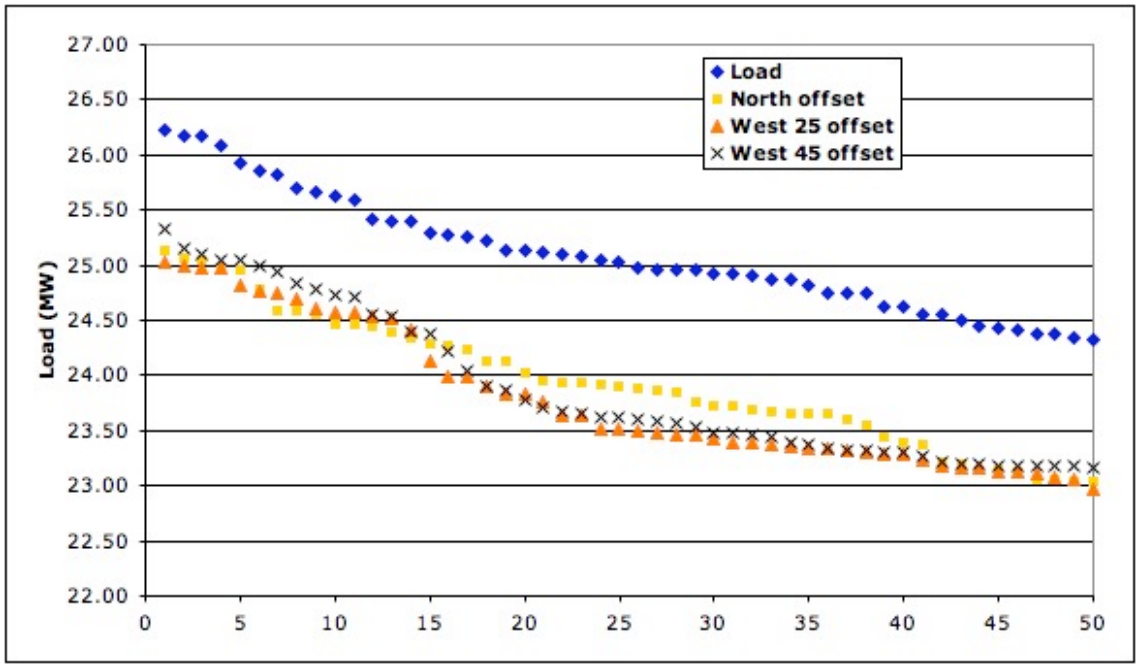

Figure 22: Load Duration Curve - top 50 load periods
North, and West (25° and 45° inclinations)
Midland Jnct TX1 Load and Midland Jnct TX1 Net Load after PV Offset (2MW)
July 2003 to June 2004

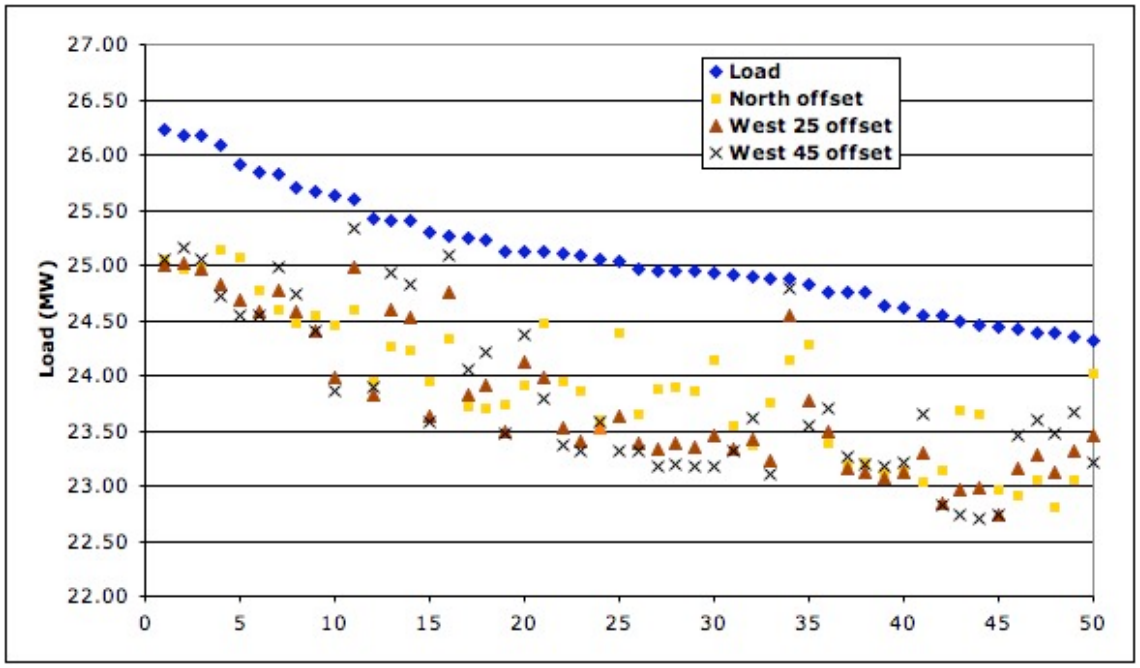

Figure 23: Load Duration Curve - top 50 load periods (linked)
North, and West (25° and 45° inclinations)
Midland Jnct TX1 Load and Midland Jnct TX1 Net Load after PV Offset (2MW)
July 2003 to June 2004

General correlation between PV Output and Load

Figure 24 shows the relationship between simulated north-facing PV output and the Midland Jnct TX1 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 25.

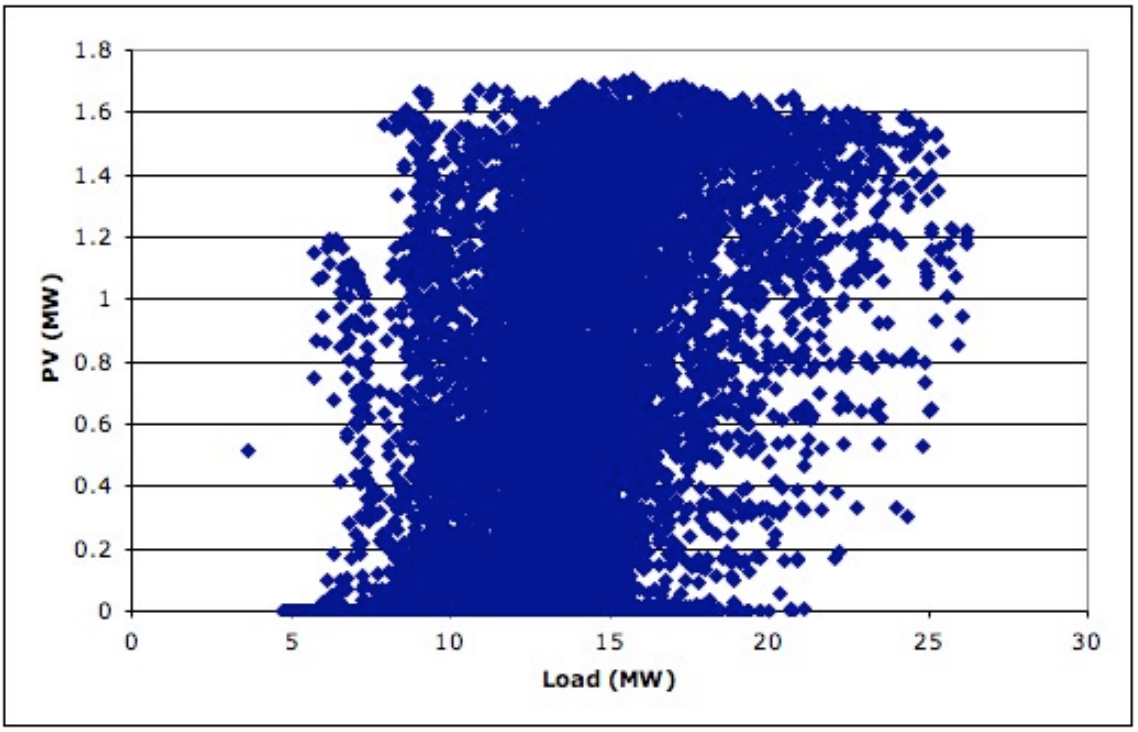

Figure 24: Midland Jnct Simulated North-facing PV (2MW) vs Midland Jnct TX1 Load
July 2003 to June 2004

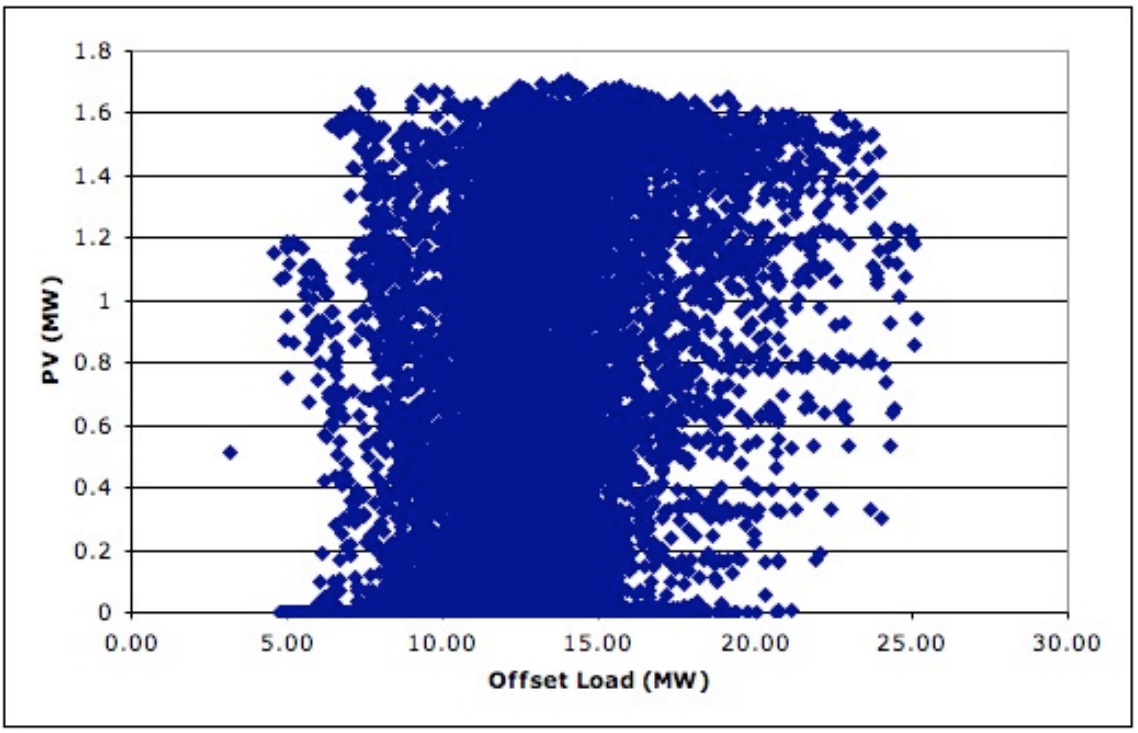

Figure 25: Midland Jnct Simulated North-facing PV (2MW) vs Midland Jnct TX1 Net Load after PV Offset
July 2003 to June 2004

Correlation with temperature

Figure 26 shows the relationship between the Midland Jnct TX1 load and temperature, and shows a good correlation, with load increasing with temperature. Figure 27 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 sudden cutoff around 1.6 to 1.7MW is likely an artefact of the PV simulation.

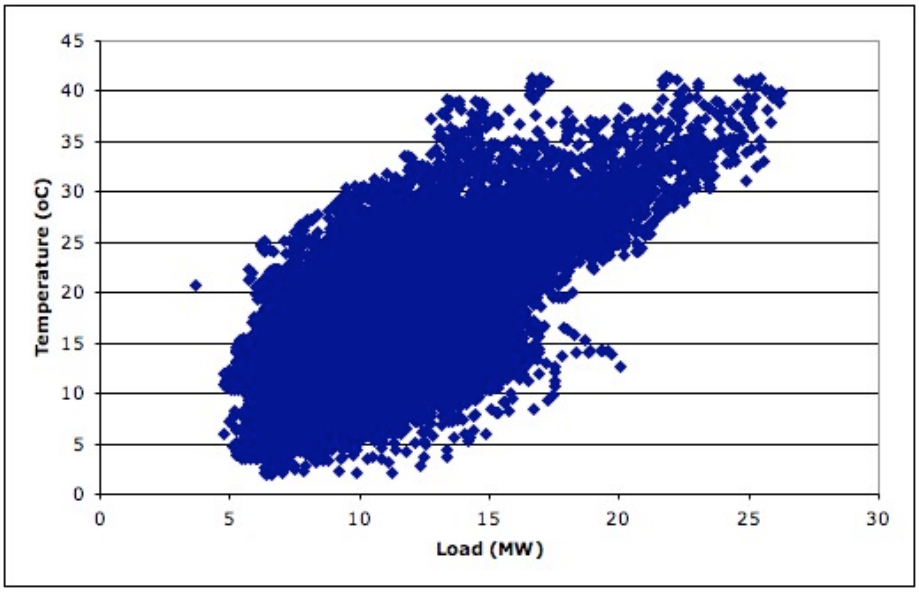

Figure 26: Midland Jnct TX1 Load vs Temperature
July 2003 to June 2004

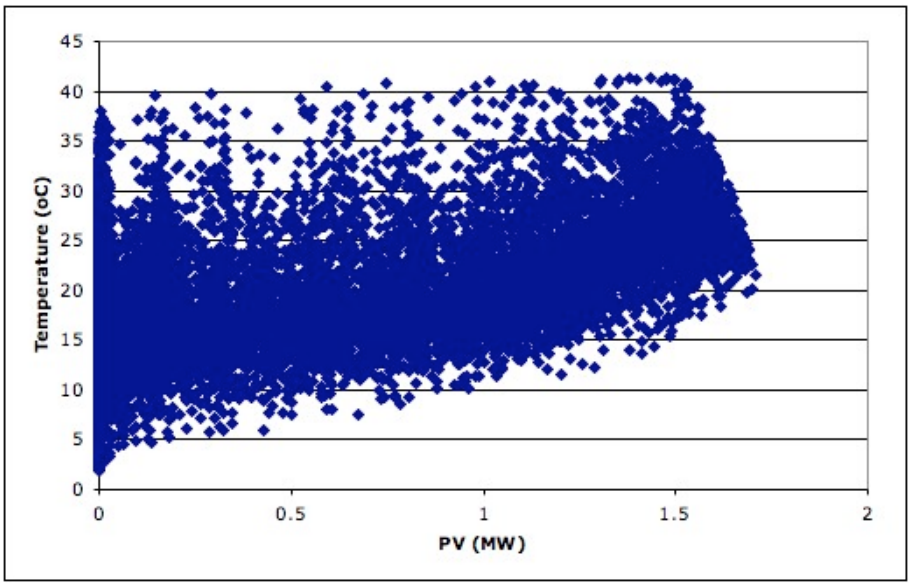

Figure 27: Midland Jnct Simulated North-facing PV (2MW) vs Temperature
July 2003 to June 2004