Merredin

Summary of characteristics
Merredin 132/66 kV substation normally supplies the 66 kV substations at Kellerberrin, Baandee, Carrabin, Yerbillon, and Merredin town. It is also used to supply Southern Cross and Cunderdin substations during line outages. The Merredin substation load consists of the town, agricultural, water pumping and some mining. Generally, Merredin substation is supplied from Merredin Terminal via a short (5km) single 132kV line (MRT-MER81) that has a very low failure rate. There is a back-up supply using the 66 kV system from Northam and Southern Cross in case of an outage of the MRT-MER81 line. Based on the latest load forecasts Networks will be unable to restore supply to all consumers for an unplanned outage of the MRT-MER81 line during high load periods. Merredin substation contains two 132/66 kV 15 MVA transformers that are 49 years old.

Annual profile
The July 2003 to June 2004 load profile for Merredin TX1 is shown in Figure 1. It is characterised by a constant baseload around 2 to 3MW, with daily maxima about double the size of the baseload and increasing during summer, especially February. It also has a clear minor cycle, with reduced weekend loads, especially on Sundays – see Figure 2 and Figure 3. There are a number of days of extreme demand peaks, which are discussed in more detail below. Figure 4 shows the 400kW simulated north-facing PV output for ACDB site ‘Kalgoorlie’, which decreases in summer, presumably due to temperature derating. No ACDB insolation data were available for Merredin. It is mid way between Perth and Kalgoorlie, and the latter is likely to have a more similar insolation and temperature profile as it is further from the coast.

Figure 1: Merredin TX1 Load
July 2003 to June 2004
(the stars indicate the peak days analysed in detail below)
Figure 2: Merredin TX1 Load - July
The first 28 days of July 2003

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


**Daily profiles**

Figure 5 shows the daily annual average load for Merredin TX1, the simulated north-facing 400kW PV output, and the net load assuming it is reduced by PV. Like Katanning, the annual average load peaks in the evening, at 7pm, and PV peaks at around midday.

As can be seen from Figure 6 to Figure 9, although the spring and autumn loads also peak at this time, the summer peak occurs about an hour later and the winter peak occurs much earlier, at around 8:30am. The highest seasonal peak occurs in summer at around 4pm and is reduced by the 400kW simulated north-facing PV and shifted to later in the day, to around 5pm. Simulated north-facing PV has no impact on any of the other seasonal peaks which all occur around 7pm. The impact of simulated west-facing PV is discussed below.
Figure 5: Daily Annual Average
Merredin TX1 Load, Merredin Simulated North-facing PV (400kW) and Net Load after PV Offset
July 2003 to June 2004

Figure 6: Daily Winter Average
Merredin TX1 Load, Merredin Simulated North-facing PV (400kW) and Net Load after PV Offset
June 2004 and July/Aug 2003
Figure 7: Daily Spring Average
Merredin TX1 Load, Merredin Simulated North-facing PV (400kW) and Net Load after PV Offset
Sept 2003 to Nov 2003

Figure 8: Daily Summer Average
Merredin TX1 Load, Merredin Simulated North-facing PV (400kW) and Net Load after PV Offset
Dec 2003 to Feb 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. Only the summer peak is altered by the use of 400kW simulated west-facing PV, being reduced to the point where it is lower than the 8pm peak – which is still higher than any of the other seasons’ evening peak.

<table>
<thead>
<tr>
<th>Orientation</th>
<th>Tilt (degrees)</th>
<th>2003 (kWh/yr)</th>
<th>2004 (kWh/yr)</th>
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<tbody>
<tr>
<td>North</td>
<td>25</td>
<td>1,610</td>
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<tr>
<td>North west</td>
<td>25</td>
<td>1,432</td>
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<tr>
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<tr>
<td>West</td>
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<tr>
<td>West</td>
<td>90</td>
<td>598</td>
<td>601</td>
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Figure 10: Daily Annual Average
North, and West (25° and 45° inclinations)
Merredin TX1 Load, Merredin PV (400kW) and Net Load after PV Offset
July 2003 to June 2004

Figure 11: Daily Winter Average
North, and West (25° and 45° inclinations)
Merredin TX1 Load, Merredin PV (400kW) and Net Load after PV Offset
June 2004 and July/Aug 2003
Figure 12: Daily Spring Average
North, and West (25° and 45° inclinations)
Merredin TX1 Load, Merredin PV (400kW) and Net Load after PV Offset
Sept 2003 to Nov 2003

Figure 13: Daily Summer Average
North, and West (25° and 45° inclinations)
Merredin TX1 Load, Merredin PV (400kW) and Net Load after PV Offset
Dec 2003 to Feb 2004
Times of peak demand
The ten top half-hour demand periods at Merredin TX1 are shown in Table 2. All occur on the 3rd and 4th Feb 2004, both of which are illustrated in Figure 15, and are the ten highest points in the load duration curves in Figure 20 to Figure 22.

The highest peak load day (4th Feb 2004; Figure 15) occurred in a cluster of days where maximum temperatures were above 30°C, reaching over 40°C on the 4th Feb. The peak periods occurred in the late afternoon and so were not well matched to simulated north-facing PV. As can be seen from the load duration curves in Figure 21 and Figure 22, use of simulated west-facing PV at tilts of 25 or 45 degrees made almost identical but minor reductions in peak load periods compared to simulated north-facing PV. Figure 16 shows the impact of simulated west-facing-25 PV.

The second highest cluster of peak load days assessed here (17th-19th March 2004; Figure 17) occurred where temperatures were not particularly high (just over 30°C), and the highest peak period occurs at 7:30pm when even simulated west-facing PV has no impact.

The third peak load day assessed here (10th June 2004; Figure 18) had a very unusual load profile, with a sudden 5MW increase at 8am, steadily dropping to early afternoon before peaking again at around 6:30pm. The impact of simulated PV was to reduce the midday dip.
The fourth cluster of peak load days assessed here (11th-14th Nov 2003; Figure 19) occurred when maximum temperatures were between 30 and 42°C (though the hottest did not have the highest peak). The peaks occurred in the middle of the day and so were well matched to simulated north-facing PV.

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

<table>
<thead>
<tr>
<th>Demand (MW)</th>
<th>Date</th>
<th>Day</th>
<th>Time</th>
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<tbody>
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<td>9.92</td>
<td>4-Feb-04</td>
<td>Wed</td>
<td>16:30</td>
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<tr>
<td>9.87</td>
<td>4-Feb-04</td>
<td>Wed</td>
<td>17:00</td>
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<td>9.83</td>
<td>4-Feb-04</td>
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<tr>
<td>9.80</td>
<td>4-Feb-04</td>
<td>Wed</td>
<td>14:30</td>
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<tr>
<td>9.78</td>
<td>4-Feb-04</td>
<td>Wed</td>
<td>15:30</td>
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<td>20:00</td>
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<tr>
<td>9.77</td>
<td>4-Feb-04</td>
<td>Wed</td>
<td>15:00</td>
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<td>14:00</td>
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<tr>
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<td>Tues</td>
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<tr>
<td>9.63</td>
<td>3-Feb-04</td>
<td>Tues</td>
<td>14:30</td>
</tr>
</tbody>
</table>

Figure 15: Summer peak days (north-facing PV)
3rd-6th Feb 2004
Merredin TX1 Load, Merredin Simulated North-facing PV (400kW) and Net Load after PV Offset
Figure 16: Summer peak days (west-facing-25 PV)
3rd-6th Feb 2004
Merredin TX1 Load, Merredin Simulated West-facing-25 PV (400kW) and Net Load after PV Offset

Figure 17: Autumn peak days
17th-19th March 2004
Merredin TX1 Load, Merredin Simulated North-facing PV (400kW) and Net Load after PV Offset
Figure 18: Winter peak day
10th June 2004
Merredin TX1 Load, Merredin Simulated North-facing PV (400kW) and Net Load after PV Offset

Figure 19: Spring peak days
11th-14th Nov 2003
Merredin TX1 Load, Merredin Simulated North-facing PV (400kW) and Net Load after PV Offset
Load duration curves

The load duration curve for Merredin TX1 is in Figure 20. The top 50% of the load occurred for just under 8% of the study period, while the top 10% occurred for just over 0.2% of the time.

Figure 21 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 400kW simulated west-facing PV at 25° and 45° tilt resulted in a lower load duration curve than simulated north-facing PV, however 400kW simulated west-facing-45 PV resulted in the highest load period being 150kW lower than the highest original load period, and resulted in the top 10 offset load periods being lower by an average of 180kW.

Figure 22 shows the same load duration curves except that the offset periods now correspond to the load periods directly above them on the chart. It can be seen that what was the 6th highest original load period was not reduced at all by PV and so became the highest offset load period. 400kW simulated west-facing-45 PV reduced the top load period by only 210MW, and the top 10 load periods by an average of 220MW.
Figure 21: Load Duration Curve - top 50 load periods
North, and West (25° and 45° inclinations)
Merredin TX1 Load and Merredin TX1 Net Load after PV Offset (400kW)
July 2003 to June 2004

Figure 22: Load Duration Curve - top 50 load periods (linked)
North, and West (25° and 45° inclinations)
Merredin TX1 Load and Merredin TX1 Net Load after PV Offset (400kW)
July 2003 to June 2004
General correlation between PV Output and Load

Figure 23 shows the relationship between north-facing simulated PV output and the Merredin TX1 load at any one time, and shows little correlation. A high correlation would result in the data points being distributed from the bottom left to the top right of the chart. The scattered points at high load correspond to the load periods 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 do not include the study period’s highest load points, to the left – see Figure 24.
Correlation with temperature

Figure 25 shows the relationship between the Merredin TX1 load and temperature, and shows an interesting correlation, with load tending to increase with temperature, but in two distinct regions, with the highest load points (on 4th Feb 2004) showing an increased correlation to temperature.

Figure 26 shows the relationship between simulated north-facing PV output and temperature, and shows some 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 cut off around 0.3 to 0.35MW is likely an artefact of the PV simulation.
Figure 25: Merredin TX1 Load vs Temperature
July 2003 to June 2004

Figure 26: Merredin Simulated North-facing PV (400kW) vs Temperature
July 2003 to June 2004