

# WIND FARMING IN SOUTH EAST AUSTRALIA

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## ABSTRACT

Wind farms in South East Australia are unlikely to supply any significant power output that system operators can rely upon. Wind farms will load the distribution system with sudden variations in power that are not currently predictable and are as significant as the random variations of user demand.

## 1. INTRODUCTION

It is often claimed by their advocates that wind farms can be a reliable source of electrical power if they are dispersed over a sufficiently wide area<sup>1</sup>. The wind will be “blowing somewhere”, it is claimed. There are now a sufficient number of wind farms in South Australia, New South Wales, Victoria and Tasmania for an assessment of the value of wind farms as a source of reliable electricity generation<sup>2</sup>.

## 2. WIND FARM PERFORMANCE

This analysis is based on the performance of 11 wind farms listed in the table below for June 2009. The data was sourced from the Australian Energy Market Operator (AEMO formerly NEMMCO) website<sup>3</sup>. The power output is recorded in 5 minute intervals and this allows the performance of the wind farms to be examined in detail.

An example of the behaviour of two South Australian wind farms and the summed behaviour of all six South Australian wind farms is shown in Figure 1.

These curves show that South Australian wind farms produced more than 8 percent of their rated output 80 percent of the time but that they produced more than 80% of their rated output just 8 percent of the time.

These power curves are representative of the general behaviour of wind farms. The performance of all the wind farms is given in Table 1

The capacity factor, the average output relative to the installed capacity shows an overall average of 30 per cent for a total installed capacity of 833 MW. The capacity factor varies from month to month and year to year in line with prevailing wind conditions but these values are indicative of the performance one might expect from new wind farms as they are brought online. A modest decline in the capacity factor for new farms might be expected if the best sites have already been taken.

The 90 per cent reliability figure represents the amount of energy that can be relied on for 90 per cent of the time. It is given as a percentage of the installed capacity so that comparative performance can be assessed. 90 per cent reliability for conventional coal fired power stations or gas turbine generators are greater than 90 per cent of the

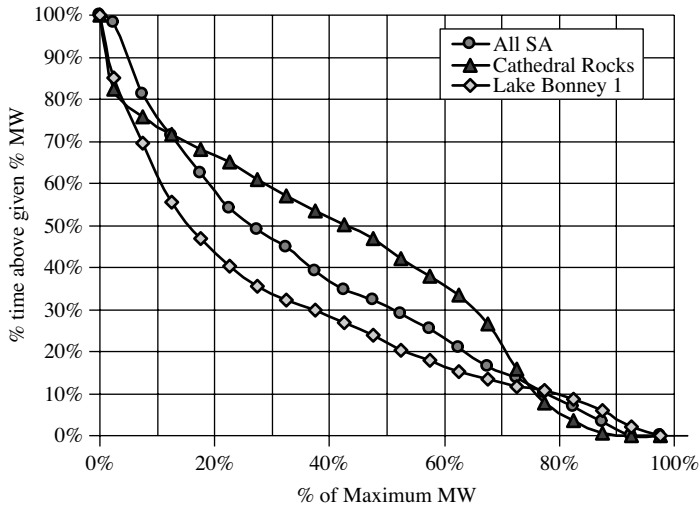


Figure 1. South Australian wind farm power curves for Cathedral Rocks and Lake Bonney 1 wind farms and the sum of six South Australian wind farms.

rated output<sup>4</sup>. It is clear that the one benefit of grouping wind farms is that the 90 per cent reliability point is increased from 6 per cent for SA, 5 per cent for Victoria, to 10 per cent overall. Again this figure should be expected to vary from month to month and from year to year.

**Table 1. Analysis of 11 wind farms in South-East Australia from 5 minute power measurements for June 2009. Note that Waubra is assumed to have only 60% of turbines available for capacity factor and reliability point calculation**

Wind Farm	State	Installed Capacity MW	Maximum Output as % of Capacity	Capacity Factor for June 2009	90% Reliability Point
<b>Cullerin Range</b>	<b>NSW</b>	<b>30</b>	<b>101%</b>	<b>34%</b>	<b>3%</b>
Cathedral Rocks	SA	66	92%	38%	2%
Canunda	SA	46	95%	26%	3%
Lake Bonney 1	SA	81	98%	25%	2%
Mount Millar	SA	70	102%	40%	5%
Starfish	SA	35	99%	30%	3%
Wattle Point	SA	91	102%	31%	2%
<b>All SA Farms</b>	<b>SA</b>	<b>388</b>	<b>91%</b>	<b>32%</b>	<b>6%</b>
<b>Woolnorth</b>	<b>Tas</b>	<b>140</b>	<b>83%</b>	<b>27%</b>	<b>5%</b>
Challicum Hills	Vic	53	93%	24%	2%
Waubra *	Vic	192	99%	29%	2%
Yambuk	Vic	30	86%	23%	2%
<b>All Vic Farms</b>	<b>Vic</b>	<b>275</b>	<b>88%</b>	<b>27%</b>	<b>5%</b>
<b>All Wind Farms</b>		<b>833</b>	<b>85%</b>	<b>30%</b>	<b>10%</b>

### 3. GEOGRAPHICAL SPREAD OF WIND FARMS

One of the most important details of this analysis is the geographical separation of the wind farms. This is shown in Figure 2. In fact the windfarms extend over 1,000 km North-South and East-West. This separation can be used to investigate if any significant benefit is gained by such a spread of wind farms.

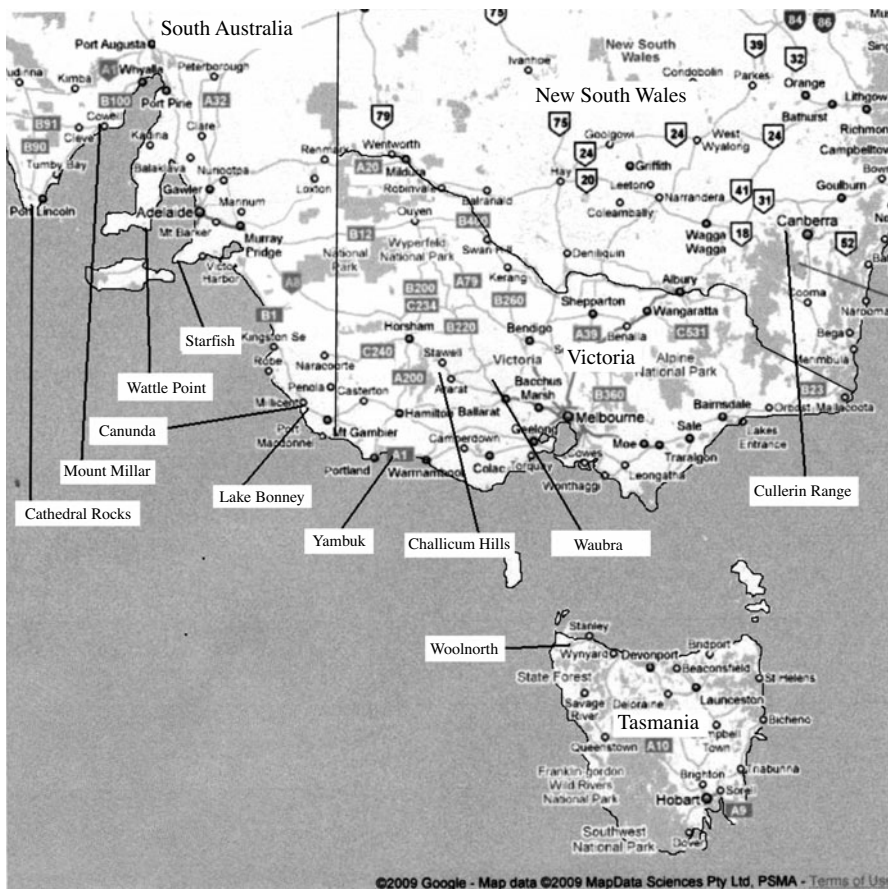


Figure 2. Location of wind farms in South-East Australia used in this report.

Figures 3a, 3b and 3c show the June 2009 performance of the wind farms in NSW, Victoria and Tasmania compared to that of South Australia. South Australian wind power generation has been used as the standard as it is the largest sample and despite having 6 wind farms added together performs as if it were one farm despite a spread of some 500 km.

It is clear that the responses in each area are correlated. The correlation of South Australia with Victoria is the clearest example. This has been refined to show a measure of this correlation in Figures 4a, 4b and 4c. This is a running correlation with a sliding 24 hour window that shows the extensive variations over time.

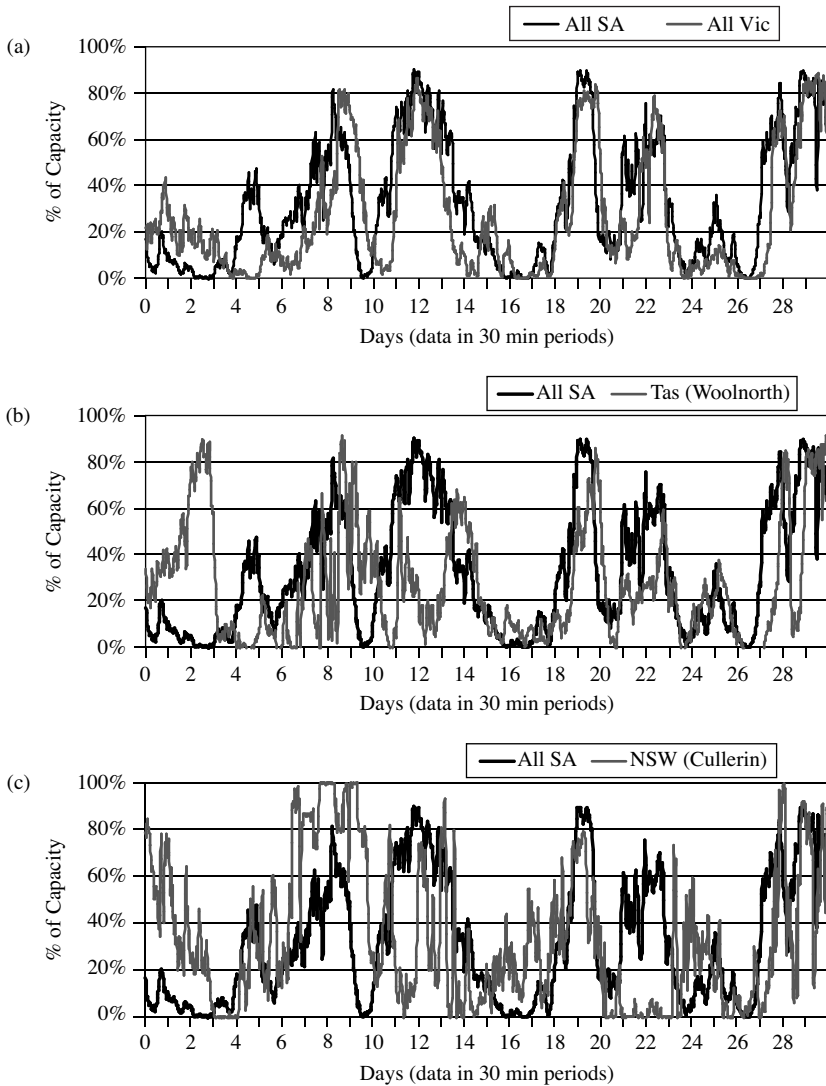


Figure 3. Power output normalised to rated capacity from six wind farms in South Australia and a) three wind farms in Victoria, b) Woolnorth in Tasmania and c) Cullerin Range wind farm in New South Wales.

A strong positive correlation for South Australia with Victoria is shown in Figure 4a. However it is important to note that the other two states do not provide any significant comfort from their geographical separation: that is they show no significant inverse of the South Australian-Victorian correlation.

Another demonstration of this general wind correlation is to look at the total wind power profile and compare that to a profile assuming equal installed capacity in all four states.

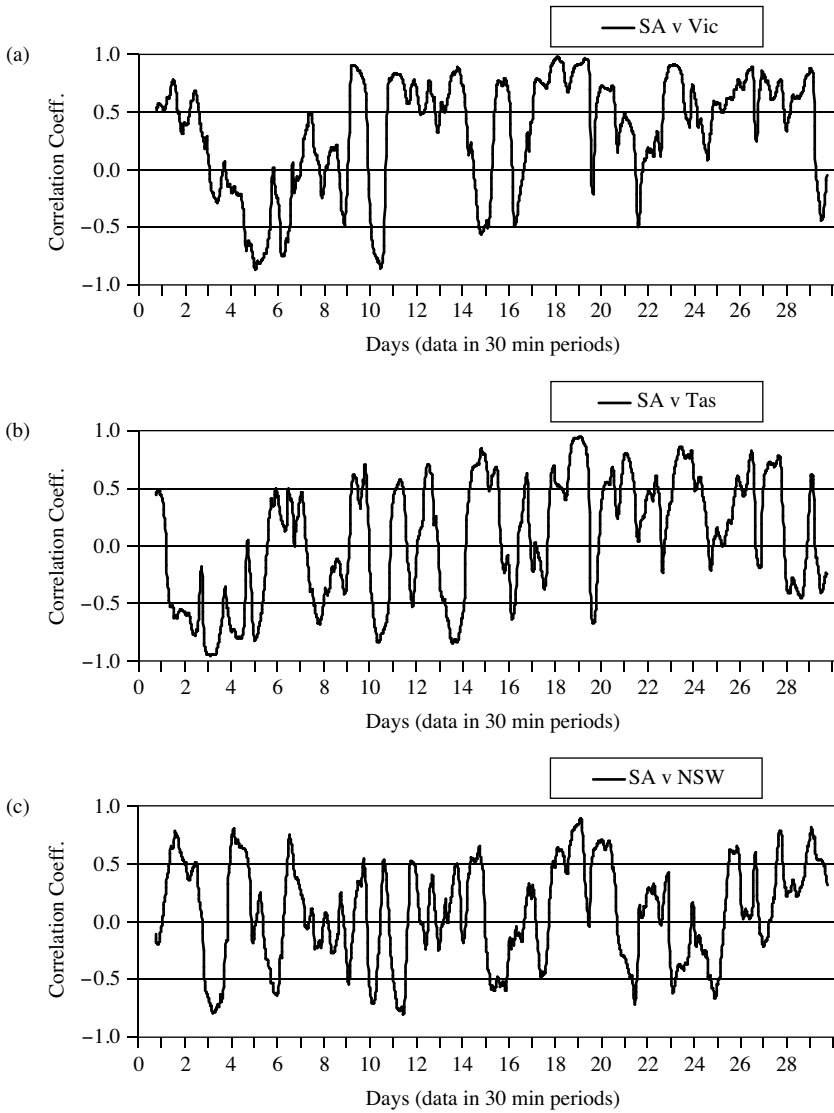


Figure 4. 24 hour running correlation for six wind farms in South Australia with a) three wind farms in Victoria, b) Woolnorth in Tasmania and c) Cullerin Range wind farm in New South Wales.

Figure 5 shows that no great change occurs and the geographical spread does not enhance performance.

The conclusion is that the only benefit from a large geographical spread is an increase in the 90 per cent reliability point from typically 5 per cent to 10 per cent.

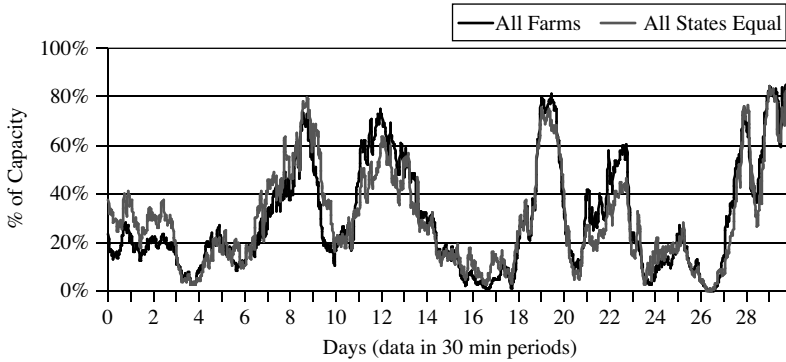


Figure 5. Sum of the power output normalised to rated capacity from all eleven wind farms and assuming all states have equal rated capacity in wind farms.

#### 4. WIND BURSTS AND FLUCTUATIONS

The other issue that can be examined is the short term fluctuations in the outputs of wind farms. These fluctuations that could be described as wind bursts add to the difficulties of maintaining voltage and frequency in the power system. Sudden changes in the demand for power raise similar problems but long experience with the daily load curve enables system operators to prepare for these changes. Fluctuations in output from the wind generators are, contrariwise, difficult to forecast.

The variations have been assessed by looking at the difference of wind farm output from one 5 minute interval to the next. By sampling over some 8,000 5 minute intervals it is possible to build up a measure of the performance of all wind farms and

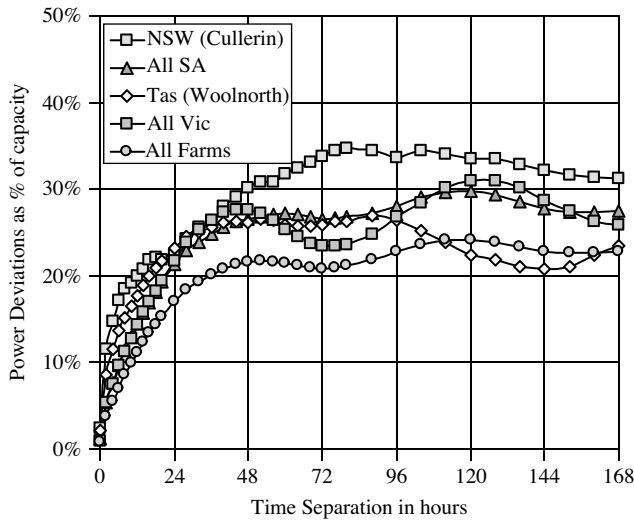


Figure 6. Power fluctuations from wind farms as a function of time separation. The results have been derived from semi-variance analysis (see text).

their aggregate output, rather like calculating a standard deviation<sup>5</sup>. This can be extended to looking at differences 10 minutes apart and so with increasing separation it is possible to see the time development of wind variations. A complete picture, extending over seven days, is shown in Figure 6. It has been standardised to the installed capacity of the wind farms as it a measure of the wind's behaviour, not the behaviour of the wind farm.

The conclusion from this is that the wind has some coherence for up to about 48 hours for wind bursts but with increasing fluctuations. Beyond that time the fluctuations are some 25 per cent of the installed capacity. This does not imply that the wind varies smoothly. On the contrary, this is the average performance of a generator with greatly varying output. This is not surprising as wind bursts can be seen by inspection in Figures 3 and 5.

## 5. CONCLUSION

The general conclusion from this analysis is that wind farms in South East Australia are not likely to supply any significant base load power that can be relied upon, and thus system operators will have to schedule generators as if there were no wind power at all. Wind farms will load the distribution system with variations in power that are certainly not predictable at the present time and are as significant as the random variations of user demand.

## REFERENCES

1. Diesendorf M. The Base-Load Fallacy  
<http://www.sustainabilitycentre.com.au/BaseloadFallacy.pdf>
2. Australian Energy Market Operator (AEMO) list of non-scheduled generation installed capacity. Non-Scheduled generation is generation whose output is not controlled through the AEMO central dispatch process. [http://www.aemo.com.au/data/gendata\\_exist.shtml](http://www.aemo.com.au/data/gendata_exist.shtml)
3. AEMO general introduction <http://www.aemo.com.au/aboutaemo.html>
4. Reliability level is also referred to as availability. This for thermal and gas turbine generators is above 90 per cent. Reliability is determined historically from forced outage performance. For an example of forced outages see NEMMCO 2006 *Minimum Reserve Level Recalculation* Table 1 <http://www.aemo.com.au/electricityops/240-0020.pdf>
5. Variance analysis is the technical term where:

$$\text{Semi-variance}(s) = (\sum(x_i - x_{i+s})^2)/(2.N)$$

with  $s$  = series interval between measurements:  $s = 1, 2, 3, \dots$

$N$  = number of samples for  $x_i$

So  $\text{Fluctuations}(s) = (\text{Semi-variance}(s))^{1/2}$

