UNIVERSITY OF TECHNOLOGY SYDNEY

INSTITUTE FOR SUSTAINABLE FUTURES

PARKES SHIRE COUNCIL: SMALL WIND SITE ASSESSMENT

2012

ABOUT THE AUTHORS

The Institute for Sustainable Futures (ISF) was established by the University of Technology, Sydney in 1996 to work with industry, government and the community to develop sustainable futures through research and consultancy. Our mission is to create change toward sustainable futures that protect and enhance the environment, human well-being and social equity. We seek to adopt an inter-disciplinary approach to our work and engage our partner organisations in a collaborative process that emphasises strategic decision-making.

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EXECUTIVE SUMMARY

In 2011, Parkes Shire Council commissioned the Institute for Sustainable Futures (ISF) at the University of Technology Sydney, to prepare a Distributed Energy Plan as part of their investigation into energy and carbon reduction strategies. The resulting Distributed Energy Plan formed part of PSC's Sustainable Water and Energy Plan (SWEP).

The Distributed Energy Plan shows that Parkes Shire Council (PSC) spent $1.3 million on electricity in 2010 and used 9,600 MWh[1]. To reduce emissions, several energy options were investigated, including wind energy at remote pump sites. The business case for 100 kW of small wind showed a potential for a return on investment (6.2% IRR) and therefore one of the 11 actions within the Distributed Energy Plan was to potentially "Install 100 kW of wind at Back Yamma Pump site, depending on the outcome of wind monitoring, capital cost and annual energy output".

To progress this action, PSC commissioned ISF to review four Parkes Shire Council sites for the feasibility of a small wind turbine (wind systems between 1kW and 100kW), and conduct a site assessment of the most viable site. In June 2012, ISF reviewed the following four PSC sites for the feasibility of small wind:

- Back Yamma pumping station
- Eugowra pumping station
- High Street pumping station
- Talla Walla pumping station

Of these four sites, Back Yamma was deemed to be the most feasible, and a more detailed small wind site assessment of this site is presented within. The purpose of this assessment is to provide site-specific information on how a wind system would perform at this specific location, including information on:

- turbine options,
- minimum tower height,
- estimated energy production,
- estimated costs, and
- financial incentives.

At this stage, a small wind system is not recommended at Back Yamma. In terms of on-site generation, a 50 kW solar PV system would be more economic, however it is recommended that a more comprehensive, integrated renewable solution is explored for all of the PSC pumping sites.

[1] Rutovitz, J., Langham, E., Ison, N., and Dunstan, C. 2011. Parkes Shire Council: Distributed Energy Plan. Prepared for Parkes Shire Council by the Institute for Sustainable Futures, University of Technology Sydney.

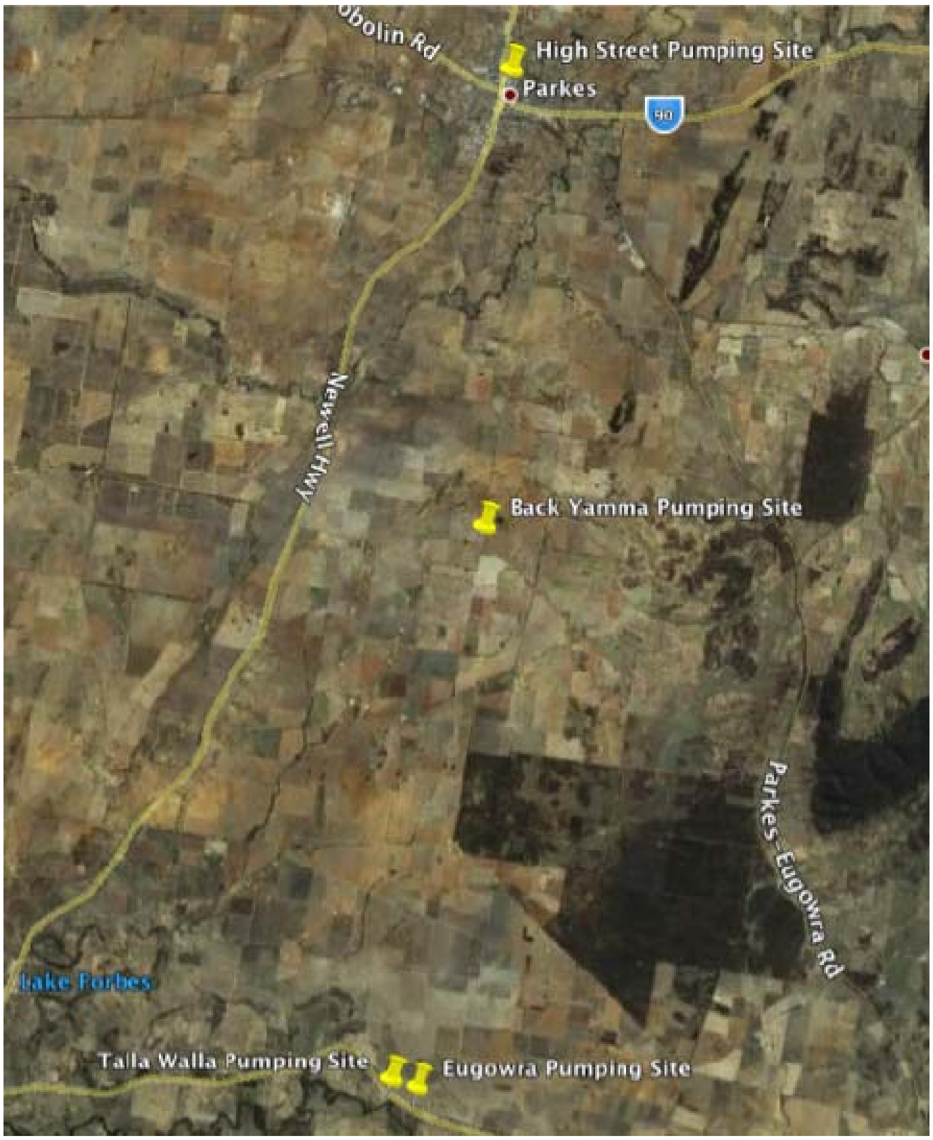
1 PROJECT OVERVIEW

PSC is investigating small wind energy systems at the water pumping locations to directly offset the energy required for pumping water to the Shire. Pumps account for by far the greatest proportion (83% of electricity, and 72% of the cost) (Rutovitz et al, 2011).

1.1 POTENTIAL LOCATIONS

The potential sites reviewed are noted in the aerial photos below, including Back Yamma, Eugowra, Talla Walla and High Street pumping stations.

Figure 1. Site reviewed for small wind site assessment (Google Earth)



At this point in time, High Street pumping station was not assessed due to its proximity to residential areas. It was decided that areas removed from residential sites would be prioritised for a PSC demonstration wind project. Eugowra and Talla Walla are on a lower elevation that Back Yamma and also experience frequent flooding, therefore Back Yamma is the focus for this wind site assessment.

1.2 BACK YAMMA SITE

1.2.1 Electrical characteristics

Back Yamma pump has the highest average energy use of PSC pumps, using 2,605 MWh/year. The pumps with the highest average energy use are shown in the table below.

Table 1. Pumps with highest average energy use

Pump account name	Avg MWH/yr	Avg annual total cost
Parkes SC Pumps, Back Yamma Rd	2,605	$317,124
Eugowra Road 2, Forbes	1,905	$241,631
High Street, Parkes	1,228	$146,541
Talla Walla Pump, Eugowra Rd	648	$30,994

PSC has undertaken efficiency measures with regards to their water pumping via implementation of a leak control program and winning a grant to significantly improve pump efficiency. PSC is also investigating further opportunities to reduce water use.

Back Yamma has 3-phase service, although the present transformer size and connection capacity would need to be confirmed with the electricity service provider, and the condition and capacity of the switchboard should be verified with an electrician.

1.2.2 Property description

The Back Yamma site includes housing for the pumps and water storage tanks. The topography is relatively flat (see Figure 4 and 5) and the surrounding ground cover is mainly agriculture with dispersed trees (see Figure 2 and 3).

Figure 2. Close aerial photo of site (Google Earth)*

*Yellow line at top indicates a distance of 1km. The red line indicates PSC property boundaries. Orange dotted line indicates overhead power lines.

As noted by PSC property boundaries, a wind system would be challenging to site within PSC Back Yamma property. The ideal location would be in neighbouring property and would require an agreement with the landholder.

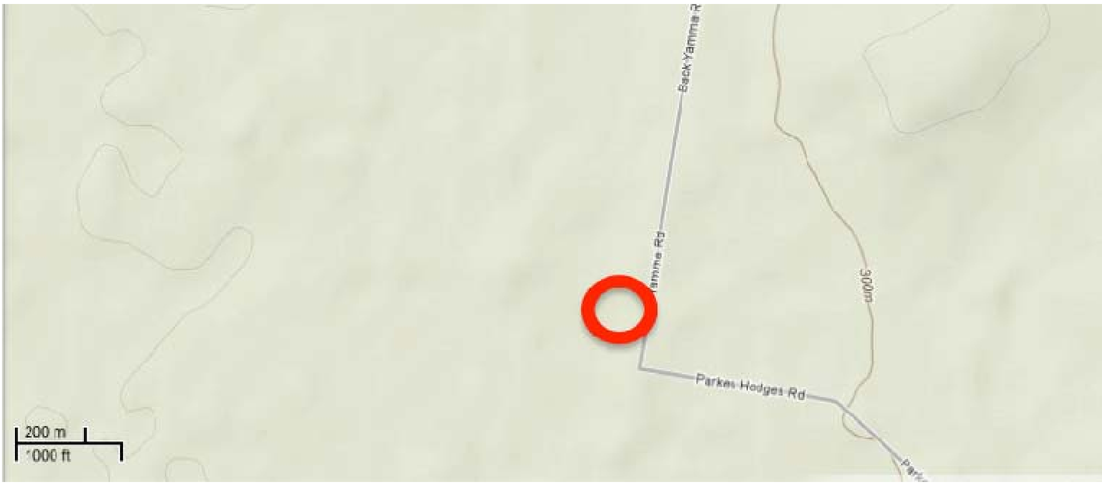
Figure 3. Distant aerial photo of the site (Google Earth)*

*Yellow line at top indicates a distance of 5km. The red line indicates PSC property boundaries.

Figure 3 shows the agricultural landscape around the Back Yamma pump site.

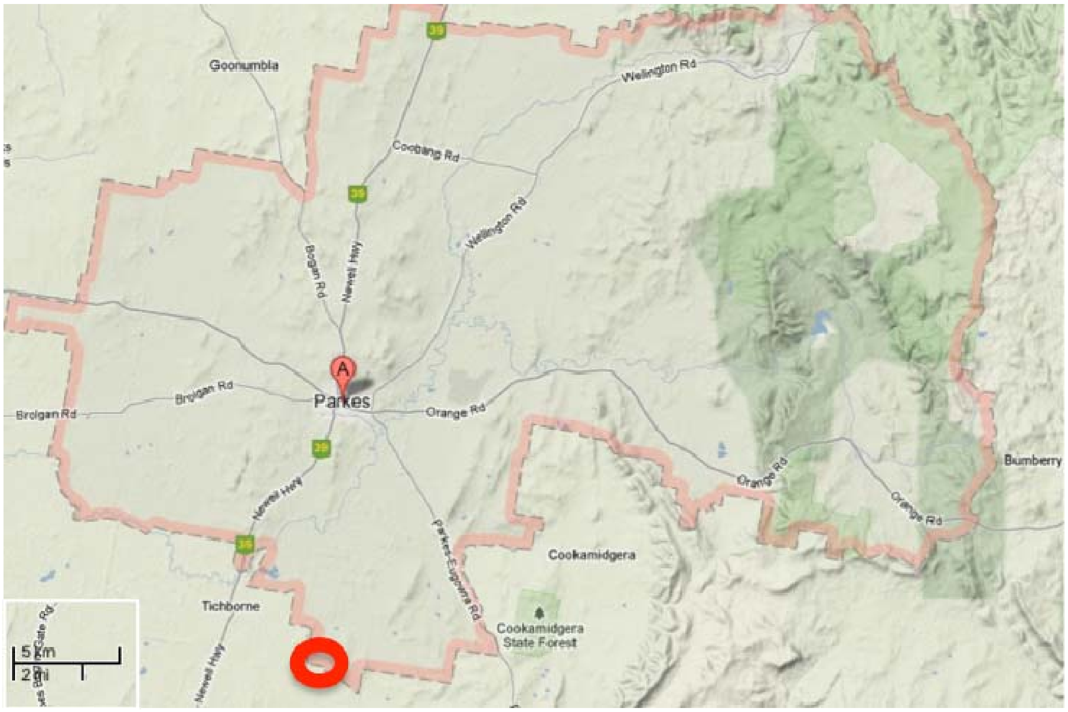
The topography across the site and within 150m of the site is consistently at 290 – 295m elevation. There is a slight rise to the east (328m) and slight decrease to the west (275m), but the landscape is fairly flat or has small undulations.

Figure 4. Close topographic map of the site (Google)



Parkes Shire Council is located on the western edge of the Great Dividing Range, roughly 15 km east.

Figure 5. Distant topographic map of the site (Google)



1.2.3 Prevailing wind direction

The wind roses for Parkes Airport (14 km north of Back Yamma pump) are shown below, and they indicate that the winds in this area prevail from the north and northeast at 9am, and the north, west and southwest at 3pm. For optimal turbine performance it is best to capture winds coming from all directions, but the wind rose helps identify locations that will be susceptible to turbulence and will therefore facilitate a consideration of how to site wind systems "upwind" of ground clutter. More information on wind roses and prevailing winds can be found in the Wind Report Supplement.

Figure 6. Wind rose for Parkes (Parkes Airport BOM) 9am average annual

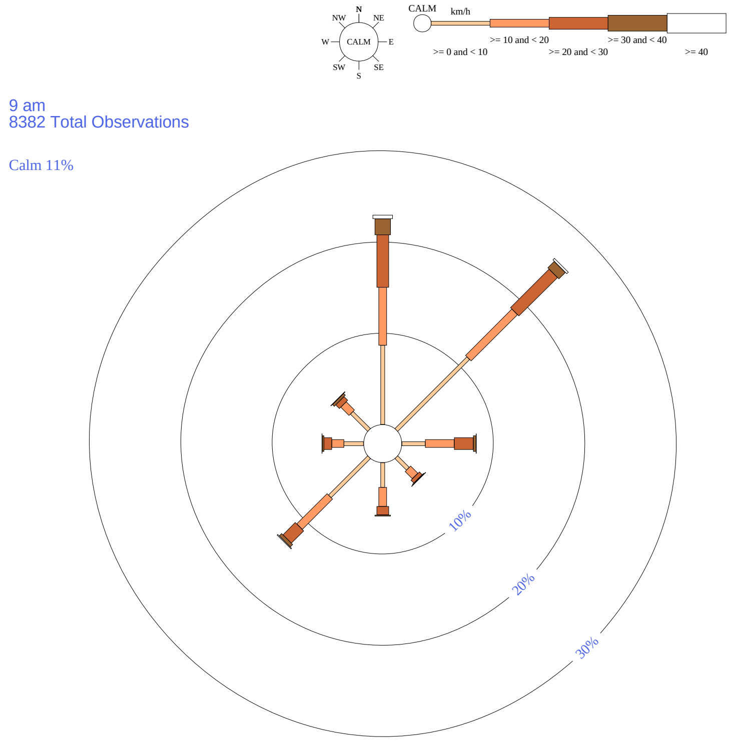
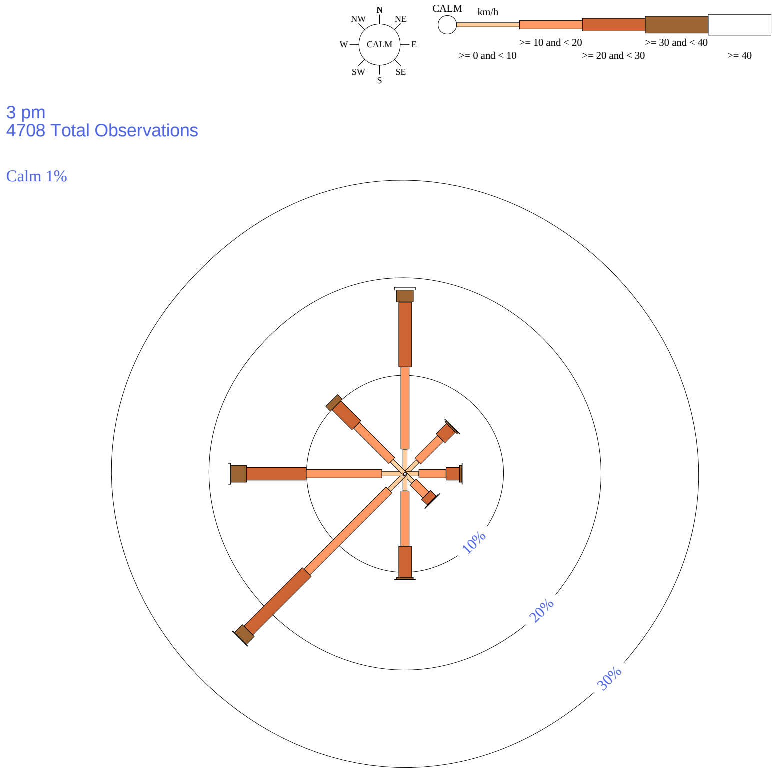


Figure 7. Wind rose for Parkes (Parkes Airport BOM) 3pm average annual



1.2.4 Site details

An assessor must consider many issues when determining the feasibility of a site for a wind system. The following table includes several such issues and the assessor's thoughts on each, as they pertain to Back Yamma site. These issues are further explained in the Wind Supplement.

Table 2. Summary of typical small wind issues

Typical issue	Summary of Back Yamma
Airport Proximity	The nearest airport is Parkes Airport, 14 km north. The turbine is well outside the Obstacle Limitation Surface Plan.
Land Use Zone	Consult the NSW Small Wind Planning Provisions for the development requirements based on rural zone and the tower height, turbine power capacity and sound power level of the chosen system.
Planning Approvals Required	It is expected that a turbine at this site would be categorised as 'development permitted with consent' because of the estimated minimum tower height (see Table 4).

Typical issue	Summary of Back Yamma
Setback Distance from Property Lines	The turbine would have to be sited on neighbour's property and an agreement would be required. Proximity to neighbour dwellings are not a concern.
Setback Distance from Utility Lines	The turbine would need to be sited clear of the near-by power lines (within the meaning of the *Electricity Supply Act 1995*).
Soil Conditions/Soil Bearing	Tower foundations normally require installation in "undisturbed soil". It is believed that Back Yamma is located on clay/alluvial soil. A soil bearing study may be required, especially for systems greater than 20kW, or consult PSC previous soil bearing studies on site.
Space Availability for Mounting Balance of Plant (BOP)	There should be sufficient space to mount the BOP components at the Back Yamma site.
Present Electric Service Adequacy	The transformer and connection capacity will need to be verified with the energy service provider.
Wire Run: Distance, expected soil type for excavation and potential interferences	The wire run is expected to be 170m if sited 150m south of the trees to the north of the site.
Accessibility for Concrete Truck	Path is clear, but truck may encounter soft ground.
Accessibility for Crane	Crane should easily be able to access site, but should confirm that the ground is firm.
Interference with Underground Services	While pumping infrastructure is underground, these systems are avoidable with careful wire run planning and trenching.
Land Use	The wind system would be placed on agricultural land. A monopole or a free-standing tower would have a much small footprint than a guyed lattice tower.
Aesthetics of System	Client has no concerns about system aesthetics.
Sound considerations	According to the NSW Planning Guidelines, the receiver type for this site is "quite rural", therefore a turbine with a sound power of 85dB(A) would need to be 126m away from any receiver. This is achievable at Back Yamma.

The advantages and disadvantages of the Back Yamma site are summarised below.

Advantages

- Easy crane access
- Preferred location of client
- Can meet the NSW zoning requirements

Disadvantages

- May experience turbulence from surrounding trees
- Will need to develop an agreement with neighbouring land owner to build turbine on his land
- Relatively long wire run (<160m) if sited to be 150m away from trees to north and east.
- Poor wind speed estimates (see section below).

The following photos are in eight compass directions from this site.

Figure 8. Site photos in all eight compass directions

North
Tallest obstacle: trees (16m tall)
Distance away: 150 m (if sited appropriately)

Northeast
Tallest obstacle: trees (16m tall)
Distance away: 150 m from trees

East
Tallest obstacle: tower, trees (16m tall)
Distance away: 150 m (if sited appropriately)

Southeast
Tallest obstacle: trees (16m tall)
Distance away: >150 m

South
Tallest obstacle: trees (16m tall)
Distance away: >150 m

Southwest
Tallest obstacle: n/a
Distance away: n/a

West
Tallest obstacle: power line, trees (16m tall)
Distance away: trees >150 m, line 50m

Northwest
Tallest obstacle: trees (18m tall)
Distance away: 150m (if sited appropriately)

1.2.5 Minimum tower height

As discussed in the Wind Supplement, minimum tower height is determined based on keeping the bottom of the turbine rotor 10m above the tallest obstruction within 150m, or 10m above the prevailing tree height. Below are the tallest obstructions within this radius that were considered for the Back Yamma site.

Table 3. Obstacles considered in minimum tower height calculation

Object near turbine site	Direction from site	Height (m) (Mature height if trees)	Distance from tower (m)	(m) +/- tower base elevation
Medium-size Eucalyptus	N	20m	150m	0
Medium-size Eucalyptus	NE	20m	150m	0
Medium-size Eucalyptus, Cyprus pines	E	20m	150m	0
Power line	W	12m	Needs to be sited clear (*Electricity Supply Act 1995*)	0

Ideally the tower would be sited far enough south and west to be 150m away from the eucalyptus trees to the north and the east. However, this siting would extend the wire run to 170m. The minimum tower height will be estimated based on the assumed mature height of the eucalypt trees (20m). It also assumes that the turbine will be sited within 150m of the eucalypt trees. The minimum tower heights are shown in the table below for two larger, 3-phase wind turbines that the client has expressed interest in. Details on each of these turbines can be found in the Wind Supplement[2].

The minimum tower heights in the table are the result of the 10m rule.

Table 4. Minimum tower heights for Back Yamma

Turbine	Rated output	Blade length (m)	Min tower height (m)	Available tower heights (m)
Endurance E-3120	50 kW	10m	40m	36.5, **42.7**
Northwind	100 kW	11m	41m	37m

The Northwind 100 does not offer tower heights tall enough to be placed sufficiently above the surround trees. Therefore, if this turbine were to be installed, it would need to be 150m away from anyone of the obstacles described above[3]. The Endurance however could be placed on the 42.7m tower within 150m of the surrounding tree line.

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[2] The Endurance E-3120 is an induction generator, 3-phase, 400 VAC @ 50 Hz: http://www.endurancewindpower.com/e3120.html. The Northwind 100 is a permanent magnet, 3 phase, 480 VAC, 50 Hz: http://www.northernpower.com/pdf/specsheet-northwind100-us.pdf

[3] If the Northwind were placed within 15m of these trees, it would be subjected to turbulence and have decreased performance in slower, more turbulent winds.

The Northwind tower is a monopole tower and the Endurance towers are offered as monopole and freestanding lattice towers. See Ian Woofenden's article on tower types for more information.[4]

1.2.6 Wind speed estimate

How well a wind turbine performs is based on the speed and the consistency of the wind intercepted by the turbine; a continuous high-speed wind is best. Once the average annual wind speed at a specific site is determined, it can be used to estimate how a variety of turbines will perform at this site. The methods that can be used to determine the wind speed at a specific site are explained in the Wind Report Supplement.

At this site, the wind shear factor was estimated to be 0.35 based on a ground cover of low row crops.

The following sources of wind speed were referenced for this site.

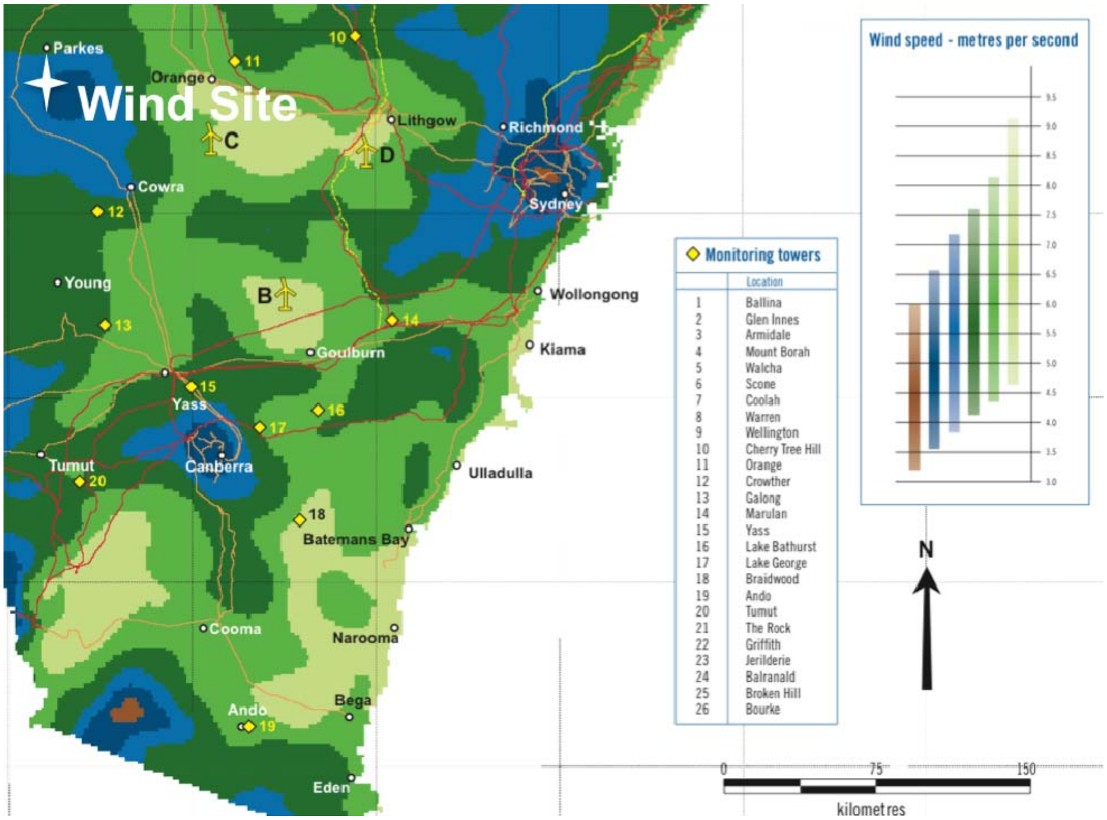
Table 5. Wind speed estimates for Back Yamma

Source	Location in relation to Back Yamma	Average annual wind speed (m/s)	Height (m)
Parkes Airport, Bureau of Meteorology	14km north	4.2	10
NSW Wind Atlas, SEDA	Estimated at site	5.5 (range of 7.2 – 3.8)	65
Windlab	Estimated at site	6.4	80
PSC Monitoring at Water Treatment Centre	10.5km north	(a full year was not available, but data was used to correlated with 3-Tier data)	10
3-Tier	25km east	4.8	80

The NSW Wind Atlas, Figure 9, shows a likely wind speed within a range of 7.2m/s to 3.8m/s at Back Yamma.

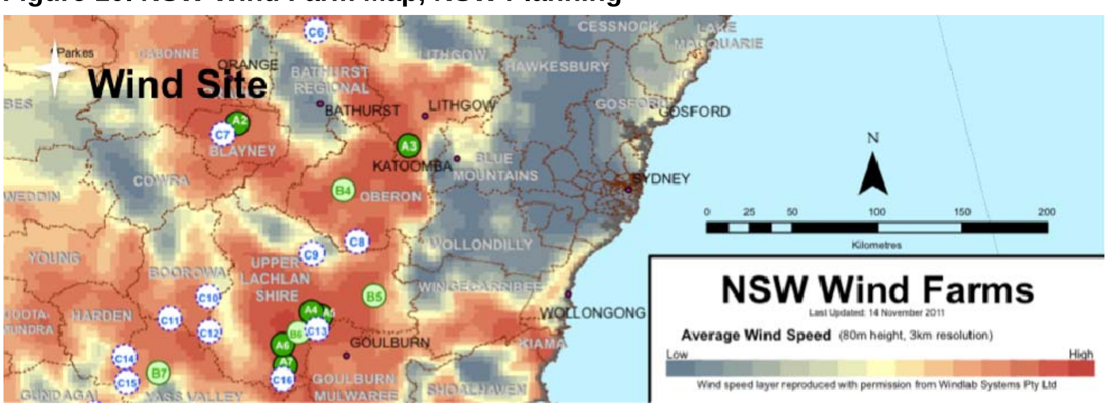
[4] http://homepower.com/view/?file=HP105_pg64_woofenden

Figure 9. NSW Small Wind Atlas, SEDA



The NSW Wind Farm Map, Figure 10, estimates a ‘medium’ wind speed at 80m.

Figure 10. NSW Wind Farm Map, NSW Planning[5]



It was not necessary to adjust the wind for any displacements heights at this site, as the there are no dense groves of trees within 300m of Back Yamma.

5 http://www.planning.nsw.gov.au/PlansforAction/PlanningforRenewableEnergy/tabid/394/language/en-US/Default.aspx

Based on the wind speed data above and the wind shear for the site, the wind speed can be calculated for different hub heights. The wind data sources provided a wide range of estimates, so this report will examine wind turbine energy production with both a high and low estimate.

Table 6. Wind speed at different hub heights

Hub height (m)	Wind speed (m/s) Low estimate[6]	Wind speed (m/s) High estimate[7]
37 (Northwind)	3.6	4.5
42.7 (Endurance E-3120)	3.8	4.7
48 (potentially Endurance E-3120)	4.0	4.9

1.2.7 Energy outputs

The wind speeds calculated above are used to determine the expected power output of wind turbines at this site at various tower heights.

The estimated energy outputs of the turbines appropriate for this site are shown in the table below. Again, details on these turbines can be found in the Wind Report Supplement. An explanation of this table and the factors taken into account to compute these outputs can also be found in the supplement.

The turbulence intensity for Back Yamma was set at 20% due to the trees to the north and east.

Table 7. Back Yamma site inputs for wind turbine performance calculator

Annual Energy Use (kWh/yr) =	2,605,000
Site Wind Speed (m/s) =	Table 6
Recommended Tower Height (m) =	Table 4
Site Altitude (m) =	295
Wind Shear Exp. =	0.35
Weibull K =	2
Turbulence Intensity =	20%

[6] Using the correlation of PSC wind monitoring data at the Water Treatment site to the 3-Tier monthly average data.
[7] Using the average of NSW Wind Atlas and NSW Wind Farm Atlas estimates.

Table 8. Wind turbine performance at Back Yamma

Manufacturer	Endurance		Distributed Energy systems	
Model	E-3120		Northwind 100	
Nameplate Capacity (kW)	50		100	
Turbine capacity at 11 m/s (kW)	55.4		80.7	
Output Voltage (V)	400		480	
Phase	3		3	
Rotor Diameter (m)	19		21	
Performance at	**42.7m**		**37m**	
Wind Speed Estimate	**Low**	**High**	**Low**	**High**
Tower Height (m)	**42.7**	**42.7**	**37m**	**37m**
Wind Speed at Hub Height (m/s)	3.8	4.7	3.6	4.5
Total Structure Height AGL (m)	52	52	47	47
Annual Energy Output (kWh)	**45,477**	**79,584**	**46,817**	**88,289**
Monthly Energy Output (kWh)	3,790	6,632	3,901	7,357
Wind % of Facility Energy Use	1.7%	3.1%	1.8%	3.4%
Excess Energy Production (kWh/yr)	0	0	0	0
Performance at	**48m**			
Tower Height (m)	**48**	**48**		
Wind Speed at Hub Height (m/s)	4.0	4.9		
Total Structure Height AGL (m)	52	52		
Annual Energy Output (kWh)	**53,390**	**89,014**		
Monthly Energy Output (kWh)	4,358	7,418		
Wind % of Facility Energy Use	2%	3.4%		
Excess Energy Production (kWh/yr)	0	0		

The wind speeds and turbine output values presented here should be taken only as estimates and should not be interpreted as a guarantee of the average wind speed or the average output of a particular wind turbine at this location.

1.2.8 System costs and incentives

A partial listing of the types of incentives that may be available is contained in the Wind Report Supplement. The Table 9 and Table 10 provide potential wind system costs based on these incentives, and Figure 11 shows the economic performance under low and high wind speeds.

Table 9. Potential wind system costs and savings with low wind estimate

Turbine and tower	Typical installed cost	kWh/yr	LGC Amount (20 years, $35/LGC)	Net Present Value	Annual savings from energy production[8]
Northwind on 37m monopole	$600,000	46,800	$32,760	-$256,894	$4,680
Endurance E-3120 on 42.7m lattice	$400,000	45,500	$31,850	-$305,630	$4,550
Endurance E-3120 on 48m lattice	$420,000	53,400	$37,380	-$306,398	$5,340

Table 10. Potential wind system costs and savings with high wind estimate

Turbine and tower	Typical installed cost	kWh/yr	LGC Amount (20 years, $35/LGC)	Net Present Value	Annual savings from energy production
Northwind on 37m monopole	$600,000	88,289	$61,802	-$203,371	$8,829
Endurance E-3120 on 42.7m lattice	$400,000	79,600	$55,720	-$217,649	$7,960
Endurance E-3120 on 48m lattice	$420,000	89,000	$62,300	-$214,547	$8,900

These costs and incentives are ballpark estimates only based on information from installers; installers should provide actual installation costs. Factors that can affect cost can be found in the Wind Report Supplement.

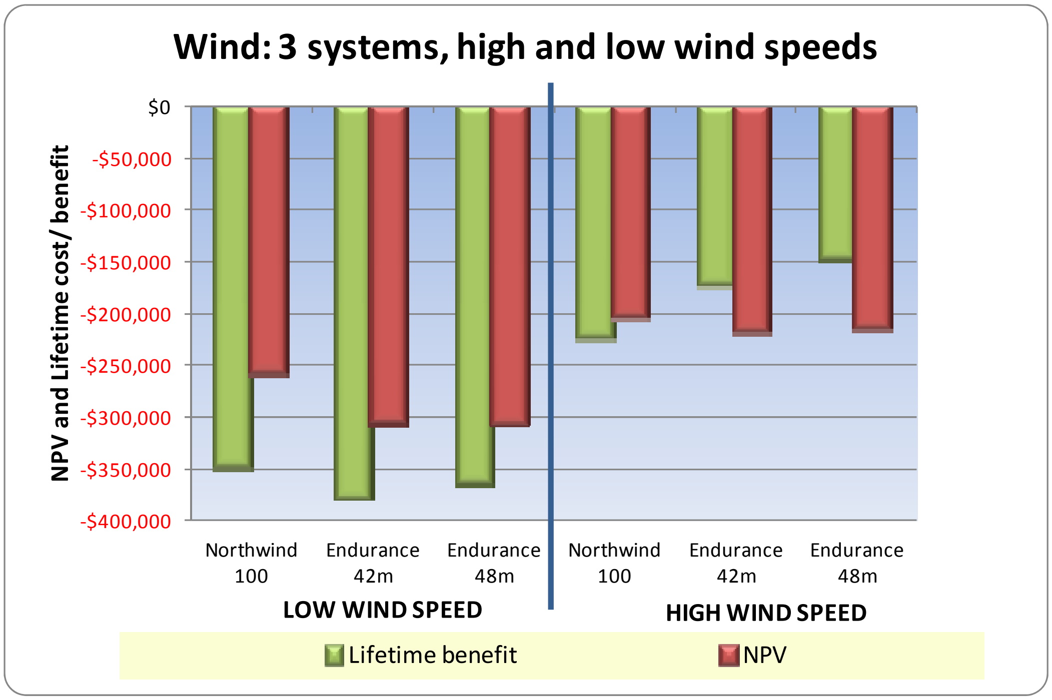
As can be seen, none of the systems have a positive economic benefit from installation at the Back Yamma pumping site under present conditions. The estimated annual savings

[8] The major pumping sites are on a $0.10/kWh tariff.

are based on the annual energy output multiplied by PSC's current utility rate for the pumping stations. Pump sites are on a low tariff, so displaced electricity is worth less than half the amount per unit compared to electricity at the high tariff sites (buildings), making positive economic outcomes much more challenging to achieve.

The current interconnection process in NSW for wind systems greater than 10kW typically involves a power purchase agreement, which may result in a different value for the wind energy produced. PSC noted that a potential costs savings might be the capability of constructing the foundation using in-house skills.

Figure 11 Payback for the three wind systems (low tariff site)



1.3 SUMMARY

The Back Yamma pumping sites is a relatively poor site for a wind energy system. The wind speeds in the region, according to the data available, show a wind regime that currently will not produce economical investments in a small wind system. If a wind system is to be installed, a 42m tower or 48m tower is strongly recommended.

The performance of an Endurance E-3120 (50kW) at this site can be compared to installing a 50 kW solar PV system. A 50 kW solar PV system may cost a total of $185,000 to install at the rates which PSC obtained for their building installations (excluding LGCs), which is less than half of the estimated $400,000 for a 50kW wind system. This PV system would produce a similar amount of renewable energy per year (70,000 kWh/yr), and at a low tariff would have an internal rate of return of 5.7%, although the NPV would still be slightly negative (-$4800).

As water pumping accounts for 83% of PSC electricity use in 2010, it is recommended that larger, more economic and potentially systemic, renewable energy systems for the water pumping energy demands are explored.

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