Wind Energy

Final Feasibility Report – June 2019

Site: CBD, Ballarat, Victoria

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Introduction

This building has significant heritage value with six tenants occupying the ground floor and two upper floors. The building owner has the freehold of office six and the roof space and approached the Community Hub Ballarat to undertake a study to determine the feasibility operating the businesses within the building on a carbon neutral basis. The aim is to enter into a co-operative agreement with the other building tenants to install renewable energy systems such as solar and/or wind to offset power consumption and enter into a power sharing arrangement between tenants.

A solar feasibility report was completed in April 2018 on behalf of the Community Power Hub in relation to this Ballarat CBD commercial site. The Community Power Hub program is supported by the Victorian Government under the Renewable Energy Action Plan for community renewable energy projects.

The Report indicated the optimum system size to fully offset the energy usage for the owners office within the building is 6kW system. Given that the other 5 offices in the building have similar energy usage profiles, a total of a 36kW system is required to offset the entire site's energy consumption. There is adequate roof space available to accommodate a system of this scale. This wind energy report aims to investigate the feasibility of installing wind turbines on the roof space at the site to offset power consumption, particularly over the winter months when solar energy generation is low.

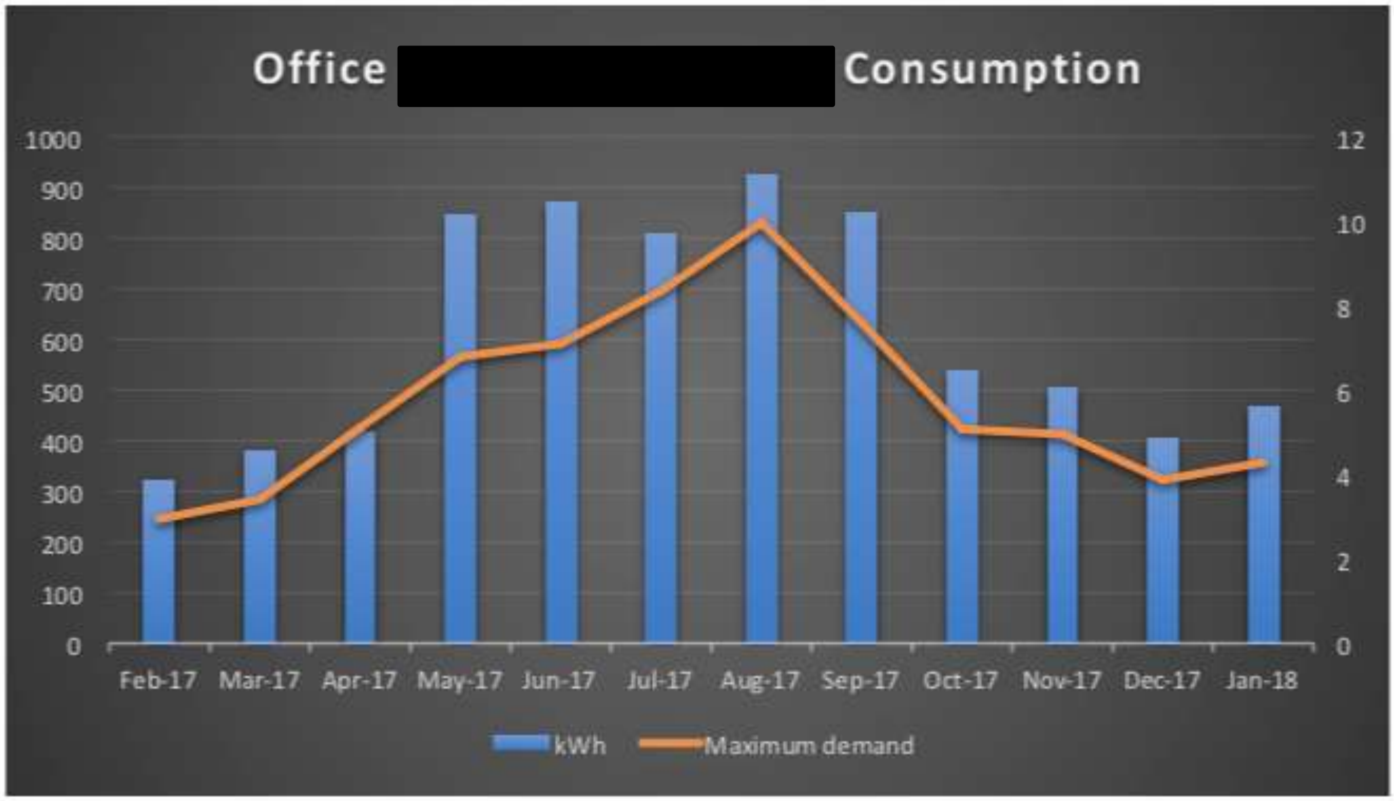
Executive Summary

This wind report provides an excellent opportunity study the feasibility of incorporating wind energy as a renewable energy source in an urban environment. The finding of this report can be used as a benchmark for future small-scale wind studies.

Wind speed and direction data was collected from four anemometers located in two locations on the roof of the site data has been monitored and analysed from June 2019 to May 2019. The data indicated an average wind speed of 2.9 – 3.10 metres/second over this period. Most turbines only generate power above 2.5 – 3.0 m/s. The wind energy analysis indicated that power would have been generated for 41% of the time, much of which would have been at low wind speeds. As wind turbine power is dependent on the cube of wind speed, a small increase in wind speed will greatly enhance the power output. As a consequence power generation has proven to be relatively low compared to a 5kW solar system. The cost to generate wind turbine energy ranges from $1.35 to $1.44 per kWh compared to $0.08/kWh for solar and the existing electricity tariff or $0.25/kWh. Therefore, wind turbines are not a financial viable proposition for this site.

Site and Power Consumption Details

The monthly power consumption at this site from February 2017 through to January 2018 can be seen below. Energy consumption for the other 5 offices in the building was not available at the time of analysis, however as discussed when meeting onsite the consumption of the other offices are noted to be similar and for this exercise to be considered the same.



Wind Speed and Direction Data Collection

In order determine the viability of installing wind turbines on the roof of the site a 12 month study of the wind speed and direction on site has been undertaken. Consequently wind data has been monitored from two locations at the north and southern ends on the roof of the site. Each location consisted of a wind vane and two wind cup anemometers (Davis Instruments) measuring wind speed at different elevations above the roof line.

Anemometer Locations

Northern Location

- Anemometers 1 - 1.7 metres above ridgeline
- Anemometers 2 - 2.6 metres above ridgeline

Southern Location

- Anemometers 1 - 4.15 metres above ridgeline
- Anemometers 2 - 4.85 metres above ridgeline

The Southern location consisted of an anemometer support pole mounted off the access railing associated with the large billboard attached to the building roof.

The wind data was captured via an electronic data logger for each location. Data was manually downloaded from the logger SD card onto a laptop on site every two months.

The LeWL wind logger is manufactured by Scottish company Logic Energy. Both the wind loggers and anemometer were supplied by TechRentals in Adelaide at email address www.techrentals.com.au

The each wind data logger monitored wind speed for anemometer s 1 &2 and wind direction on a 30 second interval basis. The loggers incorporated analysis software collects this interval data and automatically calculated.

- Ave Wind Speed - metres/sec
- Maximum Wind Speed
- Standard Deviation
- Wind Direction – point of the compass
- Turbine power generated – Based on a model 10kw turbine

Wind Data Analysis

Wind data collection commenced on the 1st June 2018 and to date has been collected and analysed through to 31st May 2019 as follows:

	North Logger							South Logger						
	Anemometer 1 (Lower)			Anemometer 2 (Higher)				Anemometer 1 (Lower)			Anemometer 2 (Higher)			
	Ave speed m/s	Max speed m/s	Standard Deviation	Ave speed m/s	Max speed m/s	Standard Deviation	Prevailing wind direction	Ave speed m/s	Max speed m/s	Standard Deviation	Ave speed m/s	Max speed m/s	Standard Deviation	Prevailing wind direction
Jun-18	2.75	13.41	2.38	2.65	12.68	2.29	NNW	2.71	13.03	2.14	2.64	13.15	2.28	NNW
Jul-18	3.89	16.53	2.54	3.64	15.37	2.36	NNW	3.64	15.76	2.26	3.54	15.12	2.4	NNW
Aug-18	3.55	15.41	2.61	3.19	14.66	2.42	NNW	3.42	14.27	2.3	3.27	14.23	2.47	NNW
Sept-18	2.82	13.48	2.14	2.69	12.39	1.97	NNW & SW	2.87	12.42	1.94	2.65	12.41	2.08	NNW
Oct-18	2.95	12.57	2.09	2.96	11.81	2.01	ESE	3.14	13.4	1.96	2.92	11.72	2.09	NE-SE
Nov-18	2.88	13.23	1.9	2.87	12.2	1.78	SE	3.08	11.97	1.78	2.88	11.83	1.89	SE
Dec-18	2.5	15.21	1.68	2.53	14.7	1.65	ESE	2.74	14.97	1.65	2.49	13.91	1.78	E
Jan-19	2.65	14.82	1.61	2.7	13.86	1.62	E	3.04	15.12	1.71	2.8	14.68	1.79	E
Feb-19	2.68	11.97	1.75	2.66	11.18	1.71	ESE	2.88	11.05	1.75	2.66	10.49	1.85	E
Mar-19	2.65	13.92	1.86	2.61	12.39	1.77	ESE	2.76	14.3	1.71	2.55	13.82	1.85	E
1/4/19	2.7	12.69	2.08	2.65	11.68	1.99	ESE	2.69	12.51	1.82	2.51	12.07	1.99	E
1/5/19	2.82	11.72	2.7	2.7	10.9	1.89	NNW	2.81	11.13	1.78	2.67	10.84	1.9	NNW

Based on the data above the lower positioned anemometers have registered higher average and maximum wind speeds and both loggers have recorded similar wind speeds. Refer to data below:

	Ave speed m/s	Max Speed m/s	BOM Ballarat –wind speed m/s	
			Ave	Max
Nth – Lower Anemometer	2.90	13.75	5.53 @ 9.00 pm	11.25 @ 9.00 pm
Nth – Higher Anemometer	2.82	12.82	6.46 @ 3.00 pm	12.71 @ 3.00 pm
Sth – Lower Anemometer	2.98	13.33		
Sth – Higher Anemometer	2.80	12.86		

The Bureau of Meteorology data measured at the Ballarat Aerodrome have in been included in the table above based on wind speeds recorded at 9.00 am and 3.00 pm. This indicates the average wind speeds at the aerodrome are higher than at the site, but conversely Peel Street has higher maximum speeds.

Wind Energy Analysis

The wind data logger incorporates a model 10kw wind turbine power curve to calculate a theoretical energy output from the interval wind speed data. The formula for the relationship between wind speed and wind turbine power is:

$$P_{avail} = \frac{1}{2}\rho A v^3 C_p$$

- P = Turbine power output
- A = Turbine swept area
- V = Wind speed
- p = Air density
- C_p = Power Coefficient

So with every other factor being held constant, the turbine power is dependent on the cube of wind speed, so a small increase in wind speed will greatly enhance the power output.

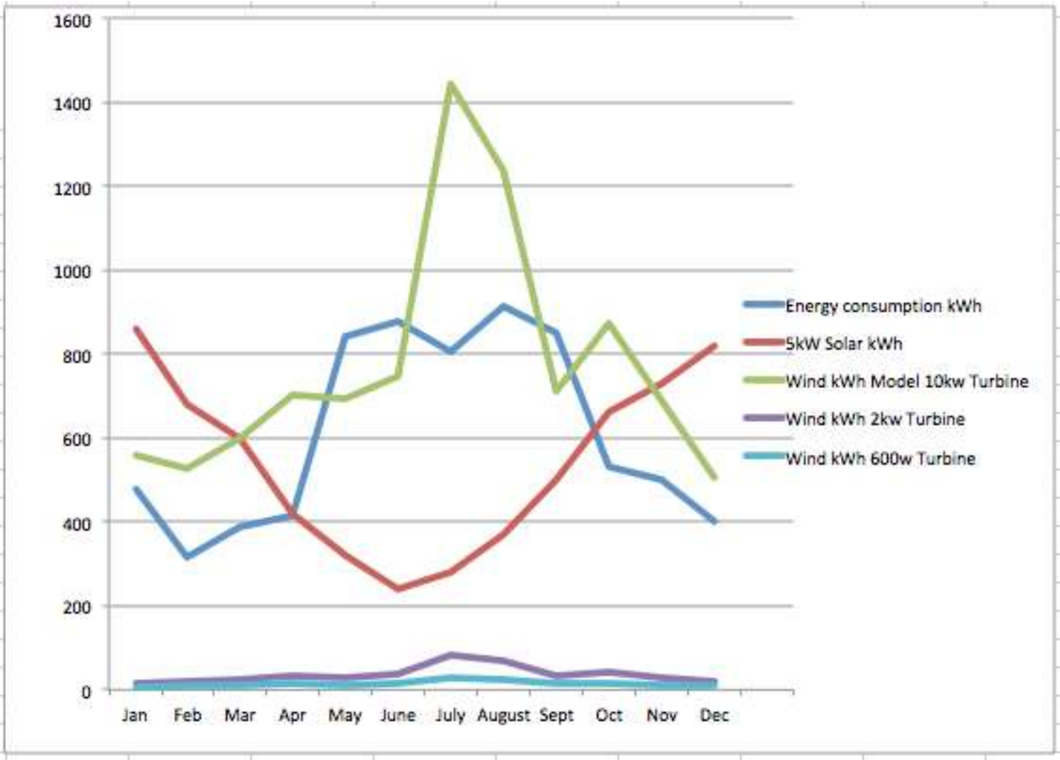
The model 10kW wind turbine incorporated in the data logger software has a power cut in wind speed of 3 m/s, so below this wind speed no power is being generated.

To meet the power consumption of the owners office at the site and physical size restrictions at this site, a 2–3 kW wind turbine or a number of smaller turbines is more appropriate. The site site has historical significance and Council approval would be required to install a turbine, as it would be highly visible. A Vertical Axis Wind Turbine (VAWT) has a greater ascetic appeal and requires less structural support, ideal for roof top applications. Two types are shown below:

The analysis below compares the energy consumption of Office 6 at the site and the energy generated by installing a 5kW solar system on the roof. In addition the energy generated by the theoretical 10kW wind turbine and a more practical 2kW VAWT and a 600W VAW turbines are compared based on the wind data collected to date.

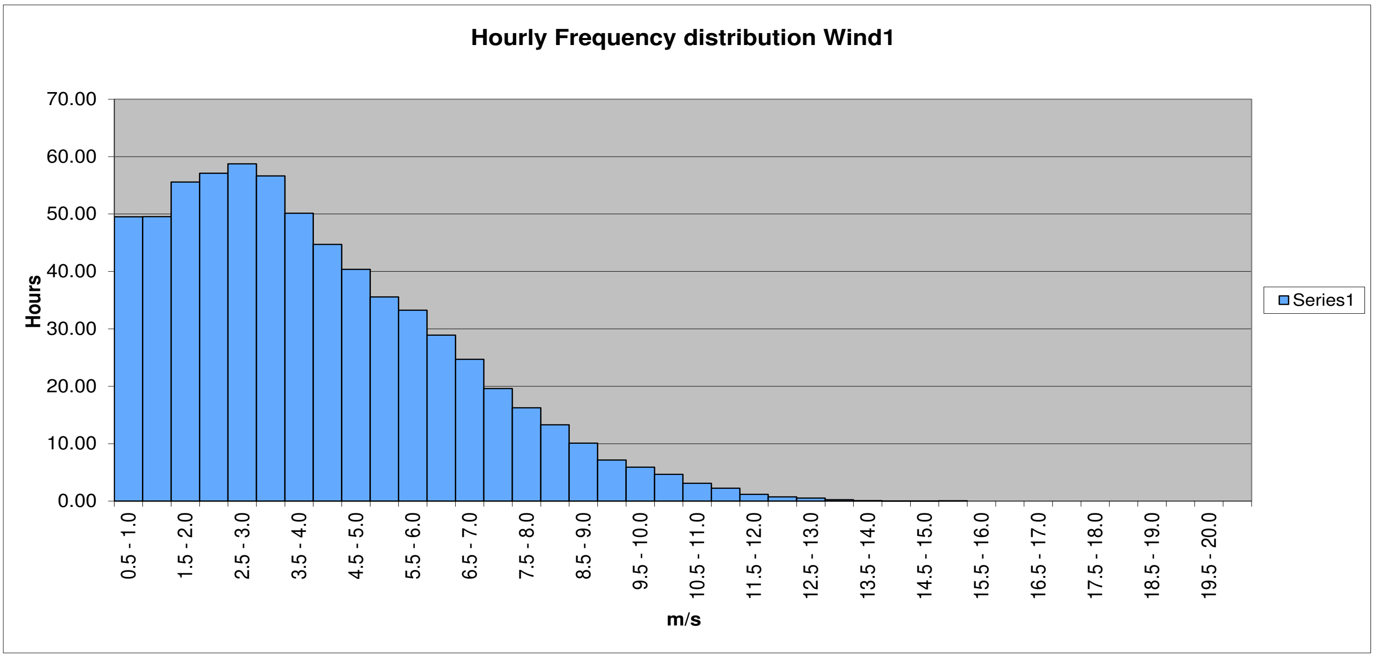
	Energy consumption kWh	5kW Solar kWh	Wind kWh Model 10kw Turbine	Wind kWh 2kw Turbine	Wind kWh 600w Turbine
Jan	480	860	557	14	6
Feb	315	680	529	21	9
Mar	390	600	598	25	10
Apr	415	420	703	33	14
May	840	320	695	29	12
June	880	240	746	37	14
July	805	280	1,444	82	30
August	915	370	1,238	70	26
Sept	850	500	712	34	14
Oct	530	660	872	43	16
Nov	500	730	690	29	12
Dec	400	820	506	20	9

This can be represented graphically:

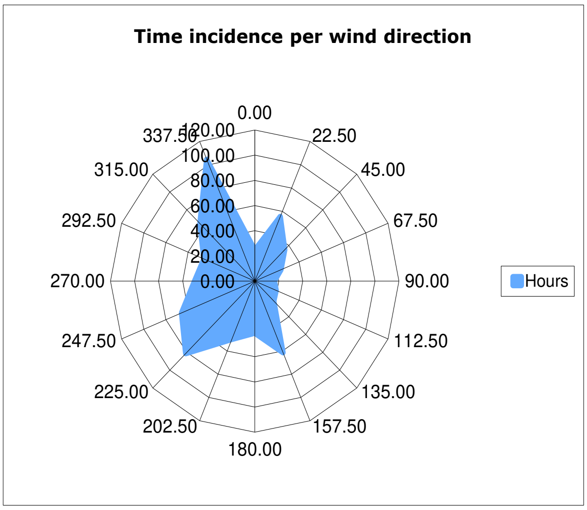


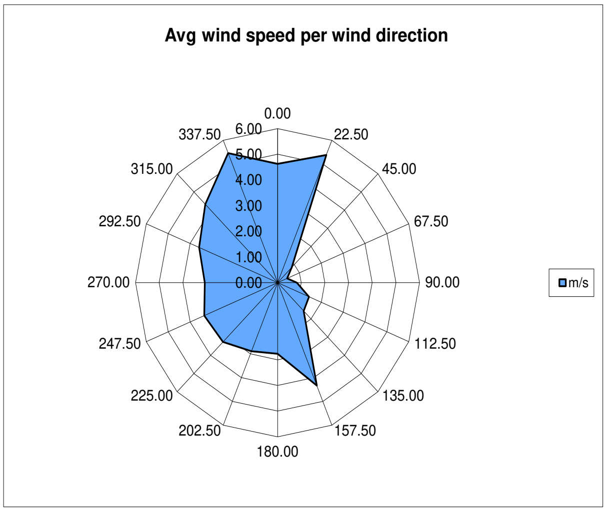
The theoretical 10kW wind turbine produces sufficient power to meet the energy consumption during the winter months, however the more practical 2kW and 600W turbines fall well short.

The wind data indicates that wind power is generated on average 41% of the time over the twelve month period. No wind power is generated at wind speeds below 3 m/s. It will be noted from earlier, the average wind speed is very close to 3 m/s resulting in relatively low power output for the small turbines.



The graph above plots wind duration period vs wind speed for the north anemometer in August 2018.





Wind direction data for August 2018.

Financial Analysis

In order to establish the financial benefits of installing a vertical axis wind turbine, we will compare capital costs of turbines, vs the capital cost of 5kW solar system in relation to the energy generated over ten years based on the wind speed data to date. Although we only have seven months of data, we will extrapolate the data for 12 months assuming wind speeds will gradually increase from January through to May.

	Capital Cost	kWh 1 yr	kWh 10 yrs	$/kWh
5kW Solar	$5,000	6,480	64,800	$0.08
2kW VAWT	$5,880	437	4,370	$1.35
600W VAWT	$2,475	172	1,720	$1.44

The Capital costs for the VAWT above are supply only, based on a Solarzone 2kW H Series VAWT and a Solarzone 600W Q4 Series VAWT, installation would be an additional cost.

The current electricity tariff is 25 cent/kWh during peak periods. The financial case for installing a 5kW solar system is very clear as the relative cost of power is 8 cents/kWh whereas there is no cost benefit of wind turbines based on the existing wind data as recorded.