

THE BUSINESS CASE FOR WIND TURBINES



TECHNOLOGY OVERVIEW

Wind turbines convert the kinetic energy generated by the wind into rotational mechanical energy to generate electricity. The power available from a typical horizontal axis wind turbine (HAWT) is proportional to the cube of the swept area, so there is a strong incentive to make larger turbines. Thus development in this field is focused on materials and manufacturing techniques which increase the blade length and increase maximum power output. Similarly, wind speed is more constant at higher altitudes so turbines are mounted on tall towers. A typical grid scale wind turbine (2MW output) sits on a tower about 60m tall, supporting a turbine with 40m long blades. They are usually sited where the wind is strongest and most reliable, such as coastlines, ridgelines and land positioned in the roaring 40's, such as the Eyre Peninsula in South Australia.

Wind is an intermittent source of power and therefore is most commonly integrated with other base-load power generating systems.

IS IT SUITABLE FOR YOUR MEAT PROCESSING FACILITY?

When it comes to wind turbines, bigger is generally better in terms of reliability and power output. However, small-scale (less than 600kW rated turbines) wind turbines can be a viable option for meat processing facilities that:

- use a significant amount of electrical energy,
- are located in windy areas (e.g. coastal or upland area), and
- are not surrounded by populated areas or areas with planning restrictions.

Assessing the potential for a wind turbine project at your facility is complex, especially due to the influence of topography on the quality of wind resource and wind characteristics. This fact sheet will provide high level guidance to conduct a preliminary assessment of the potential for wind power on your site.

HOW TO DEVELOP YOUR BUSINESS CASE

The actions to take when developing a business case for an on-site wind turbine include:

- Determine your site base load
- Identify the physical space available and regulatory constraints
- Determine the available wind resource and characteristics
- Estimate savings and cost (i.e. financial viability)
- Determine the planning constraints.

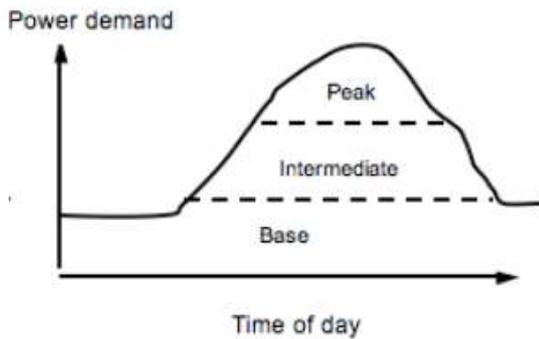


Figure 1: Illustrative demand curve

DETERMINE SITE BASE LOAD

Request 12 months of half-hourly metering data from your electricity retailer. Determine the power demand or load requirement for a typical winter and summer day by dividing the kWh consumption data by the hours. Then assess the permanent minimum load that your operations require (i.e. the base load in kW - see figure 1).

The load shape for winter and summer months are likely to be different depending on the nature of your operations. It is common practice to size any onsite generation to approximately 80% of base-load, taking into account future growth in electricity demand.

PHYSICAL SPACE AVAILABLE AND REGULATORY CONSTRAINTS

A wind turbine must be located where it will be exposed to the longest possible “fetch” (i.e. the distance over which the wind flows uninterrupted). Rough surfaces such as nearby forests or buildings can disturb the windflow, whilst hills and ridges can amplify the windflow. However, small-scale turbines are frequently located near buildings, trees and other potential obstructions. This requires careful planning to avoid a turbulent wind resource, which reduces the efficiency of the rotor and therefore the output of the turbine.

Space constraints may make a few smaller units more viable than one larger unit. However, as a rule of thumb, turbines should not be placed closer to obstructions than five times the diameter of the rotor to avoid significant loss of power.¹

Site selection may be impacted by planning regulations; there are currently laws in NSW and Victoria which limit how close to residences new wind turbines can be placed. There could also be restrictions governed by local councils and planning authorities. Check with your authorities, both state and local before committing funds as these laws are changing frequently.

Other considerations include nearby natural habitats, important plant or animal species that may be impacted, landscape impacts and preferences of nearby communities. In addition, a buffer from major infrastructure such as public roads may be required.

WIND RESOURCE AND CHARACTERISTICS

Spatial and temporal variation of wind resource and characteristics are a major challenge when planning a wind project. The choice of method to assess the wind conditions depends on the certainty to which generation must be known.

As a preliminary assessment of whether your site is in a “windy location”, you can refer to the Australian Wind Atlas, shown in Figure 2, for an indication of whether your site is located in a high wind speed zone. Sites located in the blue areas are less favourable for wind power systems. If you are in the orange to red areas, you could get an indication of the mean wind speed for your “region” from the Bureau of Meteorology’s (BOM’s) website. The

¹ McKay, David (2008), Sustainable energy – without the hot air, Version 3.5.2., page 265 Accessed at <http://www.inference.phy.cam.ac.uk/sustainable/book/tex/sewtha.pdf>

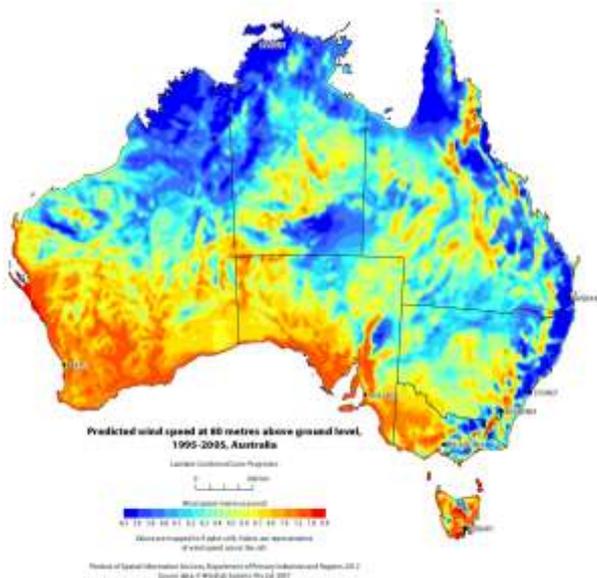


Figure 2: Australian wind atlas. A higher resolution version is available at <http://www.renewablessa.gov.au/files/121219-windresourcemappingaustralia.pdf>

BOM website publishes mean wind speed data taken at 9 am and 3 pm daily. Start by selecting a location close to your site. Using airport measurement stations typically provides more reliable results as these areas are open, generally unobstructed and the data collected is often higher quality because of its intended end use (health and safety regarding aircraft movements and weather forecasting).² This is just a proxy as on-site conditions will impact wind speed but does provide a guide to the local wind resource. To convert wind speeds provided by BOM in km/h to m/s, divide it by 3.6 (1 m/s = 3.6 km/h).

The BOM measurements are typically taken at 10m above the ground. To adjust the wind speed to take account of the likely height of your turbine hub is complicated. It depends on a range of factors such as the roughness of the surrounding terrain and the time of day. However, as a rule of thumb, wind speed increases by around 10% every time the height of the hub is doubled.³

Outlined below are two methods for assessing the wind resource at your site before engaging suppliers in more detailed investigation; the Easy Way and the Hard Way. The Easy Way is best applied to small scale projects, where the cost of detailed investigation may erode the benefits too much to proceed. The Hard Way is for larger projects, where the scale of investment warrants detailed estimation of the costs and benefits.

The Easy Way

Once you have determined your base load electricity requirement, it is possible to select a turbine and estimate its output based on its capacity factor. Capacity factor is a measure of the actual output of a turbine against its potential output. For example, a 10kW turbine could theoretically output 87,600kWh per year (10kW x 24 hours a day x 365 days).

For turbines with a rated power of less than 10kW the capacity factor is typically between 10% and 15%. This could increase for larger units of 100kW to between 15% and 20% and for large turbines in commercial wind farms, capacity factors reach 30-40%. The basic “ballpark yield”, allowing for the 10% loss factor, could be calculated as follows:

$$\text{Net Annual Electricity Generation kWh} = \text{turbine rated power kW} \times 365 \text{ days} \times 24 \text{ hours} \times \text{capacity factor} \times 90\%$$

This estimate is enough to start investigating the costs and benefits. If greater certainty is required, a more detailed method should be applied; the Hard Way.

The Hard Way

The first step is to determine the yield potential at your location (i.e. likely kWh of electricity to be generated by the wind turbine). This is a factor of the turbine’s power output at different wind speeds and the frequency that the wind blows at the different speeds. You will have the mean wind speed from the BOM website for your area. However, without detailed wind data the frequency distribution of the wind at different speeds is unknown. For a preliminary assessment, you could assume a Weibull distribution of wind speeds across the 8,760 hours available in a year. This is typical for sites with a good wind resource as illustrated in Figure 3. This illustrated example has a mean wind speed measured at hub height of 4.8 m/s.

² Select the monthly statistic dataset for “Weather & Climate” available at <http://www.BOM.gov.au/climate/data/index.shtml?bookmark=200>

³ McKay, David (2008), Sustainable energy – without the hot air, Version 3.5.2., page 266 Accessed at <http://www.inference.phy.cam.ac.uk/sustainable/book/tex/sewtha.pdf>

If the wind resource at your location is attractive, you may want to invest in wind monitoring. Wind vanes and a wide range of anemometers are available on the market of varying quality. This is not straightforward as wind is seasonal and may vary significantly over short distances. For a big project you should consider engaging specialist data providers to conduct a feasibility study. They will be able to assist you in determining the wind resource, optimal turbine location, inter-annual variability and ultimately the business case for investing in a wind turbine. The cost of this service could be anywhere between \$5,000 and \$15,000 per site.

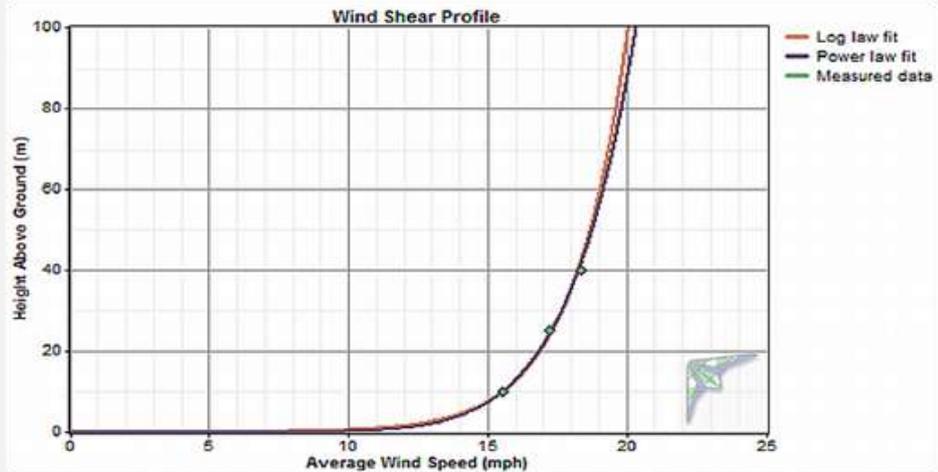


Figure 2: Typical Weibull distribution

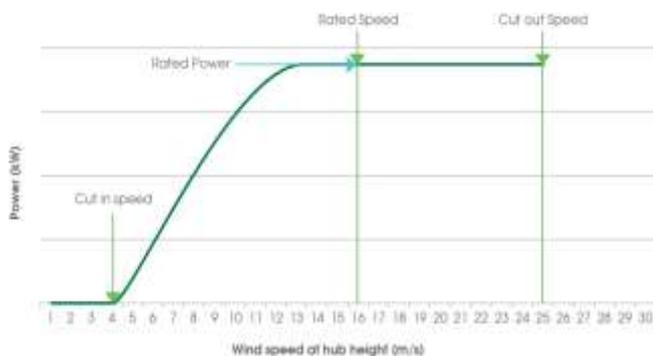


Figure 3: Illustrative wind turbine power curve

To determine the likely power output from your project, start by selecting a turbine(s) with a rated power, or cumulative rated power, close to the base load requirements of your site. You can always adjust the size of the turbine(s) in later calculations. However, the power output from two turbines with the same rated power can vary significantly. Therefore, the type of turbine you select will determine power output of your project at different wind speeds, as reflected by the unique power curves⁴ of different turbines (See Figure 4).

Wind turbines are usually designed to start generating power at windspeeds of 3-4 m/s, also referred to as the cut in speed. Since small turbines are mounted at relatively low heights, the mean hub height wind speeds may be close to their cut in speeds. The implication is that, for long periods of time, a small turbine may not operate at all. Even if it does spin, it may not generate much electricity. In calculating the yield potential, only “useful” wind resource between the cut in and cut out speeds must be considered (See Figure 4).

⁴ The power curves provides an indication of the likely power output at different wind speeds having taken account of the hub height, the rotor blade diameter, turbine efficiency factor and likely capacity factor.

By applying the power curve of a selected turbine to the Weibull distribution of wind speeds, an approximate electricity yield can be calculated (see worked example section below). This yield is usually adjusted downwards by 10% to allow for maintenance (availability), electrical losses and other disruptions (loss factor) to output.

ESTIMATE SAVINGS, INVESTMENT REQUIRED AND FUNDING SOURCES

The wind resource assessment can be used to determine the potential electricity savings from a project. It is recommended that the electricity cost savings calculation be based on the variable **electricity charge only**. Although the project may result in a reduction in peak demand charges, it is not recommended that you include this in your financial evaluation. A single calm day could result in your peak demand returning to the pre-wind project profile. This will result in the same demand charges as before.

In addition to electricity savings, also consider other revenue created by Government support programs, such as revenue from certificates under the Renewable Energy Target (RET) Scheme. You can determine whether your project qualifies under the RET Scheme for Small-scale Technology Certificates (STCs) and Large-scale Generation Certificates (LGCs) by referring to the Clean Energy Regulators website.⁵ Wind systems <10kW are eligible for STCs and those >10kW are considered large scale and qualify for LGCs. Both certificates act as revenue support for a project and typically trade in the range of \$30-\$40 each.⁶

Guidelines for the high level financial viability assessment for a wind turbine project as shown in Table 2.

Upfront cost	Life of the system	Annual maintenance cost
Cost are highly variable but average around \$5000/kW, including equipment, permits and installation cost.	25 years	\$60/kW of installed capacity

Table 1: Planning assumptions for small scale turbines (<100kW capacity)

EXAMPLE COST-BENEFIT ANALYSIS

A meat processing facility has a base load of 500 kW, taking account of seasonable variation in electricity use. The facility is located in an area with a Weibull distribution of wind speeds typical of a good site as illustrated in Table 3 (Column A and B). The facility manager has sourced the power curve for a wind turbine with a rated power of 500kW (Column C). The electricity production (column D) for each “wind speed bin” can be derived by applying the following formula:

$$\begin{aligned}
 & \text{Electricity generated per bin (kWh)} \\
 & = \text{Duration of wind at bin speed as a percentage of the total hours in a year} \times \text{wind power at bin speed} \\
 & = (\text{Column B} \times 356 \text{ days} \times 24 \text{ hours}) \times \text{Column C}
 \end{aligned}$$

⁵ <http://ret.cleanenergyregulator.gov.au/About-the-Schemes/Small-scale-Renewable-Energy-Scheme--SRES-/about-sres>

⁶ Each MWh of output = 1 LGC or 1 STC depending on the installed capacity (system size)

Assumed		ABC Wind turbine 500kW	Calculated
Wind speed bins (m/s)	Wind distribution (Weibull distribution - hours pa)	Turbine Power Curve (kW)	Turbine electricity production (kWh)
A	B	C	= (B x 356days x 24 hrs) x C
0	0.00%	-	-
1	5.27%	-	-
2	11.00%	-	-
3	15.20%	-	-
4	16.85%	-	-
5	15.89%	63	87,694
6	13.07%	127	145,406
7	9.48%	197	163,598
8	6.10%	267	142,674
9	3.50%	337	103,324
10	1.79%	400	62,722
11	0.82%	450	32,324
12	0.33%	477	13,789
13	0.12%	493	5,182
14	0.04%	500	1,752
15	0.01%	500	438
16	0.00%	500	0
17	0.00%	500	0
Total excluding losses			758,904
Less 10% losses due to maintenance			75,890
Net Annual Electricity Generation (kWh)			683,014

Wind resource range

Table 2: Illustrative application of power curve data to a good wind site

Sum the electricity produced at each bin speed to derive an estimate of the electricity this turbine will generate, namely 758,416kWh per annum. The 682,574 kWh net annual electricity generation represents a capacity factor of 15.6% (i.e. 682,574 kWh / (500kW x 365 x 24). Assuming a variable electricity charge of \$250/MWh, this represents annual savings of:

$$= 683 \text{ MWh} \times \$250/\text{MWh} \cong \$170,500 \text{ per annum}$$

Assuming the project qualifies for LGCs which have recently been trading at ~\$36/ MWh, the annual revenue from government incentives could be in the region of \$24,500 per annum, reducing total annual electricity cost by approximately \$195,000.

$$= 683 \text{ MWh} \times \$36/\text{MWh} \cong \$24,500$$

At an upfront cost of approximately 500kW x \$5000 = \$2,500,000 the simple payback on this project will be 13 years. This calculation does not account for future energy price increases and assumes no financing costs. It is further assumed that 100% of the energy is used to displace facility energy use.