Fact Sheet: Your Levy at Work

Wind power for dairy farms

Windmills have been used for more than 1,000 years to pump water and grind flour. Wind turbines convert wind energy into electricity. However, wind is the most highly variable of all the renewable resources, in terms of both speed and direction.

Wind power

Wind turbine generators are becoming increasingly common. Many regions of Australia have excellent wind resources and farmers have the opportunity to capture the energy in wind as it blows freely across their properties.

The Australian Bureau of Meteorology has weather stations across the country that record variations in wind velocity, taking both speed and direction into account. Wind speed is recorded in metres per second (m/s) or kilometres per hour (km/h). The direction is always given as the point of the compass from which the wind blew. Figure 1 shows the average wind velocity across the country for September, one of the windiest months across southern Australia.

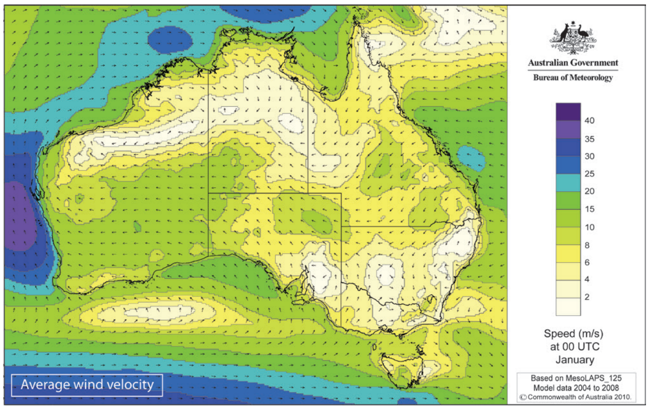


Figure 1: Average wind velocity across Australia in September Bureau of Meteorology.[1]

Components of a wind turbine system

The components of a wind turbine system will depend on whether it is designed to feed power into the mains grid or is a stand-alone system. All systems have the following components in common:

- **Wind turbine** – includes the turbine, blades and generator. Energy from the wind is harnessed by the spinning blades which turn the turbine. The generator converts the mechanical energy of the rotating turbine into electricity.
- **Turbine controller** – regulates the rotational speed of the turbine. ‘Over-speeding’ in high winds can destroy a turbine. This can also occur in a blackout if the turbine is connected to the mains grid. Taking the load off the turbine can leave it spinning too fast.
- **Tower** – supports the turbine and generator. The higher the turbine the greater the wind speed and hence the more electricity that is produced. Towers can range in height from 9 m to over 40 m, depending on the model and power output.
- **Inverter** – transforms the electricity produced by the wind turbine from direct current (DC) to alternating current (AC) at 240 volts.
- **Wires** – transmit electricity from the wind turbine to the equipment that is drawing the load.
- **Meter** – measures the amount of power produced by the wind turbine.

Stand-alone systems require deep-cycle batteries to store surplus electricity and a control system to prevent the batteries from overcharging or completely discharging.

Most small wind turbines have direct-drive generators that produce direct current. Larger commercial wind turbines used in wind farms usually produce alternating current that is fed directly into the grid.

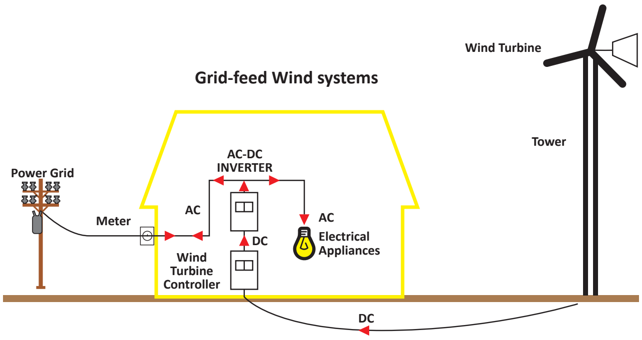
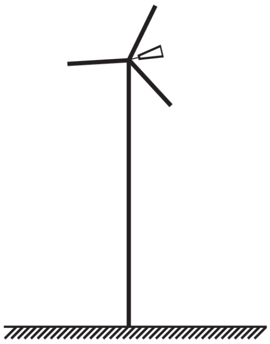
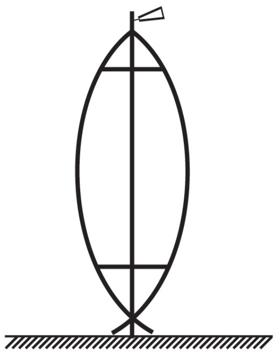


Figure 2: Typical Wind energy system.

Types of wind turbines

Axis of rotation

Horizontal axis: The turbine and generator are mounted on top of the tower with the main shaft parallel to the ground. They are the most common type of wind turbine and the most efficient in clear wind areas.	
Vertical axis: The main rotor shaft is at right angle to the ground. These are less common than horizontal axis turbines.	

Tower type

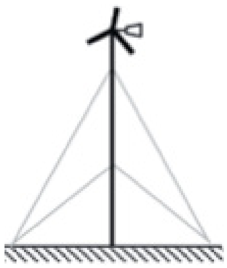
Guyed pole: This is usually the lowest-cost option, but requires a big area to accommodate the guy wires.	
Monopole: Requires a smaller area, but is normally more expensive due to the thicker and heavier steel required in the pole as well as the larger and heavier foundation compared with the guyed type.	
Lattice: These are a common sight for windmill water pumps and have also been used for electricity generation.	

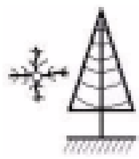
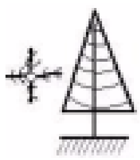
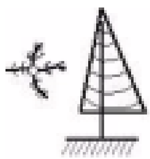
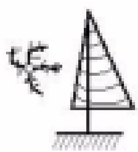
Table 1: Types of wind turbines.

Site requirements

The output from a wind turbine depends on the wind speed, wind shear and wind turbulence.

Wind speed – The higher the wind speed the greater the energy it can deliver. Average annual wind speeds below 4.4 m/s are generally not recommended for viable wind turbines.[2] That is equivalent to a moderate breeze that can raise dust. In Australia, most of the suitable sites are found close to the ocean as the wind is generally faster and more consistent.

The degree of deformity of the local vegetation such as bushes and trees can give you a good idea of the mean wind speed of your farm (Table 2).

No deformity		Speed < 3 m/s
Brushing and slight flagging		3-4 m/s
Slight flagging		4-5 m/s
Moderate flagging		5-6 m/s
Complete flagging		6-7 m/s

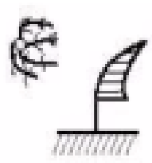
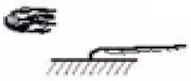
Partial throwing		7-8 m/s
Complete throwing		8-9 m/s
VI Carpeting		10 m/s +

Table 2: The Griggs-Putnam Index

This method is known as the Griggs-Putnam Index and the velocities given are at 30 m above ground level. If your turbine tower is lower than 30 m, the wind speed will also be lower than the table above.

Wind shear – As the height above ground level increases, so does wind speed – by 1% for every extra metre of height[4]. This is called wind shear and is due to the reduction in surface friction with an increase in altitude. Therefore, the higher the tower, the greater is the potential energy output.

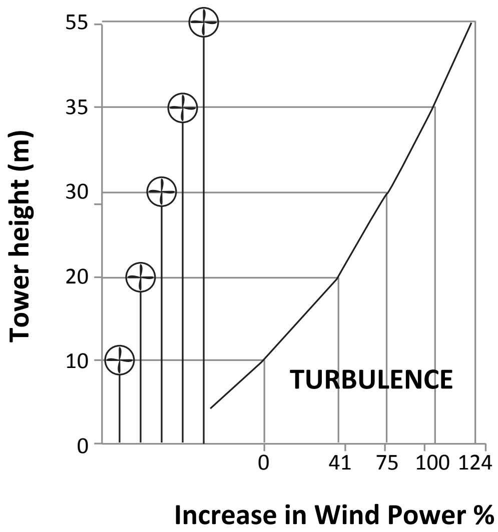


Figure 4: Wind power change with the height.

Wind turbulence – Wind turbines operate most efficiently in 'clean' air. Obstacles such as hills, trees, buildings and even the ground can cause friction and lead to fluctuations in wind speed and direction. This turbulence reduces the efficiency and energy output of wind turbines as well as increasing wear and tear on the components.

As a rule of thumb, wind turbines should be located on a cleared site 100 m from the nearest minor obstacles (trees, buildings, etc) and 200 m from hills and other landforms[5].

The minimum tower height should be 12 metres or three times the height of the tallest upwind barrier. Although the tops of hills are often windy they also have substantial turbulence and may not be the best sites for wind turbines.

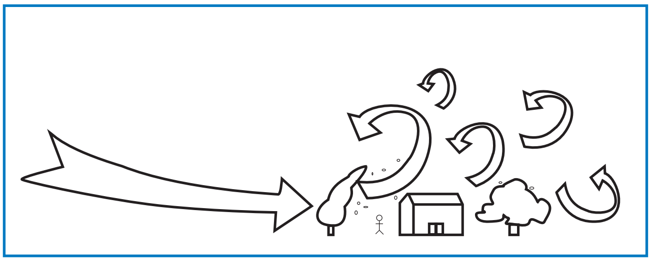


Figure 5: Turbulence.

Supply, installation and maintenance

Wind monitoring – Once it has been established that a particular region has good wind resources and a suitable clear site has been selected, the location should be monitored over a period of time.

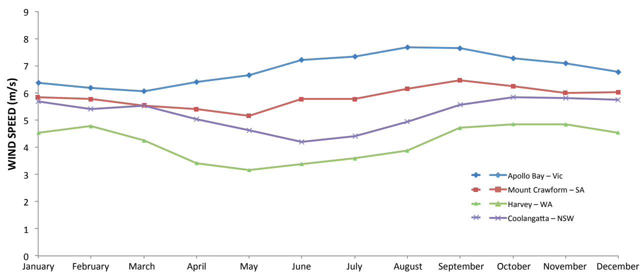
Remember: Wind is not constant; wind speed and direction can vary on a daily basis, but also during the year, depending on the season, and, of course, between years. For example:

- **Afternoons are likely to be more windy than mornings**
- **Sunny days tend to be not very windy**
- **Winter season generally has higher wind speeds than other seasons.**

Wind monitoring is an upfront cost but might save a farmer considerable expense if the site is found to be unsuitable.

Figure 6: Monthly wind speed variations for some Australian locations. NBA Consulting

Supply and installation – An Australian Standard AS 61400.2(INT)-2006 for small wind turbines has been developed based on International Standard IEC.



Australian Government rebates that are available for wind turbine systems will only be paid if the systems are installed by accredited persons. The Clean Energy Council has compiled lists of accredited installers (http://www.cleanenergycouncil.org.au/)

Maintenance –Maintenance instructions should be read and followed, and warranties and service agreements checked with the supplier. The system should be inspected twice a year by a qualified person. The inspection should include checking the blades for cracks, tightening bolts, and inspecting all moving parts and the tower itself.

What reduces wind power potential?

- **Wind is not constant –** it can vary dramatically from day to day and sometimes, from minute to minute.
- **Friction and drag –** in the rotor blades and gearbox, and losses at the generator, reduce power output to about one-third of the original power in the wind.
- **Inverters –** some of the power produced by the turbine is needed to run the inverter. Peak efficiency occurs when the inverter is running at two-thirds of its capacity.
- **Transmission –** electricity is lost as it is transmitted along wires. The greater the distance, the greater the loss.

Power production

Different wind turbines are compared by their maximum power output or 'rated' power. The rated power is often set by manufacturers as the power that can be produced in very strong winds of more than 12 m/s.

Manufacturers provide 'design' power curves for each turbine model, like the one shown in Figure 7. They show the instantaneous power output of a turbine at various wind speeds.

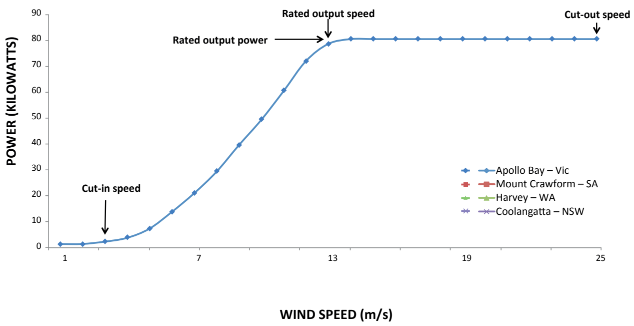


Figure 7: Source/permission

Every curve has three parts:

Cut-in speed: The speed at which the turbine first starts to rotate and generate power; it is typically between 3 and 4 metres per second.

Rated output power: As the wind speed rises above the cut-in speed, the level of electrical output power rises rapidly until reach its rated power.

Cut-out speed: The point at which the turbine will shut down due to excessive wind speeds.

Costs

The cost of a wind turbine system can vary greatly depending on the components and site characteristics. The size of the system, height of the tower and type of turbine, generator and inverter can all affect the price.

Installation costs can also vary. For example, engineering requirements for the base that supports the tower will depend on the soil type and its structural properties.

Table 3 provides a guide to prices. In general, about $10,000 needs to be added to the cost of the components for installation and connection to the grid.

Table 3: Estimates of systems costs for small wind turbines.[7]

Power rating (kW)	System costs before rebates ($)
1 – 2	10,000 – 20,000
2 – 3	20,000 – 30,000
3 – 6	35,000 – 60,000
10	60,000 – 100,000
20	200,000
50	300,000+

Renewable energy incentives

Wind turbine systems with a power output up to 10 kW that produce less than 25 MWh of electricity each year are eligible for a financial incentive under the Small-scale Renewable Energy Scheme (SRES). Each MWh of renewable electricity that can be produced by the system creates one small-scale technology certificate (STC).

Systems over 10 kW are considered to be power stations and are eligible for large-scale generation certificates (LGCs).

STCs have a dollar value which is paid for the energy produced over a 10-year period. Payments are made in three instalments – at installation, five years later and a final payment after 10 years. STCs can be traded, usually to the company supplying the system, for a reduction on the initial purchase cost. STCs can range from $15 to $40 each as they are subject to fluctuations.

For more information on renewable energy incentives, click here: (https://www.rec-registry.gov.au/sguCalculatorInit.shtml)

Advantages of wind power

- Wind is a free resource
- Many farms have suitable sites
- Minimal running costs after installation
- Systems can be expanded by adding more turbines
- Low land use

Disadvantages of wind power

- Wind speeds in some dairy districts may not be adequate to drive a turbine
- Energy output varies with changes in wind speed
- Peak power generation may not match peak load
- High initial cost
- Lengthy payback time

Does wind power suit dairy farms?

The main problems facing wind power as an energy source for dairy farms are the initial cost, the amount of power produced relative to the requirement and the time of day that power is produced.

Timing – Wind speeds tend to increase towards the afternoon (Figure 8). This type of wind speed variation is due to differential heating of the earth's surface during the daily radiation cycle.[9]

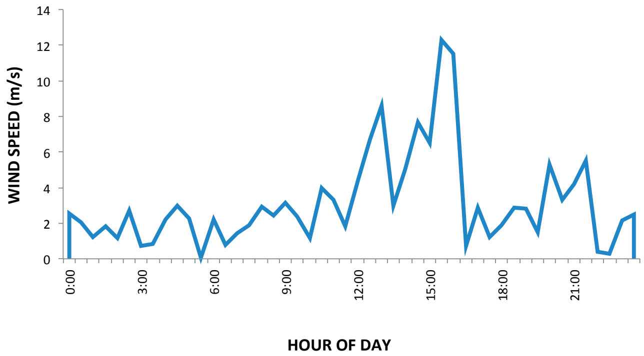


Figure 8: Daily Wind speed profile

As the wind power density is proportional to the cube of the wind speed, the wind power generated will have the same pattern shown in Figure 8. In other words, the maximum wind power generation will be reached during the afternoon (Figure 9).

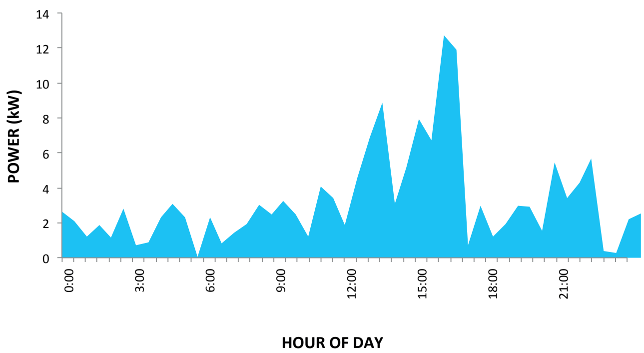


Figure 9: Daily Wind Power density.

On the other hand, energy consumption for a dairy farm occurs typically during the milking times generating a peak of consumption earlier in the morning and another during the afternoon. Other loads, such as hot water heating, are generally carried out during the night, taking advantage of off peak tariffs.

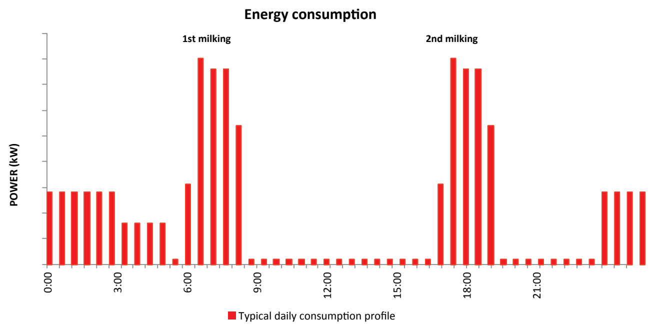


Figure 10: Typical dairy farm energy consumption. NBA Consulting

Joining the energy profiles (wind power generated and dairy load consumption) produces something similar to Figure 11, which shows that a big portion of the wind energy is not utilised.

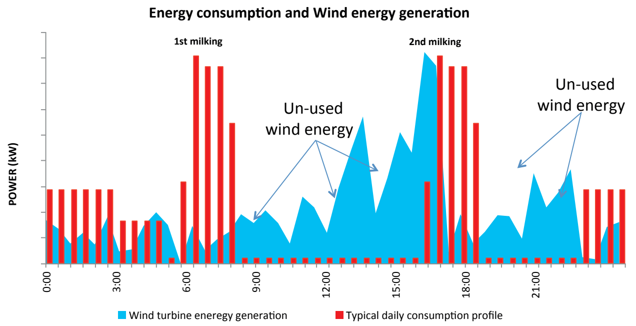


Figure 11: Dairy consumption profile and wind energy generation. NBA Consulting

One option for the un-used wind energy is to store the surplus. However, current battery storage is expensive. Another solution could be to export the surplus to the grid and 'borrow it back' when it is needed. However, this is only cost effective when the feed-in-tariff is significantly greater than the cost of mains power to allow for the capital cost of installing a wind power system. Another way to get the maximum advantage of the wind turbine energy generation may be rescheduling energy loads to the afternoon:

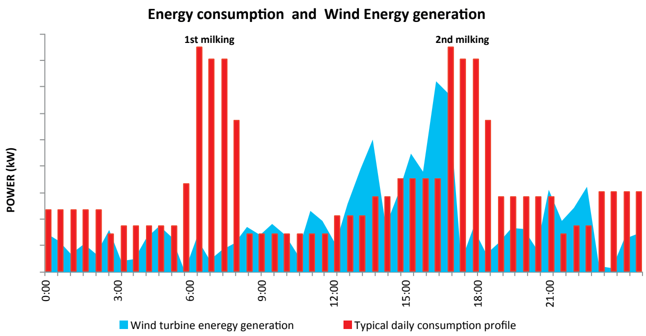


Figure 12: Ideal scenario (All wind energy generated is consumed). NBA Consulting

Wind speeds and directions are not constant. This variability and uncertainty means there is no guarantee that sufficient wind will be available for the afternoon milking on any one day.

Conclusion

Wind is a free source of power. Wind turbines have become an excellent option for providing energy in specific and suitable places where wind is abundant. Modern systems are designed to work for around 120,000 hours, however the life expectancy depend on the manufacturing quality. Regular maintenance and inspection should be done twice per year to make sure all components are still working properly.

The viability of wind turbines is highly dependent on the location. There must be enough wind to allow the turbine to work almost constantly during the day; good sites should have consistent wind speeds of 5 to 7 m/sec. If you are considering installing a wind turbine, a specific survey must be done.

Depending on the site, wind can be extremely variable: one day your wind turbine can be operational during the whole day and the next day it can shut down because there is not enough wind.

Current feed-in tariffs are much lower than the price of electricity, so it is most effective to have a wind turbine which displaces the use of grid electricity rather than to create surplus energy that is sold to the grid and must be bought back at much higher prices.

For many dairy farms, the demand does not match the energy generated by the wind turbine. To improve the cost effectiveness of the system, rescheduling dairy energy consumption should be investigated.

References and further reading

1. Bureau of Meteorology (2012) Average wind velocity – September; http://www.bom.gov.au/jsp/ncc/climate_averages/wind-velocity/index.jsp?period=sep.
2. UTS (2012) Small wind energy systems factsheet (draft). Institute for Sustainable Futures, University of Technology Sydney.
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9. NSW Small Wind Turbine Consumer Guide 2010. State of NSW and the Office of Environment and Heritage NSW.

Acknowledgements

Department of Industry – This Activity received funding from the Department of Industry as part of the Energy Efficiency Information Grants Program.

Dairy Australia – Dairy Australia gratefully acknowledges the contributions made by many people in producing this factsheet. Dairy Australia also acknowledges the co-funder which made this factsheet possible, the Department of Industry.

Note
Information and technology is changing rapidly in this area. Make sure you consult an expert about your individual circumstances to see whether renewable energy is an efficient and economic option for your farm.