Office of Environment & Heritage

NSW Small Wind Turbine Consumer Guide

Prepared by:
Enhar Sustainable Energy Solutions
Email: info@enhar.com.au
www.enhar.com.au

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Development of this Guide

This Guide was authored by Enhar during the period October-November 2010. It is an adaptation of the Victorian Consumer Guide to Small Wind Turbine Generation [Ref 1] prepared for Sustainability Victoria by Enhar. Sustainability Victoria provided permission for its content to be used for this Guide; this permission is gratefully acknowledged.

The NSW Office of Environment and Heritage (OEH) commissioned Enhar to revise this guide for the context of New South Wales, taking into account differences in feed in tariffs, development guidelines and installer contact details, plus accounting for new developments in wind turbine installer accreditation requirements which are effective nationally.

As part of the development of this Guide, a NSW Small Wind Industry Roundtable event was held on 15 November 2010 in Sydney. Invitees to this event included small wind turbine manufacturers, wind turbine installers, industry and trade associations, training organisations, skills councils and owners of small wind turbine systems. Feedback was taken from the attendants on the content of this Guide and a consultation was held on a draft of this document.

In May 2011, this Guide was updated to reflect recent changes to the NSW Solar Bonus Scheme and recent changes to NSW planning provisions relating to small wind turbines. These updates to the document were undertaken by OEH.

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Glossary

To help you understand a wind turbine system, a list of common terms used in relation to small wind energy is presented below:

Air density	Mass of air per unit of volume. Air density affects the energy available in the wind as with higher air density, more mass passes the blades for a given wind speed.
Airfoil	The shape of the blade cross-section, designed to create significant lift forces from the moving air.
Anemometer	A device that measures wind speed. A common type uses cups that use drag force to rotate a shaft.
Average wind speed	The mean wind speed over a specified period of time.
Blades	The aerodynamic surface that generates lift from the movement of the wind.
Brake	Various systems used to stop the rotor from turning.
Cut-in wind speed	The wind speed at which a wind turbine begins to generate electricity.
Cut-out wind speed	The wind speed at which a wind turbine ceases to generate electricity.
Downwind	On the opposite side from the direction from which the wind is blowing.

Feed in tariff	The rate at which the owner of a renewable generator is paid for exporting power to the grid.
Furling	Protection for the turbine where the rotor rotates out of the wind either in the yaw direction or by tilting back.
Grid	The utility power distribution system; the network that connects electricity generators to electricity users.
HAWT	Horizontal axis wind turbine.
Hub	The centre of the wind turbine rotor, where the blades join the shaft or each other.
Hub height	Vertical distance between the centre of the wind turbine rotor and the ground.
Inverter	A device that converts direct current (DC) to alternating current (AC).
kW	Kilowatt, a measure of power for electrical current (equal to 1000 watts).
kWh	Kilowatt-hour, a measure of energy equal to one kilowatt generated continually for one hour. You are normally charged in units of kWh on your power bill
MW	Megawatt, a measure of power (1,000,000 watts).
MWh	Megawatt-hour, a measure of energy equal to one megawatt generated continually for one hour.
Nacelle	The body of a propeller-type wind turbine, containing the gearbox (if the turbine has one), generator, blade hub, and other parts.
O&M Costs	Operation and maintenance costs.
Power coefficient	The ratio of the power extracted by a wind turbine to the power available in the wind stream.
Power curve	A chart showing a wind turbine's power output across a range of wind speeds. This should be measured in real field conditions, preferably by an independent accredited test centre.
Rated output capacity	The output power of a wind machine operating at the rated wind speed.
Rated wind speed	The lowest wind speed at which the rated output power of a wind turbine is produced.
Rotor	The rotating part of a wind turbine, including either the blades and blade assembly or the rotating portion of a generator.
Rotor diameter	The diameter of the circle swept by the rotor.
Rotor speed	The rotational speed of the wind turbine rotor.
Start-up wind speed	The wind speed at which a wind turbine rotor will begin to spin. See also 'cut-in windspeed'.
Swept area	The area swept by the turbine rotor, $A = \pi R2$, where R is the radius of the rotor and π is 3.142.
SWT	Small wind turbine.
Tip speed ratio	The speed of the tip of the rotor blade relative to earth divided by the wind speed. This is typically a design feature of the turbine.
Turbulence	Short term changes in wind speed and direction, frequently caused by obstacles such as trees and houses. Turbulence extends some distance downwind from the obstacles and also above the obstacles, so your turbine should be sited outside of these zones.
Upwind	On the same side as the direction from which the wind is blowing; windward.
VAWT	Vertical axis wind turbine.
Wind farm	A group of wind turbines, often owned and maintained by one company.
Yaw	The rotation of the rotor and nacelle about a vertical axis, allowing the turbine to stay facing into the wind.

With acknowledgements to the Consumers Guide to Small Wind Electricity Systems by K. O'Dell of NREL, USA (2004), reproduced by various state governments of the USA, on whose glossary of terms the above list is based. We also acknowledge Daniel Jones from RISE who provided valuable feedback on the glossary.

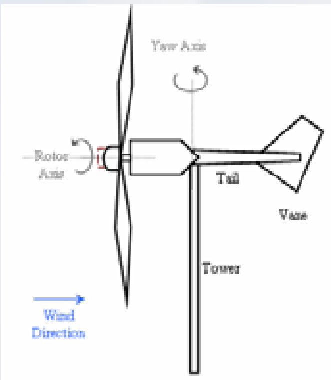
Quick Guide

In NSW, small wind turbines sized to suit domestic properties, farms or small businesses are becoming increasingly popular. Small wind turbines offer several benefits:

- ✓ generate your own electricity
- ✓ attract rebates and government incentives
- ✓ provide power day and night
- ✓ environmentally friendly, no carbon emissions
- ✓ financially attractive in high wind areas

What is a small wind turbine?

'Small wind turbines' are generally those rated at 10kW or less. Mid sized wind turbines range up to several hundred kilowatts. A typical wind system consists of a turbine, a tower, a controller, a grid connected inverter and a meter.



Off-grid wind turbines are linked to battery systems for remote properties. Grid connected wind turbines export power into the electricity grid.

Most modern small wind turbines are sufficiently quiet that you can hold a normal conversation at the base of an operating turbine without needing to raise your voice.

How much energy do they produce?

A 10kW wind turbine on a windy site may generate 25,000kWh per year. This is around three times the average power consumption of a domestic residence in NSW. A 3kW turbine might generate 9,000kWh per year.

What size are they?

A 2-3 kW turbine is around 3-4m in diameter, usually mounted on a tower between 12m and 18m tall. A 10kW turbine is usually 7-10m in diameter, normally mounted on a 12-30m tower.

Wind speeds generally increase with elevation, hence increased tower height can assist to boost turbine yields. Common tower types include guyed and monopole. Foundations are required, up to 3m wide by 2m deep for 10kW systems.

Wind turbine systems can also be mounted on buildings where the building design is suitable for the structural loading caused by the wind turbine system.

Is my site suitable?

Your site is suitable for a small wind turbine if it has:

- ✓ good wind resources
- ✓ turbine location sufficiently close to grid connection
- ✓ location for economic installation costs
- ✓ sufficient distance to neighbouring dwellings to meet noise criteria
- ✓ local grid infrastructure suitable for supporting your wind generation.

Other important siting considerations include:

- ✓ soil type (for turbine foundation)
- ✓ crane and concrete truck access
- ✓ set backs fromw roads and power lines.

Building-mounted installations have special requirements including careful assessment of building loading codes, turbulence at roof edges, vibration and amenity considerations.

Wind resource

Wind turbines require a consistent flow of wind all year round un-interrupted by nearby objects such as trees and buildings. Rural, hilltop and coastal locations offer strong wind resources, tall city buildings can also offer strong wind resources.

For most sites wind monitoring is recommended for confidence in the turbine performance predictions. Anemometer systems to record wind speeds can be purchased for a few hundred dollars.

Annual average wind speeds at your turbine position and height should be at least 4.5m/s-5m/s. More attractive paybacks are achieved at sites with 6m/s and above.

Financial incentives

Government financial incentives are in place for small wind turbines. Small wind systems also generate Renewable Energy Certificates (RECs), which can be sold throughout the project lifetime. Owners earn between approximately five to 25 percent of the initial capital cost of the small wind system from RECs. The capital cost of small wind turbines can also be depreciated against tax.

In general, payback periods of recent installations vary between seven and ten years, however this may vary as state and federal policy incentives are updated.

Milton - 5.8kW turbine for home/farm

Choosing a turbine

You can choose a turbine size to offset your annual power usage or to optimise economic benefits. Manufacturers of turbines appoint approved regional distributors or a company may design, manufacture and install your system. A range of small wind turbines available in NSW is provided in this Guide.

To minimise turbine failure and ensure high standards of safety, consumers are advised to select turbine products with demonstrated track records and which meet appropriate standards.

Australian standards for wind loading apply to tower and turbine systems, while compliance with the international standard for small wind turbines demonstrates that safety and reliability tests have been met.

Most retailers provide 'power performance curves' for their turbines, that is, the purported amount of electricity generated at various wind speeds. In making a purchasing decision, it may be prudent to check whether independent, verified power performance data for the wind turbine is available.

Noise levels from the turbine should be certified to recognised international standards. Properly measured 'sound power level' data assists in complying with development approval requirements for turbine siting.

Development approvals

Planning approval needs to be considered when contemplating installing a small wind turbine.

Some small wind turbine installations may be subject to what's called 'exempt or complying development' provisions. These provisions provide for a simpler approval process, however you must satisfy certain requirements, for example, you may need to install the turbine at a nominated distance from neighbouring houses for the provisions to apply.

Noise is considered during the approval process for small wind turbines. If development consent is required from the local council, you'll most likely need to supply a noise impact assessment as part of your application.

It is important that you establish what type of planning approval is needed, because noise and other environmental impacts are considered as part of that process.

The NSW Department of Planning and Infrastructure (DoP&I) has introduced additional planning provisions for small wind turbines in rural and other zones. The provisions will allow turbines that meet prescribed performance standards to qualify as exempt development or complying development

Finding an installer

Once you have decided on a turbine product to install you should contact the manufacturer to find an installer in the local area. Installers of small wind turbines in Australia are required to hold endorsement from the Clean Energy Council. Contact wind-endorsed CEC installers, arrange for them to visit your site and request a full quote. Compare quotes and choose your installer. Normal timescales from down-payment to completion vary between several weeks and a couple of months.

Homsbury - 15kW turbine for rural fire station

Chapter 1. Introduction

1.1 Background

If you are interested in purchasing a small wind turbine for your home or business in New South Wales, this Guide is for you. You will find useful information here to assist you make an informed decision about whether to purchase a wind turbine system and what type of wind system to get. By 'small' wind turbine, we mean a turbine of a size that would suit the needs of a domestic dwelling or small business. These are less than 150kW maximum capacity and are most commonly in the range of 1-10kW. 'Large' wind turbines are those used on wind farms for utility scale power generation, and are generally about one hundred times bigger than the wind turbines referred to in this Guide.

If you want a wind turbine system to supply power to your school, community organisation or small business, you may be considering a system larger than those used for domestic houses. This guide also provides information which remains relevant for medium sized wind turbines.

Wind turbines:

- ✓ use wind power to generate electricity for your use
- ✓ store excess electricity in batteries for later use, or feed electricity into the grid to reduce your electricity bill.

1.2 Benefits of small wind turbines

Benefits of a wind turbine system to the householder or small business

- ✓ Wind turbine systems generate electricity
- ✓ Wind turbines operate day and night – whenever it is windy
- ✓ Wind powered electricity creates no greenhouse gases or other harmful pollutants
- ✓ Once you have paid for the system, the wind turbine generates power from a 'free' and inexhaustible source – the wind
- ✓ Wind electricity can complement a solar system
- ✓ A wind turbine can supplement or supply all of your power needs.

1.3 System overview

A small wind turbine system comes with several important components. The diagram below represents a typical small wind turbine (SWT) system at a house.

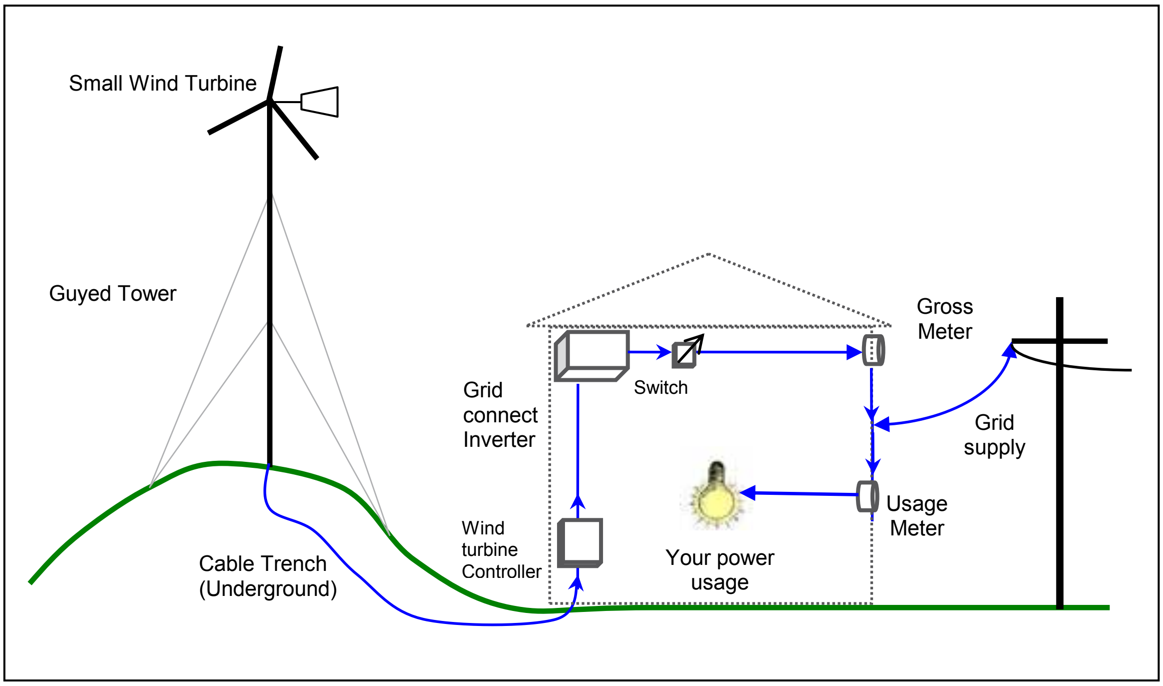


Figure 1.1: Typical wind turbine system overview

This illustration shows how a grid-connected SWT works. The meter arrangement shown here is for a 'gross metering' situation.

The diagram shows a three-bladed wind turbine sitting atop a guyed tower. The electricity generated by the wind turbine is shown travelling to a controller through a cable trench. The controller makes sure the turbine is operating within safe limits and rectifies the varying frequency AC to DC. The DC power is then passed to an inverter where it is converted into AC power of the same voltage and frequency as electricity from the grid.

There is a switch to disconnect your inverter and wind turbine system for maintenance if required. Electricity travels from your wind turbine inverter to your gross meter which records how much electric power is generated by your wind turbine, day and night. This allows your energy provider to measure the amount of power for which they are to pay you. This gross meter allows power to flow from your turbine to the grid whenever your turbine is generating power.

If you are considering a wind turbine, questions you should ask include:	
Is my site suitable for a wind turbine?	*Advice on confirming site suitability is given in Chapter 2*
How do I choose a turbine?	*Advice on choosing a wind turbine is given in Chapter 3*
How much energy will I generate?	*Advice on forecast power generation is given in Chapters 2 and 3*
What is the likely payback period?	*Advice on economics and payback is given in Chapter 3*
What funding is available in NSW?	*Information on funding sources is given in Chapter 3*
How do I obtain development approval?	*Advice on development approval is given in Chapter 4*
How do I sell my generated electricity?	*Pointers on how to sell your exported power are given in Chapter 5*
Are there examples of wind turbine installations that are relevant to me?	*Case study examples of several wind turbine installations are given in Chapter 6*
Where are wind turbines available for sale in NSW?	*Appendix B gives a list of available wind turbine products*
Where can I find an installer?	*Refer to Appendix B to learn where you can find wind installers active in NSW*

Also connected to the grid is your usage meter which records the amount of power which you consume from the grid, and is the amount for which you are charged by your energy provider.

'Net metering' is an available alternative to gross metering and is described in Section 5.4. Economic considerations influencing your decision to install either a gross or a net meter are discussed in Section 3.10.4.

1.4 How long will it take to get a wind turbine installed?

The process from first choosing a wind turbine to having it installed is likely to take several months. The Process Flowchart on the following page will give you an idea of what the overall process might look like.

YOUR WIND TURBINE PROJECT FLOWCHART

1. Site and feasibility assessment

Wind resource assessment

Options:

- Wind monitoring using an anemometer
- Online estimation tools
- Observation of wind speed indicators
- Consulting with an installer
- Checking Bureau of Meteorology Data

Turbine location

Consider:

- Distance to obstacles such as trees
- Proximity to your dwelling and to your neighbours' properties
- Public amenity
- Environmental impacts (eg birds and bats)

Budget estimation

Consider cost of:

- Site assessment
- Consultation fees
- Turbine, tower, inverter and controller
- Development approval fees
- Installation and maintenance fees
- Consider earnings from:
- Renewable Energy Credits

2. System design

Conduct your own research or contact an installer for its design recommendations.

Choose a:

- Turbine
- Tower
- Inverter
- Controller

which is well suited to your wind resource, site and budget.

Finance calculations

- Get firm quote for cost of system, installation and maintenance
- Estimate electricity generation
- Calculate Renewable Energy Credits (RECs)

3. Development approval

Contact your local council to confirm planning requirements.

Supply your council with your project details as requested to obtain relevant permits to proceed.

4. System installation

Choose a competent installer to undertake this job. The installation team must include a qualified electrician and a licensed builder.

Discuss with your installer the different options for gaining financial benefits from your RECs:

- Upfront discount
- Assist as an agent
- Become an individual trader

Arrange a gross or net meter to be installed and connected.

The system is installed and connected to the grid by your chosen installer team.

5. System operation

If you have elected to become an individual RECs trader, you can now begin the process of applying for and registering your RECs.

Begin using electricity generated from your turbine in your house. Earnings will be made from all power generated by your turbine. When necessary, electricity will be imported from the grid.

Ensure your wind turbine system is regularly maintained by a qualified person.

Chapter 2. Assessing your site

Before proceeding, you should ensure that your site is going to be a good candidate for a wind turbine. It is essential that you have strong and consistent winds at the turbine location. Low turbulence wind is preferred and also the turbine and its tower structure must be an acceptable addition to the local neighbourhood.

In this chapter, you will learn:

- ✓ what type of site is suitable for a small wind turbine
- ✓ methods to estimate and measure the strength of your wind resource
- ✓ the effect that local obstacles and turbulence have on your wind turbine
- ✓ development consent and budget considerations associated with wind resource assessment.

It is also likely to be worthwhile consulting a professional wind installer for advice on whether your site has a suitable wind resource. Details of accredited renewable energy installers with wind endorsements are available through the Clean Energy Council – see Chapter 5 and Appendix B for further information.

2.1 Site wind speed and annual yield estimation

To know how much power your turbine will produce, you firstly must know what the average wind speed is at the turbine position. Wind turbine brochures often provide an estimated annual yield calculated from average daily yield in kWh, based on your annual wind speed in m/s. To illustrate how much your wind speed affects your annual yield, we have produced the graph below.

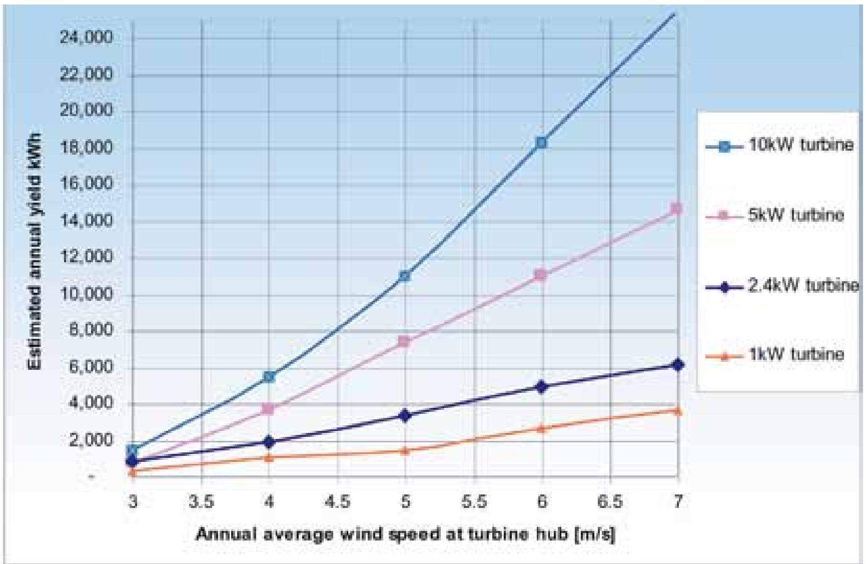


Figure 2.1: Variation of wind turbine yield with annual average wind speed

Each of the lines in the above graph is based on performance information from real turbines, from specifications published by the manufacturer of the turbines. You can see from this graph that the difference between a 4m/s site and a 6m/s site is more than twice the annual energy from any turbine. In fact, the power in the wind is proportional to the wind speed cubed, which means a small increase in speed causes a large increase in energy. The previous graph is only intended as a guide – not an absolute rule – of how much your turbine will generate.

Monitoring the wind speed is a way to find out a more exact estimate of how much a wind turbine will generate at your site. However, this is an up-front cost that you need to undertake normally at your own risk, meaning that if you find out that the wind speed is too low, you will have paid for monitoring but may choose not to proceed with installing a wind turbine. Some wind turbine installation companies may offer to supply wind monitoring equipment to you to test your site and then discount the cost of the monitoring off the final price of your turbine if you decide to go ahead.

A much debated point in small-scale wind energy is whether you are better off to save the money you would have spent on setting up a monitoring system, trust that the wind turbine will work, and put that saving towards purchasing your wind turbine system. This would only be a wise choice if you have a very strong wind resource in the first place; so strong that you don't need monitoring to confirm it. Indicators of a very strong wind resource are listed below.

If online data sources indicate strong winds in your region and your site is well exposed to regional and local winds, without any sheltering objects nearby, then you probably don't need to monitor to confirm your resource.

You can estimate your regional wind resource online, using data from the following sources for example:

i) Global 'Firstlook' database, available from 3Tier – www.3tier.com.

You can register for free and view a 5 km grid of relative windiness at any address globally.

Wind reports are also available at www.rewindenergy.com.au, which includes a wind speed estimated range at 14 m above ground level.

ii) The NSW Wind Atlas – a wind speed map at 8 km resolution, showing annual average wind speeds at 65 m above ground for the whole of NSW, available from the NSW Department of Trade and Investment, Regional Infrastructure and Services [Ref 2].

Bear in mind that at your turbine hub height, say 20 m, the wind resource will be lower than the mapped 65 m values. This map was produced for the large scale wind farm industry and at an 8 km resolution, indicates wind resource levels regionally.

When using wind maps such as i) and ii), bear in mind that wind resource is not uniform over the 8 km or 5 km grid used in these applications. This means that local effects such as sheltering from trees or houses can dominate at your site, causing significant differences between your site and the regional average; these are not shown on the online wind maps.

The NSW Wind Atlas [Ref 2] advises: *'The wind speed colours shown on the Atlas are accurate to a resolution of 8 km. While the Atlas gives a general impression of the NSW wind resource, it does not incorporate the effects of local landscape features smaller than 8 km in size, like small hills and ridges. Consequently, the Atlas cannot be used as the sole means for siting a wind farm.'*

iii) You can also refer to the Bureau of Meteorology (BoM) data published at www.bom.gov.au to check if you have a bureau station nearby. Most BoM stations record wind speed; you can tell from the site description whether wind speed records are shown. The wind speeds are normally measured at 10 m above ground level.

Bear in mind that different topography and obstacles surrounding your site compared to the BoM site will give rise to differences in wind resource. In general though, at the very least, the BoM data will give you a guide to the major local prevailing wind directions.

Once you have established that your region has strong wind resources, say above 7 m/s at 65 m, you can be confident that your site will have good wind resources if your proposed turbine location is free of obstacles in the prevailing wind directions and/or is on ground elevated about the surrounding topography.

Local vegetation grows windswept. As a supplementary indication to the other methods listed, one useful indicator of strong long-term prevailing winds is bushes and trees growing at an acute angle. The diagram below gives you some idea of the mean wind speeds which relate to conifer growth.

No deformity	*Brushing and slight flagging*	*Slight flagging*	*Moderate flagging*	*Complete flagging*	*Partial throwing*	*Complete throwing*	*Carpeting*
Speed @ 30m	*3-4 m/s*	*4-5 m/s*	*5-6 m/s*	*6-7 m/s*	*7-8 m/s*	*8-9 m/s*	*10 m/s+*

Figure 2.2: The Griggs-Putnam Index [Ref 3] linking tree growth to probable long-term average wind speeds at 30 m above ground level

Remember, if your turbine tower is lower than 30 m, the wind speed will also be lower than the table above suggests, due to a phenomenon called 'wind shear', which causes wind speeds at lower levels to be slower than higher levels.

Surrounding area is very open, grassy and free of trees and other houses. If your local area is open in all the main prevailing wind directions, with no trees or houses blocking the wind, then you can probably expect at least a moderate wind resource. If this is combined with the confirmation that your region has a high wind resource from wind maps (see above) then you probably have a high wind resource site.

Turbine position is on hilltop higher than surrounding obstacles. If you have an available site for your turbine which is atop a hill (whose peak is at least 20-40 m above the local surrounding area) and free of obstacles in the prevailing wind directions, then you probably have a good wind resource site.

Urban areas: These are less likely to have good wind resource sites compared to open rural areas, as demonstrated in urban wind resource studies. Some of the best urban wind resources are to be found along shorelines and atop tall buildings.

Will my installer be able to provide an on-the-spot estimate of my wind resource?

Yes, usually your installer will be able to provide a judgement on the likely productivity of your wind turbine. It is important to note that an educated estimate of wind speed from your installer isn't the same as a guarantee of turbine output.

You should invite wind turbine installers to visit your site and use their experience to assess your wind resource. This will allow them to advise on other aspects of the installation, which will be useful in planning your project, and provide a quotation based on real knowledge of your site.

Where can I go for further information on estimating wind resources?

There are many guides to estimating your wind resource and wind turbine productivity; some of these are published on the internet and are listed in the References Chapter below.

2.2 Avoiding excessive turbulence

What is turbulence?

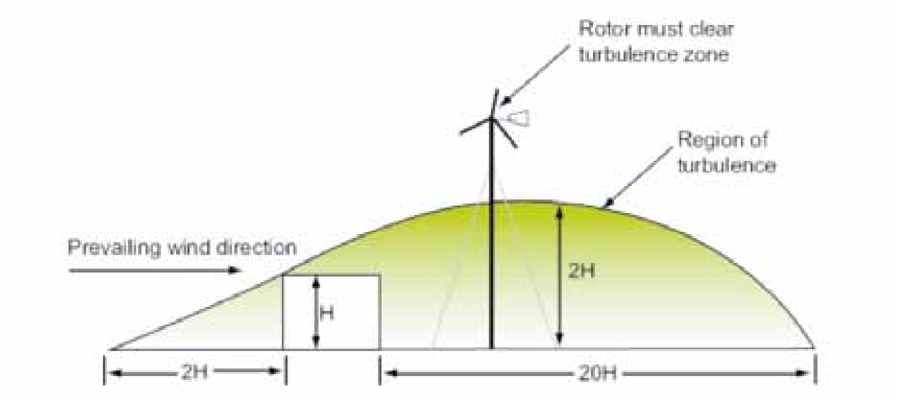


Figure 2.3: Turbulence 'shadow' cast by obstacle

Bear in mind that as well as wind speed, there is another important factor in your local wind climate – turbulence. Turbulence is the fluctuation of wind speed and direction due to eddies and other small-scale circulation of wind.

If the turbulence is low, this means you have smoother flow, whereas if it is higher you have more turbulent flow. Higher turbulence in the wind causes mechanical stresses on the wind turbine and tower structure, reducing the energy captured by the turbine. Therefore sites with lower turbulence are preferable.

The diagram above [extracted from Ref 4] illustrates how to avoid turbulence from an isolated obstacle of height, H.

2.3 Wind monitoring

Wind monitoring is the key for accurately estimating the electrical power supplied by your wind turbine. If you are unsure of your resource, you are strongly advised to monitor it using the techniques described in this section.

If online data sources indicate strong winds in your region and your site is well exposed to regional and local winds, without any sheltering objects nearby, then you probably don't need to monitor to confirm your resource.

This section provides step-by-step guidance on how to install and program anemometers and data loggers and includes a description of simple anemometers and data loggers, their installation, programming, and evaluation of wind data.

Professional wind installers and consultants can also provide advice and wind monitoring services.

2.3.1 I know it is windy here. Why do I need to measure it?

Because wind turbine output is so sensitive to wind speed, even 'small' differences in speed cause a big difference in energy output. Personal experiences of local winds are unfortunately an inaccurate way of determining wind velocities. The turbine output is a long-term function of the variation of wind speeds over days, months and years, so the 'spot values' you experience from time to time, even if you did know the exact wind velocity, are not equal to the more important long-term average.

2.3.2 Monitoring wind speed will be costly, why should I spend the extra money?

Monitoring is the best way to be sure, in advance, of how much power your wind turbine will produce and to avoid the risk of ending up with a poorly performing system. At locations with sheltering in some directions, the speeds at your turbine position may be marginal, causing your final power output to be disappointing.

Some advisors may suggest to 'suck it and see', to avoid the time and expense of monitoring. While this might suffice for a small wind turbine at a very windy site, if you are making an investment in a larger turbine or are in an area of moderate wind, or you are unsure of your wind resource, the cost of monitoring is likely to be very worthwhile

If an anemometer was purchased prior to the installation of a wind turbine it can further add value to the system by providing a useful gauge of whether the turbine is continuing to perform properly.

Another benefit of monitoring wind speeds is that if you can demonstrate a very good wind resource with measured wind data, there is a good chance you can claim a higher number of Renewable Energy Certificates (RECs), and therefore more income for your site.

2.3.3 What are anemometers and wind vanes?

An anemometer is a device used to measure wind speed. The most common and simple type in use is a 'cup' type, which consists of cups that catch the wind and spin at a rate which is proportional to the wind speed. Cup anemometers often come with wind vanes which measure wind direction. Wind vanes have a rudder type shape which causes them to line up with the incoming wind direction. Anemometers and wind vanes are often attached to each other as a single unit.

Some examples of anemometers with wind vanes are shown in Figure 2.4.

Weather monitoring kits include rain gauges and anemometers; these can be a cost effective method to obtain a first estimate of wind resource at your site. Low cost equipment generally provides lower accuracy and may not come with the warranties available with higher cost equipment.

NRG anemometer and vane

Davis Instruments anemometer and wind vane product code 7911

APRS anemometer and vane

Figure 2.4: Examples of cup anemometers with wind vanes

2.3.4 What sort of data format is most useful?

Wind speed is the most important measurement; the more precise the better. Wind speed generally fluctuates up and down during any given interval. Anemometer systems generally sample at a high frequency such as once every second, however the data is recorded on the basis of a longer averaging period. Short averaging periods such as one minute allow for more accurate analysis, however you should consider managing the available memory storage and your data handling time. Wind speeds should be set to meters per second to save time converting wind speeds if other units are used.

Wind direction is also important for your study. The wind direction data should ideally be recorded in degrees, using the meteorological convention of zero at north, running clockwise through the compass.

Turbulence is also an important piece of data that can be recorded by an anemometer system. As stated before, sites with low turbulence are preferable.

Other data such as temperature and pressure may be recorded by your system, especially if it is a weather station. This information may be of some interest but is not essential for your wind feasibility study.

2.3.5 What are data loggers?

Data loggers record the wind speed records and store them so you can retrieve them later. Some examples of data loggers are shown in Figure 2.5.

Figure 2.5: Examples of wind data loggers

Your data logger will come with either a paper manual or an online manual. It may also come with software to download and analyse the data. If you are relying on battery power rather than mains power, make sure you start with new and high quality batteries to ensure continual operation. Reading the manual can determine how long the batteries will last and when they should be replaced to avoid losing weeks or months of data.

It is recommended that you visit your wind mast regularly to collect data and to check the system. Your periodic wind monitoring checklist should include whether:

✓ anemometer and vane are working (cups are moving in response to current breeze, vane is pointing downwind)

✓ logger is receiving data (screen shows data being currently read and batteries are working) pole is vertical

✓ tension in any guy wires is okay

✓ damage from birds or other animals has not occurred (eg birds such as Cockatiels have not pecked through cables)

✓ data received is okay (data reads properly in your computer and makes sense when graphed).

2.3.6 Where can I get an anemometer system?

You can purchase a low cost wind monitoring kit from:

- EBay (be aware these may not come with warranties)
- Alternative Technology Association (www.ata.org.au) or Energy Matters (www.energymatters.com.au)
- www.davisnet.com.au (Davis wireless anemometers and weather stations)
- Wise Wind – Australian distributor of the Power Predictor from Better Generation, a relatively new anemometer product designed for domestic scale wind project feasibility.

Advanced anemometers such as ultrasonic are also available. These have the advantage of three dimensional wind profiling and no moving parts, however they normally come at a considerably higher cost than the cup type anemometers listed above.

There are other sources of anemometer kits – you should look around for the supplier that best suits you.

If you know that you want to monitor several sites, it may be worth investing in a higher grade anemometer and re-using it at multiple sites.

2.3.7 What sort of pole should I mount the anemometer on?

Wind speed varies with height above ground; it is generally weaker and more turbulent at lower levels and stronger and less turbulent at higher levels. You should therefore plan for the hub height of your wind turbine to be a good distance above the ground. It is best to mount the anemometer as close to the turbine 'hub height' as possible, so that you measure representative winds. If you end up monitoring at a lower height than the wind turbine, your wind data will generally underestimate the energy output of the turbine.

You can account for this by estimating the increase in wind speed from your monitoring height to the turbine hub height using a 'shear profile' calculation. However, this will introduce some uncertainty into your estimate, which means you may end up needing to be more conservative than if you had monitored higher up at turbine hub height.

You can install a pole yourself or ask a local company to do it for you. TV antenna masts, which are in common use on top of houses, are up to 15 m tall and are equally suited to installation on the ground for wind monitoring at prospective ground-mounted turbine locations. These are telescopic poles which can be installed by two or three people; this process would normally take a day or less.

Local TV installation companies that deal with improving your TV reception are likely to have experience in installing telescopic poles and would have the suitable skills and equipment for this type of work. CEC endorsed wind installers (see Chapter 5.1) can provide or advise on wind monitoring solutions. The cost of the pole installation including labour will be significant; it may well be higher than the costs of the anemometer itself, but is a worthwhile investment for the reasons stated above.

When mounting the anemometer on the pole, it should be positioned to experience the least disturbance from the pole itself. If you are installing an anemometer on an existing structure, it would be advisable to build a horizontal arm which holds the anemometer far from flow disturbances around the existing structure.

For the perfectionist, there is an International Standard called IEC61400-12, which specifies wind speed monitoring including the mounting of anemometers. This set of standards is written for large scale wind farming but will also be of interest to the dedicated small wind turbine project manager. Standards can be obtained free of charge through library subscriptions, or at a cost from the SAI Global or Standards Australia websites.

2.3.8 A word of caution against over-reliance on wind monitoring

Wind speed measurement by anemometers assists in making power yield estimates, however the more basic anemometer systems that are affordable for small wind projects may not take into account subtle effects such as turbulence and rapid directional changes.

These effects may cause your turbine to generate less power than would be expected from the annual mean wind speed data alone. Guarantees of annual output from wind turbines are rare, even when recorded wind data is obtained.

CASE STUDY – MR MARQUARDT'S WIND MONITORING SYSTEM

Interested in setting up a grid-connected wind turbine at his rural property, Mr Marquardt purchased a Davis anemometer and built a 5 m pole. He installed this at his prospective wind turbine site over 18 months ago. After downloading the data from the logger onto his laptop at regular intervals, Mr Marquardt engaged a consultant to analyse his wind data.

The consultants' report showed that the long-term wind speed at 5 m above ground was 4.3 m/s – and taking wind shear into account – would be around 5.3 m/s at 15 m and 5.5 m/s at 20 m.

The annual output of two turbines was predicted at 4,900 kWh/year for 2.4 kW turbines and 11,300kWh/year for 6kW turbines.

This allowed Mr Marquardt to estimate his annual returns if he were to invest in a wind turbine system.

9m wind monitoring mast with Davis equipment

2.3.9 Do I need a development approval to monitor winds?

In NSW there are currently no state-wide planning provisions designed for small scale wind monitoring masts.

Under Clause 39 of the State Environmental Planning Policy (Infrastructure) 2007 [Ref 5], large scale wind monitoring systems up to 110 m in height are exempt from the need to obtain a development approval, providing:

- the structure is in place for less than 30 months
- the structure is in a location enclosed by a fence preventing unauthorised entry (ie not
  accessible to the public)
- the structure is not within 100 m of any public road
- the structure is at least 1 km from any dwelling, except by prior written permission from the owner of that dwelling
- the Civil Aviation Safety Authority has been notified in writing before the mast is installed, including:
  (i) the tower's 'as constructed' longitude and latitude coordinates
  (ii) the ground level elevation at the base of the tower, referenced to the Australian Height Datum
  (iii) the height from ground level (existing) to the topmost point of the tower (including all attachments)
  (iv) the elevation to the top of the tower (including all attachments), referenced to the Australian Height Datum
  (v) the date proposed to remove the tower.

You can proceed without a permit if your anemometer mast meets the above criteria.The exempt development provisions, described in Chapter 4, include provisions for wind monitoring towers associated with small wind turbines. Your local council's Local Environment Plan (LEP) may also refer to planning provisions for wind monitoring masts.

Temporary structures below a certain height may also be exempt or complying development in your local Council LEP. Enquire to your local council regarding whether a temporary wind monitoring mast could qualify under such provisions.

If a development approval is required, you will need to submit a development approval application to your local council along with a description of the mast including location, height and date it is expected to be removed.

2.3.10 How long should I leave the wind monitoring system in place?

Wind climates experience cycles of many timescales including very short timescales (minutes) to long timescales (seasonal patterns). As a minimum you should monitor wind speed for several months; the longer the better.

2.3.11 How do I analyse the wind speed information?

The wind records will contain a lot of speed and direction data. If your logger system came with software, you can use this to do some of the analysis.

You should check through the data and exclude any periods when the logger was not recording or the instrument was known to be faulty or out of action. Only 'true' records should be included in your averaging calculation. If using Excel spreadsheet, you can use the 'average' function to determine your long-term wind speed.

Some systems may come with a facility to upload your measured data to a website where the analysis is performed for you.

Wind climates vary through seasons and also vary from year to year. Therefore you might like to obtain wind data from a nearby Bureau of Meteorology Station that is concurrent with your recorded site wind data, plus long term records from the same Bureau Station for a longer period such as several years. By comparing the average of the Bureau site wind speed during the period of your site monitoring to the Bureau average over the long-term period, you can estimate whether the period you measured was more or less windy than normal. You can then make an adjustment to your estimate to obtain an estimate of long-term wind speed at your site.

2.4 Budget for assessing your site

You could buy an anemometer and vane with logger for as little as $200, or up to $1,200 for the wireless anemometer products discussed above. A 9 m mounting pole with guy ropes purchased and installed yourself could be as little as $200, while a professionally installed 15 m telescopic system could be upwards of $2,000. Higher quality and more reliable products are generally worth paying more for, since they help to properly assess the site.

If a development approval application is required, application fees of several hundred dollars will be payable to your local council.

2.5 Suitability of local grid infrastructure

The continued performance of a grid connected wind turbine is dependent on the response of the local grid infrastructure to the presence of the wind turbine. The ability of the turbine and its inverter to operate properly may also be dependent on other factors external to the customer site, which affect the local grid.

Ask your installer to confirm that the power line between your meter and the local transformer will be able to accommodate your wind turbine system properly. Are the specifications of the local power line sufficient to allow your turbine and inverter system to export power continuously?

Chapter 3. Choosing a turbine

In this chapter you will learn:

- ✓ what types of wind turbine are available
- ✓ how to choose a wind turbine that suits your needs
- ✓ about important safety features of small wind turbines
- ✓ about particular requirements for turbines at urban sites
- ✓ how much a wind system will cost and what rebates are available.

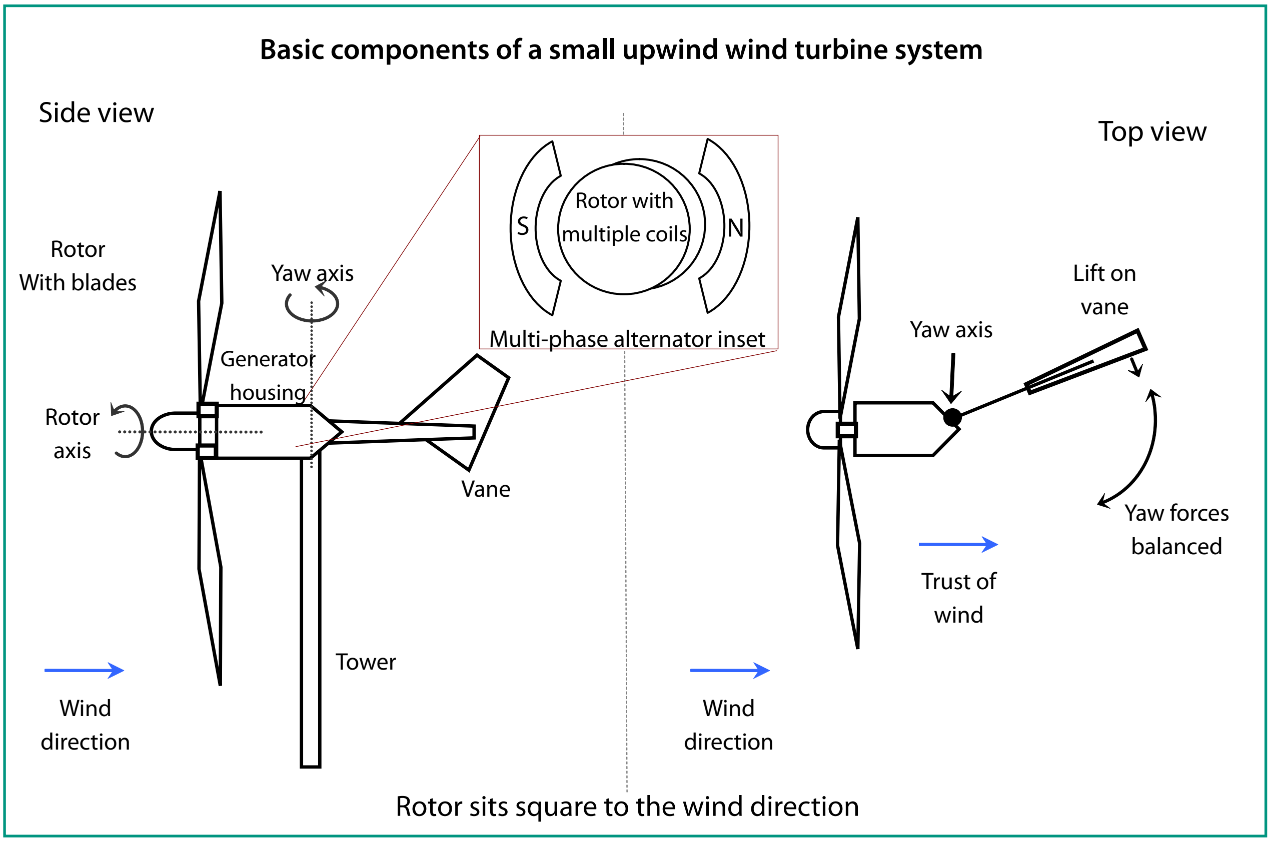


Figure 3.1: Basic components of an upwind wind turbine

The above diagram shows the basic components of a horizontal axis small wind electric system with a multi-phase permanent magnet alternator as the inset. The turbine rotates on a vertical axis called the yaw axis and faces the rotor with blades square-on into the wind direction. This is an upwind machine (ie the rotor is located upwind of the tower).

The rotor itself rotates on a horizontal axis through aerodynamic forces. There are two types of aerodynamic forces – lift and drag. It is the lift effect that is the primary force causing the blades to rotate. When the blades are turning, this mechanical energy is converted into electrical energy using an alternator, which produces alternating current (AC) electricity. Copper or aluminium coils attached to the rotor through a shaft rotate in a magnetic field generated by fixed permanent magnets. A bridge rectifier, which can be contained within or on the outside of the generator housing, converts AC electricity to direct current (DC). Some systems have a mechanism that allows the rotor to turn or furl and reduce the area of the blades facing the wind to protect it from damage during high wind speeds.

Refer to Appendix B for a selection of wind turbines available in NSW.

Below is a basic flowchart outlining how to choose the right turbine.

Consider your power demand and your estimated/measured site wind speed, then the size turbine required to meet your demand (see Figure 2.1)

↓

Review the wind turbine types on the market (see Appendix B)

↓

Select one or more turbine(s) that may suit your needs

↓

Ask the manufacturer of the selected turbine(s) to identify a local installer qualified to install its turbines

↓

Contact the installer to request information about its services

↓

Arrange for the installer(s) to visit your site

↓

Obtain full quotations from the installer(s) for the chosen turbine(s)

↓

Confirm your turbine type in light of these quotations

Alternatively, you can start by identifying local installers who service your area, then enquire what turbine types they recommend:

Contact your local wind turbine installer

↓

Find out what turbine type and size your local installers offer

↓

Select your turbine type and size in consultation with your installer, to suit your site and power demand

An energy audit of your house prior to choosing a suitable wind turbine will also help you take advantage of any energy efficiency opportunities in your household. This will be beneficial later on to maximise your potential earnings from the net feed-in tariff. The less electricity you consume and the more you export to the grid will allow for the best financial outcome under a net arrangement. Information on how to conduct a household energy audit can be found in Chapter 7 under Further Reading.

3.1 Approved wind turbine products

In relation to rebate eligibility, there is currently no formal wind turbine product approval system operating in Australia. This means that any small wind turbine product can be eligible for rebates, providing the grid connect inverter is an approved product and the installer is suitably qualified.

In future, the regulations prescribing standards to qualify small generator units for rebates may be amended to include compulsory standards for small wind turbines. The listing of approved products managed by the Clean Energy Council would then reflect this, however no specific plans have been announced for a wind product list to date. Check industry news for updates on this situation.

3.2 Types of wind turbines

Table 3.1: Types of wind turbines

Axis of rotation	Turbine orientation	Tower type	Mounting location
• Horizontal axis • Vertical axis	• *Upwind* • *Downwind*	• *Tilt-up* • *Monopole* • *Guyed pole* • *Lattice*	*Ground mounted* *Roof/building mounted*

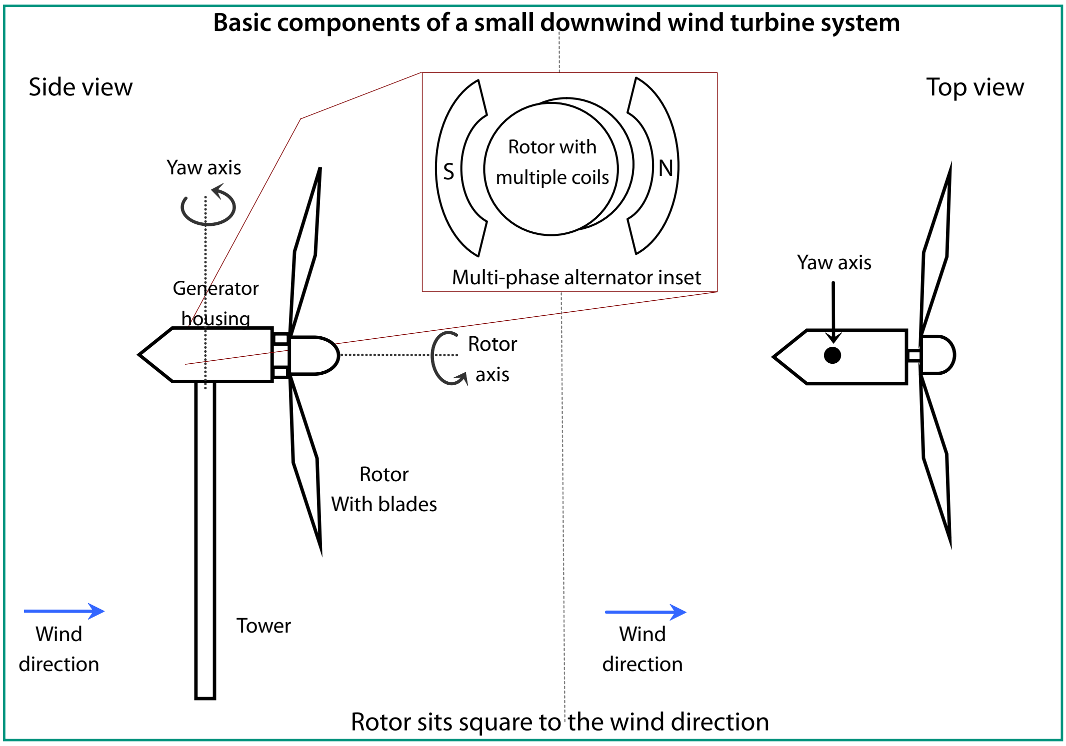


Figure 3.2: Basic components of a downwind turbine

Want a larger turbine?

If you want to install a larger wind turbine in the 100-500 kW capacity range, you will come across different challenges such as:

- fewer turbines on the market in the ranges above 100 kW
- feed in tariff rules potentially not applying above 100 kW (ie power companies are not obliged to purchase exported power).

Please note that issues specific to larger wind turbines (>100kW) are not addressed in this guide. Further information sources are given below.

Want a really large turbine?

Your community group may wish to be involved in a commercial scale wind facility (eg a 2MW or 3MW wind turbine). Community groups in Australia are successfully developing such projects, and commercial developers are also partnering with community groups who wish to own a share in a wind farm. Your approach to this scale of project should be similar to how a wind farm company approaches the development of a wind farm.

A mid sized wind turbine: 330kW

Embark is an organisation dedicated to assisting community groups to create renewable energy projects. The Embark website (www.embark.com.au) contains useful information on the process of developing a community wind farm. The NSW Renewable Energy Precincts coordinators can also assist (see 'Further Reading').

You may also consult the NSW Wind Energy Handbook for useful information. This can be found on the NSW Industry & Investment website at: www.industry.nsw.gov.au/energy/sustainable/renewable/wind

3.3 Turbine performance and power curves

Turbine manufacturers usually provide a 'power curve' that gives the instantaneous power output of the turbine at various speeds. You can generally obtain a power curve for each turbine you are considering.

An example of a turbine power curve is given below in Figure 3.3, which is a power curve for the Gaia wind turbine.

'Cut-in speed' refers to the wind speed at which the turbine starts to generate power. 'Rated power' is the stated output for the turbine at a rated wind speed. 'Cut out speed' is the point at which the turbine will shut down due to excessive wind speeds.

At high wind speeds, automatically furling turbines move to face themselves out of the wind, which causes power to be safely shed. The wind speed at which the turbine ceases to generate power is called the cut-out wind speed, this is often around 20-25m/s. If turbines are designed to withstand higher wind speeds while still generating power, then the cut-out wind speed will be higher. Although additional generation at high wind speeds is therefore available from turbines with high cut-out wind speeds, the occurrence of very high wind speeds is infrequent at most sites. The operating efficiency at the wind speeds containing with the most annual energy, normally 7-9m/s for a site with annual average wind speed around 5m/s, has a more significant effect on annual power yield than the level of the cut-out wind speed.

Typically, rated power is measured at a wind speed in the range 10-14 m/s. The BWEA and AWEA standards for small wind turbines require the rated power to be quoted at 11 m/s; this standardisation is aimed to assist consumers to compare wind turbine products. It should be noted that rated output may be different to peak output (the maximum point on the curve below).

The red area indicates the turbine operating in a stall mode, where the air foils stall due to the grid limiting the rotor speed while the wind speed increases. This reduces the power output of the turbine and protects the turbine from excessive loading.

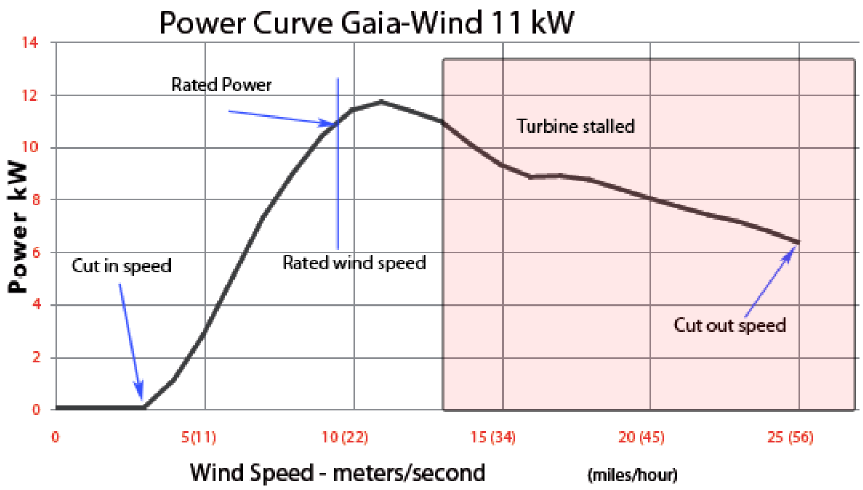


Figure 3.3: Example wind turbine power curve

Some power curves are not independently verified and a number of studies on turbine performance have shown that 'design' power curves often published in promotional literature are inaccurate compared to performance at real sites, particularly at high wind speeds. One such study is the Encraft Warwick Wind Trial Project in Britain, which assessed the data from 26 building mounted turbines from five different manufacturers over one to two years. This study showed that the power curves always overestimated power output at high wind speeds (above ~7 m/s), but were reasonably accurate at lower speeds. [Ref 7].

Another study is the ongoing Small Wind Turbine Test Field project in the Dutch Province of Zeeland [Ref 8]. Here, eleven different models of turbines have been installed at the same site, and their annual power output is measured as well as wind speed on an adjacent mast. The measured yield of each turbine is publicly published, as well as the initial manufacturer estimates based on their power curves. Comparison of the actual measured outputs to the estimates demonstrates that many of the forecasts were unrealistic, while in a minority of cases the forecasts were exceeded.

These two studies show that care should be taken when using manufacturer's power curves to estimate energy yield. Customers should ask retailers and distributors if there has been any independent testing of their turbine's performance and/or if the power curve has been verified by an independent testing body.

3.3.1 Safety and reliability

To minimise turbine failure and safety problems it is recommended to buy a turbine from a company with longer term experience and a good product track record. A five year warranty would be a good indication of this.

American wind energy expert Mick Sagrillo has produced a list of 'Questions Any Small Wind Turbine Manufacturer Should Be Willing and Able to Answer About Their Products', which is available on the American Wind Energy Association website: www.awea.org

Some of these questions include:

- How long have you or your company been in business?
- How long has this turbine model been in production?
- How many production models have been sold to ordinary consumers?
- How many of the turbines you sold are still running?

You might find these questions useful to ask a turbine manufacturer before making a purchase, or request that your installer answers them for you. Some other useful questions you might want to ask include:

- What are the maintenance requirements, who can do the maintenance and what is involved?
- Does the turbine meet small wind turbine Standards? (see Section 3.5).
- What happens if the grid is disconnected while the turbine is running? Does the turbine stop? Can it freewheel? What happens if the wind picks up while the turbine is disconnected?
- What safety features are included in the design? (question to the supplier)
- Are there are any other safety issues which are important?

The British Wind Energy Association has set up a 'Microgeneration Accreditation Scheme'. It is worth checking this website to see which turbines have completed the rigorous requirements for the scheme and received accreditation. The website of this scheme (www.microgenerationcertification.org) lists wind turbine products.

A major safety issue with small wind turbines is over-speeding. While most wind turbines are designed to handle short gusts at very high wind speeds, typically turbines need to employ some system to either stall the turbine or to brake it.

This becomes a particularly major problem when a turbine becomes unloaded. When a turbine is loaded (ie power is being drawn from the unit), the generator unit has electromagnetic forces operating around the turbine shaft. This helps to slow the turbine rotation. If a grid connected system goes offline (eg in the case of a power black out), the turbine becomes unloaded and can spin at very high speeds. This can become very dangerous, as prolonged operation at these rotational speeds can destroy the turbine and cause it to 'throw' a turbine blade. This is particularly an issue for horizontal axis turbines.

It is therefore important to check that a turbine has some method for 'overspeed protection'. This can include:

- furling – a mechanical action to physically turn the turbine out of the wind
- mechanical braking – a mechanical brake physically stops the turbine from spinning
- dynamic braking – power is diverted to a resistive bank dump load
- electronic control – varies the load on the generator to reduce the turbine RPM
- flexible blades – will limit the rotational speed of a turbine at higher speeds, but won't necessarily provide protection in unloaded situations
- blade pitching – rotates each blade about its own axis, reducing the air foils angle of attack and therefore the rotational speed.

It is generally recommended that some form of aerodynamic overspeed protection is used (eg furling/mechanical brake), as it is the most reliable means of shutting down/slowing down a turbine spinning at high speeds. However most turbines have some form of overspeed protection, which is suitable for most circumstances.

3.4 Wind turbine noise

Noise needs to be considered when you are contemplating installing a small wind turbine. Generally speaking, the louder the turbine, the further away you'll need to locate it from neighbouring or nearby houses. Noise is considered during the approval process for small wind turbines. If development consent is required from the local council, you'll most likely need to supply a noise impact assessment as part of your application. Some small wind turbine installations may be subject to what's called 'exempt or complying development' provisions (see Chapter 4).

These provisions provide for a simpler approval process, however you must satisfy certain requirements. For example, you may need to install the turbine at a nominated distance from neighbouring houses for the provisions to apply. So it is important that you establish what type of planning approval is needed, because noise is considered as part of that process.

We have consulted with the turbine companies on our estimate of the sound power level from each turbine type and notes are provided at the end of the table of turbines in Appendix B. In some cases, sound power levels have not been confirmed by manufacturers and are estimates only.

3.5 Australian Standards for wind turbines

Product Standards exist for consumer goods of many types, to protect customer rights and to protect customer safety.

All grid connected inverters attached to, or built into, small wind turbine generators must meet AS4777 and AS3100. These standards also apply to grid connected solar inverters; there are further details about this in Section 3.7. In addition, wind turbine installations are to be compliant with AS1170.2 (Wind Loading codes).

The Clean Energy Council (CEC) is the body in Australia that administers the accreditation of renewable energy installers and the listing of solar photovoltaic modules and grid connected inverters in Australia.

The draft Australian Standard for Small Wind Turbines – 'AS 61400-2 (Int) 2006' – was adapted from a series of international standards developed for the large scale wind turbine industry. Part 2 of this International Standard is specifically designed for small wind turbines, while Part 11 deals with noise from any sized wind turbine.

Wind turbines in Australia can meet this standard, or the international equivalent, IEC61400-2, however there is currently no regulated requirement enforcing this standard in Australia.

There is therefore currently no list of approved wind turbine products published by the CEC.

As new regulations and incentives promote a greater uptake of SWTs in Australia, compulsory criteria to meet Standards is more likely to emerge. A National Small Wind Turbine Testing Centre exists at RISE (Murdoch University) in Western Australia. The RISE testing centre is testing Australian-made SWT products.

As a consumer of a wind turbine, it would be a good idea to enquire with your supplier whether the wind turbine you are considering meets the International Standard IEC61400-2. Be prepared for the reality that few small turbines yet meet this standard, though your manufacturer may be quite capable of giving you other assurances of reliability and safety.

Since compliance with IEC 61400-2 is the direction in which the global SWT industry is being encouraged to move, your wind turbine supplier should at least be able to demonstrate that its business plan is heading towards this Standard.

Off grid wind turbines should be designed and installed to AS 4509 'Stand-alone Power Systems'.

3.6 Choosing a tower

There are a range of tower designs used for small wind turbines. The main types are shown in the figure on the following page.

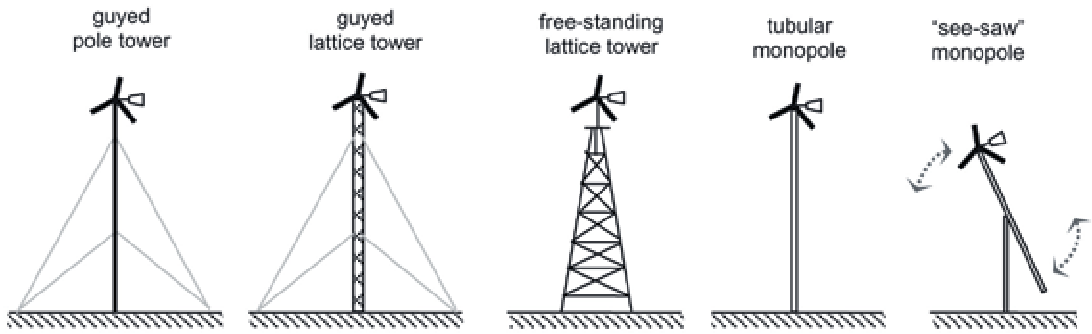


Figure 3.4: Wind turbine tower designs

Guyed towers are usually the lowest cost option, however a certain footprint area is required to accommodate the guy wires. To perform maintenance on the turbine, the tower can be lowered using a hand winch.

A monopole tower uses the least footprint area, and 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. The see-saw monopole is a special design that includes a counter-balance, allowing a person to easily lower the turbine to the ground where maintenance can be undertaken.

Lattice towers are a common sight with windmill water pumps, and have also been used for electricity generating wind turbines.

A lattice or monopole tower without a lowering system requires any maintenance work to be undertaken from a piece of machinery called a cherry picker, from a basket suspended from a crane (for very tall towers) or by climbing the pole. All of these maintenance methods should be undertaken by qualified personnel using appropriate safety procedures.

Your installer may recommend a specific tower type, or the turbine manufacturer may specify the tower type or sell the turbine and tower as a kit.

The tower with its specific wind turbine should be certified to meet the Australian Standards for wind loading, AS1170. The tower should also be manufactured to a good standard with special attention given to strength of welds and quality of materials.

Choosing a tower height

Choosing a tower height involves finding a balance between the pros (eg increased energy yield at a higher height) and the cons (eg increased visual impact of a taller tower, difficulty obtaining a planning permit for higher towers) of tower height.

Economics of taller towers

An estimate of the economics of tower height was provided by an American study undertaken by Mick Sagrillo in 1993 [Ref 9].

This showed that a professionally installed 10 kW wind turbine on a 30 m tower would produce slightly more than twice the power of the same wind generator at 18 m, for a total system price increase of only 10 per cent. In other words, two 10 kW wind turbines on 18 m towers will produce about the same amount of power as only one of the same wind turbines on a 30 m tower, but at nearly twice the cost.

This provides confidence that the extra investment in a taller tower will be worthwhile. In considering a taller tower, you need to be aware of any implications on development approval and consider neighbour amenity. You also need to check that the person undertaking the maintenance on the turbine will have sufficient area adjacent to the tower to lower it for maintenance.

3.7 Choosing an inverter

Your wind turbine product may be supplied as a package with an inverter. If the manufacturer specifies a particular inverter required for the wind turbine, it is important to use the recommended inverter.

All inverters connected to the grid in Australia must comply with the relevant Australian Standards, which are AS4777 and AS3100. Inverters that have been tested to these standards and successfully passed are then accepted by a State Regulator, for example the Office of Fair Trading, which issues Certificates of Conformity for the product.

These inverters can then be listed on the Clean Energy Council list of approved inverters, which are eligible for a government rebate.

For a list of Clean Energy Council approved grid connected inverters, you can refer to the Clean Energy Council website: www.cleanenergycouncil.org.au. A non CEC-listed inverter may still be used if it has a valid Certificate of Conformity, without attracting a rebate.

3.8 Estimating electricity generation

The output power from your turbine can be estimated from the turbine power curve and the site wind data. The output at your site will vary considerably according to the site wind speed.

For example, if you have measured your site wind speed using an anemometer, the data records can be converted into energy (kWh) by multiplying the power generation level with the amount of time that the wind speed occurs.

Alternatively, the wind turbine product specification or brochure may provide a chart of annual wind turbine yield vs annual mean wind speed, which you can use to estimate production at your site.

This type of information has been used to produce Figure 2.1 above, which you can use as a guide to estimating energy production for different sized turbines in different average wind speeds.

3.9 Urban wind turbines

Within urban environments, some sites may be suitable for wind turbines, which can be either mounted on a building structure or mounted on towers on the ground.

3.9.1 Suitability of urban sites for wind generation

Urban sites that may be considered for wind turbine systems include the rooftops of commercial or industrial buildings, industrial land and public land adjacent to coastlines.

Wind resources

Suitable wind resources are likely to occur only at high elevations such as rooftops of tall multistorey buildings, or at sites immediately adjacent to the coast such as median strips along a beach front.

The urban environment by its nature contains many tall obstacles including buildings and trees, which cause a reduction in wind resource and an increase in turbulence.

Studies such as the ATA's Victorian Urban Wind Resource Assessment [Ref 10] and Enhar's wind studies of Port Phillip Bay [Ref 11] have shown that wind resources within most built up areas are insufficient to make wind energy cost competitive. The best wind resources exist in areas immediately adjacent to the coast with no obstacles to the prevailing wind directions. Above tall buildings some reasonable wind resources can also be found. The rooftop of a tall building adjacent to the coast is likely to offer the best wind resource within an urban area.

Rooftop sites, and sites adjacent to large obstacles such as other buildings, experience high turbulence levels due to the chaotic flow around the building vertices. Increasing the tower height to raise the turbine a greater distance above the roof structure, and moving turbines away from roof edges, is likely to reduce the turbulence experienced at the turbine location.

Wind monitoring at urban sites

Wind speed measurements should be taken where possible at any urban sites proposed for wind turbines, using a system capable of recording turbulence intensity. Reference 3 provides detailed description of methodology for use of a sonic anemometer for urban wind measurements.

Telescopic poles normally used for TV antennas are ideal for wind monitoring up to 15 m, and your local TV antenna installers should be able to provide an installation service, ideally under the supervision of a wind consultant or a CEC-endorsed wind installer.

Structural suitability

For building-mounted wind turbines, the addition of the turbine and its support structure to the building may have a significant effect on the building. A wind turbine system will generally add significant weight to the roof and possibly cause vibration through the turbine tower, which may be transmitted into the building.

As all buildings are designed and constructed to meet wind loading standards, the addition of a wind-sensitive structure such as a wind turbine onto the building must be done very carefully. In general, if you are considering an urban site you should ensure that:

✓ you have confirmed a suitable wind resource (eg through monitoring winds at the site)

✓ the structural suitability of the building has been confirmed by a structural engineer

✓ suitable turbine technology is available to fit your site

✓ your budget is sufficient for turbine installation including any structural works

✓ you are able to meet any planning permit requirements

✓ you are able to meet any building permit requirements.

3.9.2 Urban wind turbine technology

Turbine types you can consider for urban application include vertical axis wind turbines (VAWTs). Vertical axis turbines are often preferred for urban application. The reasons for this include perceived aesthetic advantages, low noise levels and improved performance in turbulent flows.

Some specially designed horizontal axis turbines can also offer some of these advantages. Examples of both types of turbine are shown below. Turbine specifications including turbines designed for urban use are provided in Appendix B.

Figure 3.5: Examples of urban wind turbine systems

3.10 Finance and economics of your wind turbine system

This section discusses the budgeting process and how to find out how much you will need to spend, as well as how much you can expect to earn, from a small wind turbine system.

The values used for tariffs and rebates are accurate at the time of publication; however, readers are reminded that these are subject to change and that you should ensure you have up-to-date information.

3.10.1 Wind turbine system costs

There is a large variation in wind turbine prices depending on tower size, installation location and so on.

Keeping in mind the variables mentioned above, the table below shows an approximate guide on price ranges for grid connected wind systems (as of November 2010). Government rebates can be deducted from these figures.

Some indicative capital costs based on recent case studies in NSW are outlined below.

System size	System type	Estimated price range
1kW	Horizontal axis wind turbine on a 15-20 m tilt-up pole	$20-30,000
2-3kW	Horizontal axis wind turbine on a 10-15 m monopole	$30-$40,000
5kW	Horizontal axis wind turbine on a 20-30 m tilt-up pole	$40-$60,000
10kW	Horizontal axis wind turbine system on a 20 m monopole	$65-$75,000
1-2kW	Roof mounted horizontal axis wind turbine system	$15-$25,000
5-6kW	Roof mounted vertical axis wind turbine system	$50-60,000

Quotation

Before committing to purchasing a turbine, you should obtain a comprehensive complete quote from an installer.

The quotation should provide specifications, quantity, size, capacity and output for the major components, including:

- wind turbine generator
- tower and foundations
- inverter
- trench digging and cable laying
- any additional metering or data-logging
- travel and transport requirements
- other equipment needed
- a system user manual.

The quotation should also specify a total price, together with proposed start and completion dates. The quotation should form a basis for your contract with the designer/installer. In addition, a contract for the supply and installation of the wind power system should be included with the quotation.

The contract should include:

- an estimate of the average annual electricity output (in kWh)
- the estimated production in the best and worst months
- the responsibilities of each party
- warranties and guarantees, including installer workmanship
- a schedule of deposit and progress payments.

3.10.2 Renewable Energy Certificates for small wind turbines

What are Renewable Energy Certificates (RECs)?

A Renewable Energy Certificate (REC) represents one megawatt hour (MWh) of renewable electricity. This system of tradeable credits has been created by the Renewable Energy (Electricity) Act 2000. These certificates belong to the owner of the wind turbine, however to save you the work of trading the RECs yourself, registered agents are able to buy these certificates from you. Wind turbine installers are often registered agents.

In June 2010, the Federal Government announced amendments to the RET scheme. As part of these changes, the scheme will be split into two parts:

1. The Small-scale Renewable Energy Scheme (SRES), which covers small-scale technologies such as solar panels and solar hot water systems
2. The Large-scale Renewable Energy Target (LRET), which covers large-scale renewable energy projects like wind farms, commercial solar etc.

The SRES provides a fixed price of $40 (less brokerage fees) per REC, effective from 1 January 2011. Under this legislation, the Minister has the capacity to reduce this $40 price in the future.

Small wind systems will be covered by the SRES and as such, will attract Small-scale Technology Certificates (STCs) rather than RECs.

What is the Solar Credit Scheme?

Solar Credits is a mechanism under the expanded Renewable Energy Target (RET), which multiplies the number of Renewable Energy Certificates able to be created for eligible installations of Small Generating Units that are less than 10 kW, have a total annual electricity output less than 25 MWh and are installed after 1 April 2001.
The multiplier reduces over time; see Ref 12 for the latest information on what multiplier will apply at the date of your installation.

How many RECs will my system earn?

The Office of the Renewable Energy Regulator (ORER) publishes a 'Small Generators Owners Guide', which describes how to calculate how many RECs your system will earn [Ref 12]. This is updated from time-to-time to reflect any changes in the regulations.

The ORER website provides a handy online calculator (www.recregistry.gov.au/sguCalculatorInit.shtml), which lets you know how many RECs your system will earn. CEC wind-endorsed installers can also advise you on REC considerations.

What price will my RECs be sold for?

The price at which you can sell your RECs will depend on the prices offered by registered agents, and is linked to the price set by the Small-scale Renewable Energy Scheme. The ORER website provides a link to the current list of registered agents. If your installer is also a registered agent, they will advise you on REC prices.

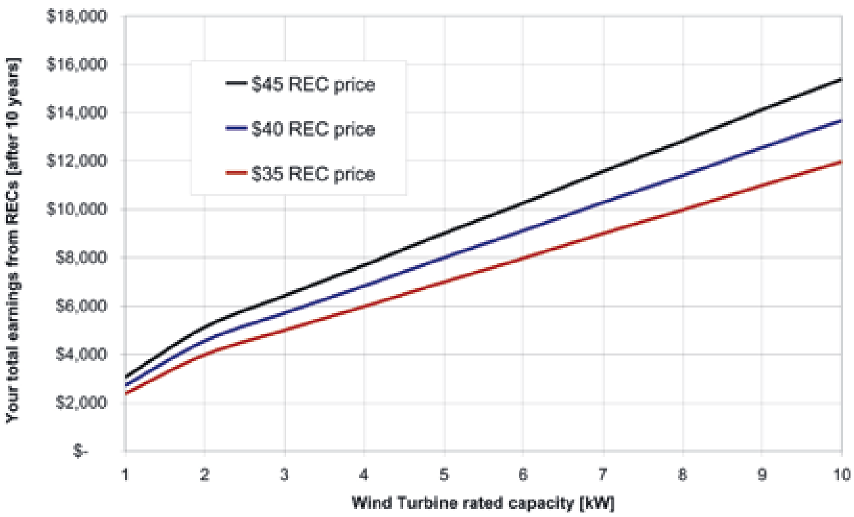


Figure 3.6: Illustration of REC income earnings from small wind turbine installations (15 year lifetime)

Rated power is the 'nameplate' power of the turbine, a number expressed in kW and normally printed on the turbine product documentation, as well as on its label and packaging. Different turbines have different rated wind speeds, however a common rated wind speed is 11 m/s.

The REC earnings usually actually occur in separate instalments, the first is at the time of installation, the second after five years, and the third and final instalment after 10 years. Although solar PV installations are permitted to claim RECs upfront for a 'deeming' period of 15 years, wind systems currently are eligible for a maximum upfront deeming period of five years. However, the good news is that over the project lifetime, if you do claim RECs at the five and 10 year point, you can expect to earn more RECs overall than the equivalent rated solar PV system. You can also opt to earn your RECs annually.

With REC prices as of November 2010 and under the Solar Credits Multiplier Scheme, customers can expect to earn between approximately 5-25% of the total price of the wind installation during a 1-5 year life turbine lifetime. The following table assumes a steady price of $40/REC (this may vary), five year deeming periods and Solar Credit multiplier values current in 2010.

Table 3.2: REC earnings from small wind turbines with current solar credit multiplier (as of November 2010)

Rated capacity	RECs			$ earnings			
[kW]	year 1	year 5	year 10	year 1	year 5	year 10	Total
1	48	10	10	$ 1,920	$ 400	$ 400	$ 2,720
2	76	19	19	$ 3,040	$ 760	$ 760	$ 4,560
3	85	29	29	$ 3,040	$ 1,160	$ 1,160	$ 5,360
4	95	38	38	$ 3,800	$ 1,520	$ 1,520	$ 6,840
5	104	48	48	$ 4,160	$ 1,920	$ 1,920	$ 8,000
6	114	57	57	$ 4,560	$ 2,280	$ 2,280	$ 9,120
7	123	67	67	$ 4,920	$ 2,680	$ 2,680	$10,280
8	133	76	76	$ 5,320	$ 3,040	$ 3,040	$11,400
9	142	86	86	$ 5,680	$ 3,440	$ 3,440	$12,560
10	152	95	95	$ 6,080	$ 3,800	$ 3,800	$13,680

If you have a very strong wind resource you can claim a higher resource availability by submitting evidence such as monitored turbine yield data (eg from the inverter of an existing wind turbine, or recorded wind data from an anemometer in advance of installing the turbine). Your evidence for a higher resource availability may be submitted by a specialist consultant. The evidence should demonstrate that the turbine does or will generate an annual total that is equivalent to its rated output for more than the default 'resource availability of 2,000 hours per year'.

Options for gaining financial benefits from RECs:

- **Option 1: AGENT ASSIGNED** – assign your RECs to an agent in exchange for financial benefit, which would be delayed cash payment or upfront discount on your small generation units (SGUs). Most owners take this option. Your installer can assist as an agent – you can sell your RECs to them in exchange for an up-front refund. You may expect to pay approximately 10 per cent commission to the agent for this service (ie you will receive the value of the RECs less 10 per cent of the total REC price).
- **Option 2: INDIVIDUAL TRADING** – become an individual trader. Find a buyer then sell and transfer RECs in the REC registry. Your income from RECs will usually occur later than under Option 1, and Option 2 can be more time consuming.

Off-grid wind systems are no longer eligible for rebates under the **Renewable Remote Power Generation Programme**, as this funding programme has ended.

3.10.3 NSW Solar Bonus feed-in tariff

Under the Solar Bonus Scheme, households received a gross feed-in tariff for electricity produced by small-scale solar and wind systems (less than 10 kilowatts). Through this scheme, around 365 megawatts (MW) of renewable energy installed by NSW households will be connected to the grid. NSW has the largest amount of installed small scale renewable generation of any jurisdiction in Australia.

The Solar Bonus Scheme is now closed to new entrants. The NSW Department of Trade and Investment, Regional Infrastructure and Services provides detailed guidance on the Solar Bonus Scheme, including a 'frequently asked questions' page on its website. See http://www.industry.nsw.gov.au/energy/sustainable/renewable/solar/solar-scheme/faq.

Finding an electricity retailer in NSW

You can visit the website of the Independent Pricing and Regulatory Tribunal (IPART) – www.myenergyoffers.nsw.gov.au – to compare retail electricity offers in NSW to help you choose a retailer.

What will I earn if I want to install a wind turbine larger than 10kW?

Renewable power systems larger than 10 kW can apply for a 'one-for-one' feed-in tariff from the electricity retailer.

Wind turbines larger than 10 kW are not eligible for the Renewable Energy Credits (RECs) multiplier under the Federal Solar Credits scheme, however if the turbine can become a registered renewable generator, it will still be eligible for earning RECs at a standard rate. This may be most feasible through the participation of a licensed electricity retailer such as Diamond Energy.

Will my income under the NSW Solar Bonus Scheme affect my tax?

You should speak to the Australian Tax Office or your accountant for advice on whether your Solar Bonus Scheme payments are taxable in your particular circumstances.

Your energy company, even it makes payments to you under the Scheme, may not be able to advise you on tax implications.

3.10.4 Net vs gross metering for a wind turbines in NSW

There are two metering options for customers: net or gross.

Both of these metering options are described in Section 5.4 later in this guide.

3.10.5 Economic analysis of small wind turbine systems

Payback periods for small wind turbines are site-specific and depend on several factors including wind speed, capital cost and electricity tariffs.

You may wish to undertake economic analysis to understand how quickly a small wind turbine generation unit will pay for itself.

To do this, you need to understand both the costs and the income associated with the investment.

In terms of costs, once your feasibility and wind resource assessment stages are complete, the capital cost of your project is made up of:

- services for obtaining any required permits

- wind turbine supply and installation
- foundation construction
- meter installation and commissioning
- maintenance contract.

Once installed, your wind turbine will provide the following income and savings:

- income under the NSW feed in tariff arrangements (see Section 3.10.3 above)
- earnings from RECs (see 3.10.2 above)
- savings on your electricity bill if you have a net metering arrangement (see Section 5.4 below). If electricity prices rise, the value of these savings will also rise.

You may also be eligible for tax depreciation benefits in relation to your wind turbine.

To calculate the payback of the system, the annual financial balance of the investment should be calculated. Imagine the project has its own bank account with its own cashflow. To begin with, a large sum is taken out of the 'account' to buy and install the wind turbine; this means the account starts with an 'overdraft' to pay off. As time goes by, the project earns money through the feed in tariff and REC earnings; this income gradually brings the project into credit.

During the project lifetime, the 'balance' of the project account becomes positive – at this stage the project has earned you more than it has cost. The time-span for the project to reach positive cashflow is referred to as the 'payback period', with shorter payback periods being more attractive. Opinions on what constitutes an attractive payback period are subjective and differ according to the product under consideration. For example, you may consider a longer payback period to be acceptable if your investment is also delivering added environmental benefits.

The cashflow should remain positive once the payback has been achieved and during the project lifetime the project should earn significantly more money than it spends.

An illustration of cashflow results for a 3 kW and 10 kW wind project is shown in Table 3.3 below.

Energy yield data and capital price estimates are based on real wind turbine products. Income is based on REC prices and feed in tariffs levels and assumes a net metering arrangement (as of November 2010). However, the numerous variables used in such calculations vary on a case by case basis, therefore the figures are strictly indicative only. In addition to variations arising from site specific costs and income, the income from REC and feed-in tariffs are subject to change throughout the state.

Therefore, the values here are indicative as of November 2010 only. The assumptions include 20c/kWh feed in tariff until 2016 and a one-for-one feed in tariff from the retailer after 2016 for the lifetime of the turbine, and annual electricity price increases in line with IPART projections to 2013 and 10 per cent per year thereafter.

Table 3.3: Indicative economics of wind turbine systems

Turbine type	Initial balance (cost of investment) before RECs	Payback period		Final balance at 20 years	
		7 m/s average wind speed	*5 m/s average wind speed*	*7 m/s average wind speed*	*5 m/s average wind speed*
3 kW horizontal axis on monopole	-$30,000 to -$40,000	Approx 7-10 years	Approx 10-13 years	+$60,000 to +85,000	+$20,000 to +$40,000
10 kW horizontal axis on monopole	-$60,000 to -$70,000	Approx 6-9 years	Approx 11-14 years	+$150,000 to +250,000	+$50,000 to +100,000

How to work out your financial benefit:

If you are provided with an estimate of the financial benefits of a wind system, you should check:

- what electricity tariff you are on at present
- whether there are any expected changes to your future electricity prices (consult IPART publications)
- what mean wind speed is expected at your site
- what power output is expected from your turbine
- what metering arrangement will best suit your needs and how that will affect the income from your wind system.

In terms of comparing the economic returns of different sized wind turbines, the larger 10 kW wind turbine system has superior economics to the 3 kW wind turbine system at stronger wind speeds – above approximately 5.5m/s. This demonstrates the general phenomenon that wind energy systems in areas with a strong wind resource are more competitive at larger scales. At moderate to low wind speed sites (eg 5 m/s), smaller wind systems can achieve equal or better payback periods than large ones due to the lower capital costs for smaller turbines.

Tax depreciation benefits

Some installers provide estimates of tax depreciation benefits, which can be earned by certain owners of small wind turbines. Tax depreciation benefits have not been included in the economic analysis above. You may wish to contact the Australian Tax Office or your accountant to discuss any tax depreciation opportunities associated with owning a small wind turbine.

Maintenance costs

The maintenance of wind turbine systems is important, due to the number of moving parts associated with a wind turbine. You should enquire whether your turbine purchase includes maintenance for a specific period, or whether an ongoing maintenance contract can be provided in addition to the installation contract.

Time of use metering

Certain electricity providers already offer time-of-use tariffs and others expect to offer these tariffs in the future. Certain meter technology is required for these tariffs to be available.

Consumers should be aware that switching to time-of-use may cause their energy bill to rise if the new time-of-use tariff is higher than the previous off-peak tariffs.

The alternative is no time-of-use, where you are charged at a flat rate regardless of the time of use.

Under a time-of-use tariff, if your net-metered wind turbine system generally outputs more power during peak times, you could earn more savings from your system. These savings are also termed 'avoided cost of power'. Conversely, if your system outputs less during peak times you would earn less savings from your system.

If time-of-use metering and tariffs are available to you, the process of determining if you would benefit under time-of-use is quite complex. Ideally, you would monitor your wind speeds and also your power consumption using a monitoring tool such as the ENVI from www.smartnow.com.au. This would allow you to see how well your wind resource matches peak usage times. This involves some fairly complex calculations and you might prefer to engage a consultant or a CEC endorsed installer to do this monitoring for you.

Chapter 4. Planning approvals

This chapter provides guidance as to whether you are likely to need planning approval for your wind turbine proposal.

Depending on the small wind turbine system, a planning approval may not be required or be considered 'complying development'. In other cases, development consent may be required from the relevant local council.

4.1 What planning approvals are required?

The planning approval process and requirements for a small wind turbine development or wind monitoring tower may be specified in a council's Local Environmental Plan (LEP) and/or a State Environmental Planning Policy (SEPP). The LEPs and SEPPs outline what type of development is permissible in land use zones and whether development consent is required.

State-wide planning provisions are in place in SEPP (Infrastructure) 2007 (the Infrastructure SEPP) to make it easier to install certain small wind turbine systems while protecting neighbourhood amenity. A 'small wind turbine' is defined in Clause 33 of the Infrastructure SEPP as 'a wind turbine that has a generating capacity of no more than 100 kW'. 'Small wind turbine system' is defined in Clause 33 as 'a system comprising one or more small wind turbines each of which feed into the same grid or battery bank'.

Subject to meeting the standards prescribed in the Infrastructure SEPP, it is expected that the majority of small wind turbines may be installed in rural areas as 'exempt development' and a planning approval will not be required. Subject to the standards, wind monitoring towers may also be installed as exempt development across a range of land-use zones.

In other situations, including rural, residential, business, industrial, special purpose, recreation and environment protection areas and subject to meeting standards in the Infrastructure SEPP, a complying development certificate can be obtained in around 10 days from a council certifier or a third party accredited private certifier.

In those cases where Infrastructure SEPP standards for exempt and complying development are not met, a traditional development application (DA) may be required to be lodged with the relevant consent authority, usually a local council.

Key considerations for each planning approval type are summarised below. The summary should be read in conjunction with the detailed provisions in the Infrastructure SEPP, which is available on the renewable energy section of DoP&I's website (www.planning.nsw.gov.au) or the NSW legislation website (www.legislation.nsw.gov.au). Alternatively, contact DoP&I's Information Centre on (02) 9228 6333 or information@planning.nsw.gov.au, or your local council for more information.

4.2 Exempt development

To determine whether a ground-mounted small wind turbine system does not require a development approval, it must comply with the exempt development provisions contained in the Infrastructure SEPP. If the small wind system is considered exempt development, it can be installed without any development approvals.

Key requirements in the Infrastructure SEPP (Clause 39) to be exempt development are summarised on the following page. As previously noted, proponents should refer to the Infrastructure SEPP for a complete list of requirements.

Table 4.1: Summary of key exempt development requirements in the Infrastructure SEPP

1. Zoning
(a) Each turbine is installed on land in a 'prescribed rural zone' (note: a 'prescribed rural zone' means the following land use zones: RU1 Primary Production, RU2 Rural Landscape, RU3 Forestry, RU4 Primary Production Small Lot or a council zone equivalent to these zones. A list of equivalent zones can be found on the NSW Housing Code website at http://housingcode.planning.nsw.gov.au)
2. Design
(a) Each turbine is ground-mounted and has a combined generating capacity of no more than 100kW, and
3. Height
(c) Each turbine has a height of not more than 35m from ground level (existing), and
4. Setback
(d) Each turbine is installed no less than 200m from any dwelling that is not owned or occupied by the owner of the system, and
5. Number of turbines
(e) The development will result in no more than two small wind turbines being situated on the lot concerned, and
6. Vegetation
(f) The development does not involve the removal or pruning of a tree or other vegetation that requires a permit or development consent for removal or pruning, unless that removal or pruning is undertaken in accordance with a permit or development consent
7. Heritage
(g) If the land contains a State or local heritage item or is in a heritage conservation area – the system is not visible from any road at the point where the road adjoins the property boundary concerned. (Note: local heritage items and heritage conservation areas are typically shown in the relevant council's LEP on the council's website. State heritage items are listed in the State Heritage Register at www.heritage.nsw.gov.au).

Exempt development provisions for wind monitoring towers associated with small wind turbine systems, that have a generating capacity of no more than 1 MW, are specified in Clause 39(1A) of the Infrastructure SEPP.

4.3 Complying development

A proposed small wind turbine system may be complying development in accordance with the provisions set out in the Infrastructure SEPP. Complying development provisions relate to ground-mounted and building-mounted small wind turbine systems with a generating capacity of no more than 10kW in prescribed residential zones or 100kW in other zones. These provisions for ground-mounted and building-mounted systems are specified in Clause 37 of the Infrastructure SEPP. The key requirements from Clause 37 for ground-mounted systems are summarised below. Please refer to the Infrastructure SEPP for building-mounted provisions.

A complying development certificate can be obtained from a council certifier or an accredited private certifier, typically in around 10 days. The certifier is responsible for checking that the proposed system complies with the complying development provisions and if so, issuing a complying development certificate. Further information on accredited certifiers is on the Building Professionals Board website at www.bpb.nsw.gov.au.

Table 4.2: Summary of key complying development requirements for ground-mounted systems in the Infrastructure SEPP

1.	**General**
(a)	It is not exempt development
2.	**Setbacks**
(b)	Each turbine is setback a distance specified in the Infrastructure SEPP from the nearest neighbour's house based on the turbine's 'source sound power level' (Note: the distances specified in the Infrastructure SEPP range between 25m and 200m)
(c)	Where the turbine's source sound power level is not known, each turbine is setback at least 200m from the nearest neighbour's house
(d)	The source sound power level value used to derive setback distances above is measured at a wind speed of no less than eight metres per second and measured in accordance with the International Standard IEC 61400—11 Noise Measurement
3.	**If in a 'prescribed residential zone'**
(e)	If in a 'prescribed residential zone' (R1 General Residential, R2 Low Density Residential, R3 Medium Density Residential, R4 High Density Residential, R5 Large Lot Residential, RU5 Village):
(i)	it is ground-mounted and has a generating capacity of 10kW or less, and
(ii)	no more than one small wind turbine situated on the lot concerned, and
(iii)	the turbine has a height of not more than 18m above ground level (existing), and
(iv)	it is not installed forward of any existing building line on the lot that faces a primary road, or Note: a 'primary road' is defined in Clause 5 of the Infrastructure SEPP as meaning 'the road to which the front of a dwelling house, or a main building, on a lot faces or is proposed to face'
4.	**If in a 'prescribed rural, industrial or special use zone'**
(f)	In a 'prescribed rural, industrial or special use zone' (RU1 Primary Production, RU2 Rural Landscape, RU3 Forestry, RU4 Rural Small Holdings, IN1 General Industrial, IN2 Light Industrial, IN3 Heavy Industrial, IN4 Working Waterfront, SP1 Special Activities, SP2 Infrastructure):
(i)	it is ground-mounted and has a generating capacity no more than 100kW, and
(ii)	it will result in no more than three small wind turbines being situated on the lot concerned, and
(iii)	each turbine has a height of not more than 35m above ground level (existing), or
5.	**If in 'any other zone'**
(g)	If in any other zone, and
(i)	it is ground-mounted and has a generating capacity of 100kW or less, and
(ii)	the development will result in no more than two small wind turbines being situated on the lot concerned, and
(iii)	each turbine has a height of not more than 26m above ground level (existing), and
6.	**Heritage**
(h)	It is not on land that comprises, or on which there is, an item of environmental heritage (that is listed on the State Heritage Register or that is subject to an interim heritage order under the Heritage Act 1977), and
(i)	It is not on land in a heritage conservation area (Note: heritage conservation areas are typically shown in the relevant council's LEP on the council's website)
7.	**Environmentally sensitive areas**
(j)	It is not located on land identified as an environmentally sensitive area (Note: environmentally sensitive areas may be identified in the relevant council's LEP. The provisions in the Infrastructure SEPP relevant to small wind turbine systems do not identify any environmentally sensitive areas).
8.	**Vegetation**
(k)	It does not involve the removal or pruning of a tree or other vegetation that requires a permit or development consent for removal or pruning, unless that removal or pruning is undertaken in accordance with a permit or development consent.

4.4 Development permitted with consent

If a proposed small wind turbine system is not exempt or complying development, it may be 'development permitted with consent' under the Infrastructure SEPP or the relevant council's LEP.

Where a small wind turbine system is development permitted with consent, a development application is required to be lodged with the relevant consent authority (usually the relevant local council for determination). The consent authority usually notifies the neighbourhood and may advertise the application. The consent authority may decide to approve an application, usually subject to conditions, or may refuse the application.

Development permitted with consent provisions for small wind turbine systems, which have a generating capacity of no more than 100kW, are specified in Clauses 34(5)–(6) of the Infrastructure SEPP, and are summarised below.

Table 4.3: Key permitted with consent requirements under the Infrastructure SEPP for small wind turbine systems (generating no more than 100kW)

(a) development for the purpose of a small wind turbine system may be carried out by any person with consent on any land, however

(b) where the system is in a 'prescribed residential zone' the system must have a generating capacity of less than 10kW and be less than 18m in height.

Note: a prescribed residential zone is defined in Clause 33 of the Infrastructure SEPP as comprising R1 General Residential, R2 Low Density Residential, R3 Medium Density Residential, R4 High Density Residential, R5 Large Lot Residential, and RU5 Village

Note: a 'small wind turbine' is defined in Clause 33 of the Infrastructure SEPP as having a generating capacity of no more than 100kW.

Additional information on planning approval processes is available on the renewable energy section of the NSW DoP&I's website (www.planning.nsw.gov.au).

For small wind turbine systems which generate more than 100kW the relevant council should be contacted in relation to their specific planning controls.

Chapter 5. Installation

In this chapter you will learn:

✓ how to find a qualified installer to assist you

✓ what steps are involved in connecting a small wind turbine to the grid

✓ about how to obtain assurances of the structural safety of the installation

✓ about net and gross metering arrangements.

5.1 The qualifications of your small wind turbine installer

To have your wind turbine installed, you will need a competent installer to undertake the job. This section describes what training a wind installer should have and how you can find a suitable installer.

The Clean Energy Council (CEC), formerly the Business Council for Sustainable Energy, runs the endorsement scheme for installers of small renewable energy systems including wind turbines.

Regulations in the Enhanced Renewable Energy Target Legislation have been amended to ensure that after December 2010, wind turbine small generation units (SGUs) are designed and installed by persons who are endorsed for wind systems under the CEC accreditation scheme.

To obtain renewable energy credits for your wind turbine system, you must select an electrician who is an accredited wind turbine installer (ie an accredited solar photovoltaic installer who has completed certain wind turbine training or an electrician who is experienced and competent in installing wind turbines).

As well as allowing you to earn RECs for your system, using installers who comply with these regulations ensures that certain safety criteria are met and, in general, you can expect professional standards throughout the job.

For example, for a small wind system installed in an on-grid location, the installer must be accredited for grid-connected installations of solar PV systems and this accreditation must also be endorsed by the CEC (after completion of CEC's required training) for small wind systems.

The regulations state that the wiring associated with the installation of any small generator unit is to be undertaken by an electrician with a valid, unrestricted licence for undertaking electrical work in NSW. The installation team will therefore include a qualified A grade electrician.

More information in regards to choosing a licensed installer and the important safety aspects associated with the installation of renewable energy systems can be found on the 'Green Energy Installations' section of the NSW Office of Fair Trading website at: www.fairtrading.nsw.gov.au

How do I find an accredited installer?

You may like to first consider which type of turbine you are interested in, using the database in Appendix B. By contacting the turbine providers, or their approved resellers, you can find out who is able to install the turbine for you.

You can also refer to the list of installers in Appendix B or consult the list of wind endorsed solar photovoltaic installers on the Clean Energy Council website, which is updated regularly: www.cleanenergycouncil.org.au

5.2 Grid connection of your wind turbine

In NSW, there are currently three electricity distribution companies. The areas covered by each distribution company are shown below.

Figure 5.1: Electricity distribution areas in NSW and ACT [Source: Ref 20]

Contact details for each company are as follows:

Essential Energy, servicing rural NSW	Tel 132 391
Endeavour Energy, servicing western and southern Sydney	Tel 131 081
AusGrid, servicing northern Sydney	Tel 131 535

For grid connected wind turbine systems, the grid connection must follow proper procedures.

The Clean Energy Council publishes flowcharts for connecting small scale renewable energy generators to the electricity grid [Ref 19]. These have been checked with individual NSW electricity providers and the resulting recommended procedures are shown on the following page.

Table 5.1: Grid connection process for small wind turbines

Step	ENDEAVOUR ENERGY	ESSENTIAL ENERGY
1	Customer to do own research	Customer to do own research
2	Customer to contact CEC accredited installer	Customer to contact CEC accredited installer
3	Customer/installer to contact electricity distributor to determine connection requirements to the grid and obtain application form/process information	Customer/installer to contact electricity distributor to determine connection requirements to the grid and obtain application form/process information
4	Installer to complete Application to Connect and submit to electricity distributor	Installer to complete Application to Connect and submit to electricity distributor
5	Electricity distributor to issue Approval to Connect to installer/customer	Electricity distributor to issue Approval to Connect to installer/customer
6	Wind turbine system is installed	Wind turbine system is installed
7	Installer/Level 2 accredited service provider (ASP) to complete electrical inspection	Electrical contractor to complete AC wiring from inverter to meter board
8	ASP to install metering	Electrical contractor to complete electrical inspection and then submit a certificate of electrical work (CCEW) to the electrical distributor
9	ASP completes a Notification of Service Work Form (NOSW) and Certificate of Compliance and submits to electricity distributor	ASP to install metering
10	Wind turbine system is connected to the grid	ASP completes a notification of service work form (NOSW) and submits to the electricity distributor
11		Wind turbine system is connected to the grid
12	Apply for any applicable Renewable Energy Certificates/Solar Credits	Apply for any applicable Renewable Energy Certificates/Solar Credits
13	Electricity retailer will make the necessary changes to the customer's account.	

At the time of publication, AusGrid had not provided an equivalent checklist. Related guidance is however provided on the AusGrid website.

Approved inverter

The inverter equipment used must be shown to meet Australian Standard AS4777 and also AS3100.

The Clean Energy Council publishes a list of approved grid connect inverter products that have been confirmed to be compliant with relevant standards and are thereby also eligible for Solar Credit and REC creation. This is important when it comes to applying for your REC rebate. To earn RECs, your wind turbine inverter should be listed on the latest version of the Clean Energy Council list of approved inverters. In all situations, your installer should have the relevant certificates of conformity demonstrating compliance with Australian Standards AS4777 and AS3100.

Meter

You should consult with your installer and your electricity company as to which type of meter will suit your needs and meet the requirements of any feed in tariff system as well as the expectations of your electricity distributor.

There can be issues around metering and electricity bill charges for renewable energy system owners. It is possible that the meter could be misread, or the data interpreted incorrectly, and you could be charged incorrectly.

Section 5.4 below deals with metering options in more depth.

Signed agreement

You need to select a retailer, obtain information from retailers on the electricity tariffs available for the sale of electricity generated and confirm the tariff you will receive. Your retailer should then send you an agreement to sign. Once your system is installed, you can sign the agreement sent by your chosen retailer for energy sold and purchased and send this back to your retailer.

Approved electrician to install to the grid

Your grid connection must be performed by a suitably qualified electrician (see Table 5.1 above) who should be able to provide evidence of suitable qualifications. Please also refer to Section 5.1 above relating to the accreditation of small wind installers. The grid connected system once installed should be inspected by an electrical inspector.

For off grid installations, different requirements apply; please refer to the booklet 'Wind Power – Plan your own wind power system' [Ref 4].

5.3 Mounting and structural safety

Whether it is a ground mounted tower or a rooftop mounted system, your wind turbine tower structure will be a significant long term installation. It is important to ensure that your installer provides evidence of structural safety. This includes evidence that the mounting, tower and foundation have been designed to withstand suitable wind loading and that it has been properly manufactured according to the design. Also important is confirmation that the installation meets the design requirements.

The relevant Australian Standards include AS 1170.2 (Wind Loading).

If a construction certificate is required, a qualified structural engineer may be engaged by your installer to approve the safety of the tower structure. A registered builder may also be involved to oversee the installation of the foundation and the erection of the tower.

5.4 Gross/net metering

How does gross metering work?

Gross metering generally involves a second meter being installed which records how much power is generated out of your wind turbine system. We can refer to this as your 'output meter'. This is called a gross metering arrangement, because it measures the 'gross' power generated by your wind turbine before any of your consumption is taken into account. Have another look at Figure 1.1 above to get an idea of how the meters fit within the overall system.

The following schematic diagram shows a gross metering system:

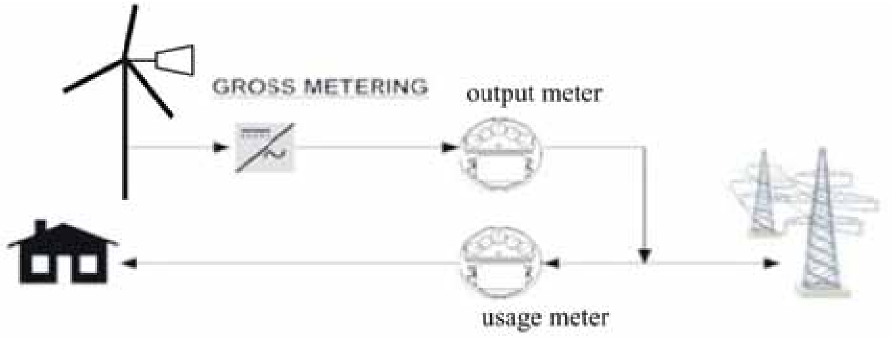


Figure 5.2: Schematic of a gross metering system [Acknowledgement: www.gogreenenviro.com.au]

After your gross meter is installed, you will have two meters, as shown in the photograph below. Your electricity distribution company will read both meters to calculate your electricity bills and credits.

One meter records all the output of the wind turbine – all this output goes into the grid and you are paid for it. The other meter records all power imported and used at your property – you are charged for all of this. You will be paid an equal rate for the power coming out of your turbine whenever it is generated. You can therefore be assured that when your turbine is generating you are earning an income from it.

Figure 5.3: Photograph of gross meter arrangement [courtesy of Rewind Energy]

You will not normally be charged for new meter equipment – your energy provider will supply that – but you will normally have to pay for the labour costs of having a gross meter installed at your property. This could be in the order of $400–$500, and should be a relatively quick job for a qualified electrician – a level 2 accredited service provider (ASP) – to complete. Customers should contact an ASP who will order a new gross or net meter from your energy provider and arrange for it to be installed. A list of ASPs is available from the NSW Office of Fair Trading and can be found on its website at www.fairtrading.nsw.gov.au. The costs associated with the installation of the meter are the responsibility of the customer and should be discussed on an individual basis with your chosen ASP.

Costs may vary depending on your existing metering equipment, switchboard location, standard of previous electrical work, etc, and may be affected by issues such as whether your existing meter can be reprogrammed or whether it needs to be removed and two fresh meters installed. Other physical factors such ease of access to your meters and whether there is sufficient space for the additional meter may affect the length of job and the price that you pay.

What about net metering?

You can also opt to have a net metering arrangement, as shown in Figure 5.4, whereby you receive payment only for the surplus that you export to the grid.

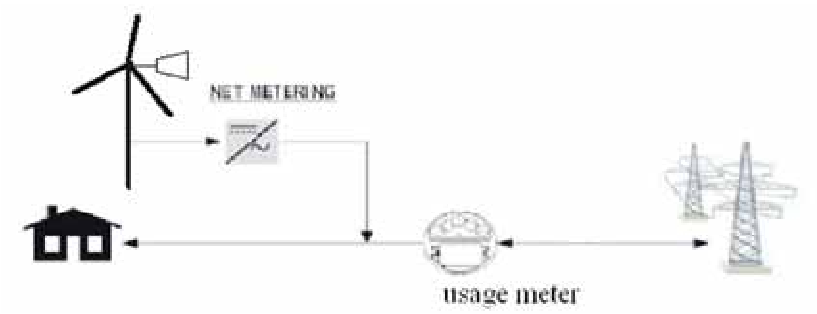


Figure 5.4: Schematic of a net metering system [Acknowledgement: www.gogreenenviro.com.au]

The benefit of a net metering system is that your own generation can directly supply your own property's power needs. This means that at times when your wind turbine is generating power, it will be partly or completely offsetting your own power consumption. At these times, you do not need to import any power from the grid and you are not charged for using your own power. This differs to a gross metering system, where you are always charged for consuming power on your property even if you are generating power at the same time.

When to go for net metering

In simple terms, a net system is economically favourable to you if your electricity retail rate is higher than a feed-in tariff rate. For example, if a feed-in tariff is offering you 25c/kWh but you expect to start paying 30c/kWh in the near future for electricity from your retailer, then you should opt for net metering as this will offset your higher electricity costs.

If you are opting for 'time-of-use' tariff with your retailer, then it is possible that at certain times of day, you will be paying more than the offered feed-in- tariff for purchasing power. Since the wind regime at your site is likely to cause your turbine to generate a proportion of its power during peak times, in these circumstances it would be advantageous to use a net metering arrangement. By using this approach, your savings from the avoided cost of purchasing electricity in peak times may be greater than earnings from the offered feed-in tariff available through gross metering.

When to go for gross metering

Again, in simple terms, if you are currently paying less for electricity from your retailer than a feed-in tariff and expect to continue paying less than the tariff for some years into the future, it may be economically preferable to start on a gross metering arrangement then switch to net at a later date. Switching to a net metering system will be economical when your power costs exceed your feed-in tariff. Bear in mind that there will be costs associated with switching your metering arrangement, including engaging a Level 2 service provider (you should budget $400-$500 for this), and your DNSP may charge you for a second set of meter equipment (budget $100-$200 for this).

Where can I get further information on metering?

Because there are so many factors affecting the lifetime economics of a small wind system in NSW, including the rate of rising power costs, electricity tariff arrangements and available meter types, you should consult an expert such as a CEC-endorsed wind installer for advice.

Case Studies

Chapter 6. Case studies

This chapter contains case studies of small wind turbine projects currently operating in NSW.

Three approaches have been used to collect these case studies.

Firstly, fact sheet templates drafted by DoP&I were provided to wind turbine installers and completed by the installers. Completed fact sheets for the Crookwell 10 kW and Randwick 2.4 kW systems have been kindly provided to Enhar by DoP&I, and are reproduced below.

Secondly, Enhar visited several sites and discussed the turbines with the owners where possible. The Breamlea 60 kW turbine was selected as a turbine of a size relevant to community group projects, and this case study is reproduced below. Enhar also visited sites in Coolangatta, and the Mountain Ridge Winery case study is included below. Enhar also visited the Randwick site and provided supplemental information to the fact sheet below.

Thirdly, questionnaires were issued via the NSW Renewable Energy Precinct coordinators for turbine owners to complete. The Belgravia North case study of a 10kW system owned by the Haynes is provided below, providing valuable consumer perspectives.

Case Study 1: Randwick Council Community Centre – 2.4 KW turbine

Randwick Council installed this turbine at its community centre in August 2010 to provide electricity for the Randwick Community Centre, educate the community about renewable energy alternatives, and provide a tangible statement of the council's commitment to reducing its carbon emissions. The time from down payment to commissioning was 1-2 months.

SITE

Location: Randwick Community Centre, Sydney
Average wind speed on site: Estimate 4.8 m/s at tower hub height (13.7 m)
Source of wind speed estimates: Bureau of Meteorology (BoM) weather stations and Sydney Airport wind speed data
Turbine is connected to: Council-owned community centre
Planning approvals: Development consent obtained under council planning provisions
Grid connection authority: AusGrid

Courtesy of edenPOWER Pty Ltd (1300 398 766)
Reproduced with the permission of the NSW DoP&I.

TURBINE

Contractor/installer: edenPOWER Pty Ltd
Designer and manufacturer: South West Wind Power (Arizona USA)
Components: Skystream 3.7 turbine with integrated 2.4 KW inverter
Tower: 13.7 m high tilt-up/hinged monopole
Electrical specifications: 2.4 kW maximum power (at 14 m/s wind speed), single-phase grid connect
Mechanical specifications: 3.7 m rotor diameter, three blades, fixed pitch fibreglass reinforced epoxy blades, passive tracking
System integration: connected at 240 AC single phase/ gross/net feed-in meter
System monitoring: Integrated Zigbee data logger, PC software supplied

BENEFITS

Projected production: 3,200 kWh/yr (at 4.8 m/s wind speed on 13.7 m high tower)
Income from Renewable Energy Certificates: $2,600 over 20 years (assuming $40 REC price and 3.2 MWh annual power generation)
Total costs of equipment, labour, permits: $30,000–$45,000 including GST
Greenhouse savings: 3.5 tonnes of carbon dioxide equivalent each year (70,000 'black balloons')

Enhar visited this site on 16 November 2010 in the company of Randwick Council's Sustainability Manager to learn more about the project. The turbine was installed on 14 September 2010 and has been operational since then. Since its installation, it has produced 269.2 kWh of renewable electricity up to 16 November, 2010.

Data logging software called SKYVIEW was included with the installation and enables the consumer to monitor the real time performance of the turbine, such as its power and RPM levels. It also provides information on current and historical energy production levels of the turbine system.

Case Study 2: Coolangatta – 10kW turbine at winery

This Rewind 10 kW wind turbine was installed by Rewind Energy to supply power to the Mountain Ridge Winery and Brewery. It is located on Coolangatta Road, Coolangatta. It is mounted on a 12 m tilt tower. The turbine was installed in mid 2010 and had generated 3,950 kWh by mid November 2010.

SITE ASSESSMENT

Wind monitoring was not undertaken prior to installation, however the site is very well exposed in the prevailing wind directions, and the online site assessment tool available from the installer indicates average wind speeds in the range 5–7.5 m/s.

DEVELOPMENT APPROVALS

No development approval was required as this is a rural property.

CONNECTING AND SELLING TO THE GRID

Two meters have been installed, recording the electricity consumption and turbine gross power production respectively. According to the turbine owner, a credit of $1,700 was achieved on the latest quarterly electricity bill thanks to the earnings from the turbine exceeding the site power consumption costs. The customer is serviced by Endeavour Energy.

COST AND BENEFITS

The total system cost was $79,990. The economic benefits of the system include:

- Solar Credits discount and RECs for five years: $8,080
- RECs for 6th – 10th year: $3,800
- RECs for 11th – 15th year: $3,800

FURTHER COMMENTS AND ADVICE

- A user friendly portable meter is connected to the turbine gross meter. It displays information such as accumulated energy production and the earnings to date.
- The recorded power production from the turbine agrees well with the electricity readings from the gross meter.
- This is an easy turbine to visit, by simply arranging a visit to the Mountain Ridge Winery.

Figure 6.1: Two SMA 5 kW inverters and controllers (Photo: Enhar)

Enhar thanks Rewind Energy for arranging a tour of this site on 16 November 2010.

Case Study 3: Bremlea – 60kW community wind project

The Breamlea is located right on the coast just south of Geelong, Victoria, and was originally installed in 1987. The 60 kW grid-connected turbine was manufactured by Westwind of Western Australia and sits atop a 22 m monopole. The turbine outputs approximately 80,000 kWh per year to the grid. The average wind speed is 5.9 m/s.

A variety of groups have looked after the turbine since construction: the Victorian Solar Energy Council, State Electricity Commission of Victoria (SECV), Alternative Technology Association (ATA), a private owner and currently Barwon Water.

Barwon Water purchased the turbine from a private owner in 2003 after a combination of moisture and salt build-up started a generator fire. The generator was restored by a firm in Geelong and the turbine was back online in early 2004. While the turbine is over 30 years old, it manages an estimated 90-95 per cent availability; currently Barwon Water is considering an upgrade of the telemetry or remote access capabilities, which may improve this.

A wind resource assessment was undertaken at a nearby site but not at the exact turbine location. Today, a hub height mounted anemometer provides independent wind speed measurements. The hub height wind speed is monitored on a dedicated wind monitoring pole adjacent to the wind turbine - the average wind speed is 5.9 m/s.

Barwon Water is considering using the turbine output to supply the new biosolids drying facility being built in the adjacent property. This facility takes sewage and turns it into nutrient rich fertiliser for local farmers.

FURTHER COMMENTS AND ADVICE

- The performance of this wind turbine is generally satisfying. In a recent year, it produced approximately 100,000 kWh of renewable electricity. The minimum annual power generation reached has been 65,000 kWh.
- According to Barwon Water, there have not been any complaints from the surrounding neighbour-hood about the wind turbine noise.
- A new and larger wind turbine has been considered to be built to replace the existing one. However, no finalised proposal has been made due to various reasons.
- This is believed to have been the first community owned wind turbine in Australia.

Enhar thanks Barwon Water, owner of the Breamlea wind turbine, for assisting Enhar with this case study.

Case Study 4: Belgravia North – 10kW

Belgravia North is situated in rural NSW, north of Orange. The 10 kW grid connected Fortis Alize wind turbine is mounted on an 18 m tall guyed mast tower, and is expected to produce 27,000 kWh per year. The wind turbine is privately owned and was installed in November 2010.

Figure 6.2: Fortis Alize wind turbine (Source: Fortis Alize brochure)

SITE ASSESSMENT

A weather station operated on the site as a part of a research project being undertaken on the owner's land. This provided detailed wind speed information.

WIND RATHER THAN SOLAR

The 10 kW wind turbine system was chosen over similar sized PV systems on the basis that it has the capacity to produce more energy and perform more consistently over its lifetime, and the replacement of components could be easily performed, preventing the need to replace the entire system.

CHOOSING A TURBINE

The owner placed priority on seeking a manufacturer with extensive history in small wind turbine manufacturing and installation. After consultation with an experienced European wind turbine manufacturer and trusting the advice given, the owner chose to invest in a manufacturer based in Holland. The particular turbine model chosen was based on the analysis of costs, performance and returns on investment of each turbine considered by the owner and their associate.

DEVELOPMENT APPROVAL

It was determined that a development approval was not required on this site after referral to the local council zoning conditions and consultation with a third party experienced in development applications regarding large scale wind turbines.

INSTALLATION

The installation procedure was undertaken by the approved distributor of the turbines, Australis Wind Energy. The owner reported that the grid connection application was approved by the network company subject to upgrading of the existing transformer. According to the owner, four months after the application was lodged the network company had not upgraded the transformer and wrote to the installer advising that the upgrade may take another four months. Shortly afterwards, the existing transformer stopped working, forcing a replacement of the transformer. The replacement transformer met the requirements of the wind installation to connect to the grid. The upgrade of the transformer was the responsibility of the network company and the delays in the upgrade were regarded by the owner as a lost opportunity in terms of lost feed in tariff income for that time period.

COST

The total cost of the system was around $81,000 and it was eligible for $6,000 in renewable energy certificates.

OTHER COMMENTS AND ADVICE

'[choose] a supplier that can fine tune the components to ensure the system is producing maximum energy. When feeding to the grid make sure your mains transformer is producing the right current. If it is producing more current that it should be you system will not be able to feed into the grid! Make sure you have got accurate wind data for your site.'

Enhar thanks Hugh and Elly Haynes, owners of the Belgravia North wind turbine, for submitting this case study.

Case Study 5: Milton – 5.8 kW wind turbine for home/farm

The property owners installed this turbine in July 2010 to provide electricity for their home and farm. The turbine is expected to pay for itself in under 10 years, reduce power bills by more than 50 per cent, or almost $1,500 each year, and halve the property's carbon footprint. The time from down payment to commissioning was 10-15 weeks.

SITE

Location: Rural site in Milton, NSW south coast

- **Average wind speed on site:** Conservative estimate of 5 m/s at 10 m height
- **Source of wind speed estimates:** Bureau of Meteorology (BoM) weather stations
- **Turbine is connected to:** home/farm (pump for stock water)
- **Planning approvals:** not required under state planning laws in specified rural zones
- **Grid connection authority:** Endeavour Energy

TURBINE

Contractor/installer: Australis Wind Energy Pty Ltd

- **Designer and manufacturer:** Fortis Wind Energy (The Netherlands)
- **Components:** 5.8 kW Fortis Montana Wind Turbine, SMA Windy Boy Inverter 6000A
- **Tower:** 18 m high tilt-up/hinged monopole
- **Electrical specifications:** 5.8 kW maximum power (at 17 m/s wind speed), single phase grid connect
- **Mechanical specifications:** 5 m rotor diameter, three blades, fixed pitch fibreglass reinforced epoxy blades, passive aligned tail
- **System integration:** connected at 240 AC single phase/gross feed-in meter
- **System monitoring:** gross feed-in meter (kWh); data logger in SMA 6,000W Inverter (kWh)

BENEFITS

- **Projected production:** 9,701 kWh/yr (at 5 m/s wind speed on 18 m high tower)
- **Income from Renewable Energy Certificates:** $8,880 in three payments over 10 years
- **Tax depreciation:** $29,316 over 10 years
- **Greenhouse reduction:** 8.8 tonnes of carbon dioxide each year (or 176,000 'black balloons')
- **Total costs of equipment, labour, permits:** $49,000 including GST .

Courtesy of Australis Wind Energy (02 6964 0070)
Reproduced with the permission of the NSW DoP&I.

Case Study 6: Crookwell – 10 kW wind turbine for home/farm

The property owner installed this turbine in 2010 to provide electricity for a home/farm. The turbine is expected to reduce power bills by almost $100,000 over 20 years, reduce greenhouse emissions by almost 80 per cent, and pay for itself in less than five years. The time from down payment to commissioning was two months.

SITE

- **Location:** Goulburn Rd, Crookwell
- **Wind speed on site:** estimated 5.5 m/s average at tower hub height (12 m)
- **Source of wind speed estimates:** wind monitoring for nearby wind farm, and site-specific desktop based wind modelling using 3 Tier.
- **Planning approvals:** not required as development was exempt development in some rural zones under state planning controls
- **Grid connection authority:** Essential Energy

TURBINE

- **Contractor/installer:** Rewind Energy Pty Ltd
- **Manufacturer:** Rewind Energy (China)
- **Date completed:** April 2010
- **Tower:** 12 m split, tilt-up tower
- **Mechanical specifications:** 3 x 4.2 m diameter blades, 470 kg nacelle
- **System components:** 3-phase alternator with pitch control
- **Electrical specifications:** 10 kW grid connect
- **System integration:** 2 x SMA 5000a inverters
- **Maintenance:** Maintenance service every five years at around $280. Tilt tower lowered with winch. Replace blades after 10–15 years at approximately $4,750 per set
- **Post installation monitoring:** power production monitoring; no wind speed monitoring

BENEFITS

- **Projected production:** 24,000 kWh/yr (at 5.5 m/s wind speed at 12 m tower hub height)
- **Income from Renewable Energy Certificates:** $13,680 in three payments over 15 years (conservatively assumed $40 per REC)
- **Tax depreciation:** $19,000 over 10 years
- **Electricity load offset:** 80 per cent (approx)
- **Total costs of equipment, labour, permits:** $72,990 incl GST
- **Financial payback period:** less than five years
- **Greenhouse savings:** 11 tonnes of carbon dioxide per year (or 220,000 'black balloons')

Courtesy of Rewind Energy Pty Ltd (1300 322 678)
Reproduced with the permission of the NSW DoP&I.

References and Further Reading

Chapter 7. References and further reading

Sources referred to in the text

[1] **Victorian Consumer Guide to Small Wind Turbine Generation**
Enhar, May 2010, for Sustainability Victoria. Available online from Sustainability Victoria: www.sustainability.vic.gov.au/resources/documents/Small_Wind_Generation1.pdf

[2] **New South Wales Wind Atlas**
Produced by SEDA in 2002. Available online on the NSW Industry and Investment site: www.industry.nsw.gov.au/energy/sustainable/renewable/wind

[3] **Griggs-Putnam Index diagram**
Image of this frequently used diagram was reproduced from the Southwest Wind Power Consumer Guide 'Siting wind turbines', page 3/7. Data prepared by E.W. Hewson, J.E. Wade, and R.W. Baker of Oregon State University. This guide is available at: www.windenergy.com/documents/guides/0372_Siting_guide.pdf

[4] **'Wind Power – Plan your own wind power system',**
Trevor Robotham and Peter Freere, published by Alternative Technology Association, 2004. You can purchase this Wind Power Booklet for $10 from the ATA online store at: http://shop.ata.org.au It is especially useful if you are aiming to get an off-grid wind system using battery storage.

[5] **'State Environmental Planning Policy (Infrastructure) 2007'**
New South Wales Government, 2007. Scroll to Part 3 >> Division 4 >> Clause 39 (Exempt Development). Available at: www.legislation.nsw.gov.au/viewtop/inforce/epi+641+2007+cd+0+N/

[6] **Review of Victorian Urban Wind Roses**
Report by Enhar, for Sustainability Victoria, April 2010.

[7] **Warwick Wind Trials**
Encraft, UK, 2009. Results available at: www.warwickwindtrials.org.uk/

[8] **Zeeland wind test site**
Zeeland, Holland. Results available at: http://provincie.zeeland.nl/milieu_natuur/windenergie/kleine_windturbines

[9] **'Wind tower economics'**
By Mick Sagrillo, published in the USA's Home Power edition #38 December 1993/Jan 1994. Available from: www.windpowerservicesllc.com/pdf/Tower%20Economics%20101.pdf

[10] **'Victorian Urban Wind Resource Assessment'**
Report prepared by Mike Baggot for Alternative Technology Association, April 2009. Project commissioned by Sustainability New South Wales. Available online from ATA website: www.ata.org.au/projects-and-advocacy/domestic-wind-turbines

[11] **'Evaluation of Wind Resources at Port Phillip Bay'**
Demian Natakhan of Enhar, for City of Port Phillip, June 2009. Available from the City of Port Phillip or online from the Enhar website: www.enhar.com.au/index.php?page=port_phillip_wind

[12] **'Small Generators Owners Guide'**
Published by The Office of the Renewable Energy Regulator, describes RET processes for owners of small generation units (SGUS) including small-scale solar photovoltaic panels, wind and hydro electricity systems. Updated as regulations change. Available via: www.orer.gov.au

[13] **'NSW Solar Bonus Scheme description'**
Website of the NSW Department of Trade and Investment, Regional Infrastructure and Services, www.industry.nsw.gov.au, by clicking through Sustainable energy » Renewable energy » Solar power » NSW Solar Bonus Scheme

[14] **NSW Solar Bonus Scheme update**
The Premier of NSW press release:'NSW Government revamps solar bonus scheme' dated Wednesday 27 October, 2010, published through the NSW Department of Trade and Investment, Regional Infrastructure and Services website. It is available at: www.industry.nsw.gov.au/__data/assets/pdf_file/0005/360194/nsw-govt-revamps-solar-bonus-scheme.pdf

[15] **'NSW Solar Bonus Scheme – Frequently Asked Questions'**
Website of the NSW Department of Trade and Investment, Regional Infrastructure and Services, www.industry.nsw.gov.au, by clicking through Sustainable energy » Renewable energy » Solar power » NSW Solar Bonus Scheme » Frequently asked questions

[16] **'Consumer Guide to Buying Solar Panels (photovoltaic panels)'**
Clean Energy Council, Volume 4: 5 October 2005. Available at:
www.cleanenergycouncil.org.au/dms/cec/resource-centre/Solar-PV-consumer-guide/Solar%20PV%20Consumer%20Guide%20Vol4%205%20Oct%202010.pdf

[17] **'Discussion Paper on Planning for Renewable Energy Generation – Small Wind Turbines'**
NSW DoP&I, April 2010, available online via: www.planning.nsw.gov.au by clicking through » Development Assessments » On exhibition » Previous On exhibition – draft policies and plans or try the link at: www.planning.nsw.gov.au/LinkClick.aspx?fileticket=yHOCF-baJXs%3d&tabid=394&language=en-AU

[18] **'NSW Industrial Noise Policy'**
Industrial Noise Policy, NSW Office of Environment and Heritage (OEH).
Available at: www.environment.nsw.gov.au/noise/industrial.htm

[19] **'Removing Impediments to Connecting Renewable Energy to the Grid'**
Clean Energy Council: www.cleanenergycouncil.org.au by clicking through Policy and Advocacy >> Industry Developments >> Removing Impediments

[20] **'Solar Bonus Scheme – Forecast NSW PV capacity and tariff payments'**
AECOM Australia, prepared by Jeremy Balding & Dominic Kua, October 2010, Page 10. Available at:
www.industry.nsw.gov.au/__data/assets/pdf_file/0016/360142/AECOM-REPORT-for-Solar-Bonus-Scheme-Review.pdf

USEFUL RESOURCES

RENEWABLE ENERGY PRECINCTS

The Renewable Energy Precincts initiative provides advice and support to individuals and communities in NSW for the uptake of renewable energy technologies, including small scale wind energy.

For more information on the NSW Renewable Energy Precincts see the website of the NSW Office of Environment and Heritage (OEH):
www.environment.nsw.gov.au/climatechange/renewableprecincts.htm

'The NSW Government is positioning NSW to take advantage of the predicted increase in investment in renewable energy that will result from the expanded national renewable energy target (RET) to 20 per cent by 2020.

The NSW Government is rolling out a wide suite of reforms to promote renewable energy, ranging from planning and regulatory reforms for cost-effective technologies through to incentives and grants for technologies that are further from commercial viability. Initially it is expected that most of the renewable energy supply will be met by wind energy developments.

One of the key components of the NSW Government's renewable energy agenda is the establishment of six renewable energy precincts in the New England Tablelands, Upper Hunter, Central Tablelands, NSW/ACT Cross Border Region, Snowy-Monaro and the South Coast.

The precincts are a community partnership initiative in areas where significant future renewable energy development is expected – especially wind farms – designed to give local communities a voice and a stake in renewable energy development.

Dedicated renewable energy staff have been put in place to help drive regional initiatives and lead stakeholder engagement to enhance knowledge, understanding and uptake of renewable energy.

IPART

IPART is an independent body that oversees regulation of the water, gas, electricity and public transport industries in NSW. You may find useful information regarding retail prices and tariff arrangements that affect your choice of system arrangement. See www.ipart.nsw.gov.au/

Recommended further reading

'Generate Your Own Power – Your Guide To Installing a Small Wind System'
Prepared by RenewableUK – the trade and professional body for the UK wind and marine renewables industries, 2010. Available online from the RenewableUK: www.bwea.com/pdf/publications/RenewableUK_SWS_Consumer_Guide.pdf

This is a very concise overview of undertaking a small wind turbine project.
'Managing the amenity impacts of low emission energy generation in commercial buildings'
Guide for Queensland local governments, the State of Queensland, Department of Employment, Economic Development and Innovation, 2010. Available from the Office of Clean Energy, Queensland: www.cleanenergy.qld.gov.au

'Small Wind Electric Systems – A U.S Consumer's Guide'
Prepared for the U.S. Department of Energy by the National Renewable Energy Laboratory, 2005.
Available online from the U.S Department of Energy website: www.windpoweringamerica.gov/pdfs/small_wind/small_wind_guide.pdf

'Stand-alone Power System – Small Wind Systems: System Design Guidelines'
Developed by the Clean Energy Council (CEC), 2004. Available online from the Clean Energy Council website: www.cleanenergycouncil.org.au/dms/cec/accreditation/Quick-Find-Forms/SWind_Design_G.pdf

'Choosing a Wind Turbine and Tower'
This is a series of articles collated by Green Energy Ohio relating to choosing a wind turbine and tower for your wind project, 2004. Available online from the Green Energy Ohio website:
www.greenenergyohio.org/page.cfm?pageId=536

'Urban Wind Turbines – Guidelines for Small Wind Turbines in the Built Environment'
Authored by Jadranka Cace, Emil ter Horst, Katerina Syngellakis, Maíte Niel, Axenne Patrick Clement, Axenne Renate Heppener and Eric Peirano for Intelligent Energy Europe, 2007.
Available online at: www.urbanwind.net/pdf/SMALL_WIND_TURBINES_GUIDE_final.pdf.

Feed in tariffs in NSW
Energy Matters website: www.energymatters.com.au/government-rebates/feedintariff.php

Energy auditing and saving power in NSW
Useful tools to conduct your own energy audits and find out how to save power at your home or business: www.savepower.nsw.gov.au

Useful websites

Australian Small Wind Energy Association: www.aswea.org.au

'Small Wind' guide within the American Wind Energy Association website: www.awea.org/smallwind

Bureau of Meteorology climate data: www.bom.gov.au

UK Microgeneration Certification Scheme: www.microgenerationcertification.org

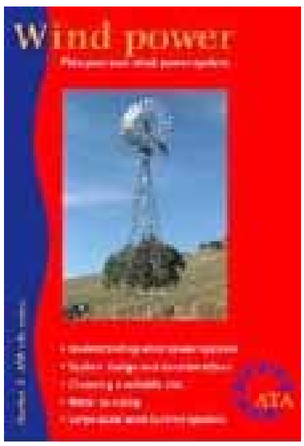
Small Wind Certification Council: www.smallwindcertification.org

The Small Wind Certification Council (SWCC), an independent certification body, certifies that small wind turbines meet or exceed the requirements of the AWEA Small Wind Turbine Performance and Safety Standard.

Planning an off–grid wind turbine?

If your property does not have affordable connection to the mains electricity grid, you may be considering an off-grid wind power system.

An existing guide is published giving you guidance on choosing and designing an off-grid wind turbine system. You can purchase the 'Wind Power Booklet' [Reference 2] for $10 from the Alternative Technology Association's online shop: http://shop.ata.org.au



Appendices

Appendix A – Small wind project checklist

1. Site and feasibility assessment

- [ ] Complete a wind resource assessment of your site to confirm feasibility for a small wind project
- [ ] Choose a location for your turbine
- [ ] Estimate your budget

2. System design

Choose a suitable:

- [ ] turbine
- [ ] tower
- [ ] inverter
- [ ] controller
- [ ] meter
- [ ] Make financial calculations considering the complete project cost and potential earnings

3. Development approval

- [ ] Contact your local council to confirm development approval requirements
- [ ] Supply council with the requested details to obtain relevant approvals to proceed

4. System installation

- [ ] Choose an installation team, which includes a CEC wind endorsed installer and licensed builder.
- [ ] System to be installed and connected to the grid by your chosen installation team

5. System operation and maintenance

- [ ] Apply and register your RECs if you have chosen to become an individual RECs trader.
- [ ] Ensure your turbine is regularly maintained by a qualified person.

Appendix B – List of small wind turbine suppliers

This section lists some active wind turbine vendors in NSW. It also lists active wind turbine installers in NSW. Often the installers are also effectively the vendors of the turbine, however in some cases you may purchase the turbine product and installation service separately.

While we have endeavoured to obtain details from all the relevant organisations, and it is possible that information on certain suppliers was not available to us and has therefore been omitted. Also, retail business changes from year-to-year and it is to be expected that this list will not remain static.

List of small wind turbine products

There is a reasonable amount of choice in the Australian market for small wind turbines. A small number of turbines are manufactured in Australia, however the vast majority are manufactured in America and the United Kingdom. In general, these manufacturers have appointed distributors of the turbines in Australia, through which suppliers and installers can order a turbine. However, turbines can often also be purchased directly through the manufacturer.

This section includes turbine specification data on all turbine models readily available in NSW and for which we have been able to obtain information. This list is not exhaustive, as there are a number of new models and suppliers coming onto the market regularly. We collected data in consultation with the industry, however we have not received responses from all relevant parties and therefore there are possibly other suppliers/resellers of turbines who we do not have information about.

Turbine prices

Typically a supplier of turbines will quote on a fully installed price, which includes an inverter, tower, batteries (if not grid connected) and installation costs. Differing ground conditions alter the foundation requirements, hence a range of prices is normally quoted to allow for this variation.

Some turbines are supplied with their own towers (eg Soma and Proven), however it is possible to obtain different towers that are still suitable for the turbine. Eden Power advises that Skystream turbines are no longer sold as individual units and are now sold as packages with tower included, as the manufacturer wishes to ensure they are installed with specific equipment.

To make the task manageable, this guide attempts to provide a recommended retail price for the turbine unit (minus towers, inverters, and installation) where possible, as the other costs will vary depending on the circumstances in which it is installed. As explained above, the Skystream has to be purchased as a fully installed package, and therefore an expected price range for a fully installed turbine is quoted.

The prices included in the list below are not a final installed price, unless stated otherwise, but simply a guide to the relative component cost of different turbines. Even in cases where an 'installed' price is quoted, this will vary from site-to-site depending on the site-specific factors such as soil types, foundation and/or mounting requirements.

For a small wind turbine project, the turbine cost (without tower, inverter or installation) normally represents about 25-35 per cent of the total project price.

In identifying turbines for inclusion on the NSW list of small wind turbine products, we have endeavoured to ensure:

- the turbine is manufactured in Australia and has both sales staff and technical support staff in Australia OR,
- for turbines manufactured overseas, the manufacturing company has sales and technical support staff in Australia,
- for turbines manufactured overseas, if the manufacturing company does not have staff in Australia, that it has approved reseller(s) in Australia who have both sales and technical support staff in Australia
- any approved resellers that are listed by the manufacturer have gone through necessary training provided by the overseas manufacturer and the reseller company details are made publicly available by the manufacturer (eg the overseas manufacturer lists its Australian resellers on its website).
- where multiple companies offer a certain turbine brand in NSW, we refer consumers instead to the manufacturer website so the manufacturer can inform the consumer of the available installers in their region. All installers are encouraged to ensure that they are publicly identified by the manufacturer (eg on the manufacturer's website). In the case of Skystream for example, the nearest approved resellers and approved service providers to any consumer address can be found using the Skystream website.
- company vending turbine offers warranty support for all customers in NSW, warranty support is demonstrated by one or more named staff or contractors who are resident in NSW, where the named staff or contractor holds accreditation for design and installation of grid connected systems including holding a valid Clean Energy Council endorsement for small wind
- the wind turbine advertised is already in production. Where a turbine is a prototype with design changes expected for the commercial version, the word 'prototype' is stated under the turbine model.

Turbine noise

For turbines where only a sound pressure level, LP, at a distance (r, in m) from the turbine is provided, the sound power level, LW, is calculated by Enhar based on the following formula: (denoted with a star * in the table below)

$$LW = LP + 20 \log10 (r) + 8 \text{ dB}$$

Brand/ made in	Model	Power rating	Cut-in speed (m/s)	Voltages available	Overspeed protection	No. of blades	Blade material	Rotor diameter (m)	Weight (kg)	Generator type	Sound power level at 8 m/s	Comments	RRP	Warranty (yrs)	Manufacturer or distributor
Aerogenesis (Australia)	5kW	5000 @ 10.5 m/s	3	80 – 500 AC	Micro-processor control and electro-mechanical brake	2	Vacuum infused fibre glass reinforced epoxy	5	1300 (inc tower)	3 phase induction generator		Recently commerc-ialised			Aerogenesis Australia david.wood@aerogenesis.com.au www.aerogenesis.com.au
Aircon (Germany)	Aircon 10kW	9800W @ 11 m/s	3.5			3		7.6				towers at height of 12, 18, 24, 30m. 18, 24m monopole		5	The Wind Turbine Company (Melb) ph: 1300 858 073, enquiries@twtc.com.au www.twtc.com.au
Ampair (UK)	Pacific 100	100W @ 12.6 m/s	3	12, 24	None	6	Glass filled polyprop-ylene	0.928	12.5	3 Phase Direct Drive Permanent Magnet	48 dBA[1]		$1,724	2	Precision Wind Technology Pty. Ltd Ph: (02) 6679 1234 www.pwt.com.au & Energy Matters (South Melbourne) Ph: 1300 727 151 sales@energymatters.com.au www.energymatters.com.au
	300	300W @ 12.6 m/s	3	12, 24	PowerFurl™ blade pitch control system	3	Glass reinforced polyester	1.2	12		~ 68.75 dBA		$3,346		
	600	698W @ 11 m/s	3	24, 230 Grid				1.7	16		89.5dB[2]		$4,366		
Bergey WindPower (USA)	BWC XL.1	1000W @ 11 m/s	2.5	24 DC, 120 AC 60Hz, 230 AC 50 Hz	Auto Furl	3		2.5		Permanent Magnet Alternator	No data	off-grid use only	$4,500	5	Bergen Wind, 26n Derby St, Walcha, NSW, Ph: (02) 6777 1044 www.bergenwind.com.au
	BWC Excel	10000W @ 13.9 m/s	3.6								98.4 dBA[3]		$30,000	5	
Endurance (Canada)	Edur-ance 5kW	5200W @ 11 m/s	4.1			3		6.37				30m guyed or standard towers available, as well as 18, 24m monopoles towers		5	The Wind Turbine Company (Melb) ph: 1300 858 073, enquiries@twtc.com.au www.twtc.com.au
Eoltec	Scir-occo 5.5-6000	6000 W @ 11.5 m/s	2.7		Full span centrifugal pitch control	2	FV + Epoxy, aluminium root insert, hollow technology	5.6	202	Synch ronous Permanent Magnet Generator	No data				Solar Inverters Ph: (02) 6655 3930, 30 Osprey Drive Urunga, NSW www.solarinverters.com.au

Brand/ made in	Model	Power rating	Cut-in speed (m/s)	Voltages available	Overspeed protection	No. of blades	Blade material	Rotor diameter (m)	Weight (kg)	Generator type	Sound power level at 8 m/s	Comments	RRP	Warranty (yrs)	Manufacturer or distributor
Evoco (UK)	Evoco 10kW	9800W @ 11 m/s	3.5			3		7.6						5	The Wind Turbine Company (Melb) ph: 1300 858 073, enquiries@twtc.com.au www.twtc.com.au
Exmork (China)	HM 2.2-300	300W @ 8 m/s	3	12, 24 DC	Yaw	3	Reinforced Fibreglass	2.2	40	3 Phase Permanent Magnet Generator	No data	turbine only (exclude installation)	$500	1	Wind Power Energy (WA) ph: (08) 9683 2101 windpowerenergy@bigpond.com www.windpowerenergy.com.au
	HM 2.5-500	500W @ 8 m/s						2.5	46				$715		
	HM 2.8-1000	1000W @ 8 m/s		24, 48 DC	Yaw & Auto Brake			2.8	70				$1,000		
	HM 3.2-2000	2000W @ 8 m/s		24, 48, 120, 240, 300 DC				3.2	123		86.5 dBA[4]		$1,650		
	HM 4-3000	3000W @ 10 m/s		48, 120, 240, 300, 350 DC				4	327		84.9 dBA[5]		$3,390		
	HM 5.5-5000	5000W @ 10 m/s						5.5	358		84.9 dBA[6]		$5,290		
	HM 7-10000	10000W @ 11 m/s		240, 300, 360, 480 DC				7	1250				$14,745		
	HM 10-20000	20000W @ 11m/s						10	1698				$22,695		
Fortis (Nether-lands)	Passaat	0.9kW @ 11m/s	3	DC: 12/24/48, AC: 240	Auto furl, generator short circuit	3		3.12	75	3 Phase permanent magnet		Pricing provided by Australis Energy, includes 18 meter guy wired mast, excluding installation.	$17,350	5	Go to Fortis's webpage: www.fortiswindenergy.com and click on 'contact' to identify the Australian dealer
	Montana	3.4kW @ 11m/s	2.5	DC: 48/120 /240, AC: 240		3		5	200				$32.000	5	
	Alize	8.5kW @ 11m/s	3	DC: 120/240, AC: 240		3		7	420				$70,000	5	
Gaia Wind (Denmark)	133-11kW	11000W @ 9.5m/s	3.5	400 AC	Passive stall, mechanical brake, centrifugal aerody-namic rotor brake	2	Fibreglass	13	900	3 phase induction generator	86 8 dBA[7]	Inverter-less	$110,000 fully installed	2	Regen Power Ph: (02)9636 4670 admin.nsw@regenpower.com www.regenpower.com

Brand/made in	Model	Power rating	Cut-in speed (m/s)	Voltages available	Overspeed protection	No. of blades	Blade material	Rotor diameter (m)	Weight (kg)	Generator type	Sound power level at 8 m/s	Comments	RRP	Warranty (yrs)	Manufacturer or distributor
Kestrel (South Africa)	Kestrel e300i	1000W @ 11m/s	2.5	12,24,36, 48,110, 200 VDC	Pitch Control	3	Fibreglass	3	75	Permanent Magnet Axial flux brushless	No data	48 Volt, Latronics	$7,728.70	2	Aura Wind Power, 30 Roberts St Old Erowal Bay, NSW, Phone (02) 4443 3662 Mobile 0411 788 234
												200 Volt, SMA	$9,095.0	2	
	Kestrel e400i	3000W @ 11m/s	2.8	48,200,300 VDC	Pitch Control	3	Fibreglass	4	150	Permanent Magnet Axial flux brushless	No data		$19,460	2	
LVM (UK)	212/224	48W @ 20.5m/s	6.2	12., 24	None	5	Glass filled poly-propylene	0.58	5	3 Phase Permanent Magnet Alternator	No data	Marine applications	$1,340	1	Neosid Australia (Importer) ph:(02) 9660 4566 sales@neosid.com.au www.neosid.com.au
	412/424	228W @ 31m/s	4.1			6		0.87	9.3		No data	4F & 6F variety will furl – land only	$2,210		
	612/624	360W @ 23.1m/s	3.3					1.22	12.5		No data		$3,520		
MUCE (China)	1kW	1000W @ 8m/s	3	48 DC	Furling and electro-magnetic brake	3	Glass Rein-forced Plastic	2.7	83	3 Phase Permanent Magnet Generator	NA[8]	Price is fully installed	$9,500	2	I Want Energy (TAS) ph: (03) 6231 0002 rob@iwantsolar.com.au www.iwantsolar.com.au
	5kW	5000W @ 10m/s			Electronic Brake			6.4	250				$29,500		
	10kW	10000W @ 9m/s		Unknown	Hydraulic Brake			8	600				$51,500		
	1.6kW	1600W @ 10m/s		48 DC	Electro-magnetic and mechanical brake	5	Un-known	2	Un-known			VAWT. Price is fully installed	$10,840		
	3.2kW	3200W @ 10m/s		148 DC				3					$25,700		
	6kW	6000W @ 10m/s	1.8	216 DC				4			Wind tunnel tests indicate less than 8dB above back-ground[8]		$46,080		
	12kW	12000W @ 11m/s		48 DC				6					$88,370		
	30kW	30000W @ 11m/s		384 DC				9					$216,010		

Brand/ made in	Model	Power rating	Cut-in speed (m/s)	Voltages available	Overspeed protection	No. of blades	Blade material	Rotor material	Weight (kg)	Generator type	Sound power level a 8m/s	Comments	RRP	Warranty (yrs)	Manufacturer or distributor
Osiris (China)	Osiris 1.6	1600W @ 10.5m/s	2.4	240V AC	Dump load, passive furling and blade stall	5	Fibreglass reinforced composite	3.2	78	Direct drive permanent magnet	No data		~$5,000 (turbine only)	5	Ginlong Australia (Australian contact details yet to be confirmed)
	Osiris 10	10,000W @ 9.5m/s	2.5	240V AC	Pitching and mechanical brake	3	Carbon Fibre reinfoced composite	9.7	1000	Direct drive permanent magnet	No data		~$30,000 (turbine only)	5	
Proven (UK)	Proven 2.5	2800 @ 12m/s	2.5	12, 24, 120, 240VDC; 300VAC	Downwind, Flexible Blades	3	Glass thermo-plastic composite	3.5	190	Brushless permanent magnet, direct drive	No data	Costs include tower	$38,544	5	Conergy Pty Ltd ph:(02) 8507 2222 sales@conergy.com.au www.conergy.com.au
	Proven 6	6000W @ 12m/s		48, 120, 240VDC; 300VAC				5.5	600		85.4 dBA [9]		$74,580		
	Proven 15	15000W @ 12		48VDC; 300VAC				9.8	1100		92 dBA [10]		$161,568		
Quiet Revolution	QR5	4200W @ 11m/s	4.5	Grid only	Overspeed Braking and automatic shutdown	3	Carbon and Glass Fibre	3.1	450	Direct Drive Permanent Magnet Generator	88.4 * dBA[11]	VAWT. Price incl inverter and controller	$53,650 (inc inverter and controller)	2	Maxim Renewable (Alphington) ph: 9490 9999 www.maximrenewable.com.au
Radotec (Australia)	Proto-type vertical axis turbine	10,000W @ 11m/s				3							Prototype stage, retail price not available		www.radotec.com.au
Renewable Devices (UK)	Swift	1000W @ 11m/s	3.58	240 Grid	Angling Furling/ Dynamic Brake	5	Unknown Plastic	2.1	52	Brushless Permanent Magnet	35 dBA[12]	Rooftop Mounted, diffuser ring		2	Cubic Solutions www.cubicsolutions.com.au Tel 1300-4-CUBIC Contact Trevor Loffel
Rewind Energy (China/ Germany)	5kW	5000w @ 10.5m/s	3	500 DC	Blade Pitch	3	Fibre-glass	5.4	450	3 Phase Permanent Magnet Generator	*95.55 dBA	Price is fully installed	$38,830	3	Rewind Energy (NSW) ph: 1300 322 678 sales@rewindenergy.com.au www.rewindenergy.com.au
	10kW	10000W @ 12m/s						7.6	550		*97.55 dBA[13]		$66,910		
	Revolut-ionAir	1000W @ 14 m/s		240 Vac	Passive stall				62	Permanent Magnet	72				

Brand/ made in	Model	Power rating	Cut-in speed (m/s)	Voltages available	Overspeed protection	No. of blades	Blade material	Rotor diameter (m)	Weight (kg)	Generator type	Sound power level at 8 m/s	Comments	RRP	Warranty (yrs)	Manufacturer or distributor
Ropatec (Italy)	Easy Vertical	1000W @ 14m/s	3	12, 24, 48	Not Required	3		1.8	130	3 Phase Permanent Magnet		VAWT	$10,780	2	Sustainable Energy Solutions (Operating as CREST), South Australia
	Simply Vertical	3000W @ 14m/s		48DC; 115, 230AC				3.3	450		NA[14]		$28,160		
	Maxi Vertical	6000W @ 14m/s		48DC; 115, 230AC			Fabricated	4.7	760				$40,920		
Rutland (UK)	913	90W @ 9.8m/s	2.6	12	None	6	Unknown	0.91	10.5	3 Phase Alternator	No data	For remote area applicattion	$ 956	2	Precision Wind Technology Pty. Ltd Ph: (02) 6679 1234 www.pwt.com.au
Soma (Australia)	Soma 400	400W @ 10m/s	4	12, 24, 32, 48, 110, 120	Tilt Up	2	Hollow Moulded Fibreglass	2	40	Brushless Permanent Magnet	Data not yet available (tests underway)		$5,400	1	Sunrise Solar ph: (02) 43811531 sunrise@dragon. net.au www. somapower.com.au
	Soma 1000	1000W @ 10m/s	3.5					2.7	50				$9,917		
Southwest Wind-power (USA)	Air X	400W @ 12.5m/s	3.58	12, 24, 48	Electronic Torque Control	3	Carbon Fibre Composite	1.15	6.2	3 Phase Permanent Magnet Alternator	~80dbA[15]	Marine is powder coated for corrosion protection	$1529 (Land)	3	Southwest Wind Power list approved resellers of Air and Whisper products To find your nearest dealer, go to www.windenergy. com/ Click on 'Locate a Dealer' and enter your address Approved Skystream dealers also sell Air and Whisper products Southwest wind power train and authorise approved Skystream resellers and service agents. To find dealers near you, go to www. skystreamenergy. com and click on 'where to buy'
	Air Breeze	160W @ 12.5m/s	2.68	12, 24, 48		3	Injection Moulded Composite	1.17	5.9	Brushless Neody-mium Alternator	No data		$1271 (Land)		
	Whisper 100	900W@ 12.5m/s	3.4	12, 24, 36, 48	Side Furling	3	Carbon Reinforced fibreglass	2.1	21	3 Phase Permanent Magnet Alternator	84.9dBA[16]		$5,415	5	
	Whisper 200	1000W @ 11.6m/s	3.1	24, 36, 48				2.7	30		~88dBA[17]	HV Avail	$6,519		
	Whisper 500	3000W @ 10.5m/s	3.4	24, 36, 48		2		4.5	70		No data		$16,456		
	Skystream	2400W @ 13m/s	3.5	120/240 VAC	Electronic stall regul-ation with redundant relay switch control	3	Fibreglass reinforced composite	3.72	77	Slotless permanent magnet brushless	84.9dBA[18]	Controls & inverter built in. Includes Tower in package	$30,000-$40,000 fully installed		
Superwind	350	350W @ 12.5 m/s	3.5	12, 24, 48 DC	Rotor Blade Pitch	3		1.2	11.5	Permanent Magnet	No data	Meets IEC 61400-2 Design require-ment			Solar Inverters Ph: (02) 6655 3930, 30 Osprey Drive Urunga, NSW www.solarinverters. com.au

Brand/ made in	Model	Power rating	Cut-in speed (m/s)	Voltages available	Overspeed protection	No. of blades	Blade material	Rotor diameter (m)	Weight (kg)	Generator type	Sound power level at 8 m/s	Comments	RRP	Warranty (yrs)	Manufacturer or distributor
Teco	WV750	750 @ 12 m/s	2.3	24, 48 DC	Aerody-namic effects of blades & Electro-magnetic brake	3	Fiber-glass Reinforced Composite	1.8	27.5	Permanent magnetic brushless 3PH AC generator	No data				McFarlane Generators www.macgen.com Clayton South, VIC wind@macgen.com Tel (0) 3 9544 4222
	WV2500	2500 @ 12 m/s	3	48, 96 DC				2.9			No data				
Urban Green Energy (USA)	UGE 600	640W @ 12m/s	3.5	24, 48 DC	None	3	Fiberglass	1.38	81.6	Direct Drive Permanent Magnet Generator	78.6*	VAWT. Prices include towers and inverters	$9,481.30	1 extend-able	Advanced Eco Solutions Pty Ltd (NSW) ph: 02 8437 6264 ben@advancedeco.com.au www.advancedeco.com.au
	UGE 1kW	1000W @ 12m/s	3				Carbon Fibre and Fibreglass	1.8	175		77.6*		$15,462		
	UGE 4kW	4000W @ 12m/s	3	50 – 580 AC				3	444		78.6* dBA[19]		$34,533		
Westwind (Northern Ireland)	3kW	3000W @ 14m/s	3	48, 120, 240 Grid	Auto Tail Furl	3	Pultruded Fibreglass	5.1	200	Direct drive permanent magnet	No data		$9,619	2	Numerous sellers, but no central distributors. See www.westwindturbines.co.uk Solartec Renewables Ph: (02) 4476 5912 phil@solartec.com.au
	5kW	5500W @ 14m/s							200				$15,466		
	10kW	10000W @ 14m/s		120, 240 Grid				6.2	380				$27,560		
	20kW	20000W @ 14m/s		240 Grid	Blade pitch/ tail furl		Epoxy/ carbon/ fibreglass composite	10.4	750				$53,190		
Windspire Energy (USA)	Wind-spire 1.2kW	1200W @ 10.7m/s	3.8	120 AC	Redundant electronic braking system	3	Extruded Aluminium	1.2	283	Brushless Permanent Magnet Generator	No data	VAWT. Integrated inverter	$14,200 (inc tower & inverter)	5	AllSafe Energy Efficient Products Ph: (07) 3855 8733 www.all-safe.com.au/
Wind Energy Ball	V200	2250W @	3	230 V, 60 Hz	Electrical Brake System	5	Reinforced Glass Fiber Polyester	1.98	90	Permanent Neody-mium Magnet	87.2 dBA[20]	$11,440 without Tower	$14,960	2	Aura Wind Power, 30 Roberts St Old Erowal Bay, NSW, Phone (02) 4443 3662 Mobile 0411 788 234
WinPower (China)	FSHD-2000	2000W @ 10m/s	3	48 V DC / 240V	Tail turning and electric magnet, Automatic	3	Reinforced Fibreglass	4	280	3 Phase, Permanent Magnet	No data			1	Energy Matters, 35 Tebbutt St, Leichhardt, NSW, Ph: 1300 727 151 www.energymatters.com.au

Brand/ made in	Model	Power rating	Cut-in speed (m/s)	Voltages available	Overspeed protection	No. of blades	Blade material	Rotor diameter (m)	Weight (kg)	Generator type	Sound power level at 8 m/s	Comments	RRP	Warranty (yrs)	Manufacturer or distributor
Xzeres ARE (USA)	Xzeres ARE110	2500W @ 11m/s	2.5	220-240 VAC 50/60 Hz, 208, 277 VAC 60 Hz	Self Governing tail furling via diversion load	3	Fibreglass	3.6	143	3 Phase, Neody-mium permanent magnet	No data		$15,044.20	10	Aura Wind Power, 30 Roberts St Old Erowal Bay, NSW, Phone (02) 4443 3662 Mobile 0411 788 234
	Xzeres ARE442	10000w@ 11.2m/s	2.2					7.2	725		87.6 dBA[21]		$44,365		
	Xzeres 442SR	10000W @ 11m/s		380-415 VAC 50 Hz					725						
Zephyr (Japan)	Aero-dolphin Mark-Zero	1000W @ 12.5m/s	2.5	25V	Downwind, Flexible Blades	3	Carbon Fibre Skin on unknown material	1.8	17.5	3 Phase Permanent Magnet Alternator	49.5 dBA[22]	Designed for turbulent wind			Water & Energy Savers (Operating as Swan Energy) ph: 02 9494 0700 www.swanenergy.com.au

REFERENCES USED IN ABOVE TABLE OF WIND TURBINE PRODUCTS

Ref	Source and notes
1	Paul Gipe measured noise emissions from Ampair 100, but could not estimate Sound Power Level at 8 m/s due to the lack of difference between background noise. In the unloaded state SPL was calculated as 80dBA at 8m/s www.wind-works.org
2	Whitson R J, 2008, Acoustic Noise Measurement on an Ampair 600-230 Mk 2.5 Wind Turbine, TUV NEL.
3	Bergey Windpower 2007, Noise test data for the 10 kW Bergey Excel wind turbine, reproduced in "Managing the amenity impacts of low emission energy generation in commercial buildings: Guide for Queensland local government", 2010
4	'Wind Turbine Generator System Acoustic Noise Test Report for the HM 2kW Wind Turbine'. National Windpower Engineering Technology Research Centre. 2009.
5	'Wind Turbine Generator System Acoustic Noise Test Report for the HM 3kW Wind Turbine'. National Windpower Engineering Technology Research Centre. 2008.
6	'Wind Turbine Generator System Acoustic Noise Test Report for the HM 5kW Wind Turbine'. National Windpower Engineering Technology Research Centre. 2008.
7	Bowen A., et al, 2010, Small Wind Turbine Testing Results from the National Renewable Energy Laboratory, NREL.
8	Sound pressure measurements at 2m from the turbine were conducted. Due to the low noise levels, reportedly indiscernible above background noise, sound power level results at 8m/s to the IEC 61400-11 standard have not been provided
9	Clive J., (2007), 'Proven Energy 6kW WTGS at Neilston Noise Survey', SgurrEnergy Sustainable Energy Solutions. Test performed to the BWEA Standard
10	Broneske S., (2010), 'Proven P35-2 Wind Turbine Noise Performance Test', Hayes McKenzie.
11	Sound Power level for QR5 turbines:ISVR Consulting 2007, reproduced in "Managing the amenity impacts of low emission energy generation in commercial buildings: Guide for Queensland local government", 2010
12	Swift Wind Turbine Specifications, by Cascade Renewable Energy. Renewable Devices publish detailed information including noise emission at 8 m/s, demonstrating quiet operation. However, the turbine sound power level at source has not been reported.
13	Calculated by Enhar based on Lp at 8 m/s, at 30m and 60 m away from the rotor, according to the product specifications.
14	Ropatec has conducted their own measurements of noise, however not according to the IEC standard and therefore are not suitable for comparison
15	Paul Gipe measured the noise emissions from two versions of the AirX model, results are available at www.wind-works.org/articles/sm_AirXNoise.html
16	Migliore et al, 2003, Acoustic Tests of Small Wind Turbines, 2004 Wind Energy Symposium Reno, Nevada, NREL
17	Bowen A., et al, 2010, Small Wind Turbine Testing Results from the National Renewable Energy Laboratory, NREL.
18	Migliore et al, 2005, Balancing Performance, Noise, Cost, and Aesthetics in the Southwest Windpower "Storm" Wind Turbine, WindPower 2005,
19	Acoustic Noise Test done by China Ceprei (Sichuan) Lab. (2010). It meets IEC 61400-11 according to the test report.
20	Dijkstra, M.T., 2009, Wind Energy Ball V200 Sound Power Level Measurements, Home Energy BV, Lichtveld Buis & Partners.
21	Dam, J. V., 2010, Wind Turbine Generator System Acoustic Noise Test Report for the ARE442 Wind Turbine, NREL.
22	Zypher has measured Sound Pressure Level. At 8m/s appears to be –around 49.5 dBA from the noise data curve. www.energyconnectuk.com/pdf/NoiseData.pdf

List of Small Wind Turbine Installers in New South Wales

From December 2010, the Clean Energy Council will list accredited installers who also hold a wind endorsement. This list is available through the website www.cleanenergycouncil.org.au

The wind-endorsed installers list on the CEC website is regularly updated to include new entrants and to remove expired installers.

At the time of production of this guide, companies active in manufacture, supply or installation of wind turbines in NSW included:

- Advanced Eco Solutions Pty Ltd
- Aerogenesis
- AllSafe Energy Efficient Products
- Aura Wind Power
- Austral Energy Pty Ltd
- Australis Wind Energy
- Advanced Eco Solutions Pty Ltd
- BergenWind
- Conergy Pty Ltd
- Cubic Solutions
- Ecowhisper
- edenPOWER Pty Ltd
- Energy Matters
- I Want Energy Pty Ltd
- Ladder Technologies Pty Ltd
- MacFarlane Generators
- Maxim Renewable
- Neosid
- Precision Wind Technology
- Radotec
- Regen Power
- Rewind Energy
- SolarTec Renewables
- Soma, trading as Sunrise Solar
- Sun Wind and Power
- Sustainable Energy Design
- The Wind Turbine Company

The above list is not exhaustive and includes some companies offering services to the NSW region who are yet to complete commercial installations in NSW. It also includes some companies who have completed significant numbers of installations in NSW and who have been operating for many years in NSW.