Victorian Consumer Guide to Small Wind Turbine Generation

Prepared by Enhar for
Sustainability Victoria
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Development of this guide

This guide was authored by Enhar during the period March-May 2010.
The scope and chapter titles were specified by Sustainability Victoria.

As part of the development of this guide, a Small Wind Industry Roundtable event was held on 27th April 2010 in Melbourne. Invitees to this event included all Clean Energy Council accredited solar PV installers in Victoria. Feedback was taken from the attendants on the topics addressed by this guide.

The development of the guide was publicised on the Enhar website during April and May 2010.

Chapter 1. Introduction

1.1. Background

If you are interested in purchasing a small wind turbine for your home or business in Victoria, this Guide is for you. You will find useful information here to assist you to 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 of a size that would suit the needs of a domestic dwelling or small business. These are less than 100kW maximum capacity and are most commonly in the range 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 that remains relevant for medium sized wind turbines.

Wind Turbines

- **Use wind power to generate electricity for your use and,**
- **Store excess electricity in batteries for later use, or**
- **Feed electricity into the grid to reduce your electricity bill**

Benefits of a wind turbine system to the householder or small business	
☑ Wind Turbine Systems generate electricity	☑ Once you have paid for the system, the wind turbine generates power from a 'free' and inexhaustible source – the wind
☑ Wind turbines operate day and night – whenever it is windy	☑ Wind electricity can compliment a solar system
☑ Wind powered electricity creates no greenhouse gases or other harmful pollutants	☑ A wind turbine can supplement or supply all of your power needs

1.2. Definitions and glossary

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

Airfoil	The shape of the blade cross-section, designed to create 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 which 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
Density	Mass 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.
Downwind	In the opposite direction from which the wind is blowing. I.e. a 'downwind' turbine is one where the wind passes through the turbine blades from behind, not infront.
Furling	A passive protection for the turbine where typically the rotor folds either up or around the tail vane.
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 nacelle.
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.
Noise emission	The noise which is emitted into an environment by an object, in this case a wind turbine
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 and 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 revolutions per minute 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 wind speed.
Swept area	The area swept by the turbine rotor, $A = \pi R2$, where R is the radius of the rotor and π is pi.
SWT	Small Wind Turbine.
Tip speed ratio	The speed at the tip of the rotor blade as it moves through the air divided by the wind velocity. This is typically a design requirement for 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 movement of the tower top turbine that allows 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.

1.3. System overview

A small wind turbine system comes with several important components. The diagram below gives a guide to a typical small wind turbine system at a house.

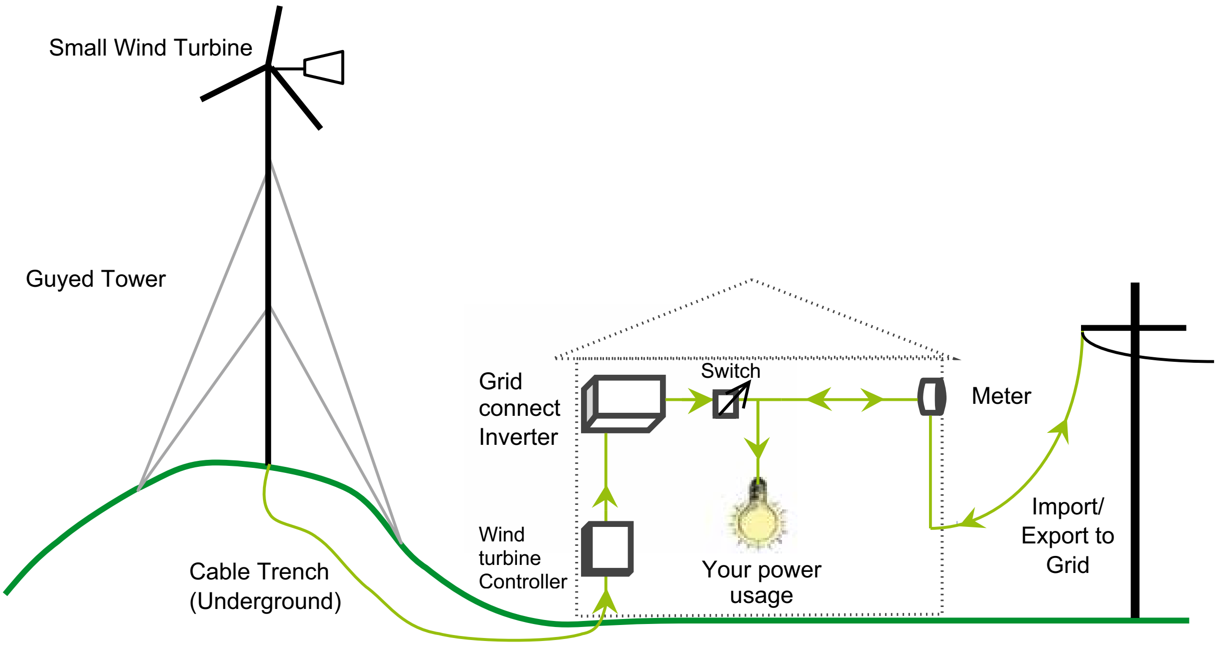


Figure 1. System components

This illustration shows how a grid-connected SWT works. The meter arrangement shown here is for a "net metering" situation, which allows you to benefit from a "net feed in tariff" which is the type of tariff currently available in Victoria[1].

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

There is a switch to disconnect your inverter and wind system for maintenance if required. Electricity travels from your inverter to your household appliances as well as to your meter. From the meter, excess electricity generated by the turbine is exported to the grid. When your power demand is greater than the output of your wind turbine, electricity is imported from the grid to the house via the meter.

1. Gross metering is an alternative system, in which a special meter would record all output from the inverter, not just the 'surplus' exported to the grid. At present, a gross tariff for small scale renewable energy is not mandated in Victoria, so equipment for gross metering is not required.

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 Victoria?	Information on funding sources is given in Chapter 3
How do I obtain planning permissions?	Advice on planning permission 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 which are relevant to me?	Case Study examples of several wind turbine installations are given in Chapter 6
What wind turbines are available in Australia?	Appendix B gives a list of available wind turbines
Where can I find an installer?	Appendix B also gives a list of installers active in Victoria

This Guide has been produced following a series of earlier reports on small wind turbines commissioned by Sustainability Victoria.

The Alternative Technology Association's report "The Viability of Domestic Wind Turbines for Urban Melbourne" was the first of these, published in 2007 [Ref 1]. It investigates types of turbine on the market and whether these would be viable for sites in urban Melbourne. To find out where you can get this report, and the other references used in this Guide, see Chapter 7 - References and further reading.

Want a larger turbine?

If you want to install a larger wind turbine over 100kW in capacity, you will come across different challenges such as

- Fewer turbines on the market in the 100kW range
- Feed in tariff rules do not apply above 100kW i.e. power companies are not obliged to purchase exported power.

These issues specific to larger wind turbines over 100kW are not covered in this Guide. You can however find some useful guidelines for planning such projects in the Victorian Wind Farm Guidelines.

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

The process beginning from first choosing a wind turbine to having it installed is likely to take several months. The Process Flowchart below gives you an idea on what the overall process might look like:

1. Site & 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, trees etc,
- Proximity to your dwelling, neighbours etc.
- Public amenity
- Environmental impacts (e.g. birds, bats etc.)

Budget Estimation

Consider cost of:
- Site Assessment
- Consultation fees
- Turbine, tower, inverter, controller
- Planning Permit fees
- Installation & Maintenance fees

Consider earnings from:
- Renewable Energy Credits
- Selling electricity to the grid

2. System Design

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

Choose a:
- Turbine
- Tower
- Inverter
- Controller

that 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 to calculate earnings from feed-in tariff
- Calculate Renewable Energy Credits (RECs)

3. Planning Permission

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

Gain approval from your electricity distributor to connect your system to the grid and install an interval meter.

System to be 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 utilising electricity generated from your turbine in your house.
Earnings will be made from excess energy exported to the grid.
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 location for a wind turbine. It is essential that you have sufficient strong and consistent winds at the turbine location, low turbulence in the wind and also that the turbine and its tower structure will be an acceptable addition to the local neighbourhood.

Examples of wind speed measurement projects are available in Victoria. A wind resource assessment of the Victorian urban area was undertaken by the Alternative Technology Association, published in 2009 [Ref 3]. Wind speeds were measured at several sites around greater Melbourne. The report concludes however that only a minority of urban sites have a wind resource suitable for wind generation. Enhar also recorded coastal wind speeds for the City of Port Phillip in 2009 [Ref 4]. You can find where to get these reports in the Chapter 7 - References and further reading.

If your site is in an urban area, adequate wind resources to generate useful power are only likely if the site is right next to the coast, or on top of a tall building or on another highly exposed area. Rural locations may generally have fewer obstacles around such as neighbouring buildings which shelter your site from the wind. Therefore your chances of having a viable wind turbine site are higher if your site is in a rural location.

This chapter gives you practical guidance on how to confirm that your site is suitable, including how to measure and assess the wind resource using cup anemometers.

Since wind turbines do generate some noise, guidance is also provided on ensuring your turbine is a sufficient distance from neighbouring dwellings to prevent your wind turbine causing any unacceptable noise levels.

2.1. Wind speed estimation

In order 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 based on published information of there selected small wind turbine manufacturer,

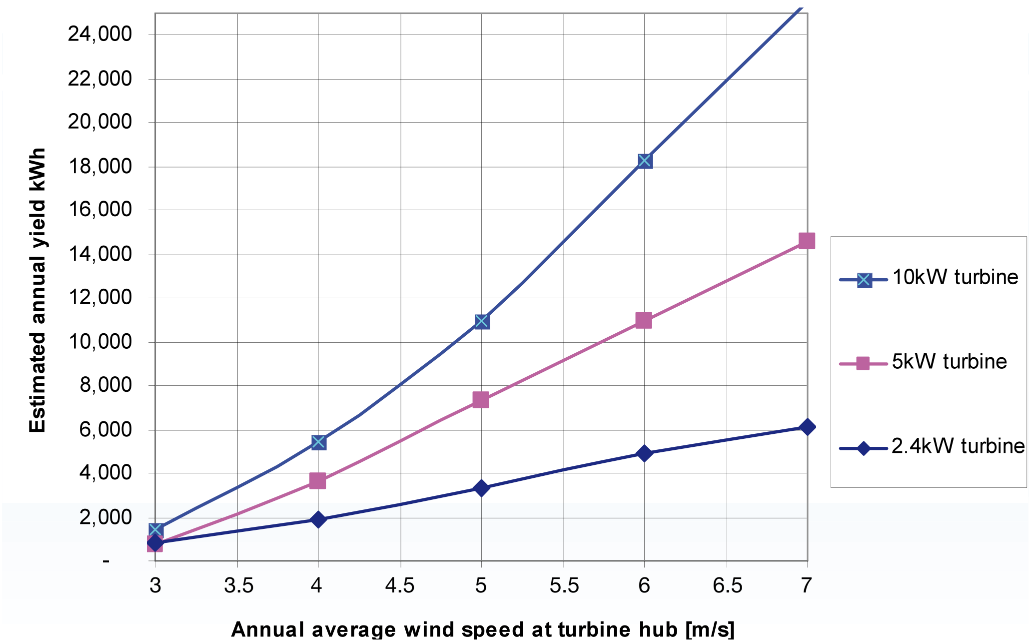


Figure 2: Variation of wind turbine yield with annual average wind speed

Each of the lines in the above graph is based on performance information of real 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 cube of the wind speed which means a small increase in speed equals a large increase in energy.

The above graph is based on some standard assumptions and is intended only as a guide, not as an absolute rule of how much your turbine will generate.

Monitoring the wind speed is one way to find out how much your turbine will generate. However this is an up-front cost which you need to undertake, normally at your own expense. 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 home-scale wind energy is whether you are better to save the money you would have spent on setting up a monitoring system, and put that saving towards purchasing your wind turbine system. This would only be a wise choice if you do have a very strong wind resource in the first place, so strong that you don't need monitoring to confirm it. Below are listed some indications of whether you have a very strong wind resource.

If online data sources indicate strong winds in your region and your site is well exposed to regional and local winds, you probably don't need to monitor to confirm your resource.

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

i) The Victorian Wind Atlas – a wind speed map at 3km resolution showing annual average wind speeds at 65m above ground for the whole of Victoria, available from the Sustainability Victoria Website [Ref 5].

Bear in mind that at your turbine hub height, say 20m, the wind resource will be lower than the mapped 65m values. This map was produced for the large-scale wind farm industry and at a 3km resolution, indicates wind resource levels regionally.

ii) Global 'Firstlook' database available from 3Tier, http://www.3tier.com

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

This interface is also available through another site http://www.skystreamenergy.com/wind/index.php which also includes a wind speed estimated range at 14m above ground level.

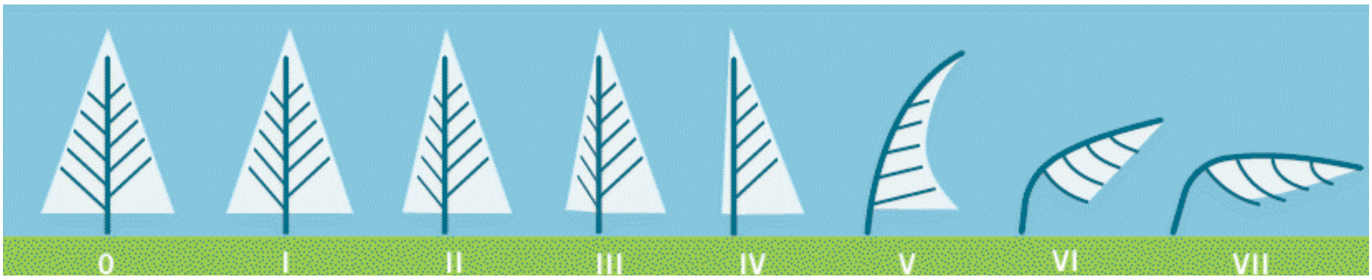
When using wind maps such as i) and ii), bear in mind that wind resource is not uniform over the 3km or 5km grid used in these applications. This means that local effects such as sheltering from trees or houses can dominate at your site causing significant differences between your site and the regional average, these are not shown in the online wind maps.

iii) You can also refer to the Bureau of Meteorology (BoM) data published at http://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. Wind speeds, if recorded at a BoM station, are normally measured at 10m above ground level and the 9am and 3pm averages are published. If you do have a Bureau station very nearby your property, you can compare the wind records at the BoM site, to see if the 9am and 3pm records are above 5m/s for example.

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. See 'what is a wind rose' in [Ref 7].

Once you have established that your region has strong wind resources, say above 7m/s at 65m, 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 that relate to vegetation growth.



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

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

This index was produced by a scientific study in the USA that observed two species of conifer, the Douglas Fir and the Ponderosa Pine. Equations have been applied to link the deformation of the tree to probably long term average wind speeds at 30m above ground level. You can use it if you have isolated trees in the vicinity of your turbine that have been growing for several years. Even if you don't have conifers around, if you can see the branches of local trees grow leaning in one particular direction, or the whole tree leans in one direction, then this is a good indication of a strong wind resource.

Remember if your turbine tower is lower than 30m, 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 confirming 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 that is atop a hill (whose peak is at least 20-40m above the local surrounding area) and free of obstacles in the prevailing wind directions, then you probably have a good wind resource site.

These are some rules of thumb that will allow you to be fairly certain that your wind resource is so good that it isn't essential for you to monitor it to confirm this.

Urban areas: as noted before these are less likely to have good wind resource sites compared to open rural areas, as demonstrated in urban wind resource studies [Refs 3,4]. Some of the best good urban wind resources are to be found along shorelines and atop tall buildings. The top of tall buildings by the sea for example would generally be a good wind resource location.

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 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. They will advise on other aspects of the installation that will be useful in planning your project, and allow them to 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 Chapter 7 - References and Further Reading,

2.2. Avoiding excessive turbulence

What is turbulence?

Turbulence is another important factor, apart from wind speed, to bear in mind. Turbulence is the fluctuation of wind speed and direction due to eddies and other circulation of wind caused by friction with the ground surface and obstacles.

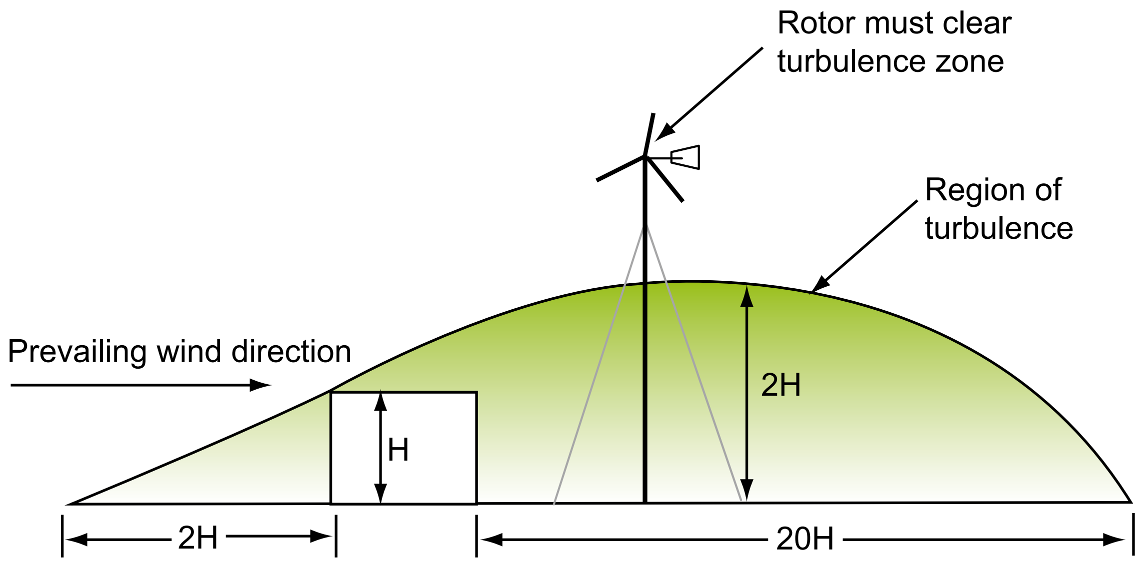


Figure 4: Turbulence 'shadow' cast by obstacle

Turbulence causes wear and tear on your turbine and its tower structure and reduces the energy output of the turbine.

This diagram [extracted from Ref 2] shows how to avoid turbulence from an isolated obstacle of height H.

2.3. Wind monitoring

Wind monitoring is the key to 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.

This section provides a 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.

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. Your personal experience of local winds at your site is probably based on listening to the noise of winds when you are at home, feeling the strength of the wind and watching the effects of the wind during daylight hours when you are at home. Although these experiences give you a general 'feel' for whether you have strong wind speeds, they are unfortunately not an accurate way of determining the actual velocity of the wind. On top of this, 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 in the sense that your final power output may be disappointing.

Some advisors may suggest to take the risk and to avoid the time and expense of monitoring. While this might suffice for small wind turbines in a very windy site, if you are making a larger 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.

In addition, if you have purchase an anemometer then go on to install a wind turbine, you can add value to your wind turbine system by incorporating the anemometer as a permanent feature of your system. Most small wind turbines don't include a wind speed measuring system. Hence a separate anemometer attached to your system will provide a useful gauge of whether the wind turbine is performing properly.

Alternatively after you install your wind turbine you can lend your anemometer system to friends or colleagues who want to assess their wind resource.

Another benefit of monitoring wind speeds is that if you record a very strong wind resource, you may be able to claim a higher income in relation to your Renewable Energy Credits (see Chapter 3). The standard 'availability factor' for wind turbines which is used in Renewable Energy Credit (REC) calculations for small wind turbines assumes a good wind resource, however if yours is very good and you can demonstrate this with measured wind data, there is a good chance you can claim a higher number of RECs, 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 that 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 the images below:



Weather monitoring kits include rain gauges and anemometers, therefore one way to get a wind measuring system is to obtain a weather monitoring system and focus on the wind speed and direction component. These often have wireless loggers which is a handy feature allowing you to locate the logger in a convenient location without running cables between the anemometer and logger. Bear in mind that weather station systems are designed to give a complete picture of local weather and are not designed with maximum anemometer accuracy in mind. It is a case of you get what you pay for, and if you need to stay within a modest budget for your anemometer equipment, you need to accept that the resulting data will not be as accurate as more expensive wind monitoring equipment. For a smaller wind turbine project, or as a first estimate of a medium sized wind turbine project, a low cost weather station kit could be sufficient for the job.

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, this means a lot of raw data! To make the process manageable and retain just the most useful information, the anemometer logger system will average the values over a given time interval, for example 10 minutes or 1 hour. These averages can be used to estimate wind turbine output over the same interval, because wind turbine power curves are generally also produced by averaging the turbine power output over similar time intervals. In fact, turbine power curves are produced from the average of many data points over many such intervals. Generally in wind energy, the key to finding the pattern in the 'noise' is averaging over the long term.

If you can select the time interval in your anemometer system, between 10 minutes and 1 hour is the recommended interval setting. If your logger's memory storage is small, increasing the interval to 1 hour will reduce the amount of data to be stored to only 24 lines per day. As well as saving disc space, a longer interval such as 1 hour, has the advantage that you will save time later when handling a reduced amount of data lines. If you set the interval to be very short, such as 1 minute, you will record a more detailed picture of the wind resource but be prepared for lots of data to analyse, it may even overflow the amount which can fit inside normal spreadsheets!

The preferred unit of wind speed for wind turbine work is metres per second. Wind turbine power curves are also quoted in terms of metres per second, enabling a direct comparison of data without first having to convert it. Therefore if your device can also be set to record in various units such as knots, miles per hour, kilometres per hour, ensure it is instead set to metres per second.

Wind direction is also important for your study. The wind direction data should ideally be recorded in degrees, using the meteorological convention of degrees. This standard assumes that the wind vane is set to read zero when pointing at true north (11° west of compass north), and counts positively upwards through the compass directions 90° (east), 180° (south), 270° (west) to 360° (north). Some vanes only record in compass points, for example 16 points such as North (N), North-North-West (NNW) etc. This is still useful but, since it involves a rounding error, it is not as useful as degrees. If recording in degrees, ideally your system should record to a resolution of 1 degree or lower. For advice on producing wind roses from your direction data, see the Enhar report 'Review of Victorian Urban Wind Roses' [Ref 7].

Turbulence is also an important piece of data which can be recorded. This is a measure of how much the wind speed fluctuates, or how 'gusty' it is. Mathematically, turbulence intensity in wind for a given time interval is defined as the standard deviation divided by the mean. 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, therefore sites with lower turbulence are preferable. Your anemometer system may be able to record standard deviation (or directly calculate turbulence intensity), in which case you can take advantage of this data to see what your turbulence levels are. Some anemometers do not record standard deviation or turbulence, if you have one of these systems you may have to do without this data and use rules of thumb for avoiding turbulence from any nearby trees etc.

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?

The data logger records the wind speed records and stores them so you can retrieve them later. Some examples of data loggers are shown below:

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. Refer to this to learn the set up procedures and ensure you follow the operational procedures too. If you are relying on battery power rather than mains power, take care to ensure the batteries in the logger are high quality and you start with new batteries. You should check the manual to determine how long batteries normally last and replace the batteries well before they drain. For the price of a spare set of batteries, you could 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 OK (screen shows data being currently read)
- ✔ Pole is vertical
- ✔ Tension in any guy wires is OK
- ✔ Damage from birds or other animals has not occurred e.g. Birds such as Cockatiels have not pecked through cables.
- ✔ Data received is OK (reads OK in your computer and when graphed it makes sense)

2.3.6. Where can I get an anemometer system?

You can purchase a low cost weather station kit from eBay. Be aware these are unlikely to come with warranties. You can purchase anemometers or weather stations in Melbourne at The Environment Shop www.enviroshop.com or the Alternative Technology Association www.ata.org.au or Energy Matters www.energymatters.com.au

You can also buy Davis wireless anemometers and weather stations from www.ecowatch.com.au (Victoria based) and www.davisnet.com.au (New South Wales)

The Power Predictor from Better Generation is a relatively new anemometer product designed for domestic scale wind project feasibility. The Australian distributor of this product is Wise Wind. Recent changes to the manufacturing process have been made to solve reliability problems which were known to affect earlier batches of this product.

There are other sources as well; you should look around for which supplier best suits you.

Advanced anemometers such as ultrasonic systems are also available. These have advantages of 3 dimensional wind profiling and no moving parts, however they normally come at a considerably higher cost than the cup type anemometers listed above.

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 have 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 15m 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 2 or 3 people, this process would normally take a day or less. Local TV installation companies who deal with improving your TV reception are likely to have experience of installing telescopic poles and would have the suitable skills and equipment for this type of work. You could purchase an anemometer then contact a local antenna specialist to install it at your site. 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 Wind turbines - Power performance measurements of electricity producing wind turbines* that specifies wind speed monitoring including 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.

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 5m 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 5m above ground was 4.3m/s, and taking wind shear into account it would be around 5.3m/s at 15m and at 20m it would be around 5.5m/s.

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

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

2.3.8. Do I need a planning permit to monitor winds?

In Victoria, temporary wind monitoring systems using anemometers are exempt from the need to obtain a planning permit, providing the structure is in place for less than three years – so the answer here is no, you won't need a planning permit if the pole you are installing is only for wind monitoring and will be taken down in less than three years. This is currently enshrined in the Victorian Planning Provisions.

2.3.9. 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, preferably a full year to obtain an annual profile and average

2.3.10. How do I analyse the wind speed information?

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

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 which are 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 site monitoring, to the Bureau average of the long term period at the Bureau, you can estimate whether the period you measured during 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.

To make a wind rose, which shows the directional frequency of the winds, you can refer to the guidelines published in a report by Enhar for Sustainability Victoria entitled 'A Review of Victorian Urban Wind Roses' [Ref 6].

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. The mounting pole if you were to purchase and install yourself could be as little as $200 for a 9m pole with guy ropes, or a professionally installed 15m telescopic system could be upwards of $2,000. Higher quality and more reliable products are generally worth paying more for, since they aid the goal of properly assessing the site.

Chapter 3. Choosing a turbine

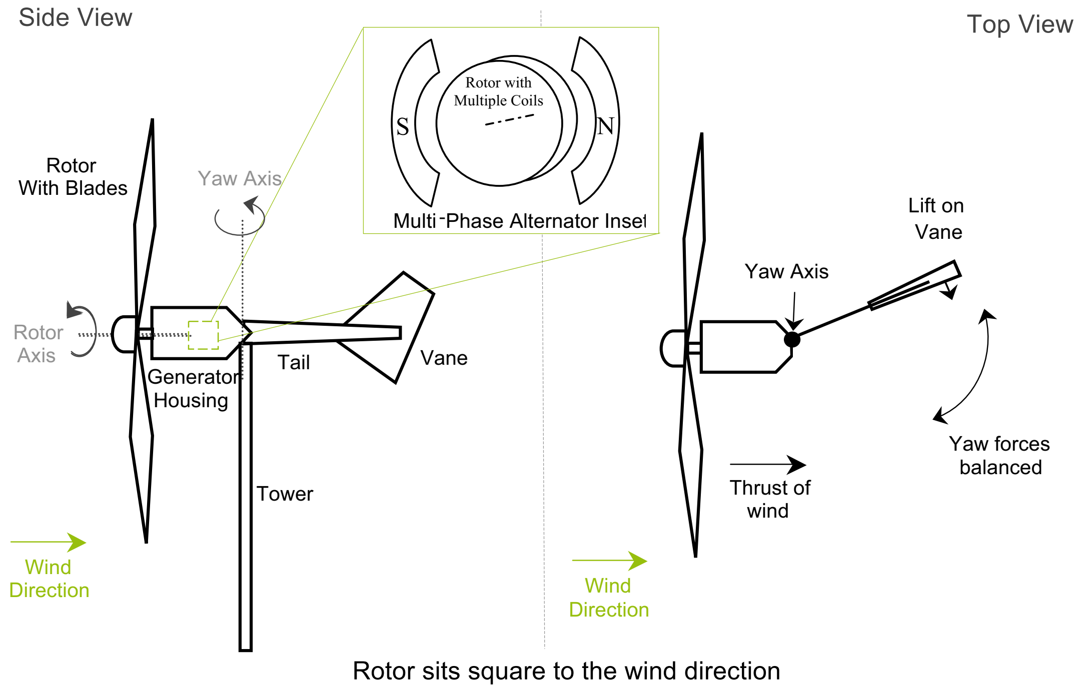


Figure 5. Basic components of a small upwind wind turbine system

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, i.e. 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 – life and drag. It is the lift effect that causes 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 rotates 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 which allows the rotor to turn and reduce the area of the blades facing the wind to protect it from damage during high wind speeds, this is called “furling”.

This chapter gives guidance on how to choose a wind turbine and determine the project viability including calculation of energy output, finance etc.

A basic flowchart of choosing the right turbine for you is as follows

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

Alternatively, you can consider the turbine types on the market, select one which suits your needs and then identify an installer with experience of installing that turbine type.

An internet search will reveal a bewildering array of small wind turbines on the market. For a shorter list, refer to Appendix B which presents a selection of wind turbines available in Victoria.

Prior to choosing a suitable wind turbine, it might be useful to conduct electricity audit of your own household. In combination with an assessment of your wind resource, the size of turbine can be chosen based on this data to best supply the needs of your household. An energy audit will also help to take advantage of any energy efficiency opportunities in your household. This will be beneficial later on to maximise your potential earnings form the net feed-in tariff. The less electricity you consume and the more you export to the grid, the better the financial outcome. Information on how to conduct a household energy audit can be found in the Chapter 7 - References and 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 can be eligible for rebates, providing the grid connect inverter is an approved product.

In future, the existing solar PV accreditation system, managed by the Clean Energy Council (CEC), may be extended to include small wind turbines, although no specific plans have been announced. Check industry news for updates on this situation.

3.2. Types of wind turbines

<table>
<tr><th>Axis of rotation</th><th>Turbine orientation</th><th>Tower type</th><th>Mounting location</th></tr>
<tr><td rowspan="2">• Horizontal axis</td><td rowspan="2">• Upwind</td><td>• Tilt-up</td><td rowspan="2">• Ground mounted</td></tr>
<tr><td>• Monopole</td></tr>
<tr><td rowspan="2">• Vertical axis</td><td rowspan="2">• Downwind</td><td>• Guyed pole</td><td rowspan="2">• Roof/building mounted</td></tr>
<tr><td>• Lattice</td></tr>
</table>

Table 1: Types of Wind Turbines

You can learn more about various wind turbine types in the Alternative Technology Association's report "The Viability of Domestic Wind Turbines for Urban Melbourne" [Ref 1]. To find out where you can get this report, and the other references used in this Guide, see Chapter 7 - References and further reading.

3.3. Turbine performance and power curves

Turbine manufacturers usually provide a "power curve" which 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 6. This is the power curve for the Gaia wind turbine, which was independently verified by the US National Renewable Energy Laboratory in 2009. Turbine performance characteristics have been highlighted on the figure, to assist you to interpret other power curve diagrams.

Cut-in speed refers to the wind speed for which the turbine starts to generate power; rated power is the turbine's quoted power output at a rated wind speed; cut out speed is the point at which the turbine will shut down due to excessive wind speeds. It should be noted that rated output is different from peak output (the maximum point on the curve below). Typically rated power is measured at a wind speed which is closer to typical wind speeds experienced in a suitable turbine location. However there are no rules for what wind speeds manufacturers use to quote "rated power" and often high wind speeds (above 12m/s) are chosen to overstate the turbine's power output.

The red area indicates the turbine operating in a stall mode, where it is has been mechanically turned out of the wind due to high wind speeds. This reduces the power output of the turbine, while preserving the integrity of the turbine.

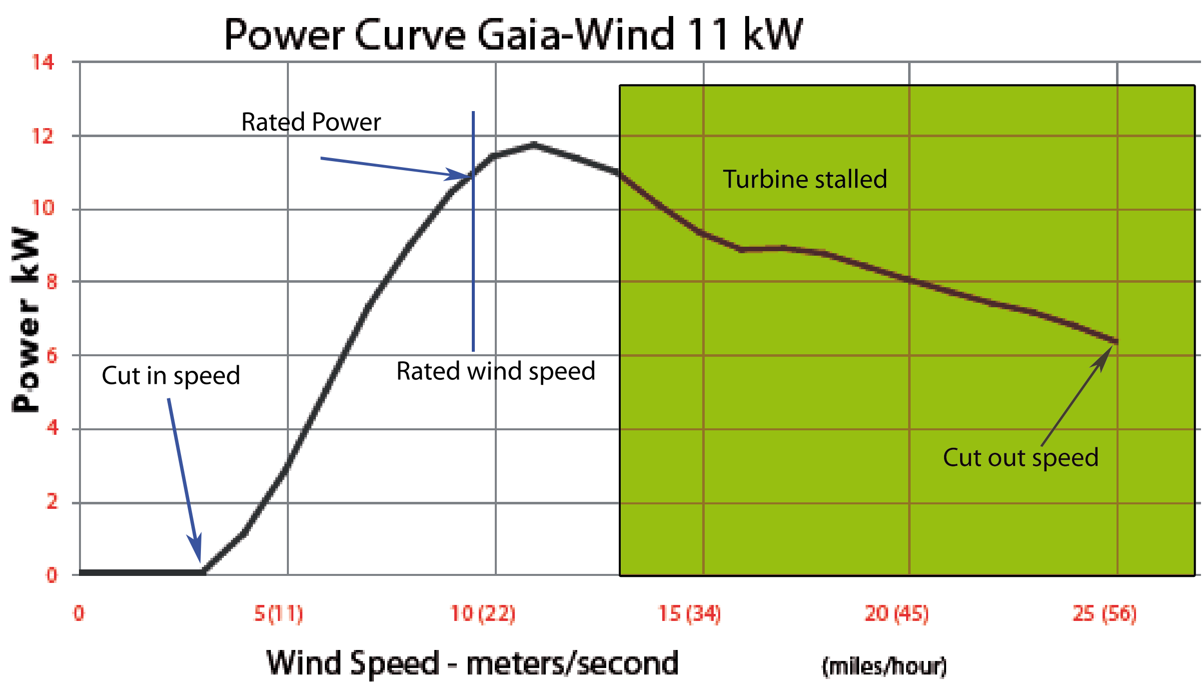


Figure 6: Gaia power curve

Power curves are typically 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 in 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 5 different manufacturers over one to two years. This study showed that the power curves always overestimated power output at high wind speeds (above ~7m/s), but were reasonably accurate at lower speeds [Ref 10].

Another study is the ongoing Small Wind Turbine Test Field project in the Dutch Province of Zeeland [Ref 11]. Here, 11 different models of turbines have been installed since April 2008, and their annual power output is measured as well as wind speed on an adjacent mast. Manufacturer estimates based on their power curves were supplied for comparison, listed as 'Expected' yields. Four of the turbines tested are not currently readily available in Australia, however all of the remainder are. The first two years of results have been published and are summarised below:

Turbine model	Measured annual energy output (kWh)			Manufacturers estimates (kWh)		Percentage difference between measured & estimated %
	First year	Second year	Total	Expected/ year	Expected total	
WRE 060	485	526	1,011	6,000	12,000	8
Skystream	2,109	2,171	4,280	1,360	2,720	157
Airdolphin	393	406	799	1,800	3,600	22
Swift	191	NA	191	1,250	1,250	15
WRE 030	404	612	1,016	900	1,800	56
Energy Ball	73	53	126	350	700	18
Passat	578	660	1,238	1,250	2,500	50
Montana	2,691	2,315	5,006	4,500	9,000	56
Turby	247	326	573	1,485	2,970	19
Ampair	245	341	586	1,500	3,000	20

Table 2: Comparative yield of turbines at the Zeeland site [Ref 11].

Only one turbine performed above its expected yield. It should be noted that, despite the turbines being pole mounted in an open rural field, the average annual wind speeds have been calculated at only 3.8m/s (12m height). This would probably not be considered viable for small wind turbines in most circumstances; however it is more typical of the wind resource expected in an urban environment. Nonetheless the results give a useful insight into the actual performance of various turbines.

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 a longer term experience and a good track record of their products. A five year warranty would be a good indication.

American wind energy expert Mick Sagrillo has given 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: http://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, what is involved?
- Does the turbine meet the draft Australian Standard on small wind turbines? (see Chapter 3.5).

The British Wind Energy Association has set up a "Microgeneration Accreditation Scheme". Whilst products and installers in this scheme are only in the initial stages of applying for accreditation, in the long term the intention is that accreditation will be necessary to qualify for renewable energy financial incentives. 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 lists wind turbine products http://www.microgenerationcertification.org

A major safety issue with small wind turbines is overspeeding. 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 brake it.

This becomes a particularly major problem when a turbine becomes unloaded. When a turbine is loaded (i.e. power is being drawn from the unit), the generator unit has electromagnetic forces operating around the turbine shaft. This helps to slow the turbine revolutions. If a grid connected system goes offline, i.e. in the case of a power black out, the turbine becomes unloaded, and spins at very high speeds. This can become very dangerous, as prolonged operation at these rotating 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 in order 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.

It is generally recommended that some form of aerodynamic overspeed protection is utilised, e.g. furling/mechanical brake, as the most reliable means of shutting down/slowing down a turbine spinning at fast speeds. However most turbines have some form of overspeed protection, which are suitable for most circumstances.

3.4. Wind turbine noise

Noise is an important issue of concern in the planning and continued operation of a turbine. It is likely that council planners will request some information about the noise emissions of the turbine to be installed.

Unfortunately, most turbine manufacturers do not conduct independent noise testing of their product, and some don't even conduct their own tests.

The most recognised method for measuring noise emissions of a turbine is outlined in the International Standard IEC 61400:11 *Wind Turbine Generator Systems - Acoustic Noise Measurement Techniques*. Whilst it is aimed at large turbines, it provides a standardised method of testing that is applicable for any sized turbine. A number of standards on noise from small wind turbines have adopted the conventions in this document.

The primary requirements are that a microphone must be placed on a sound board at a distance equal to the height of the turbine plus half the rotor diameter (for a HAWT) from the turbine, and an acoustic windshield must be used to minimise the influence of background noise. Sound pressure level (sound at the receiver) is measured at wind speeds of 6, 7, 8, 9 and 10m/s and weighted towards the band of human audible noise.

The sound pressure level of the background noise is subtracted from the total recorded value, and then converted to sound power level (noise at the source) through a formula. This gives a measure of the noise emissions from the source (the turbine), which can then be used to determine set-backs to neighbours properties and other installation decisions.

Typical values of Sound Power Level at 8m/s vary between 80dBA and 90dBA for small wind turbines.

It is important to check that any noise test results provided for a turbine are obtained according to a standardised procedure to allow comparison with other turbines and other sources of noise. In particular, customers should ask whether or not the results provided have had the background noise subtracted, or at least have the sound pressure levels of the background noise provided as well. Often turbine manufacturers will state that under test conditions the turbine was found to be indiscernible from background noise, however it is not known whether the test environment was a particularly quiet or loud environment.

3.5. Australian standards for wind turbines

Product Standards exist for consumer goods of many types, to encourage product manufacturers to make products that are safe and reliable, and to avoid short cuts that could endanger your safety.

The domestic-scale solar photovoltaic (PV) industry in Australia operates within several Australian Standards. These standards are designed to protect customer rights and to protect customer safety.

One might expect to see an equivalent compulsory testing standard in place for small wind turbine (SWT) products in Australia. Our review to date has however found that no equivalent compulsory testing standard exists for SWT products, in relation to rebate eligibility or product accreditation. An interim Australian standard is in development, AS 61400-2(Int) *Wind turbines - Design requirements for small wind turbines*, however it appears this is not yet launched as a formal Standard, and is not referenced by the Clean Energy Council as a compulsory requirement for SWT products to access rebates.

All grid connected inverters attached to, or built into, small wind turbine generators must meet AS4777 *Grid connection of energy systems via inverters* and AS3100 *Approval and test specification - General requirements for electrical equipment*. These standards also apply to grid connected solar inverters; there are further details about this in Section 3.7.

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

To date, fewer Australian (or International) Standards have been published for the small wind turbine industry, compared to the solar PV industry. This is because the small wind turbine industry caters to a smaller market than the solar PV industry and in general the smaller younger industries have fewer Standards – these evolve over time. Also remember, certification to Standards is an expensive process and the manufacturer may instead be focussing on the core business of making turbines, rather than sending samples to international testing centres. There are however similar risks and issues in small wind compared to solar PV, so you shouldn't think about this as being a more Do-It-Yourself type industry where it is easier to get away with non-compliant practices!

The draft Australian Standard for Small Wind Turbines, AS 61400.2(Int)-2006 *Wind turbines - Design requirements for small wind turbines*, has been borne from a series of Standards developed for the large scale wind turbine industry. Part 2 of this International Standard is specifically designed for small wind turbines. There is a small wind turbine working group in Australia which deals with specific issues for Australia and makes sure the Standard references other Australian Standards.

There is currently no specific list of approved wind turbine products published by the Clean Energy Council, indicating that product criteria and Standards are not currently applied to wind turbines in the same way as for solar PV panels. As such, most SWTs in Australia are eligible for rebates and solar credits without first passing tests at an accredited laboratory. As evidence of this, a wide range of SWT products have historically received rebates under the Renewable Remote Power Generation Program (RRPGP)[2] ; to the best of our knowledge no compulsory standard testing criteria were applied to the rotor/generator component of these wind turbine products.

No certified SWT testing centre is currently operating in Australia, however a wind turbine testing centre is being established at RISE (Murdoch University) in Western Australia. The RISE testing centre will focus on testing Australian-made SWT products. .

As new regulations and incentives promote a greater uptake of SWTs in Australia, compulsory criteria to meet Standards is more likely to emerge.

If AS 61400.2(Int)-2006 *Wind turbines - Design requirements for small wind turbines* becomes a formal Standard, this does not in itself mean that all wind turbines sold must meet the Standard.   The Standards Australia website states:

" Standards are voluntary consensus documents that are developed by agreement and their application is by choice unless their use is mandated by government or called up in a contract.....Australian Standards are not legal documents but many, because of their rigour, are called up into legislation by government and become mandatory."
(source: http://www.standards.org.au)

For AS 61400.2(Int)-2006 *Wind turbines - Design requirements for small wind turbines* to become compulsory for wind turbine product rebate eligibility in Australia, a body such as the Clean Energy Council would have to establish an approved product list for wind turbines and set the Standard as an essential criteria for entry onto that list.

Even at this stage, it would still be legal to sell wind turbines that have not met the Standard, however the products would no longer be eligible for rebates such as solar credits which require the product to be approved by the Clean Energy Council.

As a customer of a wind turbine, it would be a good idea to enquire with your supplier whether the wind turbine you are considering meets the interim Australian standard AS 61400.2(Int)-2006 *Wind turbines - Design requirements for small wind turbines*. Be prepared for the reality that very few small turbines do 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 *Wind turbines - Design requirements for small wind turbines* 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 their business plan is heading towards this Standard.

2. See http://www.environment.gov.au/settlements/renewable/rrpgp/index.html

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 below.

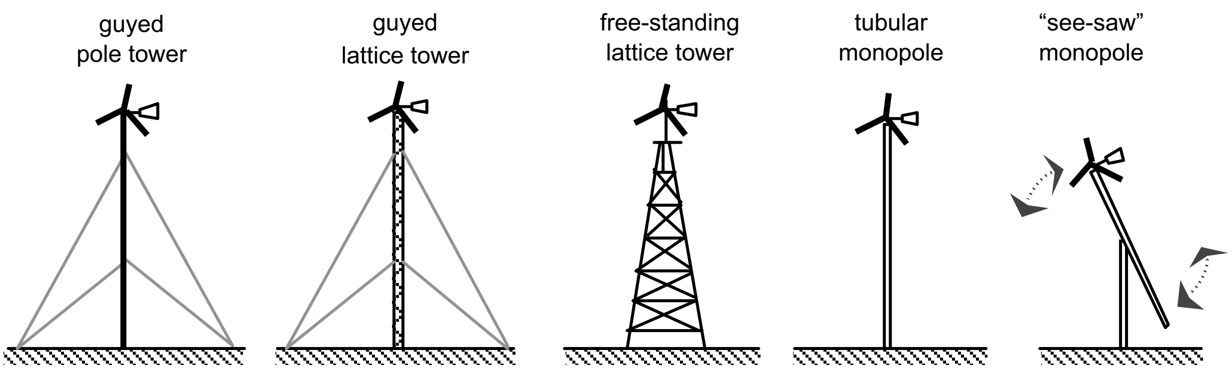


Figure 7: Wind turbine tower designs

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 smallest footprint area, and is normally more expensive due to the thicker and heavier steel required in the pole as well as the larger heavier foundation compared to the guyed type. The see-saw monopole is a special design which 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 Australian Standards for wind loading, AS1170 Structural design actions, The tower should also be manufactured to a good standard with special attention given to strength of welds and quality of materials.

3.6.1. Choosing a tower height

Choosing a tower height involves finding a balance between the pros (increased energy yield at higher height) vs. the cons (increased visual impact of a taller tower, possibly more onerous to get planning permit).

Economics of taller towers

An estimate of the economics of tower height is provided by an American study undertaken by Mick Sagrillo in 1993 [Ref 8]. Although prices have gone up with inflation, and are stated in US dollars, the numbers still demonstrate the benefit of increasing you tower height.

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

The results of the study are shown in Tables 2 and 3 below.

Tower height (ft)	System cost	Incremental cost	Percent increase	Percent over base	Wind power	Incremental power	Percent over base
60	US$6,270	-	-	-	68%	-	-
80	US$6,785	$515	8.2%	8.2%	109%	41%	41%
100	US$7,235	$450	6.6%	14.8%	147%	38%	79%

Table 3: Economics of increasing tower height for a 1.5kW wind turbine

Mike Sagrillo summed up the results saying: “in the scenario we have developed, going from a 60 foot (18m) to an 80 foot (24m) tower will cost us an additional 8.2% giving us 41% more power. Going from an 80 foot (24m) to a 100 foot (30m) tower will cost an additional 6.6% and yield 38% more power. And going from a 60 foot (18m) tower to a 100 foot (30m) tower costs 14.8% more but gives us a 79% power increase!”

Tower height (ft)	System cost	Incremental cost	Percent increase	Percent over base	Wind power	Incremental power	Percent over base
60	US$25,530	-	-	-	52%	-	-
80	US$26,790	$1,260	4.9%	4.9%	80%	32%	54%
100	US$28,220	$1,430	5.3%	10.5%	106%	26%	104%
120	US$29,880	$1,660	5.9%	17%	130%	24%	150%

Table 4: Economics of increasing tower height for a 10kW wind turbine

You can therefore be confident that the extra investment in a taller tower will be worthwhile. You need to be confident that the taller tower will be suitable for your site including planning permit issues, neighbour amenity and that you provide 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 relevant Australian Standards. These are AS4777 and AS3100. Inverters that have been tested to these standards and successfully passed are then accepted by a State Regulator, for example Energy Safe Victoria, who issue Certificates of Conformity for the product. These inverters can then be listed on the Clean Energy Council list of approved inverters that 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:

http://www.cleanenergycouncil.org.au click through to the 'Solar PV Accreditation' page then the 'Approved Products' where a "current list of approved grid-connect inverters" is published.

Although the majority of the inverters on this list are intended for use with solar PV systems, all grid connected wind turbine inverters must also be listed here in order to be eligible for rebates.

A non Clean Energy Council-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.

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. From this, or use of the graph in Figure 2, you can estimate your expected annual generation.

3.9. Finance

This section discussing 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.

3.9.1. Wind turbine system costs

The cost of your wind turbine system can be broken down by components. There is a large variation in wind turbine prices depending on tower size, installation location and so on. Some indicative capital costs based on recent case studies in Victoria are as follows:

For a 1kW horizontal axis wind turbine on a 15-20m tilt-up pole, grid connected, budget AUS$10-20,000 (before rebates)
For a 2-3kW horizontal axis wind turbine on a 10-15m monopole, grid connected, budget AUS$20-40,000 (before rebates)
For a 5kW horizontal axis wind turbine on a 20-30m tilt-up pole, grid connected, budget AUS$40-60,000 (before rebates)
For a 1-2kW roof mounted wind turbine system, grid connect, budget approximately AUS$15-25,000 (before rebates)

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.

3.9.2. Funding for small wind turbines

Solar Credits is a mechanism under the expanded Renewable Energy Target (RET) that multiplies the number of Renewable Energy Credits able to be created for eligible installations of Small Generating Units.

The good news is that under this scheme, wind turbines are eligible for Solar Credits. To be eligible, your wind turbine must be no more than 10 kW, have a total annual electricity output less than 25 MWh and be installed after 1st April 2001.

The Solar Credit scheme is linked to the Renewable Energy Target (RET) system, where each Renewable Energy Credit (REC) represents 1MWh of renewable generation and has a tradeable dollar value. These credits belong to the owner of the wind turbine, however to save you the work of trading the RECs yourself, your installers will be able to buy these credits from you. The value of the RECs under the current scheme fluctuates over time. To illustrate what you can expect to earn, we have used a value of $40 in the calculations on the following page, which is typical of recent values, and is also equal to the proposed fixed rate for RECs for renewable systems up to 10kW under the proposed Federal 'Enhanced Renewable Energy Target' legislation.

The Office of the Renewable Energy Regulator publishes a 'Small Generators Owners Guide', which describes how to calculate how many RECs your system will earn [Ref 9].

Your REC income is linked to the rated generating capacity of the turbine.

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 the number to use is simply whatever is stated on the turbine product label.

The REC earnings usually occur in separate installments, the first is at the time of installation, the second after 5 years have elapsed, and the third and final installment after 10 years have elapsed. Although solar PV installations are permitted to claim RECs for a 'deeming' period of 15 years, wind systems currently are eligible for a maximum deeming period of 5 years. However, the good news is that over the project lifetime, if you do claim RECs at the 5 and 10 year point, you can expect to earn more RECs than the equivalent rated solar PV system.

You can also opt to earn your RECs annually.

An example REC calculation is provided below:

Example: calculating the renewable energy credits for a 6kW wind system

The amount of Renewable Energy Credits (RECs) are calculated as follows:

Annual RECs = multiplier for small generating systems x rated capacity of system x resource availability hour/annum x 0.00095

The REC multiplier multiplies the number of RECs able to be created for your small wind system by five. These extra credits only applies to the first 1.5kW of the system, the remainder is 1:1. The REC multiplier is currently five, but decreases from July 2012 onwards. Check the website of the Office of the Renewable Energy Generator (www.orer.gov.au) for more information.

Here we would have
[5 x 1.5 kW x 2000 x 0.00095] + [1 x 4.5 kW x 2000 x 0.00095] = 22.8 RECs/year

The RECs deemed to be generated over first 5 years of operation can be sold at commencement.

The total RECs deemed within the first 5 years of operation would be 5 x 22.8 = 114 RECs
Assuming a REC price of $40, the owner would be eligible for $30 x 114 = $4,560 income.

After 5 years have elapsed, the owner would be eligible for a further earning.
Under the current rules, the 'Solar Credits' multiplier would not be applied a second time.
Therefore, assuming a REC price of $40 at year 5, the owner would be eligible for
[6 kW x 2000 x 0.00095] = 11.4 RECs/year x 5 years = 57 RECs x $40 = $2,280 income.

Similarly, after 10 years have elapsed, a final income can be earned for the final eligible 5 years of operation (a 15 year total lifespan is assumed).
This is also equal to 57 RECs x $40 = $2,280 income.
The total income made up of these three payments amounts to $4,560 + $2,280+ $2,280 = $9,120

The table below assumes a steady price of $40/REC and 5 year deeming periods:

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

Table 5: REC earnings from small wind turbines at $40/REC

The default 'Resource availability' of 2,000 hours is available to any wind turbine owner. If you have a very strong wind resource you can claim a higher resource availability by submitting evidence such as monitored turbine yield data e.g. 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 which is equivalent to its rated output for more than 2,000 hours per year. For example, the readings from a grid connected inverter attached to an existing 1kW wind turbine for an extended period of time may show that the annual output is 2,500kWh/year. This would earn 2,500 resource hours, a 25% increase on the default 2,000 hours.

Options for gaining financial benefits from RECs:

OPTION 1 - AGENT ASSISTED
Find an agent and assign your RECs to the agent in exchange for a financial benefit which could be in the form of a delayed cash payment or upfront discount on your SGU. A majority of owners take this option.

OPTION 2 - INDIVIDUAL TRADING
Create the REC's yourself, Find a buyer then sell and transfer RECs in the REC Registry.

Under Option 1, 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% commission to the agent for this service i.e. you will receive the value of the RECs less 10% of the total REC price.

You may also contact other major RECs agents such as Green Bank of Green Energy Trading to act as your agent.

Or under Option 2 you may decide to become an individual trader. This can be a more time-consuming process. Prices of RECs may go up in the future, which would be potentially more lucrative for you. However, you must be prepared to pay more upfront for you system installation under this option.

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

3.9.3. Feed-in tariff

For grid-connected systems, you will be eligible to receive credit for the electricity which you export, if you make suitable arrangements. The price paid to you for this exported power depends on the type and rate of feed-in-tariff.

The Department of Primary Industries advises that "The standard feed-in tariff is available for people producing power for their homes or small businesses using renewable energy systems with a capacity of up to 100 kilowatts. This includes people generating their own wind, solar, hydro or biomass power. The excess power fed back into the grid is credited at the same retail rate charged for electricity consumed."[3]

At present, small renewable generators in Victoria are eligible for 'net' feed in tariffs, i.e. you only get paid for the excess exported to the grid, not for the entire output of the renewable generator, which would be a 'gross' feed in tariff.

Renewable power systems up to 100kW including wind solar, hydro and biomass are eligible for the standard 'one-for-one' feed-in tariff which must be offered to customers by all electricity retailers.

A premium feed in tariff is in place for solar photovoltaic generators up to 5kW in Victoria, which awards a premium rate to all surplus solar power exported to the grid. The rate gives a 60c premium on energy actually exported to the grid.

Currently, wind turbines are not eligible for this premium feed in tariff, it applies only to solar PV installations.

3. Department of Primary Industries webpage entitled 'What is a Feed in Tariff?" accessed at http://new.dpi.vic.gov.au/energy/energy-policy/greenhouse-challenge/feed-in-tariffs/faq

Chapter 4. Planning permission

This chapter gives you an overview on the issues likely to need addressing for planning permits.

It gives an outline of questions likely to be asked by Victorian local government councils in relation to planning and building permits for small wind turbines.

The information is the section was obtained through consultation with the Department of Planning and Community Development and via a cross section survey of Victorian council planning departments. 11 councils were contacted representing a diversity of metropolitan and regional areas, covering regions of limited to high wind resource.

It was hoped that this subset could encompass a broad picture of the various issues and requirements involved in council planning procedures for domestic wind turbines.

4.1. General

In Victoria the State Government is responsible for streamlining and coordinating the various local government planning schemes through the Victorian Planning Provisions. It acts as a statewide reference document from which local council planning schemes are sourced and constructed. This ensures that there is reasonable continuity to each council's planning scheme, however councils are able to amend the document as necessary.

Despite the statewide structure there is a lack of consistency between councils on the planning requirements and procedures for small scale domestic wind turbines. In general small wind turbines are treated in the same way, however the criteria used for planning approval vary across councils. This is in part due to the differences in topography, natural environment, and population density.

However there is also a lack of understanding from some council planners about small scale turbines. This is primarily due to the relatively slower uptake of domestic wind turbines installed in Australia compared with other renewable energy technologies, notably solar photovoltaic. Additionally wind turbines are typically associated with large scale wind farms.

Therefore it's expected that council planning understanding will increase with prevalence of small scale domestic wind turbines in Australia and the improved circulation of information on them.

This chapter seeks to give an overview of the key issues involved and, based on a cross section survey of Victorian local councils, to present a suite of key information to present to the council planning department to assist permit decisions.

4.2. Statewide planning provisions for small wind turbines

Currently no provisions exist that explicitly cover domestic use wind turbines. A clause exists in the "particular provisions", which refers to "Wind Energy Facilities". However this clause explicitly excludes "turbines principally used to supply electricity for domestic or rural use of the land."

The requirements in the clause for a wind energy facility are intended for large wind farms, and involve extensive and time consuming studies.

This is an important distinction, however there is a lack of clarity within planning departments about its applicability. During our study of council planning provisions, some council planning departments indicated that domestic wind turbines would be covered by the clause. To clarify if this was the case we rang the Department of Planning and Community Development. The respondent stated that it would cover domestic wind turbines. This was questioned, but the staff member checked with a superior who reinforced this view.

The Victorian Planning Provisions also sets out the exemptions from permits for Buildings and Works. An exemption is listed for a "solar energy facility attached to a building that primarily services the land on which it is situated." However no such exemption exists for small scale domestic use wind turbines.

Until a planning provision is created to cover domestic use wind turbines, the handling of planning requirements and issues is left to the discretion and interpretation of local councils.

4.3. Overview of existing council planning requirements

In general small wind turbine installations would be considered ancillary to a dwelling and therefore their installation would be classified as building and works.

Property owners and/or installers should contact their council to determine if a permit is necessary.

Owners and installers may need to submit detailed information to the planning departments in order to determine if a planning permit application should be formally lodged.

Council planning departments typically assess permit applications on a case by case basis.

Within and between councils there is significant difference in what criteria a domestic turbine would need to meet in order to trigger a planning permit requirement. This is typically due to the different overlays that may exist over non residential zone land. Some overlays in residential zoned land including heritage overlays will trigger the need for a planning permit application as well.

Some rural properties may not need a permit to install a domestic wind turbine. Representatives from City of Greater Geelong council and Moyne Shire council suggested that domestic use small scale wind turbines on rural properties in their jurisdiction would not need a permit. Similarly the planning department in the South Gippsland Shire suggested that residential properties do not require a permit for the installation of a domestic use wind turbine. Nonetheless property owners and installers should check with their council before commencement of works.

A survey of councils was conducted to determine the planning procedure and requirements for small wind turbines. This revealed a set of issues that may act as possible triggers for permits. These are listed and summarized in Table 6 (page 40).

Height restrictions

Some councils have absolute height thresholds both for above ground installations and on top of the roof installations. These vary, however Colac Otway Shire, City of Greater Geelong council, and Moreland City council all have height thresholds above 8m (Moreland City council is above 9m) from the ground. City of Greater Geelong council also has a restriction of 3m above the roof. Other councils have different height thresholds for different overlays.

Given that ground mounted towers for small scale wind turbines may have typical heights of between 10 and 25m, it's expected that the height requirements will be a trigger for a permit application.

However the planning provisions exempt structures such as flagpoles and domestic antennas (not satellite dishes) from requiring a permit. Therefore gaining a permit for a wind turbine which is above the standard height threshold is certainly feasible.

An additional issue for height thresholds exists for properties within councils that have airports. In these cases applications submitted to councils will be referred on to the planning departments of the airport. These departments will assess the proposed height in conjunction with the turbine location to determine if it will interfere with an aircraft's flight path.

However the Melbourne Airport Planning Department stated that outside of a 2km boundary from the airport and at typical tower heights for small scale wind its very unlikely that proposals would be rejected by the airport planning department.

The planning department illustrated the point by saying that there are light towers around the airport higher than 15m.

Property size

Some Metropolitan councils require permits for all building and works undertaken on properties below a certain threshold. For example Moreland council requires a permit for all building and works conducted on properties below $300m^2$ and Banyule council requires a permit for properties below $500m^2$.

Amenity

The issue of amenity is likely to trigger the need for a planning permit. If a feature is likely to be easily visible from adjoining properties, a major road or public place such as a park, then it will generally require a permit.

Associated with this is the issue of noise. While most councils did not explicitly refer to this issue, it's expected that concerns about noise will need to be addressed.

No statewide planning guidance currently exists in Victoria to prescribe the approach local councils should take to assessing applications for small wind turbines. A discussion paper has been released by the NSW Planning Department to streamline the planning process for small wind turbines in NSW. Included in this paper is a proposal to introduce setbacks to neighbouring dwellings based on sound power level (SPL) of the turbine, independently tested according to the IEC 61400-11.

These are:

- 25m for SPL of 0-70 dB(A)
- 40m for SPL of 70-80 dB(A)
- 126m for SPL of 80-90 dB(A)
- 200m for SPL greater than 90 dB(A).

If these guidelines are adopted as planning policy by the NSW government, it is quite likely that it will be used as a guide by councils assessing a wind turbine project in other states around Australia.

Some domestic use small scale turbines are designed to be quiet, and can be suitable for a high density environment. Installers should provide information about the acoustic noise emissions of the turbine, preferably sound power level at 8m/s, to facilitate council approval.

Alterations to the building

Because domestic turbines are typically classed as "buildings and works" a permit will possibly be required if the dwelling a turbine is to be installed onto is significantly altered in the process.

Environmental impact

In correspondence with the Strathbogie Shire planning department, the planner indicated that a small wind turbine would need a permit if there is an impact on the natural environment, particularly to birds. While bird strike from small scale turbines has been found to be low, turbines installed in an environmentally sensitive area may need to meet extra requirements to ensure impact is minimised. An environmental impact assessment is not expected to be required.

Based on the consultation with councils the list in Table 6 has been compiled of key information that should be provided to assist the planning departments to determine if a permit is necessary and approve a permit for a domestic wind turbine.

It should be stressed that the exact basis upon which planning permit applications will be assessed is determined by the council in question and therefore the list below is merely indicative of the key information required. Councils will determine in which zone the property lies and if there are any overlays found on the planning scheme over that property. Different requirements will be needed depending on the zone and overlays the dwelling is located in. In overlays where additional planning restrictions apply it's likely that all of the information provided (and possibly more) in Table 5 will be needed. However in some overlays, much less information may be required.

Information to provide	Description
Location of property	Address, which zone (residential or rural)
Property size	For Metro Melbourne
Proposed location of turbines	Roof or pole mounted, proximity to neighbours
Visibility	Expected visibility from street or public area, e.g. park. Photographic illustrations will help.
Height	Proposed height of turbine, either above ground or on roof
Dimensions & Turbine Power	Diagrams may be required
Noise	Estimate of noise generated by turbine
Connection to building	Any alterations to building needed
Materials used	Main materials that comprise installed turbine
Grid connection	If it will be connected to grid or not

Table 6: Information to be provided to councils for planning applications

In addition to a planning permit, in many cases a building permit may be required. Applications need to be filed with the council building departments as well as planning departments. Applications will be addressed on a case by case basis, and would need to address similar issues as those in the above table.

Finally it should be stressed that the aforementioned planning requirements and issues are solely for turbines where the majority of power is consumed on the land where it is situated. Turbines which are expected to predominantly generate power that will be exported to a grid or to a specific consumer for commercial gain, will likely come under the Wind Energy Facility Clause in the planning provisions i.e. the same criteria which is applied to large scale wind farms. In these cases, even if a dwelling is present, the turbine would not be considered ancillary to the dwelling and therefore a permit would be needed to approve the new use of the land as a wind powered generating facility.

4.4. Case Study: City of Port Phillip guidelines

One Victoria council has a formal process for consumers looking to install a wind turbine for domestic use, this is City of Port Phllip. City of Port Phillip has a Sustainable Environment Officer who assists in the planning procedure for domestic renewable energy installations. City of Port Phillip has produced a document called "Urban Wind Turbines, A General Guide for Residents and Industry". This document sets out the planning requirements for small scale wind turbines.

Small scale wind turbine for domestic use in City of Port Phillip would be considered ancillary to a dwelling and therefore classified as building and works. Depending on the zoning and overlays where the turbine would be located, a permit may be required. If a permit is needed the council has waived the application fees for various sustainable design initiatives, including urban wind turbines. These are said to be processed through a "Fast Track Service" and typically completed in less than 3 weeks.

The "URBAN WIND TURBINES A General Guide for Residents and Industry", is available from the City of Port Phillip.

"The following are some key considerations Council regards as important:

A planning permit will typically be required if the system is visible from a street (other than a lane) or a public park. Specific heritage controls may also apply.

The historic fabric of a building should not be unnecessarily disturbed or destroyed, in line with minimum intervention and reversibility principles.

Every effort should be made to minimise the visibility of the system from the street and its impact on surrounding properties, and public areas.

Systems should not include any form of private advertising or branding.

Shadows should be minimised, with less bulky systems preferred.

The council and the community prefer the installation of silent or ultra-quit systems.

Avoid placing the system on or near the property boundary without first obtaining consent from the adjoining owner(s)."

Chapter 5. Installation

5.1. Accreditation of small wind installers

In order to have your wind turbine installed, you will want a competent installer to undertake the job.

Your installation team must include a qualified A grade electrician.

The wind turbine installer may or may not be accredited under the Clean Energy Council renewable energy installer scheme.

Wind installation accreditation does not follow the same structure as the solar photovoltaic business. It is currently not compulsory for wind turbine installers to be accredited under the Clean Energy Council scheme, although this may change in the future. A form of endorsement of wind energy installers may be developed, for example, in advance of a formal training and accreditation scheme.

The renewable energy installers training course, the Certificate IV or Diploma in Electrotechnology: Renewable Energy, is taught at several Technical and Further Education (TAFEs) around Victoria. This course includes an optional training module on wind turbine installation which includes siting, system design, installation processes and safety. It would be advisable that your installer has completed this course – you can check with them – although as an alternative, plenty of prior hands-on experience with installing wind turbines and other renewable energy systems including solar photovoltaic may be sufficient. In order to obtain renewable energy credits for your wind turbine system, you may select either an electrician who is an accredited renewable energy installer (e.g. a solar photovoltaic installer who has completed wind turbine training) or an electrician who is experienced and competent in installing wind turbines.

To find an installer, you can refer to the list of installers in Appendix B. You can also consult the list of accredited solar photovoltaic installers on the Clean Energy Council website, which is updated regularly, since a number of the solar photovoltaic installers also install wind turbines.

5.2. Grid connection of your wind turbine

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

The electricity retailer servicing your property and the local electricity distribution company should be notified.

Approved inverter

The inverter equipment used must be shown to meet Australian Standard AS 4777 Grid connection of energy systems via inverters and AS3100 *Approval and test specification - General requirements for electrical equipment*. A certificate of conformity from Energy Safe Victoria, or an energy regulator authority from another State, should be presented. This certificate demonstrates that the energy regulator authority has confirmed that the inverter has been tested to, and passed, these electrical safety standards. These ensure that the inverter being connected provides failsafe control in the event of grid failure and other specified conditions.

The Clean Energy Council publishes a list of approved grid connect inverter products. The inverters on this list have been previously approved by the energy regulator, the Clean Energy Council do not approve inverters, that is the role of the energy regulators. The inverters on the Clean Energy Council list have however been confirmed to be suitable for installation and are 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 AS 4777 *Grid connection of energy systems via inverters and AS3100 Approval and test specification - General requirements for electrical equipment.*

Bidirectional meter

If your only renewable energy system is a grid connected wind turbine, you will be eligible for net feed in tariff. This means your electricity meter should be able to run both ways to record power exported to, and imported from the grid. This is termed a bidirectional meter. You can apply to receive one-for-one payment for the electricity you export i.e. at a rate equal to that at which you are charged for electricity.

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 the 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. If your wind turbine produces more than you use and your meter goes backwards a long way, this would present an unusual situation to the electricity company. It is possible that the meter could be misread and you could be charged incorrectly.

Signed agreement

To confirm your feed in tariff agreement, you need to first obtain information from retailers on the electricity tariffs available for the sale of electricity generated and for the purchase of energy consumed.

You then need to select a retailer 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. This is required by regulations.

Your installer should be able to provide evidence of suitable qualifications. Please also refer to the above section relating to 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 2].

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 system has been designed to withstand suitable wind loading and that it has been properly manufactured according to the design. If a building mounted tower is chosen, the potential load on the building (weight and lateral loadings) needs to be estimated. Also important is confirmation that the installation meets the design requirements.

Since every installation site may have unique features such as unusual ground conditions or other structural loading limits, the method of installation, anchoring and bolting to the existing surface is just as important as the design and fabrication of the tower.

If a building permit is required, as it is for most ‘building and works’, a qualified structural engineer may be engaged by your installer to approve the safety of the tower strucuture. A registered builder may also be involved to oversee the installation of the foundation and the erection of the tower.

5.4. Metering

The Department of Primary Industries (DPI) has published advice on its website to Victorian consumers seeking feed-in tariffs for small scale renewable energy generating systems. This contains extensive advice for solar photovoltaic customers and also some relevant advice for wind turbine system owners.

The following information is taken from the DPI webpage entitled "What is a Feed-in Tariff?" [4]. Words in square brackets have been added here to interpret this information for wind turbine systems.

How is excess electricity fed to the grid measured?

"To access feed-in tariffs you will need a new meter that is capable of recording the electricity used and exported for each half hour interval during the day. This means that if, during any part of any half hour period, your [wind] system is generating more power than you are using, you will get the [one-for-one] feed-in tariff for the electricity exported to the grid.

Overall a household would generally use more electricity than it produces [wind turbine system]. However, a household is likely to export some electricity into the grid at some times of the day and will therefore be paid the [net] feed-in tariff for these exported volumes.

The amount of electricity exported from [wind turbine systems] for community groups and small business depends on their electricity usage patterns.

When you receive a new "smart meter" as part of the Government's separate advanced metering infrastructure rollout program, this meter will be fully capable of supporting feed-in tariff payments."

I have a solar-wind hybrid system. Am I eligible for the premium solar feed-in tariff?

"No. The premium solar feed-in tariff is available for solar PV systems (of up to 5 kilowatts capacity) only, not for hybrid systems using a mix of technologies. You may, however, be eligible to receive a standard "one-for-one" offer which is available for wind, solar, hydro and biomass systems of up to 100 kilowatts capacity."

I already have a smart meter. Can I get a feed-in tariff if I now wish to install a [wind turbine] system?

"Distribution businesses are required to install smart meters that are fully capable of supporting imports to and exports from the grid as well as feed-in tariffs. The distributor may, however, need to revisit your property to configure the smart meter to handle imports and exports. Please contact your distribution business to inquire about the necessary arrangements."

4. http://new.dpi.vic.gov.au/energy/energy-policy/greenhouse-challenge/feed-in-tariffs/faq

Chapter 6. Case studies

This chapter contains case studies of small wind turbine projects currently operating in Victoria. They have been selected for their relevance to the most common issues facing wind turbine customers. A range of wind turbine sites were researched by Enhar and turbine owners invited to submit completed case study descriptions including the specifications of their system, benefits of the system, issues encountered and any advice to other consumers considering a wind turbine.

The case studies have been written by the end users of the wind turbines, as representative examples. Enhar have edited the case studies.

6.1. Sugarloaf Farm & Cottage – 5kW grid connected wind turbine

Sugarloaf farm is situated on the Great Ocean Road roughly halfway between Kenett River and Skenes Creek. The 5kW Westwind turbine is mounted on a 24m tilt-up guyed pole and has been operational since April 2009. At the end of March 2010, the turbine had generated 1982 kWh. The grid-connected system uses two inverters – a Latronics PVEdge grid connect inverter and a Latronics LS Series sine-wave inverter.

Site assessment

A small wind speed indicator was used to monitor the site. However, the data collected was considered unhelpful because the indicator was situated much lower than the final hub height of the turbine. Due to the many trees planted on the farm the wind speeds recorded by the meter was vastly different than the wind speeds at 24 m.

A wind speed map was also obtained from Otway Shire Council, which showed the average wind speed of the areas to be 7.5 m/second.

Choosing a turbine

A turbine was chosen through internet research. Westwind was selected because their turbines were built to withstand Australian conditions and required little maintenance. Their website was considered to be very helpful and also included a map of installers who had installed Westwind turbines.

Planning & permits

Prior to applying for a permit from Colac Otway Shire a geotechnical assessment of the area and other overlay details were required to be submitted. In the permit application, submitted in July 2007, details of the turbine and its output were required to be included. Although photos of the proposed position were not required, these were also submitted to show that the turbine would be inconspicuous to those passing on the Great Ocean Road. The permit was approved within 6 weeks of the submission.

Installation

The initial installer for this turbine was selected from the Westwind website. Unconfident with the safety standards of the initial installer, a second installer was brought on board to complete the installation. It was discovered that the initial installer was unqualified to give a Certificate of Compliance for his work, without which you are unable to connect your turbine to the grid. The project was delayed for 12 months. The turbine was completed and operational in March 2009.

Connecting & selling to the grid

It was initially difficult to reach an agreement with the electricity retailer to buy the excess energy generated by the turbine. However, once they were informed that an energy retailer with more than 5,000 customers cannot refuse due to the Standard Feed in Tariff Scheme developed in January 2007 by the Department of Primary Industries, an agreement was made. A problem was encountered with the installation of a smart meter, which shows import and export power. The meter considered the off-peak times to be between 0100h – 0700h; while according to the electricity retailer, the off-peak times should be between 2300h – 0700h. They have now agreed to readjust the settings on the smart meter accordingly.

Cost

The original cost of the project was expected to be AUD$45,000. However, due setbacks resulting from the first installer the end cost of the turbine was AUD$66,000. A rebate for AUD$2,444 was received from the Victorian Government.

Since the wind turbine became operational a saving of approximately AUD$674 p.a. has been made in reduced energy bills. The turbine is due for a 12-month service hence there have been no maintenance costs so far.

Further comments & advice

The owners are satisfied with their wind turbine since it has been operational. There are still days when it has been useful to be connected to the grid especially when water needs to be pumped on the farm for stock. Alternatively, another renewable energy source could be considered such as solar.

Advice given by the owners of this wind turbine include:

- ensure a qualified installer is chosen especially if you intend to connect and sell to the grid
- consider the furling mechanism of the turbine if you are frequently away from your property as some need to be manually returned
- avoid poor operation due to turbulence by completing a site assessment and positioning your turbine appropriately

Enhar thanks Marianne Fountaine, owner of the Sugarloaf wind turbine, for submitting this case study. This case study was edited by Enhar.

6.2. Limeburners Point – 3kW vertical axis wind turbine

Limeburners Point is situated in Geelong next to Eastern Beach. The 3kW Ropatec vertical-axis wind turbine (VAWT) is situated near the boat ramp on crown land zoned as Public Park and Recreational Zone and is owned by the City of Greater Geelong. The turbine is grid connected and mounted on a 10 m steel pole. The inverter used is the Power One Aurora PVI 3600-AU-W. The turbine was installed in September 2009 and commissioned in January 2010. Since being operational, it has generated 210 kWh.

Site assessment

Wind speed information was gathered for the site from the Victorian Wind Speed Atlas. Limited to average wind speed figures, the sites was listed as 6 m/second. Public visibility was a strong driver for site selection. No site specific wind monitoring was conducted.

Choosing a turbine

Research into the turbine was initially undertaken online. At the time there was only one VAWT available and compatible locally

Planning & permits

A planning permit was not required. Currently, there are no provisions under the Vic Planning Scheme to install a turbine on crown land zoned Public Park and Recreation Zone. Under the Coastal Management Act 1995 it was a requirement to consult with the Victorian Department of Sustainability and Environment (DSE) to get consent. DSE required the City of Greater Geelong to provide expert advice on the flying fox population, which is listed as a species of national significance under the Environment Protection and Biodiversity Conservation Act 1999.

Installation

A local installer was engaged based on their knowledge and experience with renewable energy systems. The installer also teaches renewable energy classes at Gordon TAFE, Geelong. Erecting the turbine was straightforward. Difficulties and delays were encountered with the chosen inverter, which was imported from Italy – this took four months after the turbine was installed. The inverter had to be reconfigured to meet Australian standards. Once installed the fuses had to be upgraded from 6 amps to 15 amps. There have been no operational issues since the inverter was reconfigured.

Connecting & selling to the grid

Commissioning of the system was delayed due to still days. The lack of wind meant that on initial visits the inverter was not showing any signal and could not be properly tested. Later a further inspection on a windy day was undertaken during which the system could be commissioned.

Cost

The total cost of the system was approximately AUD$70,000. A rebate of AUD$725 was received. Earnings so far will be available after 12 months of the system being operational.

Further comments & advice

Comments from the public have been overwhelmingly positive. The City of Greater Geelong considers the turbine to have a positive visual impact. Some advice for other customers:

"Try and use installers who have appropriate experience in small scale wind energy if possible."

Enhar thanks Tim Moodie, Greenhouse Officer at City of Greater Geelong, for submitting this case study.

6.3. Gruyere – 1kW off grid system

Gruyere is situated in the Yarra Valley. The 1kW Soma turbine is mounted on a 19.5 tilt-up guyed monopole and has been operational since January 2008. The system includes a Selectronics SA41 inverter and is not grid connected.

Site assessment

No wind resource measurements were undertaken by the owner, instead an installer was consulted to predict the likely energy output for this site. The turbine system was seen to be a auxiliary energy system to the already installed solar PV system at this site. It was known that in general sunlight hours were low in winter and spring, whilst wind resources were high in the Yarra Valley.

Choosing a turbine

The owner researched different turbines initially through his associates and then an installer before making a final selection.

Planning & permits

A site plan, which showed the turbine location in addition to elevations to show tower height was submitted to the Shire of Yarra Ranges in order to obtain a planning permit. A permit was issued within 2 months.

Installation

The installation procedure was considered to be reasonably straightforward. The professional installer completed all electrical works while the owner assisted with the tower and turbine installation as well as construction the tower footings.

Cost

The total cost of the project was approximately AUD$14,000. The owner received a AUD$7000 rebate under the federal Renewable Remote Power Generation Programme. Savings are currently made from needing to use the back up petrol generator less often. The owner considered reduction in greenhouse gas emissions to be more important than potential earnings.

Further comments & advice

The owner comments that with the right wind resource a small wind turbine can generate a lot of power over a 24 hour period. Combined with a solar PV system, this makes for a very good overall energy system. The owner also comments on the importance of a seeking out a reliable installer

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Enhar thanks Ian Braham, owner of the Gruyere wind turbine, for submitting this case study.

Chapter 7. References and further reading

References

	Title	Author and publisher
[1]	The Viability of Domestic Wind Turbines for Urban Melbourne Authored by Alicia Webb, Research Officer of the Alternative Technology Association. This report prepared for Sustainability Victoria, and was published in June 2007	Available online from ATA website: http://www.ata.org.au/projects-and-advocacy/domestic-wind-turbines [link last checked active April 2010]
[2]	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.
[3]	Victorian Urban Wind Resource Assessment	Report prepared by Mike Baggot for Alternative Technology Association, April 2009. Project commissioned by Sustainability Victoria Available online from ATA website: http://www.ata.org.au/projects-and-advocacy/domestic-wind-turbines
[4]	Evaluation of Wind Resources at Port Phillip Bay	Demian Natakhan of Enhar, for City of Port Phillip, June 2009. Available online from ATA website: http://www.ata.org.au/projects-and-advocacy/domestic-wind-turbines
[5]	Griggs Putnam Index diagram	Image of this frequently used diagram was reproduced from the Southwest Wind Power Consumer Guide 'Siting wind turbines', page 3. Data prepared by E.W. Hewson, J.E. Wade, and R.W. Baker of Oregon State University.
[6]	Victorian Wind Atlas	Produced by Sustainability Victoria, available online on http://www.sustainability.vic.gov.au/www/html/2123-wind-map.asp
[7]	Review of Victorian Urban Wind Roses	Report by Enhar, for Sustainability Victoria, April 2010
[8]	Wind tower economics	By Mick Sagrillo, published in the USA's Home Power edition #38 December 1993/Jan 1994

	Title	Author and publisher
[9]	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 at www.orer.gov.au
[10]	Warwick Wind Trials	Encraft, UK, 2009. Results available at http://www.warwickwindtrials.org.uk/
[11]	Zeeland wind test site	Zeeland, Holland. Results available at http://provincie.zeeland.nl/milieu_natuur/windenergie/kleine_windturbines

Recommended further reading

Title	Author and publisher
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: http://www.bwea.com/pdf/publications/RenewableUK_SWS_Consumer_Guide.pdf This is a very concise overview of undertaking a small wind turbine project.
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: http://www.windpoweringamerica.gov/pdfs/small_wind/small_wind_guide.pdf
Stand-alone Power System – Small Wind Systems: System Design Guidelines	Developed by the Australian Business Council for Sustainable Energy, 2004. Available online from the Clean Energy Council website: http://www.cleanenergycouncil.org.au/dms/cec/accreditation/Quick-Find-Forms/SWind_Design_G.pdf

Title	Author and Publisher
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: http://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: http://www.urbanwind.net/pdf/SMALL_WIND_TURBINES_GUIDE_final.pdf.
Find out how you can start your journey to a sustainable home	resourceSmart - a website-based initiative by Sustainability Victoria, which gives advice for being resource efficient in your home. Accessible online at: http://www.resourcesmart.vic.gov.au/for_households.html

Useful websites:

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

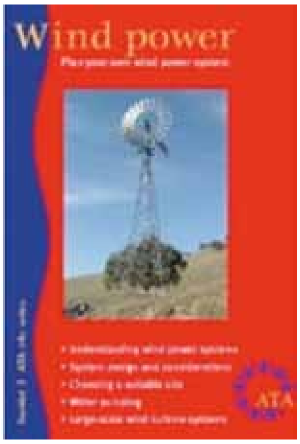
Bureau of Meteorology climate data http://www.bom.gov.au

UK Microgeneration Certifation Scheme http://www.microgenerationcertification.org

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 this 'Wind Power - Plan your own wind power systems' [Ref 2] for $10 from the ATA's online shop: http://shop.ata.org.au



Appendix A – Small wind turbine project checklist

1. Site & Feasibility Assessment	
☐	Complete a wind resource assessment of your site to confirm feasibility for a small wind project.
☐	Consider the location of your turbine.
☐	Estimate your budget.
2. System Design	
Choose a suitable:	
☐	Turbine
☐	Tower
☐	Inverter
☐	Controller
☐	Make financial calculations considering the complete project cost and potential earnings.
3. Planning Permission	
☐	Contact your local council to confirm planning permit requirements.
☐	Supply council with the requested details to obtain relevant permits to proceed.
4. System Installation	
☐	Choose an installation team, which includes a qualified electrician & licensed builder.
☐	Gain approval from your electricity distributor and install an interval meter.
☐	System to be installed and connected to the grid by your chosen installation team.
☐	New utility meter installed.
5. System Operation & 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 as at July 2010

This section lists some active wind turbine vendors in Victoria. It also lists active wind turbine installers in Victoria. 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.

7.1. List of small wind turbine installers in Victoria

This list has been developed in consultation with the industry. Enquiries were sent to Clean Energy Council accredited PV installers in Victoria asking who supplies wind turbine installation services. This process was not exhaustive and it is expected that there are additional installers who are not included on the list below. Inclusion on the list does not guarantee any particular standards or accreditation levels, but simply lists some active installers of wind turbines.

Installer company	Contact	Experience and services	Number of installers
Braemac Energy	www.braemacenergy.com.au 1/15 Howleys Road, Notting Hill VIC 3168 Contact: Matthew Wilson Tel: 1800 759 769	Ampair 100W up to 600W models	2
Energy Matters	www.energymatters.com.au 63-69 Market Street South Melbourne, Victoria Contact: Matt Lyons Tel 1300 727 151	Whisper, Air, Skystream, Soma, Proven, Ampair, LVM, Westwind	5-10
Enter Shop	www.enter-shop.com.au Units 2-3/38 Bridge St Eltham Vic 3095 Contact: Gary Flood Phone 03 9431 0006 M.0430 505 572	Futurenergy 1kW wind turbine, installation service through Sun, Wind and Power	1
Environment Shop	www.enviroshop.com.au High Street, Thornbury Tel 03 9480 1905	Rutland turbines up to 200W (customer generally self-installs these)	
Greenlight Energy	info@greenlightenergy.com.au Nathan Martin Mob: 0415 868 209	Soma 1kW turbines	1
K & C Stork Solar Power Consultants	www.kcsolar.com.au 114 Nelson St, Maryborough, Vic 3465 Chris Stork Ph 03 5460 4224 M 0418 54 84 99	Supplies and installs SOMA, Rutland, Aeromax and Air turbines. Chris is also an authorised repair agent for SOMA turbines	1

Installer company	Contact	Experience and services	Number of installers
MacFarlane Generators	wind@macgen.com, Clayton South VIC Carlos Ogues Renewable Energy Systems Department – Manager (03) 9544 4222	Rutland and Teco wind turbines	14
Maxim Renewables	www.maximrenewable.com.au 3 Abbott Street, Alphington, VIC 3078 Damian Wills Tel 03 94909944	'QR5' 6kW vertical axis wind turbines	several
Radiant Energy Systems	www.pipeline.com.au/users/solar Phil Hapgood - Geelong Tel 03 52444086 Email solar@pipeline.com.au	Soma 1kW, Exmork 1/2/35/10/20kW, Unitron 1.5kW, Ropatec 3/6Kw	2
Saltwater Solar	Sunshine Oliver Crowder Mob: 0408 576 730	Ampair, Soma	2
Solar Charge	www.solarcharge.com.au Showroom: Unit 12, 19 – 23 Clarinda Road, Oakleigh South VIC 3167 Contact: Richard Potter – Managing Director Tel: (03) 9544 2001 e-mail: online@solarcharge.com.au	Importer and wholesaler of Rutland turbines (up to 200W), suited to charging battery banks e.g. for sailing boats. Customer generally self installs.	n/a (customer can self install from box)
Solarquip	www.solarquip.com.au PO Box 1734, Healesville VIC 3777 Contact: Glen Morris Tel. 1300 851 255 Mbl. 0419 299 140 sales@solarquip.com.au	Approved reseller of Skystream turbines through Eden Power (NSW). Also sell and install AirBreeze and AirX	2-3
Sun Real Renewable Energy Systems	www.sunreal.com.au PO Box 924 Wangaratta VIC 3676 Contact: Richard Morton Tel: 03 5768 2248	Soma	2
Sun Wind and Power	Hurstbridge VIC Trevor Robotham Email sunwind@fastmail.fm	Soma, FuturEnergy and Westwind turbines	1
Tambo Valley Electrics	www.tambovalleyelectrics.com.au Great Alpine Road, Swifts Creek 3896 Victoria Contact Stephen Richardson Phone 03 5159 4292	Soma 1kW	1
The Wind Turbine Company	www.twtc.com.au Glenferrie, Melbourne Contact Richard Johnston Tel 1300 858 073	Redriven, Skystream, Unitron, Windspire	
Water and Energy Savers	www.swanenergy.com.au ph: 03 9834 2600 Contact: Sean Sleeman	Zephyr AirDolphin	

7.2. List of wind turbine tower suppliers

The wind turbine you purchase will require a suitable tower. It may be that your turbine supplier provides a tower purpose made for the turbine, or alternatively you can enquire for a tower to be made up by the following fabricators:

Supplier/Installer company	Contact	Experience and services
INGALS EPS	www.ingaleps.com.au Ingal EPS Suite 10, 202-220 Ferntree Gully Road Notting Hill VIC 3168 Mathew Pentreath Tel 03 9541 9322	INGALS supply steel towers for street lighting and flood lighting. Their see-saw towers can be modified to suit small wind turbines. INGALS also offer a tower installation service including civil works.
Radiant Energy System	http://users.pipeline.com.au/~solar/ Geelong Phil Hapgood Tel 03 52444086 Email solar@pipeline.com.au	Radiant offer guyed tilt-up tower kits: 13.5m tower kit, 19m tower kit. To build these kits, you need to also purchase 6.5m water pipe sections from steel suppliers. They are also able to supply towers to most specifications

7.3. 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, the United Kingdom and China. In general these manufacturers have appointed distributors of the turbines in Australia, through which suppliers and installers can order a turbine. However, it is usually the case that most turbines can also be purchased directly through the manufacturer.   This section includes turbine specification data on all turbine models readily available in Australia 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 full package, which includes an inverter, tower, batteries (if not grid connected) and installation costs. Some turbines are supplied with their own towers, e.g. Soma and Proven, however it is possible to obtain different towers which are still suitable for the turbine. Eden Power advise that Skystream turbines are no longer sold as individual units and are now sold as packages with tower included, as the manufacturer wants to ensure they are installed with approved equipment.

We have attempted 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 full 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.

The following organisation is also known to supply wind turbine products. Full specifications of the products were not obtained at the time of publishing this document.

Company	Contact	Services
Ausino	Mr Li 129-131 McEwan Road Heidelberg West VIC 3081 (03) 9459 6011	Importers of Chinese wind turbines including 20kW, 500W and 1kW models. Equipment supply only

Brand (made in)	Model	Power Rating	Cut-in speed (m/s)	Voltages Available	Overspeed Protection	Number of Blades	Blade Material
Soma (Australia)	Soma 400	400W @ 10m/s	4	12, 24, 32, 48, 110, 120 DC	Tilt Up	2	Hollow Moulded Fibreglass
	Soma 1000	1000W @ 10m/s	3.5				
Southwest Windpower (USA)	Air X	400W @ 12.5m/s	3.58	12, 24, 48 DC	Electronic Torque Control	3	Carbon Fibre Composite
	Air Breeze	160W @ 12.5m/s	2.68			3	Injection Moulded Composite
	Whisper 100	900W@ 12.5m/s	3.4	12, 24, 36, 48 DC	Side Furling	3	Carbon Reinforced fibreglass
	Whisper 200	1000W @ 11.6m/s	3.1	24, 36, 48 DC			
	Whisper 500	3000W @ 10.5m/s	3.4			2	
	Skystream	2400W @ 13m/s	3.5	120/240AC	Electronic stall regulation with redundant relay switch control	3	Fibreglass reinforced composite
Westwind (Northern Ireland)	3kW	3000W @ 14m/s	3	48, 120 DC; 240 AC	Auto Tail Furl	3	Pultruded Fibreglass
	5kW	5500W @ 14m/s	3				
	10kW	10000W @ 14m/s	3	120, 240 AC			
	20kW	20000W @ 14m/s	3	240 AC	Blade pitch/tail furl		Epoxy/carbon/fibreglass composite
LVM (UK)	212/224	48W @ 20.5m/s	6.2	12, 24 DC	Battery Charge Voltage regulator (optional extra)	5	Glass filled polypropylene
	412/424	228W @ 31m/s	4.1			6	
	612/624	360W @ 23.1m/s	3.3				
Ampair (UK)	Pacific 100	100W @ 12.6m/s	3	12, 24 DC	None	6	Glass filled polypropylene
	300	300W @ 12.6m/s	3		PowerFurl™ blade pitch control system	3	Glass reinforced polyester
	600	698W @ 11m/s	3	24 DC; 230 AC			
	6000	6000W @ 11m/s	3.5	48 DC; 240 AC	Electronic speed control & triple redundant relay brake		Glass filled polypropylene
Rutland (UK)	913	90W @ 9.8m/s	2.6	12 DC	None	6	Unknown
	FM910-3	90W @ 9.8m/s		12, 24 DC	Auto Tail Furl		
	FM1803-2	720W @ 12m/s	3		Auto Tail Furl	3	Unknown
Proven (UK)	7	2800 @ 12m/s	2.5	12, 24, 120, 240 DC; 300 AC	Downwind Flexible Blades	3	Glass thermoplastic composite
	11	6000W @ 12m/s		48, 120, 240 DC; 300 AC			
	35	15000W @ 12		48 DC; 300 AC			
Zephyr (Japan)	Airdolphin Mark-Zero	1000W @ 12.5m/s	2.5	24 DC	Regenerative Electromagnet Braking System	3	Carbon Fibre Skin on unknown material
Renewable Devices (UK)	Swift	1000W @ 11m/s	3.58	240 AC	Angling Furling/Dynamic Brake	5	Unknown Plastic
Ropatec (Italy)	Easy Vertical	800W @ 14m/s	3	24, 48 DC	Not Required	3	Extruded Aluminium Fabricated
	Simply Vertical	3000W @ 14m/s	3	48 DC, 230 AC			
	Maxi Vertical	5800W @ 14m/s	3	48 DC, 230 AC			
Futurenergy (UK)	FE1012	600W @ 12.5m/s	3.2	12 DC	Mechanically furling	5	Glass Filled Polyamide
	FE1024/FE1048	1000W @ 12.5m/s	3	24, 48 DC			
Quiet Revolution (UK)	QR5	4200W @ 11m/s	4.5	Grid only	Overspeed Braking and automatic shutdown	3	Carbon and Glass Fibre

Rotor Diameter (m)	Weight (kg)	Generator Type	Comments	RRP	Warranty (years)	Approved distributor
2	40	3 Phase Permanent Magnet		$5250-$5300	1	Sunrise Solar ph: (02) 43811531 sunrise@dragon.net.au www.somapower.com.au
2.7	50			$6,800		
1.15	6.2	3 Phase Permanent Magnet Alternator	Marine is powder coated for corrosion protection	$1529 (Land)	3	Apollo Energy ph: 1300 855 484 windpower@apolloenergy.com.au www.apolloenergy.com.au
1.17	5.9	Brushless Neodymium Alternator		$1271 (Land)		
2.1	21	3 Phase Permanent Magnet Alternator		$5,415	5	
2.7	30		HV Avail	$6,519		
4.5	70			$16,456		
3.72	77	Slotless permanent magnet brushless	Controls & inverter built in. Includes Tower in package	$25,000-$40,000 fully installed		Eden Power ph: 1300 398 766 sales@edenPOWER.com.au www.edenpower.com.au
5.1	200	Direct drive permanent magnet	Price includes towers	$13,663	2	Numerous sellers, but no central distributors. See http://www.westwindturbines.co.uk
	200			$16,412		
6.2	380			$25,547		
10.4	750			$45,745		
0.58	5	3 Phase Permanent Magnet Alternator	Marine applications	$1200 + GST	1	Neosid Australia (Importer) ph:(02) 9660 4566 sales@neosid.com.au www.neosid.com.au
0.87	9.3		4F & 6F variety will furl – land only	$1800 + GST		
1.22	12.5			$2650 + GST		
0.93	12.5	3 Phase Direct Drive Permanent Magnet		$1,724	2	Conergy Pty. Ltd & Energy Matters (South Melbourne) Ph: 1300 727 151 sales@energymatters.com.au www.energymatters.com.au
1.2	12			$3,346		
1.7	16			$4,366		
5.5	190			$25,000		
0.91	10.5	3 Phase Alternator		$956	2	Solar Charge ph: 9544 2001 online@solarcharge.com.au www.solarcharge.com.au
0.91	17			$1,105		
1.8	35.32	Brushless 3 Phase		$2,991		
3.5	190	Brushless permanent magnet, direct drive	Aus name: "2.5". Cost inc tower	$38,544	5	Conergy Pty Ltd ph:(02) 8507 2222 sales@conergy.com.au www.conergy.com.au
5.5	600		Aus name: "6". Cost inc tower.	$74,580		
9.8	1100		Aus name: "15", Cost inc tower.	$161,568		
1.8	17.5	3 Phase Permanent Magnet Alternator	Uses self start motor	Unknown	Unknown	Water & Energy Savers (Operating as Swan Energy) ph: 03 9834 2600 www.swanenergy.com.au
1.04	52	Brushless Permanent Magnet	Rooftop Mounted	Unknown	2	Cubic Solutions ph: 1300 428 242 www.cubicsolutions.com.au
1.66	80	Brushless Permanent Magnet Generator	VAWT. Note costs inc. inverters	$10,780	2	Sustainable Energy Enterprises (Operating as CREST), ph: (08) 8267 2366 heinzrechten@bigpond.com www.crestaustralia.com.au
3.3	400			$28,160		
4.7	800			$40,920		
1.8	22	3 Phase Brushless Permanent Magnet Generator		$3,080	2	Enter-shop (Eltham) ph: (03) 9431 0006 enter-shop@bigpond.com www.enter-shop.com.au
3.1	450	Direct Drive Permanent Magnet Generator	VAWT. Price inc inverter and controller	$53,650	2	Maxim Renewable (Alphington) ph: 9490 9999 www.maximrenewable.com.au

Brand (made in)	Model	Power Rating	Cut-in speed (m/s)	Voltages Available	Overspeed Protection	Number of Blades	Blade Material
ReDriven (Canada)	10kW	10000W @ 10m/s	2	240 AC	Dynamic Braking	3	Fibreglass
Unitron (India)	UE 15	1500W @ 10.5m/s	2.7	Unknown	Angle Governing (Furling) and electronic control	3	Carbon Fibre Composite
	UE 33	3300W @ 10.5m/s					
	UE 42	4750W @ 11m/s					
Windspire Energy (USA)	Windspire 1.2kW	1200W @ 10.7m/s	3.8	120 AC	Redundant electronic braking system	3	Extruded Aluminium
Gaia Wind (Denmark)	133-11kW	11000W @ 9.5m/s	3.5	400 AC	Passive stall, mechanical brake, centrifugal aerodynamic rotor brake	2	Fibreglass
Aerogenesis (Australia)	5kW	5000w @ 10.5m/s	3	80 – 500 AC	Microprocessor control & electro-mechanical brake	2	Vacuum infused fibre glass reinforced epoxy
Urban Green Energy (USA)	UGE 600	640W @ 12m/s	3.5	24, 48 DC	None	3	Fibreglass
	UGE 1kW	1000W @ 12m/s	3				Carbon Fibre and Fibreglass
	UGE 4kW	4000W @ 12m/s	3	50 – 580 AC			
IWE (China)	1kW	1000W @ 8m/s	3	48 DC	Furling and electromagnetic brake	3	Glass Reinforced Plastic
	2kW	2000W @ 9m/s		120 DC			
	5kW	5000W @ 10m/s			Electronic Brake		
	10kW	10000W @ 9m/s			Hydraulic Brake		
	1.6kW	1600W @ 10m/s	1.8	48 DC	Electromagnetic and mechanical brake	5	Unknown
	3.2kW	3200W @ 10m/s		148 DC			
	6kW	6000W @ 10m/s		216 DC			
	12kW	12000W @ 11m/s					
	30kW	30000W @ 11m/s		384 DC			
Exmork (China)	HM 2.2-300	300W @ 8m/s	3	12, 24 DC	Yaw	3	Reinforced Fibreglass
	HM 2.5-500	500W @ 8m/s					
	HM 2.8-1000	1000W @ 8m/s		24, 48 DC	Yaw & Auto Brake		
	HM 3.2-2000	2000W @ 8m/s		24, 48, 120, 240, 300 DC			
	HM 4-3000	3000W @ 10m/s		48, 120, 240, 300, 350 DC			
	HM 5.5-5000	5000W @ 10m/s					
	HM 7-10000	10000W @ 11m/s		240, 300, 360, 480 DC			
	HM 10-20000	20000W @ 11m/s					
Rewind Energy (China/Germany)	5kW	5000w @ 10.5m/s	3	500 DC	Blade Pitch	3	Fibreglass
	10kW	10000W @ 12m/s					

Rotor Diameter (m)	Weight (kg)	Generator Type	Comments	RRP	Warranty (years)	Approved distributor
8	591	Direct Drive		$72,500 (inc tower & inverter)	5	The Wind Turbine Company (Melb) ph: 1300 858 073, enquiries@twtc.com.au www.twtc.com.au
3.2	34	Permanent Magnet Alternator	1.8kW available, with 3.4m rotor	$15,300 (inc tower & inverter)	5	
4.65	77			$20,800 (inc tower & inverter)		
5.2	89			$32,700 (inc tower & inverter)		
1.2	283	Brushless Permanent Magnet Generator	VAWT. Integrated inverter	$14,200 (inc tower & inverter)	5	
13	900	3 phase induction generator	Inverter-less	$110,000 fully installed	2	Gaia Wind LTD (UK) ph: +44 (0) 845 871 4242, ukmail@gaia-wind.com www.gaia-wind.co.uk
5	1300 (inc tower)	3 phase induction generator	Built to order. Inverter yet to be approved in Aus	$30,000 fully installed	2	Aerogenesis Australia ph: 0413 357 473 david.wood@aerogenesis.com.au www.aerogenesis.com.au
1.38	81.6	Direct Drive Permanent Magnet Generator	VAWT. Prices include towers and inverters	$9,481.30	1 extendable	Advanced Eco Solutions Pty Ltd (NSW) ph: 02 8437 6264 ben@advancedeco.com.au www.advancedeco.com.au
1.8	175			$15,462		
3	444			$34,533		
2.7	83	3 Phase Permanent Magnet Generator	Price is fully installed	$9,500	2	I Want Energy (TAS) ph: (03) 6231 0002 rob@iwantsolar.com.au www.iwantsolar.com.au
3.2	215			$13,250		
6.4	250			$29,500		
8	600			$51,500		
2	Unknown		VAWT. Price is fully installed	$10,840		
3				$25,700		
4				$46,080		
6				$88,370		
9				$216,010		
2.2	40	3 Phase Permanent Magnet Generator		$500	1	Wind Power Energy (WA) ph: (08) 9683 2101 windpowerenergy@bigpond.com www.windpowerenergy.com.au
2.5	46			$715		
2.8	70			$1,000		
3.2	123			$1,650		
4	327			$3,390		
5.5	358			$5,290		
7	1250			$14,745		
10	1698			$22,695		
5.4	450	3 Phase Permanent Magnet Generator	Price is fully installed	$39,990	3	Rewind Energy (NSW) ph: 1300 322 678 sales@rewindenergy.com.au www.rewindenergy.com.au
7.6	550			$69,990		

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