Energy^3 Frequently Asked Questions

What is wind energy?

Wind energy is a converted form of solar energy. The sun's radiation heats different parts of the earth at different rates, most notably during the day and night, but also when different surfaces (for example, water and land) absorb or reflect at different rates. As a consequence this causes portions of the atmosphere to warm differently. As hot air rises, cooler air is drawn in to replace it creating wind.
Air has mass and therefore when in motion it contains the energy of that motion. A proportion of that energy can be extracted by turbines to create electricity.

What is a wind turbine and how does it work?

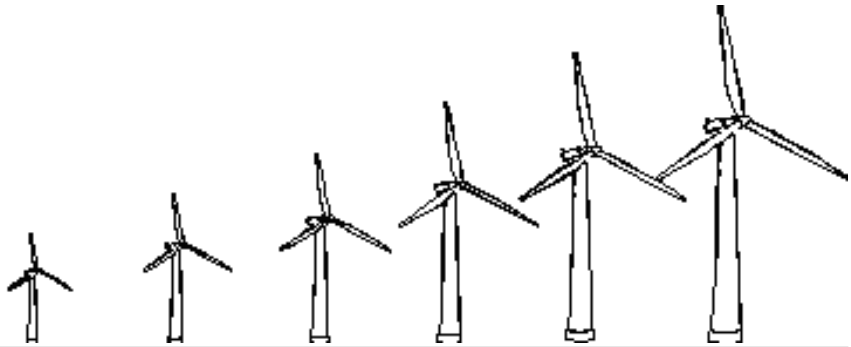
A wind turbine is an energy conversion system that transforms the energy of the wind into electrical energy. Modern wind turbines can generate electricity for homes, businesses and for sale to retail companies.

Major components of a wind energy system are:

- a rotor, or blades, which convert the wind's energy into rotational shaft energy, most modern turbines use 3 blades as this design is the most efficient;
- a nacelle (enclosure) containing the drive train, usually including a gearbox to increase shaft speed and decrease torque, brakes, yaw gear to face the turbine into the wind, and a generator which converts the shaft energy into electrical energy;
- a tower, to support the rotor and drive train; and
- electronic control equipment, electrical cables, and grid connection equipment.

Note: Some turbine designs do not require a gearbox

Wind turbines vary considerably in size. The following table shows a historical trend of average turbine size and output. (Source: American Wind Energy Association)



	1981	1985	1990	1996	1999	2000
Rotor (meters)	10	17	27	40	50	71
Rating (KW)	25	100	225	550	750	1,650
Annual MWh	45	220	550	1,480	2,200	5,600

How much electricity can one wind turbine generate?

Electricity generation is measured in watts. As a watts are a comparatively small unit, kilowatts (kW, 1,000 watts) and megawatts (MW, 1 million watts), are typically used to describe the capacity of generating of wind turbines as with other generation equipment.

Electricity production and consumption is measured in kilowatt-hours (kWh). A kilowatt-hour means one kilowatt (1,000 watts) of electricity produced or consumed for one hour. One 100-watt light bulb left on for 10 hours consumes one kilowatt-hour of electricity (100 watts x 10 hours = 1,000 watt-hours = 1 kilowatt-hour).

The output of a wind turbine depends on the turbine's size and the wind's speed through the rotor. Wind turbines currently available have power ratings that range from 250 watts to 5 megawatts (MW).

For example a 100-kW wind turbine can generate about 200,000 kWh annually at a site with wind speeds averaging 6 metres per second, or approximately enough to power 30 typical households.

Wind speed is a crucial element in projecting turbine performance; therefore a potential site's wind speed must be measured through wind resource assessment prior to a wind farm's construction. The power available in the wind is approximately proportional to the cube of its speed, which means that doubling the wind speed increases the available

power to be converted to electricity by a factor of eight. The implication is a small difference in wind speed can mean a large difference in available energy and in electricity produced, and therefore, a large difference in the cost of the electricity generated.

What are wind turbines constructed of?

The towers are mostly tubular and are made of steel; however some are of lattice construction. The blades are typically made of fiberglass-reinforced polyester or wood-epoxy.

How fast do the blades rotate?

Blade rotational speed is dependant on the size of the blades, for example a 100kW machine with a 20 meter rotor diameter will rotate at a speed of approximately 45 rpm. However a 750kW machine with a rotor diameter of 48 metres will rotate at a speed of approximately 22 rpm.

What size are wind turbines?

Wind turbines are manufactured in various sizes, rotor diameters ranging from about 20 metres to about 90 metres, and towers range from 30 metres to 120 metres. Electrical output can range from less than 1 kilowatt to 5000 kilowatts.

What colour are wind turbines?

Wind turbines are usually painted in a matt off white colour so that they blend into the sky and are the least noticeable. In some situations the lower third of the tower may be painted green graduating to white to blend into pastoral landscapes.

What weight are wind turbines?

Weights vary considerably depending on the design and the size. For example a standard 750kW machine would have a nacelle weight of around 22 tonnes, a rotor weight of 15 tonnes, and a tower weight of 55 tonnes.

Are birds affected by wind turbines?

Modern wind turbines are easily avoided by birds as the blades rotate relatively slowly and thus can be easily seen. Numerous studies have been commissioned which support this finding.

Are farm livestock affected by wind turbines?

No. Farm livestock soon become used to wind turbines and often use them for shade and rubbing posts.

How many homes can one megawatt of wind energy supply?

The number of homes that are able to be supplies depends on the amount of wind available and this will vary depending on the site. On average however a one megawatt turbine would supply 400-500 average households.

Are turbines noisy?

No, wind turbines typically produce less than 35 decibels at a distance of 350 metres. This equates to the noise level of a quite bedroom.

What is "capacity factor"?

Capacity factor is a measure of the productivity of a wind turbine or any other power plant. It compares the plant's actual production over a given period of time with the amount of power the plant would have produced if it had run at full capacity for the same period.

$$\text{Capacity Factor} = \frac{\text{Actual amount of power produced over time}}{\text{Power that would have been produced if turbine Operated at maximum output 100\% of the time}}$$

A wind turbine is powered by the wind which fluctuates throughout the day; this translates to fluctuating power output. Thus although wind turbines typically operate 60%-90% of the time, they often run at less than full capacity. Therefore, a capacity factor in the range of 25% to 40% is common.

If a wind turbine's capacity factor is 33%, doesn't that mean it is only running one-third of the time?

No. A modern wind turbine should run about 60-90% of the time. However, much of the time it will be generating at less than full capacity due to light winds, in turn making its capacity factor lower.

What is "availability" or "availability factor"?

Availability factor is a measurement of the reliability of a wind turbine or other power plant. It refers to the percentage of time that a plant is available to generate (that is, not out of service for maintenance or repairs). Modern wind turbines have an availability of more than 98%, this higher than most other types of power plant.

How much land is required?

A wind farm will typically require about 20 hectares per megawatt of installed capacity. However, only 3% or less of this area is actually occupied by turbines, access roads, and other equipment, 97% remains free for farming. Wind energy provides rural landowners and farmers with a supplementary source of income through leasing and royalty arrangements with wind power developers. Wind energy can also provide rural land owners with energy for farm use.

Specific Project Questions

What constitutes a potentially good wind turbine site?

A good wind turbine site should obviously be exposed to strong consistent winds; this can be inferred by trees bent away from the prevailing wind. Close proximity to power lines is also important to minimize connection costs. Access is another important issue as large machinery must be able to access the site for construction and maintenance. Ideally there should be no shelter belts or obstacles which may impede the flow of wind.

What monitoring needs to be commissioned?

A metrological mast needs to be positioned on site for a least a year to accurately measure mean wind speed. From the mean wind speed an estimated energy production schedule can be calculated from which the potential project economics are deduced. This is crucial as a 10% error in wind speed can translate to a 30% error in estimated energy production

How reliable is the wind?

Wind fluctuates markedly from day to day, however on average a yearly departure from the mean of no more than 10% has been observed. This translates to a +/- 30% variation in yearly energy production.

Where are the wind turbines sourced from?

Secondhand turbines will be sourced from a number of reputable dealers in Europe. All wind turbines will have a specialist engineering report to ensure they are of high quality.

How are the wind turbines transported?

Turbines are shipped from Europe to New Zealand, depending on the turbine size they can be either packed into containers or may be deck cargo. From port they can be transported to site by standard semi trailers. Turbines larger than one mega watt may require special trucking due to size constraints. It typically takes 6 weeks for delivery.

What age are the wind turbines?

Generally the aim is to use turbines between 5-8 years old, however newer or older turbines can be sourced depending on the parameters of a particular project.

What are the scheduled maintenance requirements?

Wind turbines are relatively maintenance free, typically servicing is carried out on a 6 month basis and includes lubrication, brake checks, electrical checks, and bolt tightness checks. Every 5-7 years the blades need to be inspected and may need reconditioning. Likewise every 10-15 years major bearings will need to be replaced and the gearbox overhauled if required. On average maintenance costs are in the order of 0.8-1.2 cents per kWh produced by the turbine.

What refurbishing is initially carried out?

Refurbishment will depend on the age of the turbine and general condition, and will be linked to the specialists report. Typically major bearings will be replaced if required, blades refurbished, and servo systems overhauled.

What is the availability of spare parts?

Projects will have a spare machine built into the cost for fast access to spare parts. All additional parts are readily available and are well within the scope of local industry to repair and maintain.

What is the average reliability of wind turbines?

Wind turbines will typically achieve a 97-98% availability factor when coupled with a good scheduled maintenance program.

What are the grid connection requirements?

Permission to connect needs to be sought from the local lines company. Typically the turbines have all the necessary electrical safeguards and meet all the technical

specifications without modification. Depending on location the local lines may need upgrading if deemed necessary, this would be payable by the developer.

Can electricity produced be easily sold?

Yes, a power purchase agreement can be obtained from retailers. This can be either on a floating spot rate basis or a fixed price contract for a specified time period.

Can a wind turbine be used to power a factory or farm?

Yes, a wind turbine can be wired in parallel to existing plant and machinery to directly power machinery that is grid connected. It is important to note that the load must be grid connected at all times to allow the wind turbine to function correctly, wind turbines will not operate without the support of the grid. Likewise it is important to size the turbine to existing infrastructure such as transformer size. Excess electricity can be sold when not required. When there is insufficient wind to generate electricity can be drawn off the grid as per normal. This method of electricity production is relatively common in Europe.

Can carbon credits be obtained?

Yes, providing the project is greater than one megawatt, carbon credits can be sought. Note this is a competitive bidding process so credits are not guaranteed.

Can line charges be reduced?

Yes, although this depends on the individual lines company, pattern of consumption, and the output of the turbine.

How much does a wind turbine project cost?

A large scale wind farm using new wind turbines will cost in the order of NZ$ 2-3000/ kW fully installed. For instance, if a project consisted of five 500kW turbines (total 2.5MW), then the cost would be NZ$ 5- 7.5 million. However, this can be reduced by at least 50% by implementing second hand machines, at a targeting a cost of $1000/kW fully installed (in the above example, the cost would be NZ$2.5 million).

In this example, the project would deliver 8,000MWh of electricity per year, enough to power approximately 1,200 homes (assuming an average wind speed of 8 m/s and a resultant capacity factor in the order of 40%).

What is the cost breakdown between the cost of a turbine and the fully installed project?

Usually, approximately 55% of the cost is for the turbines, and the balance is for all the other wind measurement, consenting, connection, sales, project management etc. However, this split does vary from project to project depending on site, intended use, and transmission considerations.

What is the revenue?

In our example, the project delivers on average 8,000MWh of electricity per year. If the electricity is sold for 7c/kWh, then the annual revenue is $560,000. Deducting operating and maintenance costs of 1.5c/kWh, this gives a net proceed of $442,000 per year.

How does someone decide if it's a good project or not?

Each project is subject to accurate site wind measurement, independent analysis of wind data by experts, and detailed financial projections. From this analysis, investors can decide whether or not the project rate of return is a good investment relative to other investment options available to them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