

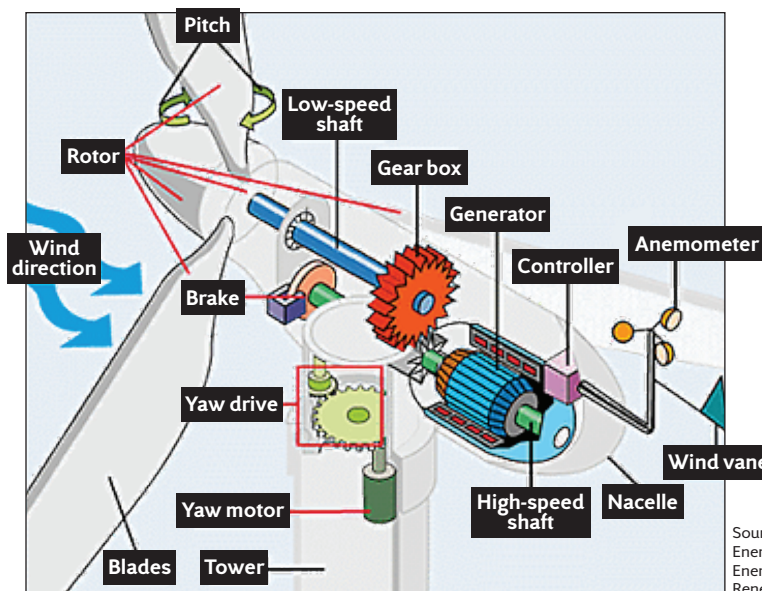
A fact sheet developed by the
Midwest Rural Energy Council



How Do Wind Turbines Generate Electricity?

Wind turbines generate electrical power in the same way as all other generation technologies. The only difference is in the source of the mechanical power supplied to the electrical generator: wind, rather than a diesel engine or steam turbine, provides the energy. Blades capture energy in the wind and turn the turbines. Control mechanisms point the blades into the wind (yaw control) and, on large wind turbines, adjust the pitch of the blades (blade angle) as wind speeds change. Typically, a gearbox connects the shaft from the blades (rotor) to the electrical generator.

The electrical generators used on wind turbines may either be induction generators or synchronous generators. The electrical power from the generator is typical 60 Hz, AC power with 600V output for large wind turbines. A transformer may be required to increase or decrease the voltage so it is compatible with the end-use, distribution or transmission voltage, depending on the type of interconnection. Small wind turbines produce a variety of voltages and some produce DC power. Small wind turbines generally require an inverter to match the power output with the load and/or interconnection frequency and voltage.



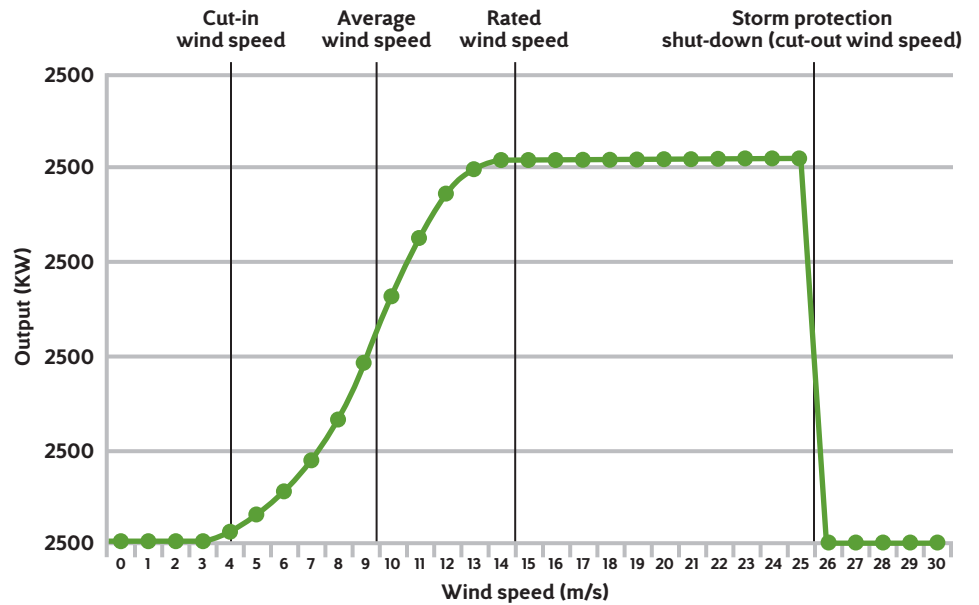
Source: US Dept. of
Energy - Office of
Energy Efficiency and
Renewable Energy

Energy produced by wind turbines

The nameplate rating of a wind turbine should indicate the capacity or maximum power output of the turbine in kilowatts (kW). This usually occurs at very high wind speeds and is not representative of the average power production over time. Energy production is commonly estimated as the annual average energy or the amount of energy produced over the course of one year. The power produced by a wind turbine at any moment is related to the wind speed at that moment. A power

curve for a wind turbine indicates the power produced across the entire operating range of the wind turbine. Wind turbines have a cut-in wind speed, typically about 8 to 9 mph, when they will start to produce a small amount of electricity. Below the cut-in wind speed there is not enough energy in the wind to produce electrical power. Wind turbines also have a cut-out wind speed (very high wind speed) where the wind turbine will shut down to protect the wind turbine from damage.

Example of a wind turbine power curve (varies with turbine models)



Energy production is estimated from the wind turbine power curve together with an estimation of the amount of time in a year that the wind will be blowing at each specified speed. The wind speed distribution is a function of location. Good wind sites have high and steady wind speed while others have low average wind speed with considerable variability over the course of a day, month and year. The capacity factor (CF) is a single number that is used to estimate annual average energy production from a wind turbine as a percentage of its maximum capacity.

Large turbines located at good wind sites can achieve capacity factors of 40% or more. Small wind turbines located at poor sites can have capacity factors of 20% or less. Remember that the rated power is a property of the wind turbine, while the capacity factor is a property of the location of the wind turbine (a measure of the available wind energy at this location). An example calculation of the estimated annual energy production of a wind turbine with rated capacity of 10 kW located on a site with a capacity factor of 25% is as follows:

$$\text{Capacity (kW)} \times \text{Capacity Factor} \times 8760 \text{ hrs/yr.} \\ = \text{Estimated annual energy production (kWhr/yr)}$$

$$10 \text{ kW Capacity} \\ \times 0.25 \text{ Capacity Factor} \\ \times 8,760 \text{ hrs/yr} \\ = 21,900 \text{ kWhr/year}$$

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This publication was developed by the Midwest Rural Energy Council (MREC).



The mission of the MREC is to initiate, develop, support, and coordinate education, research, and communication programs on significant and emerging rural energy issues for the consumer, energy suppliers, and allied industries through cooperative efforts of council members.

For more publications and information on this topic visit the MREC website at: www.mrec.org

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