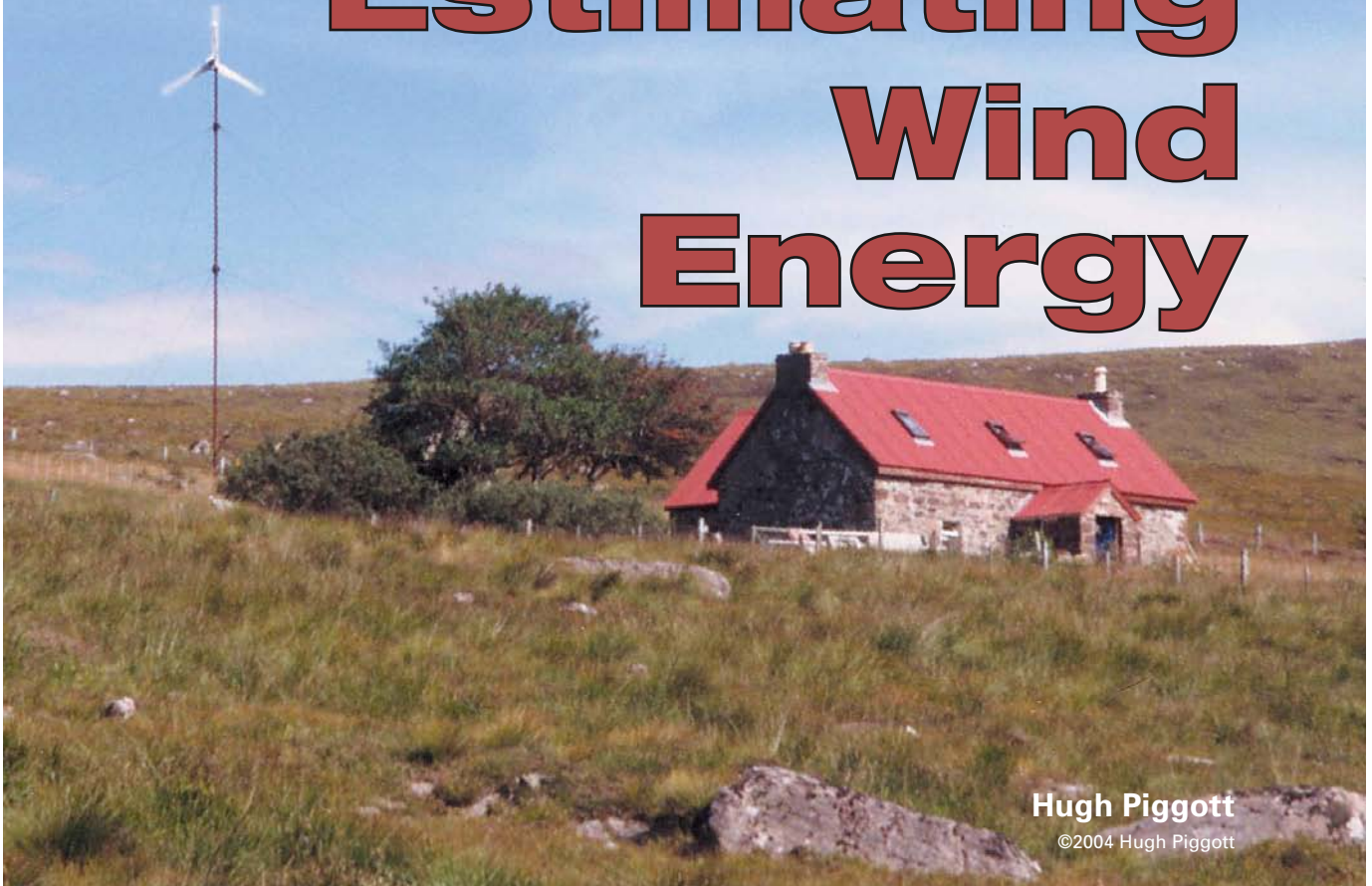


Estimating Wind Energy



Hugh Piggott

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This AWP 3.6 turbine has a comparatively large, 3.6 meter rotor diameter, and produces well in low winds as a result.

What can you run from a wind turbine? How much does it produce? What size turbine do you need to power your home? This article will begin to help you answer these questions.

Wind generators are sold with power ratings. For example, a particular model might be advertised as “1 kilowatt” (1,000 watts). But you cannot conclude that it will produce energy at the rate of 1 kilowatt all the time. In fact, it will only produce its rated output a very small percentage of the time.

Few energy sources are as variable as the wind. A wind turbine is designed to deal with a whole range of wind speeds, often from 3 meters per second (7 mph; 11 kph) to 12 m/s (25 mph; 40 kph). You will only see the advertised output in strong winds. The average output is going to be a fraction of the advertised output because the wind is rarely high enough to enable rated output.

The Power & Probability of Wind Speed chart illustrates what happens at different wind speeds on a typical site, where the average (mean) wind speed is 5

meters per second (11 mph). One curve shows the power available at each wind speed. The second curve shows “probability” of the wind speed—in other words, the percentage of the time for which the wind will blow at that speed. The wind turbine might produce 1,000 watts at the highest wind speed shown, but it only occurs for 3 percent of the time.

You will typically need a battery to store the energy produced by your wind turbine, and to make the energy available when you need to use it. The peak power output of the wind generator in windy weather is therefore not very important. What matters is how the actual power output averages out into energy production (kilowatt-hours) over a period of time, and whether that energy total meets your needs for that same period.

Average Energy Use

You can convert between the average power and the kilowatt-hours of energy per day, month, or year by knowing the number of hours involved. For example on a daily basis, 100 watts average output translates into the following amount of electrical energy per day:

$$\begin{aligned} 100 \text{ watts} \times 24 \text{ hours} &= \\ 2,400 \text{ watt-hours} \div 1,000 &= 2.4 \text{ KWH} \end{aligned}$$

On a monthly basis, that means:

$$100 \text{ watts} \times 720 \text{ hours} \div 1,000 = 72 \text{ KWH.}$$

Here in the UK, the average person's domestic electricity needs average out at 210 watts, or:

$$210 \times 24 \div 1,000 = 5 \text{ KWH}$$

With energy efficiency measures, this demand can easily be reduced by half. See Scott Russell's load analysis article in this issue for help with predicting your energy needs.

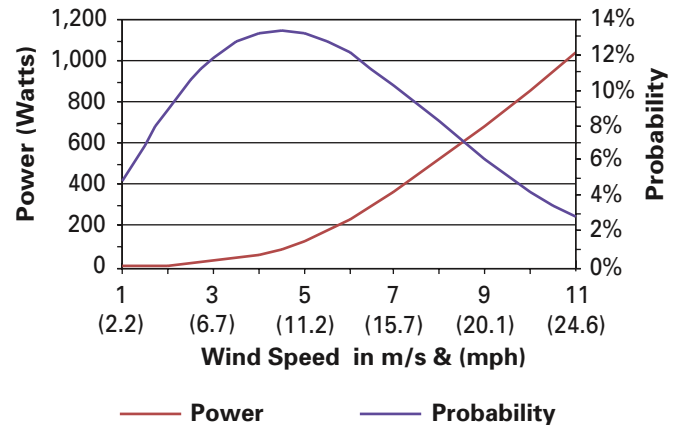
Wind Speed & Swept Area

Energy production from wind turbines depends on two main variables—wind speed and blade rotor diameter. The fuel is the wind. The wind speed and the amount of that wind you can catch with the blades are the best indicators of the useful output.

The author with a Windseeker turbine. Rated power is 500 watts, but the diameter is only 1.5 meters. This machine is rated at a high wind speed. It will not capture much energy in low winds.



Power & Probability of Wind Speed



If you have a rotor that sweeps a large area, exposed to a good wind, you can get plenty of energy. Finding out the average wind speed for your site and tower height is no simple task, but there are good books to help you. Paul Gipe's *Wind Power for Home and Business* is one (see Access).

This assumes that the machine does a good job of converting the wind's energy into electricity. Conversion efficiency varies somewhat, but there is an upper limit that no manufacturer can break through without breaking the laws of physics. Manufacturers will publish figures for energy production, but it is a good idea to check these and see how realistic they are. Maybe their product is super-efficient, or maybe they are hyping it up a little.

A Rough Guide

As a rough guide, the average power output equals the cube of the wind speed, times the square of the diameter, divided by "X." The constant X depends on the efficiency and the units used. The ultimate theoretical best value of X is just under 1.25 for metric units (meters and meters per second) or 150 for "English" units (feet and mph).

But this theoretical case is like a car without friction—a nice idea, but it's not going to happen. In manufacturers' data, X often comes out close to 3.5 (420 for English units), and this is around the limit of credibility. In the real world, it is maybe safer to assume that X equals 5 for metric units, and X equals 600 for feet and mph.

There is no point in trying to be precise with this calculation. There are too many uncertainties. It is unlikely that you will have a very accurate idea of the average wind speed on your site, and the energy produced is very sensitive to wind speed. So I do not recommend trying to predict energy figures to several decimal places.

Example

Average output from a wind generator equals:

$$(\text{wind speed in mph})^3 \times (\text{rotor diameter in feet})^2 \div 600$$

Estimated Average Power

Average Wind Speed		Avg. Power (W) for Rotor Diameters			
m/s	mph	1.0 m 3.3 ft.	2.0 m 6.6 ft.	3.0 m 9.8 ft.	4.0 m 13.1 ft.
3.0	6.7	5	20	50	90
5.0	11.2	25	100	225	400
7.0	15.7	70	270	600	1,100

Site with average wind speed of 5 m/s (11 mph). Data generated by WindCad from Bergey Wind Power Co.

For example, take an average wind speed of 4.5 m/s or 10 mph (16 kph), and a rotor diameter of 3 meters or 10 feet. The cube of 10 is 1,000, and the square of 10 is 100. Multiply them together and divide by 600 to get 167 watts average power output. Energy per day would be:

$$24 \text{ hours} \times 167 \text{ watts} \div 1,000 = 4 \text{ KWH}$$

You can be reasonably confident that you will get about 4 KWH on an average day. If there is no wind on one day, you will get nothing. Another day you might get much more.

Losses

Do not forget that you will lose energy in the process of storing it in the batteries and taking it back out. Twenty

percent or more of the energy can be lost in this way. Another loss in a stand-alone system is the dump load that regulates your battery charge rate. If the battery reaches full charge, surplus energy will be dumped into heat. This is inevitable unless you have such a huge battery that it never reaches full charge, which would be both expensive and foolish. The battery needs to be fully charged regularly or it will deteriorate.

Batteryless grid-intertie systems do not suffer these issues with battery storage, but you still have to take account of the efficiency of the inverter that converts your wind-generated electricity into utility-grade AC electricity.

Use the Wind

Wind energy is free, so let's use it. If we are careful, it can meet our needs and free us from the unwelcome side effects of other energy sources. I hope this short article has helped you understand what you can realistically do with the wind blowing past your door.

Access

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 WindCad Turbine Performance Model spreadsheet

"Apples & Oranges 2002: Choosing a Home-Sized Wind Generator," Mick Sagrillo • HP90 and available on the HP Web site.

Wind Power: Renewable Energy for Home, Farm, and Business, Paul Gipe, 2004, Paperback, 498 pages, ISBN 1-931498-14-8, US\$50 from Chelsea Green Publishing Company, PO Box 428, White River Junction, VT 05001 • 800-639-4099 or 802-295-6300 • Fax: 802-295-6444 •
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This LMW has a diameter of 5 meters. With its large rotor and tall tower, it is ready to catch the slightest wind.

