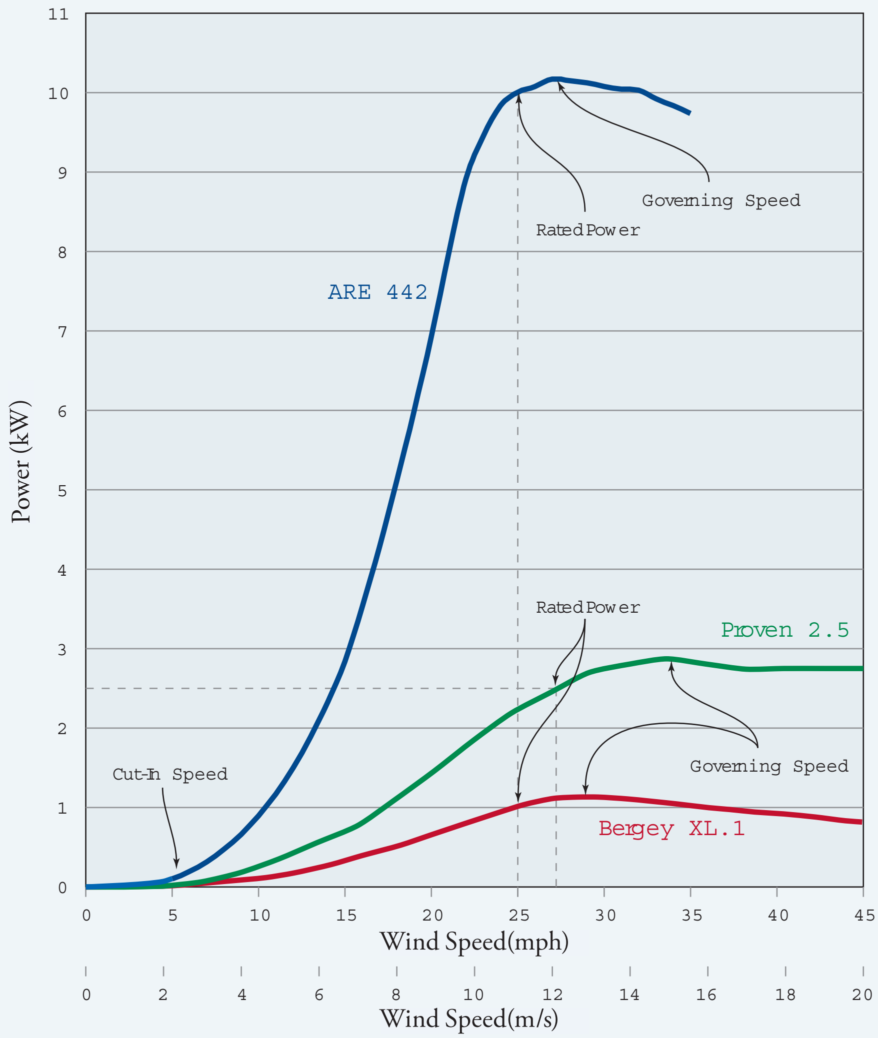
Energy Curve Verses Power Curve

By Ian Woofenden

Power Curves for Three Turbines



Power curves are frequently presented by wind turbine manufacturers in their marketing literature. They generally distract consumers from what they really need to know—how much energy a wind generator will produce at a given site.

Any wind generator produces electricity at varying levels, depending on its rotational speed (rpm). We can plot the generator output against wind speed, which gives us what is typically called a "power curve" for the wind generator (see the "Power Curves" graph). It shows wind speed in miles per hour (mph) or meters per second (m/s), and power in kilowatts (kW). Kilowatts (power) are an instantaneous measure of the rate of electricity generation, transfer, or use, and not a measure of energy (kilowatt-hours).

What's Wrong with the Curve?

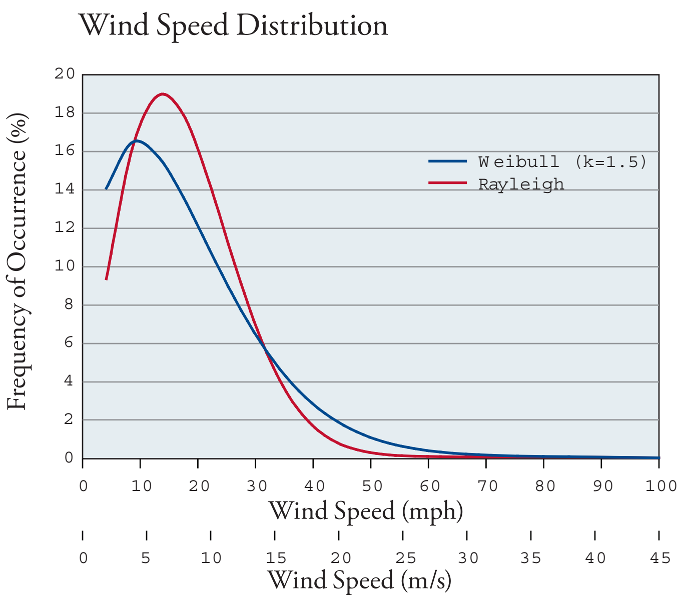
The untrained eye is naturally drawn to the top of the curve—the peak power. If we were looking at a gasoline-powered generator, this could be useful information. As long as it's supplied with gasoline and a load, it continues to produce at or near its rated output.

Peak power for a wind generator is very different—at most sites, the wind speed at which a turbine generates its peak power occurs only a very small percentage of the time. A wind "distribution" plots the frequency of each wind speed (see "Distribution" graph). For example, one site may experience 15 mph winds 8% of the time, and another site may see winds of 15 mph only 2% of the time. If you assume that a wind generator will give you peak power much of the time, you'll have wildly exaggerated energy expectations.

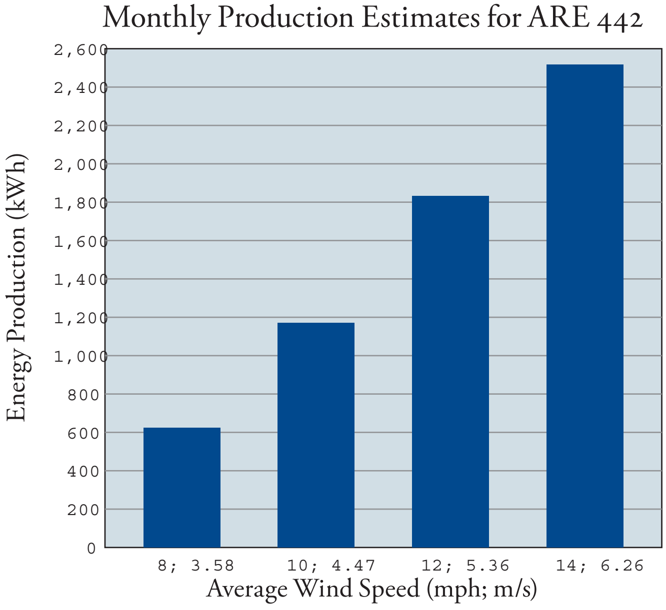
Trying to compare one wind generator to another using power curves is another common mistake. While there is some useful comparative information in the curves, it's not a simple comparison. For example, I've lived with two turbines that had about the same peak power, yet one produced 2.3 times more energy than the other in similar conditions (since it has a much larger blade diameter, and therefore more collector area).

Velocity Cubed

The most crucial fact to understand about wind energy is that the power available in the wind is related to the cube of the wind speed (V3). Humans are fairly comfortable with linear functions: Spend twice as much money and you'll get twice as much coal; double the rainfall will result in doubling the catchment water into your tank



Cubic functions are not as intuitive. Doubling the wind speed gives eight times the power, so a 20 mph wind has eight times the energy (20 x 20 x 20 = 8,000) of a 10 mph wind (10 x 10 x 10 = 1,000). If a wind generator produces 1,000 watts at 24 mph, it will produce only 125 watts or less in a 12 mph wind. Understanding the V^3 law and a wind distribution curve helps you look at power curves—and wind energy—differently.



*based on a Rayleigh distribution

Energy is the Goal

Power curves do show you at what wind speed a turbine will "govern," protecting itself in high winds, "spilling wind" to avoid overspeed and damage. Power curves are also valuable to electrical designers who create the other components needed in wind-electric systems. Knowing the cut-in point, peak voltage and current, and what is in between is necessary to specify appropriate components, and design robust controllers and inverters to match the generating characteristics of a wind turbine.

For most people, wind generator power curves only create confusion about wind generator performance. When we buy a car, most of us don't look at the displacement of the cylinders or the cold cranking amps of the battery. We turn to more important overall measures like fuel economy. So we should leave power curves to the number nerds, and stop distracting ourselves from the prize—energy output.

Veteran wind-energy expert Hugh Piggott says, "The power curve on its own doesn't tell you anything about energy, nor is there any simple way to determine that from a given power curve." We don't buy watts from the utility, and we don't put watts into our battery bank or into the grid. We buy, produce, and sell watt-hours—energy. So we should evaluate wind machines based on their energy performance, not peak power, or any other single point on the power curve.

Instead of using power curves, look on the manufacturers' Web sites or in their literature for energy curves or graphs (see the ARE 442 example). By using an estimate or measurement of the average wind speed at your site, energy curves can help you project the energy yield (kWh) from a particular turbine. Then you can determine how that projection matches up with your energy needs, and get on with the job of designing and installing your wind-electric system.

This article is excerpted by the author from, "Wind Power Curves: What's Wrong, What's Better," originally published in Home Power magazine #127. For more information and to subscribe, go to www.homepower.com or call 800-707-6585