Back to the Basics: Collector Size

By MICK SAGRILLO

Power is proportional to rotor swept area.

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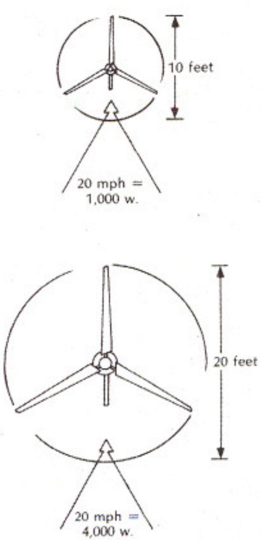
Several fundamental concepts about small wind turbines are often misunderstood. The first misconception is about the power available in the wind and what diminishes that power: ground drag and turbulence. The second misunderstanding concerns the importance of tower height in maximizing the fuel (that is, the wind) available to the wind turbine. These are wind resource and siting issues, and we've covered these concepts in the last four columns.

However, equally misunderstood is the importance of the size of a wind turbine's *rotor* — that is, the blades and hub that extract the energy in the wind and convert it to electricity for our use.

Rotors Capture Energy

I often get inquiries from people who have come across ads for an inexpensive wind device with a very small rotor that promises to generate incredibly large amounts of electricity relative to its cost. They are intrigued by claims of a breakthrough technology offering the promise of "never-before-seen efficiencies." Consumers are unfamiliar with the nuances of small wind technology, and that unfamiliarity is compounded by a misunderstanding of wind resource and siting. They're understandably confused.

The rotor of a wind turbine is made up of the blades that spin and capture energy in the wind that passes through them. Some rotors are traditional horizontal-axis devices that typically sport two or three blades. Others are vertical-axis systems of various blade configurations. Still others are hybrids of these two orientations. Regardless, it is the rotor that extracts the kinetic energy in the wind and converts it to rotational momentum used to drive an electric generating device.



Source: *Wind Power for the Homeowner*, by Donald Marier

Longer blades increase a wind turbine's swept area, which can lead to a dramatic rise in energy output.

Small Rotor = Small Output

It is well understood with other renewable technologies that the size of your collector determines the amount of renewable energy that you can collect and convert to some useful purpose. Let's use solar water-heating collectors as an example. One 4-foot by 8-foot solar water collector has an area of 32 square feet (3 square meters). It can collect only the amount of sunlight that falls on it, no more. The collector is limited in the amount of hot water it can process, based on the amount of sunlight it collects.

If we double the area exposed to the sunlight by adding a second solar collector, we double the amount of sunlight that can be collected, resulting in a doubling of the amount of hot water that can be pumped. This is pretty straightforward: The amount of solar energy that can be extracted from the sunlight is proportional to the size of the solar collector used. Simple stuff!

The same holds true for a wind turbine. A small rotor can only extract small amounts of kinetic energy out of the wind and generate small amounts of electricity. The amount of energy that can be extracted at a given wind speed is proportional to the size of the rotor, period. No magic can happen beyond the simple mathematics of the swept area of a wind turbine's rotor.

Increase Swept Area for More Energy

Swept area is defined as the circle delineated by the rotating blades of the rotor. The only way to extract more energy at a given wind speed is to increase the area that the rotor sweeps. Increasing rotor area is quite easily accomplished: Simply increase the length of the blades.

The results of increasing blade length are quite dramatic due to the fact that the area of a circle is proportional to the square of the radius of the circle. In the case of a wind turbine, the radius is the length of one blade. As shown in the diagram at left, doubling the length of the blades results in a four-fold increase in the volume of wind the rotor can capture and convert to rotational momentum used to drive the generator.

The output of a wind turbine depends primarily on the amount of fuel available (the wind resource) and on the size of the collector utilized to harvest that fuel (swept area of the rotor). Unfortunately, one confounding factor often thrown into the mix is the wind turbine's maximum generating capacity or peak electrical output. While the size of the generator is important, it is often very misunderstood from the perspective of determining how much electricity can be generated by the wind system. For any given wind speed, generator size is of no consequence (provided it's large enough to control rotor output) because it is the rotor diameter that determines the amount of energy that can be extracted. In other words, a huge generator bolted to a small rotor can only generate small amounts of electricity.

The following table, adapted from author Paul Gipe, makes a good rule of thumb for estimating the generator capacity of a typical horizontal axis wind system:

Nominal Rotor Diameter in Feet	Nominal Power Rating
4	100 watts
8	800 watts
12	2 kilowatts (kW)
24	10 kW
32	20 kW
50	40 kW
70	100 kW

Don't be deluded into thinking you can generate huge amounts of electricity with a small rotor — it simply is not going to happen. To quote Paul Gipe, "Nothing says more about the output of a wind turbine than its rotor." ST