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SMALL TURBINE COLUMN:

Back to the Basics 5: Collector Size

--Mick Sagrillo, Sagrillo Power & Light

There are several fundamental concepts about small wind turbines and how they work that are often misunderstood by people interested in utilizing the technology to generate some or all of the electricity that they otherwise would purchase from their utility. The first misconception is about the power available in the wind, and what diminishes that power: ground drag and turbulence. The second misunderstanding is 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. (See: www.awea.org/windletter/091223_AWEA_WL.pdf , www.awea.org/windletter/091125_AWEA_WL.pdf, www.awea.org/windletter/091022_AWEA_WL.pdf, and www.awea.org/windletter/090818_AWEA_WL.pdf)

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.

Rotor Basics

I often get inquiries from people who are interested in installing wind turbines and have come across an advertisement for an inexpensive device with a very small rotor that will generate incredibly large amounts of electricity relative to its cost. They are completely taken in by claims of a breakthrough technology offering the promise of "never-before-seen efficiencies." Unfamiliar with the nuances of small wind technology, compounded by a misunderstanding of wind resource and siting, consumers are 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. While some rotors are traditional horizontal axis devices typically sporting two or three blades, others are vertical axis systems of various blade configurations, and 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.

Math Basics

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 collectors as an example. One four-foot by eight-foot solar water collector has an area of 32 square feet (4 x 8 = 32). It can collect only the amount of sunlight that falls on it, no more. The collector is limited in the amount of hot water that it can “generate” based on the amount of sunlight that it “collects.”

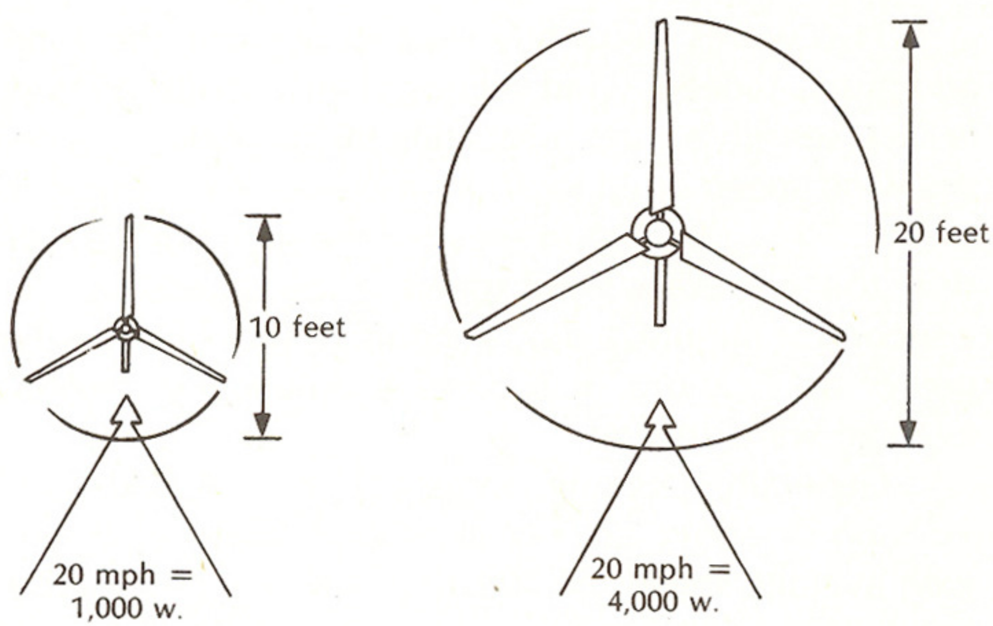
If we double the area exposed to the sunlight by adding a second solar collector, we double the amount of sunlight that can be collected, resulting in a doubling of the amount of hot water that can be “generated.” This is pretty straightforward: the amount of solar energy that can be extracted from the 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.

Swept area

Swept area is defined as the area of wind intercepted by the turbine’s 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 that make up the rotor.

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 on the circle. In the case of a wind turbine, the radius is the length of one blade. As can be seen in the diagram below, doubling the length of the blades results, not in a doubling of the swept area, but a four-fold increase in the amount of wind that the rotor can capture and convert to rotational momentum used to drive the generator.



Turbine output

From this discussion, it should be obvious that the output of a wind turbine is primarily dependent on two things: the amount of fuel available (wind resource) and 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) since it is the rotor diameter that determines the amount of energy that can be extracted from the wind. 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" table 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 kW
24	10 kW
32	20 kW
50	40 kW
70	100 kW

So don't be deluded into thinking you can generate mega-amounts of electricity with a micro-sized 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."

Size matters!

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Editor's note: The opinions expressed in this column are the author's and may not reflect those of AWEA's staff or board.