Back to the Basics: Ground Drag

Why roof-mounted and short-tower turbines won't perform well.

By **MICK SAGRILLO**

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More than ever before, the buying public is interested in generating its own electricity for either cost-saving or environmental reasons. Understandably, many people are investigating "breakthrough technologies" that promise very low upfront costs or reduced installation footprints. One common aspect of these "innovative" systems seems especially attractive to potential customers: They mount on roofs or on very short towers. This would presumably make small wind turbines more accessible to consumers living in urban areas where photovoltaic panels would normally be the most practical option for generating one's own clean energy. In addition, we humans are a ground-dwelling species and the prospect of scaling a very tall tower in order to maintain a wind turbine leaves many people understandably weak-kneed. The tower can also comprise 50 percent or more of a system's total cost. So a short tower has emotional appeal.

You can indeed install a wind turbine on your roof (if your roof is strong enough and your insurance company knows what you are doing) or on a short tower, but you had better have a good understanding of the meager wind resource at those locations before plunking down your hard-earned savings. In this column, we'll take a look at why rooftops and short towers invariably offer poor wind-resource sites.

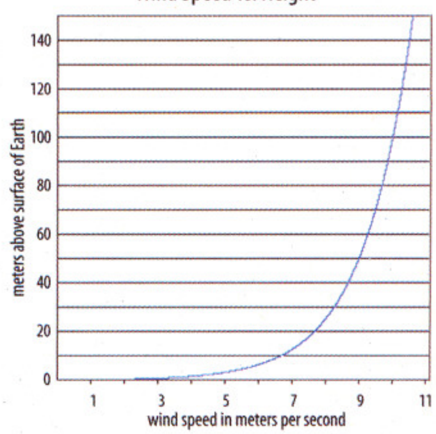
Imagine that you are sitting in a park down by a river. You pick up a few small twigs to toss into the river. You notice that a twig splashing in near the bank moves quite slowly downstream. If you toss the twig a bit farther toward the middle of the river, it moves a bit faster with the water. And if you throw the twig all the way to the center of the river, it moves quite quickly downstream.

It is a fundamental law of physics that any time two materials move across one another, movement is slowed by the friction between them. The greater the friction between the two materials, the slower the movement of the two materials relative to each other. When one of the materials is a fluid, friction is high close to the boundary but diminishes farther away. Let's look at how this law applies to the river and its bank.

The water in the river is a fluid, and the bank of the river (and the riverbed) is a solid. The rate of flow depends on the moving water's location relative to the nonmoving riverbed. Friction between the earth and the flowing water causes the water near the bank to move quite slowly. Then, as you move into deeper water away from the shallow bank, the riverbed's influence on the moving fluid decreases until you reach the deep center channel, where the effect of friction between the solid and the liquid is lowest. In the center of the river, the farthest we can get from the bank, we have smooth "laminar" flow, or we would if not for turbulence generated by rocks on the bottom. A canoeist who wants to move quickly downstream sticks to the center; coming back upstream, he'll paddle against the gentle flow near the bank.

Like water, the ever-moving atmosphere flows over a rough friction-producing surface. Winds blowing across the Earth demonstrate similar flow movement close to the ground, just like water in contact with a riverbed. The big difference for us as observers is that we can see the flow of water, whereas we sense the flow of air only by its effect on clouds, flags, leaves and other visible windblown objects. As you move away from the surface of the Earth — like moving away from a riverbed — friction is reduced and wind speed increases. With distance from the ground, laminar flow of wind increases and friction with the ground decreases. That friction is called "ground drag." It can be graphed as shown at right.

Wind Speed vs. Height



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Note that ground drag starts "breaking" in the graph at about 20 meters above the ground, or 66 feet. This is the point where wind speeds begin increasing more quickly as the effect of ground drag diminishes and the laminar flow of air over air increases.

This graph demonstrates the laws of fluid dynamics, which dictate the flow behavior of wind. The graph describes the kinetic energy in the wind that we capture with wind turbines and convert into electricity. The greater the wind speed, the greater the kinetic energy in the air mass that is available to power a wind turbine.

Air flow and ground drag operate irrespective of the technology used to capture the kinetic energy. Whether your turbine is conventional or innovative, whether it is has a horizontal axis or vertical axis or even some hybrid of the two, if it's located below the steep part of the curve, it simply doesn't have access to much energy.

This may seem pretty obvious, but some people still don't get it. These are the folks who make claims for "technology breakthrough" devices that can mount on the roof or the ground. Their customers also don't get it.

Next time, we'll take a look at turbulence created around buildings and trees, the second problem with rooftop and short-tower installations. **ST**