WINDLETTER

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SMALL TURBINE COLUMN:

Back to the Basics: Ground Drag

--Mick Sagrillo, Sagrillo Power & Light

More than ever before, the buying public is interested in generating their own electricity for either cost-saving or environmental reasons. Understandably, many are investigating "breakthrough technologies" that promise very low up-front costs or "revolutionary designs." One common aspect of these "innovative" systems seems especially attractive to potential customers: they are either mounted on roofs or on very short towers. This would presumably make small wind turbines more accessible to consumers living in densely populated or urban areas where ordinarily solar photovoltaic panels would present 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 access a wind turbine for inspections, maintenance, or repairs leaves many people understandably weak-kneed. Towers can also comprise up to 50% of a system's total cost. So now there's an option of a short tower or rooftop installation? Now we're talking! …Right?

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 first look at why roof tops and short towers invariably offer poor wind resource sites.

Field trip

Imagine that it is a beautiful summer day, and you are sitting in a park down by a river. You've just had lunch, and, feeling quite contented, you're ready for a nap. You look around the ground and pick up a few small twigs to toss into the river. As the twigs drop into the water, you notice something. When one lands near the bank of the river, it flows downstream, but takes its sweet old time about doing so, moving quite slowly downstream. If you get the twig a bit farther toward the middle of the river, you note that the twig moves a bit faster with the water. And if you muster up the effort to get the twig all the way into the center of the river, the twig moves quite quickly downstream. Dozing off into nap land, you contemplate what is happening with your twigs flowing downstream.

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

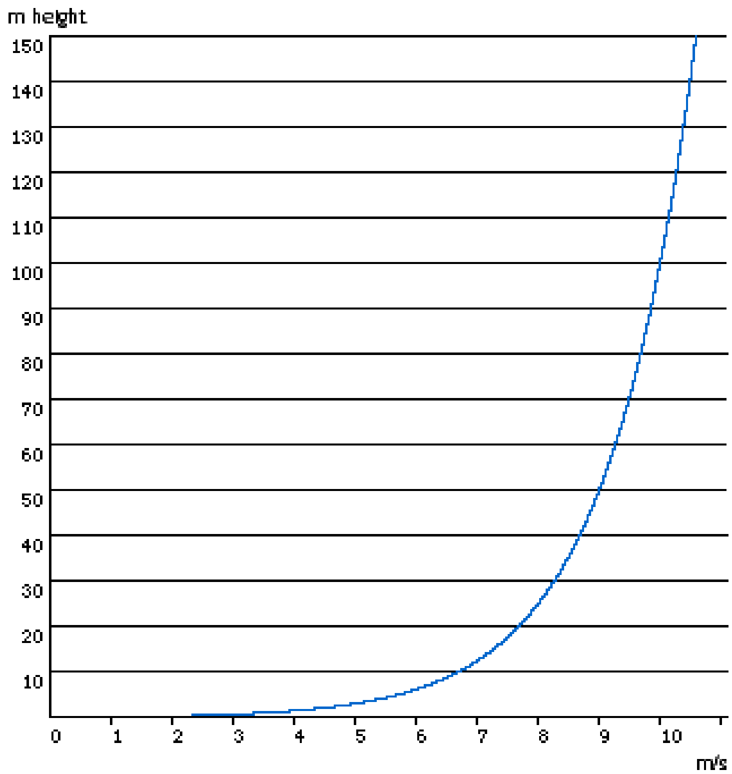
The water in the river is a fluid and the bank of the river is a solid. Depending on the location of the water in the river, you will get differential flow which is completely dependent on the moving water's location relative to the nonmoving river bank. Friction between the fixed bank and the flowing water causes the water in the river near the bank to move quite slowly.

As you move further into the river and away from the bank, the bank's influence on the moving fluid is decreased until you reach the middle of the river, where the zone of friction between the solid and the liquid is at its lowest. In the center of the river, the furthest we can get from the bank, we have laminar (that is, undisturbed straight-line movement) flow of water over water, allowing for the least friction and greatest velocity downstream. Compare this to the area near the bank of the river where there is the greatest amount of friction between the moving water and the stationary bank. This is where you'll notice the water is moving at its slowest.

Drawing conclusions

Like water, the ever-moving atmosphere on our planet is also a fluid (the definition of fluid includes both liquids and gases), flowing over the fixed surface of the Earth. Although we cannot see the air that makes up our blowing winds, we can draw some lessons by watching what happens to water in a river. Since water and air are both fluids, they both fall under the same laws of physics, known as fluid dynamics, which describes their properties and how they "work." The rules regulating the movement of winds on Earth, which we cannot see, are the same ones that describe water flowing in a river, which we can see.

Winds that are blowing across the Earth demonstrate similar flow movement in close proximity to the ground surface of our planet, the zone where we live, as does water in contact with a river bank. As you move away from the surface of the earth -- like moving away from a river bank -- friction is reduced and wind speed increases, as laminar flow of wind over wind increases and friction with the ground decreases. This phenomenon of friction, which reduces wind speed close to the surface of the earth, is known in fluid dynamics as "ground drag," and can be demonstrated visually with a graph, such as the following from the Danish Wind Energy Association:



Note that the Y axis is in meters above the surface of the Earth and the X axis is wind speed in meters per second. Also 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 very nicely demonstrates the laws of fluid dynamics that dictate the flow of air in the atmosphere, which is what we call "wind." In other words, the graph visually describes the kinetic energy in the wind that we attempt to 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. This occurs higher in the moving air mass, not in the considerable zone of friction near the Earth's surface

Air flow and ground drag exist and operate irrespective of the technology used to capture the kinetic energy, whether that technology is conventional or "innovative", or whether it is a horizontal axis or vertical axis wind turbine, or even some hybrid of the two. Regardless, wind is the "fuel" that powers the wind turbine, or the system's energy "collector," and if you have no fuel, then it doesn't matter what collector you use to try to capture it, as there is simply little or no fuel to capture in the first place. This may seem pretty obvious, but it apparently isn't, considering all of the claims made on the Internet for "technology breakthrough" devices that can be roof or ground mounted, and all of the customers who bite on such claims.

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

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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.