# WINDLETTER

THE MONTHLY NEWSLETTER OF THE AMERICAN WIND ENERGY ASSOCIATION

**Volume 28 Issue No. 12**

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## SMALL TURBINE COLUMN:

## Back to the Basics: Determining the Minimum Tower Height for your Site

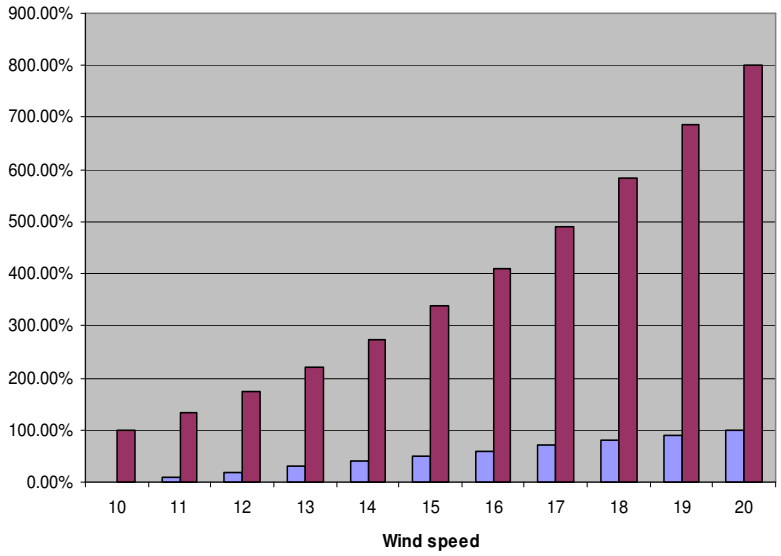
**--Mick Sagrillo, Sagrillo Power & Light**

In order to operate as they were designed to, wind generators need access to fuel of sufficient quantity and quality. Therefore, wind turbines are mounted on towers. The reason is to overcome the bane of all wind energy systems: ground drag and turbulence.

Ground drag (Small Wind Column, www.awea.org/windletter/090818_AWEA_WL.pdf ), the friction between moving air masses and the earth, reduces the wind's speed, or quantity—and therefore the kinetic energy that could have been available to convert to electricity with a wind turbine. Ground drag decreases with increasing height above the Earth's surface.

Turbulence (Small Wind Column, www.awea.org/windletter/091022_AWEA_WL.pdf ), the chaotic tumbling and random swirling of wind, compromises the wind's quality. Turbulence is caused by obstacles on the Earth, such as trees and buildings. Turbulence is mitigated with clearance above obstacles and complex terrain.

In order to minimize both ground drag and turbulence and maximize energy production, wind turbines are placed on tall towers to get them above the surface of the Earth and the surrounding ground clutter. Exposure to good clean winds results in considerably higher production due to the fact that power available to a wind turbine is a function of the cube of the wind speed, as depicted in a graph appearing in last month's column:



As Steve Wilke of Bergey Windpower likes to say, “More tower, more power.”

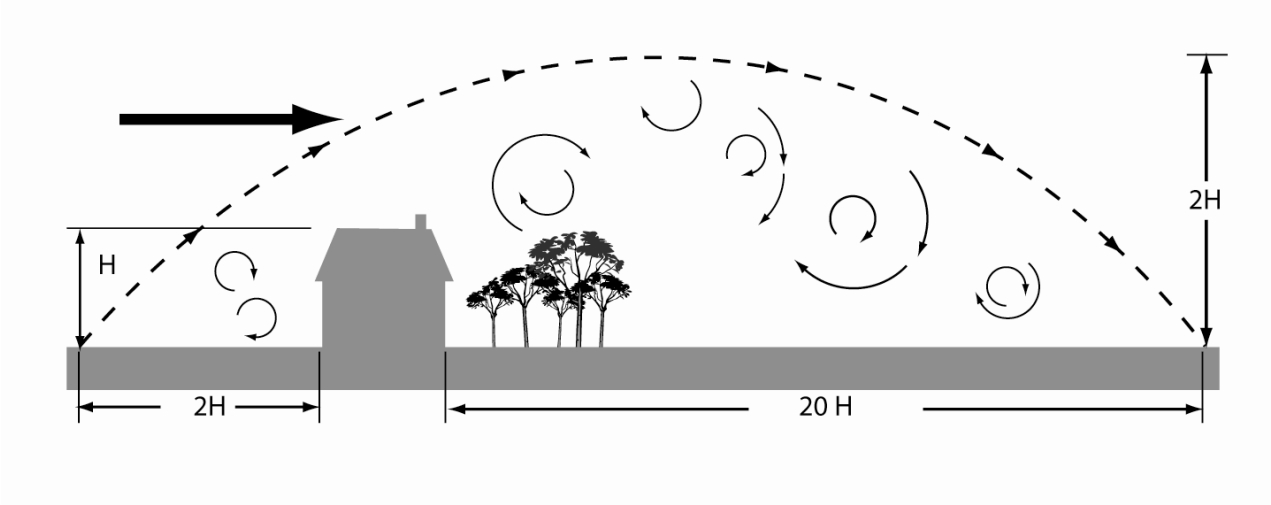
But just how far above the ground and obstacles do we need to be?

**Wind Prospecting**

When siting wind farms, wind prospectors scour the countryside seeking elevated, well exposed property with sufficient distance from trees and buildings. What they are trying to do is provide clearance, or horizontal separation, from farms, houses, fencerows, and woodlots in order to maximize wind speed and minimize turbulence—thus optimizing the exposure that will exploit $V^3$. And since they have no vested interest in any given piece of property, wind prospectors are free to scout for the best sites over the landscape, those with minimal ground drag and turbulence.

Since most of us are stuck with the piece of real estate we live on, and that property likely is cluttered with buildings and trees, we cannot achieve the horizontal separation that wind prospectors search out. Therefore, we need to focus on minimizing turbulence, as well as ground drag, by increasing vertical separation with tower height, in order to increase energy output. As such, wind turbines are mounted atop tall towers.

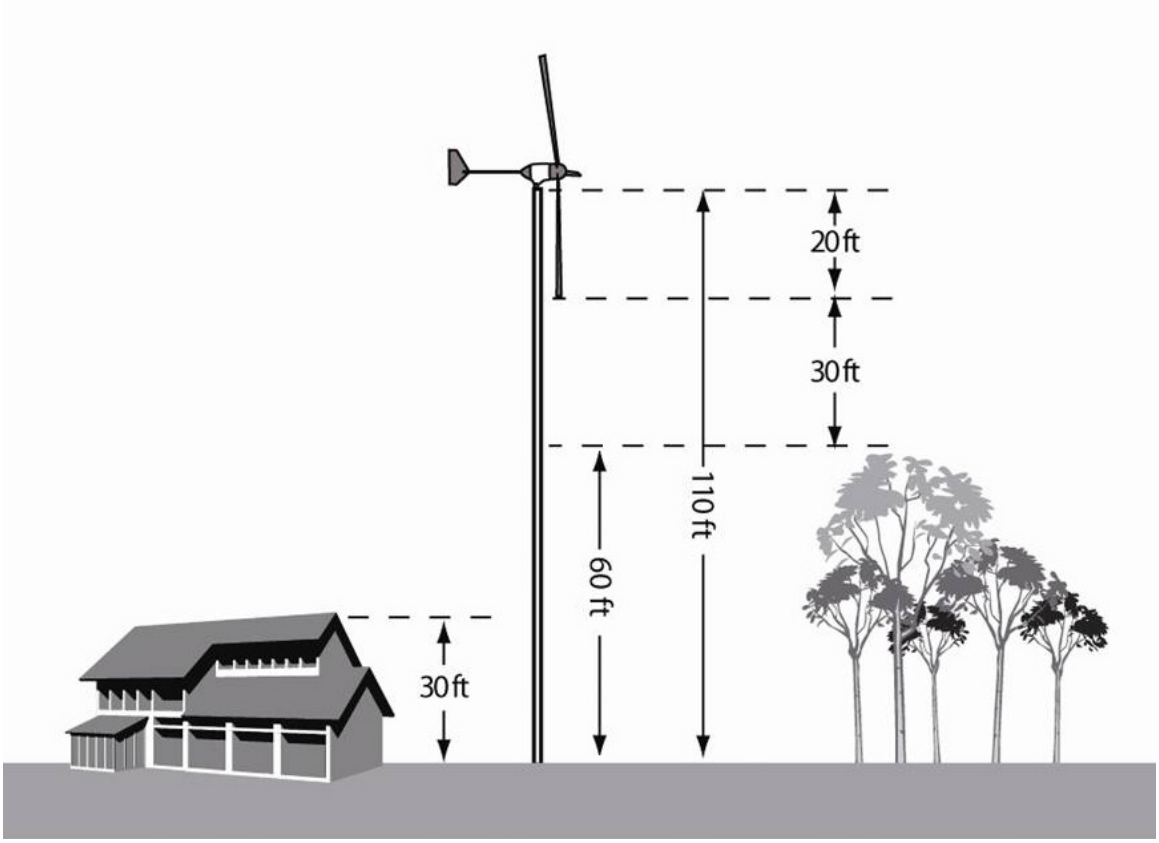
Reviewing the diagram from Dan Chiras’ *Power from the Wind* in the Small Wind Column on turbulence, below,, we can see that turbulence reaches up to twice the height of whatever obstacle the wind is passing over. If we use an example of a treeline that is 80 feet tall, does this mean that we need a 160’ tall tower? According to the diagram, yes. However, at some point, it may simply not be cost effective to install towers this tall for small wind turbines.




**The 30-foot rule and corollaries**

The standard rule of thumb that is used for sizing towers for small wind turbines (up to 100 kW in capacity) is that the entire rotor of the wind turbine must be at least 30 feet above anything within 500 feet of the tower. This is the entry level tower height that you should consider, not the optimal height. Again, this is the *minimum* tower height that you will need to overcome the

effect of obstacles and the resulting turbulence they create. The diagram below, also from Chiras' *Power from the Wind,* graphically illustrates the 30-foot rule.




There are several corollaries to the 30-foot rule that take into consideration a few invariable complications. These include the following situations:

- Since the largest obstacles that usually pose a problem for wind turbines are trees, you will need to know not just the current height, but the *mature* height for the trees around your area, or at least the height that they will grow to over the 20-30 year life of the wind system. Over time, trees will grow, but towers don't, no matter how much it rains. There are numerous examples of installations where the tower was sized based on the tree height at the time of the installation. I have a collection of pictures depicting wind installations that are obscured by surrounding trees twenty years later, rendering the wind turbine nothing more than an expensive wind vane.

- If you have a prevailing tree line in you area, or your area consists of 50% tree cover, that tree line becomes the effective ground level for your tower. Size your tower accordingly.

- In most locations, the strongest seasonal winds come from one to several prevailing wind directions. To reduce the effect of turbulence from trees and buildings, site the wind turbine upwind of those obstacles towards the prevailing wind direction. This may

compromise occasional winds from other directions, but we are trying to optimize the site's wind resource with a tower tall enough to clear turbulence from ground clutter without breaking the bank.

**Shop wisely**

The tower height you calculate for your site based on mature tree height and other obstacles may not correspond to the tower the manufacturer sells with its turbine, or what the dealer proposes to install. Oftentimes, people rationalize a short tower height based on the cost of the turbine. I have heard it said that a small wind turbine in the size range of 1-3 kW or so does not justify the expense of a tall tower, which could be four or five times the cost of the turbine. In order to trim costs, shorter towers are frequently offered, sort of a "one size fits all locations" solution for hopefully getting the wind turbine into its fuel stream. This reasoning completely ignores the physics of fluid dynamics that dictates the tall tower in the first place, and is irrespective of the technology used to extract energy from the wind.

Experienced installers well know that the site and surrounding ground clutter dictates the tower height, not necessarily what the manufacturer sells or a dealer is comfortable with installing. A wind turbine close to the tree tops suffers from lack of fuel, the wind, due to ground drag. In addition, the turbulence caused by the surface clutter at the site will cause increased maintenance on the turbine as well as shorten its life. In light of this, shorter towers than the site requires are no bargain because the turbine is not producing much electricity and its life expectancy is decreased.

If you come up against "a short tower is the only tower we sell," keep looking. Based on decades of successful installations, the 30-foot rule is well established as being the minimum acceptable tower height to mitigate turbulence.

Tower height always is "site specific."



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[Editors Note: The opinions expressed in this column are those of the author and may not reflect those of AWEA staff or board.]