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SMALL TURBINE COLUMN:

Wind Generator Tower Styles

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Towers for small wind turbines (up to 100 kW) come in two basic styles, freestanding and guyed. In most home wind system applications, either will do the job of getting the wind generator away from the earth's surface and ground clutter and up into the turbine's fuel: free flowing, non-turbulent winds. However, there are considerable differences in tower and installation costs between the two, as well as the amount of space the different styles take up.

The wind sees a tower essentially as a lever with which to do some work. The amount of work a lever can do is a defined as "force times distance." The "work" the wind is trying to accomplish is to push the tower over and extract the concrete footings from the ground. The "force" exerted by the wind is a function of the wind speed as well as the swept area of the wind turbine's rotor. The "distance" is the height of the tower. As swept area (force) or wind speed (force) increase and tower height (distance) increases, so does the overturning force exerted by the wind on the tower and its concrete footings. As a result, as swept area and tower height increase, the tower and its footings must be built stronger.

Like a stool, the stability of a tower is a function of the spread of the legs. If you bring the stool's legs close together, it becomes less stable. Spread the stool's legs out and it becomes more stable. With freestanding towers, the three (or sometimes four) legs of the tower are analogous to the legs of the stool. With guyed towers, the guy cables serve as the "stool legs."

The amount of concrete in the ground required to keep the tower upright is related to how far the "legs" are spaced (as well as the height of the tower). The closer the legs are together, the more concrete is required to keep the tower from tipping over. Consequently, freestanding towers with legs relative close together are formidable pieces of heavy steel compared to guyed towers. All guyed towers use trigonometry to their favor. The angle the guy cables make between the tower and the ground shifts the loads exerted upon the tower base to some distance away from the tower, just like the leg spread of a stool.

In addition, as a lever (distance) gets longer the resultant work the wind can do increases. While a short piece of wood can easily pry a small rock out of the ground, lengthening that piece of wood without increasing its thickness usually only results in breaking the wood, not moving the rock. As the wood lever gets longer, it must also get thicker. Because the legs of a freestanding tower are close together, they require much more steel to keep them from buckling under the loads placed on the tower by the swept area or the rotor and the wind (force) compared to a guyed tower.

The result of all of this physics is that guyed towers use relatively little steel in their structures and concrete in their footings. Freestanding towers must incorporate considerable steel and concrete in order to stand the wind's overturning forces. This results in a more expensive tower and installation.

There are two basic styles of freestanding towers, monopoles and freestanding lattice towers. Monopole or tube towers are what people think of first because they are currently used for wind farm turbines. These towers are structural tubes that taper from base to the top. Monopole towers are aesthetically very pleasing. Because there is only one leg on a monopole tower, the tower structure uses the most steel, as well as concrete for its foundation, compared to all other tower options. These are expensive towers and installations, and, as such, are not usually considered for most small wind turbine applications.

An old farm water pumping windmill tower is a good mental image of the most common freestanding lattice towers used for small wind turbines. Freestanding lattice towers are three- or four- legged towers, the legs being made of either angle iron or pipe, with cross and horizontal bracing connecting the legs. The tower legs for a 120-foot tower are only about 12 feet apart, from leg to leg. Using considerable concrete and steel, freestanding lattice towers are on the expensive end, but not nearly as expensive as monopoles. Freestanding towers, whether monopole or with legs, have a small footprint on the property where they're installed, meaning they take up very little ground space. This is their primary attraction to most people.

The second style of tower is the guyed tower. There are two styles of guyed towers: guyed lattice towers and tilt-up towers, and both are quite common for small wind systems, although with very different applications. All guyed towers are held upright with guy cables which stretch from the tower to their anchors in the ground some distance away from the base to the tower.

Guyed lattice towers are the type of tower typically used for tall radio or television broadcasting antennas. Guyed lattice towers for home-sized wind systems are three legged, with the legs being anywhere from 12 to about 18 inches apart. Unlike freestanding towers, the legs of a guyed lattice tower do not taper from base to top. Cross bracing between the legs gives the appearance of a very tall three-sided, three-dimensional ladder. Guyed lattice towers use guy cables strung out in three directions, the minimum required to keep the tower upright. The anchors for a guyed lattice tower are usually spaced about 75% of the height of the tower away from the tower's base. For a 120-foot tower, this means that the guy anchors would be about 90 feet out from the tower base.

Since there are three sets of guy cables stretching out in three directions, considerably more land is required for guyed lattice towers compared to freestanding towers. Because of the geometry of the guy cables spreading out the loads, guyed lattice towers are the lightest in weight and use the lease amount of concrete, making them the cheapest tower option for the homeowner.

The second style of guyed tower used with home-sized wind systems is the tilt-up tower. These towers are usually made of pipe or tubing, with four sets of guy cables stretching out in four directions to support the tower. Four sets of guy cables are required to safely raise and lower tilt-up towers. Guy cables can stretch anywhere from 30% to 75% of the tower height to the four guy anchors, depending on the tower manufacturer's design.

Tilt-up towers are a real advantage to turbine owners who don't want to climb to service their wind generators. Unlike freestanding or guyed lattice towers, you are not even able to climb a tilt-up tube or pipe tower. Instead, and the name implies, the entire tower is lowered to the ground for turbine installation or when repairs or maintenance are necessary, then tilted back up to put the wind generator into service. Tilt-up towers require the most land around them for the guy cables, as well as when they are tilted down. Because of the added complexity and hardware required to raise and lower these towers, tilt-up towers are more expensive that guyed lattice towers to purchase and install, but less than freestanding towers.

What's the best tower? That depends on your needs, the space you have available for the tower, and your budget. If you are dead set against climbing, then a tilt-up tower is for you. If you are on a tight budget, a guyed tower is your least expensive option. And if the area you have to squeeze the tower into is limited, a freestanding tower can be tucked away just about any where.

One bias I often hear is about aesthetics. Some folks are really attracted to freestanding towers, even though -- because of the large amount of steel they require -- they are highly visible on the landscape. Tall monopole tube towers, arguably the sleekest looking of them all, are out of the reach of most folks because of cost. Guyed towers, on the other hand, quickly disappear on the horizon. If you are shopping for a tower and aesthetics is a concern, your best bet is to visit several different towers and get an idea what they really look like.

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