Wind Generator Tower Basics

Ian Woofenden

You've decided you want to make electricity with the wind. You have your eye on a high-quality wind generator, and you've chosen the balance of systems (BOS) components. What's left is the biggest and most important job—choosing and installing the tower.

The mounting structure for a photovoltaic (PV) array puts the solar energy collectors up in the fuel—sunshine. Towers for wind generators do the same thing. Wind is the fuel for a wind generator, and to collect it, you have to get your machine above obstructions. Buildings, trees, and hills block the wind, slowing it down and causing turbulence. The standard guideline is to site a wind generator *at least* 30 feet (9 m) above anything within 500 feet (150 m). The entire rotor needs to be well above obstructions, so start your measurement from the tip of the lowest blade. Doing less is shortchanging your investment in wind energy—it's like putting solar-electric panels in the shade.

Your tower needs to support the weight of your wind turbine and handle the thrust loads put on it by the wind. It's easy to underestimate the severity of the environment that wind generators work in. If you ever see a catastrophic failure of a wind-electric system, you won't forget it. And if you make the tower too short, you won't get much energy. Purchase and install a tall, sturdy, permanent tower, so your wind energy experience will be long lasting and as productive as your wind site allows.

Tower Perspectives

It's easy to get focused on the wind generator as the primary component in a wind-electric system. After all, it's the collector—the machine that converts the energy in the wind to electricity. It moves, which is exciting and attracts attention. But it is quite often not the most expensive component in the system. The BOS components can easily cost more than the turbine, and the tower can cost two to ten times as much as the turbine, depending on the site and situation. Take a realistic view of your plans to tap wind energy by looking at the total system cost, not just the turbine cost. Costs for a typical off-grid installation are shown in the table on page 66.

A freestanding tower can be the most visually pleasing and adaptable to varied terrain, but is the most expensive.

A similar situation occurs when it comes to installation. Students attending wind system installation workshops often expect that they will spend a lot of time dealing with the wind generator. In fact, most of the installation time of a six-day wind workshop is spent with the tower. Assembling the wind generator and attaching it to the tower takes only a few hours, while assembling and installing the tower can take two to four days.

As the gin pole goes down, the tower goes up—tilt-up towers need wide open and level spaces, but make installation and maintenance easy.

Tower Types

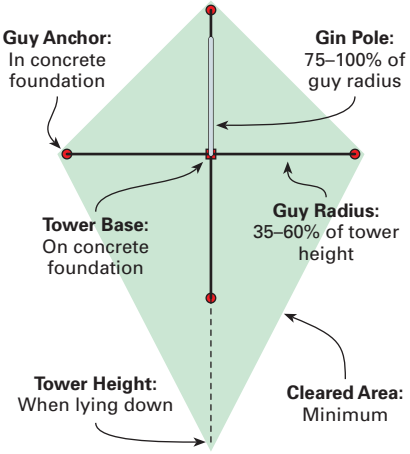
Three basic tower types are used for almost all home-scale wind generator installations. Tilt-up towers make maintenance easy, with no climbing. Fixed, guyed towers are very common, climbable towers. Freestanding towers, with no guy wires, are costly, but attractive, and also climbable.

Tilt-up towers. My advice: If you have space for a tilt-up tower, use one! You will never have to climb your tower (in fact, you won't be able to). All maintenance will be done with your feet on terra firma. If there's any trouble with the machine, you can have it down in less than an hour, and back up in the same time once you've done the repair.

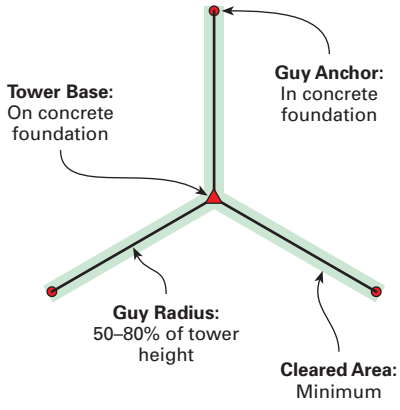
Tilt-up towers come in heights up to around 130 feet (40 m) for small-scale machines, with various sizes for different machine weights and thrusts. The most common tilt-ups are tubular steel, with sections of pipe coupled together, and guy wires attached at each joint. All the guy wires on one side of the pole (from each of the pipe joints) make up a set of guy wires. For tilt-up towers, four sets of guy wires are required, with three sets attached to one of the concrete anchors placed at four separate points in a radius around a concrete base at the center. The fourth set is attached to the gin pole, which in turn gets attached to the fourth concrete anchor when the tower is raised.

The major drawback of tilt-ups is the footprint needed. You need a clear, open area for the tower, a diamond-shaped space (see diagram) that is as long as the tower height plus the guy wire radius, and as wide as the guy radiuses extending from the sides of the tower base. For a 100-foot (30 m) tilt-up tower, the guy radius will be about 50 feet (15 m); so a diamond-shaped area 150 by 100 feet will be required. This area needs to be clear of trees and structures so the guy wires can lie down cleanly. You'll also need a clear lane to drive a lifting vehicle, if you use one. Other drawbacks: for minor repairs or service by people who are comfortable climbing, a tilt-up can be less convenient than a climbable tower. And you won't enjoy the views from the top of your tower!

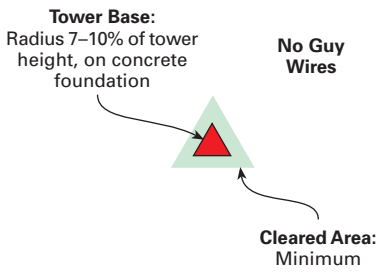
Tilt-Up Tower Footprint



Fixed, Guyed Tower Footprint



Freestanding Tower Footprint



Fixed, guyed towers share characteristics of both tilt-ups and freestanding towers.

Example Off-Grid Wind System Costs*

Item	Cost (US$)	% of Total
Tilt-up tower kit, 127 ft.	$5,100	31%
Inverter & power panel	3,439	21%
Wind turbine, 12 ft. dia. rotor; controller; & dump load	2,500	15%
8 Batteries, 6 V, 415 AH	1,500	9%
Misc. wire, conduit, etc.	1,200	7%
Tower engineering (may not be required)	1,200	7%
Concrete & rebar for footings	800	5%
Trenching & footings	700	4%
Watt-hour meter	220	1%
Total	$16,659	

* Your cost may vary widely. Labor, shipping, and tax not included.

Tilt-up towers consist of the tower pole and a "gin pole" that is attached to it at 90 degrees. When the tower is down, the gin pole sticks straight up in the air. When the tower is up, the gin pole rests horizontally near the ground. The gin pole is a big lever that allows you to easily lift the tower, which pivots at its concrete base.

You can raise and lower the tower with a truck, tractor, winch, come-along, or grip-hoist. The latter options allow you to install towers in remote locations not accessible to vehicles. The gin pole is generally 75 to 100 percent of the guy radius in length. I prefer tower systems that use the full guy radius for the gin pole length and permanently attach the rear guys directly to the end of the gin pole.

Like all towers, tilt-ups have their hazards. Things can go wrong. They can get dropped. Tow vehicles can slip. There are real dangers if the anchors are not correctly positioned and the guys get too tight while lowering or raising the tower. You should do your homework before attempting to install one, and always put the tower up without the turbine on it the first time.

Fixed, guyed towers. Another type of guyed tower, a fixed tower is lifted up once, and does not tilt down. Guy wires hold it up, and any maintenance on the tower or turbine is done by climbing the tower. These towers come in various configurations, the most common being triangular lattice sections, 10 or 20 feet (3 or 6 m) long, that bolt together. You've probably seen this type of tower used for commercial radio antennas and the like.

These towers must have a minimum of three sets of guy wires, with an underground concrete anchor for each set, and a concrete base under the tower itself. It's possible to install them one section at a time, using a different type of gin pole, a vertical temporary crane that mounts on the tower. The gin pole is moved up the tower one section at a time, and is used to lift each succeeding section. This is a slow, laborious process, and many people opt instead to lift these towers with a crane.

While fixed, guyed towers don't require the open area that a tilt-up tower needs, you still must have open lanes for the guy wires. The guy radius will be 50 to 80 percent of the tower height, and the guy wires will be visible. Costs for fixed, guyed towers are in the same general range as tilt-ups, but these towers can be installed on many sites that will not accommodate a tilt-up tower, mostly because fixed towers don't need as much cleared space, or as level ground.

Freestanding towers. If your budget isn't tight, a freestanding tower might be your first choice. No guy wires, no tilting, and it only needs a modest clear space for the tower base. The drawback, of course, is cost. Freestanding towers rely on steel and concrete to hold them up instead

Tower Comparison

Tower Type	Advantages	Disadvantages
Tilt-up	No climbing	Large footprint
	Maintenance on ground	Four sets of guy wires
	Medium cost	Need relatively level site
	Pipe locally available	Cannot climb for minor work
		Takes longer to assemble
Fixed, guyed	Modest footprint	Three sets of guy wires
	Lowest cost	Must climb
	Uneven sites OK	Crane cost
Freestanding	Small footprint	High cost
	No guy wires	Must climb
	Uneven sites OK	Cost of crane installation
	Safest installation (crane)	

of guy wires—lots of steel and concrete. This means higher cost for these materials, as well as for excavation, concrete forms, rebar, and labor.

Freestanding towers take two basic forms. Most common is the three-legged Eiffel Tower style, with tubular legs connected by angle iron braces. The other option is a monopole tower—a large, single tube, similar to what is used for utility-scale wind turbines. These are often quite expensive, and out of the financial reach of most small-scale renewable energy (RE) users. Both types are usually assembled on the ground and lifted with a crane.

A freestanding tower will cost at least a third to half more than a tilt-up or fixed, guyed tower. But the end result may be worth it. Aesthetically speaking, most people prefer not to look at guy wires. Less land clearing is necessary, and the tower is less vulnerable to damage than a guyed tower.

Homebrew towers. Many RE enthusiasts like to do things for themselves. While I have a great deal of respect for homebrewers, I urge you to be careful when it comes to towers. This is no place for lightweight construction or engineering guesswork. If you're going to try to build your own tower, do careful research. Look at engineered towers and get a sense of the designs, as well as the size and quality of hardware used.

When in doubt, overbuild. Better yet, stick with engineered towers that are professionally designed for the job. To obtain permits, you may need an engineer's stamp on your plans, anyway. Most tower manufacturers have engineers on staff who can provide you with specifications and calculations that will make your local engineer's job easier, and less expensive for you.

Choosing Your Tower

So how do you choose your tower? First of all, look at the function. Each turbine manufacturer will tell you what tower size (pipe diameter or lattice tower size) is necessary to hold your wind generator. Using the 30-foot/500-foot rule, determine how tall your tower needs to be. Consider mature tree height, and remember that trees grow, while towers don't. Then look at what tower options you have.

Look at your site. Is there space for a tilt-up tower? Do you have the available footprint for guy wires? Then ask yourself whether you or someone you hire is going to be willing to climb the tower to do the regular, twice-a-year maintenance. And ask yourself, your family, and neighbors about the aesthetics. Take the time to go and look at installed wind-electric systems to get a sense of what you're getting into. Look at your budget. Many people would love to have a freestanding tower, but the cost is prohibitive.

Whatever your tower choice, avoid the most common mistake in wind system design—don't make your tower too short! Taller towers will always give you more energy for your investment, and you will not regret going higher. Take the time to research your tower choices, and make the best investment for the long-term. If you don't

Check the Regulations

When considering potential sites for your wind generator, make sure to check local land use laws, zoning laws, and with building officials, for any regulations that will affect installing a wind turbine. Some local codes may restrict tower height or require a "fall zone" around your tower. Other issues about noise and aesthetics may come up, as well.

However, if you live in a rural location, and aren't within a mile of an airport, the height of your wind turbine's tower probably won't be an issue. And fall zones should be a concern only when you are installing or raising and lowering towers. Common sense should suffice about how close an installation should be to a residence or other structures. Fall zones are not required for utility poles, trees, or buildings. Properly engineered and installed wind generator towers are safe to install within range of people and buildings. If you're worried about a tower falling, perhaps you should buy a sturdier tower, or not install a wind generator.

Nonetheless, local restrictions may apply, whether they're practical or not. You may need to start your project by educating and lobbying local government. See *HP86*, "The Hard Part about Wind Turbines" by Douglas Stockman.

have experience installing wind generators and towers, seek qualified help. Tower installation is not something to be taken lightly, but if you do it right, you'll have a solid base for making some or all of your electricity with the wind!

Access

Ian Woofenden, PO Box 1001, Anacortes, WA 98221 • ian.woofenden@homepower.com

What the Heck? "Gin Pole," by Ian Woofenden, *HP99*

Major U.S. distributors of wind generator towers:

Abundant Renewable Energy, 22700 NE Mountain Top Rd., Newberg, OR 97132 • 503-538-8298 • Fax: 503-538-8782 • info@abundantre.com • www.abundantre.com

Lake Michigan Wind & Sun Ltd., 1015 County Rd. U, Sturgeon Bay, WI 54235 • 920-743-0456 • Fax: 920-743-0466 • info@windandsun.com • www.windandsun.com