Tower Economics 101

Mick Sagrillo

Wind generators live on tall towers. And for good reason. Their "fuel" is way up there. As we'll see, the quality of your wind resource improves radically with height.

Physics

The power available to the rotor (that is, the spinning blades) of a wind generator is defined by the equation:

$$P = \tfrac{1}{2}d \times A \times V^3$$

where P is the power at the rotor, d is the density of the air, A is the swept area of the rotor, and V is the velocity of the wind.

We can increase the power available to the rotor of a wind generator three ways — by increasing any variable in the power equation: d, A or V. Each variable in the power equation has its own effect on the power available to the rotor. Let's look at why these factors influence the power equation, and what our options are.

Density (d)

Wind generator blades spin because air molecules are moving past them. The more molecules we can move past the blades, the faster the blades will spin, and the more electricity the wind system will produce.

Density refers to the number of molecules in a given volume of air. Air is more dense in winter than in the summer. Therefore, a wind generator will produce more power in winter than in summer at the same wind speed. However, density of air is one variable that we can't do anything about.

Swept area (A)

Area of the rotor is included in the power equation because the rotor is, in essence, the collecting device for the wind generator. The rotor "captures" the power in the molecules that are moving past it. It makes sense that the larger the collecting device (that is, the rotor), the more electricity we can produce.

Increasing rotor area is not as simple as putting bigger blades on a wind generator. Many a manufacturer has learned this lesson the hard way. The swept area of the rotor is defined by the equation: $A = \pi r^2$

Because we square the radius (which is the length of one blade), doubling the diameter of the rotor has the effect of quadrupling the swept area. For example, let's increase the rotor diameter of a wind generator from 10 feet to 20 feet. The 10 foot rotor has a radius, or blade length of 5 feet. Squared, this becomes 25 square feet. Multiplied by π, and we get a swept area of 78.5 sq. ft. If we double the rotor diameter to 20 feet, the radius becomes 10 feet. Squared, this is 100 sq. ft. Multiplied by π, we get 314 sq. ft.!

At first glance, this appears to be a very easy way to increase the amount of energy that a wind generator can capture. And it is. But by increasing the swept area to the tune of 400%, we have also increased all of the stresses on the wind system by that same 400% at any given wind speed. In order to compensate for this change and have our wind system survive, we must make all of the mechanical components 400% stronger. While this can be done, obviously this approach is going to get very expensive very quickly.

Velocity Velocity Velocity

Increasing wind velocity increases the number of air molecules passing the rotor, so increasing wind speed will also have an effect on the power output of the wind system. But because velocity is cubed in the power equation, wind speed is the one variable that has the greatest impact on the power equation.

As an example, let's take a look at what happens when we double the wind speed for a given wind generator. At 5 mph, the V^3 part of the power equation is 125 units of something (5 x 5 x 5) that is multiplied by density and swept area. Doubling the wind speed to 10 mph gives us 1000 units to multiply by density and swept area (10 x 10 x 10). This is an 800% increase in power output from the same wind generator!

From all of this we can conclude that we can get the biggest bang for our buck with our wind generator, not by fiddling with air density or increasing swept area, but by somehow increasing the speed of the air that the rotor sees. (For a more in-depth discussion of this topic, read "Wind Generator Tower Height" in *HP* #21.)

Fluid Dynamics

Like water, air is a fluid. We can learn some lessons about how the air moves by sitting on a stream bank and watching the water go by.

If we throw a twig into a stream near its center, we will see that twig move rather rapidly downstream, depending on how fast the current is flowing. If we throw another twig in the water near the stream's bank, we'll observe the twig move rather lazily downstream. Why is this?

Near its edge, the stream is slowed down because of friction between the bank and the water. As we move towards the center of the stream, the effect of the bank's friction diminishes. The laminar flow of the water moving over water allows the stream to pick up speed.

The same thing occurs with air masses as they pass over the surface of the earth. The face of the earth itself, as well as its vegetation, significantly reduce the speed at which the air can flow over the earth's surface. This is called ground drag. As you move away from the earth's surface, ground drag decreases and the laminar flow of air increases. Expressed another way, increased height means greater wind speeds.

Turbulence

Let's go back to the stream. Our twig is still cruising along down the center of the stream. Up ahead, however, is a stump sticking straight up out of the water. Watch what happens.

As the twig approaches the stump in the stream, it slows down considerably as water piles up in front of this obstacle. The twig almost comes to a stop, but then passes slowly around the stump. Now behind the stump, the twig slowly spins around and around, until it gradually moves back into the swift flowing stream.

What we have witnessed is fluid turbulence. The same thing will happen with our wind generator if it is sited too close to trees or buildings. Turbulent air robs our wind generator of the energy available in laminar flowing air. The quality of our "fuel" has depreciated!

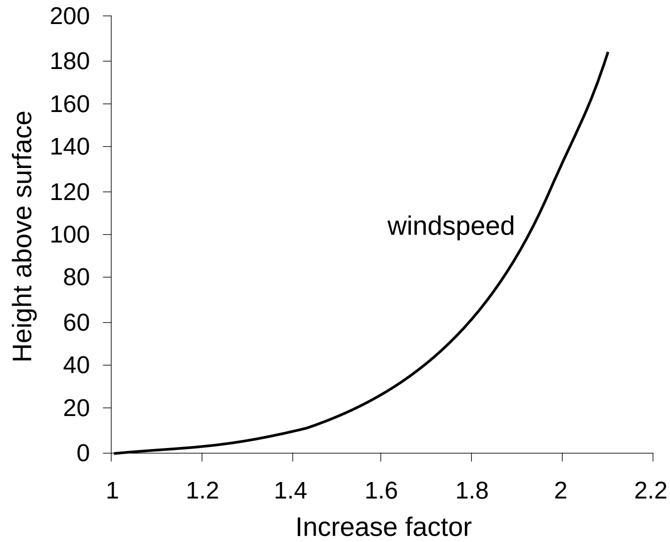
The obvious difference between the twig and a wind generator is that the stationary wind generator cannot escape the effect of turbulence on it as the moving twig did. Which brings us to a *major* rule of thumb: Wind generators *must* be sited *at least* 30 feet above anything within 500 feet.

Picture this

Graph 1 (above right) depicts the increase in wind speed as a function of height above the earth's surface (actually above a relatively frictionless surface, such as a body of water.)

Wind speed increases significantly at first, but then the rate of increase begins to diminish with height. An example will clarify what this graph is telling us.

Let's assume that we measure the wind speed with a hand-held meter at shoulder height, 5 feet above the ground. Our measurement is 10 mph. How fast is the wind blowing at 100 feet above the ground?

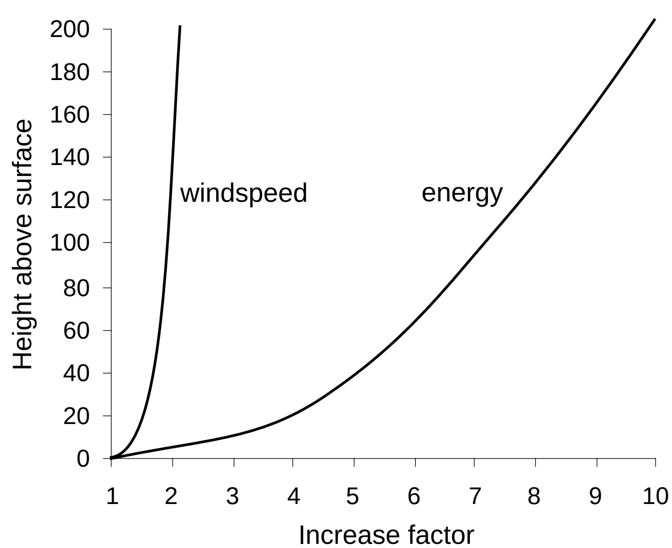


Graph 1

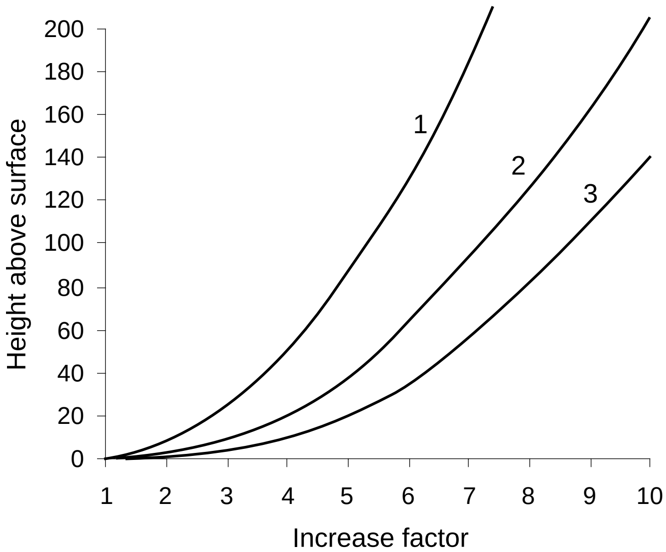
Reading Graph 1, at 5 feet the increase factor is about 1.25. If we divide 10 mph by 1.25, we get a wind speed of 8 mph at ground level. At 100 feet, the increase factor is about 1.93. If we multiply 8 mph by 1.93, we find that the wind is blowing at 15.8 mph at 100 feet. That's a significant increase!

How significant, you ask. Remember that the power available to a wind generator rotor is a function of the cube of the wind velocity. Graph 2 below illustrates the increase in power available to the rotor as a function of height above relatively open ground. (The "windspeed" curve is the same one depicted in Graph 1 only compressed.)

Remember that this graph only depicts increase in power over relatively open ground, such as that



Graph 2



Graph 3

covered by crops like corn or wheat. When we look at power increases over other types of surfaces, we get different results (see Graph 3 above).

In Graph 3, curve 1 represents power increases over open water. Curve 2 represents power increases over low vegetation growth, like corn or wheat. And curve 3 represents power increases over taller vegetation, such as trees. All three curves reveal significant gains over ground level with increasing heights.

Note that the rate of increase of wind speed (and therefore, power) as a function of height decreases with surface vegetation. This makes sense when you think about it. Tall towers are much more important if your installation is surrounded by trees. The tree line is, in effect, your “ground line”.

The Plot Thickens

Let’s go back to our example used with Graph 1. We determined that at 100 feet, the wind speed would be 15.5 mph. If we cube 15.5 (as though we were going to plug the numbers into the power equation), we get the number 3724. Half of this is 1862, the cube root of which is 12.3 mph. In other words, there is only half as much power in a 12.3 mph wind as there is in a 15.5 mph wind.

If we divide 12.3 by 8 mph, the wind at “ground 0”, we get an increase factor of 1.54. Going back to Graph 1, this corresponds to a tower height of about 25 feet. We can generate the same amount of power by installing one wind generator at 100 feet or two identical wind generators on their own 25 foot towers.

For Example

Let’s assume, for simplicity’s sake, that we need a very small system, say a 500 watt Windseeker. We determine our power requirements, and come up with two options: installing one wind generator on a 100 foot tower, or two identical systems using 25 foot towers. Both systems will be installed on two inch guyed water pipe as per the owner’s manual. Both systems also include the price of the anchors, guy cables, miscellaneous fittings, and tower wiring. Batteries and inverter have not been included, as they are the same for either system. Here’s what it would cost:

Cost Breakdown

Equipment	*100' tower*	*25' tower*
wind generator	$900.00	$900.00
2" pipe for tower ($2.50/ft)	$250.00	$62.50
guy cable ($0.10/ft)	$68.00	$11.00
anchors ($10 ea)	$40.00	$40.00
miscellaneous fittings	$40.00	$10.00
wiring	$40.00	$10.00
Total per system	$1,338.00	$1,033.50
Grand total	$1,338.00	$2,067.00
Cost per watt	$2.68	$4.13

Remember we need two complete systems on 25 foot towers to produce as much power as one system on a 100 foot tower.

Lessons Learned

What does this all mean? We can draw some general conclusions based on the data presented.

- Turbulence and ground drag reduce wind velocity.
- Turbulence and ground drag are minimized with height.
- The rate at which wind speed increases with height is a function of surface vegetation, ground roughness, and buildings around the wind installation.
- The top of these obstacles is the effective ground line for the wind system.
- The higher we go above the effective ground line at our site, the more power our wind installation will produce.

In the next article, we’ll examine the cost effectiveness of incremental tower heights.

Access

Mick Sagrillo plots power curves at Lake Michigan Wind & Sun, E3971 Bluebird Rd., Forestville, WI 54213 • 414-837-2267

Graphs adapted from “Planning a Wind Powered Generating System,” by Enertech Corp., 1977.

Tower Economics 102

Mick Sagrillo

Turbulence and ground drag are the enemies of any wind generator, robbing it of its precious fuel, the wind. As we move away from the surface of the earth, the effect of turbulence and ground drag are reduced. The higher up we go, the stronger the wind speed. The lesson is that tall towers are a must for wind generators. But how high is high enough? What is cost effective?

Recap

In the last issue of *Home Power* (*HP*#37), we examined why turbulence and ground drag are detrimental to the production of wind generated electricity. We looked at the relationship of height above ground and wind speed, and how the power available to a wind generator increases with wind speed. Finally, we analyzed the economics of a simple wind installation at two different tower heights.

The conclusion we reached is that a taller tower is always cost effective. Now, being essentially terrestrial animals, most folks don't like to hear this. After all, if we were meant to service wind generators on 100 foot towers, we would have been given 95 foot legs!

Try to put your fear of heights aside for a little while as we examine the economics of increasing tower height cost versus additional power output.

Shear Factor

How much wind speed increases with height is fairly well documented. The major variable of wind speed versus height is the terrain over which the wind is blowing. Land forms, vegetation, and buildings all impact the speed of the wind in their own way.

The increase in wind speed with height over various ground obstacles is known as "wind shear". Wind shear is less pronounced over relatively flat open ground and considerably greater over hilly terrain with many buildings and trees. Wind shear can be represented as a percentage of increased wind speed as height increases over the ground or over vegetation and buildings. The above chart depicts wind shear for us.

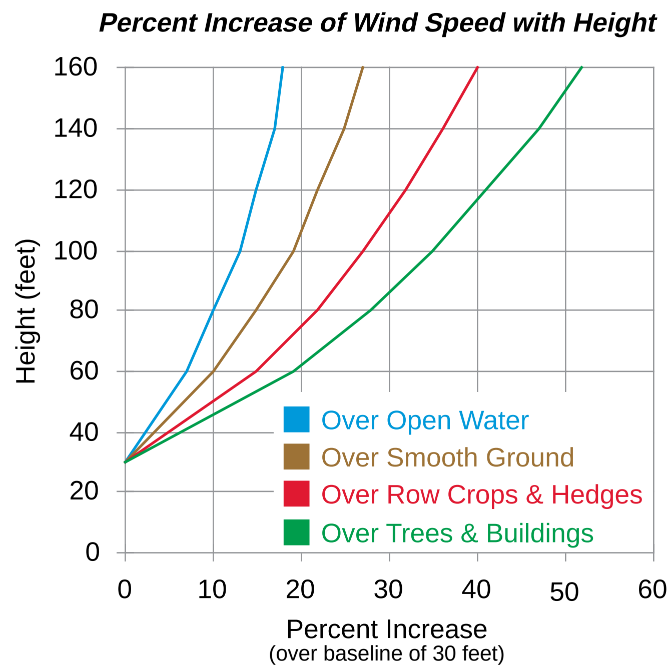


Chart 1

Thirty feet is the baseline used to determine wind shear at higher levels. It is a typical adjusted height for measuring wind speed at weather bureaus and airports.

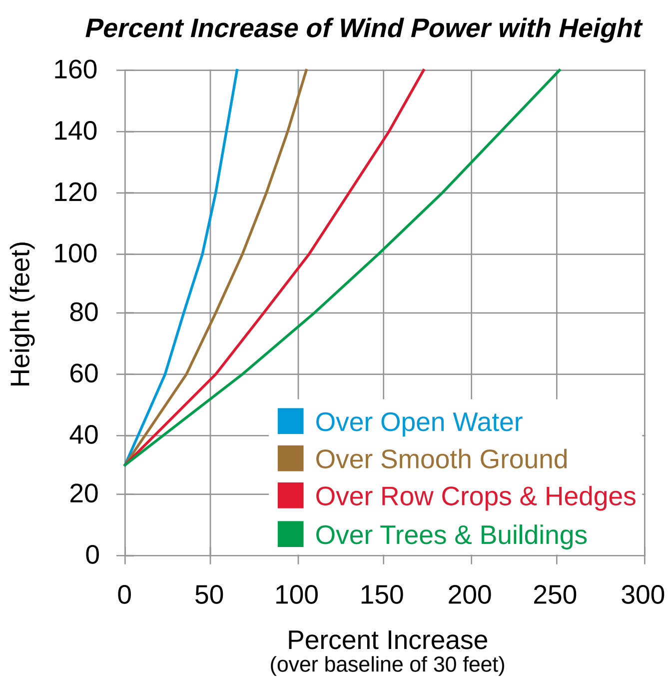


Chart 2

Tower Height (ft)	BWC 1500 w/controller	Rohn 25G Tower	Tower Wiring	Concrete	Backhoe	**Total**
40	$4,290	$1,275	$40	$75	$120	$5,800
60	$4,290	$1,725	$60	$75	$120	$6,270
80	$4,290	$2,195	$80	$100	$120	$6,785
100	$4,290	$2,625	$100	$100	$120	$7,235

Table 1

Remember (back to *HP*#37) the wind power equation states that: P = ½d x A x V³. The power in the wind is a function of (among other things) the cube of the wind speed. Therefore, the easiest way to increase the power available to a wind generator is to increase the wind speed. We can increase wind speed by either installing a taller tower (as depicted in Chart 1) or by moving to a windier location.

Note that as a percentage, wind speed increases much faster over terrain cluttered with trees and buildings than over flat open ground. The lesson here is that, with the exception of the middle of a lake or desert, wind speed increases significantly with height.

From Chart 1, we can now determine how power to a wind generator increases with height by cubing the values represented (but not the actual numbers) in Chart 1. Our percentages would look somewhat different (see Chart 2, previous page).

This chart dramatically illustrates the beneficial relationship of greater height above ground obstructions. The numbers represent the percent increase in power (and therefore watts) produced by the same wind generator at the same point in time that the wind is blowing over a given piece of ground, but at different heights. While the wind is blowing, the wind speed and therefore wind power, is obviously not the same at increasing heights.

For example, compare the power available at 30 feet, our baseline, to that at 100 feet above row crops and hedges. There is 106% more power available at 100 feet as compared to 30 feet. Said another way, two wind generators on two 30 foot towers will produce as much power as one wind generator on a 100 foot tower. And the system with the 100 foot tower will be cheaper to install than the "twin" systems at 30 feet (see *HP*#37).

It's time to apply what we've learned so far to some real life installations to determine the cost effectiveness of increasing tower heights.

DIY System

Our first system will be a small (by wind standards) do-it-yourself installation. We are going to install a 1500 watt Bergey wind generator on a Rohn 25G guyed tower. The cost of the 24 VDC wind generator is $3395, and Bergey's automatic controller is an additional $895. Since we already have the batteries, inverter, various disconnects, and all the house wiring, we will not include these costs.

We also need to make a few other assumptions. Since I don't know where you live, shipping costs for the wind generator and tower have not been included. We'll need a backhoe for half a day to dig the holes for the tower base and guy anchors at a cost of $120. Since the anchor specs for all of the towers options we are considering are nearly the same, we'll use the same backhoe cost for all towers. We'll also need some Redi-mix concrete at about $50 per yard.

Finally, we will be doing the installation ourselves with the help of a few friends on a labor trade, so there are no costs for the installation. Here are the four tower height options we will consider with their cost breakdowns (see Table 1 above).

The system is to be installed on a homestead that was once a working farm. The usual farm buildings, barn, short silo, and a few fruit trees fill the yard along with the house. In other words, we have lots of ground obstructions. Because this is a low voltage system (i.e., 24 VDC), the wind generator needs to be near the battery bank, which is in the shop in the center of the yard. The rule of thumb for siting (see *HP*#37) is that the wind generator must be at least 30 feet above any obstacle within 500 feet. The 40 foot tower is too short for this site, so it cannot be considered.

We need a way of comparing the different costs of taller towers with the additional power output at higher levels. Table 2 (below) does this for us.

An explanation is in order. Our base tower height, against which we will compare taller options, is 60 feet. "System Cost" comes from the column labeled "Total" in

Tower Height (ft)	System Cost	Incremental Cost	Percent Increase	Percent Over Base	Wind Power	Incremental Power	Percent Over Base
60	$6,270	—	—	—	68%	—	—
80	$6,785	$515	8.2%	8.2%	109%	41%	41%
100	$7,235	$450	6.6%	14.8%	147%	38%	79%

Table 2

Tower Height (ft)	System Cost	Incremental Cost	Percent Increase	Percent Over Base	Wind Power	Incremental Power	Percent Over Base
60	$25,530	—	—	—	52%	—	—
80	$26,790	$1,260	4.9%	4.9%	80%	32%	54%
100	$28,220	$1,430	5.3%	10.5%	106%	26%	104%
120	$29,880	$1,660	5.9%	17.0%	130%	24%	150%

Table 4

Table 1. “Incremental Cost” refers to the difference in price between the tower height considered and the next lower height option. “Percent Increase” refers to this cost increase as a percentage. “Wind Power” refers to the power increase given in “Over Trees & Buildings” for various tower heights in Chart 2. “Incremental Power” is the increase in power as a percent over the next lower tower height.

In the scenario we have developed, going from a 60 foot to an 80 foot tower will cost us an additional 8.2% giving us 41% more power. Going from an 80 foot to a 100 foot tower will cost an additional 6.6% and yield 38% more power. And going from a 60 foot tower to a 100 foot tower costs 14.8% more but gives us a 79% power increase!

UTI System

Our next example will feature a much larger system with a different form of storage. We are going to install a 10 kiloWatt Bergey EXCEL utility-tie-in (UTI) wind generator with its own grid intertie inverter. Excess electricity will be stored on the grid in the form of a credit to our monthly electric bill. The wind generator will sit atop a Rohn SSV freestanding tower. This is a real “cadillac” installation that will be the envy of the neighborhood.

The cost of the Bergey EXCEL with the UTI inverter is $17,495. This installation is going to help power a working farm. Since it is a high voltage system, it can be placed a considerable distance away from the farmyard, thereby eliminating most of the problems of turbulence associated with buildings and trees. The best place for it is determined to be a low fence row between two corn fields.

Since this is a major project, we are going to contract out all of the labor for the installation. This includes digging the holes for footings with a backhoe, pouring the concrete for the footings, assembling the tower, running the wire down the tower and over to our house, erecting the tower and wind generator with a crane, and installing the inverter and disconnect switches in our house. The cost for the wire and concrete have been broken down because they change depending on the installation. Again, shipping has not been included in the calculations.

This is a complete “turn-key” installation, meaning we pay the bill but don’t have to lift a finger! We’re going to consider four different tower heights for this installation (see Table 3 below).

As with the previous system, we’ll now compare the incremental cost differences with the different tower options listed above against the incremental power increases for those tower heights in Chart 2. Since this system is to be placed in a fence row surrounded by row crops, we’ll use “Over Row Crops and Hedges” from Chart 2. Table 4 (above) summarizes the results.

The explanation of what the columns are telling us is the same as for Table 2.

Conclusions

So, how high is high enough? And what is cost effective? The numbers don’t lie! Although people don’t like to hear the message, the truth is that the cheapest way to increase the power output of a wind generator is to increase tower height.

For example, a 10 kW Bergey wind system on a 100 foot tower will produce slightly more than twice the power of the same wind generator at 60 feet, for a little better than 10% increase in total price. In other words, two 10 kW Bergeys on 60 foot towers will produce about the same amount of power as only one of the same wind generators on a 100 foot tower, but at nearly twice the cost.

The investment in the system with a 100 foot tower will pay for itself in half the time of the system with the 60 foot tower. In simple economic terms, increasing tower height cuts the payback time in half in this example.

You now have the tools to determine the economics of various tower height options when planning for a wind system. All you need to do is compare the incremental cost of the taller tower you

Tower Height (ft)	EXCEL w/inverter	SSV Tower	Wire Kit	Concrete	Installation	**Total**
60	$17,495	$4,435	$800	$300	$2,500	$25,530
80	$17,495	$4,980	$890	$425	$3,000	$26,790
100	$17,495	$5,750	$975	$500	$3,500	$28,220
120	$17,495	$6,735	$1,050	$600	$4,000	$29,880

Table 3

are considering to the increased power output at the additional height as we just did in Table 2 and Table 4. If you wish, you can even extrapolate the numbers for the two scenarios we developed to even taller heights.

Access

Although he doesn't like it either, Mick Sagrillo dangles from very tall towers at Lake MIchigan Wind & Sun, E 3971 Bluebird Rd, Forestville, WI 54713 • 414-837-2267.

Tower Economics 103

Mick Sagrillo

The amount of power produced by any renewable energy technology is, to a great extent, a function of the quality of the fuel resource being used: wind, sun, or water. The higher the "quality" of your fuel, the more power your site specific electron generator will crank out.

Recap Recap

In Tower Economics 101 (*HP*#37), we defined turbulence and ground drag and why each is detrimental to the production of wind-generated electricity. We then examined the relationship of height above ground and wind speed, and how the power available to a wind generator increases with wind speed.

In Tower Economics 102 (*HP*#38), we compared the incremental cost of taller towers versus the incremental increases in power generated by the wind system on those taller towers. Depending on the system size, incremental tower costs varied between just under 5% to just over 8% of the cost of the entire system. Yet those same tower increases yielded a whopping 24% to 38% in additional incremental power output!

The Dilemma

I don't know of any other investment that offers those kinds of dividends. Yet, folks continuously resist installing tall towers for their wind generators. And for good reason. I'm not all that fond of heights either. However, the numbers don't lie.

In this article (part three of a two part series, and the last one I promise), we'll take a look at a few poorly sited installations with inadequate tower heights and the consequences. To cover various generator sizes that might be installed by a home power producer, we'll analyze three different sized wind systems installed in three different locations by three different individuals. As different as these three examples are, however, the mistakes by the installers are unfortunately the same.

Photo 1

We'll start out small, and use myself as the first example of what not to do.

Mick's Marlec

The first system incorporates a micro-wind generator, a Furlmatic, manufactured by Marlec Engineering in England. It is rated at 140 Watts in a 36 mph wind. The Marlec mounts on a 2 inch water pipe, which is typically sold in 21 foot lengths. This machine was installed next to our shop for testing purposes. For a load, we can connect the Furlmatic to an automotive headlight, a car battery, or three electrolyzers to produce hydrogen.

Figuring that most people with a machine this size would probably install it on a very short tower, we bought two 21 foot lengths of galvanized water pipe for the Furlmatic to perch on. With this, we fabricated a 42 foot tilt-up tower that is guyed at two heights on the pipe. Anchors were installed, guy cables attached, wire was run down the tower and into the shop, the Marlec bolted on, and up she went.

In a light breeze, the Furlmatic aimed straight to the wind and produced a few watts. In a day or so, the winds picked up to a steady 35 mph, just about at the

Marlec's rated wind speed. However, connected to a car headlight, the Furlmatic would only put out 19 Volts at about 4 Amps, or 76 Watts. That's only half this micro-genny's rated power! What gives?

A trip outside revealed an odd thing happening whenever the wind picked up. Photo 1 (left) shows the Marlec spinning away on its 42 foot tower. On the right is a much larger Survivor wind generator on an 80 foot tower. The Survivor is pointing right at the north/northwesterly gusts, but the Marlec is aimed....backwards. It's pointing to the south! Again, what gives?

Let's analyze the installation for problems. A look around showed that the wiring is oversized and all of the connections secure. No losses due to resistance. The load happened to be a headlight, so there wasn't a problem of a battery not being able to draw any more current. If we look at the site, we find that the 42 foot tower stands 20 feet over the 22 foot peak of the shop, and .... Bingo!

Take a gander at Figure 1 below. This diagram depicts the zone of wind turbulence caused by ground level obstructions, such as trees and buildings. Now look at Figure 2 (right), the layout of the shop and buildings around the Marlec's tower, along with their heights. Our problem is turbulence. The tower is too short for this site, even with this tiny machine.

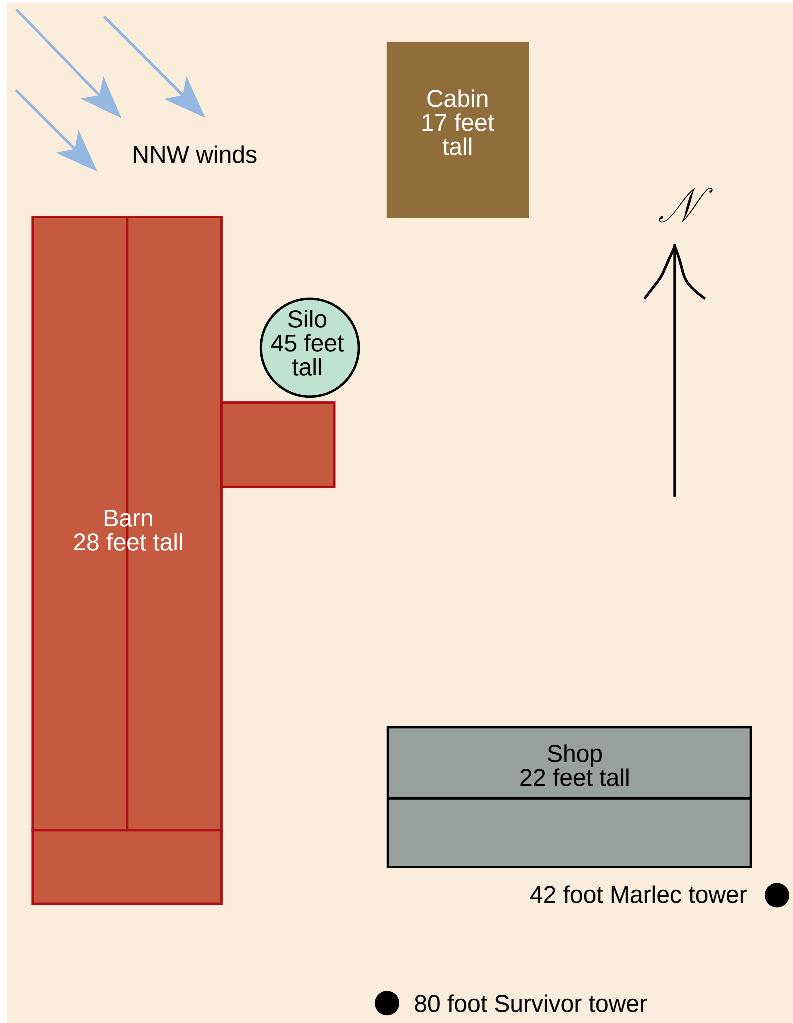


Figure 2

But Mick, you say, how do you know that? Elementary...all the evidence is presented. Go back and look at Photo 1, the one showing the Marlec and Survivor are aimed in different directions. Combined with terrible power production and the information presented in Figure 2, our culprit reveals himself. It's true that we can't see the wind. But between Photo 1 and Figure 1, the only conclusion that we can come up with is that the Marlec's problem obviously is caused by that archenemy of wind generators everywhere: turbulence.

The solution? Add at least another 21 foot section of pipe to the Marlec's tower. While the Marlec was installed for demonstration purposes only, a 63 foot tower would demonstrate its abilities far better than the existing 42 foot tower. A 21 foot tower extension is in the works.

An Un-EXCEL-ent Bergey

John and Kay bought a beautiful passive solar, superinsulated, earth-bermed house complete with a solar hot water system and a wind generator. The wind

Figure 1

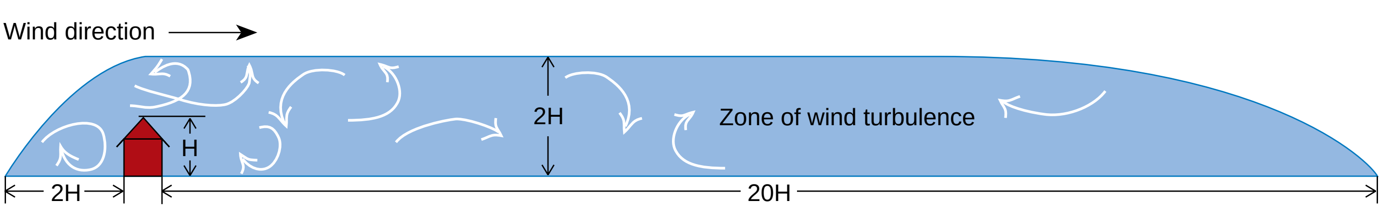


Photo 2

Photo 3

system (Photo 2, top left) is composed of a 10 kW Bergey EXCEL mounted on a 92 foot guyed tower with a synchronous inverter to sell excess electricity back to the utility company.

An engineer with a penchant for numbers, John began taking monthly kiloWatt-hour (kWh) production readings for the EXCEL. After four years of numbers, John is somewhat disappointed with the wind generator's output. The EXCEL only averages 530 kWh of electricity per month. Yet John and Kay live in an area with a decent average wind speed of about 10 mph. Bergey's literature indicates that John should expect at least 1000 kWh per month at that annual average wind speed. What gives?

A check around with other EXCEL owners finds Sid, who is not too far away, touts a monthly average of 1133 kWh per month. Sid's EXCEL is on a 99 foot tower, a mere seven feet taller than John and Kay's tower. Sid's annual average wind speed is also 10 mph. Again, what gives?

The view of John and Kay's EXCEL in Photo 2 was shot from the west-southwest. Notice the lovely backdrop of trees behind the wind generator. The trees are mature oaks, standing only about 45 feet tall. But, they are on a ridge that runs from the north to south along John and Kay's property, the same ridge that their home is bermed into. If we drive 45 feet up to the top of the ridge and look back to the west, we would have the view portrayed in Photo 3 (previous page, bottom).

What happened to the wind generator, you ask. It's still there, in amongst the tree tops. You can really see the problem from Photo 3 — 45 foot trees combined with a 45 foot ridge equals virtual ground level, as far as the wind is concerned. The laminar flow of the wind is interfered with the nemesis of wind generators everywhere: turbulence.

The former owner installed the EXCEL on the flat in front of the house so that he could admire the wind generator, rather than on the ridge behind the house where his view would have been obscured. The trees and ridge form an effective wall over which the wind must climb, leaving the EXCEL in its wake.

The solution? Relocate the wind generator tower to the top of the ridge, albeit in the trees. John and Kay bought a pre-existing condition. A well thought out site analysis by the previous owner or the dealer who originally installed the EXCEL would have foreseen and caught the problem before any concrete was poured.

Things that don't work

Edwin had a set amount of money to invest in his life-long dream: a wind system. His local wind/used car dealer sited the tower in a field surrounded by fencerows of six foot Christmas trees. Both a 2 kW and 4 kW wind generators were considered, as well as towers from 40 feet to 90 feet tall.

Since he only had so much money to spend, the dealer advised Edwin to cut back in tower height but install the larger capacity wind generator to compensate for the reduced height. A 4 kW wind generator was installed on a 42 foot tower rather than a 2 kW wind generator on a 90 foot tower. After all, everyone knows that Christmas trees rarely grow over 12 feet tall, so the tower would always be above the minimum 30 feet above anything within 500 foot rule. Right!

Well, for various reasons Edwin quit cutting and selling Christmas trees out of the fence rows. That was fifteen years ago. Because it rains where Edwin lives, today those six foot Christmas trees are approaching 45 to 48 feet. The tower, however, is still only 42 feet tall! Trees grow, towers don't. (Note: this installation is too embarrassing to include a picture.)

Possible solutions? Cut down all of the Christmas trees. Or install a taller tower. Neither option is very palatable when you realize that the problem could have been avoided with some forethought. (I hope Edwin never buys a used car from this guy.)

Actually, if we go back to "Tower Economics 102" in HP#38 and examine Table 2 on page 28, we find that going from a 40 foot to an 80 foot tower yields a 109% increase in power. Extrapolation to 90 feet gives us about a 130% power increase. This is backed up in Chart 2 on page 27. The bottom line? The 2 kW wind generator on the 90 foot tower would have produced 30% more power for Edwin than the existing 4 kW unit on the 42 foot tower, even on open ground without the Christmas trees.

Lessons Learned

Folks often ask what pitfalls to avoid when sizing and siting a wind generator for their homes. The three most common mistakes made in wind installations are:

1. Too short a tower
2. Too short a tower, and
3. Too short a tower.

Short towers rob you of your precious fuel, the wind. Turbulent winds compounded by ground drag result in poor fuel quality. A wind generator is a serious investment that you make affecting your life and lifestyle for, presumably, many years into the future. Settling for poor fuel quality means you are squandering your investment dollars, wasting your time, and compromising your better judgement.

An analogy I use is that of buying PV panels. but then permanently installing them on the north side of your house. Sure, they'll work, but not very well. Would anybody in their right mind do this? You either have to buy a whole lot more panels than you really need (i.e., a bigger wind generator) or settle for poor performance. I am dismayed when I listen to someone complain that their wind generator, which was installed at tree-top height, doesn't live up to their expectations. A frequent comment is that wind generators don't work, or that wind-generated electricity is too site specific. It's not wind power technology that's at fault.

Back in "Tower Economics 101 (*HP*#37), I used an example of a Windseeker installed on a 100 foot tower versus two Windseekers each on 25 foot towers. Each installation would produce about the same amount of power at a given site. What this means is that installing a Windseeker on a 25 foot tower, in effect, derates the generator from 600 watts to 300 watts in a given wind speed. This is a lot like facing your PV panels north.

The examples I have cited are typical of poor judgement in siting as well as mediocre economic investments. Cutting corners by cutting costs at the expense of tower height compromises the entire wind installation, its power output, and your investment for the several-decade life of the system.

Onward

Next time we'll take a look at the tools you can use to determine the tower height you need at your site, as well as where on your property to locate your wind system.

Access
Mick Sagrillo looks way up at his wind generators at Lake Michigan Wind & Sun, E 3971 Bluebird Rd., Forestville, WI 54213 • 414-837-2267