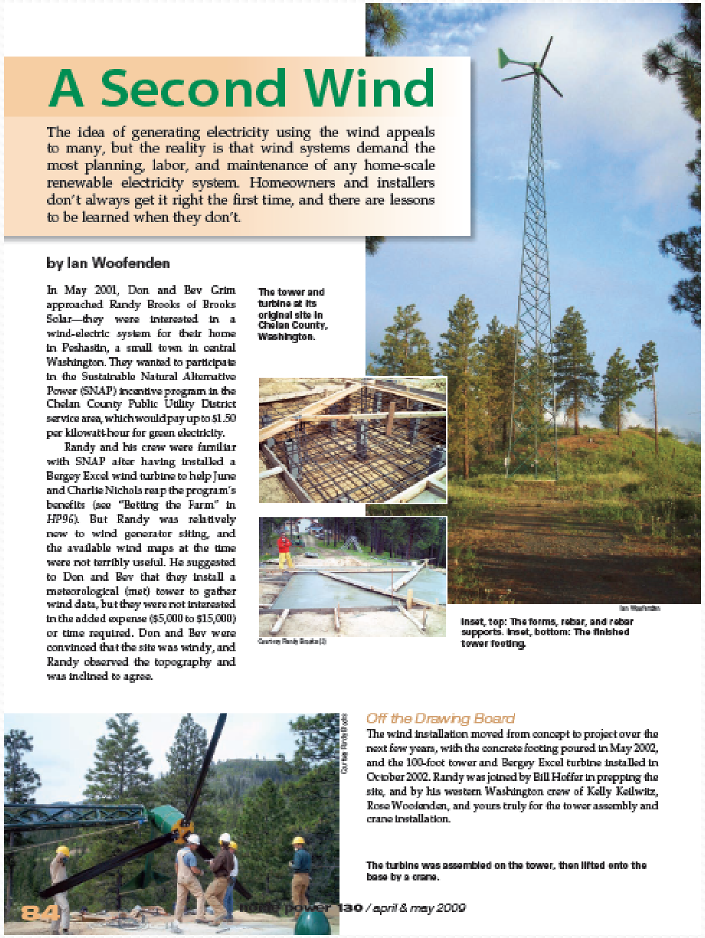
# Site Your Wind Turbine Right The First Time

Workshop #157
Randy Richmond
RightHand Engineering, LLC
Booth A23

# Second Wind – good or bad?

- A Turbine with two lives – two owners & two sites
- My Story is from the Second owner perspective.
- Article appeared in Home Power #130 written by Ian Woofenden



## A Second Wind

The idea of generating electricity using the wind appeals to many, but the reality is that wind systems demand the most planning, labor, and maintenance of any home-scale renewable electricity system. Homeowners and installers don't always get it right the first time, and there are lessons to be learned when they don't.

by Ian Woofenden

In May 2001, Don and Bev Grim approached Randy Brooks of Brooks Solar—they were interested in a wind-electric system for their home in Peshastin, a small town in central Washington. They wanted to participate in the Sustainable Natural Alternative Power (SNAP) incentive program in the Chelan County Public Utility District service area, which would pay up to $1.50 per kilowatt-hour for green electricity.

Randy and his crew were familiar with SNAP after having installed a Bergey Excel wind turbine to help June and Charlie Nichols reap the program's benefits (see "Betting the Farm" in *HP96*). But Randy was relatively new to wind generator siting, and the available wind maps at the time were not terribly useful. He suggested to Don and Bev that they install a meteorological (met) tower to gather wind data, but they were not interested in the added expense ($5,000 to $15,000) or time required. Don and Bev were convinced that the site was windy, and Randy observed the topography and was inclined to agree.

The tower and turbine at its original site in Chelan County, Washington.

Inset, top: The forms, rebar, and rebar supports. Inset, bottom: The finished tower footing.

*Off the Drawing Board*

The wind installation moved from concept to project over the next few years, with the concrete footing poured in May 2002, and the 100-foot tower and Bergey Excel turbine installed in October 2002. Randy was joined by Bill Hoffer in prepping the site, and by his western Washington crew of Kelly Keilwitz, Rose Woofenden, and yours truly for the tower assembly and crane installation.

The turbine was assembled on the tower, then lifted onto the base by a crane.

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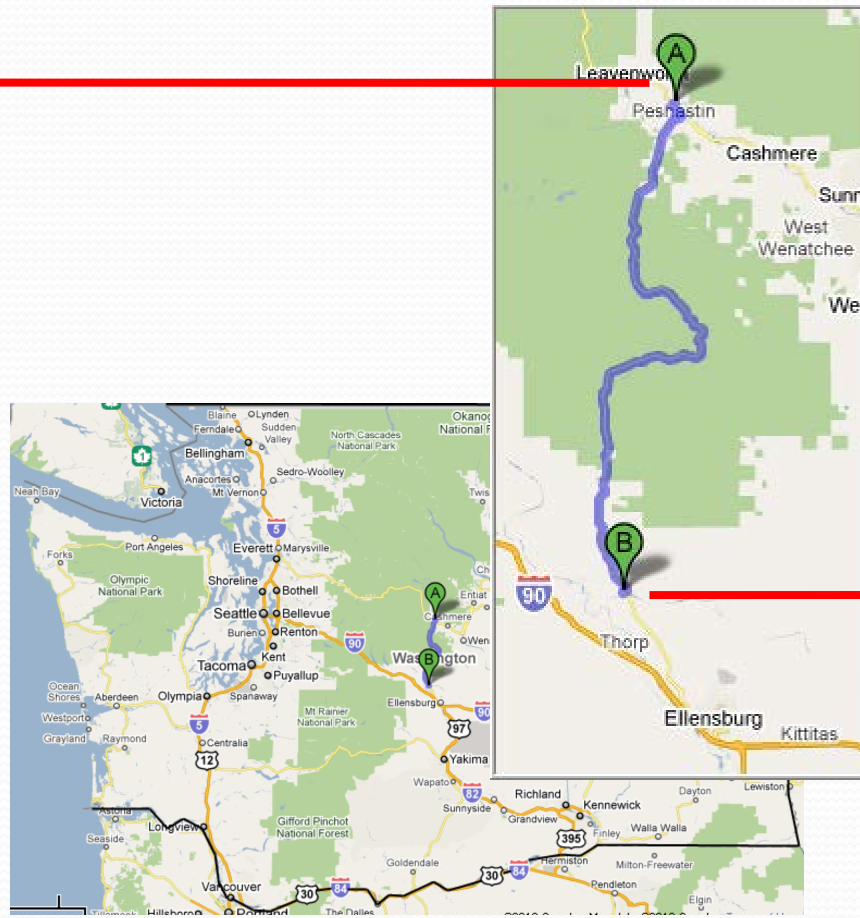
# A Tale of Two Sites





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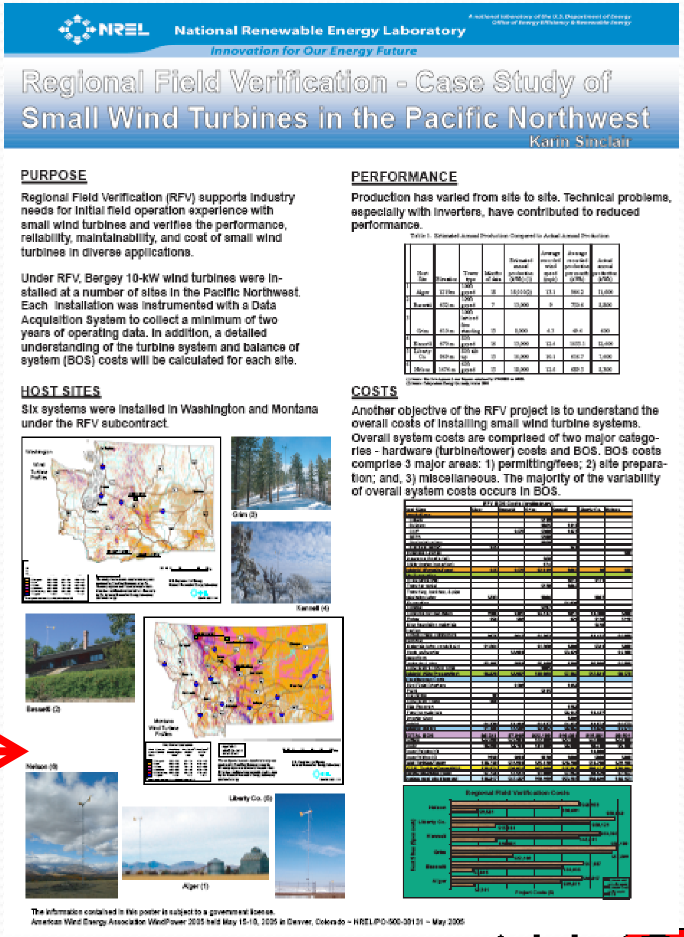
# The First Site

- Construction 2002
- Wind maps have little or no info < 8-12 MPH
- No wind measurement performed
- Used word-of-mouth and tree flagging as evidence of wind
- Part of NWSeed & NREL Study – remotely monitored



# The First Site (cont'd)

- System on-line Oct 2003
- Monitored for > 1 year
- Estimated 8000 kWhrs annually
- Measured 600 kWhrs – 13 times less than estimate
- Measured average wind speed 4.3 MPH @ 20 m

| Elevation | Tower type | Months of data | Estimated annual production (kWh) (1) | Average recorded wind speed (mph) | Average recorded production per month (kWh) | Actual annual production (kWh) |
|---|---|---|---|---|---|---|
| 610 m | 100ft latticed free standing | 15 | 8,000 | 4.3 | 49.4 | 600 |



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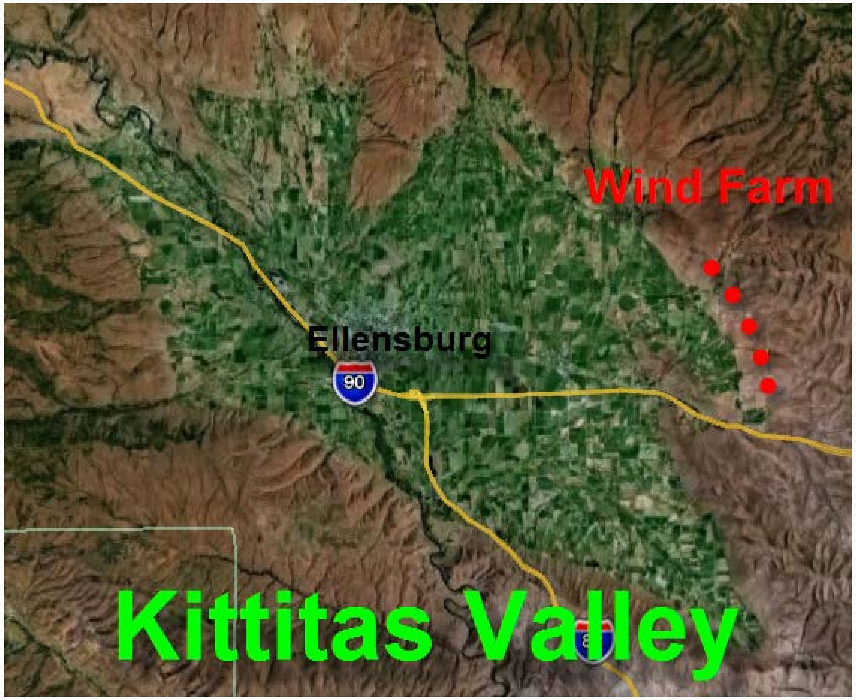
# The Second Site

- My search for a site began early 2008
- My primary residence (Western WA) not viable
- Nearest "windy" spot 2 hours East over the Cascade range – Kittitas Valley
- Home of Wild Horse Wind Farm



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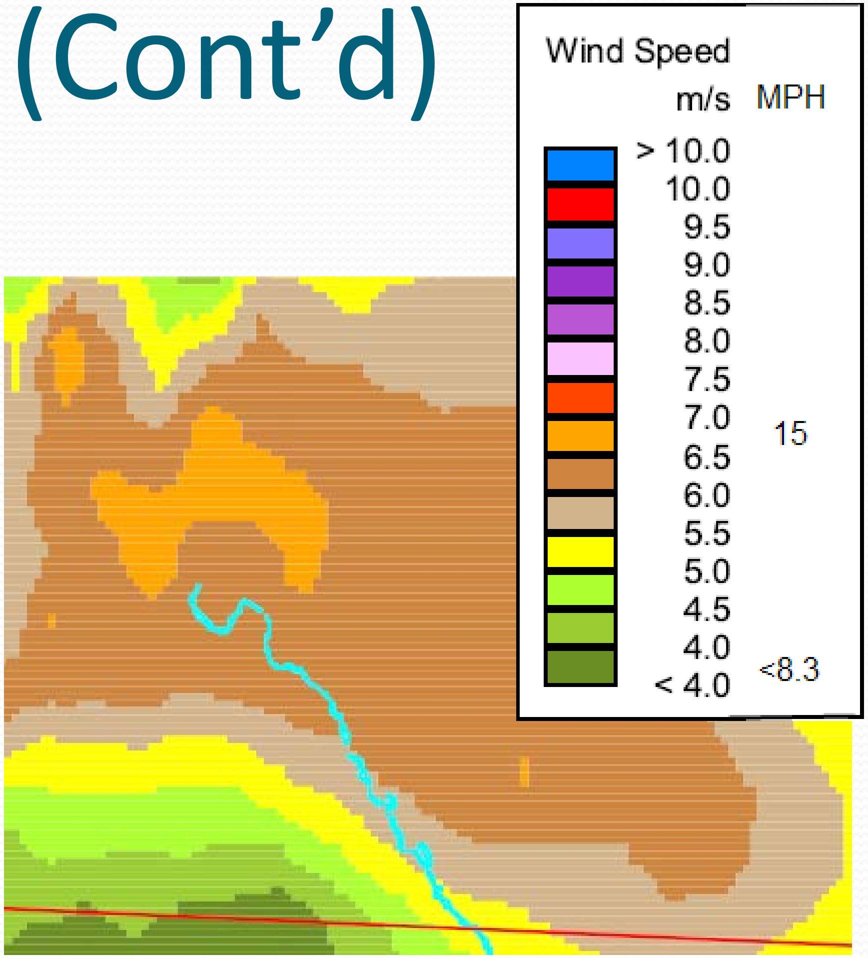
# The Second Site (Cont'd)

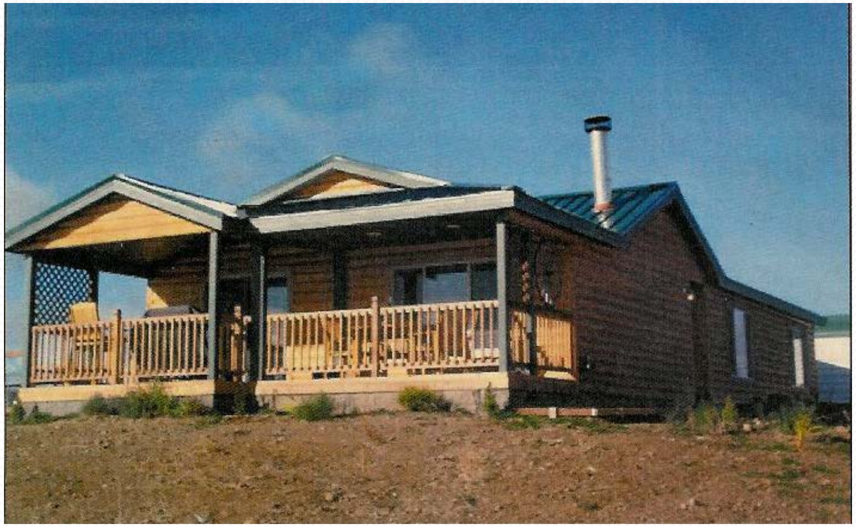
- NREL 80 m Wind Map Showed Promise
- Most of the area shows 14-15 MPH average wind @ 250 feet.
  (MPH = m/s * 2.24)
- BUT I still needed to choose a specific available parcel…

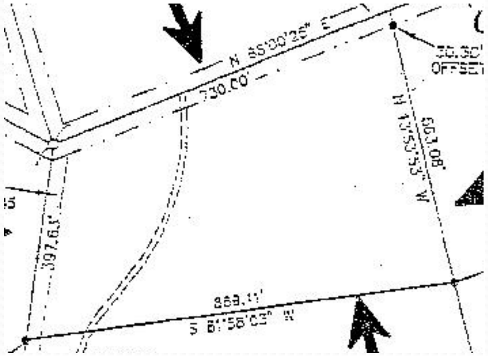


# Site Selection

How about this one?

- 8 acres – room enough for a guyed tower
- Nice vacation home
- Local grid power present
- PUD participates in State RE Incentive
- Neighbors don't object to a small wind turbine

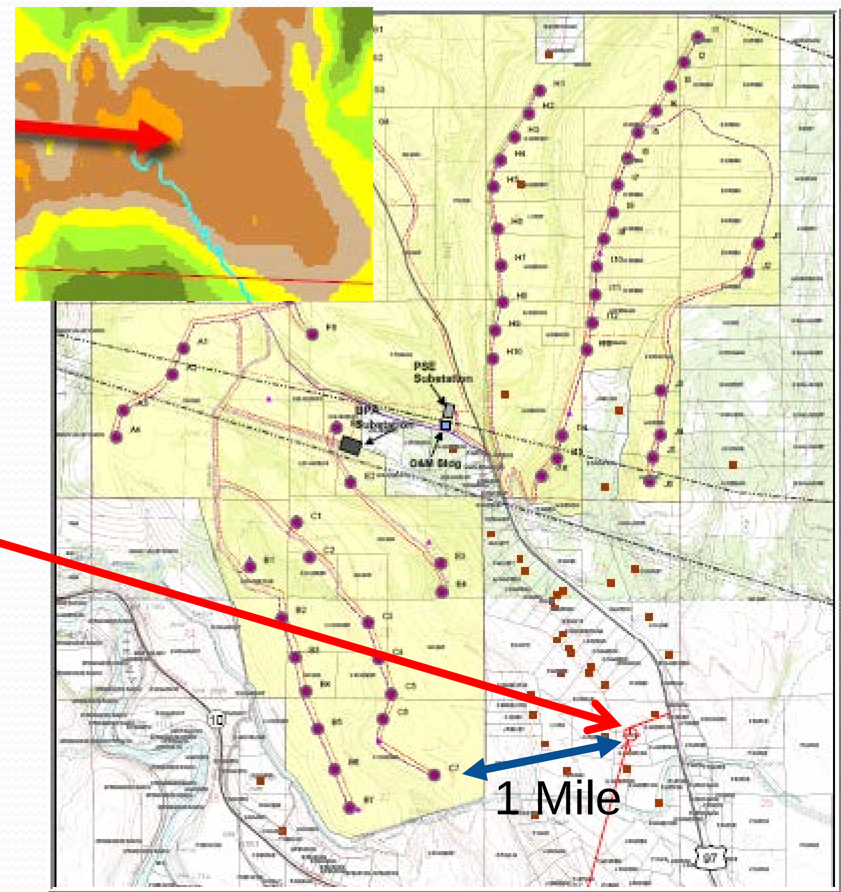




# Site Selection (Cont'd)

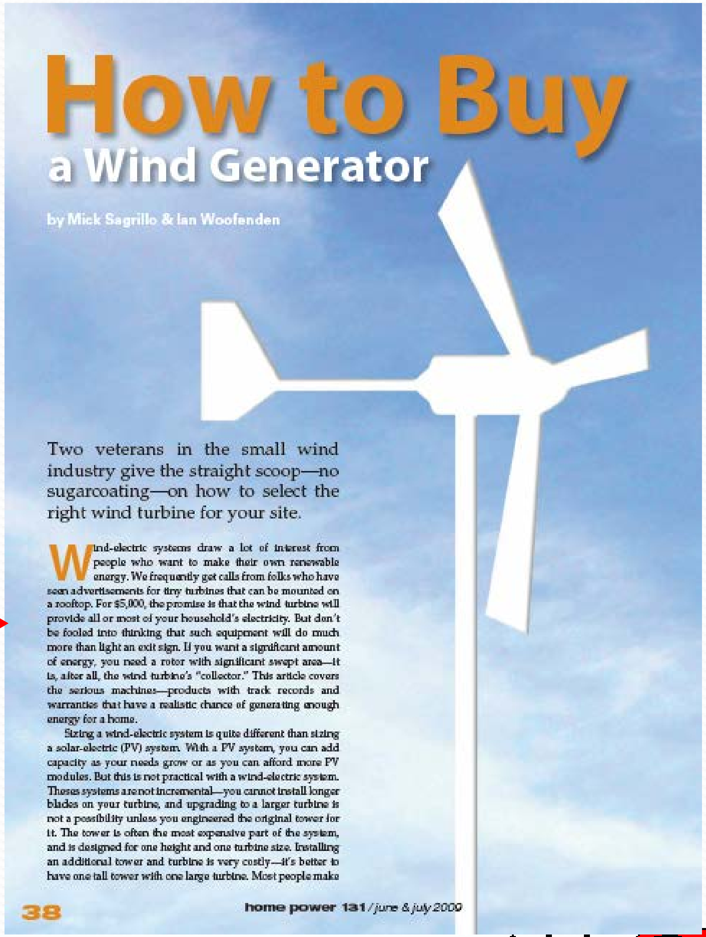
What about parcel-specific wind?

- NREL Wind Map looked good – 14-15 mph @ 80m
- New wind farm planned 1 mile to the West!
- Confident that 12 months of wind measurement were not necessary



# Turbine Selection

- Goal was to maximize income from WA State RE Incentive – 12¢/kWhr, max $2K/year. Need 16+ MWhrs annually.
- Home Power's Wind Buyer's Guide VERY helpful!
- @ 13 MPH, need 10KW turbine.



# How to Buy
## a Wind Generator

by Mick Sagrillo & Ian Woofenden

Two veterans in the small wind industry give the straight scoop—no sugarcoating—on how to select the right wind turbine for your site.

Wind-electric systems draw a lot of interest from people who want to make their own renewable energy. We frequently get calls from folks who have seen advertisements for tiny turbines that can be mounted on a rooftop. For $5,000, the promise is that the wind turbine will provide all or most of your household's electricity. But don't be fooled into thinking that such equipment will do much more than light an exit sign. If you want a significant amount of energy, you need a rotor with significant swept area—it is, after all, the wind turbine's "collector." This article covers the serious machines—products with track records and warranties that have a realistic chance of generating enough energy for a home.

Sizing a wind-electric system is quite different than sizing a solar-electric (PV) system. With a PV system, you can add capacity as your needs grow or as you can afford more PV modules. But this is not practical with a wind-electric system. Theses systems are not incremental—you cannot install longer blades on your turbine, and upgrading to a larger turbine is not a possibility unless you engineered the original tower for it. The tower is often the most expensive part of the system, and is designed for one height and one turbine size. Installing an additional tower and turbine is very costly—it's better to have one tall tower with one large turbine. Most people make

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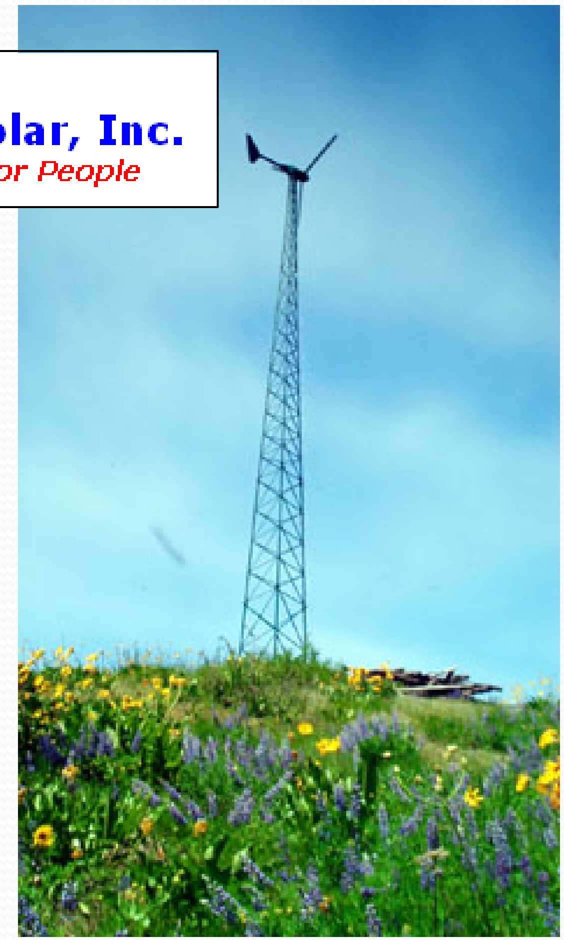
# Turbine Selection (Cont'd)

- Contacted Brooks Solar and Ian Woofenden for a recommendation.
- They knew of an under-used 10 kW Bergey Excel for sale in Peshastin 40 miles North.
- I visited the owners and closed the deal.

Brooks Solar, Inc.
Solar Power for People



# Moving the Tower/Turbine

- I hired Brooks Solar & team to move the system to the new site.



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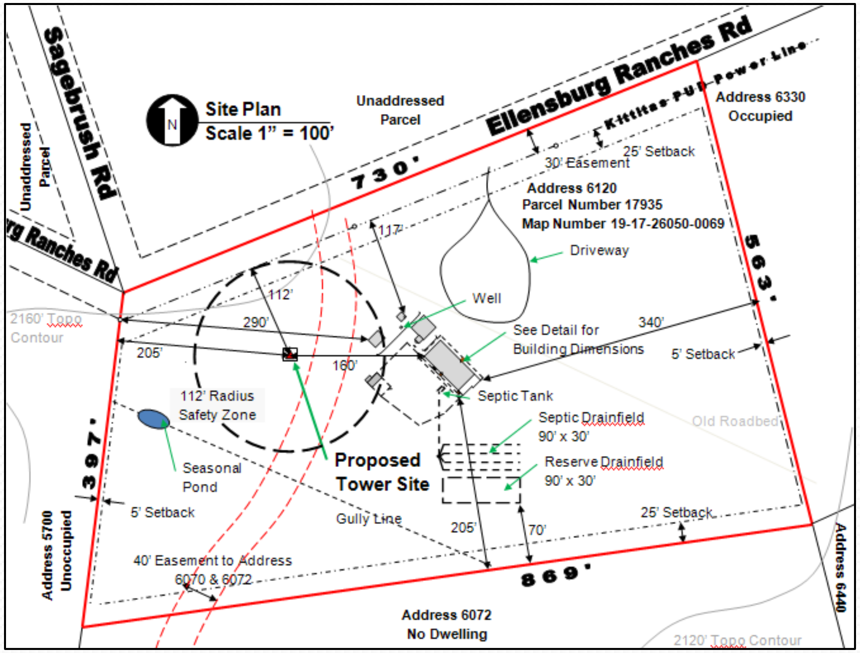
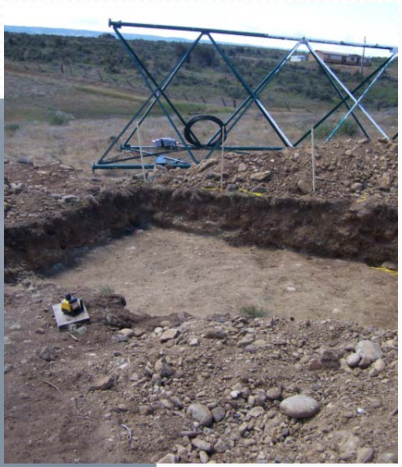
# Permits

- I dealt with the County for permits (NOT easy)
- Initially they wanted to restrict the hub height to 60’ (40’ lower).
- Discovered that I was outside urban zone so 100’ was finally allowed.
- Draft Small Wind standard requires a 1.5 x setback.
- State required the non-UL listed turbine to be engineer approved.



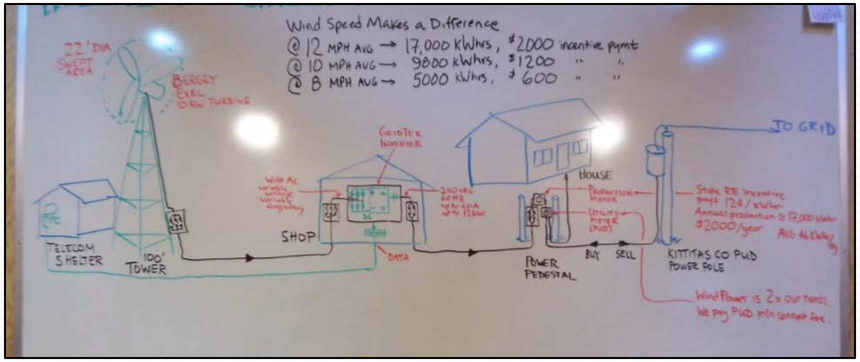
# Foundation & Resurrection

- I did my own excavation (good excuse for a new tractor).
- I hired a contractor to do the concrete work – had problems.
- Brooks Solar & Team returned to put the tower/turbine back up.



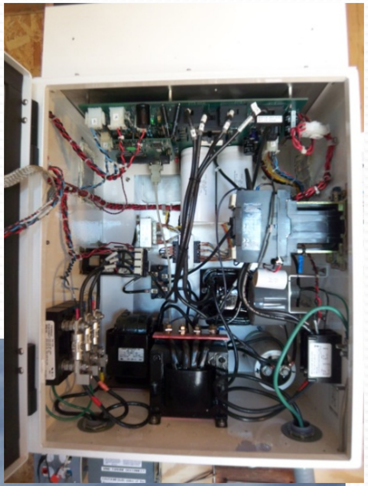
# Electrical Work & Cut-over

- Being an EE I did my own electrical work – design & installation.
- State required an electrical permit and inspections.
- Got final approval from state for cut-over.
- On-line, October 2, 2008



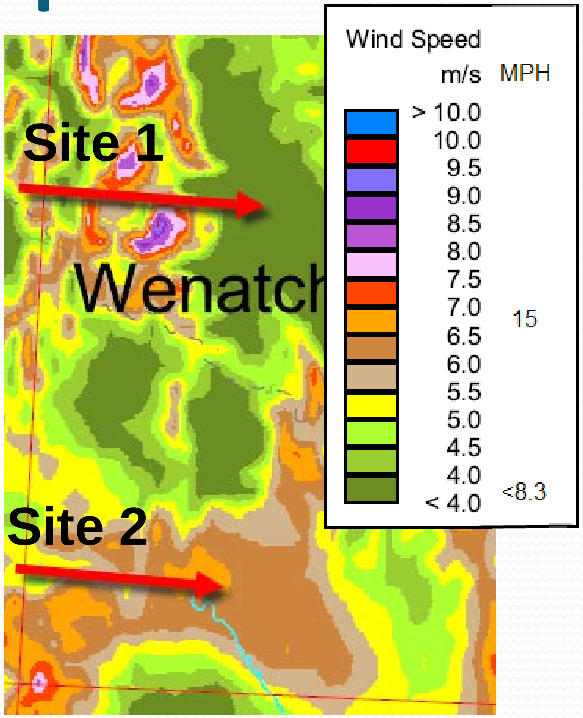

# Post-cutover Problems

- The used inverter died within 2 weeks – was off-line for 1 week while a replacement circuit board was sent.
- The new, more efficient turbine blades were out-of-balance. Bergey shipped out new ones and The Team replaced them at Bergey's expense.



# Site Wind/Power Comparison

| Parameter | Site1 | Site2 |
|---|---|---|
| 80 m Wind Map Wind Speed | < 8.3 MPH | 14-15 MPH |
| 50 m Wind Map Wind Speed | < 12.5 MPH | 15.7-16.8 MPH |
| 30 m Wind Map Wind Speed | < 11.2 MPH | 12.3-13.4 MPH |
| Estimated Wind Speed | 8+ MPH | 12 MPH |
| Estimated Annual Energy | 8000 kWhr | 16,700 kWhr |
| Actual Wind Speed @ 20 m | 4.3 MPH | 11.5 MPH |
| Actual Annual Energy | 600 kWhr | 16176 kWhr |




**△Wind = 2.7 x**

**△ Energy = 27 x**

# Local Wind/Power Comparison

| Location | Avg Wind Speed June 09-May 10 | Wind Speed Difference | Energy Production | Energy Difference |
|---|---|---|---|---|
| Site 2 30 m Turbine Hub | 12 MPH* | reference | 16,176 kWhrs | reference |
| Site 2 20 m Tower | 10.4 MPH | -13% | 10,530 kWhrs* | -35% |
| Site 2 10 m Near Tower | 9.7 MPH | -19% | 8543 kWhrs* | -47% |
| Ellensburg Airport 9 mi SE | 9.2 MPH | -23% | 7290 kWhrs* | -55% |
| *Calculated | | | | |

**NOTE: A small increase in wind yields a LARGE increase in energy!**

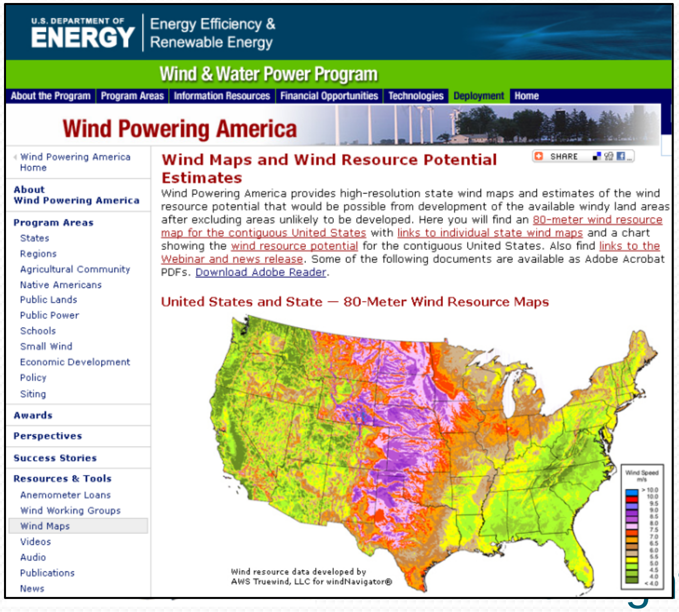
# How to Avoid being the First Owner of a Second Wind system

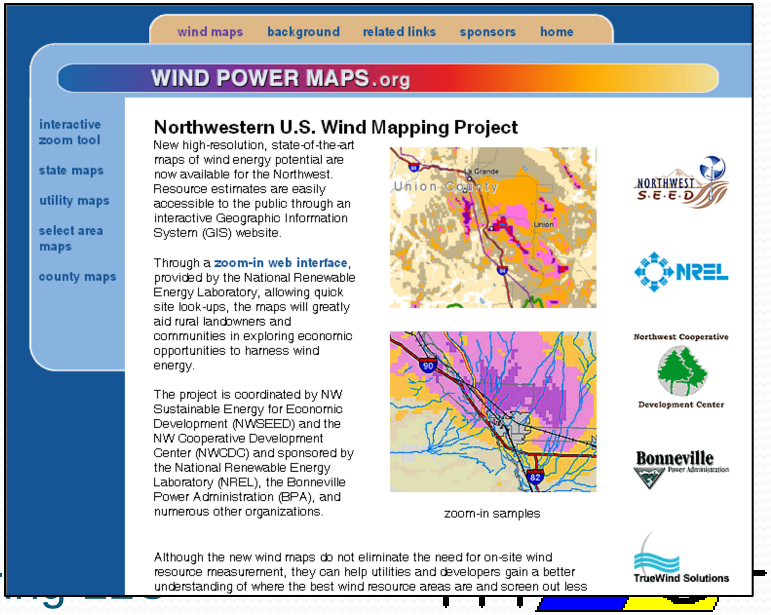
- Know Your Wind!
- Go As High As You Can!

# Know the Wind at your Site

**Make use of free, on-line wind maps:**

- http://www.windpoweringamerica.gov (80 m maps)
- http://www.windmaps.org (Northwestern states only)
- http://lwf.ncdc.noaa.gov/oa/ncdc.html



# Know the Wind at your Site

**OR, you can purchase more detailed data from:**

- AWS True Wind
- 3Tier
- First Look
- NASA

**OR, find a local wind advocacy group that subscribes to one of these pay services. Often they can give you a free wind assessment.**

# Know the Wind at your Site

**Make use of near-by airport data:**

- http://www.wunderground.com/history/airport/xxxx (replace “xxxx” with your airport code)

Weather Underground
wunderground.com

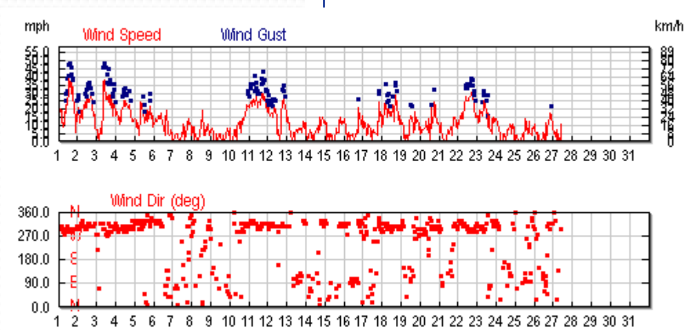
## History for Ellensburg, WA

Month of May, 2010 — View Current Conditions

**Monthly Summary**

« Previous Month | May | 1 | 2010

Daily | Weekly | **Monthly**

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**Daily Observations**

| 2010 | Temp. (°F) | | | Dew Point (°F) | | | Humidity (%) | | | Sea Level Pressure (in) | | | Visibility (mi) | | | Wind (mph) | | Gust Speed (mph) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May | high | avg | low | high | avg | low | high | avg | low | high | avg | low | high | avg | low | high | avg | high |
| 1 | 57 | 50 | 43 | 37 | 34 | 31 | 68 | 56 | 41 | 29.98 | 29.90 | 29.87 | 10 | 10 | 10 | 39 | 20 | 48 |
| 2 | 59 | 49 | 41 | 36 | 33 | 30 | 73 | 56 | 37 | 30.12 | 30.03 | 29.86 | 10 | 10 | 10 | 28 | 19 | 37 |
| 3 | 55 | 46 | 36 | 40 | 30 | 22 | 86 | 58 | 29 | 30.14 | 29.86 | 29.66 | 10 | 10 | 10 | 38 | 15 | 48 |
| 4 | 54 | 44 | 36 | 29 | 26 | 24 | 70 | 53 | 32 | 30.28 | 30.23 | 30.15 | 10 | 10 | 10 | 25 | 18 | 33 |
| 5 | 53 | 44 | 34 | 32 | 27 | 24 | 73 | 53 | 32 | 30.19 | 30.14 | 30.09 | 10 | 10 | 10 | 24 | 14 | 30 |
| 6 | 57 | 47 | 37 | 37 | 33 | 29 | 79 | 56 | 35 | 30.29 | 30.25 | 30.22 | 10 | 10 | 2 | 20 | 13 | 24 |
| 7 | 64 | 44 | 28 | 40 | 33 | 24 | 86 | 62 | 29 | 30.29 | 30.20 | 30.11 | 10 | 10 | 10 | 14 | 4 | 20 |
| 8 | 63 | 52 | 39 | 40 | 34 | 26 | 85 | 58 | 31 | 30.09 | 30.01 | 29.95 | 10 | 10 | 10 | 20 | 6 | 26 |
| 9 | 69 | 49 | 30 | 34 | 26 | 16 | 76 | 44 | 14 | 30.00 | 29.91 | 29.80 | 10 | 10 | 10 | 8 | 4 | - |
| 10 | 59 | 50 | 44 | 43 | 37 | 30 | 74 | 62 | 42 | 29.92 | 29.83 | 29.75 | 10 | 10 | 10 | 23 | 7 | 32 |
| 11 | 64 | 53 | 46 | 40 | 38 | 37 | 68 | 60 | 41 | 30.15 | 30.06 | 29.93 | 10 | 10 | 10 | 30 | 24 | 44 |
| 12 | 75 | 64 | 51 | 40 | 37 | 34 | 63 | 39 | 22 | 30.17 | 30.12 | 30.08 | 10 | 10 | 10 | 26 | 17 | 34 |
| 13 | 78 | 58 | 39 | 41 | 36 | 27 | 79 | 45 | 16 | 30.09 | 30.02 | 29.94 | 10 | 10 | 10 | 15 | 8 | - |
| 14 | 82 | 62 | 43 | 46 | 40 | 35 | 76 | 48 | 20 | 30.02 | 29.96 | 29.91 | 10 | 10 | 10 | 15 | 6 | - |
| 15 | 84 | 64 | 46 | 46 | 42 | 35 | 76 | 46 | 18 | 29.99 | 29.93 | 29.87 | 10 | 10 | 10 | 15 | 7 | - |
| 16 | 84 | 68 | 55 | 52 | 48 | 43 | 74 | 53 | 25 | 29.89 | 29.80 | 29.71 | 10 | 10 | 10 | 21 | 8 | 28 |
| 17 | 75 | 64 | 54 | 55 | 51 | 48 | 86 | 70 | 41 | 29.78 | 29.72 | 29.65 | 10 | 10 | 10 | 24 | 9 | 31 |
| 18 | 69 | 60 | 50 | 49 | 45 | 41 | 82 | 65 | 42 | 30.00 | 29.81 | 29.67 | 10 | 10 | 8 | 29 | 17 | 37 |
| 19 | 70 | 56 | 42 | 50 | 42 | 36 | 85 | 66 | 35 | 30.01 | 29.86 | 29.65 | 10 | 10 | 2 | 18 | 8 | 26 |
| 20 | 57 | 50 | 39 | 37 | 35 | 31 | 79 | 63 | 44 | 30.11 | 30.05 | 29.89 | 10 | 10 | 10 | 24 | 9 | 32 |
| 21 | 61 | 47 | 34 | 38 | 32 | 27 | 85 | 61 | 28 | 30.02 | 29.84 | 29.73 | 10 | 10 | 10 | 15 | 6 | - |
| 22 | 61 | 51 | 42 | 37 | 34 | 31 | 74 | 55 | 37 | 29.90 | 29.79 | 29.73 | 10 | 10 | 10 | 32 | 19 | 39 |
| 23 | 61 | 52 | 43 | 38 | 33 | 28 | 71 | 53 | 36 | 29.93 | 29.89 | 29.85 | 10 | 10 | 10 | 25 | 15 | 31 |
| 24 | 66 | 51 | 36 | 39 | 34 | 28 | 82 | 54 | 23 | 29.92 | 29.89 | 29.86 | 10 | 10 | 10 | 12 | 7 | 17 |



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# Know the Wind at your Site

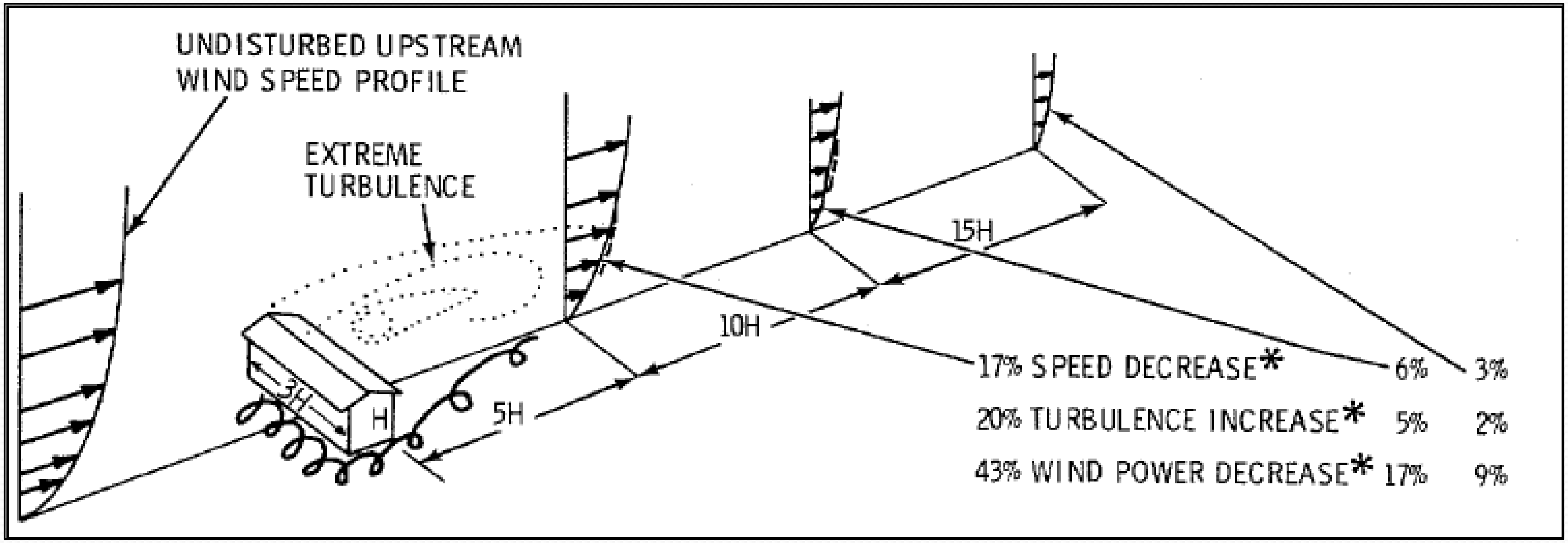
**Measure your actual wind yourself:**

- WindMonitoring.com
- Etesian-tech.com
- Talco, Power Predictor (www.talcoelectronics.com)
- APRS World (booth X74)
- Solar Energy Technologies (booth A50)
- West Winds Renewable (booth X99)
- **OR look for an anemometer loan from a wind advocacy group.**



# Go as High as You Can

- Rule of thumb – at least 30' higher than anything within 500'. Maximizes wind, reduces turbulence.




From NREL Wind Resource Assessment Handbook

# Go as High as You Can

- Even with flat terrain there is an increase in wind speed as you go higher.

$$\frac{V_2}{V_1} = \left(\frac{H_2}{H_1}\right)^{\alpha}$$

$$\alpha = \frac{Log_{10}\left[\frac{v_2}{v_1}\right]}{Log_{10}\left[\frac{z_2}{z_1}\right]}$$

From HP126 article "*How Tall is Too Tall*" by Raichle and Summerville & *NREL Wind Resource Assessment Handbook*

## Calculating Wind Speed from Known Data

Assume a Midwestern farm site, which is mostly flat grassland, has a wind-shear coefficient of 0.2 ($\alpha = 0.2$) and your 50-foot-high anemometer ($H_1$) has recorded an annual average wind speed of 15.6 mph ($V_1$).

What annual average wind speed ($V_2$) can you expect at turbine hub height on a 75-foot tower ($H_2$)?

$$\frac{V_2}{V_1} = \left(\frac{H_2}{H_1}\right)^{\alpha};\ V_2 = V_1\left(\frac{H_2}{H_1}\right)^{\alpha};\ V_2 = 15.6\text{ mph}\left(\frac{75\text{ ft.}}{50\text{ ft.}}\right)^{0.2}$$

$V_2$ = 16.9 mph

| α | Description |
|---|---|
| 0.1 | Perfectly smooth (calm water) |
| 0.2 | Flat grassland or low shrubs |
| 0.3 | Trees or hills, buildings in area |
| 0.4 | Close to trees or buildings |
| 0.5 | Very close to trees or buildings |
| 0.6 | Surrounded by tall trees or buildings |

# Go as High as You Can

**Power in the wind is in proportion to the CUBE of its velocity!**

- Complex formula: **P = 0.5 x rho x A x $V^3$ x Cp**, where
  P=power in watts
  rho = air density (about 1.225 kg/m3 at sea level)
  A = rotor swept area - $\pi r^2$ ($m^2$)
  V = wind speed in meters/sec (mph/2.24 = m/s)
  Cp = coefficient of performance & system efficiency (typically 0.25)
  from AWEA

- Simplified formula: **AEO = 0.01328 x $D^2$ x $V^3$**, where
  AEO=Annual Energy Output in kWhrs
  D=diameter of swept area in feet
  V=velocity of wind in MPH
  from *Wind Power Basics*, Gipe, & HP *Apples & Oranges 2002*, Sagrillo

# Other Hints

- Talk to your neighbors BEFORE you start. Hostile neighbors can impede your permit.
- Find and read the applicable building code used by your permit dept. Be prepared to educate the staff you talk with. Be prepared to file for a variance if necessary.
- Select a manufacturer who stands behind their product. There are dozens of new manufacturers & products now – but look for a proven track record.

# Summary – Its About WIND!

**Pick your X/Y (horizontal) location for best wind.**

- Use on-line wind maps for starters.
- Check nearby airport data – if available.
- Do actual measurements for a full year to verify your specific local conditions.

**Pick your Z (vertical) location for best wind**

- Be at least 30' higher than anything within 500'.
- The higher the better. Even a little increase in wind will yield an great increase in power.

# Questions & Answers

Thank You!

HP Magazine Raffle

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