Tips for Designing, Building, and Flying Wind Generators

Raising a wind machine and watching it produce power is an exhilharating experience. And if it does fly apart during a gale, the show is often worth the price of admission--plus you've obtained more knowledge for the next try!

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Where the Heck do you start???

First, figure out how big a wind generator you are willing to tackle, either commercial or home-brewed. There is really only one important measure of windmill size...the *swept area*. That's how many square feet (or meters, if you are into that sort of thing) of area the windmill's blades cover during a rotation. The formula for swept area is Pi r^2, where Pi is 3.1415 and r is the radius of your prop. The available power from the wind increases dramatically with the swept area...but so do the stresses on your blades, tower, bearings, tail. More stress means stronger engineering and materials are required, and a much larger, more complicated and expensive project. Windmills with props of 4 feet diameter and under are fairly easy to design, build and handle. Once you get into the 7-8 foot range, everything must be very strong and rock-solid. At 10 feet and above, your materials and engineering need to be top-notch! We have learned this from the experience of watching windmills blow up, and we highly recommend building a smaller windmill like our 4 foot diameter Wood A-X before trying a large windmill.

Next, look into different resources and opinions on the topic. Our LINKS page is a great place to start, you should read every site in our wind listings before committing to the project!

And finally, here's some of our advice and ramblings about various aspects of designing, flying, building and destroying wind generators. We are always open for suggestions and comments, please Email us.

Site

- **Location--**First, figure out the direction from which the prevailing winds in your area usually come. You can determine this by observation during wind storms, and by looking at the trees near your site. Trees that are all leaning the same direction and that have branches mostly on one side of the trunk are a good indication of prevailing wind speed and direction. Local airports and weather stations can sometimes provide you with this information. The National Renewable Energy Laboratory in Golden, CO publishes an excellent Wind Energy Resource Atlas of the United States on the internet, for free. A Logging anemometer that also records wind direction can be useful here too, though expensive.
- **Height:** Flying a wind generator close to the ground is like mounting solar panels in the shade! Your wind generator should be located at least 30 feet above any obstruction within 400 feet --many sources recommend even more. Of course, this may be impractical, so just keep in mind that turbulance caused by obstructions will rob you of huge amounts of potential power, and cause extra stress on all components of your wind machine. A higher tower is usually MUCH easier on your machine! At least make sure there are no obstructions between your windmill and the direction from which the wind usually blows.
- **Distance:** The distance between your wind generator and your batteries can also be a problem--the closer the better, to avoid losses in long wires and to keep the wire size required down to a reasonable thickness and cost. Transformers can be used to keep the voltage high for long distances, but they cause added complexity and losses.

Tower

Check out our TOWERS page for some home-brewed solutions that are cheap and easy to fabricate, plus lots of details and pictures!

- Your tower must be *extremely* sturdy, well-anchored, and tall enough to get above obstructions. We've seen 1.5 inch steel pipe bend like a pipe cleaner in 50 mph winds, underneath a wind machine with only an 8-foot prop. Some wind energy guidelines tell you to plan on spending at LEAST as much on your tower and power wiring as on the wind generator itself!
- **Do you like to climb?** The two basic kinds of tower are the Tilt-Up and Stationary. A stationary tower is the most sturdy and trouble-free, but you have to climb it to install, maintain or remove the wind machine. A crane is often used for installation, an expensive proposition! If climbing towers disagrees with you, go for a tilt-up. Then all maintenence can be performed while standing safely on solid ground.
- **Roof mount?** We strongly recommend against mounting a wind generator on your roof. Though the manufacturer of the AIR 403 says it works, we have observed first-hand the vibration and noise during a windstorm in two different roof installations...it is VERY noticable and irritating. And keep in mind that the AIR 403 is a very small unit (only a 1.3 meter prop) that makes very little power...a larger mill would be unbearable, and possibly dangerous to your house itself. Most

commercial and homemade wind generators don't make much physical noise, but the vibration is unavoidable due to the nature of permanent magnet alternators. Listen to the vibration of Ward's 7 foot diameter windmill (12 second .WAV file, 140K) and hear why we don't recommend roof mounts! Ward's mill is actually very quiet; this audio clip was taken with the microphone pressed against the steel mast to give an idea of the vibration that would be transmitted into your house with a roof mount. The buzzing sound is the vibration of magnets spinning past coils; the clanking is from the sectional tower itself.

Anemometers

- It is essential to know the real windspeed in any wind generator installation, commercial or homemade. This allows you to see if the machine is performing correctly, and extremely high windspeeds might be a clue that you should shut the mill down for the duration of the storm. If you plan on investing significant money in wind power, a logging anemometer might help you decide if your local wind resource is worth the investment. Commercial anemometers and weather stations are very expensive, but can be found with a quick Google search...we recommend you try one of the options below.
- **Build your own anemometer:** We built a highly accurate anemometer for under $10. See it here! It counts frequency with a simple circuit, and can be adapted to use with computer data acquisition equipment.
- **Logging anemometer kit:** This ingenious kit is from Australia and costs less than $100 US, including shipping. It tracks wind speed and direction, and logs data to its own memory, including average and peak readings. And, it interfaces directly to a PC...your wind data can import live right into a spreadsheet! See it here! DanF is currently building one of these kits...more to come soon.

Generators and Alternators

- **Terms--**On our site, we try to use the term *Generator* to describe a machine that produces Direct Current (DC), and use the term *Alternator* to describe a machine that produces Alternating Current (AC). However, the term Generator is also used generically to describe any machine that produces electricity when the shaft is spun.
- **Options--**The alternator or generator is the heart of your wind machine, and it must be both properly sized to match your swept area, and produce the right type and voltage of power to match your application. Options include commercial and homemade permanent magnet (PM) alternators, PM converted induction motors, DC generators, DC brushless PM motors, vehicle alternators, and induction motors.

We cover the different types extensively on our Alternator and Generator Comparison page.

- **Application--**Wind-generated electricity can be used for battery charging, heating, and for connection with the power grid. All of our designs and information are about battery charging, as we heat with wood and the nearest power line is 12 miles away from Otherpower.com headquarters.
- **Single Phase vs. Three Phase--**Homemade three-phase PM alternators do have some minor advantages, such as slightly better use of space, less vibration, and less resistance loss from the wire. Many people build only 3-phase machines. In our experience, however, it is VERY difficult to safely pack 3 sets of coils into a crowded stator while maintaining a tight air gap between the magnets and laminates. Single phase machines perform almost as well, and our opinion is that their ease of construction more than compensates for any advantages of using 3-phase. Of course some folks may disagree with us, but...we can sure make single phase alternators quickly!
- **Speed--**The shaft speed is a very crucial factor in all types of alternator and generator. The unit needs to make higher voltages at lower rpms, otherwise it is not suited for wind power use. This goes for all power units...even motors used as generators and alternators should be rated for low rpms. This is also why vehicle alternators are not suited for wind power use, see our Alternator and Generator Comparison page for more details.
- **Cut-In Speed--**A wind generator does not start pushing power into the battery bank until the generator or alternator voltage gets higher than the battery bank voltage. Higher shaft speed means higher voltage in all generators and alternators, and you want to try and get the highest shaft speed possible in low winds--without sacrificing high-wind performance. Most commercial wind generators cut in at 8-12 mph. The generator's low-speed voltage performance, the design of the rotor (the blades and hub), and the wind behavior all factor into where cut-in will occur.
- **Voltage--**With battery-charging windmills, voltage control is not generally needed--until the batteries fill up. Even if your alternator is producing an open-circuit voltage of 90 volts, the battery bank will hold the system voltage down to its own level. This does affect cut-in speed...an alternator that cuts in at 300 rpm into a 12v battery bank will not cut in until 600 rpm into a 24v battery bank. However, the same machine may produce half again as much power at higher speeds into a 24v battery than into a 12v one! This is because of...
- **Inefficiency--**Every generator has a certain speed at which it runs most efficiently. But since the wind is not constant, we must try to design to a happy medium. As the wind speed rises, the raw power coming into the generator from the wind becomes more than the generator can effectively use, and it gets more and more inefficient. This power is wasted as heat in the stator coils. Alternators with wound fields can adjust the magnetic flux inside to run most efficiently, but PM alternators cannot. An alternator that uses many windings of thin wire will have better low-speed performance than one that uses fewer windings of thicker wire, but higher internal resistance. This means it will become inefficient more quickly when producing higher amperage as wind speeds and power output rise. The formula used to calculate power wasted from inefficiency is AMPS^2 * RESISTANCE = Power wasted as heat in the alternator windings (in watts).
- **What does this mean in practice?** Compare the performance of our Volvo Disk Brake Alternator to that of our Induction Motor PM Conversion Alternator. The Volvo alternator internal resistance is 1/4 ohm, while the converted motor's resistance is 4 ohms. The conversion alternator reaches 12 volts at very low rpms for cut-in, but look what happens at 10 amps of output: 400 watts being used as heat while charging the batteries at 130 watts. With the Volvo alternator at 10 amps, only

25 watts are used up as heat, and at 50 amps it is wasting 625 watts while charging at 600 watts...and therefore is starting to become inefficient.

Alternator Design

- **Factors--**Making PM alternators from scratch is sort of a "black art"--there are many factors that enter in to it, we try to discuss some of them below. And then, you must add in another important factor, the design of the blades! We discuss that below also. We didn't start building windmills and alternators by doing a bunch of math...we just jumped right in, made lots of mistakes, and eventually wound up with a satisfactory design by observing performance and changing one variable at a time!
- **Bearings--**The operative word here is STRONG! Besides having to withstand vibration and high rotation speed, there is a significant amount of thrust back on the bearings from the wind, and it increases geometrically as the prop size increases. That's why we've moved to using automobile wheel bearings in our designs, they are tapered and designed to take the thrust loads. The front bearings in our converted AC induction motors have so far held up well, but they are not designed for that kind of load. DC tape drive motors are especially vulnerable--the front bearing will eventually fail dramatically in high winds if extra bearings are not added.
- **Number of Poles--**The faster that alternating north and south magnets poles pass the coils, the more voltage and current are produced. It is an advantage to use more magnets, and more coils...but the coil resistance does add up and hurt high-speed efficiency. If your cut-in speed remains acceptable, though, you can connect your stator in parallel instead of series, which reduces the total resistance. More on series and parallel below. Of course, the number of poles and magnets is also limited by the physical size of your unit.
- **Series or Parallel?**When the coils are connected in series, the voltage increases and so does resistance. When connected in parallel, voltage stays the same but amperage increases and resistance decreases. The correct configuration for your project depends on many factors. Our Volvo disc brake windmill design has each half of the stator coils connected in series, and the two halfs connected in parallel. With a 3-phase machine, these configurations are known as Delta (series) and Star (parallel). One good solution would be a unit that starts up in series for better cut-in, and then switches to parallel for better efficiency and performance when the speed increases. Others have built regulators like this...we do not generaly use them, and therefore we trade a small amount of efficiency loss for a MUCH simpler and more reliable machine.
- **Magnets--**The stronger, the better. The larger and stronger your magnets are, the more power you can produce in a smaller alternator. Neodymium-Iron-Boron ("rare earth", NdFeB) are by far the strongest permanent magnets known to man, and are ideal for building permanent magnet alterantors. Many older designs call for strong ceramic magnets, this was mainly because of price. We do sell large, high-grade ceramic magnets on our PRODUCTS pages that are suitable for alternator use, but in practice NdFeB magnets will give over 4 times as much power in the same space than ceramics. Plus, prices on large NdFeB magnets have dropped dramatically since they were first invented in the 1980s. We have a big selection of them on our PRODUCTS pages, and be sure to check out our sister site WONDERMAGNET.COM for more magnet information and

FAQs. **WARNING! Large NdFeB magnets are EXTREMELY powerful, and can cause serious injury from pinching. A steel armature packed with 20 NdFeB magnets is powerful enough to break your fingers if you get them between it and a large piece of metal! Also, NdFeB magnets are brittle, and will shatter if allowed to snap together, sending sharp shards flying at high velocity. Use gloves, eye protection, and zen-like concentration when handling large magnets and assemblys!**

- **Wire--**Enamelled magnet wire is always used for winding the stator, because the insulation is very thin and heat-resistant. This allows for more turns of wire per coil. It is very difficult to strip, use a razor knife or sandpaper, and be sure to strip each lead thoroughly! Choosing the gauge of wire is yet another trade off--thinner gauge wire allows for more turns per coil and thus better voltage for low-speed cut-in, but using longer, thinner wire gives higher resistance and therefore the unit becomes inefficient faster at high speeds. Our larger alternators use 14-16 gauge wire, the smaller ones 18-22 gauge.
- **Air Gap--**This is the distance between the magnets and the laminates. The smaller the distance, the better the alternator performs. This means it's important to keep the coils as flat as possible, and to make the armature fit very precisely near the stator...if it is not perfectly square, the air gap will be larger on one side of the alternator than the other, and performance will be compromised.
- **Laminates--**The laminates serve to complete the MAGNETIC circuit, increasing power output dramatically over designs that don't use them. Each piece of laminate is insulated from the next to prevent the build up of eddy currents, which waste power and slow the unit down. We have found that thin coils of cold rolled steel strips, insulated from each other by tape, work very well for this. The important factor is that the material must make a POOR temporary magnet...in other words, it must be difficult to magnetize. We've tried pallet banding and bandsaw blades, and the results are very bad...these materials magnetize too easily. Stick with cold rolled steel (easy), or modify the laminates from an electric motor (difficult).

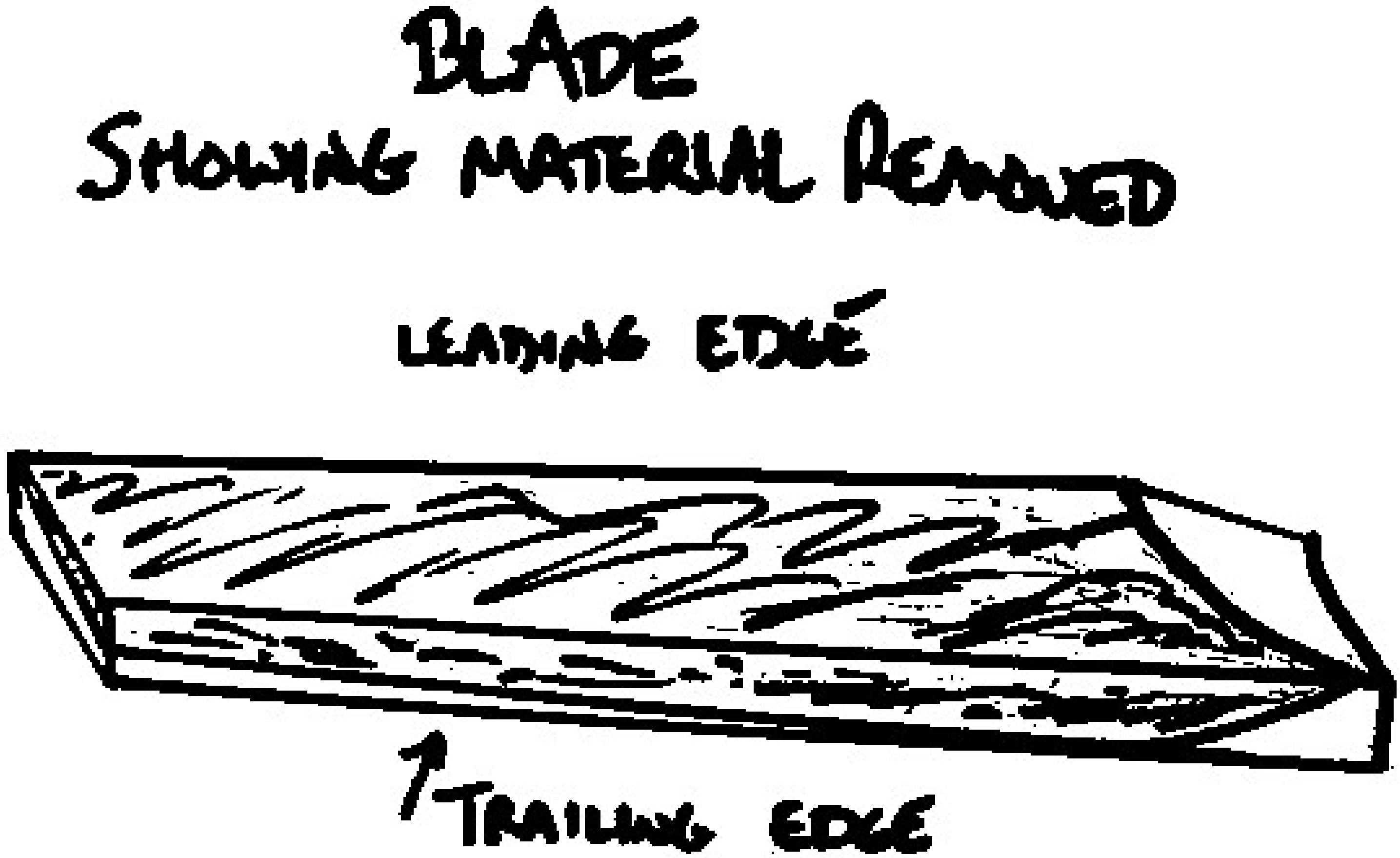
Rotor

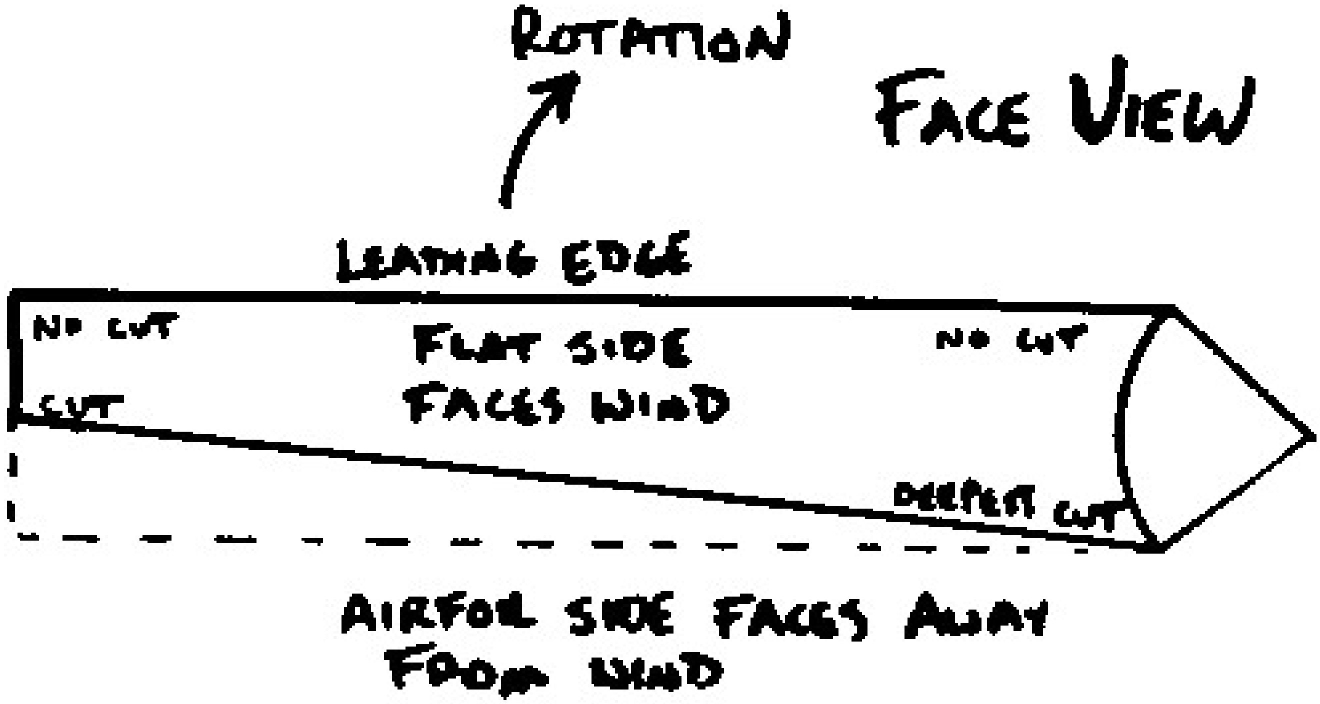
- A wind generator gets its power from slowing down the wind. The blades slow it down, and the alternator collects the power. BOTH must be correctly designed to work together and do this efficiently. We are not experts at blade design...we sort of started in the middle with a functioning design, and made changes from there. Really, you could make a simple set of blades with a straight 5 degree pitch down the entire length and they would work JUST FINE! But to really tune in the performance of your wind generator, it's important to pay attention to a few factors. ALSO--please forgive us when we slip up and refer to the rotor as a "prop" or "propellor"--it doesn't propel anything! Rotor is the proper term, not to be confused with the rotor of an armature. But we slip up sometimes...
- **Some REALLY GOOD rotor design information** can be found in Hugh Piggott's free downloadable PDF Blade Design Notes. His notes and diagrams of the blade layout and carving process are located HERE. Another excellent resource is WindStuffNow.com, with good information and low cost blade design software.
- **Blade Material--**Wood is really an ideal material for blades. It is very strong for its weight, easy to carve, inexpensive, and is resistant to fatigue cracking. Choose the best, straightest, most knot-free

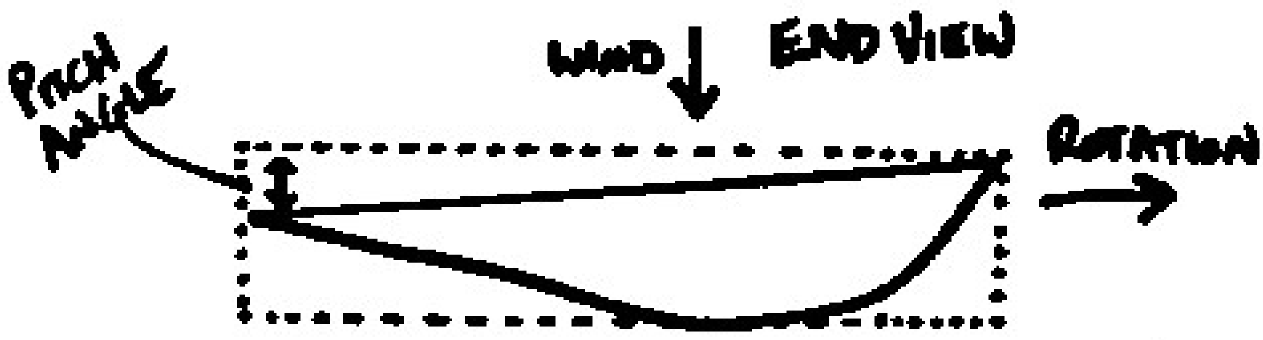
lumber you can find; pine and spruce are excellent. Hardwoods are generally too heavy. Steel and aluminum blades are much too heavy and prone to fatigue cracking; sheet metal would be a poor choice, and extremely dangerous...check out the photo of fatigue cracks on a sheet metal windmill TAIL in Ward's Prop Gallery and imagine what the vibration would do to sheet metal blades! Cast reinforced Fiberglas® blades are very strong, and are common on commercial windmills--but the moldmaking process would take longer than carving a complete set of blades from wood, and there would be little or no gain in strength.

- **Diameter--**Blades that are too short attached to a large alternator will not be able to get it moving fast enough to make good power. Blades that are too large for a small alternator will overpower and burn it up, or overspeed to the point of destruction in high winds--there's not enough of an alternator available to collect the energy coming in from the wind.
- **Number of Blades--**The ideal wind generator has an infinite number of infinitely thin blades. In the real world, more blades give more torque, but slower speed, and most alternators need fairly good speed to cut in. 2 bladed designs are very fast (and therefore perform very well) and easy to build, but can suffer from a chattering phenomenon while yawing due to imbalanced forces on the blades. 3 bladed designs are very common and are usually a very good choice, but are harder to build than 2-bladed designs. Going to more than 3 blades results in many complications, such as material strength problems with very thin blades. Even one-bladed designs with a counterweight are possible!
- **Tip Speed Ratio (TSR)--**This number defines how much faster than the windspeed the tips of your blades are designed to travel. Your blades will perform best at this speed, but will actually work well over a range of speeds. The ideal tip speed ratio depends on rotor diameter, blade width, blade pitch, RPM needed by the alternator, and wind speed. Higher TSRs are better for alternators and generators that require high rpms--but the windspeed characteristics at your particular site will make a big difference also. If in doubt, start in the middle and change your blade design depending on measured performance.
- **Taper--**Generally, wind generator blades are wider at the base and narrower at the tips, since the area swept by the inner portion of blades is relatively small. The taper also adds strength to the blade root where stress is highest, gives an added boost in startup from the wider root, and is slightly more efficient. The ideal taper can be calculated, and it varies depending on the number of blades and the tip speed ratio desired. Hugh Piggott's Windpower Workshop book and his free Blade Design Notes contain the relevant formulas, and WindStuffNow.com's blade design software will help you with this too. Honestly, though...if you simply take a look at a picture of a functioning small-scale wind generator's blades and estimate the taper by the eyeball method, you will come very close to meeting the criteria and have a very functional blade! The calculation is done by balancing the thrust from lift with the energy needed for Betz's momentum change and Newton's Laws (whew).
- **Pitch and Twist--**As we've said before, a simple wind generator blade with a straight 5 degree pitch down the whole length would give adequate performance. There are advantages to having a twist, though--like with taper, having more pitch at the blade root improves startup and efficiency, and less pitch at the tips improves high-speed performance. One of our common blade designs that's right in the middle for design parameters is to build an even twist of 10 degrees at the root and 5 degrees at the tip--but the ideal solution will also depend on your alternator cut-in speed, efficiency and local wind patterns.
- **Carving--**Our layout and carving process is very simple...after marking the cut depth at the trailing edge at both the root and tip, the two depths are connected with a pencil line. DanF likes to use a hand saw to make layout cuts into the blade every couple inches along the length before firing up the electric

planer...when the saw kerfs disappear, the pitch is correct. DanB prefers to hack into it with a planer right from the start. In case you are fuzzy about how this all goes together, the drawings below might help.







- **Airfoil--**There are great lengths that you can go to for designing an airfoil...NASA has some great information and calculations out there on the net. But all an airfoil needs to do is maximize lift and minimize drag. You will do fine if you do like we did--find a likely looking airfoil cross section from a working wind generator blade, and copy it! A power planer makes quick work of carving it, and the airfoil side is a great place to change the weight distribution when balancing the blades.
- **Balancing--**The blades must be very well balanced to prevent vibration. This is more easily accomplished with a 2-blade rotor than a 3 bladed one. But generally, we simply use a homemade spring scale to make sure that each blade weighs exactly the same, and that each has the same center of balance. A simple balancing jig for any rotor configuration can be made with an upright spike that sticks into a dimple punched at the exact center of the hub. Excess material from the heavy areas can be removed quickly with a power planer.

Furling and Shutdown Systems

- **Furling Systems--**We use the term "furling system" to describe a mechanism that turns the wind generator rotor at an angle out of the wind, either horizontally or vertically, to protect the machine from damage during high winds. We generally don't use them up here at Otherpower HQ--we try to make our machines last through our normal 60 mph winds with no furling, and we use an electrical shutdown system if winds get severe. The disadvantage of furling the unit out of the wind is that all of the output power is lost during the furling incident (despite some manufacturer's claims to the contrary--they get around it by using 'average' windspeed in their furled power calculations), and in turbulent winds the furling action can be extremely violent, stressing the entire unit greatly.

There are a variety of furling system designs:

- **Variable Pitch--** An ideal but extremely complicated solution is to use blades which change pitch depending on the wind speed....these also have the advantage of keeping power output at the most efficient point for the current windspeed. During low winds, the blades are pitched for best startup. In higher winds, they rotate and adjust shaft speed to the ideal RPMs for the generator. In extreme winds, they turn the blades even further to protect the unit from damage. The problem is the complexity of making a system work reliably...but it can be done! Large commercial wind generators use this system exclusively, as do antique and modern Jacobs turbines, and some old WinChargers.
- **Tilt-Back--**In these designs, the generator body is hinged just behind the nacelle. When wind speed gets too high, the entire nacelle, hub and blade assembly tilts back out of the wind to nearly vertical. As the wind slows down, it returns to normal horizontal operating position by either springs, wind action on a tilted tail, or a counterweight. Commerical wind generators that use this method are the old Whisper models (from before the buyout), the Windstream, and many homemade designs.
- **Furling Tail--**The generator is mounted off-center horizontallly from the yaw bearing. The tail is also angled in this axis. The tail is also angled in the vertical axis, and hinged. When the wind force back on the rotor is strong enough to overcome the off-axis generator making it want to yaw and the angled tail trying to keep it from yawing, the tail folds up and away from the wind direction, forcing the wind turbine to yaw out of the wind. When wind speeds drops, the tail is returned to normal operating position by gravity, or springs. Many commercial and homemade designs (including the new Whisper series, Hugh Piggott's Brakedrum windmill, and Bergey turbines (up to 10 kW!) use this system, and it has proven to be very reliable.
- **Folding Vane--**Similar to the furling tail, but the tail boom is fixed, with a hinged vane underneath. Used on some older Winchargers and homemade designs, the disadvantage is that tail and vane are more highly stressed from wind force during furling, as they still are sticking out there in the gale.
- **Flexible Blades--**The theory is that the blades flex both back toward the tower and around their main axis, and therefore protect themselves from overspeeding. It does work if the materials and details are correct...for example, the blades must not flex back far enough to hit the pole, and they must withstand flexing during cold weather too. The popular Air 403 and new Air X from SouthWest Windpower use this system for furling. One problem is that it is noisy....in fact the Air 403 is noisy even in gentle 15 mph winds, BEFORE it starts producing power! The Air X has some fancy electronic circuitry to reduce noise.
- **Air Brakes--**Noisy and full of vibration, but they do work! Older WinChargers used this

system. Metal cups extend from the hub from centripetal force durinhg high winds, and noisily slow the machine down; they retract back into the hub when the wind slows.

- **Shutdown Systems--**This is a manual control that completely shuts the wind generator down. It is not allowed to spin at all, and should be able to survive extremely violent winds in this condition. It can be electrical or mechanical.
  - **Electrical Shutdown--**With permanent magnet alternator machines, simply shorting the main AC power output leads together should effectively shut down the wind turbine. The problem is that when the machine is spinning at high RPMs during a windstorm, the shutdown may be either impossible electrically (the turbine is performing too inefficiently for shorting the output to have any effect), or too damaging to the alternator (the heat produced in the stator coils by shutdown at high speeds turns the coils into molten slag.) Our normal method is to simply wait for a space between high wind gusts to short the mill with a switch. We have successfully shut down Ward's turbine while it was putting 30 amps into 12vdc...numerous shutdowns at 10-20 amps of output have caused no vibration or problems.
  - **Mechanical Shutdown--**These systems physically brake the wind generator, or force it out of the wind by turning the tail parallel to the blades. Even the mighty Bergey Excel 10kW wind turbine has a mechanical crank for emergency shutdown! Generally, a cable is attached to a hinged tail, with a small hand winch located at the bottom of the tower for the operator.

Regulation

- With battery-charging wind generators, regulation of the incoming voltage is accomplished by the battery bank itself, *until* it is fully charged. Though a PM alternator or DC generator's open-circuit voltage might be 100 volts, the battery bank keeps the wind generator circuit voltage at its own level. Once the battery bank fills, system voltage will rise rapidly and something must be done with the uneeded incoming power. Simply disconnecting the windmill is *not* an option--a windmill allowed to 'freewheel' will quickly blow itself up from overspeed. The power must be diverted into some sort of load.
- **Turn on Some Lights! --**This is the oldest, simplest and most reliable method of regulation. Problem is, you have to be there to do it. But by turning on house lights, heaters, etc. that more or less equal the extra power coming in, you prevent the batteries from overcharging, keep a load on the windmill and keep your system voltage in the normal range.
- **Shunt Regulation--**These systems simply sense the battery voltage and divert all or part of the incoming wind power into heating elements (known as a 'dump load'), thus keeping a load on the windmill while ceasing to charge the batteries. The very simplest solution is a manually thrown switch that disconnects the incoming power from the batteries and connects it to some heating elements...just keep in mind the voltage requirements of the heaters must be a good match to the alternator for braking to occur. Simple systems that divert all the incoming power at once can be built using Trace C-series charge controllers or relays and voltage sensors. More complicated systems use power transistors or pulse width modulation to divert only part of the incoming

power, or the entire amount, as charging needs require. Both Home Power Magazine and Hugh Piggott's Website have plans and schematics for building shunt regulators.

- **Diodes--**A permanent magnet DC generator (such as a surplus tape drive motor) does need a diode in the line--otherwise, the battery bank will simply spin it as a motor. The diode should be rated for higher amperage than the maximum output of the motor, and must be well heat-sinked.
- **Bridge Rectifiers--**Since alternators make AC power and batteries need to charge with DC power, conversion is needed. This is accomplished with bridge rectifiers, which are simply an array of diodes. For single-phase alternators, standard bridges with 4 diodes are used. The biggest bridge that's commonly available at a reasonable cost is 35 amps--for larger wind generators multiple 35 amp bridges can be hooked in parallel to give greater power handling capacity. The bridges must be well heat-sinked to a large piece of finned aluminum or steel. Three-phase alternators need rectifiers that use 6 diodes in an array...these can be scavenged from old car alternators, or built using 6 large barrel diodes. We sell both on our PRODUCTS pages.

Slip Rings

The power produced by the generator must be transferred down the tower to your power system. Since the actual wind generator must yaw to keep pointed into the wind, the main power wires must be able to handle this. There are 2 options...

- **No Slip Rings--**Our personal experience up here in Colorado is that it is much easier to simply use a length of flexible cable and a steel safety cable instead of slip rings. Use the highest quality stranded, flexible cable you can find and attach it in a loose loop from the wind generator power terminals to where your feed wire comes up the pole. Use a length of wire that allows about 3 or 4 wraps around the pole. Or, run the wire down the center of the tower pipe and let it twist inside. Provide heavy-duty strain relief at the generator and at the tower. So the power wire will not get stretched or twisted, cut a length of aircraft cable and attach it on both ends too, so the cable will wind around the tower and stop the machine from yawing before the power wire streches and pulls loose. Our experience is that while the cord can eventually wind itself around the pole, it will also eventually unwind itself. Some of our models have flown for years with this kind of system and required no maintenance. This is because during wind storms in our area, the prevailing winds are usually from a very narrow range of directions, so very little direction "seeking" from the wind generator occurs.
- **Make or Convert Slip Rings--**Slip rings can be salvaged from old car alternators and converted to wind generator use, or built from scratch using copper pipe, PVC pipe and graphite brushes. Home Power Magazine has had articles in the past about both methods. We have never felt the need to use them, so have not experimented with it.

More Homebrew Wind Power Information on Our Site:

Tips on Designing and Building a Wind Generator at Home	**Choosing Alternators/Generators for Wind Power**
Glossary of Wind Power Terms	**Building a Tower**

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