Warlock Engineering

Topic 1: Plan Questions

Question 1 (before purchase)

I am interested in a blade radius between 5.5 m and 10.0 m (approx 30kW - 100kW) - $89.95. I have a few questions

1. Does the plan include how to construct the stator?
a. Coil how many turns?
b. What size of wire awg

2. What diameter size of rotor?

3. Wiring schematics
a. How to wire the individual rectifier?
b. how to wire battery system?

Question 1: Answer

Our plans specify blueprints of airfoil cross sections, as shown on the preview page. These are generated as .pdf files.

Use the blade calculator to match these airfoil sections with the RPM and power of the generator you currently own, It is important to match the RPM and power to an existing generator as it is more challenging to design a generator to match existing blades

Please note: no materials for constructing the turbine blades are included (pdf document only). We offer custom blueprints for the blades alone. The plans for turbine blades between 5.5 m and 10 m are quite large and include many cross sections, taking from 7 to 10 business days to produce.

Question 2 (after purchase & delivery)

In the plans that you attached for 3 blades, 960 W at 10 m/s, there appears to be a page missing that shows the assembly order for the differing chord shapes, as per that given in the bonus 3 blade: 500 W: 12.5 m/s version.

Can you please supply an assembly figure to illustrate the order, or resend an updated/corrected pdf with the page?

Question 3 (after purchase & delivery)

I just bought a set of plans, how long will they take to reach my inbox?

The wind speed did not appear to change on the sample preview. I also am curious about using airfoils other than NACA2412 in a plan, are these profiles available?

Question 2: Answer

There is no page missing, the assembly order of the blades is in numerical order.
The lowest number is closest to the hub (center) and the highest number is the one at the tip (at maximum radius). The 3 blade bonus is given as a working example for how to position the chord shapes along the root and the same method is applied to all size blades.

When you get closest to the hub, you may notice that some of the chord shapes are missing (for example, chord 1 will never be used). The chord closest to the hub should be an appropriate shape to fit to your generator and the next few equally spaced chord sections will allow your blades to attach firmly to the generator.

Depending on your generator design, the shape of the first chord sections will vary and you'll have to customize it to fit. General assembly illustrations are now included on the order page.

Question 3: Answer

Thanks for your questions, your **plans will be ready within 7 - 14 days**.

The rated power output is specified for each wind speed.
You will get the power output rated at whichever wind speed has been specified on your plans. This correlates to power output at your custom wind speed in the design page.

We are currently working on an easy system for custom airfoil shapes. We would still be happy to receive your enquiry for custom airfoil orders.

Topic 2: Design Questions

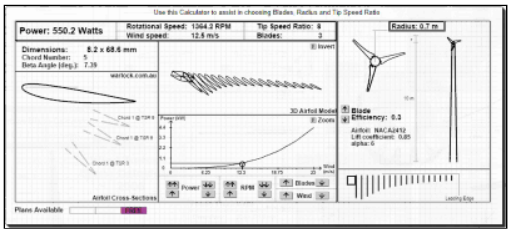
Question 1 (after purchase & delivery)

Hi Warlock, I bought some plans off you a short while ago and my blades are looking really good. Now this might seem like a silly question, but there is a small lingering doubt in regards to the direction of rotation.

Does the 'lift' face of the aerofoil face into or away from the wind?

Any info here would be most appreciated!

Regards, Chris



Design custom blades for your generator and calculate power output at each wind speed.

Question 1: Answer

Our 2 bladed projects have used a normal camber (leading edge is the rounded edge) and we have tried an inverse camber for the 3 bladed example (leading edge is the sharp edge). In all cases the side of the blade with the more shallow camber is facing the wind. The blade will actually spin if it is put on the wrong way, but only due to drag and will never start to generate lift.

A good (and serious) starting point to look at the effects of lift are; http://www.grc.nasa.gov/WWW/k-12/FoilSim/index.html .... and its surrounding contents.

I also enjoyed this simple wind tunnel experiment.
http://www.youtube.com/watch?v=RgUtFm93Jfo

Your first turbine will look odd.....you're probably going to build it and put it on in both orientations and that really is the best thing to do. Even if it takes off like a rocket, see what it does when it gets hit with a gust of wind from behind by trying the opposite way, be careful of electronics when doing so.

At a design TSR of 8, you can expect a big change in turbine speed over the range from TSR 6 to 9. The turbine will literally take off like a plane propeller and you need to be able to measure large changes in open circuit voltage with small changes in wind speed. A brake is essential for this and we found that by applying a much higher load (or dump-load) or pulsing a short circuit on the coils was most effective to slow the turbine if it was spinning too fast.

P.S. Make sure the root of the blade (first 1/3 from the hub) is reinforced well

Question 2

... when choosing lower TSR,

the angle of attack for the various blade airfoil sections increases?

Also, what about the efficiency? Moving to lower efficiency, what changes on the blades?

Many thanks in advance for your feedback, Michael.

Question 2: Answer

The lower angle of attack will help with startup, generating power at lower wind speeds. Efficiency is lost in manufacturing. Choose a size for your blades that you can build accurately and this will increase the efficiency. Also make sure that the finished surface is smooth.

Question 3 (after purchase & delivery)

Can you please send us only in ACAD format via this email?

Thank you. Regards, Besnik.

Question 3: Answer

The wind turbine blade cross-section are generated in Portable Document Format. This allows the wind turbine plans to be printed to scale with free software. It was decided not to generate in AutoCAD as it is not free. Unfortunately, there is no easy way to convert PDF to ACAD format.

Question 4 (after purchase & delivery)

I get different beta angle when using the Wind Turbine Blade Calculator on your site than the one mentioned in the data sheet you sent me for the following turbine:

TSR = 7
Blades = 3
Efficiency = 0.3
Wind speed = 7 m/s
Blade length = 0.5 m

For example, at 50mm (0.05m) the site lists an angle for beta = 37.6 deg. In the specs sheet you sent me, the corresponding angle is 4.875 deg.

Why this difference? Am I missing something?

Q&A Topics

Question 4: Answer

You might have noticed in the plans that chord sections 1, 2 and 3 progressively taper back to an angle of 0 degrees as the blade approaches the hub. There is also a gradual reduction in chord size. This is necessary to attach the blade to the hub or directly to a generator.

The 'theoretical' chord size is calculated using our software on;
www.warlock.com.au/bladecalc-abstract.htm

Radius (m)	Chord (m)	Beta (deg.)
0.05	0.224	37.6
0.1	0.112	19.5
0.15	0.075	11.6
0.2	0.056	7.4
0.25	0.045	4.8
0.3	0.037	3
0.35	0.032	1.7
0.4	0.028	0.8
0.45	0.025	0
0.5	0.022	-0.6

The 'theoretical' chord size for the second row matches 'chord section 4' in your plans. This is the largest chord used for this blade. The chord sections from chord 4 to 20 are also exactly the same as the ones calculated on the web page.

In practice, the remaining chord at 0.05 m is usually found to be too large to incorporate into the blade as it prevents it from easily being attached to the generator. For this reason, the 'practical' chord size and angle close to the generator are different from the 'theoretical' ones found by calculation.

Hope this helps

PS: If you wish us to provide the chord sections 1 to 3 at their theoretically calculated sizes and angles we would be happy to do so at no charge. It may require 28 days for manuscript editing but it is possible.

Question 5

Your blade calc is great piece of software although, I'm confused about some measurements and must ask about it:

1. When you say radius, do you mean radius of one blade or whole turbine?

2. When I put these parameters:

TSR = 6
Blades = 3
Efficiency = 0.35
Wind speed = 14.4 km/h
Blade length = 4.2m

It says that blade in its root must be 2.562m wide?! Is this some kind of error in calculations or what? Or i mismatched or misunderstood something? Is the width of the wing, right? If so, it would be strange if the wing length of 2.1 meters is 2.5 meters wide at the base?? Then it's a tent, not a wing of wind generator :)

Question 5: Answer

The radius is the distance from the center outwards. For example, if the blade radius is 4.2 m, one blade is 4.2m. The overall diameter (distance across) is 8.4m. If the theoretical chord size is about 2.5 m at the root, this is almost impossible to build.

This is a THEORETICAL size for if you wanted to continue the shape all the way to the middle of the wing. Most blades don't do this and neither do we. We use the chord sizes generated by the software from the tip to as close as possible to the hub, but when they get too large (or too close to the center) we taper the chord size to fit onto the hub. This way we have a shape as close as possible to the theoretical for most of the blade except for the distance closest to the center. We have to make the center part of the wing smaller for convenience and this is the same with almost all wind turbine blades.

Question 6

Dear Sir,
Thank you for sharing your design for the 500 W turbine. I am very interested in building similar. I plan to build the blades first and would be very grateful if you could answer the following;

- Our average wind speed is 11knts (20km/hr), would a T.S.R of 8 be okay?
- Approx what would start up speed be?
- How noisy are these blades as live in a suburban setting?

I am hoping to have tail furling before blade noise gets to loud.

Question 6: Answer

To answer your question, the blades will spin at 20 km/h but the output will be very low (~50 W). Real power begins to be generated at 30 km/h and the blades begin to generate thrust. T.S.R. of 8 is OK but no higher, try to match the blade TSR to the generator RPM. The blades shown are not noisy even at 50 km/h and cannot really be heard above the noise of wind through trees and other objects

Question 7

Can you help us design a turbine blade that is efficient and safe to meet the requirements of EN 61400?

Question 7: Answer

The structural requirements are specific to your location, you may need to follow a procesure given in the standards documentation and verify the physical strength: WG8 Full Scale Structural Testing of Rotor Blades for WTGS; (from "http://www.awra.org/standards/iec_stds.html")

Topic 3: Electrical Questions & Generator Matching

Question 1

In your plans "10 kW, 15phase Axial flux pancake generator for 2-blade Wind Turbine" in the abstract page;

"Each coil is individually rectified to dc, reducing cogging and allowing better control over the output voltage".

Can you help me with the schematic of how each coil is individual rectified and how they are wired to the battery? I would highly a appreciate you assistance.

Question 1: Answer

The coils were wired individually to collect more data during testing.

I advise you to use a 3-phase coil wiring, or use single phase for simplicity.

Can you provide some more information on your design?

Question 2

I am building the blades for down wind turbine that will go on to a 1 kW generator.

Blades = 2
Wind speed = 5 m/s
Blade length = 1.15 m

Why have you used the NACA2412 airfoil?

Question 2: Answer

Thanks for supporting our site. The reason we used NACA2412 airfoil was because it was described by a reference in our early research, and it worked, so there was no need to change it.

-You haven't specified TSR. This can be calculated from the RPM of your generator at rated power.

Please email your required TSR or power @ RPM

-You are running at very low wind speed, I would suggest a few guidelines for a low start-up:

1. Use a very low cogging generator, axial flux core-less would be the best.

2. More blades at a low TSR will give a better startup torque to get over the cogging effect.

-If you are not using a axial-flux core-less generator i would recommend 3 - 5 blades with a TSR of 4 - 7 depending on the RPM of your generator.