6 Generator Testing Data Analysis

1. Using the generator equations below.
2. Insert your measured component values.
3. Create a spread sheet and plot the data.
4. How close is the calculated and measured data?

Turbine Generator Voltage

Student_______________________________________

Procedure

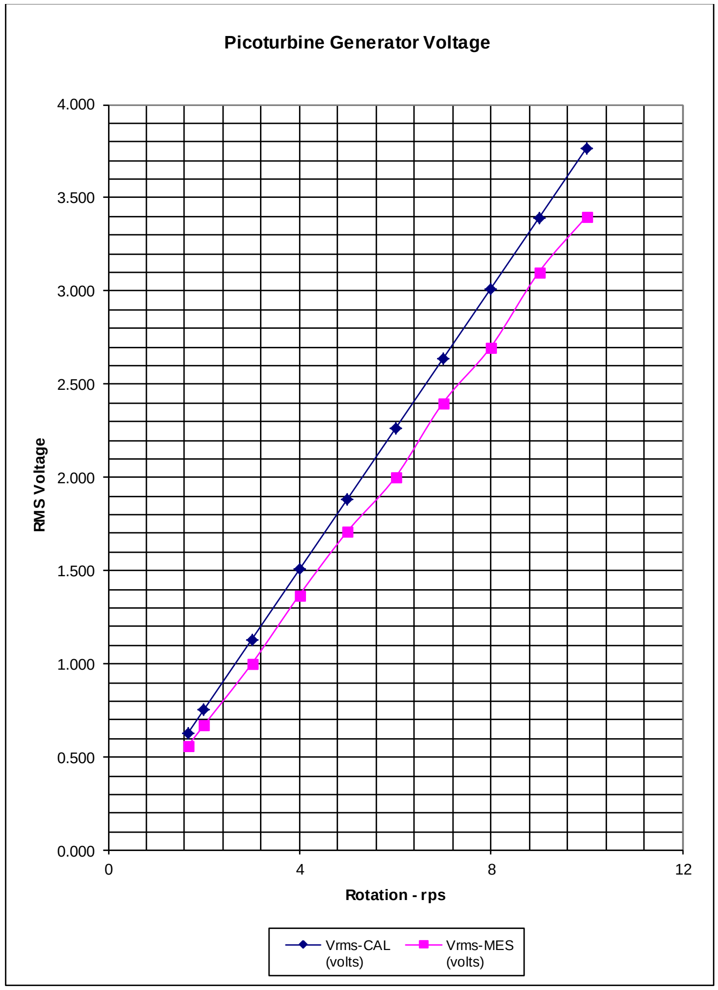
1. Vary the RPM using the frequency as an indicator
2. Record frquency and voltage

	Nominal	
N - Number of loops of wire	888	
A - Area enclosed by loop (m^2)	0.001154	* Average
P - Number of Magnetic poles	4	
B - Magnetic pole strength (Tesla)	0.13	
Z - Rotational velocity of magnets (rps)	below	
F - Frequency of Voltage (Hz)	below	

Calculated No-Load rms Voltage

V_{rms} = 0.707 * N *A *P *B *Z

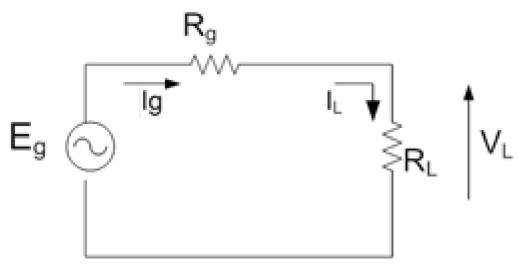
Target Values		Measured				Calculate
Tach RPM	F Hz	Tach RPM	F (Hz)	Z (rps)	$V_{rms-MES}$ (volts)	$V_{rms-CAL}$ (volts)
100	3.3	100	3.3	1.665	0.56	0.627
120	4.0	120	4.0	2	0.67	0.753
180	6.0	180	6.0	3	1	1.130
240	8.0	240	8.0	4	1.37	1.507
300	10.0	300	10.0	5	1.71	1.884
360	12.0	360	12.0	6	2	2.260
420	14.0	420	14.0	7	2.4	2.637
480	16.0	480	16.0	8	2.7	3.014
540	18.0	540	18.0	9	3.1	3.391
600	20.0	600	20.0	10	3.4	3.767



Generator Model and Analysis

A complete analysis in Appendix-A

The following is the equivalent circuit for a wind turbine.



Equivalent Circuit

Where:

- E_g = the open circuit voltage with R_L open.
- R_g = the internal generator resistance
- Ig = the current flowing out of the generator
- R_L = the load resistance
- I_L = the load current
- V_L = load voltage

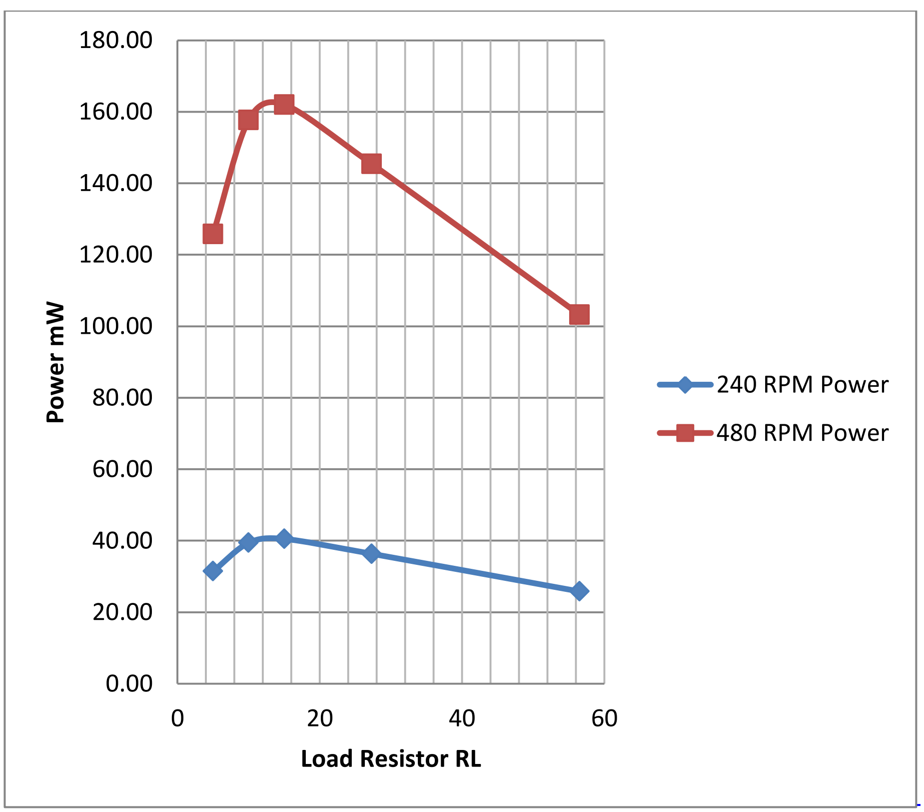
The conclusion of the analysis is the total generated power P_T is:

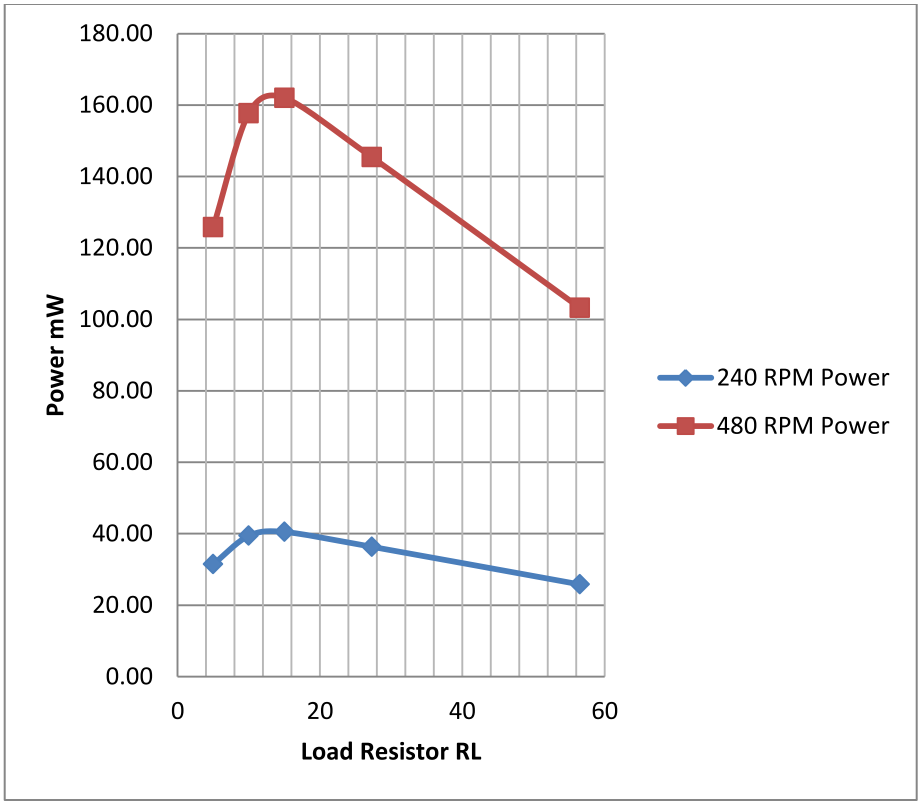
$$P_T = (V_L^{\ 2} / R_L)\,(1 + R_g / R_L)$$

Some of the power is lost in the internal windings of the coils, R_g and some of the power is delivered to the load R_L. Only the load power can be used for some useful application.

Create a spreadsheet plotting Load Resistance vs. Total Power. Create another spreadsheet of Load resistance vs. Load Power.

You should get a chart that looks like this:





What value of RL gives you the peak output power?

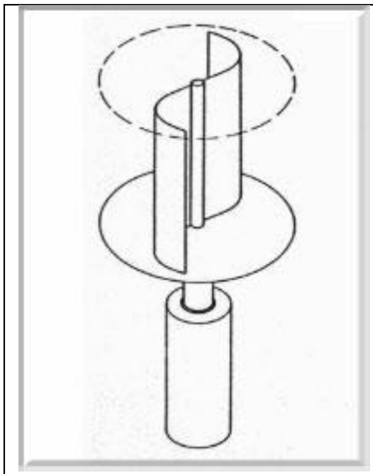
7 Add Wind Blades

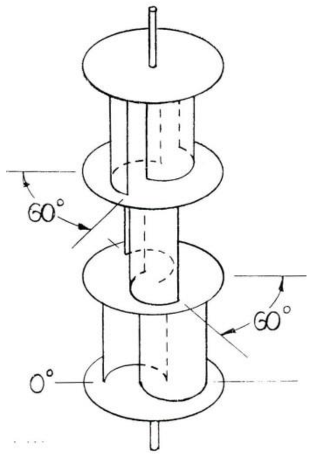
This part of the project will require the teams get creative about how your turbine will capture wind energy, convert it to mechanical energy and turn the generator shaft for electrical energy. This will require an effective application of the engineering design process, Think-it, Design-it, Build-it, Test-it, Fix-it. Given the semester time frame, team meetings at school and out of school are going to be required.

Things you will have consider:
The first wind blade implementation will not be your final one. You will be given an opportunity to learn from your first design and design, build and test a second one.

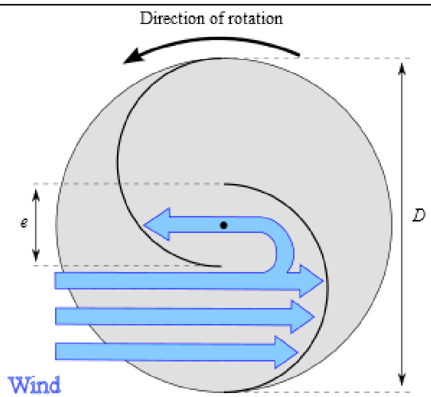
We recommend that the first blade design be a Savonius type design. This paper will give you an introduction to this design but your team will have to do some additional research, discussion and decision making. The outcome will be its construction and integration with the turbine unit you have already built and tested. (see references or Google)

Savonius Wind Turbine

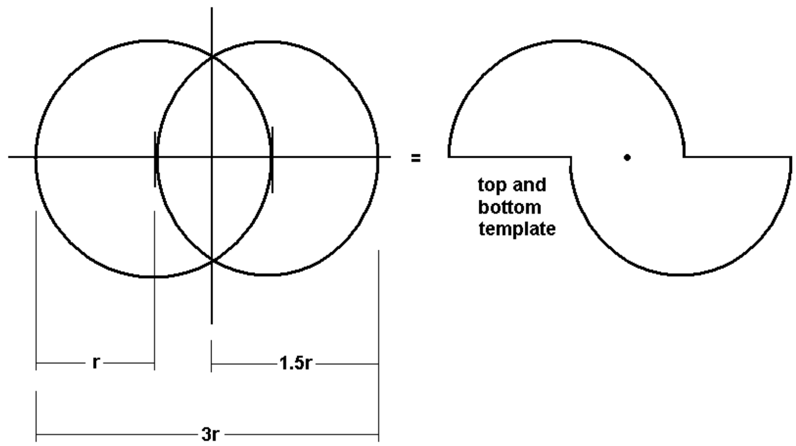




Principle of Operation

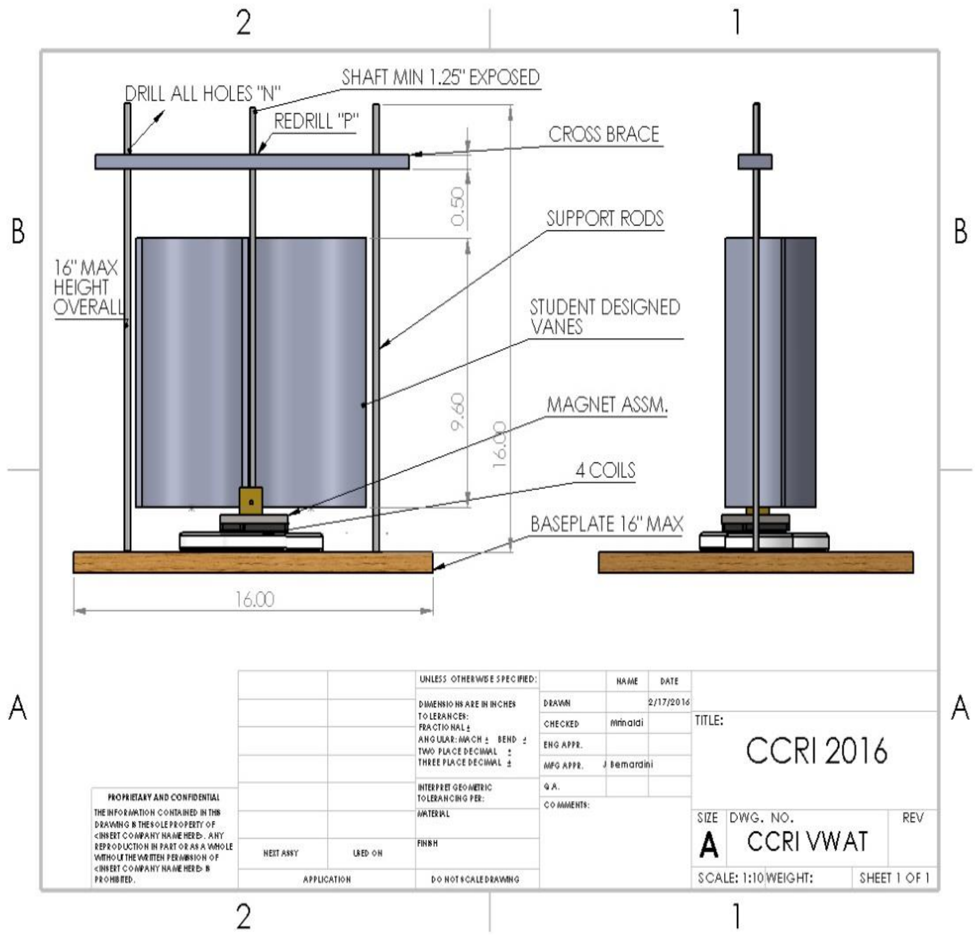


Darrius Model VAWT (Top View). Source Wikipedia.



A starting place for the design is the amount of overlap of the two semicircles. From the figure below a starting place is 0.5r; where "r" in the radius of the blade structure. There is some trade -off between the rate of rotation and the maximum power that can be obtained from the turbine. If "r" is smaller the turbine will turn faster in low wind but in high winds produced very limited power. By increasing "r" the power required to start the turbine turning will be greater but the maximum power output will be greater at higher wind speeds.

Starting with the requirement that the overall wind turbine cannot be any higher tan 16 inches the drawing below show that the height of wind blade is approximately 11 inches. Your blade design should make the blade height as close to dimension as possible.



The overall width of the wind blade unit has to fit in between the two vertical supports. Using a 11.75 inch base, the spacing is approximately 9.5 inches. If you us the overall width as "3r" (from the drawing above), "r" is approximately 3 inches (3r =9, therefore r=3). You could make "r" somewhat small as a starting point. Remember the wider the blade the more power that will be required to start the turbine rounding and rate of rotate the shaft and shaft rotation determines the output voltage.

The next problem you have to consider is how you are going to couple the wind blade to the turbine shaft. This will insure that the blade turning will turn the turbine shaft and generate electrical power. You want to be able to remove the wind blade from the shaft to possible experiment with the blade design. A set screw adjustment would be a simple solution. You might come up with another solution.

With the wind blades attached to the shaft you are ready to test the wind turbine in the wind tunnel.