Wind Turbine Generator Construction

Travis Gibbons

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Lab Section 2

Historically, the power of wind has been used as a means of completing mechanical tasks such as grinding grain in rural communities, pumping water out of wells, or getting people from place to place on sail ships. (Burton, et al. 2001) Further on from these simple beginnings, the concept of gathering energy from free, typically readily available, wind has advanced to where the kinetic energy from the wind can be converted to usable electrical energy through electromagnetic induction in a generator. Though this technology has been slow to implement in comparison to other energy resources, recent years have shown an increase in installed wind generating turbines in the United States. (U.S. Department of Energy 2011) It can be proposed that the popular 'green' trend pushed forward by increasing environmental concerns has a part to play in the allocation of money and interest in this form of energy attainment.

The idea of constructing a small wind turbine for use at one's home to cut down on electricity bills is an idea that has become popular within small groups and the accessibility of others' plans and success or failure stories has become as simple as an internet search which has made for a wealth of information of this topic. Before going full scale to a freestanding home turbine, a miniature, proof of concept design is selected. A design based off of Renewable Energy UK's website (Renewable Energy UK 2012) is used for this miniature turbine. For this, an everyday computer case fan serves as the turbine. *(Figure 1)* After successfully generating a small current, enough support in the design is present to proceed with scaling the turbine up and looking further to understand the physics behind this form of electricity production.

Figure 1- Computer Case Fan

Major design elements for the full scale project originate from two key online sources, *thekevdog*'s (Harris n.d.) design and the *Chispito* (Vela Creations n.d.) design. Both of these web pages detail the process used to construct a relatively inexpensive home wind turbine, and as with any construction project, the first step is gathering materials.

As per suggestion on both of my main resource sites (Harris n.d.) (Vela Creations n.d.), the first material to acquire is the heart of the wind turbine, the generator. Selecting a robust generator is crucial to the success of this project as it is what will actually convert kinetic energy to electrical energy and to choose a suitable generator, this process must be understood.

The basic function of a generator is to convert mechanical energy to electrical energy and this is accomplished through electromagnetic induction. Electromagnetic induction is the generation of emf and current when the flux passing through a conducting loop changes. By Faraday's Law, the emf which is induced in a wire will be proportional to the change in flux through the loop as can be represented with *Equation 1* where *N* is the number of loops, $\Delta\Phi$ is the change in flux, and Δt is change in time. (CliffsNotes n.d.) Now, to get the direction of

$$\textit{Equation 1}: \quad \varepsilon = -N\frac{\Delta\Phi}{\Delta t}$$

current produced from the magnetic field of the induced emf, Lenz's Law and the right hand rule can be applied. Lenz's Law dictates that the current's magnetic field will oppose the direction of the change in flux through the loop.

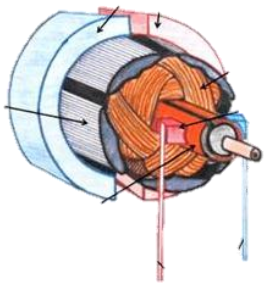

Figure 2: Motor Cutaway (CVEL n.d.)

With this information, the workings of a generator can now be understood. *Figure 2* shows a cutaway view of a motor which will function as a generator. On the figure, three key parts should be observed, the permanent magnets on the

outer part of the motor, the orange coil, and the shaft around which the coil is wrapped. When used as a generator, the shaft will be spun causing the conducting coil wrapped around it to rotate within the magnetic field of the permanent magnets. This movement converts the mechanical energy from the rotation of the shaft to electrical energy as electromagnetic induction does its work.

Various types of generators can be used depending on the purpose of the wind turbine—the same type of generator used on huge turbines on wind farms will not be used on small wind turbines used at an individual's home. (Shepard and Zhang 2011) For this application of a home wind turbine, a permanent magnet DC motor will be ideal for producing at most a few hundred watts for charging a bank of batteries or powering DC equipment when functioning as a generator. With this choice in mind, the next thing to look when repurposing a motor as a generator is the Volts-to-RPM Ratio *(Equation 2)* to get a general idea of the RPM needed to attain any particular voltage *(Equation 3)*. This ratio is found by simply by dividing the rated voltage of the motor by the rated RPM. In addition, the amperage rating on the motor should also be observed. Though it is difficult to predict how a particular motor will behave as a generator, it is a general rule that the higher the amperage rating, the better (windynation 2010) for use as a generator.

$$Equation\ 2\text{:}\quad Volts - to - RPM\ Ratio = \frac{rated\ voltage}{rated\ RPM}$$

$$Equation\ 3\text{:}\quad Desired\ Voltage = RPM * V\ to\ RPM\ Ratio$$

For the construction, an SEM SE26 5A6 motor was purchased used on eBay. This motor is rated 24 Volts, 1500 RPM, 14 Amps (140 Amps peak), with an output of .25 KW making for a fairly good choice of a motor.

Purchased to go along with the motor was a 40 Amp, 600 Volt blocking diode so as to assure current will only flow from the generator to whatever it is powering (this would be very important when charging batteries), miscellaneous pipe and connectors for the tower, a steel floor flange and nipple to create a pivoting head, PVC for blades, miscellaneous 5/8" hardware for creation of a motor arbor, wood for the hub, 10 gauge wire, several crimping sheaths, and a quick disconnect harness.

The construction of the blades is based off of *thekevdog*'s design (Harris n.d.) of cutting PVC pipe to make thin, fairly efficient blades. The blades currently mounted on the turbine are rather short. This is not the ideal design for areas with low wind as longer blades provide more area to gather wind, but for the sake of transportation, these shorter blades were constructed based off of the same design as a larger set. That being said, it is difficult to predict what amount of or type of blade will work for one's particular location and this is something I would like to continue research and experimentation on in hopes of getting a little bit closer to the Betz Limit, the theoretical maximum efficiency of any wind turbine. (Tiwari and Mishra 2012)

Figure 3: Turbine mounted in truck with camera setup for getting multimeter readings

In the end, the wind turbine came together successfully in the form shown in *Figure 4* and in terms of performance, the wind turbine exceeded my expectations. Left outside, during mild wind, the turbine will spin freely and generate a fair voltage and amperage representing success in the design of the blades. However, as the wind was not very strong when testing, the turbine was mounted to a vehicle to test the turbine's full capability. Surprisingly, maximum voltage readings were in

excess of 20 Volts and 25 Amps, blowing the fuse of the multimeter rated at a maximum of 10 Amps.

As wind turbine generators become more popular and more effort is put toward research, it will soon be increasingly commonplace to see huge wind turbines across the landscape. The work and research done on this project has provided insight toward their inner workings on how motion created by the wind can be changed into usable electricity from a concept as simple as a rotating coil within a magnetic field. Though this project has been completed successfully, leaving me with a better understand the function of generators and electromagnetic induction, there is much that can be improved upon this homemade turbine to make it more efficient, durable, and aesthetically pleasing.

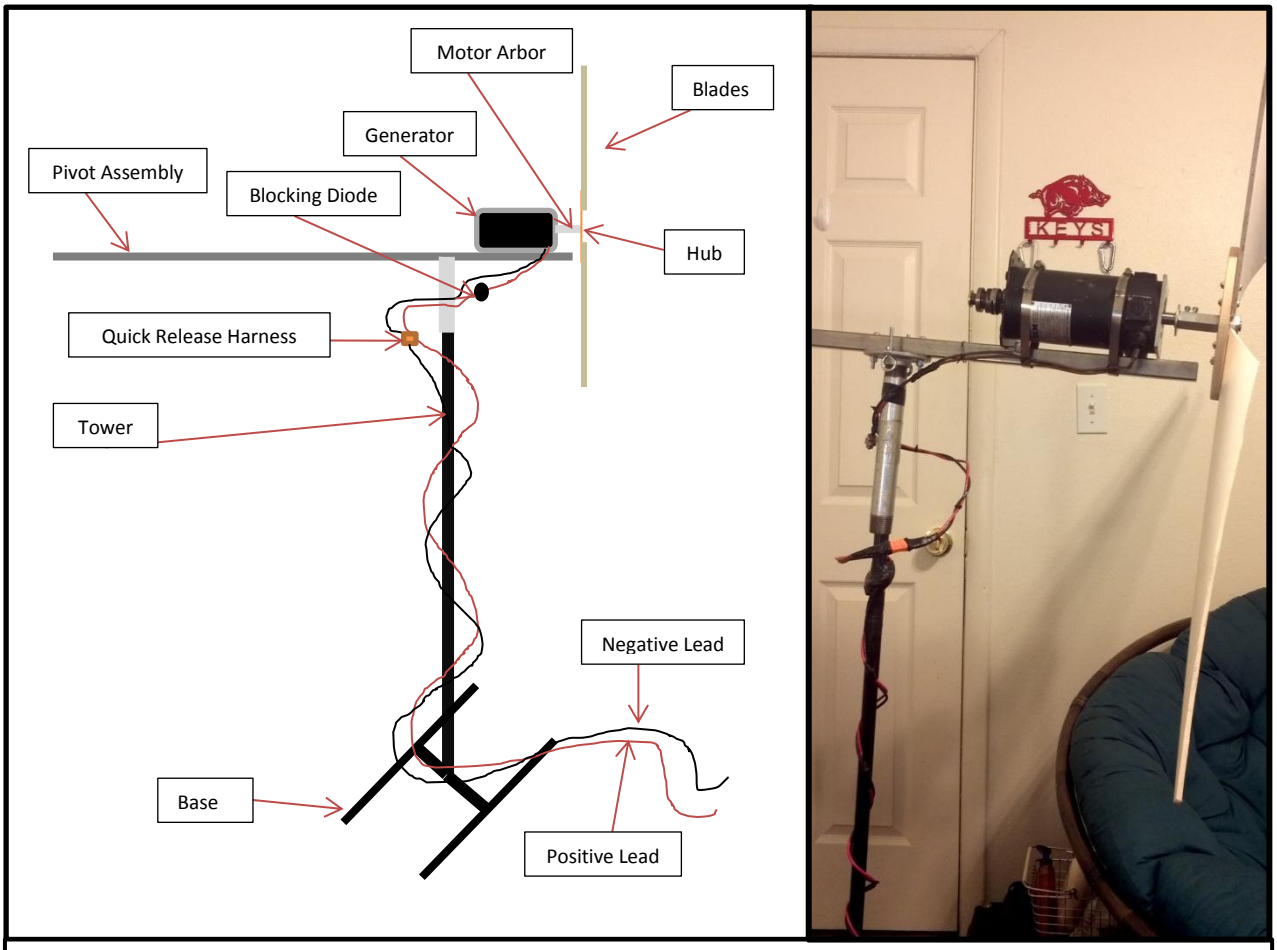

Figure 4: Construction diagram

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