Do-It-Yourself Wind Turbine Project

NOTE: **GreenTerraFirma** is looking for people in the **New York area**, who have built a diy wind turbine. Please us the feedback form to send us your details. Thanks. Feedback Form

4 Foot Wind Turbine - option for 6 Foot Sweep

There are 3 parts to this project:

1. Build the Wind Turbine
2. Build the Tower
3. Variations for your science project

Build the Wind Turbine

INTRODUCTION

There are several DIY wind turbine science projects on the internet. This project is appropriate for high school level and was originally sourced from http://www.velacreations.com a very good site, maintained by a couple living off-grid. Their site is definitely worth a look. Another good website to visit for wind turbine projects is http://www.otherpower.com though these turbines can be fairly large.

We have included some modifications to the original instructions for a larger treadmill motor which weighs more, takes larger blades, requires better fastening for the blades and uses a **bearing to attach to the tower**.

Making a wind powered generator from scrap materials is very rewarding and empowering. Most of the tools and materials you need, can be found in your local hardware shop or junk pile. We highly recommend you search your local dump and/or junkyards for the materials required. If you live in a city, do a search on freecycle.org for salvaged parts. For the wind turbine built in these pictures, we picked up the motor on eBay for $10 plus shipping and the PVC pipe for the blades from a junk pile. The tail is made from an old roller paint pan.

Safety should be your highest priority. Human life is more important than electricity, so please follow any and every safety guidelines you come across. Wind generators can be very dangerous, with fast moving parts, electrical sparks, and violent weather conditions.

This wind turbine is based on the Chispito Wind Generator with it's simple and efficient design and assembly. We have included several photos showing our changes, using the larger 20 amp motor.

SUPPLIES
A 260 VDC, 5 A continuous duty Treadmill Motor with a 6 inch threaded hub is best suited for a small wind turbine. These motors are available from motor surplus stores and on eBay. You can get about 7 amps in a 30 mph wind. In other words, it is a simple, cheap little machine to get you started.

I also picked up a 90 VDC, 20A treadmill motor off eBay for $10 plus shipping. This motor requires an upgrade to most of the original Chispito instructions due to the increase in size and weight. It also produces a lower output voltage. The motor is better suited for a vertical axis wind turbine (VAWT) with gearing to increase the RPM.

You may use any other simple permanent magnet DC motor that returns at least **1 V for every 25 rpm** and can handle **upwards of 10 amps**. The Ametek 30 is one of the best motors and can still be found on eBay, though the price seems to be getting rather high. If you do go with another motor, there will be certain changes to this supply list, for example, you will have to find a hub - a circular saw blade with a 5/8" shaft adaptor will work. For our larger motor we initially used a metal slow moving vehicle sign, bolted to a 3.5 inch pulley. The triangular shape was just what we were looking for. We reinforced the sign with a wooden ring. This hub ended up blocking much of the wind on the smaller blades and we eventually switched to a six inch wooden hub, reinforced with metal plating. When hurricane Ike went through, that hub was also damaged. Thus we'd recommend a metal hub such as the saw blade or a used metal frying pan.

Tools

- Drill
- Drill Bits (7/32", ¼", 5/16")
- Jigsaw with a metal blade
- Pipe Wrench
- Flat Head Screwdriver
- Crescent Wrench
- Vise and/or Clamp
- Wire Strippers
- Tape Measure
- Marker Pen
- Compass + protractor
- ¼" #20 Thread Tapping Set
- An extra person helps a lot!

Materials

Mount

- 36" of 1" Square Tubing - for the larger motor I used 6 ft of "L" tubing
- 2" Floor Flange - or a rotating dolly wheel with a hole in the centre (see picture)
- 2" X 4" Nipple
- 3 X 3/4" Self-tapping Screws
- For the larger 20Amp motor, I used a caster wheel with a hole in the centre(**Caster with a Hollow Kingpin)** to attach the motor to the tower. This allows the heavy motor to turn very easily and doesn't provide wear to the tower or flange.

NOTE: if you have access to a welder, you can weld a 4" section of 2" pipe onto your square tubing instead of using the flange, nipple and sheet metal screws.

Motor

- 260 VDC, 5 A continuous duty Treadmill Motor with a 6 inch threaded hub or an Ametek 30
- 30 - 50 Amp Blocking Diode (one-way)
- 2 x 5/16" x ¾" Motor Bolts
- 3" X 11" PVC Pipe - or larger depending on the size of the treadmill motor

Tail

- 1 sqft (approx) lightweight material (metal) - used roller paint tray will work
- 2 X ¾" Self-tapping Screws

Blades

- 24" length of 8" PVC Pipe (if it is UV resistant, you will not need to paint it)
- 6 X ¼" X 20 Bolts
- 9 x ¼" washers
- 3 sheets A4 paper and tape

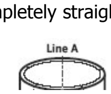
PREPARATION

Cutting Blades - makes 8 blades (or 2+ blade sets) and a thin waste strip.

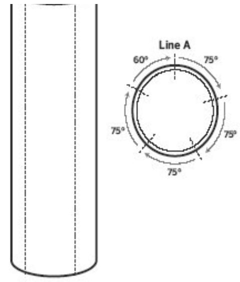
I have created a separate page with more pictures and expanded on this process a bit. After you've done this once, it makes sense. These instructions could use a little help for the first time wind turbine blade maker.

Here's the link to the page: Making PVC Turbine Blades

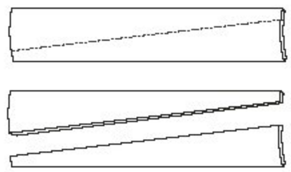
1. Place the 24" Length of PVC pipe and square tubing (or other straight edge) side by side on a flat surface. Push the pipe tight against the tubing and mark the line where they touch. This is Line A.
2. Make a mark near each end of Line A, 23" apart.
3. Tape 3 sheets of A4 paper together, so that they form a long, completely straight piece of paper. Wrap this around the section of pipe at each of the two the marks you just made, one then the other. Make sure the short side of the paper is straight along Line A and the paper is



straight against itself where it overlaps. Mark a line along the edge of the paper at each end. Call one LineB and the other Line C.



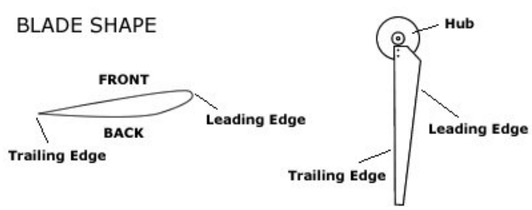
4. Start where Line A intersects Line B. Going left around Line B, make a mark at every 145 mm. The last section should be about 115 mm.
5. Start where Line A intersects Line C. Going right around Line C, make a mark at every 145 mm. The last section should be about 115 mm.
6. Mark each line using a straight edge.
7. Cut along these lines, using the jigsaw, so that you have 4 strips of 145 mm and one strip about 115 mm.
8. Take each strip and place them with the inside of the pipe facing down.
9. Make a mark at one end of each strip 115 mm from the left edge.
10. Make a mark at the other end of each strip 30 mm from the left edge.
11. Mark and cut these lines, using the jigsaw.



Note: we also made a set of blades 38 inches long using the same measuremenst - only the length was changed - 24 inches to 38 inches.

Sanding the Blades
You should sand the blades to achieve the desired airfoil. This will increase the efficiency of the blades, as well as making them quieter.

The angled (leading) edge wants to be rounded, while the straight (tailing) edge wants to be pointed.



Any sharp corners should be slightly rounded to cut down on noise.

Cutting Tail
The exact dimensions of the tail are not important. You want about one square foot of lightweight material, preferably metal. You can make the tail any shape you want, so long as the end result is stiff rather than floppy.

Drilling Holes in Square Tubing - using the 5/16” drill bit

1. Place the motor on the front end of the square tubing, so that the hub part hangs over the edge and the bolt holes of the motor face down.
2. Roll the motor back so you can see the bolt holes, and mark their position on the square tubing.
3. Drill a 5/16” hole at each mark all the way through the square tubing.

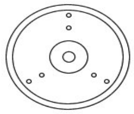
Floor Flange Holes
This will be dealt with in the assembly section of this manual, as these holes are what determine the balance.

Drilling Holes in Blades - using the ¼" drill bit

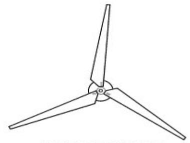
1. Mark two holes at the wide end and along the straight edge of each of the three blades. The first hole should be 3/8 " from the straight edge and ½ " from the bottom. The second hole should be 3/8 " from the straight edge and 1 ¼" from the bottom.
2. Drill these 6 holes.

Drilling and Tapping Holes in Hub - using the 7/32" drill bit and ¼" tap

NOTE: You may want to modify these instructions. Try replacing the hub with an old, used 7 1/4 inch skill saw blade. The larger surface area will give you more space to screw or bolt the blades to. We also used 1/4 inch bolts rather than drilling and tapping holes. I've also see old aluminum frying pans used for this purpose. They are light and solid!



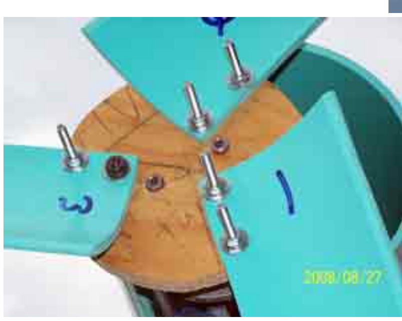
HUB LAYOUT



BLADE LAYOUT

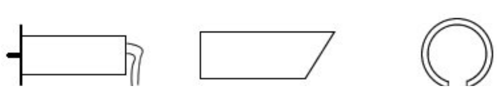
1. If the Treadmill motor comes with the hub attached, take it off, hold the end of the shaft (which comes through the hub) firmly with pliers, and turn the hub clockwise. This hub unscrews clockwise, which is why the blades turn counter-clockwise.
2. Make a template of the hub on a piece of paper, using a compass and protractor.
3. Mark 3 holes, each of which is 2 3/8" from the center of the circle and equidistant from each other.
4. Place this template over the hub and punch a starter hole through the paper and onto the hub at each hole.
5. Drill these holes with the 7/32" drill bit.
6. Tap the holes with the ¼" x 20 tap.
7. Bolt the blades onto the hub using the ¼" bolts. At this point, the outer holes have not been drilled.
8. Measure the distance between the straight edge of the tips of each blade. Adjust them so that they are all equidistant. Mark and punch each hole on the hub through the empty hole in each blade.
9. Label the blades and hub so that you can match which blade goes where at a later stage.
10. Remove the blades and then drill and tap these outer three holes.

Note: the metal slow moving vehicle sign is not solid enough to stand-up in high winds. We screwed on a wooden ring to the back of the sign to give it the required strength. This blocked to much wind so we ended up replacing it with a 6 inch wooden hub, reinforced with a metal plate on the back.



Making a Protective Sleeve for the Motor

1. Draw two straight lines, about ¾" apart, along the length of the 3" x 11" PVC Pipe. Cut along these lines.

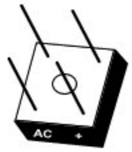


2. Make a 45º cut at the end of the pipe.
3. Place needle nose pliers inside the strip that has been cut out, and pry the pipe apart.
4. Making sure the bolt holes of the motor are centered in the middle of the missing strip of PVC pipe, push the motor into the pipe. An extra person will make this a lot easier.

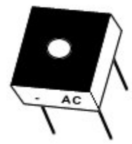
MOTOR SIDE VIEW SLEEVE SIDE VIEW SLEEVE FRONT VIEW

ASSEMBLY

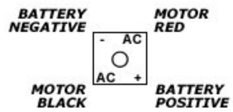
1. Place the motor on top of the square tubing and bolt it in, using the two 5/16" x ¾" bolts.
2. Place the diode on the square tubing, about 2" behind the motor, and screw it into position using the self-tapping metal screw.
3. Connect the black wire coming out of the motor to the positive incoming terminal of the diode (Labeled AC on the positive side).



DIODE TOP VIEW



DIODE BOTTOM VIEW



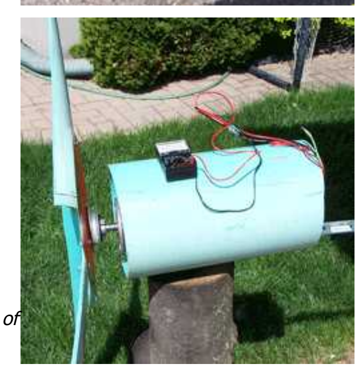
DIODE WIRING

4. Connect the red wire coming out of the motor to the negative incoming terminal of the diode (Labeled AC on the negative side).
5. Center the tail over the square tubing, at the back end. Clamp your tail onto the side of the square tubing.
6. Using 2 self-tapping screws, screw the tail in place.
7. Place each blade on the hub so that all the holes line up. Using the ¼" bolts and washers, bolt the blades to the hub. For the inner three holes, use two washers per bolt, one on each side of the blade. For the outer three holes, just use one washer next to the head of the bolt. Tighten.
8. Hold the end of the shaft of the motor (which comes through the hub) firmly with pliers, and turn the hub counterclockwise until it tightens and stops.

9. Screw the nipple tightly into the floor flange using a pipe wrench.
10. Clamp the nipple in a vice so that the floor flange is facing up and level.
11. Place the square tubing (and everything that is on it) on top of the floor flange and move it so that it is perfectly balanced.
12. Through the holes of the floor flange, mark the square tubing at the point of balance.
13. Drill these two holes using a 5/32" drill bit. You will probably have to take off the hub and tail to do this).
14. Attach the square tubing to the floor flange with two sheet metal screws.

15. For our larger (heavier) motor, we used a rotating caster with a hollow kingpin, bolted to the top of the tower. The dolly/caster needs to have a hole in the middle that you will run the power wires down, through the tower. The dolly is bolted directly to the DC motor which made the complete mounting system much easier.

For a longer life span of your wind generator, you should paint the blades, motor sleeve, mount and tail.



On the larger 20A treadmill motor, we attached a dolly bearing directly to the bottom of the motor and then onto the top of the tower. Get a dolly wheel with a hole in the middle, which you thread the power wires through.

We also used the same PVC Blade Pattern to cut 3 foot blades.

Just make the length 3 feet rather than 2 feet. The measurements at both ends stay the same - 145 cm wide sections that are next cut into 2 blades. This gives the same curve to the blades.

Depending on the size of your motor, you may want to experiment with different lengths of blades. Our larger blades were not balanced as well as the shorter blades initially and thus turned slower. We cut them down in length from 36 inches to 32 inches and balanced them. To balance the blades, we placed the blades and hub, onto a long pointed nail. We than slid a washer along the blades to find the balance point. Then epoxy the washer in place (try to account for the weight of the epoxy as well).

How much power can we get from the wind?

Power **AVAILABLE** in the wind = .5 x air density x swept area x (wind velocity cubed)

Example: air density = 1.23 kg per cubic meter at sea level. Swept area = pi x r squared. Our 2 foot blades = 0.609m, 4 ft = 1.219m. 10 mph = 4.4704 m/s, 20 mph = 8.9408 m/s.

How much power is in the wind: **2 ft blade, 10 mph winds** = .5 x 1.23 x 3.14 x 0.609squared x 4.4704 cubed

= .5 x 1.23 x 1.159 x 89.338 = **63.7 watts**

With 4 foot blades and 10 mph winds = .5 x 1.23 x 4.666 x 89.338 = **256 watts**

With 4 foot blades and 20 mph winds = .5 x 1.23 x 4.666 x 714.708 = **2051 watts**

That's the MAXIMUM power in the wind. However, it's impossible to harvest ALL the power. The **Betz Limit** tells us that the maximum percentage of power we can harvest from the wind is 59.26%.

Thus our maximum power from these turbines would be:

2 ft blades, 10 mph wind = **37.7 watts**

4 ft blades, 10 mph wind = **152 watts**

4 ft blades, 20 mph wind = **1,215 watts**

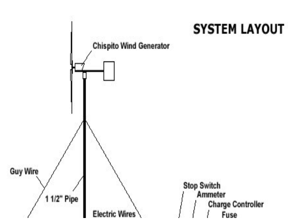
These values are the maximum power achievable. Your results will be less, depending on how well you shape the blades, how well balanced the blade assembly is, drag going over the hub, copper losses, etc. A very well built DIY HAWT would not likely get more than 50% of the above numbers.

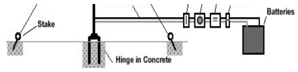
ADDITIONAL INFORMATION

Gearing for a higher RPM motor

If you can't find a good, low RMP motor such as the Ametek 30 and need to gear-up the motor you have, here's a video of one possible layout:

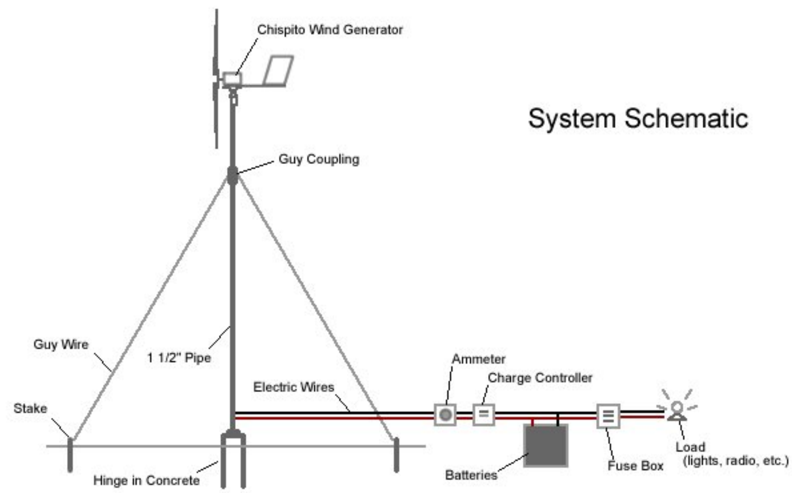
Build The Tower





Tower
The tower is one of the most important components in your wind generator system. It must be strong, stable, easily raised and lowered, and well anchored. The higher your tower is, the more wind your generator will be exposed to. Guy wires must be placed at least every 18 feet of tower height. Guy wires must be anchored to the ground at least 50% of the height away from the base.

How to Build a Tower for a DIY Wind Generator



SUPPLIES

Tools

- Pipe Wrench
- Vise
- Shovel
- Wheel Barrow (mix concrete)
- Wire Strippers
- Drill and Drill Bit

Materials
Base

- 2 X 2' X 1 ¼" Steel Pipe Nipple
- 6" X 1 ¼" Steel Pipe Nipple
- 2 X 1 ¼" 90 elbow
- 1 ½" Steel Pipe T

Pole

- 10 - 30 ft piece of 1 ½" Steel Pipe
- 2 pieces #8 Copper Stranded Wire (must be long enough to go through the pole to the batteries)

Guy System

- 1 ½" U-bolt
- 4 X Guy Wires, at least 25ft long (must be long enough to go from pole to stakes)
- 4 X Stakes
- 4 X Turnbuckles

ASSEMBLY

Base

1. Dig a hole about 1 ft in diameter and 2 ft deep.
2. Feed the 6" X 1 ¼" Steel Pipe Nipple through the horizontal part of the 1 ½" Steel Pipe T
3. Screw the elbows onto each end of the 6" X 1 ¼" Nipple.
4. Screw the 2 ft X 1 ¼" Steel Pipe Nipples into the elbows.
5. Set the hinge base in the hole, so that the T clears the ground. The horizontal part of the T should be level.
6. When the base is plumb and level in the hole, pour concrete

into the hole.

Pole

1. Drill a large hole about one foot from the bottom of the 10 - 30 ft 1 ½" Steel Pipe for the wire to exit.
2. Screw the pipe into the vertical part of the T.
3. Make 4 loops of wire, each loop consisting of several turns of wire.
4. Place the 1 ½" U-Bolt round the pipe, 3 feet from the top of the pipe, threading it through the four loops you just made.
5. Move the loops so that they are equally spaced.
6. Tighten the nuts of the U-Bolt.
7. Secure a guy wire to each of the loops on the U-Bolt.

Guys

1. Put the four stakes (spaced evenly apart) about 12 feet from the base.
2. Drive each stake firmly into the ground, slightly angling them away from the base.
3. Wire a turnbuckle to each stake, using several strands of wire.
4. Raise the pole upright and level.
5. Attach the guys to the turnbuckles.
6. Hold the pole level and tighten all turnbuckles to ensure a secure fit.
7. Mark the front turnbuckle for future reference.

Wiring

1. Release the front guy and lower the pole to the ground.
2. Feed the #8 wires down through the pole an out through the hole in the bottom of the pipe.
3. Wrap the bottom ends of the wires together to provide a closed circuit.

Mounting the Chispito Wind Generator

1. Slide Chispito over the top of the pole.
2. Pull the wires up through Chispito.
3. Wrap the positive (red) wire from Chispito to the positive (red) wire going through the pole. Secure the connection, and use either wire nuts or heat-shrink connectors. Do the same for the negative wires.
4. Raise the pole by pulling the front guy into place. Tighten the front guy to the mark made earlier.
5. Unwrap the ends of the wires and connect them to the positive and negative terminals of your battery bank. If you have a charge controller and/or ammeter, please refer to manufactures instructions for system wiring.

Variations for Science Project

Chances are, if you're making a science project, you'll need to vary a couple of parameters and measure the change. So what factors affect your power output? The power will vary with wind speed and with the size of the blades (swept area). Of course the power output will also vary as you change the height of the tower, but this is really just changing your wind speed. So what can you do?

1. Power as a factor of wind speed. Measure the power output (amps times voltage = watts) for various wind speeds. What do you think you'll find? If the wind speed doubles, what do you think happens to the power output?
2. Power as a factor of blade length (swept area). Since you get 3 sets of blades from one tube, try cutting down the length of the "other" blades. If you shorten the length by 10%, what is the impact on power output (measured at the same wind speed of course)
3. Tower height changes? This is a long term project as you'd need to measure your "total" output over time, at different heights... You are really just measuring the "wind speed" at different heights, so I'm not sure your science teacher will go for this one.

Additional Information:

Various plans for DIY Vertical Wind Turbines

Detailed instructions for making blades from PVC

Information on Ametek DC Motors