# As the Rotor Turns: Wind Power & Your Worldview (Teacher Notes)

*(An Investigation of Wind Power as a Sustainable Resource in Pennsylvania)*

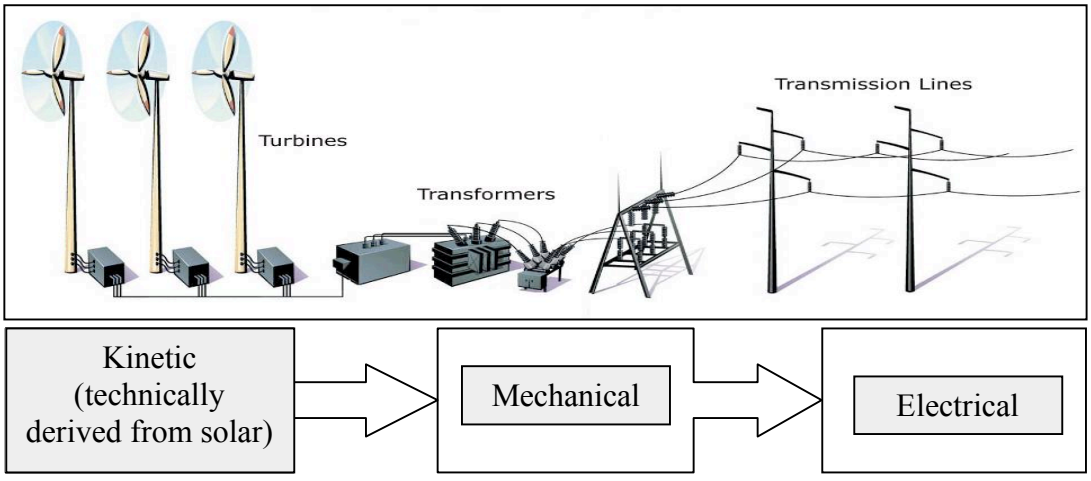
*Notes on Part 1*

**Beaufort scale history**: The Beaufort scale was one of the first scales to estimate wind speeds and the effect of wind on land and sea features was created by Britain's Admiral Sir Francis Beaufort (1774-1857). He developed the scale in 1805 to help sailors estimate the winds by making visual observations. The scale starts with 0 and goes to a force of 12. The Beaufort scale is still used today to estimate wind strengths and without using any complicated equipment!

*Notes on Parts 2 and 3*

One of the most challenging pieces of these sections to present and help your students to wrap their minds around is the idea of power. Please view the, "Power in the Wind" PowerPoint presentation from Walt Musial of the National Wind Technology Center to pull together resources that will best suit your students' level of experience with this concept. A good statement to make for kids is that a wind turbine works the opposite of a fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity.

In the following diagram that is presented on page 10 of the student handout, the transformation that should be clear is that kinetic energy is being transformed into electrical. Depending upon the level of depth to which the information is presented, you may find it useful to spend some time discussing the difference between an inverter (which turns direct current, or DC, from the turbine to alternating current, or AC, to a transmittable form) and a transformer. (The transformers shown in the diagram may be misleading and this is an important point to convey to students).




The Kidwind website is one of the most comprehensive resources for getting kids excited about wind energy and helping educators to think and work through the details of experimenting with table-top wind turbines in the classroom. At the following website, *http://www.kidwind.org/materials/buildingwindmills.html* there are many great frameworks to use, as well as a helpful compilation of troubleshooting suggestions for building classroom turbines which is included on the next page.

## Wind Turbine Troubleshooting Guide from Kidwind

**Why won't my dowels fit into the Tinkertoy hub?**
Sand more! Or you can cut some slits in the end of the dowel. If sanding is a pain then you should head out and buy yourself some Tinkertoys. They work great but are a bit expensive!

**Why are the dowels flying out of the hub?**
You sanded too much!

**Why won't the rotor spin when I put my turbine in front of the fan?**
Check the orientation of the blades. Are your blades oriented in the same direction? Are they flat? Are they hitting the tower? Look at some pictures of old and new windmills to get some ideas about how to orient your blades.

**Why does the turbine slow down when I attach it to load (pump, bulb, motor)?**
Loading the generator forces it to do work. This makes it harder to push electrons through the circuit. The more load you add the harder it is for the generator to turn and the more torque you must generate from the blades. The only way to do this is to make bigger blades or relocate your wind turbine to a place with higher wind speeds.

**Why are the readings on my multimeter all over the place?**
Your readings are fluctuating because the wind coming out of your fan is fluctuating. It can also be caused because your blades are not spinning smoothly. This can be caused by blades that are not balanced, evenly distributed or are causing unequal amounts of drag.

**What are the best blades?**
That is for you to figure out! Lots of testing and playing will get you closer to your answer.

**Is a fan a good wind source to test with?**
Well, it is the best we have got, unless you want to build or have a wind tunnel handy. The wind that comes out of a fan has a great deal of rotation and turbulence. It isn't very smooth. While it will still make your turbine spin it is not exactly like the wind outside. To see this turbulence, hold a short piece of thread in front of a fan and move it from the center out. It should head out straight all the time...does it?

**Can I take my turbine outside? Can I leave it there?**
You can certainly take, use and test your wind turbine outside. But unless you have a yawing turbine it will not track the wind and may not perform optimally. To make it work well you will have to continually face it into the wind. I would not leave your turbine outside for too long. It is designed for basic lab tests and not to endure the rigors of the outdoor environment!

**Based on the power in the wind equation it seems that longer blades should make more power. On my turbine this is not true!! WHY??**
The blades on your turbine may be bigger than the diameter of the fan. If that is the case, the extra part is only adding drag so your blades will slow down. Additionally if you poorly design large blades they will have lots of drag near the tips and slow down. This will negate any positive effect of the added length. Also short blades spin faster than long ones, so if you are just recording voltage they will seem better. Try short blades with a load in series and see if they have enough torque to spin. Many cases they do not!

*Notes on Special Materials from Kidwind*

Kidwind sells all of the parts for the *Basic PVC Wind Turbine*. These are easy to build and for a classroom of 25 kids, at least 3 set-ups are recommended. Listed below is a parts list for the wind turbine shown at the right.

**PVC Pipe & Fittings**
Head to your local hardware store or *Home Depot* the prices are not that bad and you don't need too many parts. All pipe is 1". This turbine has:

*(5) 1" PVC 90° Fittings*
*(3) 1" PVC T Fittings*
*(5 ft) 1" PVC Pipe*
*(1) 1" PVC Coupler*

**DC Motor, Wires & Clips**
A local electronics shop or *Radio Shack* will have wire, clips and multimeters. Kidwind also sells some of these materials. There are also a variety of online vendors. The DC Motor we use is the ***Motor 500*** by Pitsco. Other motors will work, but we have tested many of them and this is a very smooth spinning and has high output! This turbine has:

*(1) Motor 500 (Pitsco)*
*(4 ft) 22 Gauge Hook Up Wire*
*(2) Clips (Alligator or Banana)*

**Special Parts**
The Tinkertoy hub, adapters and the Delrin 6 hole hub are specially made for our turbines. But for years we used to fashion your own using Tinkertoys. Head to your local toy shop or an online vendor to get yourself a barrel of Tinkertoys. A small junior barrel will run around $20 and have plenty of materials for your turbines. When you want something rugged and tested though come to Kidwind.

- *(1) Crimping or Tinkertoy Hub w/ sold by Kidwind*

**Tools & Materials**
To build this turbine you'll need a drill, pliers, ruler, PVC cutter, hacksaw, wire strippers, soldering iron, solder, duct tape, epoxy and probably lots of other stuff that we can't recall! Most of all have fun and be safe!