KidWind MINI Wind Turbine

Kidwind Project ®
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http://www.kidwind.org

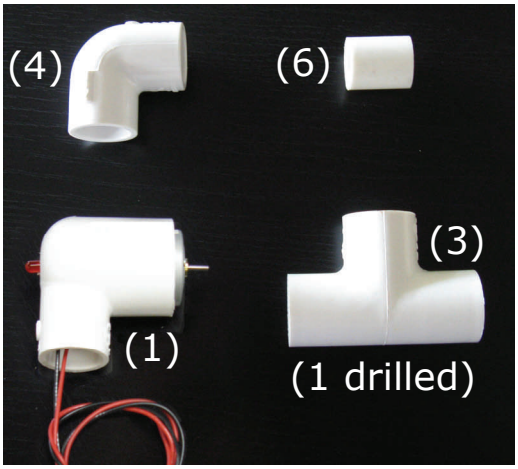
Children should use this kit only under the close and direct supervision of adults who have familiarized themselves with the safety instructions outlined in this manual. When performing experiments, keep small children and animals away. This kit contains moveable parts. When in use, be sure to stand a safe distance away from the moving portions of the kit. Please keep the manual and instructions for future reference and refer to these each time you use the kit.

KidWind MINI Wind Turbine

The KidWind MINI is perfect for demonstrating how a wind turbine generates energy. The MINI is easy to build and produces enough electricity to power LED bulbs, a small power output board, and other small load devices (mini water pumps, motors, buzzers, etc).

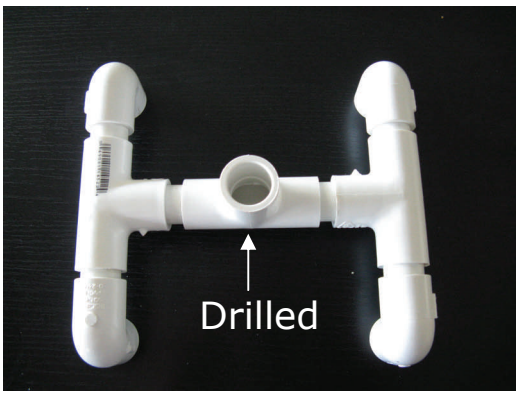
The KidWind MINI Kit includes the full turbine, a power output board with lights and sound generator and a pair of clip wires to attach your own electrical devices.

Parts Included



- 1/2" PVC "T" Fittings (3) (1 drilled)
- 1/2" PVC Elbow Fittings (4)
- 1/2" PVC sections, 1" long (6)
- 1/2" Blue HDPE Tower, 8" long (1)
- PVC Nacelle with generator, LED Bulb, and wires (1)
- Blade Set (1)
- Power Output Board (1)
- Alligator clip cords (2)

Building the Wind Turbine



1. Using (4) 90° PVC fittings, (2) PVC Ts and (4) 1" PVC pipe sections, construct the two sides of the PVC turbine base.
2. Fit the parts together <u>without</u> using glue (PVC glue is really nasty stuff). To make them fit snuggly tap them together with a hammer or bang them on the floor once assembled.
3. Next, connect the two sides of the base using the *drilled* PVC "T" and two more 1" pipe sections.
4. Run the red and black wires from the nacelle (head) through the blue HDPE Tower and connect the nacelle to the tower.
5. Push the red and black wires through the drilled hole in the PVC "T" at the bottom of the base. Connect the blue HDPE Tower to this drilled "T"
6. Push the blades onto the generator drive shaft. The hole on the back of the blade set will friction-fit onto the drive shaft. This may be a very tight fit, so you may have to push fairly hard. **Be careful not to push too hard, or the generator may slide backwards in the housing.** If you push the blades on too far, the blades will rub on the PVC housing. Make sure there is some clearance there for the blades to spin freely.

7. If you need to remove the blades, you can use a screwdriver to "pry" the blade set off the generator. Use caution not to break a blade.

Setup for Testing the MINI Wind Turbine

It is important to clear your testing area of debris and materials that could block the wind or be blown away. Place your turbine in front of the fan so that the blades are facing into the wind.

When you are testing, stand BEHIND your turbine or BEHIND the fan. Do not stand in the "plane of rotation" of the blades, in case something hits them and flies out.

Some things to note about fan wind that reduce the efficiency. Fans create:

- *Highly Turbulent & Rotational Wind*— This turbulent fan wind is different from real wind outside.
- *Highly Variable Wind Speed*— Wind speed is about 10-13 MPH on high for a $20 circular fan. Wind speeds near the middle will be much different than the edges.

Going Outside?

While you can use your wind turbine outside, you must make sure that you face it into the wind. This is because this turbine is not designed to *YAW* (or rotate) to face the wind. If the wind shifts and the turbine cannot rotate, wind will hit the blades from the sides causing stress and inefficiency. For a challenge, try to adapt your tower to be able to yaw.

Connecting the Turbine to Electrical Devices

The KidWind MINI Turbine can power a variety of electrical devices beyond the included LED bulb! For more fun experiments, try pumping water with the KidWind mini water pump, electrolyzing water in a hydrogen fuel cell, or storing energy in a supercapacitor! All of these accessories can be found in the KidWind online shop.

The turbine will spin COUNTER-CLOCKWISE with the included blade set. When spinning this way, the red wire is POSITIVE and the black wire is NEGATIVE. This is called the *POLARITY* of the turbine, and is important for certain electrical devices that are polarized. For example, if you are charging a supercapacitor, make sure the red turbine wire (+) goes to the longer lead (+) of the supercapacitor. If you are electrolyzing a fuel cell, connect the red turbine lead to the red input terminal of the fuel cell.

Once your circuit is connected, turn on the fan and the turbine will start pumping out power to your electrical device!

If you want to know the electrical power output of your wind turbine, you will need a *multimeter.* This is a very helpful tool for measuring voltage and amperage output.

SAFETY—IMPORTANT (PLEASE READ!)

- *DO NOT TOUCH THE BLADES WHILE THEY ARE SPINNING. They are moving very fast and will hurt your hand if they hit you.*
- *Do not stand in the "plane of rotation" of the blades (to the side of the blades) in case something hits them and flies off. Stand in front of or behind the turbine.*
- *Wear safety goggles when the turbine is spinning.*
- *Use caution when working with electricity. Although this turbine will not produce enough electricity to shock you, it is important to practice safety with electricity.*

KidWind MINI Turbine Experiments

The KidWind MINI was designed to demonstrate wind power technology, and you can still do some cool experiments!

Changing Wind Speed

Place the turbine about three feet in front of a fan, and turn it on HIGH. What happens when you turn the fan to MEDIUM or LOW? Does the LED bulb light up at any wind speed?

Now leave the fan on MEDIUM and move your turbine away from the fan by about a foot. Continue moving the turbine away from the fan, one foot at a time, until the LED bulb no longer works. How far away can you get? Why is the turbine unable to power the light bulb as you back away from the fan?

Try this experiment with a *multimeter* to measure voltage. What happens to the voltage as you move your turbine further from the fan, or slow down the wind speed?

Use the Turbine to Power Other Devices

This turbine can be used to operate other electronic devices besides the attached LED bulb, but only devices that require very little electricity. For example, the power output board included in the kit can light bulbs or play music. You can also connect it to another DC motor, which could spin a small propeller. Or, attach the wires to a multimeter. A multimeter allows you to more accurately measure how much electrical energy your turbine is producing. KidWind (www.kidwind.org) also sells other items like water pumps, fuel cells, and battery charging systems that can make your experiments more advanced.

Test Blades

The blades included in the package are designed to be very efficient, but if you want, you can design your own blades, too. First you will need a hub to attach your blades to the generator. The 12 Hole Crimping Hub from KidWind is perfect for blade-design experiments. Slide off the plastic blade set, and replace it with the hub. Design your blades, and glue or tape them to 1/4” dowels. These dowels fit perfectly in the 12 Hole crimping hub.

Now you can do a lot of great experiments by isolating blade variables and examining how they affect the power output of your turbine. Try these variables to get started: Blade pitch (angle), blade size, blade shape, number of blades, etc. After you have attached your new blades, try to light the LED bulb or measure your power with a multimeter. How has the efficiency of your turbine changed? Try a few blade designs to learn what makes blades more efficient.

The 12 hole crimping hub allows you to use up to 12 blades, so be sure to try some experiments with the number of blades. If you are feeling adventurous try using one blade!

Different Generators

The DC generator in your wind turbine is actually a DC motor that spins using the energy in the wind. The magnets and wires in the generator transform the energy in the wind into electricity. By manipulating the strength of the magnets used and coils of wire inside the generator we can affect the power output. In this kit we provide you with a DC generator. If you wanted, you could compare this output to a different DC generator that you harvest from some old electronics in your house. Old VCRs, electrical toys and CD players are good places to start finding DC motors. Do some research on how generators work or electromagnetism to learn more.

Build a MINI Wind Farm (see page 6)

Power in the Wind — A Simple Look

If a large truck or a 250lb linebacker was moving toward you at a high rate of speed, you would move out of the way, right?

Why do you move? You move because in your mind you know that this moving object has a great deal of ENERGY as a result of its **mass** and its **motion**. And you do not want to be on the receiving end of that energy.

Just as those large moving objects have energy, so does the wind. Wind is the movement of air from one place on earth to another. That's the motion part.

What is air though? Air is a mixture of gas molecules. It turns out that if you get lots of them (and I mean lots of them) together in a gang and they start moving pretty fast, they can definitely give you — a sailboat or a windmill — a serious push. Just think about hurricanes, tornadoes, or a very windy day!

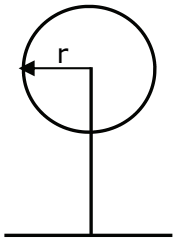
Why aren't we scared of light winds while we stay inside during a hurricane or wind storm? The velocity of those gangs of gas molecules have a dramatic impact on whether or not we will be able to stay standing on our feet. In fact, in just a 20 mph gust you can feel those gas molecules pushing you around.

Humans have been taking advantage of the energy in the wind for ages. Sailboats, ancient windmills and their newer cousins the electrical wind turbines, have all captured the energy in the wind with varying degrees of effectiveness. They all use a device such as a sail, blade or fabric to "catch" the wind. Sailboats use wind energy to propel them through the water. Windmills use this energy to turn a rod or shaft.

A simple equation for the ***Power in the Wind*** is described below. This equation describes a the power found in a column of wind of a specific size moving at a particular velocity.

P = Power in the Wind (watts)
ρ = Density of the Air (kg/m3)
r = Radius of your swept area (m2)
V = Wind Velocity (m/s)
Π = 3.14

$$P = 1/2\ \rho\ (\Pi\ r^2)V^3$$



From this formula you can see that the size of your turbine and the velocity of the wind are very strong drivers when it comes to power production. If we increase the velocity of the wind or the area of our blades we increase power output.

The density of the air has some impact as well. Cold air is more dense than warm air so you can produce more energy in colder climates (as long as the air is not too thin!).

How much wind power is coming from a regular house fan?

V = 5 m/s (meters/sec)
ρ = 1.0 kg/m3 (kilograms/cubic meter)
r = .2 meters
A = .125 m2 (Area of Circle = Πr^2)

Power in the Wind = ½ρAV³

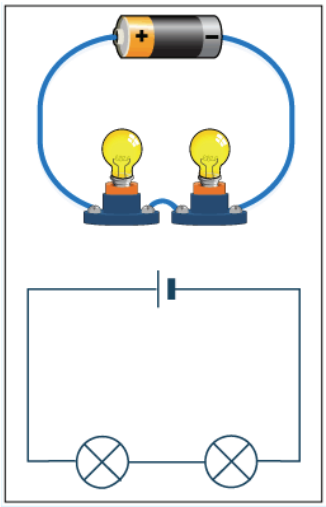
Power = (.5)(1.0)(.125)(5)3
= 7.85 Watts

There are 7.85 watts of wind power coming out typical house fan on high. Can our little turbines capture all of this power? Do some research on the **BETZ LIMIT** to find out.

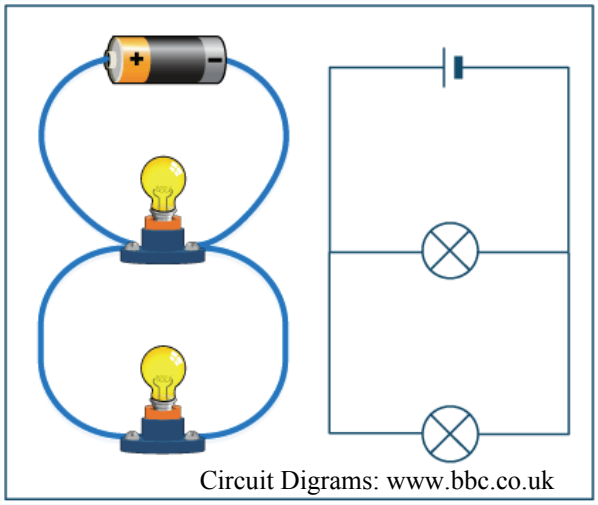
How To Build a MINI Wind Farm

A **wind farm** is a collection of wind turbines in the same location. This may also be called a "wind power plant," because many wind turbines working together can produce a lot of electricity—just like coal or nuclear power plants. Wind turbines are often grouped together in wind farms because this is the most economical way to create electricity from the wind. In other words, wind farms give us the most power for our buck! Electricity from wind farms is one of the most affordable sources of electricity today, and may soon be the cheapest form as technology advances and fossil fuels become less abundant.

When you connect your various components together (wind turbines, load, meter, etc.), you are making an *electrical circuit.* There are two ways of connecting components in a circuit: **series** and **parallel**. A circuit wired in **series** has components connected end to end, like a chain. The electrons must travel a single path through all of the various parts of the circuit. A circuit wired in **parallel** provides a different path for current to travel through each of the components. In parallel, each component has a separate loop.



Series circuit



Parallel circuit

Connecting Turbines:
If you are connecting the turbines in series, connect the wires of the turbines from positive (RED wire) to negative (BLACK wire), making one continuous loop through the circuit.

If you are connecting the turbines in parallel, connect each positive wind turbine wire (RED) individually to the red lead from the multimeter or load device. Connect each negative wind turbine wire (BLACK) individually to the black lead from the multimeter or load device.

The wires you use to connect your mini wind farm to various loads act just like the high voltage transmission lines that bring the electricity of real wind farms to our homes and schools!

The Power of Wind Farms

Recall the Power in the Wind equation:

$$P = 1/2\ \rho\ (\pi\ r^2)V^3$$

P = Power in the Wind (watts)
ρ = Density of the Air (kg/m3)
r = Radius of your swept area (m2)
V = Wind Velocity (m/s)
π = 3.14

What are we changing in this equation when we add more wind turbines and create a wind farm? The density of the air will not change, and adding more turbines will not change the wind velocity either. But you definitely are changing the radius of your swept area (**r**).

Assuming your blades are all the same size, having three wind turbines as opposed to just one will effectively triple your swept area! Of course, due to resistance and losses, we cannot expect to get exactly 3 times the power. What are some of the causes of inefficiency and losses that reduce your total power?

If you use a multimeter to record voltage and current as you add wind turbines to your wind farm, you will find some interesting results.

When you have multiple turbines wired in **series**, the voltage will increase with each additional turbine, but the current will stay the same!

If you wire the turbines in **parallel**, the current will increase with each additional turbine, but the voltage will not change!

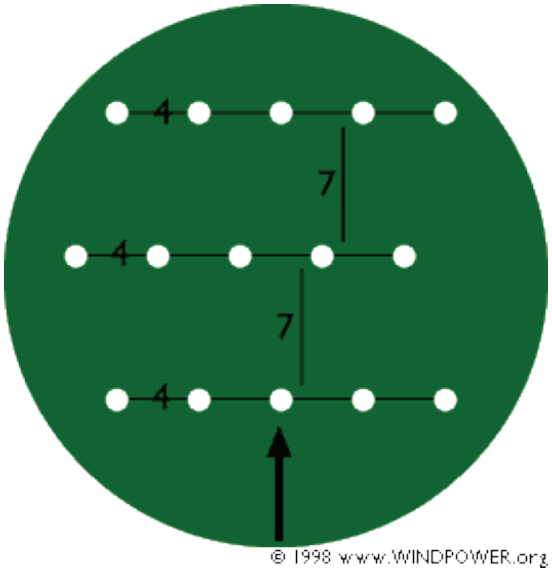
Power (Watts) = I (current) x V (voltage)

Three turbines in parallel will produce the same Power as the same three turbines wired in series. If you put three turbines in series, you will basically triple the voltage with the same current. Three turbines in parallel will effectively triple the current with the same voltage.

The Wind Park Effect:

If multiple wind turbines are placed too close to one another, the efficiency of the turbines will be reduced. Each wind turbine extracts some energy from the wind, so directly downwind of a turbine winds will be slower and more turbulent. For this reason, wind turbines in a wind farm are typically placed 3-5 rotor diameters apart perpendicular to the prevailing wind and 5-10 rotor diameters apart parallel to the prevailing wind. Energy loss due to the "Wind Park Effect" may be 2-5%.

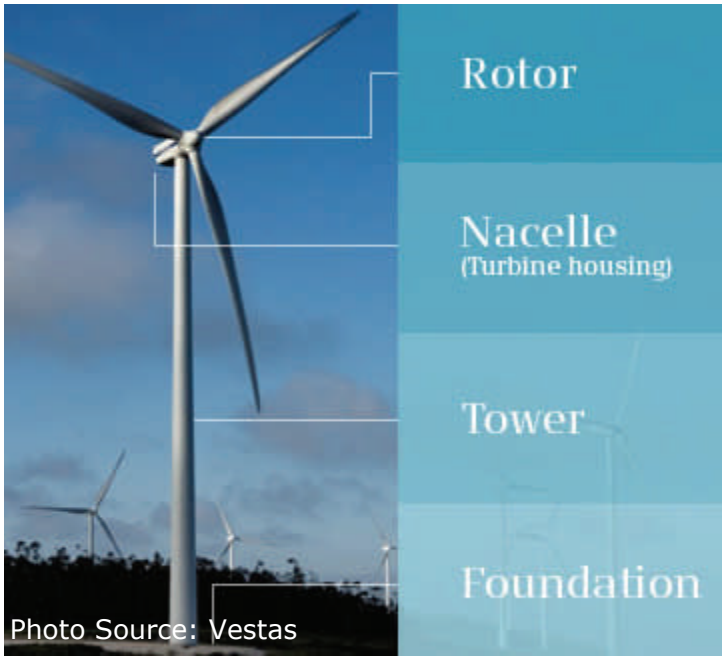
What effect do you find when you move the turbines around in your miniature wind farm? Try placing a few turbines very close together, or right behind each other. Do you notice a reduction in the efficiency of your wind farm?



Wind Farm Layout to minimize "Wind Park Effect" (www.windpower.org)

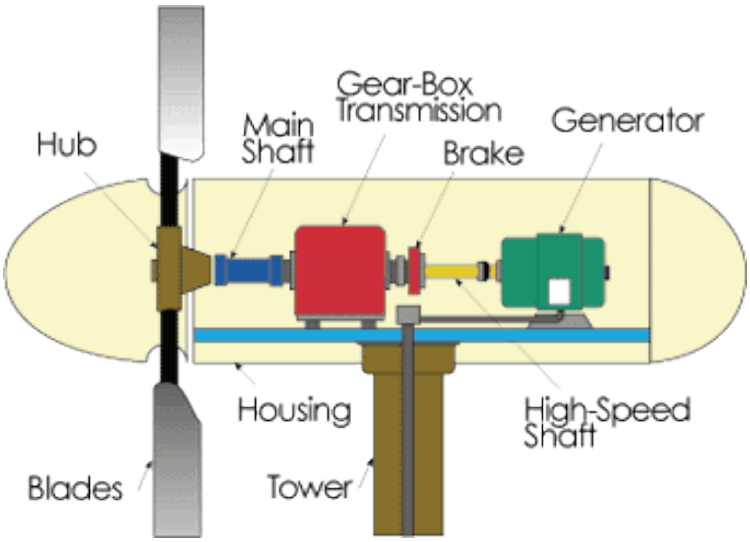
Wind Energy Facts

A wind turbine is the modern advancement of the windmill. Instead of using the wind to lift water or move heavy rocks to grind seeds wind is used to turn an electrical generator to make electricity.



The force of the wind on the blades causes them to move. If the blades are all oriented in the same direction they will start to spin, just as the wind spins a pinwheel. The blades are attached to a hub, which spins as the blades turn. Most modern wind turbines have two or three blades. This is due to the physics of wind energy capture and a desire to reduce the cost of the wind turbine. Blades are an ever evolving aspect of wind turbines as the more efficiently we can build and design them the more energy we can capture from the wind.

The blades and the hub together are called the *rotor*. As the rotor turns, it spins a drive-shaft which is connected to a generator inside a housing at the top of the tower which is called the nacelle. The spinning generator produces electricity. Most utility sized wind turbines have a gearbox between the spinning rotor and the generator; this is to help the generator spin fast enough to make electricity for the grid. Generators on large grid connected turbines spin at 1200 to 1800 revolutions per minute (RPM). On the smaller residential turbines the rotor and the generator spin at the same speed anywhere from 0-500 RPM.



Wind Energy Resources & Links

Are you doing a science fair project on wind energy? These links will take you to some of the most up to date and reliable information on the web.

KidWind Project	http://www.kidwind.org
Wind With Miller	http://www.windpower.org/en/kids/index.htm
American Wind Energy Association	http://www.awea.org
Wind Powering America	http://www.eere.energy.gov/windandhydro/windpoweringamerica/

Check out www.kidwind.org for more great wind energy kits, free slide shows, experiment ideas, lesson plans, and activities, and links to other helpful resources.