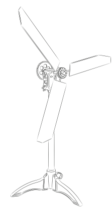
Basic Wind Experiment Kit

(Order Code KW-BWX, KW-BWXC)



The Basic Wind Experiment Kit is a great introduction to wind energy science and engineering concepts. This is a robust, experimentally rich turbine kit that is appropriate for middle and high school students.

Experimentally Rich

- Test electricity production and weightlifting
- Explore torque and energy transfers
- Measure electrical and mechanical power
- Experiment with wind turbine blade design

Renewable

- Plastic parts made from recycled plastic

Note: Vernier products are designed for educational use. Our products are not designed nor are they recommended for any industrial, medical, or commercial process such as life support, patient diagnosis, control of a manufacturing process, or industrial testing of any kind.

What's Included

- KidWind Power Output Board
- 4′ String*

Bag 1 (class pack contains 3)

- Wind Turbine Generator with Wires
- Nacelle Body Half (2)
- Motor Mount Pack
- Hex Shaft (8″) with Hub
- Wind Turbine Hub
- Tower Base Legs (3)
- Tower Base Locking Ring
- Tower Base Hub
- Plastic Weightlifter Bucket
- Blade Pitch Protractor
- Gear Set (3 hex locks and 8, 16, 32, and 64 tooth gears)
- 1/2″ Washer (25)
- Dowels* (25)
- Power Output Pack* (clip wires, motor, plastic spinner, LEDs)
- Wooden Spool

Bag 2 (class pack contains 3)

- Grey PVC Tower
- 3″×12″ Balsa Wood Sheet* (5)
- 3″×12″ Chipboard Blade Sheet* (10)

Bag 3 (class pack only)

- Wind Turbine Hubs (5)
- Dowels* (75)
- 3″×12″ Balsa Wood Sheet* (10)
- 3″×12″ Chipboard Blade Sheet* (20)
- 8.5″×11″ Chipboard Sheet* (25)

*This part is a consumable and is excluded from warranty.

Assembly Video Instructions

Detailed assembly instructions are provided in a step-by-step video at
www.vernier.com/x384

Scan for assembly video

Configuring the Basic Wind Experiment Kit

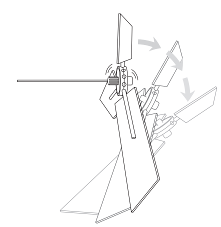
Hex Lock and the Hub Quick Connect

1. The hex-shaped driveshaft allows you to connect the hex lock to the driveshaft. If you mount your gears or a weightlifting spool on the back of the nacelle, the hex lock will not slip on the driveshaft.
2. The Hub Quick Connect (HQC) allows for easy removal and attachment of the hub. This enables users in busy classroom environments to change blade configurations quickly and easily.

Strong wind, large or out of balance turbine blades, and wear can make the HQC unstable.

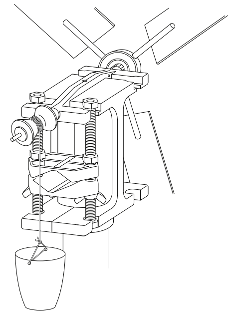
The HQC ships with a small screw holding the hub in place. If the hub is still slipping, adjust your blades to make sure their weight, pitch, size, and shape are all equal so that your rotor is well balanced. Push the hub in as far as you can. Glue the hub into the HQC.

Note: The hub is designed to have a very tight fit to the Quick Connect, but if your blades are unbalanced or your turbine is not directly facing the wind, it may come loose. Be careful with blades that are out of balance.



Weightlifter Kit

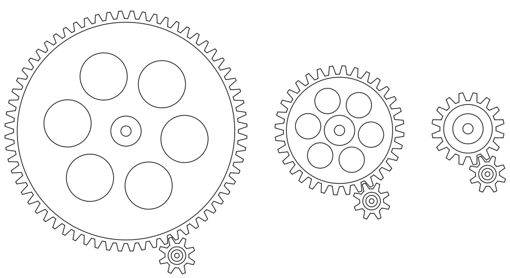
Lifting weights with the wind turbine is another great way to explore wind energy and provide students with a simple visual display of mechanical work. To convert the kit to a weightlifting turbine, watch the assembly video at
www.vernier.com/x384



Compare the mechanical and electrical power of wind by setting up a weightlifter.

Gear Ratios

To generate the electricity, the generator has to spin very fast. To summarize the process, the faster the coils rotate near the magnet, the more electrons will be pushed along the wire. If you've seen a utility-scale wind turbine, you probably noticed that the blades spin pretty slowly. To get the generators to spin fast enough, they use gears. Gears give a wind turbine mechanical advantage and multiply the mechanical force of the turning blades. This is done by using gears with different numbers of teeth. When the larger gear makes one full revolution, the smaller gear has to spin faster to keep up.



This kit offers three different gear ratios. The smallest gear attaches to the generator driveshaft and is called the pinion. The pinion gear has 8 teeth. The other three gears attach to the main hex shaft and have 16, 32, or 64 teeth.

A "gear ratio" is the relationship between the number of teeth on two or more gears that are meshed. So when you ride your bicycle, the gear in front might have 48 teeth, while the gear in back has 16 teeth. That would mean every time your pedals spin around once, the back wheel spins three revolutions (48÷16 = 3). This is called a 3 to 1 (3:1) gear ratio. Wind turbines work the same way except that they have much larger gear ratios. A modern wind turbine may have a gear ratio of 100:1 or more. So every time the blades make one revolution, the generator shaft spins 100 times.

Using the 64-Tooth Gear (Largest Ratio)

If you are using the largest gear size, you will notice that it will only fit with hex nuts under the motor mounts, as wingnuts are too tall. If you are using the smallest gear size, you will have to use hex nuts above the motor mounts. Give the hub a spin to make sure that the gear turns and rotates the small pinion gear on the motor.

Note: Using the 16 tooth gear requires the High Torque Generator which is sold separately as order code KW-HIGEN.

Using the 16-Tooth Gear (Smallest Ratio)

Since the 16-tooth gear is so small, it is challenging to mount the generator high enough in the main body to mesh gears. In order to use this small ratio, you have to use the High Torque Generator. Remove the upper half of the Motor Mount and slide a small cardboard or folded paper shim in between the generator and the main body housing. You will have to adjust the width of this shim to get the gears to mesh perfectly.

Tighten the nuts below the Motor Mount to secure the generator in place. If the gears do not mesh well, adjust the shim.

Determining Polarity

To determine the proper polarity of the turbine, connect it to a voltage probe or a multimeter. If the voltage reading is positive, the lead connected to the red voltage probe or multimeter wire comes from the positive terminal. If the voltage reading is negative, the lead connected to the red voltage probe or multimeter wire comes from the negative terminal. It is a good idea to mark the wires with tape so you know which is positive and which is negative.

Generators

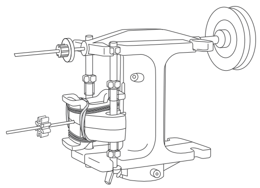
The DC generator in the wind turbine is a DC motor that spins using the energy in the wind. The magnets and wires in the generator transform the energy in the wind into electricity. By manipulating the strength of the magnets used and coils of wire inside the generator, we can affect the power output.

GENPack Option

With the optional GENPack kit (order code, KW-GP), you can construct your own generator instead of using one of the stock generators. Explore Faraday's law, AC power generation, and electromagnetism to learn about how electricity is generated.

The GENPack fits into the nacelle. It includes a powerful neodymium magnet, copper magnet wire, and a housing to build your generator.

A well-constructed GENPack generator can vastly out-perform the stock generators included in your kit!



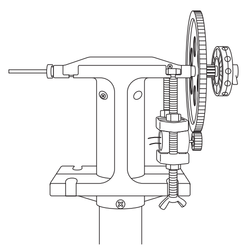
Adding the GENPack expands the experimental value of this kit

Troubleshooting

Review the below questions for common troubleshooting questions. More information about the Basic Wind Experiment Kit can be found at
www.vernier.com/til/3220

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

Why does the gearbox seem to turn slowly or feel stiff?
The addition of the gearbox adds some friction to the system. Because of this, you will need to make sure that the blades generate enough torque (turning force) to overcome this friction. You can also adjust the generator (move it up or down) to make sure the gears are meshing well. Make sure they are not too tight or too loose.



If you are mounting your gear at the front of the nacelle, slide the Hex Lock and your gear up the driveshaft right behind the hub, as shown in the picture. Again, be sure to line up the main drive gear with the pinion attached to your generator.

Why does the turbine slow down when I attach it to a load (resistor, pump, bulb, motor)?
Electrical loads all have some resistance. Resistance "resists" the flow of current. This makes it harder to push electrons through the circuit. The more load that is added, the harder it is for the generator to turn, and the more torque must be generated from the blades. The best ways to do this are to increase blade pitch, make bigger blades, or find stronger wind.

Why are the voltage readings all over the place?
Readings may fluctuate because the wind coming out of the fan is fluctuating. This can also be caused by blades that do not spin smoothly or change shape as they spin. Additionally, readings will be irregular if the blades are not balanced, evenly distributed, or are producing unequal amounts of drag

Is a fan a good wind source to test with?
While a fan will make a turbine spin, it is not exactly like the wind outside. The wind that comes out of a fan has a great deal of rotation and turbulence. It isn't very smooth. 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 tower, 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. It is not a good idea to leave your turbine outside for too long. It is designed for basic lab tests, 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. Why isn't this true on my turbine?
The blades on your turbine may be bigger than the diameter of the fan. If that is the case, the extra length is only adding drag so the blades will slow down. Additionally, if large blades are designed poorly, 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. In many cases they do not.

My tower is rocking or falling over. How can I stabilize it?
If your rotor is very large, a strong wind may force your tower to wobble or fall. Try taping the tower base to the floor or to the lab table. Weighting the base with sandbags or other weights can also help.

Accessories/Replacements Parts

Item	Order Code
Go Direct Energy Sensor	GDX-NRG
Vernier Energy Sensor	VES-BTA
Vernier Resistor Board	VES-RB
Vernier Variable Load	VES-VL
Renewable Energy with Vernier	REV
Wind Energy Explorations	MSB-WIND-E

Warranty

This kit contains many parts. The Generator is warranted to be free from defects in materials and workmanship for a period of one year from the date of shipment to the customer. Other parts in the kit, excluding consumables (as indicated in the What's Included section of this user manual), are warranted for a period of five years.

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