ELECTRIC WIND GENERATOR

Capture the wind and light LEDs using recyclable materials!

Curriculum topics

- Natural and Renewable Resources
- Energy Conversion
- Environmental Impact
- Science Investigations

Subjects

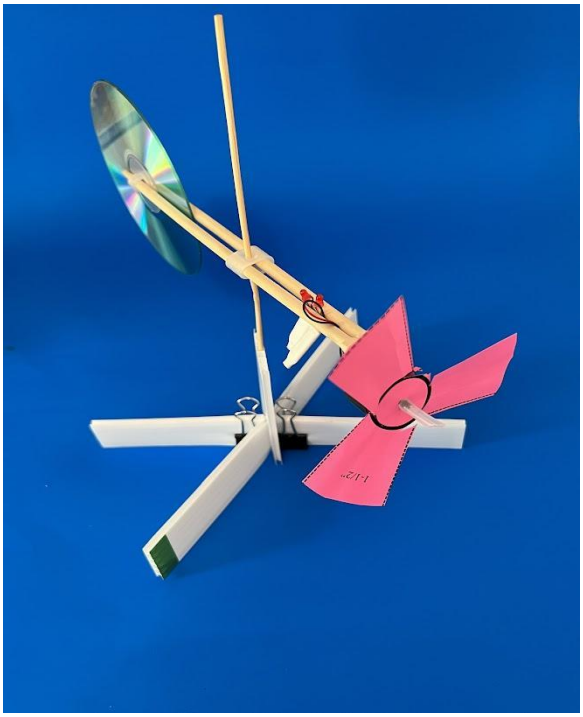
- Earth & Space Science
- Engineering
- Physical Science

Grade range: 6 – 12

Who we are: Resource Area for Teaching (RAFT) helps transform the learning experience by inspiring joy through hands-on learning.

The development of this kit was funded in part by Electrify America

The Electric Wind Generator uses recycled and recyclable materials to demonstrate how wind power can be harnessed to generate clean, renewable electric energy. You will build an electric generator windmill, and design, make, and experiment with different windmill blades. You will connect the blades to a small DC electric motor/generator that converts energy from the wind into electrical energy. The electric energy will light up the connected LEDs. You can use natural wind or an electric fan or blower to operate the windmill. Either way, your objective is to design the windmill blades to spin quickly in a breeze. When used on a large scale, electric windmills can generate the power needed by towns and cities without consuming fossil fuels or any limited natural resources. The power is renewable, limitless, and clean.



Scan this QR code or visit https://bit.ly/49pYqPu to view the assembly video!

Share Your feedback!
http://bit.ly/RAFTkitsurvey

Materials

Materials in this kit may vary. This kit contains the following components or equivalent substitutes:

- Applicator stick/silicone tubing assembly (1)
- Binder clip, mini (2)
- CD (1)
- Chopstick pair, connected (1)
- Chopstick, single (1)
- Fan blade templates printed on cardstock (1), downloadable at http://bit.ly/FanBlades
- Heat shrinkable tubing (1)
- Motor/generator with 2 LEDs assembly (1)
- Paper clip (1)
- Pipette tip (1)
- Plastic strips, notched (3 pieces)
- Tubing, 1/16 in ID x 1/8 in OD x 1/8 in, (1)
- Tubing, 1/16 in ID x 1/8 in OD x ¾ in, w/ end slant cut (1)
- Tubing, 7/16 in OD x 5/16 in ID x ¼ in (1)

Not included: Scissors, electric fan

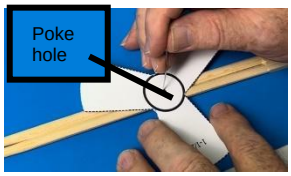
WARNING: CHOKING HAZARD – Small parts not suitable for children under 3 yrs. Rubber bands contain natural latex which may cause allergic reactions.

To Do and Notice

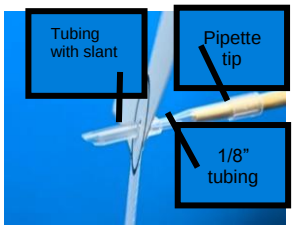
Note: You may watch the assembly video to supplement these step-by-step instructions.

1 Cut out windmill blades and assemble the blade test jig: Cut out your choice of 1 or more windmill blades from the templates printed on the enclosed card stock. Use scissors to cut on the dotted circle outline around the blades, then cut out the material between the blades along the dotted lines (right).

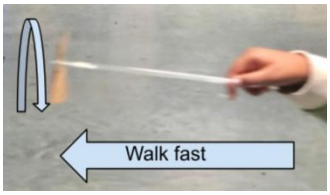
2 Unbend the paperclip, forming a wire. Use the wire to poke a hole in the center of the blades that you just cut out. Place the center dot of the blades on top of the gap between the double chopsticks, then poke the wire through the dot.



3 Firmly fit the wide end of the pipette tip onto the small end of the single chopstick. Use the sharp end of the pipette tip to enlarge the hole you just made in the center of the blades. Make the hole about 1/16 inch diameter. Press the 1/8 inch long piece of clear silicone tubing onto the pipette tip and slide the tubing to about ½ inch from the tip. Then, place the test blade onto the pipette tip up to this tubing. Next, place the ¾ inch long tubing with one end cut at a slant onto the end of the pipette tip with the slanted end out, as shown. The blades should be able to freely spin, but not wobble too much (right).



4 Test the blade design: You now have a chopstick with windmill blades on the end. The windmill blades should be able to rotate freely. Hold this chopstick with the blades facing into a breeze. You can find or create a breeze several ways: 1) Bring the jig to a windy place, or 2) Blow a breeze from an electric fan or blow dryer **(set to cold air)** straight at the blades, or 3) Quickly push the chopstick with blades forward through the air (see right).



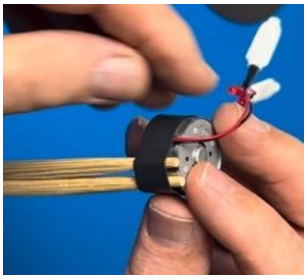
Do the blades rotate? If not, try bending the blades as shown in the picture (right). Hold the blades in a breeze again. Experiment with different angles of tilt and twist, different size windmill blades, and variations until the blades rotate in the breeze. Choose the best blade design from your experiments to continue. To learn more, refer to the **Experiment and Observe** section below.

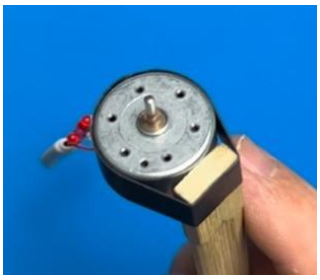
Reflect: Think about why the different blade designs behave as they do. If possible, closely examine the blades on a ceiling fan and on a box fan. How are the blade designs similar, and how are they different?

5 Assemble the windmill base: Insert the slits on the 2 long plastic strips into one another so that the 2 strips form an **X**. Then, insert the short plastic strip (with the wide slit) vertically across the intersection of the long strips (right). To increase stability, add the 2 binder clips to the bottom of just one of the horizontal strips, 1 on each side of the vertical strip, then fold up the handles, as shown.

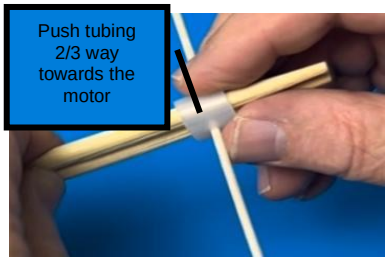
6 Mount the motor/generator onto the wind vane: Slip the heat shrinkable tubing onto the motor/generator. Insert the tapered ends of the chopstick pair between the motor/generator and the tubing. Point the motor shaft towards the end where the chopsticks are attached to one another (below, left). Carefully slide the assembly along the chopsticks to the joined end (below, right). The edge of the motor should be aligned with the end of the chopsticks and the shaft should extend beyond the chopsticks.

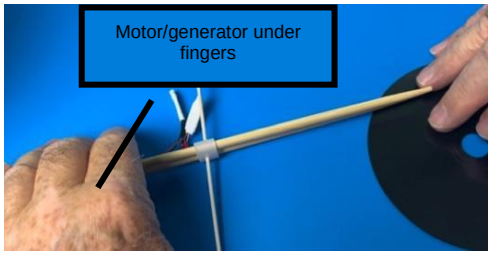
7 Test the motor/generator and LEDs: Hold the motor/generator and chopsticks in one hand, then use your fingers to give the shaft a fast twist. If you twist fast enough, one of the attached LEDs should blink on. Repeat, but twist the shaft in the opposite direction. The other LED should light. Only one LED can light at a time, depending on the direction of the electric current that is generated.



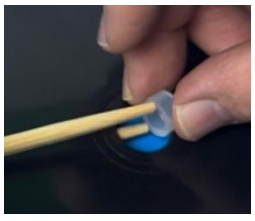


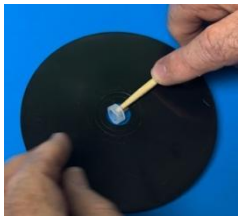
8 Assemble the pivot: Push the ½ inch tubing about 1/3 down the applicator stick. Place the applicator stick between the 2 chopsticks and slide the applicator stick/tubing assembly onto the tapered end of the chopsticks, stopping when the stick is about 2/3 the way towards the motor (below, left). Orient the chopsticks so that the motor is on the bottom of the chopsticks and the short side of the applicator stick extends from the top of the chopsticks when the chopsticks are held horizontally (below, right).

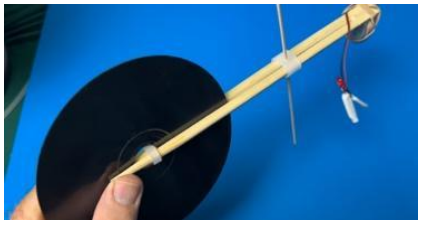




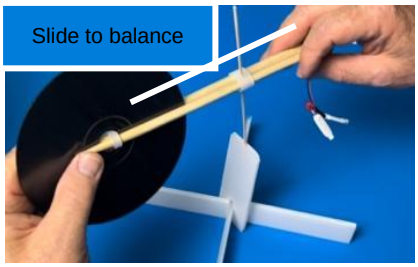
9 Mount the tail (CD) of the wind vane: The Electric Wind Generator uses a CD as the tail of the wind vane that causes the chopstick assembly to rotate so that the blades always face into the wind. Lay the double chopstick assemble on a horizontal surface. Position the CD between the tapered ends of the chopsticks (below, left and middle) then slide the ends of the chopsticks into the remaining (1/4 inch long) piece of tubing, (below, right). Slide the tubing and CD about 1 inch towards the connected end of the chopsticks.







10 Mount the wind vane, generator, LED assembly: Insert the applicator stick from the wind vane/generator assembly into an open channel in the vertically oriented plastic strip on the base (right). The motor should be underneath the chopsticks of the wind vane. Slide the applicator stick/tubing assembly along the wind vane chopsticks until the wind vane assembly remains horizontally balanced when untouched. This may take several attempts.



11 Attach windmill blades to the motor/generator: Slip the hole in the middle of the blades onto the motor shaft. Put the tubing with the slanted end onto the shaft so the slant is visible at the end of the shaft (right). Push firmly. Turning the blades will also turn the shaft if installed correctly. If the blades are turning but the shaft and slanted tubing are not, press the slanted tubing more firmly onto the shaft.

12 Place the completed windmill in a stream of air (natural or other). If the blades spin fast enough, one of the LEDs should light up.

Experiment and Observe

Blade design: One of the most important aspects of windmill design is to create blades that capture the wind pressure efficiently. Search for photos and physical examples of traditional windmill blades and the blades on windmills in electric wind farms. Take careful note of the characteristics of the designs. Also look for and note the design of ceiling fan blades, box fan blades, circular fan blades, and propellers on small airplanes. What do these blades have in common? What is different about them? The blades are all designed to transfer energy from or to the air. Generators capture energy from the air and convert wind energy to electrical energy. Fans transfer energy from electricity, gravity, or other physical movement to the air (causing the air to move).

Using your observational notes, experiment with different blade templates, with the blades differently sized, shaped, slanted, or twisted. Your goal for this project is to capture as much wind energy as you can to spin the blades and light the LED.

The Content Behind the Activity

Capturing wind energy: The sun provides most of the earth's energy. Wind and weather are just two of the many observable phenomena on the earth that are made possible by energy from the sun. Oceans, mountains, geographic rotation of the earth, altitude, latitude, and many other factors affect the wind. Capturing and converting energy from the wind is a great way to generate electricity. No fossil fuel is consumed, no noxious emissions are generated, and the source of energy is free, originating from the sun's energy. Although generating electricity from the wind has been done on a small scale for about 130 years, humans have built and used different types of windmills to capture power from the wind to do different types of work for thousands of years.

There is a cost to designing, building, and maintaining windmill generators, and a cost to distribute generated electricity to homes and businesses over wires. When you place windmills in a windy area, the shape of the blades will determine how much energy will be harvested from the force of the wind (air pressure) and transferred to the generator. The spinning blades cause the shaft of the generator to spin, and the electricity generated is transmitted to the power grid for distribution.

Core Content Skills:

Science & Engineering (NGSS)

Developing and Using Models, Planning and Conducting Investigations, Analyzing and Interpreting Data, Constructing Explanations and Designing Solutions; Definition, Transfer, and Conversion of Energy, Weather and Climate, Earth's Materials and Systems, Human Impact on the Environment

Social Emotional Learning

- Self-awareness
- Self-management
- Responsible decision-making

The Content Behind the Activity (cont'd)

Converting wind energy to electric energy: When the wind energy is captured by the windmill blades, the shaft of the motor/generator rotates, meaning the force of the wind is converted to rotational energy. The motor then converts the rotational energy into electrical energy. Surprisingly, an electric motor and generator are basically the same! Putting energy into a motor/generator by physically turning the shaft yields electricity as an output. Connect the battery to the motor and the shaft will rotate. The motors in electric and hybrid cars move the car on the road and charge the battery when the driver slows down the car.

Inside the motor/generator: The motor in this activity has an outer case (below, left) with two crescent shaped permanent magnets inside. The center component, called the armature, has a rotating shaft (left side) and surrounded by an electromagnet. The component on the right of the armature contains the copper brushes that direct electricity by brushing against the electromagnet as the motor rotates.

LEDs: Light emitting diodes (LEDs) are semiconductor components that emit light when an electrical current passes through them. They only conduct in one direction, which is why this kit comes with 2 LEDs connected in reverse directions. Only one will light up at a time depending on the direction of rotation of the shaft and windmill blades.

Reuse

This kit uses reusable materials designed for other uses. To continue making a positive impact in reducing waste, reuse these materials in other projects. Additionally, any unused materials can be collected and delivered back to RAFT.

Feedback

Please comment on this kit by taking this short survey: http://bit.ly/RAFTkitsurvey. Let us know of any material concerns (missing, broken, or poorly fitting parts) as well as any suggestions for improvement.

Resources

How do wind turbines work? Video (5:02) - https://bit.ly/3KLsrz1

RAFT Electric Wind Generator assembly video (3:03) - https://bit.ly/49pYqPu