Renewable Energy Science Kit - Wind Turbine Activity

Activity

Grade Level: 10-12

Topics: Renewable Energy Technology, Wind Power, Energy Monitoring

Time: 45-60 Minutes

Overview:

Through trial and error testing, students will learn what factors are involved in making the best (most efficient, safest, most power generated) wind turbines they can. Groups will take what they already know about wind turbines to build what they think is best for the first round of testing. After that, they will make changes to their turbine blade combinations based on what they learned from those tests to improve their design.

Objectives:

Groups will be able to understand the how differences in blade angles, blade type and blade number can affect the performance of a wind turbine. They will also record energy monitor data which includes: Volts, Amps, Ohms, Watts, Joules and rotations per minute (RPM) (Higher grades can do electrical math related to this data).

Background:

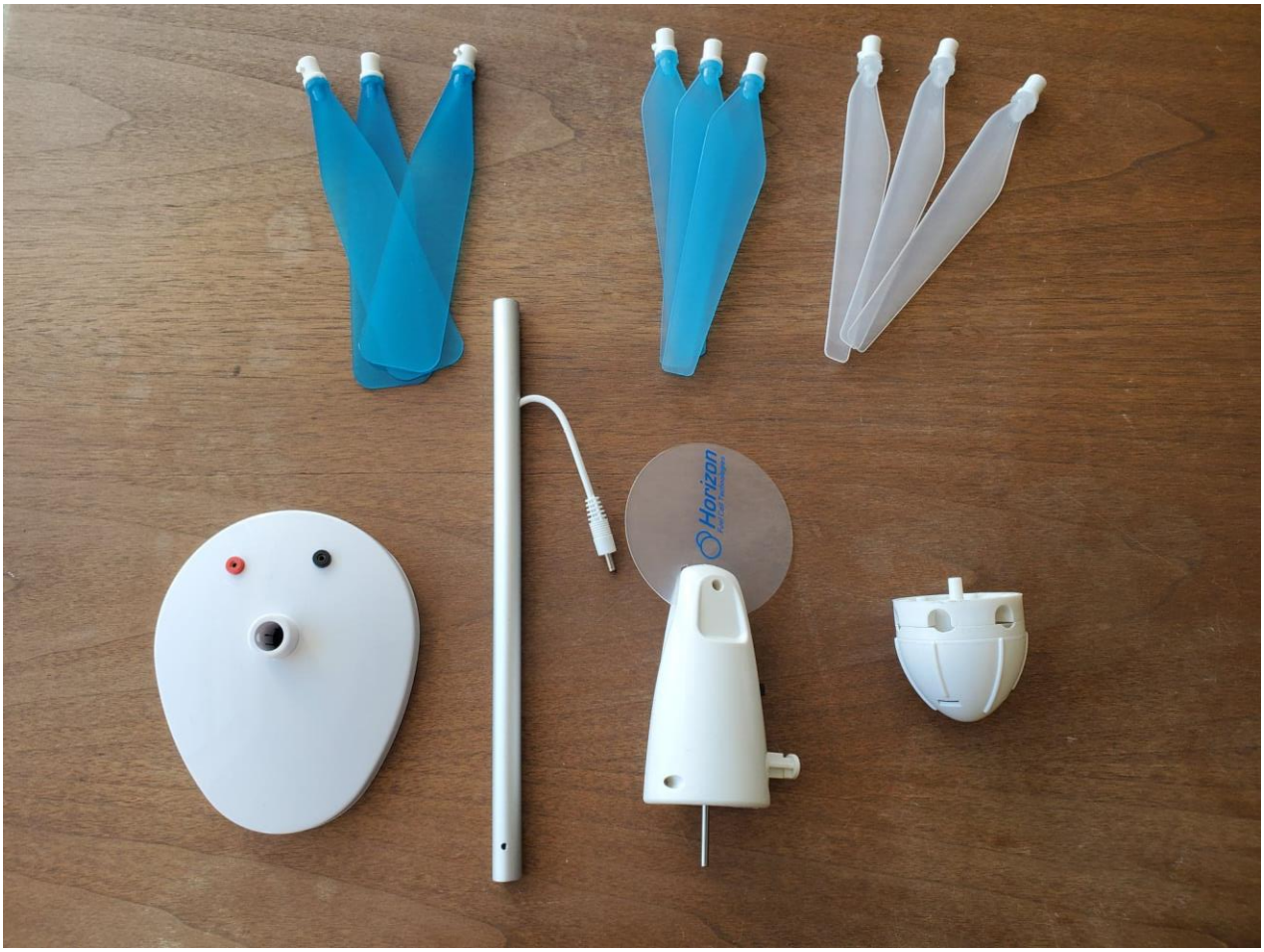
Nova Scotia is one of the leading provinces when it comes to renewable energy technologies in Canada. Nova Scotia generates electricity mostly from coal. The province is trying to escape coal use through the adoption of many different renewable energy sources.

Types of technologies used are: wind power, in-stream tidal power, water dams, biomass energy, geothermal, and solar power. Solar power includes photovoltaic (PV) and solar hot water heaters. Wind power is Nova Scotia's most used renewable energy source.

The reason we want to make a combination of these technologies is because their power generation can vary throughout the day. Wind power in Nova Scotia can vary from less than 1% of the provinces energy demand to over 40% depending on the weather

Materials:

- Renewable Energy Science Education Kits (15 kits available, 5/tote)
    - Wind Turbine Parts: Base, Shaft, Nacelle, Nose Cone
    - Blades: 3 'A' Blades, 3 'B' Blades, 3 'C' Blades
    - Other: Screwdriver
- Renewable Energy Monitor (3 available)
- 20" Box fan (3 available)
- Something to record energy monitor data



1 - **Pictured from left to right (Top) 'A' Blades, 'B' Blades, 'C' Blades**

(Bottom) Base, Shaft, Nacelle, Nose Cone

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Procedure:

Room Setup:

1. Set the room up so that groups can easily work in groups of 2-3. Set up the box fan in an area where all the groups will be able to see the testing.
2. Set the energy monitor up near the box fan with one red wire and one black wire.

Warm Up:

1. Ask the groups "What types of renewable energy technology do you know are used in Nova Scotia?" Any information you know about these technologies you can add in after they mention it. Such as:
    a. Solar - Would be a great resource for large unshaded rooves like schools or government buildings;
    b. In Stream Tidal - a newer technology that uses floating barges to generate electricity through turbines extended under the barge. These can be turned on and off quickly to reduce harm to local species.
    c. Geothermal - Some of Dalhousie University's buildings use a large geothermal system for heating and cooling;
    d. Water Dams - Berwick is on its own electricity grid due to the amount they can generate from their water dams;
    e. Biomass - biomass, which can include forest biomass, wood processing wastes, agricultural wastes, and energy crops. For example biogas, which is largely methane, can be used in engine generator sets to produce electricity and heat from the digestion of wet organic waste materials. Biofuels are renewable fuels that can replace gasoline, diesel, or home heating fuels.
    f. Wind Power - Nova Scotia's most utilized renewable energy resource.
2. Tell the students what the plan is for the activity. Often the plan is:
    a. They will be building and testing wind turbines;
    b. There will be at least 2 tests. If there is time there can be more;
    c. Mention how the kits are meant to be reused and should be treated with respect;
    d. Only take out the parts listed below as there are more than just wind turbine parts in the kit:
        i. **Wind Turbine Parts**: Base, Shaft, Nacelle, Nose Cone
        ii. **Blades**: 3 'A' Blades, 3 'B' Blades, 3 'C' Blades
        iii. **Other**: Screwdriver
    e. The group that generates the highest voltage in the energy monitor gets bragging rights.
3. Before you hand out the kits, open one, show them the parts that will be used and speak briefly about each of the parts and how they relate to a wind turbine.

a. Base - Large turbines have bases that go straight into the ground.
b. Shaft - Often has a door and stairs or ladder so that repair technicians can climb them to work. Holds the next important part, the Nacelle.
c. Nacelle - The part that houses all of the sensor equipment and generator. When the axle turns the generator creates electricity.
d. Nose cone - Holds the turbine blades. Unscrews into 3 pieces. There are 6 slots for the blades to clip in to. This makes it so the combination of blades can be 2, 3, 4, or 6. 1 and 5 are just unbalanced.
e. Turbine blades - Often the blades are referred to by their letter. Mention how the blade angles can be changed.

ATTENTION!

The turbine base and the shaft are connected through the wire that goes through the shaft. The base metal plate is removed via 4 screws. There is a positive and negative terminal in the base that the wires from the shaft have to be attached to. Feed the turbine shaft wire through the top of the base to the bottom. Unscrew the two nuts. Attach the coloured wires to their respective terminals and screw back on the nuts and the metal base. The wires are small and have to be placed carefully back before the base can be completely screwed on or you will damage the wires. Due to this the activity is broken into two groups.

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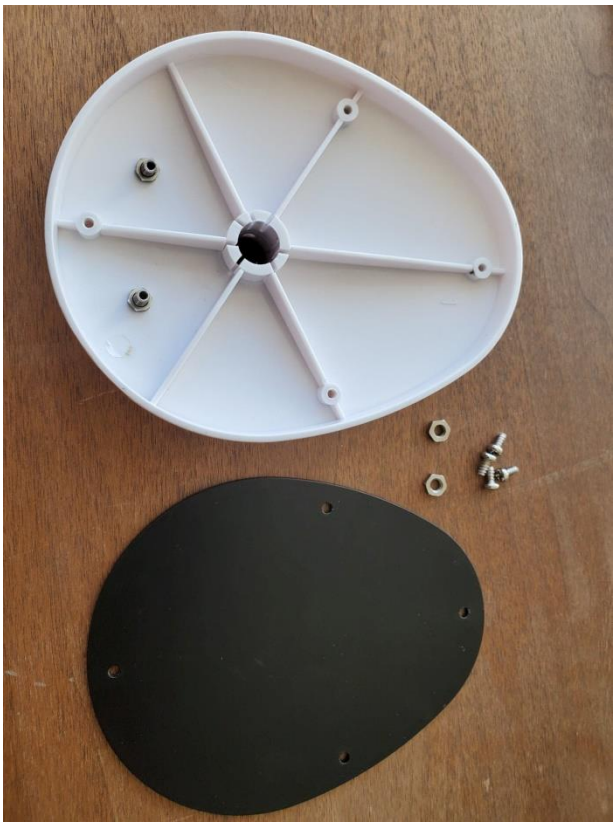
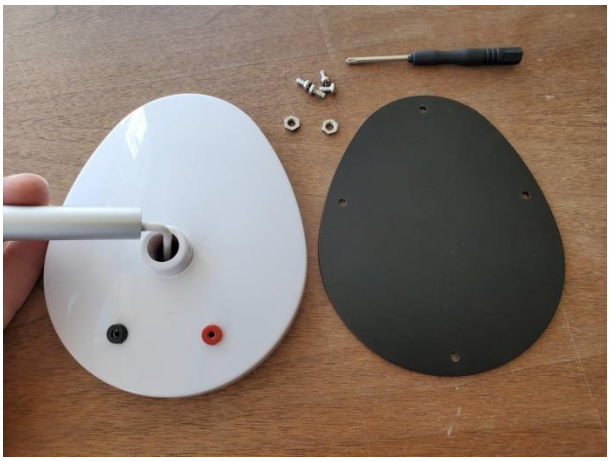
Turbine Base and Shaft Assembly Photos:

Step 1 - Remove screws from beneath base



Step 2 - Remove metal plate and the two nuts attached to terminals



Step 5 – Using the screwdriver carefully unfold the wire in the bottom of the shaft and feed it into the top of the base

Step 4 - Place the wires on their respective terminals and replace the nuts. Before the base is reassembled and to make sure the wires are not crushed by the metal plate, push the wires into the slots provided.

Step 3 - After the base and shaft are assembled attach the nacelle to the top of the shaft and plug the white wire into the bottom of the nacelle

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Grades 10-12 Activity:

Testing:

1. Hand out the kits to the groups. Mention that after all required parts are removed to then close the box and move it away from the work space. Kits which have a thin foam insert groups can use that as a work surface.

2. Give the groups time to decide which blades they want to use, how many blades to use and what angles they think will work best.

3. IMPORTANT: Show the students how to attach the wires from the turbine shaft into the base without damaging the wires.

4. When attaching the nose cone to the nacelle they should feel and hear a 'click'. This will ensure the blades are rotating the axle of the nacelle.

5. When the groups are ready have them hold their turbine up with two hands and mention the differences and similarities they have created.

6. Have the groups stay at their work stations and call one group at a time up for testing.

7. Turn on the energy monitor and plug the wires into their respective 'Input' terminals.

8. Plug the other end of the wires into their respective terminals in the wind turbine base.

9. Mention to the groups that for this first round of testing, they should not be touching their turbines unless they have already done their first test. This will prevent groups from modifying their design as they see what works well for other groups.

10. Test the turbines with the fan on 3 and with the nose of the turbine facing the fan about 2 or 3 inches away. This is to best utilize the wind that is being generated from the fan.

11. Give the turbines a chance to reach their peak speed and have the groups' record their voltage produced.

12. When they have completed their test they can make and changes they would like to improve their design.

13. Once test one has been completed, give all the groups time to finish their changes. Talk about the things that worked and what didn't in the first test. Mention how the blade

angle is very important and they should make sure they have no blades on opposing angles. The opposing angles will create forces the conflict with each other to stop the rotation of the turbine.

14. If there is time for more rounds before packing up and final information have them do more tests.

Wrap-up:

1. After testing is completed check the voltages produced by the groups and give them their bragging rights.
2. Have the groups pack the parts away and be very careful when removing the shaft from the base. Remember there are wires in there!
3. Ask the groups what they learned about wind turbines and if they had fun with the activity that day.
4. Groups can take their data from the energy monitor to conduct some electricity related math.

Extra Wrap-up Information:

What is the best combination of blades for these kits?
The best combination is 2 or 3 'C' blades. All angled to face the fan with their largest surface area catching the wind.

We had the same set up as group 'X'. Why did we have different Voltages?
Each Nacelle has a generator in it. Some generators are more efficient in converting energy to electricity than others.

What is the difference between the blades?
'A' Blades – These blades are flat and wide with a lot of weight distributed near the end of the blade. These are similar to what are used for old wind grain or water mills.
'B' Blades - More like what is used on airplanes. The weight is shifted closer to the center. The shape of the blade generates lift like an airplane wing and if you put that sideways on an axle you have a lift force that will produce rotation.
'C' Blades - NASA engineers to the idea of the airplane wing design and changed it to better suit the task of a wind turbine. They are also much lighter than the 'A' and 'B' Blades.

All of the large wind turbines have 3 blades. Where would I see other numbers of blades? Why?
Wind turbines are trying to balance out weight and surface area. Too much weight will cause them to need more and more wind power to rotate. Too little weight and the blades don't capture enough energy from the wind to produce power. More surface area means more energy from the wind captured but also means more weight.

What is often seen is that once a turbine becomes large enough 3 blades is the right amount. If they are small, such as ones which are used for residential homes, sailboats or scientific research laboratories, more blades are needed to increase the surface area as weight is much less of a factor.

I've seen videos of turbines breaking from spinning too fast. What safety features does a turbine have to stop that?
During high wind events turbines can be damaged. To reduce the likelihood of this turbines have a braking system to slow down the rotation. The blades can also be angled in a way that stops them from picking up so much of the energy from the wind. If they are like the 'C' Blades they can be rotated sideways and the wind will flow around the blades.

What makes a good wind turbine?

1. Proper blade shape
2. Proper blade angle
3. Proper number of blades
4. Location - You don't want to have many structures around making the air turbulent. Best places are: on shores (Digby), on mountains (Parker Mountain) or in large stretches of flat land (Between Nova Scotia and New Brunswick)

Resources

Lesson Plans:
https://www.horizoncurriculum.com/stem-lesson-plans

Energy Textbook:
https://www.horizoncurriculum.com/chapter-1/1-1-introduction/

About the Renewable Energy Kits

Booking the kits:

The Renewable Energy Kits are available to be borrowed from the Valley Regional Library. Teachers are able to loan the kits and bring them into classrooms. Other educators, youth group leaders or other groups can book a time at their local Valley Regional Library to use the kits on site. There is a kit kept in the Innovation Lab at the Annapolis Royal Library for community use.

Check for availability or loan the kits by visiting the AVRL online catalogue:

- https://avrl.catalogue.library.ns.ca/Record/1632122
- The kits are listed under the name "RENEWABLE ENERGY KIT"

For teachers who are checking the kits out, there is a 2 week maximum loan period before the kits need to be returned. Each tote provides enough equipment for 15 students to work in groups of 3 (3 students/1 Renewable Energy Science Kit, 5 kits/tote).

About Clean Annapolis River Project:

The Renewable Energy Education Kits were assembled as part of Clean Annapolis River Project's *Powering Innovation* project.

This project was made possible thanks to the financial support of the Nova Scotia Low Carbon Communities Fund, the Farm Credit Canada AgriSpirit Fund and the Parker Mountain Wind Turbine Society Community Fund.

Clean Annapolis River Project (CARP) is a community-based non-government organization driven by its mission to enhance the ecological health of the Annapolis River watershed through science, leadership and community engagement.

Learn more about this project or CARP at:
www.annapolisriver.ca
carp@annapolisriver.ca
(902)-532-7533