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NRELEd: The Power of the Wind

(Adapted from: https://www.teachengineering.org/activities/view/cub_environ_lesson09_activity2)

Background

What creates wind?

Wind is caused by the differences in atmospheric pressure that result from the uneven heating of the atmosphere. Incoming energy from the Sun heats air, making it less dense and causing it to rise. As the air rises, it leaves behind an area of low pressure and cooler air moves in under the rising warm air mass. This constant exchange of air masses, in an attempt to maintain equilibrium, creates wind.

How do we measure wind speed?

Wind speed is commonly measured using an anemometer, which typically has three or four cups that capture the force created by the wind. The number of times the cups rotate each minute can be counted electronically. Anemometers are used to provide data for weather observations and predictions and are often use in conjunction with wind vanes, which tell us which direction the wind is blowing. ***You will make your own model anemometer today.***

How do we generate energy from wind?

People have been converting wind into energy to do their work for generations. Windmills have been traditionally used in agricultural settings to convert wind energy into mechanical energy in order to mill grain, pump water, and generate electricity. Today's wind turbines use generators to convert mechanical energy into electricity that we use to power our lives. Wind is one type of renewable energy, which means the supply is constantly replenished and we can always generate energy from it.

What factors do we consider when designing wind turbines?

Some of the things we need to think about when designing wind turbines and wind farms are wind direction, wind speed at different elevations, geography, air density, and the lengths of the blades. It's also important to consider the effects of very windy days and how wildlife might be affected by wind machines (related video).

Blowin' in the Wind!

In order to develop an understanding of how we can use the power of the wind to generate electricity, we can build and use model anemometers to better understand and measure wind speed. You can measure some spots around your home or nearby spaces to see where the wind blows more consistently and where you might consider trying to capture some of its energy for your own use.

What you need:

- 4 small paper cups, 6-ounce or smaller size
- 1 push pin
- 1 sharpened pencil with an eraser on the end
- Stopwatch, watch, clock or timer (with seconds)
- 1-2" diameter ball of modeling clay
- 2 pieces of stiff corrugated cardboard, 3-inches wide x 16-inches long (~7.5 x 41 cm)
- 1 pair of scissors
- 1 stapler

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- Colored marker
- Anemometers can be built by students of all ages, with varying levels of adult supervision.

Procedure:

- Cut the cardboard strips to the appropriate lengths. You may need to adjust the strip size to accommodate cups of different sizes.
- Test your anemometer on a day when you can be outside, preferably with some wind.

1. Cut off the rolled edges of the paper cups to make the cups lighter.
2. Color the outside of one of the cups with a marker.
3. Join the two cardboard strips so they make a plus sign (+) and staple them together in the center where the two strips join.
4. To find the exact center, use a ruler and pencil to draw lines connecting the diagonal corners through the center (overlap) section of the cross. Where the pencil lines intersect is the exact middle of the plus sign.
5. Staple the sides of the cups to the ends of the cardboard strips, making sure the cup openings all face the same direction, as shown in Figure 2.
6. Next, push the pin through the center of the cardboard strips (where the pencil lines intersect) and attach the cardboard plus sign to the eraser end of the pencil.
7. Gently blow on the cups to make sure the cardboard structure spins freely around on the pin. You may need to adjust your model slightly before proceeding.
8. Go outside with your anemometer, timer, and clay.
9. Choose different spots where you want to measure wind speed.
10. Place the modeling clay on a stable, horizontal surface (such as a wooden fence rail, picnic table, wall, or flat rock). Stick the sharpened end of the pencil into the mound of clay so that the pencil stands vertically, and the anemometer is free to spin.
11. Measure and record wind speed by counting the number of times the anemometer spins around in one minute. Count one rotation each time the colored cup passes by the pencil. Take at least three wind speed measurements at each location.
12. Calculate the average wind speed for each location. Discuss the minimum, maximum, and average wind speeds.

Activity Extensions:

- Brainstorm some advantages and disadvantages of using wind power. Are there ways to address the challenges you thought of?
- Build different types of wind vanes, so your anemometer can also tell you the direction of the wind.
- Scale the activity up in size and see if and how the measurements change.
- Use your anemometer to determine the air speed of different size fans.
- Investigate and discuss how wind speed changes at different times of the day.
- VIDEO: Take a Tour of a Wind Turbine

NREL has pioneered many of the components and systems that have taken wind energy technologies to new heights, providing global leadership in fundamental wind energy science research, development, and validation activities.

From conceptualizing taller turbines capable of greater energy capture to assessing the United States' offshore wind energy needs and potential, NREL's wind energy program advances wind technologies from initial concepts to deployment. NREL's 305-acre Flatirons Campus, which houses the National Wind Technology Center, is an ideal setting for evaluating the reliability and performance of wind turbines because it experiences diverse and vigorous wind patterns of more than 100 miles per hour.