**Blowin’ in the Wind**

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| **5-Part Plan Title:** | **Blowin’ in the Wind** |
| **Engineering Grand Challenge(s) Covered:** | **Renewable Energy and Solar Energy** |
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| **Grade Level(s):** | **6-8** |



Source: National Renewable Energy Laboratory (Public Domain)

1. Subject / Subject Area (s):
2. Time Required: 50 minutes
3. Group Size:
4. Expendable Cost per group:
5. Summary: As the demand for renewable energy sources increases, so must the creativity of the younger generation tasked in tackling these issues. This lesson aims to sharpen students’ design and problem solving skills as they work within a team to create a structure that will use the wind as an energy source. Student teams will competitively create pinwheels from different materials to model wind turbines in order to determine which one is most effective in producing energy.
6. Engineering Connection: This lesson is vital as it encourages students to formulate, plan, and create all from their own ideas. In order to be innovative and meet the needs of the future, students should not be dependent on the past’s way of doing things but must actively take part in the creation process. The pinwheel as a model for wind devices is engineering related as it deals with renewable energy resources in addition to the fact that it introduces students to the very real world of models and prototypes. Moreover, at the end, testing to see which model is most effective in harnessing the wind will enable discussions on the best designs and what they consisted of.
7. Keywords: Energy, wind, windmills, turbines, design, optimization
8. Educational Standards: See attached standards grid for a complete mapping to all pertinent STEM standards:

North Carolina Essential Standards

6-8 SCIENCE

7.P.1.1, 7.P.2.1,7.P.2.2,7.P.2.3,7.P.2.4,7.E.1.2,7.E.1.3,7.E.1.5, 8.P.2.1,8.P.2.2

1. Learning Objectives (After this lesson students should be able to):
   1. recognize wind as a renewable energy source, as well as what the term means and its importance today
   2. understand that wind can be harnessed through devices such as windmills and wind turbines and understand the difference between the two
   3. plan, design, and create the best model pinwheel using the materials given
2. Materials List (Each group should have access to):

Colored construction paper

Thicker paper, such as poster board or cardstock

Foam paper

Copy Paper

Wine corks

Pins

Glue

Scissors

Tape

Pencils with erasers

Pipe cleaners

Twine

Paper clips

Washers

Hand-held hair dryer with cold setting (2 for the class to share)

Stopwatch

Ruler

Hole punch

1. Introduction/Motivation

How many of you have ever been outside during a storm or on a very windy day? Have you ever felt a wind so strong that you were certain it would carry you away at that very minute? Well, that wind might very well be the answer to the energy crisis of the world today. In this lesson, the main goal is to introduce the concept of using the wind as a source of energy. Why this is so important is that the world today is running on non-renewable energy supplies, meaning that what is used up in our homes, schools, and libraries will never again be available for future generations to use. This is a serious problem because there is not an unlimited supply of these resources-- in fact, the supply is depleting more and more each day as the world population increases and as more countries develop their infrastructure. The advantage in using renewable energy sources is that they will never run out and our usage of it today will not make it harder for future generation to survive as well. Good thing that there will always be wind!

With this motivation in mind, the main goal of this lesson is to make pinwheels in order to model structures that use the wind to create energy. From windmills to wind turbines, students will understand how these different structures work. Moreover, they will discover what it takes to design these structures through teamwork.

1. Lesson Background & Concepts for Teachers

*History*

Wind turbines and windmills are machines that convert wind’s energy into mechanical and electrical energy. The Greek engineer, Heron of Alexandria, created the first documented device he dubbed the wind wheel in the first century AD. From windmills that rotated horizontally to those that rotated vertically, these wind devices were first originated to mill grain and for other food production purposes. As time progressed, the types and functions of wind devices grew. Now, there are entire wind farms dedicated to the purpose of harnessing the kinetic energy from the wind.

*Types of Wind Machines*

While the history of wind turbines is fascinating, the actual definition of these structures can be downright confusing! The entire class of structures that converts wind energy into mechanical energy is called *wind turbines*. Windmills are examples of wind turbines that use the mechanical energy produced to power machinery and to drive other simple processes. Throughout history, the Netherlands has used windmills to mill corn, grind grain, and pump water. However, if the mechanical energy is then converted to electrical energy, then the device is commonly referred to as a wind turbine. California is home to many wind farms, which are sites that include rows and rows of these devices. Lastly, a wind charger is a wind turbine that solely charges batteries. The possibilities are endless.

*How do windmills and wind turbines work?*

Wind energy machines generally consist of rotor blades that spin when the wind is blowing on them. These blades are attached to a shaft at the center of the rotor that also spins while the blades spin as the energy from the wind is being transferred into mechanical energy. Although it varies with the exact type of windmill or wind turbine, this shaft is generally connected to a gearbox that increases the speed of the shaft and then finally to a generator (in the case of electricity-producing wind turbines) or a mechanical system that suits its purpose (for example, a system of pumps for a water pumping windmill).

1. Vocabulary/Definitions

Wind turbines: 1. The class of structures that converts wind energy into mechanical energy 2. A specific device that converts the mechanical energy into electrical energy.

Windmills: Examples of wind turbines that simply convert wind energy into mechanical energy to drive simple process.

Wind farms: An area of land consisting of groups of windmills or wind turbines.

Wind Energy: Renewable energy created from the wind. It is a form of kinetic energy that can then be converted into mechanical energy and electrical energy.

Renewable energy: Energy generated from natural resources such as wind, water, and sun. They are continuously replenished and will never run out.

Pinwheel: A structure that consists of a wheel and a handle.

Mechanical energy: Energy of a mechanical system. Components include kinetic energy, energy of motion, and potential energy, stored energy.

1. Procedure:

Before the Activity-

* Gather pinwheel materials.
* Inform students that different designs are available online and that, while they are encouraged to be creative, may do some research to get started.
* Print out pinwheel template/instructions, but indicate that it is only one example and other designs are welcome.
* Hand out Data Collection Worksheets.
* Show students a sample pinwheel and demonstrate how it works.

With the students –

Building the Model Windmills -

* Divide students into small groups and have them discuss or sketch out briefly what their design will look like and which materials they will need.
* Allow students to use the different materials available to them (located in the front of the classroom) to construct their pinwheels.
* If students choose to follow a traditional pinwheel design for the blades of their model windmill, they may follow the template and instructions on the sheet provided.

Testing the Designs -

* Explain to the students that their designs will be tested and modified (if time allows) the way engineers always seek to evaluate and improve the devices they build.
* Communicate to students the parameters that will be tested:
  + The time it takes for their pinwheel to lift a load of 1 paper clip 6 inches (at a fixed distance from the dryer of 3 inches)
    - With the hair dryer blowing facing the pinwheel straight on
    - With the hair dryer blowing on the side of the pinwheel
  + The time it takes for their pinwheel to lift a load of 1 paper clip 6 inches
    - From 3 inches away from the dryer
    - From 6 inches away from the dryer
  + The maximum load of paper clips and washers their pinwheel can lift 6 inches upwards

Optional*-*

The time it takes for their pinwheel to lift a load of 1 paper clip 6 inches (at a fixed distance from the dryer of 3 inches)

Using the normal heated setting

Using the cold setting

Also communicate to the students that each group will be competing to see which pinwheel design can lift a load of one paper clip a distance of 6 inches the fastest, and which can lift the greatest load of paper clips and/or washers.

As groups finish building, have them take their pinwheels to the hair dryers for testing. Make sure that they record their results in the table provided to them.

For each of the timed activities, have students start the timer when the dryer is turned on, and stop it when the paper clip has been raised six inches (as indicated by a ruler held by one of the students next to the paper clip).

In order to find the maximum load of paper clips and washers, have the students add paperclips 1 at a time (up to 5) and then washers and observe whether their pinwheel can continue to lift this weight 6 inches. Tell students to stop testing if their pinwheel fails. Again, be sure that they record their maximum load

Analysis -

* Collect the data from each group and identify the winners from the two “competitions” (which pinwheel design can lift a load of one paper clip a distance of 6 inches the fastest, and which can lift the greatest load of paper clips and/or washers)
* Have groups calculate their average time, speed with which their pinwheel could lift the objects for each condition (distance divided by time in ft/s), and average speed for each condition.
* Have students discuss with their results with their group and come up with reasons why the observed what they did (for example, why might the direction of the air from the hair dryer affect how fast the pinwheel spin and therefore lifted objects?)
* Have a class discussion about why some pinwheels worked better than others. Ask students to identify which factors in their designs may have contributed to their group’s success or failure.

Attachments

See Pinwheel Template (from teachengineering.org) and Data Table

1. Safety Issues and Guidelines: Ensure that students use scissors correctly. If they will be operating the blow dryers, make sure they are trained to use electrical appliances.
2. Lesson Closure - Have students explain the significance of renewable energy. Ask what was their favorite part of the design process and why. Also, ask about their most challenging part. What ways do they think they can improve? Discuss what they learned about the different competitions of the shortest time to raise the load and the largest distance achieved. Let them tie the connections to wind turbines and windmills. Also, see whether they can pinpoint when wind energy is most effective-- when it’s hot or when it’s cold.
3. Troubleshooting tips: Test the dryers beforehand. Depending on the brand, the power of the air may be too high or too low, so distances from the dryer may need to be adjusted as necessary
4. References

<http://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_earth/cub_earth_lesson04_activity2.xml>

<http://en.wikipedia.org/wiki/Wind_turbine>

<http://www.sciencebuddies.org/science-fair-projects/project_ideas/Energy_p025.shtml#summary>

<http://www.eia.gov/kids/energy.cfm?page=wind_home-basics-k.cfm>

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<http://www.ironmanwindmill.com/how-windmills-work.htm>

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2. Supporting Program: Boeing Grand Engineering Challenge Scholars