

Wind Turbine Demonstration Guide

Abstract

The purpose of this demonstration is to promote interest in S.T.E.M. (Science, Technology, Engineering, and Math) and to emphasize the importance of renewable energy. This project is focused on one of the Grand Challenges for Engineering from the National Academy of Engineering. The Grand Challenges are important science and engineering problems that need to be addressed in the upcoming years. The inspiration for this project arose from the need to make wind energy more economical, an issue which branches off of the renewable energy Grand Challenge. With the pollution that comes from most sources of energy, finding an affordable alternative is necessary if we wish to keep the environment we live in healthy. Wind is a source of clean energy that is already being used in the United States. Through our project we hope to inspire young students to be creative and innovative while opening their eyes to where energy comes from. We will rely on a hands on demonstration to stimulate the students' interest in the S.T.E.M. fields and couple this interest with a brief lecture to assist with learning about renewable energy.

Age Levels

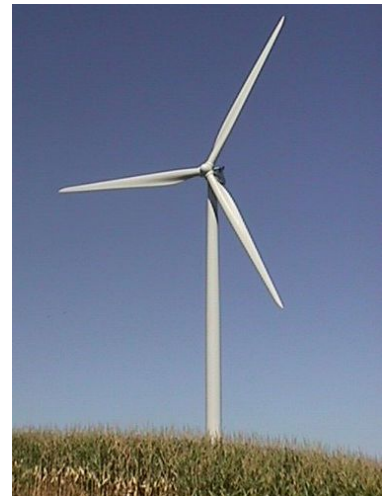
8-18.

Estimated Time

45 minutes

Objectives

- Learn about wind energy and turbines
- Learn about teamwork and problem solving
- Learn to be creative and innovative



Key Ideas

- Wind can be used to make things happen
- Predicting, observing, designing, building, testing, and analyzing are all parts of the design process
- Things we observe every day, like the wind or the sun, can be turned into energy

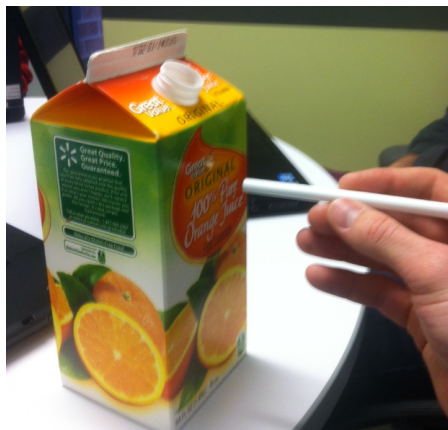
Sample Materials List: (6 groups/class of 30)

Materials Needed	Quantity per group	Total Used	Average Cost
Index Cards	6	36 cards	\$ 1.39/pack of 100
Tape	1 roll	6 rolls	\$13.00/pack of 6
Twine	3 ft	18	\$ 5.00/ball (475ft)
3/16" Dowel Rods 12 inch	1	6	\$2.00/pack of 12
2 " Styrofoam Ball	1	6	\$0.55 each
Small paper cups	1	6	\$5.00/pack of 200
Hairdryer/fan	---	1	Teacher should have
Milk Carton	1	---	\$1.00
Scissors	1	---	Teacher should have
Wooden Craft Sticks	6	36	\$3.47/pack of 750
Pen Body	---	---	\$4.83/pack of 12
		Total Cost	\$38.99

Preparation for the Demonstration

Prepare the carton

1. Poke two holes on opposite sides of the carton 1 inch below the bottom of the sloped portion of the carton
2. Push the casing of a pen through the holes so that the ends are sticking out of the carton



Prepare the dowels

3. Draw a line on the dowel, 4 inches from one end (*The short side of the stick is where the blades will be made, the long end will be inserted into the carton*)



Prepare an example “working” turbine



4. Cut or form index cards into the shape you want your windmill blades to be
5. Tape the index card onto the end of a craft stick (if your stick has a pointy end, make sure you tape the index card onto the other, blunt end)
6. Insert the craft stick of your blade into your styrofoam ball
7. Repeat steps 1-3 for the number of blades you want your windmill to have (make sure to keep blades evenly placed around the ball for proper balance)
8. Insert *the short side* of the dowel rod into the styrofoam ball so that it's perpendicular to your blades like shown above (make sure the dowel fits tight into the ball so it doesn't slip)

Ways to vary your design

- Different number of blades
- Different length, width, or shape of the blades
- Folding your blades in different ways
- It is possible to make your turbine without using the styrofoam ball as shown in the instructional video
- Be creative and think outside the box

Prepare the cup

9. Cut a length of string approximately 3 feet long
10. Poke two holes in the cup near the top, on opposite sides
11. Pass the string through both holes
12. Pull 6 inches of string through one end of the cup
13. Tie the short end of the string to the long end



Assembling the pieces

14. Add water to the carton or tape it to the table to keep it steady (make sure to place the carton near the edge of the table so the cup will hang off the edge)
15. Tie the string from the cup to the dowel near the mark on the dowel
16. Tightly tape around the knot to prevent it from sliding around the dowel
17. Slide the dowel through the pen body in the carton so that the blades and string are not over the table
18. Add weights to the cup (3 pennies works well)
19. Point the fan at the wind turbine
20. Turn the fan on and move if necessary. Sometimes the turbine works best being closer or further away. Also, some designs may work better if the wind hits them from the side.
21. Weights can be added or removed to test the effectiveness of the turbine design

Troubleshooting

Make sure that you have a working set of blades to show the students. In the case their designs don't work, this will allow you to still teach the scientific principles at play in the demonstration. A working set of blades can consist of just two blades made from note cards that haven't been modified like shown in the picture on the previous page. The key to working blades is making sure they are angled all the same way.

If your design does not work

- Vary the angle of the blades to better catch the wind
- Make sure they are angled to spin in the same direction
- Try moving the wind source around

Demo Outline

- Discuss STEM and Grand Challenges
- Discuss wind energy (Figure 1)
- Show sample turbine
- Discuss predictions
- Pass out materials to the groups
- Construction of the wind turbine, help students construct their design
- Test student designs
- Discuss results
- Clean up

Discuss STEM and Grand Challenges

Introduce STEM and explain the Grand Challenges. See abstract and sources for more information.

Discuss wind energy

Explain how wind power spins the blades and how that energy is transferred to work. Figure 1 explains the basics of how wind energy powers wind turbines. Figure 2 includes some technical terms that could be discussed along with an explanation of how they apply.

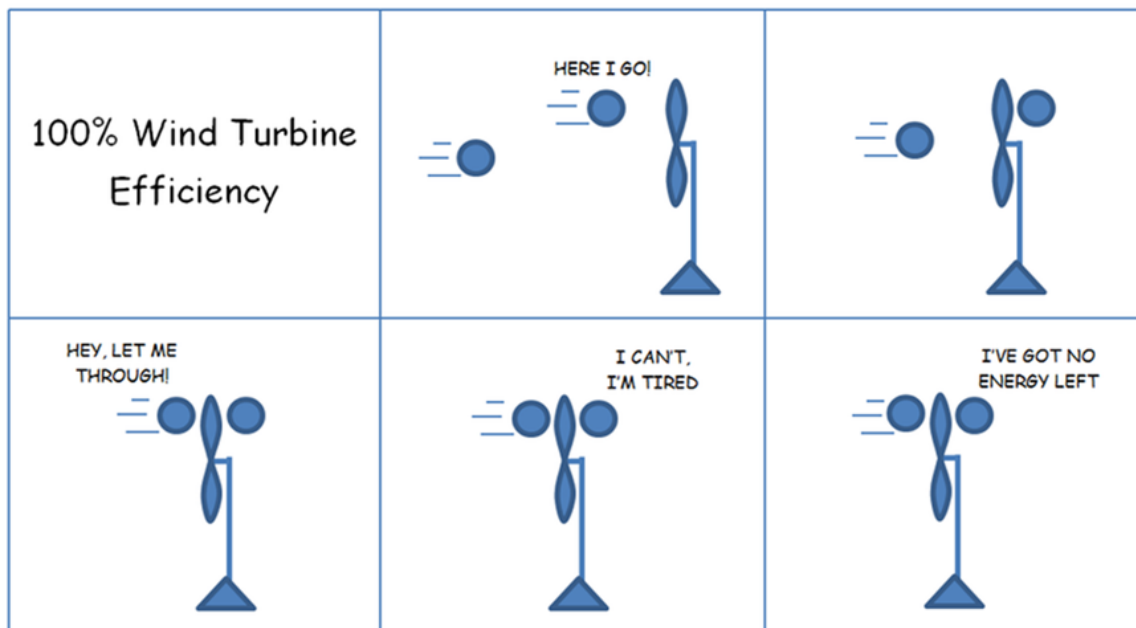


Figure 1: Wind turbines capture the wind's kinetic energy by trying to stop the wind.

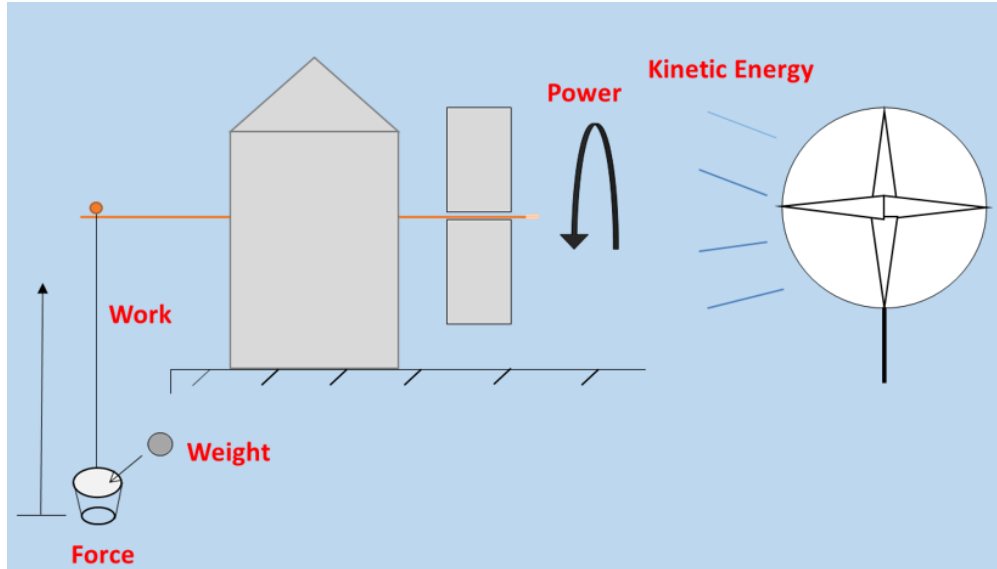


Figure 2: Wind energy is contained in the kinetic energy of air molecules. The turbine blades capture the power of the wind and transfer this energy along the shaft. The spinning of the shaft exerts a force on the string and weight. The shaft does “work” by applying this force to the cup to lift it up over a distance. This work is stored as potential energy at the top after lifting. By releasing the weight, the turbine blades spin as the weight lowers and this potential energy is transferred back into kinetic energy in the form of wind. These principles previously described and shown in the diagram are the scientific principles this demonstration is meant to teach.

Show Sample Turbine

Show the students images of real wind turbines so they have an idea of what they are trying to make. It is recommended that the students do not see a turbine made with the supplies that they are given, this will hopefully lead them to be more creative with their designs.

Discuss Predictions

Ask the students which designs they think will be the most effective and why.

Pass out materials to groups

The recommended supplies to give each group:

- 6 index cards
- 1 roll of tape
- 1 dowel premarked
- 1 styrofoam ball
- 1 pair of scissors
- 6 craft sticks

Construction of the Wind Turbine

Tell the students to make their blades on the short side of the mark on the shafts, this leaves room for the weight and inserting the blades into the carton. Also, if the students choose to use the foam ball they should only put it on the dowel once, otherwise it will spin independently of the dowel. It is an important part of the learning process to let the student groups create their own designs even if it may not seem practical. Help students construct *their design* as needed.

Test the Student Designs

Putting it all together

1. Add water to the carton or tape it to the table to keep it steady. Make sure to place the carton near the edge of the table with one of the holes on the edge side
2. Tie the string from the cup to the dowel near the mark made when preparing the dowel
3. Tape around the knot to prevent it from sliding
4. Slide the dowel through the pen body in the carton so that the blades and string are not over the table
5. Add weights to the cup (3 pennies works well)
6. Point the fan at the windmill
7. Turn the fan on, move the fan if necessary, sometimes it works best closer or farther away, also some designs may work if the wind hits them from the side
8. Weights can be added or removed to test the effectiveness of the turbine

Discuss Results

Potential Questions to ask the Students:

1. What problems did you face with designing the wind turbine?
2. What things do you find interesting about what you saw happen with the wind turbine?
3. Somehow evoke a discussion about why a mix of practicality and design is necessary.
4. What did you learn from this? (all sorts of answers are possible)

Possible Discussion:

Show the students how potential energy is stored when the weights are lifted. Stop the fan and then show how the blades spin the other way as gravity pulls the weights back down. The energy captured by the wind is the same as electricity powering the fan. In a real turbine, this energy is used to turn the generator that produces electricity. Also, discuss the different steps of the design process and how they influence the final outcome, i.e. good/bad teamwork, problem solving, etc. Lastly demonstrate how the different variables affect the efficiency of the blades. Length, angle, and shape of the blades are a few of these variables.

List of Teacher Resources

This is a Bill Nye video. The video talks about the effects of pollution and about other possible sources of energy.

Disney Educational Productions. (2012, July 16). Safety Smart Science with Bill Nye the Science Guy: Renewable Energy--Preview [Video file]. Retrieved from <http://www.youtube.com/watch?v=grl3BDSGEC4>

This is the homepage for the Grand Challenges of Engineering.

Grand Challenges of Engineering. National Academy of Engineering. [Online]. Available: <http://www.engineeringchallenges.org/cms/challenges.aspx>

How Stuff Works article on wind power. Discusses the history of wind power, how power is generated, and different types of windmills.

J. Layton. (2006, August 9). *How Wind Power Works* [Online]. Available: <http://science.howstuffworks.com/environmental/green-science/wind-power.htm>

Many interesting new designs for wind turbines are explained on this website.

Other Power. Wind Turbine Concepts Defined and Explained. [Online].

Available: <http://www.popularmechanics.com/science/energy/solar-wind/4324331>

This website has many facts about wind energy that can be used to stress its importance and relevance.

Wind Energy Foundation. About Wind Energy. [Online].

Available: <http://www.windenergyfoundation.org/about-wind-energy>