EITC Engineers in the Classroom

NATIONAL GEOGRAPHIC + LOCKHEED MARTIN

Level M Middle | Grades 5-8

Wind Energy Lab

Photograph by Mark Thiessen

ACTIVITY: WIND ENERGY LAB

Big Idea

Wind is a form of renewable energy that can be used to turn a turbine to generate electricity. The size, material, and shape of the blades on the turbine can affect their efficiency and the amount of electricity that can be generated with a given amount of wind.

Guiding Question

How do the size, shape, materials, and other characteristics of wind turbine blades affect their efficiency?

Materials Gathered by Teacher (enough for 8 groups)

1. Assorted found items, such as 20-oz. plastic soda bottles, cardboard, cereal boxes, etc.
2. Scissors (2 pair per group)
3. Electric fans (2)

Materials Provided in the EITC Kit

1. Multimeter (1 per kit)
2. Masking tape (2 rolls per kit)
3. Toothpicks (1 box per kit)
4. Corks (1 per group)
5. Motors (2 per kit)

Set up

Communicate with the teacher at least one week before your scheduled classroom visit. Desks should be arranged so students can work in small groups. Two testing stations should be set up next to each other with a shared multimeter between them. Each testing station should contain a motor and a fan. A table should be set up with all the materials students will need for the activity.

Introduction

Teacher introduces the engineer/classroom visitor.

Setting the Stage

- Show the introductory video.
- Tell them who you are, what you do, and what it's like to work in your career.
- Tell them a story about how you got interested in engineering/your career or something that happened in your work that was really exciting–something that truly made a difference in your life.
- Show the activity PowerPoint presentation, as appropriate.

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Hands-on Activity

Briefly discuss students' prior knowledge of sources of electricity and how wind energy works.

Ask: *Where does the electricity we use for lights, computers, and other things come from? What are some different sources of electricity or ways that electricity can be generated? Accept a variety of answers from students. Then explain that you will be focusing on one way to generate electricity–wind energy.*

Briefly explain that wind turbines are used to convert wind energy into electricity. Project the animation of a wind turbine from the Resource Carousel. Point out the blades on the turbine and explain that the blades are turned by the wind. Point out the gears that connect the turbine to a generator. As the winds turn the blades on the turbine, the turbine turns the generator, which converts this mechanical energy into electricity.

The design of the blades is very important in making the turbine efficient. Efficient turbines mean that more electricity can be produced from the same amount of wind. Engineers are working to improve the design of turbine blades and other parts of the system to make them as efficient as possible. Where wind turbines are located can also make a big difference in how efficiently they work. At Lockheed Martin, engineers have developed WindProspector technology to find the best locations for wind turbines. They have also developed a way to use technology to forecast changes in wind to help wind turbines operate more efficiently every day.

Students design and make wind turbine blades.

Explain to students that today, they are going to be wind-turbine engineers. They will be designing and testing blades for a wind turbine. Explain that they will create turbine blades of any size and shape they want out of the found materials that their teacher gathered. Show the students a sample blade that you have made and demonstrate how to tape the blade to a toothpick. Then demonstrate how they should carefully push the toothpick into the cork hub.

Divide students into eight groups of three or four. Point out the found materials that the teacher gathered on the materials table. Ask each group to briefly discuss which found materials they want to use for their blades. Then have one person from each group gather paper, pencil, scissors, five toothpicks, a cork, some masking tape, and some found materials from the materials table.

Ask the groups to think about the size and shape of the blades, how many blades they will use, and any other enhancements they think will make the blades more efficient. They may want to draw their design ideas on paper first to use as a template. Once students are satisfied with their design, they should cut out the blades from the found materials. Then have two or three students from each group tape each blade to a toothpick and insert the toothpicks in the cork hub. Meanwhile, the remaining student should document the turbine hub by carefully drawing it, showing the size, shape, and placement of the blades. Give students about ten minutes to create and document their hubs.

Students test their wind turbines.

When at least one group has completed engineering and documenting its turbine prototypes, ask all groups to pause as you demonstrate how to test the turbines at the testing stations. Show students how to connect their finished hubs to the motor. Demonstrate how to touch the diodes from the multimeter to the wires of the motor and how to read the current and voltage on the multimeter.

Station yourself at one testing station and the teacher at the other to assist students as needed. As the groups finish construction, have them go to the testing stations. Have one member from each group carefully place the cork hub on the rotor of the motor. It is important that the cork fits tightly onto the rotor, so caution students to twist the cork as little as possible so they don't over-widen the hole. Have students turn the fan on high. Then have one student hold the motor, with the hub and blades attached, and carefully move it in front of the fan until the blades begin to turn rapidly. Once the blades begin to turn, have the second and third students touch the diodes from the multimeter to the ends of the motor's wires. One student will read, report, and record the current and the voltage from the multimeter. When they have successfully recorded their measurements, instruct them to disconnect their hub from the motor. Again, caution them to avoid twisting the cork so the hole where the rotor was attached stays as small as possible. Continue testing until all groups have tested their turbines.

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Students make improvements and retest their turbines.

As each group finishes testing its turbine, have students reassess the design. Ask them to discuss the following questions in their small group: What did you observe when the turbine was turning in the wind? What changes could you make to the blade so they can make more efficient use of the wind? Would changing the size or shape of the blades improve them? Would changing the number of blades or their placement on the hub improve the efficiency of the turbine? What different materials might work better? What other changes could you make?

Give students time to adapt their existing blades or make new blades from the found materials. Again, have them tape the blades to the toothpicks, attach them to the cork hub, and document the design of their turbine hub by drawing it. Once students have finished their redesign, they should go to the testing stations to retest their design and record the voltage generated.

Wrap-Up

Discuss the activity with students.

Invite students to share their results. Create a chart on the board showing blade shape, number of blades, and electricity generated. As one student from the group briefly reports to the class and shows its hub, another student should fill in the group's information on the chart. Once all groups have added their information, ask students to examine the chart. Ask:

- *Do you notice trends in blade shape, number of blades, and electricity generated?*
- *What changes did you make to your blades that were successful in producing more electricity? Why do you think those changes were successful? What changes did you make that were not successful? Why do you think those changes didn't work? What additional changes would you make if you had more time? Why?*

Ask students to identify the different parts of the electrical system they created.

Which part of the system generated electricity? How did that work? Which part transmitted electricity? Which part used electricity?

Now that you have experienced the engineering process, do you think that engineers in companies such a Lockheed Martin can make improvements to our energy systems? What are some ways you think engineers in the future might make it possible for us to use electricity with much less damage to the environment?

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SUPPORT MATERIALS—FOR THE CLASSROOM VISITOR

Background Information

Wind is a renewable energy resource. Wind turbines are used to convert wind energy into electricity. A turbine consists of blades attached to a central hub. The blades on the turbines are designed to be easily turned by the wind. The turbine is connected to a generator. As the winds turn the blades on the turbine, the turbine turns the generator. The generator converts the mechanical energy of the moving turbine into electrical energy. The design of the blades is very important in making the turbine efficient. Efficient turbines mean that more electricity can be produced from the same amount of wind.

National Standards Alignment

- (5–8) Standard A-1 Abilities necessary to do scientific inquiry
- (5–8) Standard B-3 Transfer of energy

Next Generation Science Standards Alignment

- PS2.3: Ask questions about data to determine the factors that affect the strength of electrical and magnetic forces.
- ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.
- Science and Engineering Practices: Constructing Explanations and Designing Solutions
- Science and Engineering Practices: Developing and Using Models

Preparation For Your Classroom Visit

Once a classroom visit has been established, check in with the host educator to make sure students are prepared and have some prior knowledge about the topic you have selected to share with the class.

An educator guide has been created for you to share with the host educator before your classroom visit. This guide includes pre- and post-visit resources and suggested activities that support the content you will be presenting during your classroom visit. Some of the information in the educator guide has been provided in the "Support Materials–For the Educator" section at the end of this document. Share the educator guide for this activity with the classroom educator as soon as you have a date for your visit. The educator guide can be found in the educator version of the Engineers in the Classroom website (www.classroomengineers.org).

Before your visit, watch the tutorial provided in the Resource Carousel to see how to make, assemble, and test a turbine for this activity. Make one sample blade to use as you demonstrate how to assemble the turbine.

Prior Knowledge

Students should be able to follow step-by-step instruction.

Other Resources to Explore

Article: How a Wind Turbine Works
http://energy.gov/articles/how-wind-turbine-works

Interactive: Harness the Power of Wind
http://environment.nationalgeographic.com/environment/global-warming/wind-power-interactive/

Article: National Geographic Environment–Wind Power
http://environment.nationalgeographic.com/environment/global-warming/wind-power-profile/

Website: U.S. Department of Energy: Energy.gov–Wind
http://energy.gov/science-innovation/energy-sources/renewable-energy/wind

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Website: Wind Energy Development
http://windeis.anl.gov/index.cfm

Map: Wind Farms
http://eerscmap.usgs.gov/windfarm/

Article: National Geographic News–Watching Wind Turbines in Snow Sheds Light on Inefficiencies
http://news.nationalgeographic.com/news/energy/2014/06/140624-wind-turbine-turbulence-snow-study/

Article: National Geographic– Wind Energy
http://education.nationalgeographic.com/education/encyclopedia/wind-energy/?ar_a=1

Website: Lockheed Martin WindOptimize
http://www.lockheedmartin.com/us/products/windptimizer.html

Classroom Management Tips

1. Consult the teacher prior to the class period so your classroom management approach aligns with the management plan, routines, and procedures the teacher already has in place. When relevant, discuss learning needs or behavioral challenges of specific students.
2. Establishing a culture of mutual respect and trust is key. At the beginning of the class period, tell students about yourself and why you are there. Discuss a clear and concise set of rules/expectations that are phrased positively.
3. Complete any necessary setup prior to the start of the class period. Be well-prepared and organized so you can keep things moving. “Down time” can lead to a loss of student attention.
4. Help yourself stay on track with the activity and its objectives by using a timing device and notecard to guide you. The notecard could include a brief outline of the activity, key concepts/vocabulary, and questions to facilitate discussion. Use a timing device to stay on schedule. You could even enlist the help of one or more students to be your “timekeepers.”
5. If you do lose students’ attention, use existing strategies the teacher has in place to “bring them back” to the task at hand. Examples include interactive clapping, counting, hand-raising, and other forms of nonverbal communication.
6. Moving around the classroom, varying the tone and volume of your voice, enlisting volunteers to assist you, and calling on students to answer questions and share their ideas can help keep students engaged and focused. Avoid lecturing and talking at students without any interaction, especially for more than a few minutes at a time.
7. Avoid open-ended questions that encourage students to share their own experiences in a story-like manner. This can use up valuable time and distract students from the task at hand.
8. Seek teacher assistance in grouping students. Groups could be predetermined based on specific criteria, i.e. student learning and communication styles, ability to self-direct, and collaboration skills. During group work, be sure to circulate around the room, engage students with questions, and use proximity control to keep students on track.
9. Be yourself and have fun! If you are enjoying yourself and engaging with the students and the activity, then they will do the same.

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SUPPORT MATERIALS—FOR THE EDUCATOR

Tips

- Watch the tutorial provided in the Resource Carousel to see how to make and assemble a turbine for this activity. Prior to your visit, make one blade to use as a model.
- To have enough time for at least two tests, make sure all students in a group work on cutting out blades.
- When students attach the blades to the hub, they should hold the toothpick a close to the bottom as they can. Students should insert the toothpick as deeply a possible into the cork so that it doesn't come out when the blades start turning.
- If the turbine doesn't turn when it is held to the fan, students may need to adjust it by moving closer or farther away, tilting it, etc.
- Students need to be very gentle with the wires coming from the motor to ensure they are not broken.

Pre-Visit Resources and Activities

- Use these resources to give students an idea of how a wind turbine works prior to the activity.
  - Article: How a Wind Turbine Works
    http://energy.gov/articles/how-wind-turbine-works
  - Interactive: Harness the Power of Wind
    http://environment.nationalgeographic.com/environment/global-warming/wind-power-interactive/

Post-Visit Resources and Activities

- Have students read this article to see how engineers continue to identify areas for improvement in wind turbines.
  - Article: National Geographic News–Watching Wind Turbines in Snow Sheds Light on Inefficiencies
    http://news.nationalgeographic.com/news/energy/2014/06/140624-wind-turbine-turbulence-snow-study/
- Have students read this encyclopedia entry from National Geographic Education for more details about wind turbines.
  - Article: National Geographic–Wind Energy
    http://education.nationalgeographic.com/education/encyclopedia/wind-energy/?ar_a=1

For Further Exploration

- Article: National Geographic Environment–Wind Power
  http://environment.nationalgeographic.com/environment/global-warming/wind-power-profile/
- Website: U.S. Department of Energy: Energy.gov–Wind
  http://energy.gov/science-innovation/energy-sources/renewable-energy/wind
- Website: U.S. Department of the Interior–Wind Energy Development
  http://windeis.anl.gov/index.cfm
- Map: USGS–Wind Farms
  http://eerscmap.usgs.gov/windfarm/