


Wonders of Wind

Teacher Guide

Students learn about wind through reading and hands-on activities that focus on observation and inquiry. Activities explore measuring wind, how wind does work, and the generation of electricity using wind.



Grade Level:


 Elementary

Subject Areas:

 Science

 Social Studies

 Math

 Language Arts

 Technology



Teacher Advisory Board

Constance Beatty
Kankakee, IL

Barbara Lazar
Albuquerque, NM

James M. Brown
Saratoga Springs, NY

Robert Lazar
Albuquerque, NM

Amy Constant - Schott
Raleigh, NC

Leslie Lively
Porters Falls, WV

Nina Corley
Galveston, TX

**Jennifer Mitchell -
Winterbottom**
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Greene, RI

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Robert Griegoliet
Naperville, IL

Wayne Yonkelowitz
Fayetteville, WV

Bob Hodash
Bakersfield, CA

DaNel Hogan
Tucson, AZ

Greg Holman
Paradise, CA

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In support of NEED, the national Teacher Advisory Board (TAB) is dedicated to developing and promoting standards-based energy curriculum and training.

Energy Data Used in NEED Materials

NEED believes in providing teachers and students with the most recently reported, available, and accurate energy data. Most statistics and data contained within this guide are derived from the U.S. Energy Information Administration. Data is compiled and updated annually where available. Where annual updates are not available, the most current, complete data year available at the time of updates is accessed and printed in NEED materials. To further research energy data, visit the EIA website at www.eia.gov.



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Wonders of Wind Teacher Guide



Wonders of Wind was developed by The NEED Project with funding from the American Wind Energy Association.

Wonders of Wind Kit

- 1 Anemometer
- 1 Compass
- 1 Roll masking tape
- 30 Pencils
- 30 Binder clips
- 75 Snow cone cups
- 1 Box straight pins
- 100 Extra-long straws
- 30 Small straws
- 1 Wind gauge
- 1 Wind vane
- 1 Set of alligator clips
- 30 Student Guides

Kid Wind™ Kit Materials

- 50 Dowels
- 2 Hubs
- Blade materials (corrugated plastic, cardboard)
- 1 Multimeter
- 50 Washers
- 2 Small plastic buckets with string
- 2 Tower and base setups
- 1 Weightlifter nacelle (spool only)
- 1 Assembled geared nacelle (generator attached)
- 1 Firefly™ assembly package

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**Cover Photo: 129MW Forward Wind Energy Center.
Photo by Ruth Baranowski, NREL 16411**





Standards Correlation Information

www.NEED.org/curriculumcorrelations

Next Generation Science Standards

- This guide effectively supports many Next Generation Science Standards. This material can satisfy performance expectations, science and engineering practices, disciplinary core ideas, and cross cutting concepts within your required curriculum. For more details on these correlations, please visit NEED's curriculum correlations website.

Common Core State Standards

- This guide has been correlated to the Common Core State Standards in both language arts and mathematics. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED curriculum correlations website.

Individual State Science Standards

- This guide has been correlated to each state's individual science standards. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED website.

The screenshot shows the NEED National Energy Education Development Project website. At the top left is the NEED logo. To the right are social media icons for Facebook, Twitter, Instagram, Pinterest, LinkedIn, and YouTube. Below these is a search bar with the text "Search this site:" and a blue arrow icon. A navigation menu contains links for "About NEED", "Educators", "Students", "Partners", "Youth Awards", "Contact", and "Shop". On the left side, there is a vertical menu with dropdown arrows for "Curriculum Resources", "Professional Development", "Evaluation", "Supplemental Materials", "Curriculum Correlations", and "Distinguished Service and Bob Thompson Awards". The main content area is titled "> Educators > Curriculum Correlations" and "Curriculum Correlations". Below the title, a paragraph states: "NEED has correlated their materials to the Disciplinary Core Ideas of the Next Generation Science Standards. NEED has also correlated all of their materials to The Common Core State Standards for English/Language Arts and Mathematics. All materials are also correlated to each state's individual science standards. Most files are in Excel format. NEED recommends downloading the file to your computer for use. Save resources, don't print!" Below this paragraph is a list of links: "Navigating the NGSS? We have What You NEED!", "NEED alignment to the Next Generation Science Standards", "Common Core State Standards for English and Language Arts", and "Common Core Standards for Mathematics". At the bottom of the list are state names: "Alabama", "Alaska", "Arizona", "Arkansas", and "California". On the left side of the screenshot, there is a green calendar icon with a white grid and a blue square in the bottom right corner. Below the icon is the text: "NEED is adding new energy workshops all the time. Want to".



Wonders of Wind Materials

ACTIVITY	MATERIALS IN KIT	ADDITIONAL MATERIALS NEEDED
<i>Measuring Wind</i>	<ul style="list-style-type: none"> ▪ Pencils ▪ Straight pins ▪ Extra-long straws ▪ Snow cone cups ▪ Wind gauge ▪ Anemometer ▪ Wind vane ▪ Compass ▪ Masking tape 	<ul style="list-style-type: none"> ▪ Hole punches ▪ Watches with second hand or stopwatches ▪ Markers ▪ Rulers ▪ Scissors
<i>Wind Can Do Work</i>	<ul style="list-style-type: none"> ▪ Extra-long straws ▪ Small straws ▪ Straight pins ▪ Binder clips ▪ Masking tape 	<ul style="list-style-type: none"> ▪ Foam cups ▪ Scissors ▪ Fans ▪ Markers ▪ Rulers ▪ Hole punches ▪ Paper clips ▪ Thread or string
<i>Wind Can Generate Electricity</i>	<ul style="list-style-type: none"> ▪ Firefly™ (assembled)* 	<ul style="list-style-type: none"> ▪ Fan
<i>Introduction to Blade Investigations</i> <i>Blade Investigation</i> <i>Blade Redesign Investigation</i>	<ul style="list-style-type: none"> ▪ Weightlifter windmill (assembled)** ▪ Wind turbine (assembled)** ▪ Dowels ▪ Hubs ▪ Washers ▪ Multimeter ▪ Masking tape ▪ Alligator clips ▪ Buckets with string ▪ Blade materials (corrugated plastic and cardboard) 	<ul style="list-style-type: none"> ▪ Alternative blade materials ▪ Fans ▪ Scissors ▪ Poster board
<i>Trying the Other Tower</i>	<ul style="list-style-type: none"> ▪ Blade sets from previous activities ▪ Weightlifter windmill (assembled)** ▪ Wind turbine (assembled)** 	<ul style="list-style-type: none"> ▪ Fans
<i>Wind Reflections</i>	<ul style="list-style-type: none"> ▪ Masking tape 	

*See page 28 for the Firefly™ assembly instructions.

**See pages 29-30 for windmill and turbine assembly instructions.



Teacher Guide

Grade Level

- Elementary, grades 3–5

Time

- Approximately eleven 45-minute class periods to conduct all of the activities and evaluation

Language Arts Connection

Further integrate *Wonders of Wind* into your reading curriculum by checking out wind and energy related books, both fiction and nonfiction, from your library. Have these available for students to read during silent reading or when they are finished with work. Use the books as you instruct students on reading strategies, or give a more formal assignment of having students read a book and write a report about it.

A booklist of fiction and non-fiction energy related books can be found at www.NEED.org.

Background

Wonders of Wind is an inquiry-based unit for elementary students. This unit includes nonfiction background information on wind energy, with activities that focus on observation and inquiry. The kit includes most of the materials to conduct the hands-on and inquiry-based activities, as well as a class set of Student Guides with space for recording observations, conclusions, and reflections.

★ Concepts

- Wind is moving air. It comes from the uneven heating of the Earth's surface by the sun.
- Wind can do work.
- Wind speed and direction can be measured.
- Wind speed and direction vary by location and time of day.
- A wind turbine changes wind energy into electricity.

Preparation

- Become familiar with the Teacher and Student Guides. It is suggested that the teacher conduct the hands-on activities before assigning them to students.
- Gather the materials needed to conduct the activities. A list of materials by activity can be found on page 5 of the Teacher Guide.
- Make copies of the student worksheets as needed.

Science Notebooks

Throughout this curriculum, science notebooks are referenced. If you currently use science notebooks or journals, you may have your students continue using them. A rubric and checklist to guide assessment of student notebooks can be found on pages 18-19 in the Teacher Guide.

In addition to science notebooks, student worksheets have been included in the Student Guide. Depending on your students' level of independence and familiarity with the scientific process, you may choose to use these instead of science notebooks. Or, as appropriate, you may want to make copies of worksheets and have your students glue or tape the copies into their notebooks.

Additional Resources

NEED has many other resources that can be used in the classroom to extend students' learning about wind, and integrate the topic into other curriculum areas. Visit NEED's Curriculum Resource section at www.NEED.org and search for the following by title:

- Energy on Stage*—Plays about energy including, *Harry Spotter and the Chamber of Windy Myths*.
- Energy Live!*—Students write and perform songs about energy sources, including wind.
- Energy Stories and More*—This guide includes stories and supplemental activities about energy sources including two stories specific to wind, *A Trip to the Farm* and *The Tale of Windy Wizard*. Students may enjoy reading and illustrating these stories to share with younger students in their school or community.
- Activity 5 utilizes a Firefly™ wind wheel from Recharge Labs® and KidWind Project. For more activities and extensions to use with your Firefly™, visit www.rechargelabs.org/firefly.

Activity 1: Introduction to Wind

Objective

- Students will be able to use observational skills to describe wind.

Materials

- Windy day
- Student Guides
- Wind Pre/Post Assessment*, Teacher Guide page 34

Time

- 45 Minutes

Procedure

1. Have the students take the *Wind Pre/Post Assessment*. An answer key can be found on page 15 of the Teacher Guide.
2. Introduce today's question, "What evidence is there that the wind is blowing?" Using your own Student Guide or science notebook, model for students the observation process of taking notes and drawing sketches from what you see outside.
3. Take the students outside for five to ten minutes with their Student Guides and a pencil. Have them use page 15 of the Student Guides or their science notebooks to answer the question, "What evidence is there that the wind is blowing?" They should draw sketches with labels and/or write notes.
4. After returning to class, have students share with a partner their evidence that the wind was blowing.
5. Show students the page titled *New Learning About Wind and Energy* (Student Guide page 16). Instruct students that when they read, they should be on the lookout for information that is new to them. When they notice they have learned something new they should write it in one of the stars. Students will continue to use this page throughout the unit. If students happen to fill up the stars, they can keep track of new learning on sticky notes and post them on this page, or extra copies of this page can be provided.
6. Have students read *What is Wind?* on pages 2-4 in the Student Guide. As they read, they should write down any new learning on page 16 of the Student Guide.
7. After the class finishes, have students share at least one piece of new learning with a neighbor.

Activity 2: Measuring Wind

Objective

- Students will be able to measure wind speed and direction using appropriate tools and units.

Materials *FOR EACH PAIR*

- Pencil
- 1 Straight pin
- 2 Extra-long straws
- 5 Snow cone cups
- Hole punch
- Masking tape
- Scissors
- Watch with second hand or stopwatch
- Marker

- Ruler
- Build an Anemometer* worksheet, Teacher Guide page 24
- Wind Speed Tables*, Teacher Guide page 25

Materials *FOR THE CLASS*

- Wind gauge
- Anemometer
- Wind vane
- Compass
- Student Guides

CONTINUED ON PAGE 8

Time

▪60 Minutes

Preparation

▪Make copies of *Wind Speed Tables*. Cut out the tables so that each student has one table to place into his/her notes.

Procedure

1. Review yesterday's reading with the class. Highlight that scientists use the following tools to measure the wind: anemometers, wind gauges, and wind vanes. Show these tools to your students and explain how they work. A wind gauge explanation is included on page 23 of the Teacher Guide.
2. Following the *Build an Anemometer* directions, pairs should make their own anemometers. Before going outside, each student should make a diagram of his/her anemometer in his/her notebook or in the Student Guide on page 17. Give each student a *Wind Speed Table* and have them glue or tape the table into his/her notebook or Student Guide to use as a reference.
3. When the class is ready, take everyone outside. First, set out the wind vane that came with the kit. Use the compass to orient it correctly. Have students record the direction the wind is blowing.
4. Have students test their anemometers. Students should record their location and how many times the anemometer rotates in ten seconds. Have students test at least three different locations around the school grounds and record the time of day for each measurement. (Try to choose locations where wind speed might vary—on a hill, an area partially shielded by a building, in an open field, etc.) Let groups try the wind gauge and assembled anemometer and see how that reading compares to their anemometer reading.
5. After returning to class, discuss with the students the wind speed measurements they recorded. Were they surprised by the results? Why do they think there was variation in wind speed around the school grounds?

Activity 3: Introduction to Energy

Objective

▪Students will be able to list basic facts about energy and how it can be used.

Materials

▪Student Guides

Time

▪45 Minutes

Procedure

1. Ask students, "What do you think you know about energy?" Record their thinking on a class KWL chart or on the board.
2. Have students read pages 5-8 in the Student Guide, *Introduction to Energy*. Remind students to keep track of new learning in their Student Guides.
3. After reading, have students expand on what they understand about energy. What are the forms of energy? How do they use energy?
4. After talking about energy as a class, students should work independently to compare and contrast their energy use at home and at school using the *My Energy Use* worksheet on page 18 of their Student Guides. In the box they should list all of the ways they use energy similarly at home and school. On the T-chart, students should list differences in the ways they use energy at home and school.
5. Allow students to work for 5-10 minutes independently. Have students share with one or two partners.

Activity 4: Wind Can Do Work

Objective

- Students will be able to explain how wind can do work.

Caution

The straight pins are sharp. Review with students how to safely handle sharp objects. After the pin is in place, carefully wrap a small piece of tape around the sharp end.

Materials FOR EACH PAIR

- 1 Extra-long straw*
- 1 Small straw
- Masking tape
- 2 Straight pins
- 1 Binder clip
- 50 cm Thread or string
- Paper clips
- Foam cup
- Scissors
- Marker

- Ruler
- Hole punch
- *Wind Can Do Work* worksheets, Teacher Guide page 26, Student Guide pages 19-20
- *4-Blade Windmill Template*, Teacher Guide, page 27

***NOTE:** The extra-long straw is long enough for two windmills when cut in half.

Materials FOR THE CLASS

- Fans
- Student Guides

Time

- 60 Minutes

Preparation

- Cut thread or string into 50 cm lengths for each pair.
- Make copies of the *4-Blade Windmill Template* for students.

Procedure

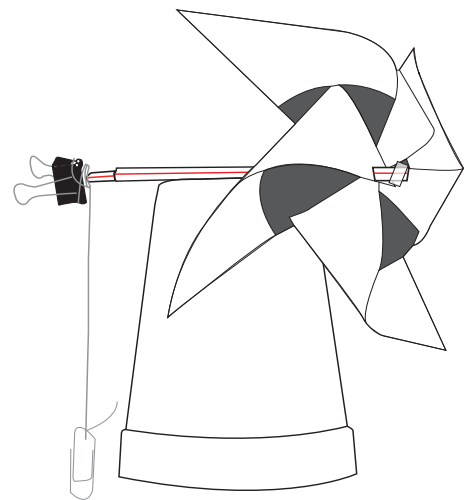
1. Introduce today's lesson that the wind is energy, and that people use wind's energy to do work.
2. Have students read *Wind Energy History* on pages 13-14 in the Student Guide.
3. Working with a partner, students should follow the directions on the *Wind Can Do Work* page to construct a windmill that can lift paper clips.
4. Students should follow the investigation procedure and record data, observations, and write a conclusion in their notebooks or on pages 19-20 of their Student Guides.

Extension

- Let students redesign the windmill changing one of the variables and conduct new tests.

Volunteers

This is a good day for parent volunteers to come into your classroom and help with the investigation.



Activity 5: Wind Can Generate Electricity

Objectives

- Students will be able to identify items that use or require electricity.
- Students will be able to explain how wind can do work (to create electricity).

Materials

- Firefly™ (assembled)
- Fan
- Student Guides

Time

- 20-30 Minutes

Preparation

- Assemble the Firefly™ using the attached instructions. Instructions can also be found on page 28 of the Teacher Guide. Visit www.rechargelabs.org/firefly for more information and extensions to use with this wind wheel.

Procedure

1. Review the previous windmill investigation with the class. Ask them to describe what kind of work the windmill did. Ask them to describe how it did the work – what was required?
2. Have students read *Electricity* in the Student Guide, pages 9-12.
3. After reading, discuss with the class that energy is the ability to do work. The wind has energy of motion. That motion energy can do work on a pinwheel or turbine, and turn its blades. Electricity is also a form of energy. Just like when the pinwheel lifted the paper clips, wind can turn a turbine, which can turn a generator to make electricity. Wind can do work and make electricity!
4. Have students make observations about the Firefly™.
5. Ask a student volunteer to hold the Firefly™, as you turn on a fan.
6. Have students make observations of the Firefly™ again. Ask them to describe how the Firefly™ is doing work and how electricity is being generated. Have them share their ideas with a partner or the class.
7. Discuss with students that they will be investigating how wind can do work and generate electricity in the next few investigations.

Activity 6: Introduction to Blade Investigations

Objectives

- Students will be able to explain how wind can do work.
- Students will be able to list factors that can affect how turbines work.

Materials

- | | | |
|-------------------------------------|-----------------------|--|
| ▪ Weightlifter windmill (assembled) | ▪ Multimeter | ▪ Student Guides |
| ▪ Wind turbine (assembled) | ▪ Buckets with string | ▪ <i>Turbine Assembly Instructions</i> , Teacher Guide pages 29-30 |
| ▪ Blade materials | ▪ Fans | ▪ <i>Benchmark Blade Template</i> , Teacher Guide page 31 |
| ▪ Poster board | ▪ Scissors | ▪ <i>Measuring Electricity</i> , Teacher Guide page 32 |
| ▪ Alternative blade materials | ▪ Hubs | |
| ▪ Dowels | ▪ Masking tape | |
| ▪ Washers | ▪ Alligator clips | |

CONTINUED ON PAGE 11

Time

- 30 Minutes

Preparation

- Pre-assemble the weightlifter windmill and the wind turbine using the *Turbine Assembly Instructions*. When attaching the bucket to the weightlifter windmill, use enough string so that the bucket rests on the floor without any slack in the string. A Vimeo© video showing assembly instructions can be viewed at <https://vimeo.com/114691934> or by visiting www.vernier.com.
- Construct three blades using the basic *Benchmark Blade Template*. It is recommended that these blades are made from poster board.
- Familiarize yourself with the multimeter using the information on page 32. Pre-test your blades before the demonstration to make sure you are able to generate a voltage reading.
- Place students in small groups and assign them to initially investigate either the weightlifter windmill or the electricity generating wind turbine.

INSTRUCTIONAL NOTES:

- Individual student needs can be met when you assign them to either the weightlifter windmill or the electricity generating wind turbine.
- In either assignment, students will be investigating which blade design will produce the most work—either by generating more electricity or lifting more mass.
- Blade Materials: Some corrugated plastic and cardboard sheets are included in your kit, but blades can be made out of almost anything. You may want to gather additional materials (paper plates, paper cups, foil pie pans, foamboard, etc.) or have students bring in materials they would like to use.
- You may want to suggest that students use the fan speed you used when they test their designs in subsequent activities.

Procedure

1. Demonstrate how the weightlifter windmill and the wind turbine work with the benchmark blades. Students should record the results of your blades for each apparatus in their Student Guides on page 21. When students test their own blades, they can try to design blades that will produce more work than the standard blade design you have demonstrated.

NOTE: When demonstrating the electricity generating turbine, explain to students how the multimeter works and that they will be measuring voltage (volts). Voltage is a measure of electrical energy. Project the multimeter instructions, if desired.

2. Brainstorm as a class all of the variables that could be changed in the blade design (size, shape, blade material, angle of blade, mass of blade, etc.).
3. Give students their group assignments and, on page 21 in their Student Guides, have them write their focus question based on which tower (weightlifter or electric) they will be working with.
 - a. Weightlifter Windmill Question: What blade design will lift the most mass all of the way up to the spool?
 - b. Wind Turbine Question: What blade design will generate the most electricity?
4. Today students should brainstorm different blade design ideas individually using page 22 in their Student Guides. If time allows, students should share their ideas with their teammates. Groups will have to choose one design with which to move forward.

Activity 7: Blade Investigation

Objectives

- Students will be able to explain how wind can do work.
- Students will be able to list factors that can affect how turbines work.

Materials

- Weightlifter windmill (assembled with bucket and string)
- Wind turbine (assembled)
- Blade materials
- Alternative blade materials
- Dowels
- Washers
- Multimeter
- Masking tape
- Alligator clips
- Fans
- Scissors
- Hubs
- Student Guides
- *Measuring Electricity*, Teacher Guide page 32

Time

45-60 Minutes

Preparation

- Set up two testing stations for students to test their designs. The weightlifter station should include the assembled weightlifter turbine, bucket, string, and washers. The electric station should include the assembled wind turbine, alligator clips, multimeter, and hubs. Both stations should have a fan. It is suggested students have the fan speed set on the same speed used in the introduction activity.

Procedure

1. Groups should discuss their ideas and decide on one blade design to use. Students should record the design in their Student Guides on page 23 and predict why this design will produce more work than the standard blade demonstrated by the teacher.
2. Working as a group, students should construct their blades.
3. Using their notebooks or page 24 in their Student Guides, students should re-write their focus question, and test their design. They should record the data from their investigation. Remind students that they should conduct three trials with their blade design and find the average of their trials. Assist students with the multimeter, if needed. Instructions can be found on page 32 of the Teacher Guide.
4. When groups are done they can watch the other groups, or they can move on to redesigning blades as described in Activity 8 and 9.

NOTE: Groups will have to wait their turn to test their blades. As they are waiting, have students observe how other blade designs are working. What is the same about their designs compared to other groups? What is different? What design elements might they want to include in a redesign of their blades later?

Extension

- Create a class chart showing the results for both the weightlifter windmill and wind turbine. On the chart, create columns to show results from initial design (Activity 6 and 7), blade redesign (Activity 8), and trying the other tower (Activity 10). An example is shown below.

	Blade Design 1	Blade Redesign	Trying the Other Tower
Group Name			
Group Name			
Group Name			

Activity 8: Blade Redesign Investigation

Objectives

- Students will be able to explain how wind can do work.
- Students will be able to list factors that can affect how turbines work.

Materials

- | | | |
|--|-------------------|--|
| ▪ Weightlifter windmill (assembled with bucket and string) | ▪ Washers | ▪ Hubs |
| ▪ Wind turbine (assembled) | ▪ Multimeter | ▪ Student Guides |
| ▪ Blade materials | ▪ Masking tape | ▪ <i>Measuring Electricity</i> , Teacher Guide page 32 |
| ▪ Alternative blade materials | ▪ Alligator clips | |
| ▪ Dowels | ▪ Fans | |
| | ▪ Scissors | |

Time

- 45-60 Minutes

Preparation

- Set up two testing stations for students to test their designs. The weightlifter station should include the assembled weightlifter turbine, bucket, string, and washers. The electric station should include the assembled wind turbine, alligator clips, multimeter, and hubs. Both stations should have a fan. Utilize the same fan speed as in previous investigations.

Procedure

1. Groups should review their design and results from their first blade investigation. Using page 25 of their Student Guides, students should plan what changes they would make to their blades.
2. Groups should agree on a plan and construct their redesigned blades. When ready, they should conduct three trials to test the new blades on the same tower they used previously. They will record observations and data in their notebooks or on page 25 of the Student Guides.
3. Students should find the average of their trials and add it to the class chart, if one was constructed.

NOTE: Students should save the redesigned blades for Activity 10—do not have them take them apart yet.

Activity 9: Blade Investigation Conclusion

Objectives

- Students will be able to explain how wind can do work.
- Students will be able to list factors that can affect how turbines work.

Materials

- Student Guides

Time

- 30-45 Minutes

Preparation

This is a "Writing in Science Day." Let students know that scientists have to take time to analyze their results and think about what they learned. They write conclusions so that other people can learn what they did, and what their results are. Other scientists may replicate their work to test it again, or make changes and continue testing.

CONTINUED ON PAGE 14

✓ Procedure

1. Have students look over their results. Did their results improve with the new blade design? Why or why not? Remind students that in a conclusion scientists use data to support the statements they make. Students should write a conclusion about their results on page 26 in their Student Guides or in their notebooks.
2. When students are done writing, have them switch with someone who used the opposite tower and read each other's conclusions. Each person should summarize his or her partner's conclusion out loud, then suggest what he or she might try next based on the results.

Activity 10: Trying the Other Tower

🔄 Objectives

- Students will be able to explain how wind can do work.
- Students will be able to list factors that can affect how turbines work.

📄 Materials

- | | | |
|--|-------------------|--|
| ▪ Blade sets from Activity 8 | ▪ Dowels | ▪ Scissors |
| ▪ Weightlifter windmill (assembled with bucket and string) | ▪ Washers | ▪ Hubs |
| ▪ Wind turbine (assembled) | ▪ Multimeter | ▪ Student Guides |
| ▪ Blade materials | ▪ Masking tape | ▪ <i>Measuring Electricity</i> , Teacher Guide page 32 |
| ▪ Alternative blade materials | ▪ Alligator clips | |
| | ▪ Fans | |

🕒 Time

- 45 Minutes

📋 Preparation

- Set up two testing stations for students to test their designs. The weightlifter station should include the assembled weightlifter turbine, bucket, string, and washers. The electric station should include the assembled wind turbine, alligator clips, multimeter, and hubs. Both stations should have a fan. Utilize the same fan speed as in previous investigations.

✓ Procedure

1. Using their redesigned blades, students now have the opportunity to test their blades on the other tower that they have not yet used. Data should be recorded in their Student Guides on page 27 or in their notebooks.
2. After they have tested their blades, students should write an observational conclusion on page 27 in the Student Guides or in their notebooks. How are the towers the same and different? What were the results on the new tower? How do the results between the two machines compare?
3. Discuss with the class the similarities and differences between the two towers and how their results compared.

📖 Extension

- Have students who are interested explore other variables such as fan speed, fan height, dowel length, etc. Have them share/present to the class how these variables affected their optimal designs.

Activity 11: Wind Reflections

Objective

- Students will be able to demonstrate their understanding of wind turbines and energy.

Materials

- Masking tape
- Student Guides
- *I Learned—You Learned*, Teacher Guide page 33
- *Wind Pre/Post Assessment*, Teacher Guide page 34
- *Wind Energy Bingo*, page 35

Time

- 30-45 Minutes

Preparation

- Make copies of the worksheets and assessment, as needed.

Procedure

1. Students begin by using pages 28-29 in their Student Guides to reflect on what they learned about wind from their reading, wind observations, use of wind tools, and their blade investigations.
2. Pass out the *I Learned—You Learned* sheet to each student.
3. Each student should write one thing he or she learned in one box.
4. Students then get up and move around the room and talk to each other. Student A shares what he or she learned and Student B adds Student A's learning to his/her paper. Student B shares what he or she learned and Student A writes Student B's learning on his/her paper. Students then switch partners and continue this process until their papers are full.
5. When the students are done they can glue or tape their *I Learned—You Learned* sheet into the back of their Student Guides or notebooks.
6. Have students complete page 30 of the Student Guide, *New Questions about Wind and Energy*.
7. As a fun, formative assessment, play *Wind Energy Bingo* with your students. Instructions are found on pages 16-17 of the Teacher Guide. Some of the clues may seem challenging for younger learners. Allow students to look up answers or provide substitute clues for easier vocabulary as needed.
8. Have students take the *Wind Pre/Post Assessment*.

Wind Pre/Post Assessment Answer Key

- | | | | |
|------|------|------|-----------------------|
| 1. a | 4. a | 7. c | 10. b |
| 2. c | 5. b | 8. a | 11. Answers will vary |
| 3. b | 6. a | 9. c | 12. Answers will vary |

Evaluation

Evaluate the unit with your students using the *Evaluation Form* on page 39 and return to NEED using the information on the form.



Wind Energy BINGO Instructions

Wind Energy Bingo is a great icebreaker for a NEED workshop or conference. As a classroom activity, it also makes a great introduction to an energy unit.

Preparation

▪5 minutes

Time

▪45 minutes

Bingos are available on several different topics. Check out these resources for more bingo options!

- Biomass Bingo—*Energy Stories and More*
- Change a Light Bingo—*Energy Conservation Contract*
- Coal Bingo—Coal guides
- Energy Bingo—*Energy Games and Icebreakers*
- Energy Efficiency Bingo—*Monitoring and Mentoring and Learning and Conserving*
- Hydrogen Bingo—*H₂ Educate*
- Hydropower Bingo—Hydropower guides
- Nuclear Energy Bingo—Nuclear guides
- Oil and Natural Gas Bingo—Oil and Natural Gas guides
- Science of Energy Bingo—*Science of Energy* guides
- Solar Bingo—Solar guides
- Transportation Bingo—Transportation guides

Get Ready

Duplicate as many *Wind Energy Bingo* sheets (found on page 35) as needed for each person in your group. In addition, decide now if you want to give the winner of your game a prize and what the prize will be.

Get Set

Pass out one *Wind Energy Bingo* sheet to each member of the group.

Go

PART ONE: FILLING IN THE BINGO SHEETS

Give the group the following instructions to create bingo cards:

- This bingo activity is very similar to regular bingo. However, there are a few things you'll need to know to play this game. First, please take a minute to look at your bingo sheet and read the 16 statements at the top of the page. Shortly, you'll be going around the room trying to find 16 people about whom the statements are true so you can write their names in one of the 16 boxes.
- When I give you the signal, you'll get up and ask a person if a statement at the top of your bingo sheet is true for them. If the person gives what you believe is a correct response, write the person's name in the corresponding box on the lower part of the page. For example, if you ask a person question "D" and he or she gives you what you think is a correct response, then go ahead and write the person's name in box D. A correct response is important because later on, if you get bingo, that person will be asked to answer the question correctly in front of the group. If he or she can't answer the question correctly, then you lose bingo. So, if someone gives you an incorrect answer, ask someone else! Don't use your name for one of the boxes or use the same person's name twice.
- Try to fill all 16 boxes in the next 20 minutes. This will increase your chances of winning. After the 20 minutes are up, please sit down and I will begin asking players to stand up and give their names. Are there any questions? You'll now have 20 minutes. Go!
- During the next 20 minutes, move around the room to assist the players. Every five minutes or so tell the players how many minutes are remaining in the game. Give the players a warning when just a minute or two remains. When the 20 minutes are up, stop the players and ask them to be seated.

PART TWO: PLAYING BINGO

Give the class the following instructions to play the game:

- When I point to you, please stand up and in a LOUD and CLEAR voice give us your name. Now, if anyone has the name of the person I call on, put a big "X" in the box with that person's name. When you get four names in a row—across, down, or diagonally—shout "Bingo!" Then I'll ask you to come up front to verify your results.
- Let's start off with you (point to a player in the group). Please stand and give us your name. (Player gives name. Let's say the player's name was "Joe.") Okay, players, if any of you have Joe's name in one of your boxes, go ahead and put an "X" through that box.
- When the first player shouts "Bingo," ask him (or her) to come to the front of the room. Ask him to give his name. Then ask him to tell the group how his bingo run was made, e.g., down from A to M, across from E to H, and so on.

Now you need to verify the bingo winner's results. Ask the bingo winner to call out the first person's name on his bingo run. That player then stands and the bingo winner asks him the question which he previously answered during the 20-minute session. For example, if the statement was "can name two renewable sources of energy," the player must now name two sources. If he can answer the question correctly, the bingo winner calls out the next person's name on his bingo run. However, if he does not answer the question correctly, the bingo winner does not have bingo after all and must sit down with the rest of the players. You should continue to point to players until another person yells "Bingo."

WIND ENERGY BINGO

ANSWERS

- A. Has used wind energy for transportation
- B. Knows the average cost per residential kilowatt-hour of electricity
- C. Can name two renewable energy sources other than wind
- D. Can explain how wind is formed
- E. Knows what an anemometer does
- F. Can name two forms of energy
- G. Can name two factors to consider when siting a wind farm
- H. Knows how electricity is generated by a wind turbine
- I. Has seen a modern wind turbine
- J. Knows how wind speed is measured
- K. Has experienced the wind tunnel effect
- L. Knows the energy efficiency of a wind turbine
- M. Can name two uses of windmills
- N. Can name two myths many people believe about wind turbines
- O. Has been to a power plant
- P. Knows what a gear box does

A	B	C	D
Sailboat Sailboard etc.	\$0.127 (13 cents) national average for residential customers	biomass geothermal hydropower solar	The sun heats Earth's land and water surfaces differently. Warm air rises, cool air moves in.
E	F	G	H
measures wind speed	potential, elastic, chemical, gravitational, nuclear, radiant, thermal, sound, motion, light, electrical	wind speed and consistency, environment (land and animals), public opinion, access to grid	Turbine spins a shaft, which spins a generator producing electricity
I	J	K	L
ask for location/description	meters per second, with anemometer	ask for details	The Betz Limit is 59% for wind, today's wind turbines are about 25-45% efficient.
M	N	O	P
Grind grain, pump water, generate electricity, etc.	Noisy, unpredictable, expensive, kills birds, interferes with TV and communication signals, etc.	ask for location/description	Connects low-speed shaft to high-speed shaft and increases the rotational speeds to produce electricity



Grading Rubric

Student Guide/Science Notebook Rubric

This is a sample rubric that can be used with investigations and science notebooks. You may choose to look at one activity specifically or the notebook as a whole. It is suggested that you share this rubric with students and discuss the different components ahead of time.

GRADE	SCIENTIFIC CONCEPTS	SCIENTIFIC INQUIRY	PRESENTATION
4	Student demonstrates thorough understanding of concepts through pictures, writing, and verbal communication.	Student is able to follow all steps of the scientific process: predicting, observing/recording data, and drawing a more complex conclusion related to his/her data. Student shows higher level thinking by asking his/her own questions.	Handwriting is legible. Pictures are realistic and include labels. All parts of the assignment are complete.
3	Student demonstrates understanding of concepts through pictures, writing, and/or verbal communication.	Student is able to predict, observe/record data, and draw a basic conclusion.	Handwriting is legible. Pictures are realistic and include most labels. All parts of the assignment are complete.
2	Student demonstrates a beginning understanding of concepts, may have a couple of lingering misconceptions.	Student is able to do two of the following: predict, observe/record data, draw conclusions.	Words and/or pictures may be hard to decipher at times. Pictures are present but are missing labels. The notebook has some missing components.
1	Student demonstrates confusion about concepts. Many misconceptions remain.	Student is able to do one or fewer of the following: predict, observe/record data, draw conclusions.	Words and/or pictures are hard to decipher. They may not be connected to the investigation. The notebook has many missing components.



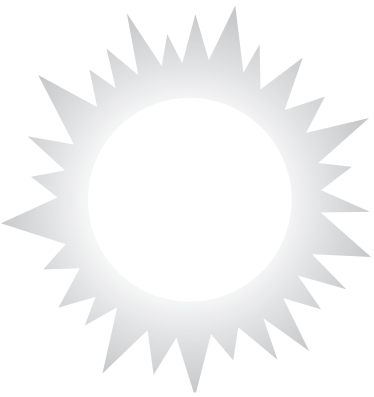
Science Skills Checklist

Designed to be a formative assessment tool, you may find this checklist useful as you work with students. Put all of your students names down the left hand side. When you look at a child's notebook or Student Guide and see a skill demonstrated, put a dot in the box. Decide how many times (typically 3-5) you want to see the student use the skill independently before checking off the box as a sign that the student has mastered this skill.

Student Name	Drawings	Picture is realistic (colors, shape, size)	Includes appropriate labels	Notes and Observations	Uses senses to record observations	Observations are "big picture"	Observations focus on details	Graphs and Charts	Data is accurate	Includes appropriate labels	Clear presentation	Communication	Communicates verbally	Communicates in writing	Makes predictions	Makes predictions with reasoning	Uses evidence to support reasoning	Compares and contrasts	Communication is personal



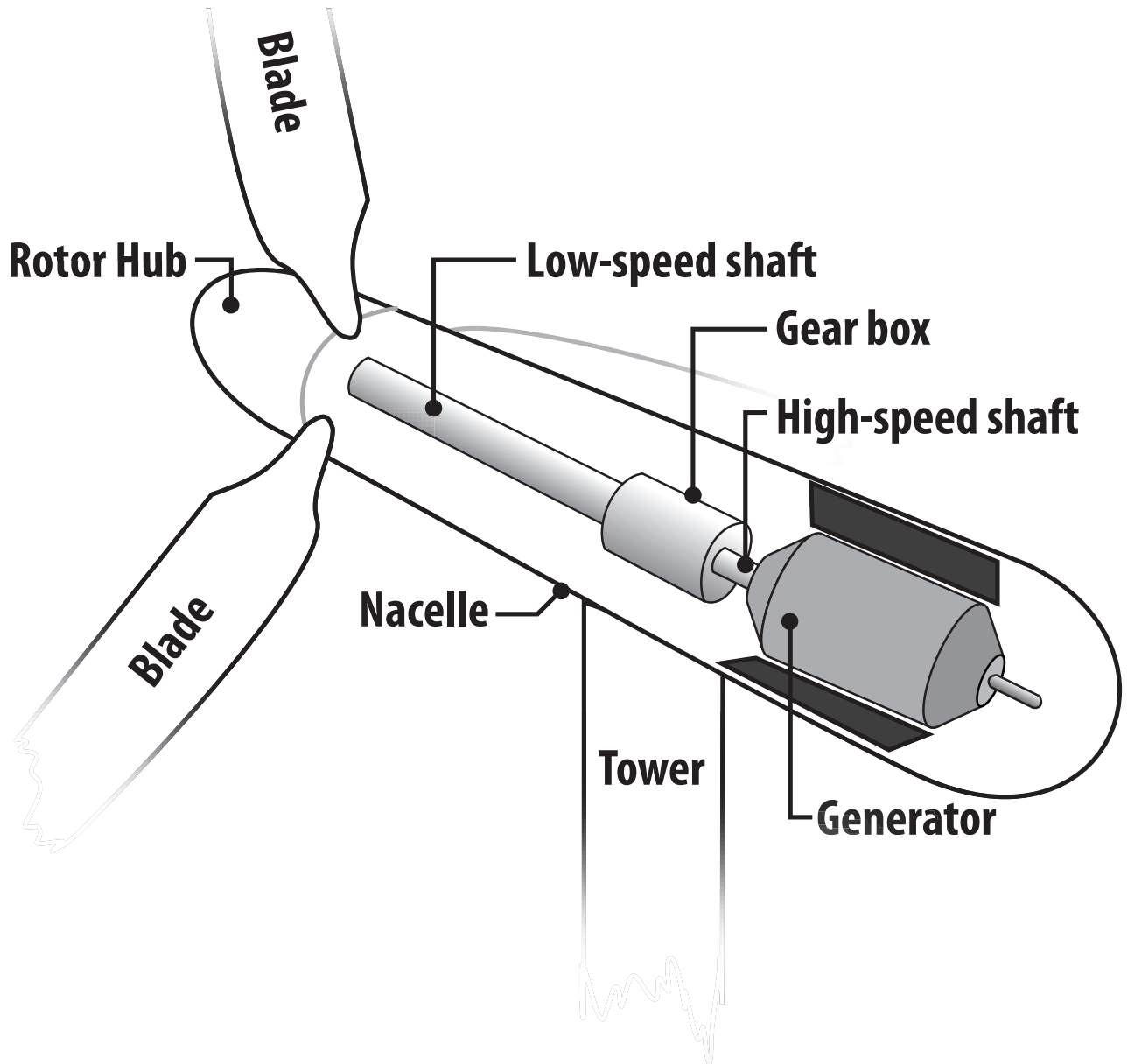
How Wind is Formed

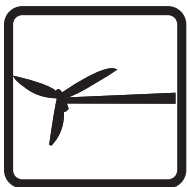


1. The sun shines on land and water.
2. Land heats up faster than water.
3. Warm air over the land rises.
4. Cool air over the water moves in.

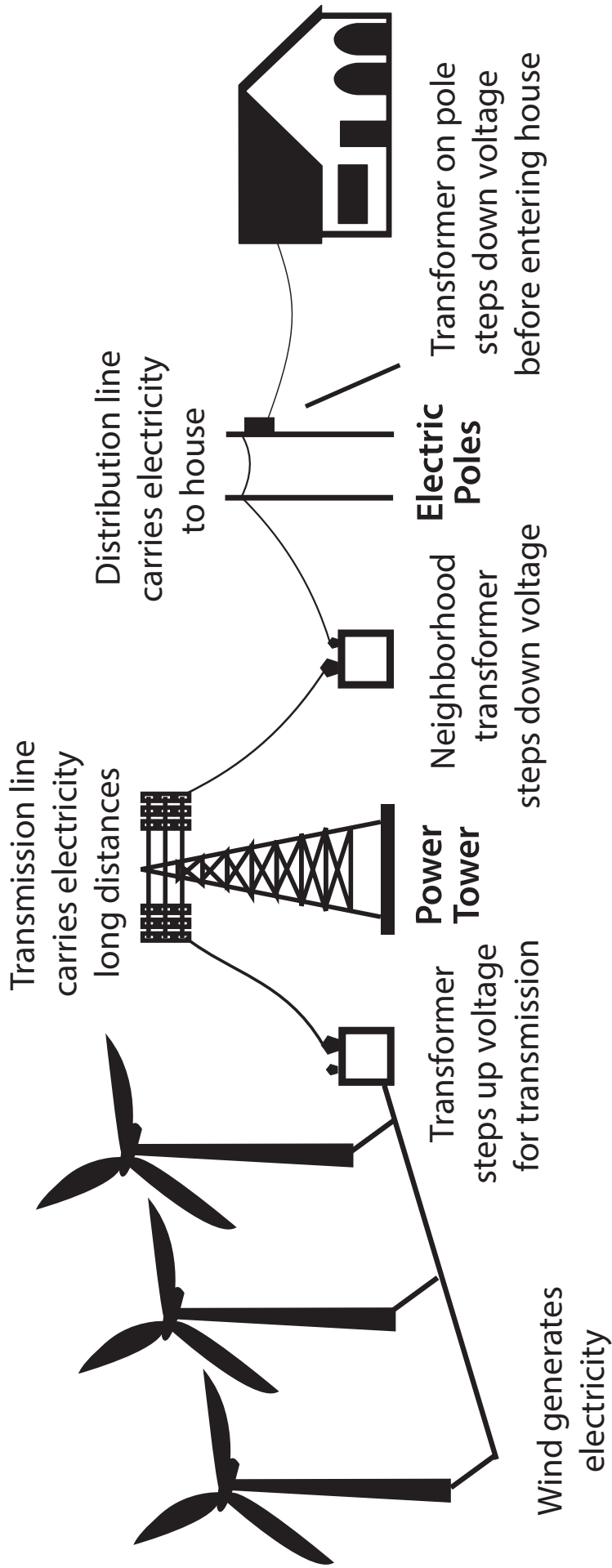


Inside a Wind Turbine





Transporting Electricity from Wind





Wind Gauge Directions

This type of wind gauge is designed to measure wind speed based on Bernoulli's Principle, which states that energy is conserved in a moving fluid (liquid or gas). If the fluid is moving in a horizontal direction, the pressure decreases as the speed of the fluid increases. If the speed decreases, the pressure increases. This means that as the speed of the wind increases, its pressure decreases. Pressure moves from high to low.

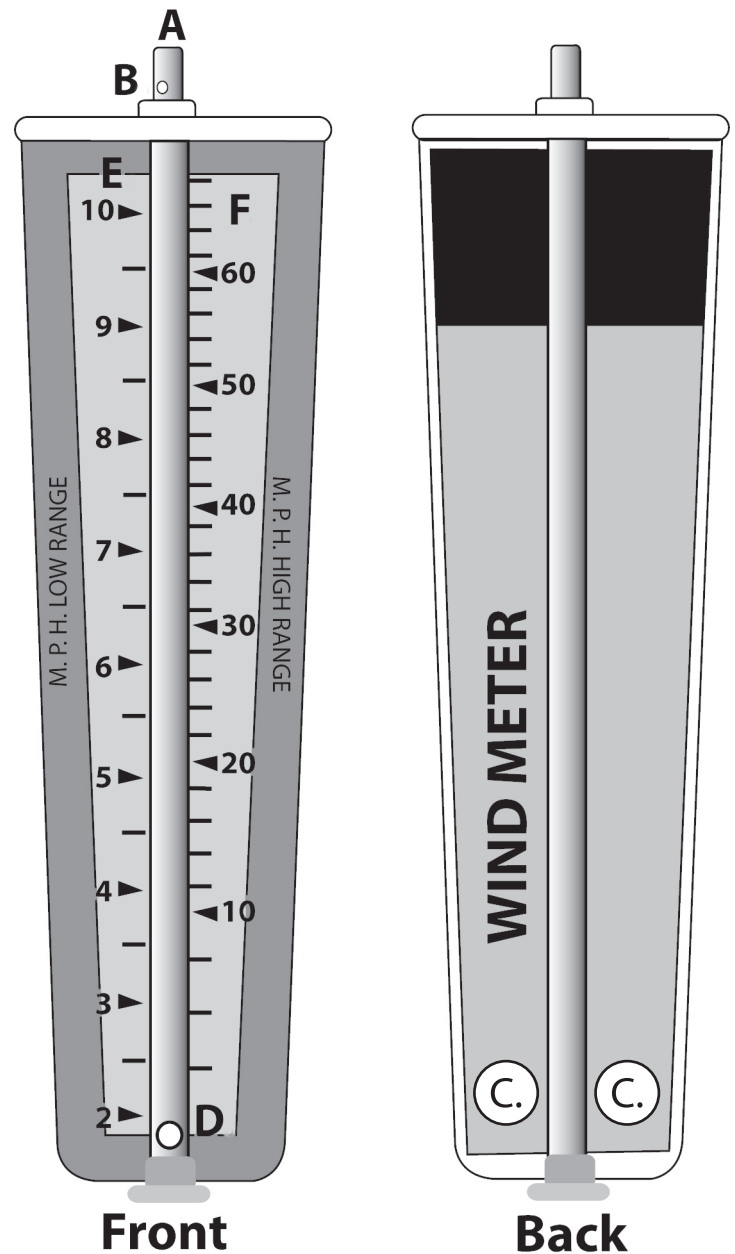
The wind gauge has the following features:

- A. one large hole in the top of the hollow stem;
- B. one small hole on the side of the hollow stem;
- C. two holes on the lower back; and
- D. a very light ball at the bottom of the hollow stem that can move up and down the stem.

The wind gauge has two ranges:

- E. low; and
- F. high.

To operate the wind gauge, hold the wind gauge upright into the wind with the scale side facing you. Do not block the bottom holes on the back. As the wind flows across the top holes it creates lower pressure at the top of the stem. No wind flows across the bottom holes, so the pressure there remains the same (at a higher pressure than at the top). Air flows into the bottom holes, lifting the ball. The faster the wind blows, the lower the pressure at the top of the stem. If the wind is blowing faster than 10 mph and the ball is at the top of the stem, cover the large hole at the top of the stem with your finger. Be careful not to obstruct the smaller hole on the side of the stem. The wind will create lower pressure only at the smaller hole. Read the wind speed using the high range on the wind gauge when the top hole is covered.





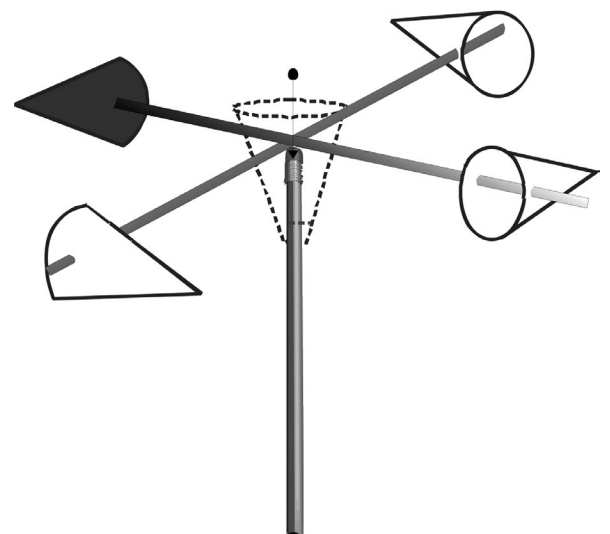
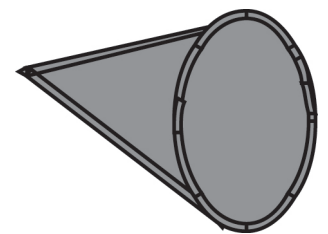
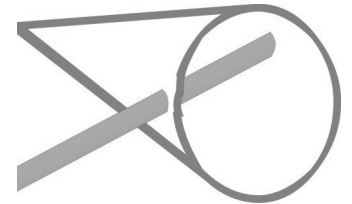
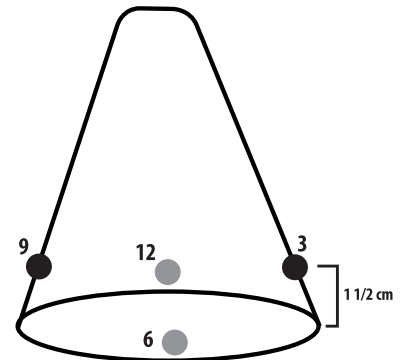
Build an Anemometer

Materials

- 1 Pencil
- 5 Snow cone cups
- 2 Extra-long straws
- Masking tape
- Hole punch
- Scissors
- 1 Straight pin
- Marker
- Watch with second hand or stopwatch
- Ruler

✓ Procedure

1. Take one cup and cut the tip off so it can slide onto a pencil. This is your base cup.
2. Think of the circle end of the cup like a clock. Imagine where 12, 3, 6, and 9 would be located.
3. Use the hole punch to make two holes opposite each other very near the rim at 12 o'clock and 6 o'clock.
4. Punch two more holes opposite each other 1 ½ cm from the rim at 3 o'clock and 9 o'clock.
5. Slide the first straw through the 12 o'clock and 6 o'clock holes. Slide the second straw through the 3 o'clock and 9 o'clock holes.
6. In the other cups, use the hole punch to make two holes opposite each other at 3 o'clock and 9 o'clock.
7. Color one cup a bright color or make lots of markings so that it is easy to see.
8. Slide one cup onto the end of each straw. Make sure the cups all face the same direction. Tape the cups to the straw.
9. Center the straws in the base cup.
10. Slide the base cup over the pencil as shown in the diagram.
11. Push a straight pin through the middle of each straw and into the pencil eraser. Lightly push the cups to make sure the straws spin smoothly.
12. Take your anemometer outside. Hold the anemometer so the colored cup is facing you.
13. Measure the speed of the wind by counting the number of revolutions in 10 seconds. Use the *Wind Speed Table* to find the speed in miles per hour.





Wind Speed Tables

REVOLUTIONS PER 10 SEC.	MPH
2-4	1
5-7	2
8-9	3
10-12	4
13-15	5
16-18	6
19-21	7
22-23	8
24-26	9
27-29	10
30-32	11
33-35	12
36-37	13
38-40	14
41-43	15
44-46	16
47-49	17
50-51	18
52-54	19
55-57	20

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36-37	13
38-40	14
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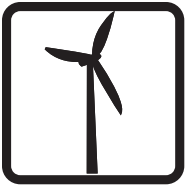
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44-46	16
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52-54	19
55-57	20



Wind Can Do Work

Question

What is the maximum load that can be lifted all of the way to the top of the windmill shaft?

Materials

- 4-Blade Windmill Template
- 1 Extra-long straw
- 1 Small straw
- Masking tape
- 50 cm String or thread
- Paper clips
- Large foam cup
- 2 Straight pins
- Binder clip
- Fan
- Ruler
- Hole punch
- Marker
- Scissors

Procedure

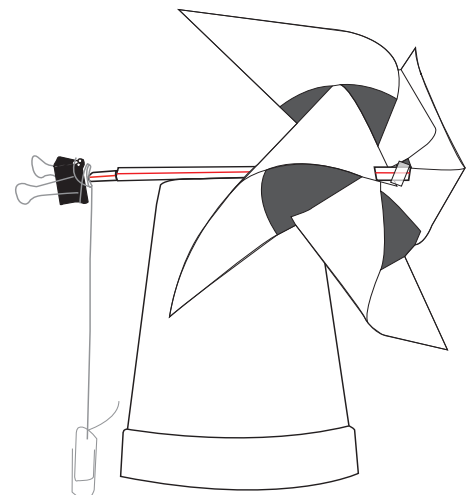
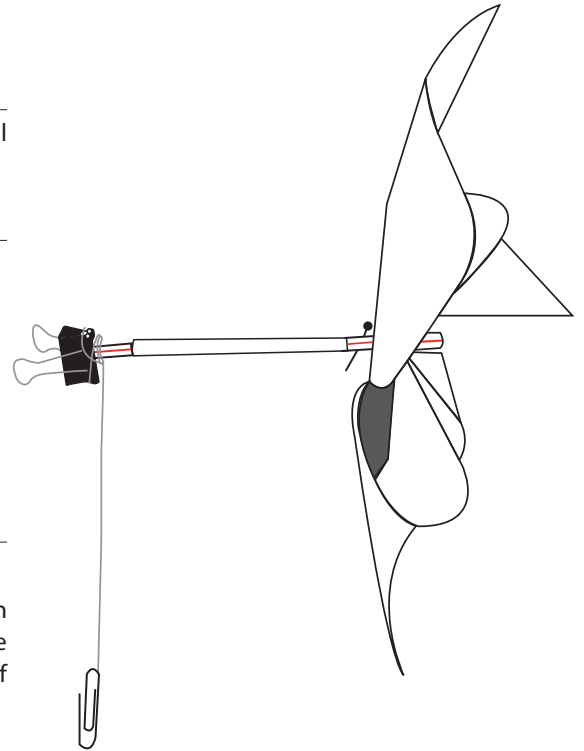
1. Turn the cup upside down.
2. Cut the longer straw so that you have an 8 cm length. Share the other portion with another student or group, or discard it. Tape this straw horizontally to the bottom of the cup (which is now the top) so that there is an equal amount of straw on both ends. Set this aside.
3. Prepare the windmill blades using the 4-Blade Windmill Template.
4. Measure 1.0 cm from the end of the small straw and make a mark. Insert a pin through the small straw at this mark. This is the front of the straw.
5. Slide the small straw through the windmill blades until the back of the blades rest against the pin. Gently slide each blade over the end of the straw. Secure the blades to the straw using tape.
6. Insert the small straw into the larger straw on the cup.
7. Tape the string to the end of the small straw. Tie the other end of the string to a paper clip. Make sure you have 30 cm of string from the straw to the top of the paper clip.
8. On the very end of the small straw near where the string is attached, fasten a binder clip in place for balance and to keep the string winding around the straw.
9. Slide the small straw forward to bring the binder clip next to the larger straw. Place a second straight pin through the small straw at the other end of the larger straw. This will keep the blades away from the cup while still allowing them to move and spin.
10. Place your windmill in front of the fan and observe. Record observations in your science notebooks.
11. Investigate: Keep adding paper clips one at a time to determine the maximum load that can be lifted all of the way to the top. Record your data.

** Conclusions

Draw a diagram of the system. Label the energy transformations that occurred in order for work to take place.

Extensions

- How could you change the design of your windmill to produce more work from the system?
- What variables can you change in this investigation? Create a new investigation changing one variable at a time.

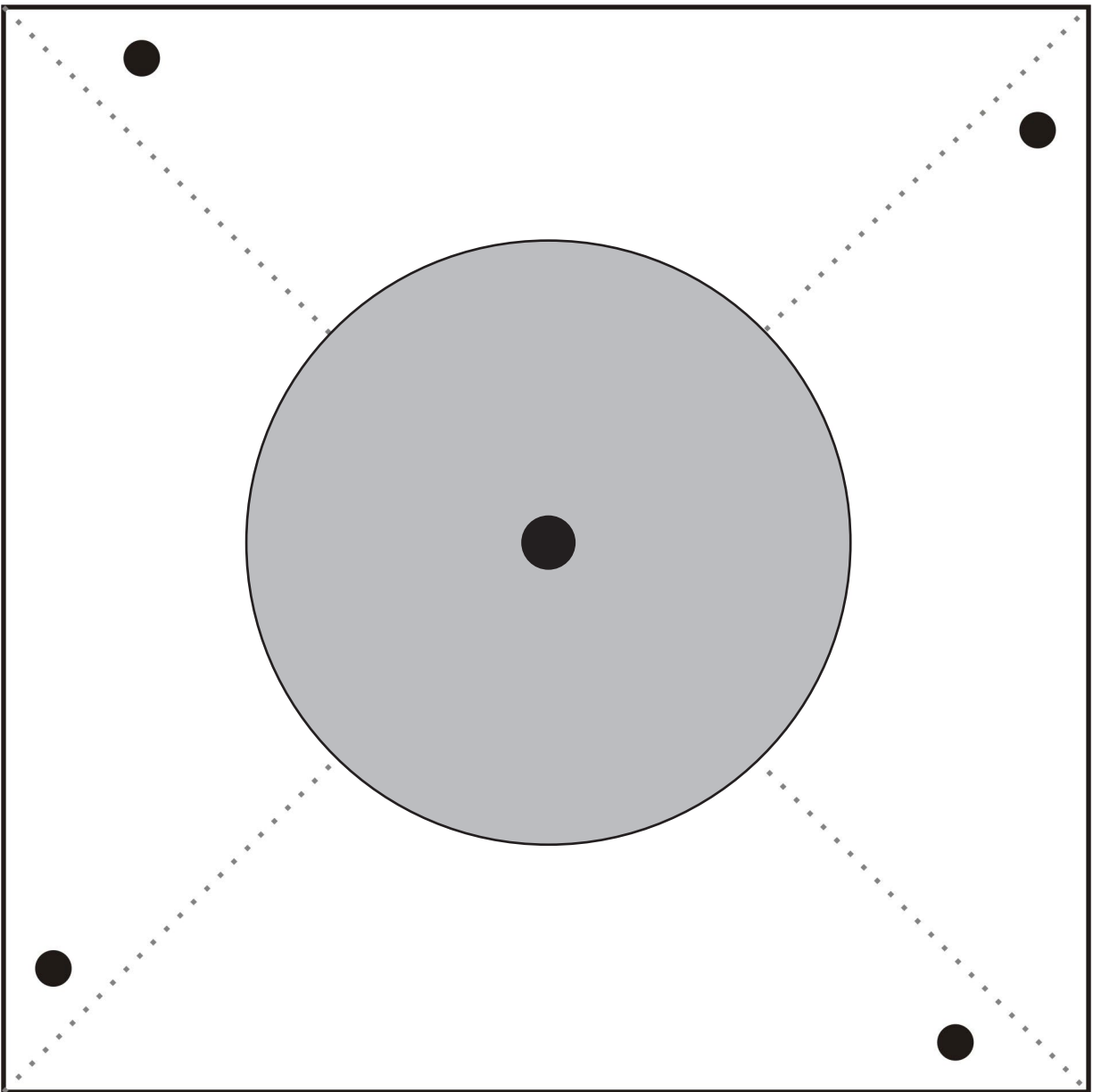




4-Blade Windmill Template

✓ Procedure

1. Cut out the square.
2. Cut on the dotted, diagonal lines.
3. Punch out the four black holes along the side (being careful to not rip the edges) and the black hole in the center.
4. Follow the directions on the *Wind Can Do Work* worksheet to complete the windmill.





WIND WHEEL EXPERIMENT PACK INCLUDES:



1 Screw Hub



1 Extra LED Light



1 Acorn Hex Nut



1 Plastic Tube



Lights with the wind!
No batteries required.



Demonstrate how wind can
generate electricity!



Experiment with wind wheel
designs. Try different shapes!

ASSEMBLE THE FIREFLY

1

Cut the plastic tubing in half.

2

Slide a piece of tubing onto
each LED leg.

3

Thread the LED legs through the generator connections. The longer (positive) leg should go through the positive connection.

MAKE YOUR OWN WIND WHEEL

You will need: a 4" x 4" square of paper, scissors, and a pencil

1. Use a pencil to draw diagonal lines across a square of paper.

2. Cut along the pencil lines, stopping about an inch from the center.

3. Fold down the corners according to the diagram above (on the top section, this is the **right corner**). You must fold these corners because the wind wheel must **spin clockwise** to light the LED.

4. Next, re-position the folded corners so that they point up.

4

A.

B.

A) Bend the LED legs so they hook onto the generator connections. **B)** Slide the plastic tube pieces over the junctions.

5

Push the generator into the firefly until it fits snugly and the LED peeks through the window.

6

Sharpen the pencil before placing it into the holder to help the firefly pivot into the wind.

7

OR

Push either the included propeller or your own wind wheel onto the generator shaft.

8

Holding the pencil upright, blow on the firefly and watch your LED light up!

CAUTION: Pencil remains loose inside firefly™ to allow rotation into the wind. Keep firefly™ upright at all times.



firefly™ is a REcharge Labs® activity kit. Your purchase helps support teacher training. Learn more at rechargelabs.org

Assembled in the USA.



WARNING! CHOKING HAZARD



is a trademark or registered trademark of KidWind Project. All rights reserved.

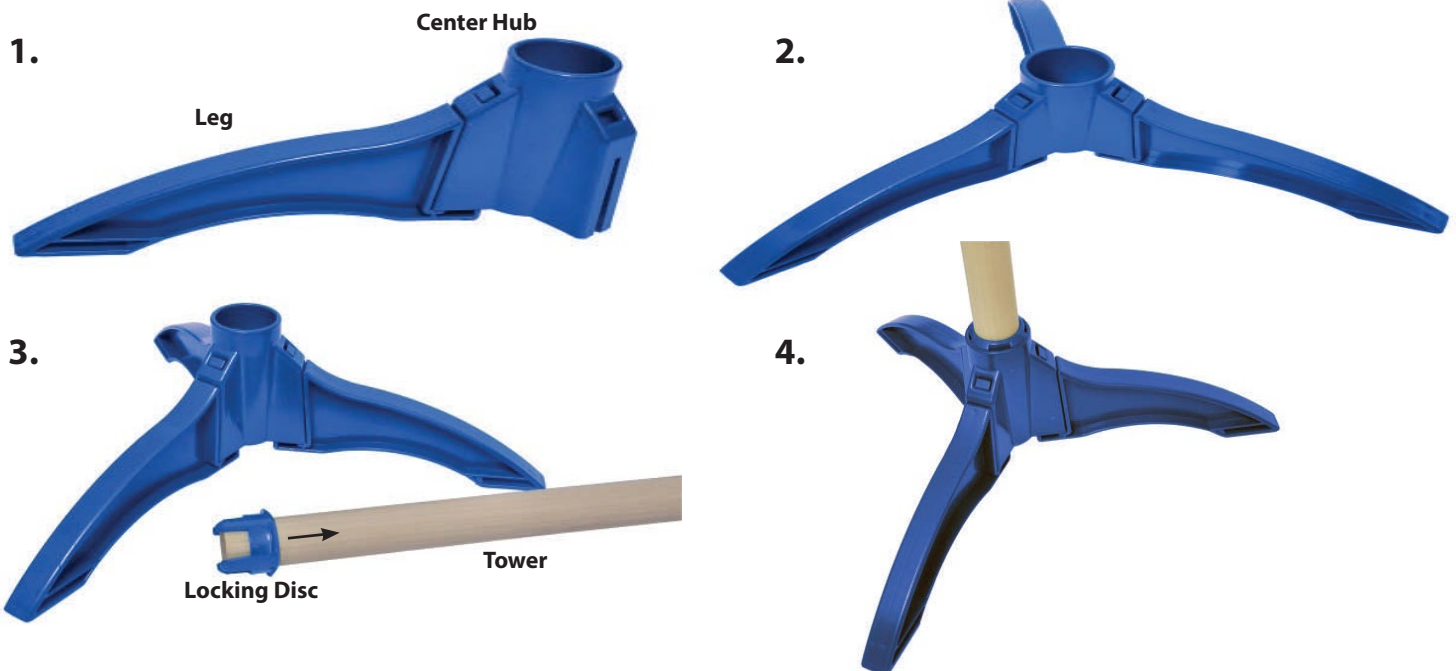


Turbine Assembly Instructions

For Each Tower You Will Need

- 3 Legs
- 1 Center hub
- 1 Locking disc
- 1 Wood tower
- Nacelle (pre-assembled)
- Gears
- 12 Hole crimping hub
- Blades

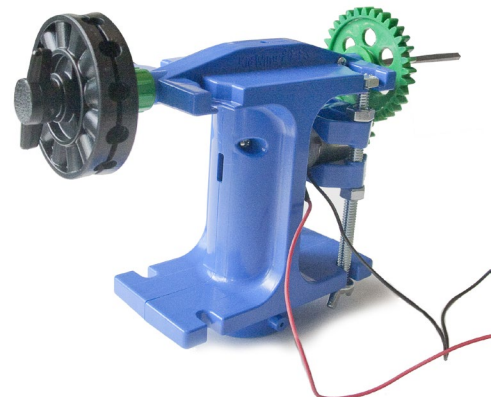
Tower Assembly



1. Lock one leg onto the center hub.
2. Attach the two other legs in the same way.
3. Slide the locking disc onto the tower about 3 inches.
4. With the teeth of the locking disc pointing down, insert the tower into the center hub, locking the tower in place.

Turbine Nacelle Generating Electricity

1. The turbine nacelle comes pre-assembled as part of the NEED wind kit. It slides directly onto the tower. You can secure the nacelle in place by screwing in one or two more small screws in the holes at the bottom of the nacelle.
2. Electrical wire comes pre-connected to the motor. Tell students not to pull on the wires or they will detach from the motor. Make sure enough wire is exposed so that the alligator clips come in contact with enough of the wire. Strip off additional plastic coating as necessary.
3. Attach a hub as shown in the diagram, and explained on page 30.



Turbine Nacelle

Weightlifter Nacelle

1. One nacelle comes pre-assembled with a spool on one end of the shaft. Tie string through the bucket and attach it to the spool. There should be enough string so that the bucket can rest on the floor or table without any slack in the string.
2. Test the efficiency of the blades by adding mass to the bucket and seeing how much the wind turbine can lift.

Adding the Hub and Blades

1. The HEX shaped driveshaft allows you to connect the Hex-Lock to the driveshaft. If you mount your gears or a weightlifting spool on the back of the nacelle, it will not slip on the driveshaft.
2. Turn the knob on the front of the hub to loosen the two hub sides. Do not turn the knob too far or the hub will separate completely.
3. Place the blades into the slots. Tighten the hub to hold the blades in place.

Video Assembly Instructions

Vernier and KidWind teamed up to provide a short video showcasing turbine assembly from beginning to end. The Vimeo© video can be found on Vernier's website, www.vernier.com, and also by visiting <https://vimeo.com/114691934>.



Use the nuts to adjust the motor up and down so the gears mesh.



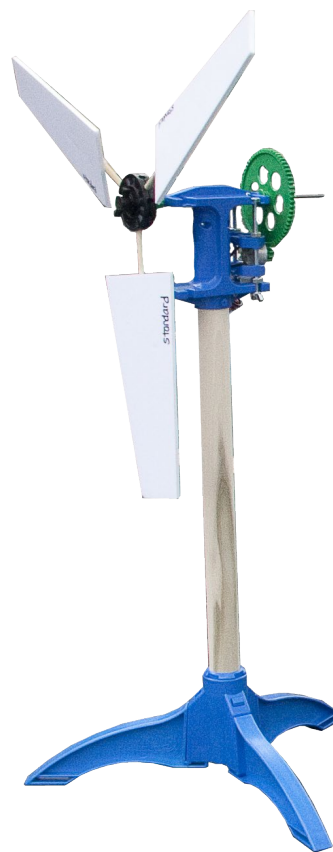
Hub Quick-Connect

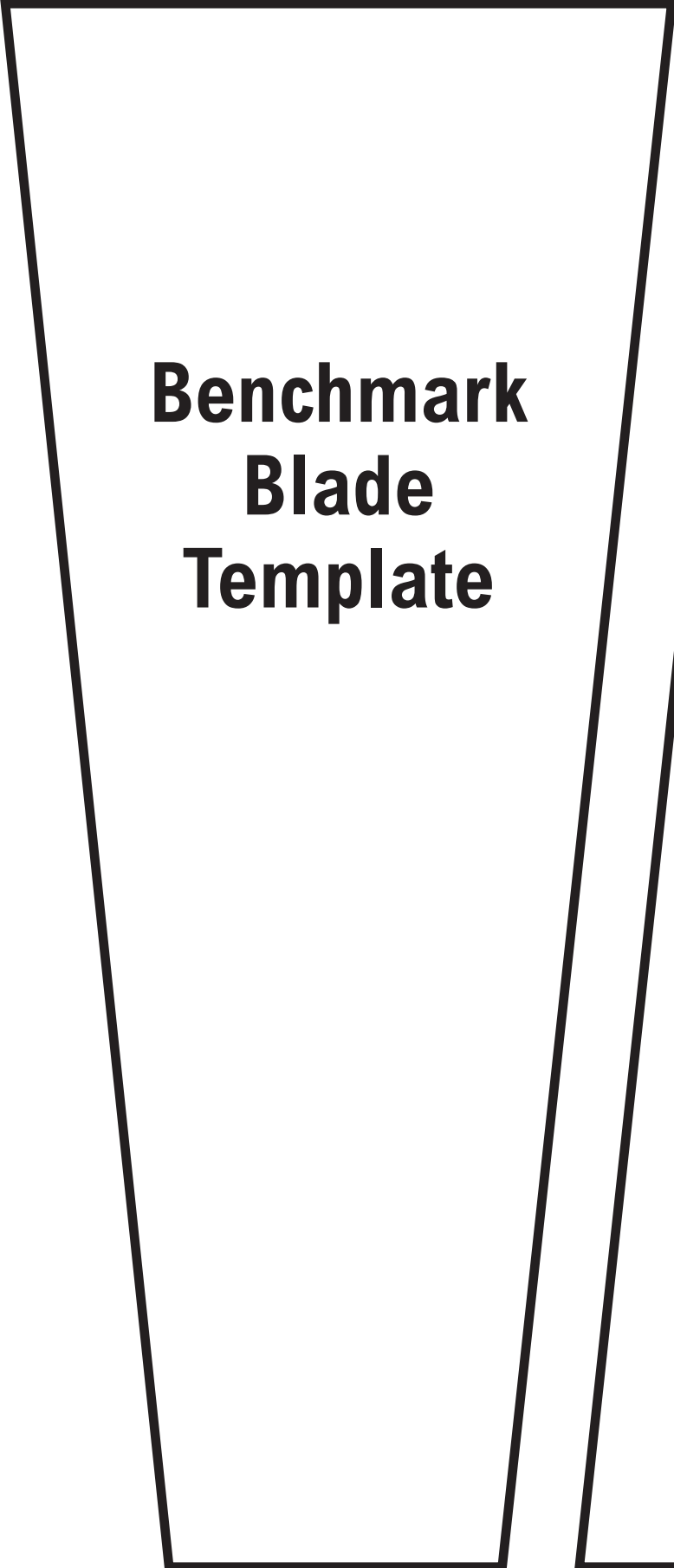


Hub

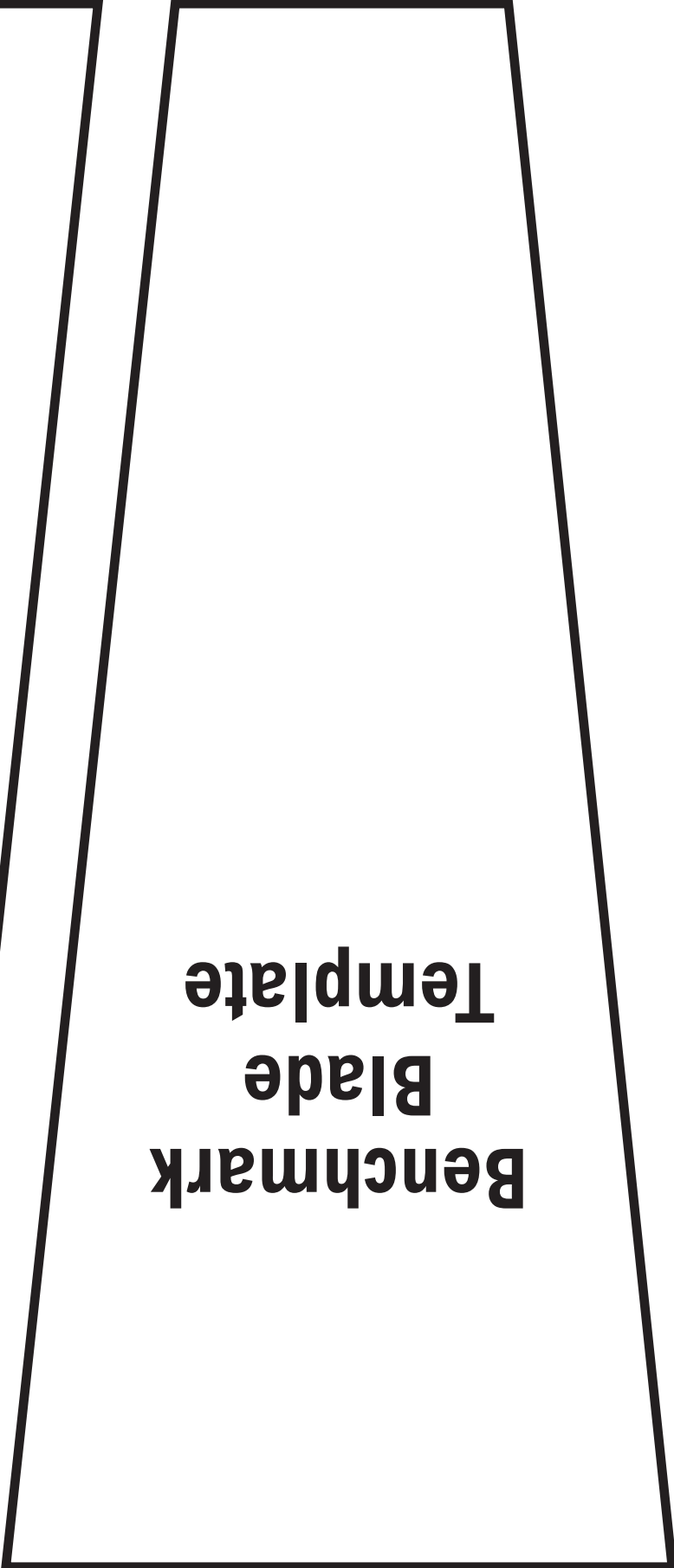


Weightlifter Nacelle





**Benchmark
Blade
Template**



**Benchmark
Blade
Template**



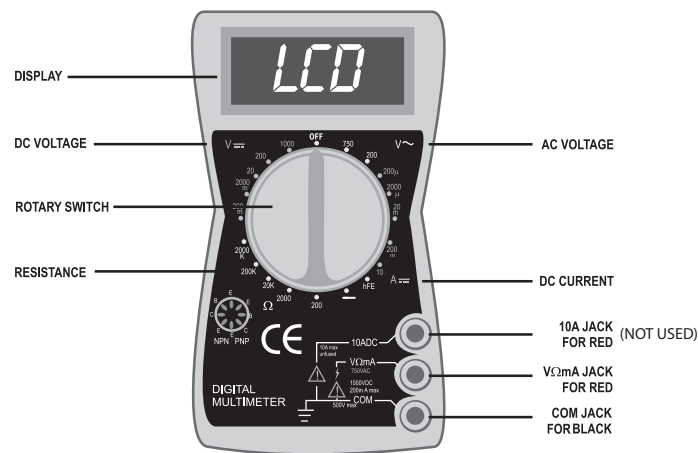
Measuring Electricity

Included in the kit is a tool to measure electricity—a multimeter. The multimeter allows you to measure current, resistance, and voltage, and displays the reading numerically.

When using a multimeter it should be noted that some measurements will never “stay still” at a single repeatable value. This is the nature of the variables being monitored in some circumstances. For example, if you were to measure the resistance between your two hands with the ohmmeter setting on the multimeter (megaohm range—millions of ohms), you would find that the values would continuously change. How tightly you squeeze the metal probes and how “wet” or “dry” your skin is can have a sizable effect on the reading that you obtain. In this situation you need a protocol or standardized method to allow you to record data.

We recommend that you discuss with your class the variability of measurement and let them come up with a standard for collecting data. They may decide to go with the lowest reading, the highest reading, or the reading that appears most frequently in a certain time period.

Digital Multimeter



▀ Directions:

DC VOLTAGE

1. Connect RED lead to VΩmA jack and BLACK to COM.
2. Set ROTARY SWITCH to highest setting on DC VOLTAGE scale (1000).
3. Connect leads to the device to be tested using the alligator clips provided.
4. Adjust ROTARY SWITCH to lower settings until a satisfactory reading is obtained.
5. With the wind turbine, usually the 20 DCV setting provides the best reading.

DC CURRENT (NOT USED IN THIS ACTIVITY)

1. Connect RED lead to VΩmA jack and BLACK to COM.
2. Set ROTARY SWITCH to 10 ADC setting.
3. Connect leads to the device to be tested using the alligator clips provided.
Note: The reading indicates DC AMPS; a reading of 0.25 amps equals 250 mA (milliamps).

YOUR MULTIMETER MIGHT BE SLIGHTLY DIFFERENT FROM THE ONE SHOWN. BEFORE USING THE MULTIMETER, READ THE OPERATOR'S INSTRUCTION MANUAL INCLUDED IN THE BOX FOR SAFETY INFORMATION AND COMPLETE OPERATING INSTRUCTIONS.



I Learned–You Learned

Directions

1. In the first box write down one new piece of information you learned about wind or energy.
2. Find a partner. Share what you learned with your partner. Your partner will write down your learning in one of his/her empty boxes.
3. Listen to what your partner learned. Write down his/her new learning in one of your empty boxes.
4. Switch partners. Continue finding new people to talk to until all of the boxes on your paper are full.



Name _____

Wind Pre/Post Assessment

1. The ability to do work is called_____.
a. energy b. electricity c. a job
2. Wind is_____.
a. moving clouds b. moving trees c. moving air
3. The energy in wind comes from the_____.
a. Earth b. sun c. ocean
4. Wind is made by the uneven heating of the_____.
a. Earth's surface b. sun c. ocean
5. Wind moves best_____.
a. in the forest b. over flat land c. in the city
6. A tool that measures the speed of the wind is a(n)_____.
a. anemometer b. thermometer c. wind vane
7. A tool that shows the direction from which the wind is blowing is a(n)_____.
a. anemometer b. thermometer c. wind vane
8. A wind turbine uses wind energy to make_____.
a. electricity b. heat c. motion
9. What part of a wind turbine captures the wind?
a. tower b. gear box c. blades
10. Deciding where to build many wind turbines is called_____.
a. picking a windy place b. siting a wind farm c. choosing a windy spot

11. Give two examples of work that wind can do.

12. Give two reasons why wind is a good energy resource.



WIND ENERGY BINGO

- A. Has used wind energy for transportation
- B. Knows the average cost per residential kilowatt-hour of electricity
- C. Can name two renewable energy sources other than wind
- D. Can explain how wind is formed
- E. Knows what an anemometer does
- F. Can name two forms of energy
- G. Can name two factors to consider when siting a wind farm
- H. Knows how electricity is generated by a wind turbine
- I. Has seen a modern wind turbine
- J. Knows how wind speed is measured
- K. Has experienced the wind tunnel effect
- L. Knows the energy efficiency of a wind turbine
- M. Can name two uses of windmills
- N. Can name two myths many people believe about wind turbines
- O. Has been to a power plant
- P. Knows what a gear box does

A NAME	B NAME	C NAME	D NAME
E NAME	F NAME	G NAME	H NAME
I NAME	J NAME	K NAME	L NAME
M NAME	N NAME	O NAME	P NAME



NEED's Online Resources

NEED'S SMUGMUG GALLERY

<http://need-media.smugmug.com/>

On NEED's SmugMug page, you'll find pictures of NEED students learning and teaching about energy. Would you like to submit images or videos to NEED's gallery? E-mail info@NEED.org for more information.

Also use SmugMug to find these visual resources:

Videos

Need a refresher on how to use Science of Energy with your students? Watch the Science of Energy videos. Also check out our Energy Chants videos! Find videos produced by NEED students teaching their peers and community members about energy.

Online Graphics Library

Would you like to use NEED's graphics in your own classroom presentations, or allow students to use them in their presentations? Download graphics for easy use in your classroom.

AWESOME EXTRAS

Looking for more resources? Our Awesome Extras page contains PowerPoints, animations, and other great resources to compliment what you are teaching in your classroom! This page is available under the Educators tab at www.NEED.org.

THE BLOG

We feature new curriculum, teacher news, upcoming programs, and exciting resources regularly. To read the latest from the NEED network, visit www.NEED.org/blog_home.asp.

EVALUATIONS AND ASSESSMENT

Building an assessment? Searching for standards? Check out our Evaluations page for a question bank, NEED's Energy Polls, sample rubrics, links to standards alignment, and more at www.NEED.org/evaluation.

E-PUBLICATIONS

The NEED Project offers e-publication versions of various guides for in-classroom use. Guides that are currently available as an e-publication can be found at www.issuu.com/theneedproject.

SOCIAL MEDIA



Stay up-to-date with NEED. "Like" us on Facebook! Search for The NEED Project, and check out all we've got going on!



Follow us on Twitter. We share the latest energy news from around the country, @NEED_Project.



Follow us on Instagram and check out the photos taken at NEED events, instagram.com/theneedproject.



Follow us on Pinterest and pin ideas to use in your classroom, Pinterest.com/NeedProject.



Subscribe to our YouTube channel!
www.youtube.com/user/NEEDproject

NEED ENERGY BOOKLIST

Looking for cross-curricular connections, or extra background reading for your students? NEED's booklist provides an extensive list of fiction and nonfiction titles for all grade levels to support energy units in the science, social studies, or language arts setting. Check it out at www.NEED.org/booklist.asp.

U.S. ENERGY GEOGRAPHY

Maps are a great way for students to visualize the energy picture in the United States. This set of maps will support your energy discussion and multi-disciplinary energy activities. Go to www.need.org/energyinsocietymaterials to see energy production, consumption, and reserves all over the country!

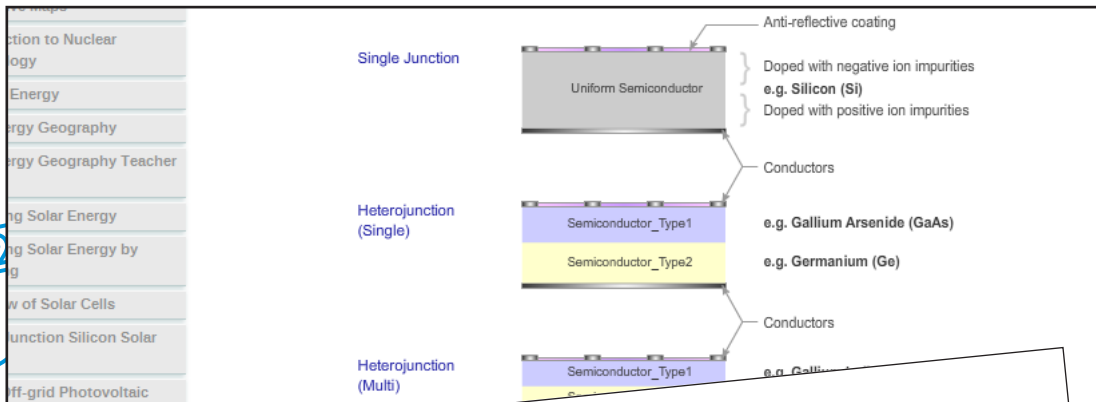




Awesome Extras!

Our Awesome Extras page contains PowerPoints, animations, and other great resources to compliment what you are teaching!

This page is available at www.NEED.org/educators.



SOLAR AT A GLANCE

NEED National Energy Education Development

WHAT IS SOLAR?
Solar energy is radiant energy that is produced by the sun. Every day the sun radiates, or sends out, an enormous amount of energy. The sun radiates more energy in one second than people have used since the beginning of time!

NUCLEAR FUSION
The process of fusion most commonly involves hydrogen isotopes combining to form a helium atom with a transformation of matter. This matter is emitted as radiant energy.

PHOTOVOLTAIC CELLS
Photovoltaic comes from the words photo meaning "light" and volt, a measurement of electricity. Sometimes photovoltaic cells are called PV cells or solar cells for short. These are the four steps that show how a PV cell is made and how it produces electricity.

- 1** A slab (or wafer) of pure silicon is used to make a PV cell. The top of the slab is very thinly diffused with an "n" dopant such as phosphorus. On the base of the slab a small amount of a "p" dopant, typically boron, is diffused. The boron side of the slab is 1,000 times thicker than the phosphorus side. The phosphorus has one more electron in its outer shell than silicon, and the boron has one less. These dopants help create the electric field that motivates the energetic electrons out of the cell created when a light strikes the PV cell. The phosphorus gives the wafer of silicon an excess of free electrons; it has a negative character. This is called n-type silicon (n = negative). The n-type silicon is not charged—it has an equal number of protons and electrons—but some of the electrons are not held tightly to the atoms. They are free to move to different locations within the layer. The boron gives the base of the silicon a positive character, because it has a tendency to attract electrons. The base of the silicon is called p-type silicon (p = positive). The p-type silicon has an equal number of protons and electrons; it has a positive character but not a positive charge.
- 2** A conducting wire connects the p-type silicon to an electrical load, such as a light or battery, and then back to the n-type silicon, forming a complete circuit. As the free electrons are pushed into the n-type silicon they repel each other because they are of like charge. The wire provides a path for the electrons to move away from each other. This flow of electrons is an electric current that travels through the circuit from the n-type to the p-type silicon. In addition to the semi-conducting materials, solar cells consist of a top metallic grid to collect electrons from the semi-conductor and
- 3** If the PV cell is placed in the sun, photons of light strike the electrons in the p-n junction and energize them, knocking them free of their atoms. These electrons are attracted to the positive charge in the n-type silicon and repelled by the negative charge in the p-type silicon. Most photon-electron collisions actually occur in the silicon base.
- 4** A conducting wire connects the p-type silicon to an electrical load, such as a light or battery, and then back to the n-type silicon, forming a complete circuit. As the free electrons are pushed into the n-type silicon they repel each other because they are of like charge. The wire provides a path for the electrons to move away from each other. This flow of electrons is an electric current that travels through the circuit from the n-type to the p-type silicon. In addition to the semi-conducting materials, solar cells consist of a top metallic grid to collect electrons from the semi-conductor and

TOP SOLAR STATES

- 1 CALIFORNIA
- 2 ARIZONA
- 3 NEVADA

When the n-type silicon and p-type silicon meet, free electrons from the n-layer flow into the p-layer

CANADA ENERGY FACTS

WORLD RANKING OF ENERGY PRODUCTION

Canada ranks fifth in the world in total energy production, fifth in annual petroleum production, third in natural gas production, second in uranium production, and fifth in electricity produced by hydropower.

Rank	Category
5 TH	TOTAL
5 TH	PETROLEUM
3 RD	NATURAL GAS
2 ND	URANIUM
5 TH	HYDROPOWER

WORLD RANKING OF ENERGY CONSUMPTION



YOUTH ENERGY CONFERENCE AND AWARDS

The NEED Youth Energy Conference and Awards gives students more opportunities to learn about energy and to explore energy in STEM (science, technology, engineering, and math). The annual June conference has students from across the country working in groups on an Energy Challenge designed to stretch their minds and energy knowledge. A limited number of spaces are available for a special two-day pre-conference event, which allows students access to additional information, time to discuss energy with their peers, and access to industry professionals. The conference culminates with the Youth Awards Ceremony recognizing student work throughout the year and during the conference.

For More Info: <http://tinyurl.com/youthenergyconference>

YOUTH AWARDS PROGRAM FOR ENERGY ACHIEVEMENT

All NEED schools have outstanding classroom-based programs in which students learn about energy. Does your school have student leaders who extend these activities into their communities? To recognize outstanding achievement and reward student leadership, The NEED Project conducts the National Youth Awards Program for Energy Achievement.

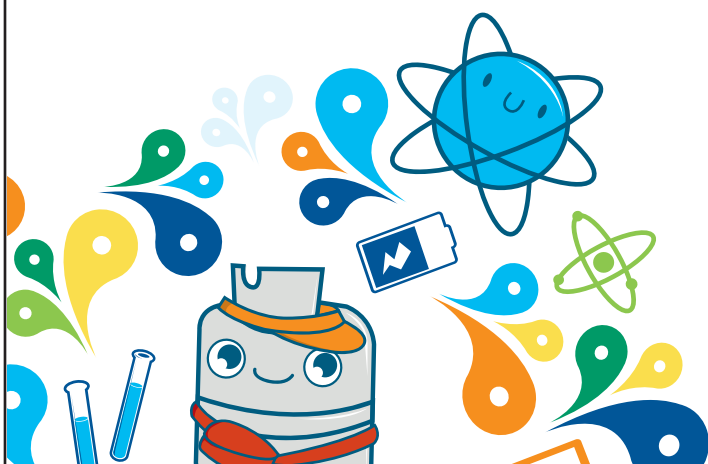
Share Your Energy Outreach with The NEED Network!

This program combines academic competition with recognition to acknowledge everyone involved in NEED during the year—and to recognize those who achieve excellence in energy education in their schools and communities.

What's involved?

Students and teachers set goals and objectives and keep a record of their activities. Students create a digital project to submit for judging. In April, digital projects are uploaded to the online submission site.

Want more info? Check out www.NEED.org/Youth-Awards for more application and program information, previous winners, and photos of past events.





Wonders of Wind Evaluation Form

State: _____ Grade Level: _____ Number of Students: _____

- 1. Did you conduct the entire unit? Yes No

- 2. Were the instructions clear and easy to follow? Yes No

- 3. Did the activities meet your academic objectives? Yes No

- 4. Were the activities age appropriate? Yes No

- 5. Were the allotted times sufficient to conduct the activities? Yes No

- 6. Were the activities easy to use? Yes No

- 7. Was the preparation required acceptable for the activities? Yes No

- 8. Were the students interested and motivated? Yes No

- 9. Was the energy knowledge content age appropriate? Yes No

- 10. Would you teach this unit again? Yes No

Please explain any 'no' statement below.

How would you rate the unit overall? excellent good fair poor

How would your students rate the unit overall? excellent good fair poor

What would make the unit more useful to you?

Other Comments:

Please fax or mail to: The NEED Project
8408 Kao Circle
Manassas, VA 20110
FAX: 1-800-847-1820



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U.S. Energy Information Administration
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Wayne County Sustainable Energy
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