2017-2018

Energy From the Wind

Teacher Guide

Hands-on, critical thinking and language arts activities that help intermediate students to develop a comprehensive understanding of wind formation, wind energy, and electricity generation from wind.

Grade Level:

Int Intermediate

Subject Areas:

- Science
- Social Studies
- Math
- Language Arts
- Technology

NEED
National Energy Education Development Project

Teacher Advisory Board

NEED Mission Statement

The mission of The NEED Project is to promote an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs.

Permission to Copy

Teacher Advisory Board

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.

NEED
National Energy
Education Development

1.800.875.5029
www.NEED.org

Energy From the Wind

Energy From the Wind **was developed by The NEED Project with funding from the American Wind Energy Association.**

AWEA AMERICAN WIND ENERGY ASSOCIATION

Table of Contents

Energy From the Wind Kit

- 2 Alligator Clips
- 1 Anemometer
- 30 Binder clips
- 1 Compass
- 1 Genecon
- 1 Roll masking tape
- 2 Multimeters
- 30 Pencils
- 75 Snow cone cups
- 1 Box straight pins
- 100 Extra-long straws
- 30 Small straws
- 1 Wind gauge
- 1 Wind vane
- 30 Student Guides

KidWind™ Kit Materials

- Blade materials sheets (balsa and corrugated plastic sheets)
- 150 Dowels
- 10 Airfoil blades
- 10 Hubs
- 2 Tower and base setups
- 2 Geared nacelles
- 1 Power output pack
- 2 Gear sets
- 1 Sandpaper sheet
- 1 Visual Voltmeter
- Blade pitch protractor

PROUD MEMBER OF IREC Interstate Renewable Energy Council

Standards Correlation Information

www.NEED.org/curriculumcorrelations

Next Generation Science Standards

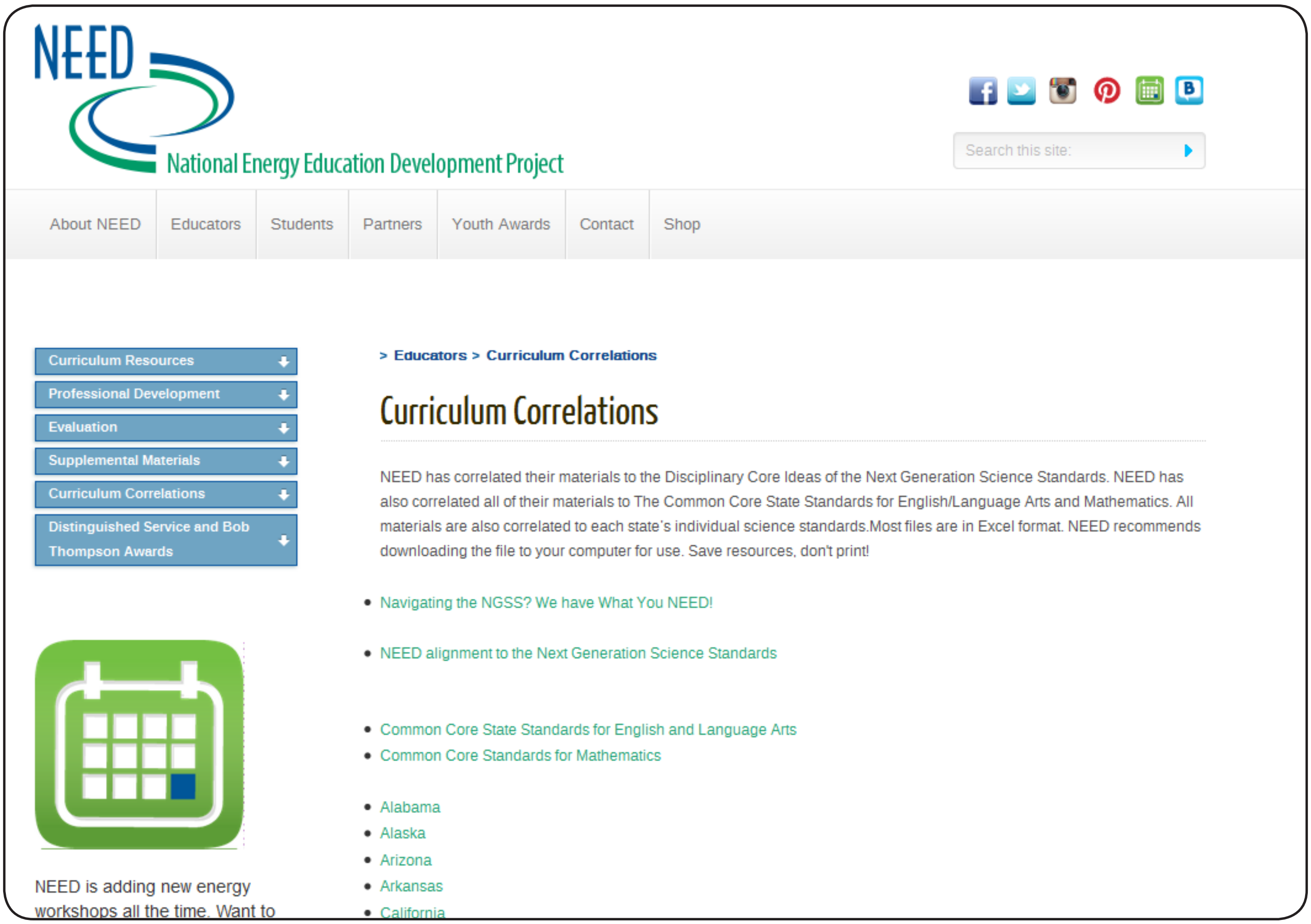
- This guide effectively supports many Next Generation Science Standards. This material can satisfy performance expectations, science and engineering practices, disciplinary core ideas, and cross cutting concepts within your required curriculum. For more details on these correlations, please visit NEED's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



Energy From the Wind Materials

ACTIVITY	MATERIALS IN KIT	ADDITIONAL MATERIALS NEEDED
Measuring Wind Speed	▪Pencils ▪Snow cone cups ▪Extra-long straws ▪Straight pins ▪Masking tape ▪Anemometer ▪Wind gauge ▪Wind vane ▪Compass	▪Hole punches ▪Markers ▪Scissors ▪Stopwatches or watches with second hands ▪Rulers
Wind Can Do Work	▪Extra-long straws ▪Small straws ▪Binder clips ▪Straight pins ▪Masking tape	▪Large foam cups approximately 14 cm tall ▪Rulers ▪Hole punches ▪Markers ▪String or thread ▪Paper clips ▪Fan(s) ▪Scissors
Introduction to Electricity	▪Dowels ▪Hubs ▪Masking tape ▪Turbine tower set-up (assembled)* ▪Genecon ▪Alligator clips	▪Poster board ▪Small light bulb (3.8 V, 0.3 A) in socket ▪Battery (any 1.5-volt AAA, AA, or D) ▪Fan ▪Glue
Wind Blade Investigations	▪Dowels ▪Visual voltmeter ▪Hubs ▪Blade pitch protractor ▪Sandpaper ▪Masking tape ▪Multimeters ▪Turbine tower set-ups (assembled)* ▪Blade materials (flat balsa sheets, corrugated plastic sheets)	▪Extra/alternative blade materials ▪Scissors ▪Fan(s) ▪Pennies (or other mass) ▪Rulers ▪Glue
Blade Aerodynamics	▪Turbine tower set-ups (assembled)* ▪Hub ▪Dowels ▪Airfoil blades ▪Masking tape ▪Blade pitch protractor ▪Multimeter	▪Glue ▪Fan

***See pages 23-24 for turbine tower assembly instructions.**

NOTE: You can build your own turbine towers using PVC pipe. For directions, visit www.NEED.org.

Teacher Guide

Grade Level

- Intermediate, grades 6-8

Web Resources

American Wind Energy Association
www.awea.org

Bureau of Land Management
www.blm.gov

Bureau of Ocean Energy Management
www.boem.gov

Energy Information Administration
www.eia.gov

EIA Energy Kids
www.eia.gov/kids

U.S. Department of Energy Wind Program
http://energy.gov/eere/wind/wind-energy-technologies-office

U.S. Department of Energy WindExchange
https://energy.gov/eere/wind/windexchange

Additional Resources

NEED has several guides and activities that can support and enhance the content covered in this unit. Visit www.NEED.org for free downloads of the titles below and many more!

- *Intermediate Energy Infobook*
- *Intermediate Energy Infobook Activities*
- *Energy Games and Icebreakers*
- *Energy Live!*

Technology Connection

These activities also work nicely with probewear in the technology-savvy classroom. Use Vernier's Energy Sensors to measure output of turbines. www.vernier.com

Background

Energy From the Wind is an inquiry-based unit with Teacher and Student Guides containing comprehensive background information on wind energy and electricity generation. Through hands-on inquiry investigations, reading nonfiction text, and critical thinking activities, students will learn about the physics of wind, the history of harnessing wind's energy, and how we harness wind's energy today. The kit that accompanies this curriculum contains most of the materials necessary to conduct the activities and investigations. Please refer to page 5 of the Teacher Guide for a complete list of materials included in the kit and additional materials needed to conduct the activities.

Time

The sequence of lessons was designed for use in a 45-50 minute class period. In this setting, the unit will take approximately 2-3 weeks, if done in its entirety.

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 to guide assessment of student notebooks can be found on page 15 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.

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.

Activity 1: Introduction to Wind

Objective

- Students practice making observations using their senses.

✔ Procedure

1. Students should read *Introduction to Wind* on pages 2-6 in the Student Guide.
2. Take the class outside to make their own wind observations. In their science notebooks, students should use reference objects in the environment to record visual cues in words and/or sketches.
3. Back inside the classroom, have students share their observations with each other and write a paragraph about their observations.

Activity 2: Measuring Wind Speed

Objective

- Students will be able to measure wind speed and direction.

Materials *FOR EACH STUDENT OR PAIR*

- 5 Snow cone cups
- 1 Pencil
- 2 Extra-long straws
- 1 Straight pin
- Masking tape
- Hole punch
- Marker
- Stopwatch or watch with second hand
- Scissors
- Ruler
- *Build an Anemometer* worksheet, Student Guide page 20

Materials *FOR THE CLASS*

- Anemometer
- Wind gauge
- Wind vane
- Compass

Procedure

1. Students should review *Measuring Wind Direction and Speed* on page 5 in the Student Guide.
2. Students will use the *Build an Anemometer* worksheet for directions to build their anemometers.
3. Teach students how to use their anemometers and other wind measuring tools. Directions for the wind gauge are on page 17 of the Teacher Guide, project as needed.
4. Bring students outside with their anemometers and science notebooks, along with the wind measuring tools included in the kit. If possible, allow students to spread out to different areas of the campus to record wind speed and direction and the time each measurement is taken. Students should record data and observations in their science notebooks, and compare readings from various tools.
5. Return to class and discuss with students their observations. Were there differences in wind speed around the school grounds? Why might that be? Why might it be important to consider time during measurements?

Activity 3: History of Wind Energy

Objective

- Students will be able to describe ways in which humans have been using the wind to do work.

Materials

- *History of Harnessing the Wind's Energy* worksheet, Student Guide page 21

Procedure

1. Instruct the class to read *Wind Turbines Yesterday and Today* and *Windmills in America* (Student Guide, pages 5-6), and the *Wind Energy Timeline* (Student Guide, pages 18-19). These can also be completed as a jigsaw.
2. Using the *History of Harnessing the Wind's Energy* worksheet, students should choose five important events and analyze them.
3. Next, students choose one event and write a more detailed paragraph about the event, what brought it about, and what impact it had.

Extension

- As an extension, this can be turned into a more in-depth research report.

Activity 4: Wind Can Do Work

Objective

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

Materials *FOR EACH STUDENT OR PAIR*

- 1 Large foam cup (approximately 14 cm tall)
- 1 Extra-long straw*
- 1 Small straw
- 1 Binder clip
- 2 Straight pins
- Ruler
- Hole punch
- Marker
- 50 cm String or thread
- Paper clips
- Masking tape
- Scissors
- *Forms of Energy* master, Teacher Guide page 18
- *4-Blade Windmill Template,* Teacher Guide page 19
- *Wind Can Do Work* worksheet, Student Guide page 22

Materials *FOR THE CLASS*

- Fan(s)

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

✔ Procedure

1. Have students read *Energy* on pages 7-8 in the Student Guide.
2. Using the *Forms of Energy* master, discuss energy transformations with students.
3. Using directions from the *Wind Can Do Work* worksheet, students should build windmills.
4. Students should diagram their windmill assembly and trace the energy transformations that occur in this system.
5. Encourage students to investigate the question, "What is the maximum amount of paper clips that can be lifted all of the way to the top of the windmill shaft?" Students should record data and observations in their science notebooks.

Extension

- Students can redesign the windmill to see if they can produce more work from the system. This can also become a class competition.

Activity 5: Introduction to Electricity

Objective

- Students will be able to describe how electricity is produced.

Materials *FOR ACTIVITY*

- Poster board
- Dowels
- Hubs
- Glue
- Masking tape
- 1 Turbine tower, assembled (see Preparation below)
- Genecon
- 1 Bulb (3.8V, 0.3A) in socket with leads
- 1 Battery (any 1.5-volt AAA, AA, or D)
- 1 Fan
- 2 Alligator clips
- *Observing a Genecon* worksheet, Student Guide page 23

Materials *FOR TURBINE ASSEMBLY*

- 20" Wood towers
- Tower stand sets (1 locking disc, 3 base legs, 1 leg insert)
- Turbine nacelle
- Hex driveshafts
- Motor mount (2 bolts, 4 wing nuts, 4 nuts, 8 screws, 2 motor mounts (blue), 1 wind turbine motor with wires, 1 hi-torque motor with wires)
- Turbine gear pack (3 gear keys, 1 8-tooth gear, 1 16-tooth gear, 1 32-tooth gear, 1 64-tooth gear, 1 wooden spool)
- *Turbine Assembly Instructions*, Teacher Guide pages 23-24
- *Benchmark Blade Template*, Teacher Guide page 25

Preparation

- Assemble at least one turbine tower (you will need both for Activity 6) using the *Turbine Assembly Instructions* and the materials listed above. A Vimeo© video showing assembly instructions can be viewed at https://vimeo.com/114691934 or by visitng www.vernier.com.
- Using poster board, dowels, hubs, glue, and tape, create your own set of benchmark blades using the blade template.
- Familiarize yourself with the Genecon. Download a PDF of activities and investigations that further explore the genecon by visiting www.nadascientific.com/media/PDF/Catalog/N99-B-2637-002_Manual.pdf

✔ Procedure

1. Have students read *Electricity* on pages 9-11 in the Student Guide.
2. Demonstrate with the Genecon the difference between a motor and a generator. Use page 20 in the Teacher Guide for more detailed instructions. Students can take notes in their science notebooks or use the *Observing a Genecon* worksheet.
3. Explain to students that they will be working in teams to design the most efficient turbine blades possible. To do this, they will first investigate isolated variables using "benchmark" blades. It is recommended that all of the students make blades out of poster board before changing the blade materials in the fifth blade investigation. Demonstrate the benchmark blades by showing yours to the students using the turbine tower set-up.

Extension

- For additional Genecon activities, please refer to your Genecon booklet, at the web address above.

Activity 6: Wind Blade Investigations

✪ Objective

- Students will investigate the effect of blade variables on electrical output and design blades to achieve the optimum electrical output.

Materials *FOR INVESTIGATIONS*

- Dowels
- Flat balsa sheets
- Corrugated plastic sheets
- Visual voltmeter
- Hubs
- Blade pitch protractor
- Sandpaper
- Extra/alternative blade materials
- Masking tape
- Multimeters
- Rulers
- Fan(s)
- Glue
- Scissors
- Pennies, or other masses
- Poster board
- 2 Turbine tower set-ups (assembled)
- *Benchmark Blade Template,* Teacher Guide page 25
- Blade investigations worksheets, Student Guide pages 26-31

Materials *FOR TURBINE ASSEMBLY*

- 20" Wood towers
- Tower stand sets (1 locking disc, 3 base legs, 1 leg insert)
- Turbine nacelle
- Hex driveshafts
- Motor mount (2 bolts, 4 wing nuts, 4 nuts, 8 screws, 2 motor mounts (blue), 1 wind turbine motor with wires, 1 hi-torque motor with wires)
- Turbine gear pack (3 gear keys, 1 8-tooth gear, 1 16-tooth gear, 1 32-tooth gear, 1 64-tooth gear, 1 wooden spool)

Preparation

- If you haven't done so already, construct the turbine towers as directed on pages 23-24 of the Teacher Guide, using the materials listed above.
- ***BLADE MATERIALS***: It is recommended that the benchmark blades be made of poster board, which is not included in the kit. Some balsa and corrugated plastic sheets have been included in your kit, but anything can be used as blade materials. You may want to gather your own materials, or have students bring in different materials, before Blade Investigation #5.
- Gather remaining materials and set up investigation stations.

✔ Procedure

1. Students should read *Wind and Electricity* on pages 12-13 in the Student Guide.
2. Teach students how to use the multimeters and voltmeter to measure electricity. Resources for measuring electricity can be found on pages 21-22 in the Teacher Guide and pages 24-25 in the Student Guide.
3. Divide students into small groups. Each group should be given their own hub and blade materials.
4. Have students complete each blade investigation. The investigations have been designed to build upon each other and should be done in order in a gradual release model. When groups are ready to test their blades they can put their hub onto the tower.
    - *Blade Investigation #1—Exploring Blade Pitch* (Student Guide, page 26)
    - *Blade Investigation #2—Exploring Number of Blades* (Student Guide, page 27)
    - *Blade Investigation #3—Exploring Surface Area* (Student Guide, page 28)
    - *Blade Investigation #4—Exploring Mass* (Student Guide, page 29)
    - *Blade Investigation #5—Designing Optimum Blades* (Student Guide, page 30)
    - *Blade Investigation #6—Investigating Gear Ratios* (Student Guide, page 31)

WIND TURBINE MANAGEMENT TIP: NEED's *Energy From the Wind* kit has two towers and ten hubs. In your classroom you can set up two testing stations using the towers provided. Each student group should receive their own hub, and they can use this to prepare their blade investigations. When they are ready to test their designs, students can bring their hub over to the tower and connect it to the generator.

WARNING: When removing hubs from the generator, students need to be careful not to pull the generator out of the nacelle, so that gears remain connected.

Extensions

- Have students calculate wind power using the *Calculating Wind Power* worksheet on page 34 of the Student Guide.
- Have students investigate what happens to the electrical output when a load and/or resistors are added to the circuit.

Activity 7: Blade Aerodynamics

Objectives

- Students will be able to describe the following terms: drag, lift, and torque.
- Students will be able to describe how aerodynamics of blades can affect the turbine's efficiency.

Materials

- Turbine tower set-up (assembled)
- Hub
- Dowels
- Airfoil blades
- Glue
- Masking tape
- Blade pitch protractor
- Multimeter
- Fan
- *Blade Aerodynamics Graphic Organizer*, Student Guide page 32
- *Blade Aerodynamics* worksheet, Student Guide page 33

Preparation

- Assemble a turbine tower, if you have not done so already, using the *Turbine Assembly Instructions* on pages 23–24 of the Teacher Guide.
- Make benchmark airfoil blades by attaching the balsa wood airfoil sheets to dowel rods. They can be shaped more, if desirable.

✔Procedure

1. Using the small groups from the previous blade investigations, assign groups a topic to be responsible for as they read. Topics students should be assigned to include: drag, lift, torque, and blade aerodynamics.
2. Have students read the insert on blade aerodynamics, found on pages 14-17 of the Student Guide. Students should pay attention to, and look for information related to, their topic areas as they read the insert. They will then use the graphic organizer to record any pertinent information.
3. While students are reading, place the benchmark blades into the hub and attach the hub to the tower.
4. Have students revisit their small groups to share what they learned about each topic, as a jigsaw activity. The group should help each other to complete the graphic organizer together. Discuss as a class and fill in any missing information, if needed.
5. After the discussion, or during discussion, demonstrate how the blades are shaped, and how they work. Experiment with the different variables that students may have experimented with in their wind blade investigations (pitch, number, mass, and surface area), as time allows. Students can work individually or in groups to record observations and conclusions on the *Blade Aerodynamics* worksheet.
6. If time allows, ask groups to brainstorm how they might improve upon their optimum blade design, using the principles of aerodynamics they have just observed.

NOTE: The reading could also be completed as a homework assignment, if you choose.

Extension

- Allow student groups to experiment with creating their own airfoil blades (folding, cutting, etc.), and redesigning their optimum blades. This could be made into a further engineering and design challenge for groups to create the highest electrical output while incorporating all they have learned through various investigations.

Activity 8: Siting and Permitting a Wind Farm

Objective

- Students will identify the many benefits and challenges of siting a wind farm.

Materials

- *Siting and Permitting a Wind Farm* activity, Teacher Guide pages 26-27
- *Role Group* worksheet, Student Guide page 35

✔ Procedure

1. Introduce the activity by reading the instructions as a class. Hold a class discussion about what steps they think the developer might take before introducing wind as an option for a community with no turbines. What might happen prior to the meeting and who might it involve?
2. Assign students different roles to investigate and decide how much time students will have for research and presentation. Be sure to visit the web resources provided on page 27 on your own prior to the activity to best guide your students to relevant and appropriate resources.
3. Students should research their roles, answer the questions, and assess the positives and negatives of the proposal based on their roles.
4. Students will present to the class their perspective in a mock town hall meeting. You may have teachers or students from other classes act as community members who vote based on the presentations.
5. At the close of the activity, discuss the results as a class. Ask if they think other sources of energy would have similar or different experiences in this process, and why. Also discuss as a class how the community might weigh landowner rights with the needs of the community. How do we respect both?

☑ Assessment and Evaluation

Objective

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

Materials

- Copies of the *Wind Energy Assessment* for each student, Teacher Guide page 16
- *Wind Energy Bingo*, Teacher Guide page 28

✔ Procedure

1. Give students the *Wind Energy Assessment*. You may also choose to do this at the beginning and end of the unit as a pre/post test. Discuss answers as needed.
2. As a formative assessment tool, play *Wind Energy Bingo* with the students. Instructions are found on pages 13-14.
3. Assess student responses and work using the rubrics on page 15.
4. Evaluate the unit using the *Evaluation Form* on page 31 and return it to NEED.

☑ Wind Energy Assessment Answer Key

1) c 2) b 3) b 4) a 5) b 6) a 7) b 8) d 9) d 10) a

Language Arts Extensions

Visit www.NEED.org to find plays and rock song lyrics relating to wind energy, efficiency and conservation, and renewable energy sources. These are fun reinforcement extensions for your class, which also provide an outreach opportunity for your students to perform for and teach students at younger levels. From NEED's homepage, go to the section "For Educators" and then to "Curriculum Materials." Search for these materials by title:

- *Energy on Stage*
- *Energy Live!*

Wind Energy BINGO Instructions

Get Ready

Duplicate as many *Wind Energy Bingo* sheets (found on page 28) 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.

***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—*H_2 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

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

Rubrics for Assesment

Inquiry Explorations Rubric

This is a sample rubric that can be used with inquiry investigations and science notebooks. You may choose to only assess one area at a time, or look at an investigation as a whole. It is suggested that you share this rubric with students and discuss the different components.

	SCIENTIFIC CONCEPTS	SCIENTIFIC INQUIRY	DATA/OBSERVATIONS	CONCLUSIONS
4	Written explanations illustrate accurate and thorough understanding of scientific concepts.	The student independently conducts investigations and designs and carries out his or her own investigations.	Comprehensive data is collected and thorough observations are made. Diagrams, charts, tables, and graphs are used appropriately. Data and observations are presented clearly and neatly with appropriate labels.	The student clearly communicates what was learned and uses strong evidence to support reasoning. The conclusion includes application to real life situations.
3	Written explanations illustrate an accurate understanding of most scientific concepts.	The student follows procedures accurately to conduct given investigations, begins to design his or her own investigations.	Necessary data is collected. Observations are recorded. Diagrams, charts, tables, and graphs are used appropriately most of the time. Data is presented clearly.	The student communicates what was learned and uses some evidence to support reasoning.
2	Written explanations illustrate a limited understanding of scientific concepts.	The student may not conduct an investigation completely, parts of the inquiry process are missing.	Some data is collected. The student may lean more heavily on observations. Diagrams, charts, tables, and graphs may be used inappropriately or have some missing information.	The student communicates what was learned but is missing evidence to support reasoning.
1	Written explanations illustrate an inaccurate understanding of scientific concepts.	The student needs significant support to conduct an investigation.	Data and/or observations are missing or inaccurate.	The conclusion is missing or inaccurate.

Culminating Project Rubric

This rubric may be used with the *Siting and Permitting a Wind Farm* activity starting on page 26 of the Teacher Guide, or for any other group work you ask the students to complete.

	CONTENT	ORGANIZATION	ORIGINALITY	WORKLOAD
4	Project covers the topic in-depth with many details and examples. Subject knowledge is excellent.	Content is very well organized and presented in a logical sequence.	Project shows much original thought. Ideas are creative and inventive.	The workload is divided and shared equally by all members of the group.
3	Project includes essential information about the topic. Subject knowledge is good.	Content is logically organized.	Project shows some original thought. Work shows new ideas and insights.	The workload is divided and shared fairly equally by all group members, but workloads may vary.
2	Project includes essential information about the topic, but there are 1-2 factual errors.	Content is logically organized with a few confusing sections.	Project provides essential information, but there is little evidence of original thinking.	The workload is divided, but one person in the group is viewed as not doing a fair share of the work.
1	Project includes minimal information or there are several factual errors.	There is no clear organizational structure, just a compilation of facts.	Project provides some essential information, but no original thought.	The workload is not divided, or several members are not doing a fair share of the work.

Wind Energy Assessment

Name____ **Date**________________________

1. The energy of moving molecules, electrons, and substances is called ____________________ energy.

a. potential b. elastic c. kinetic d. electrical

2. Renewable energy sources provide what percentage of total U.S. energy consumption?

a. 0.1-4% b. 5-10% c. 11-20% d. 21-30%

3. The energy in wind comes from ____________________ .

a. ocean currents b. solar radiation c. jet streams d. climate change

4. The direction of a wind blowing from Chicago toward Washington, D.C. is called a ____________________ .

a. northwest wind b. southeast wind c. northeast wind d. south wind

5. Wind is measured by the ____________________ .

a. Doppler Scale b. Beaufort Scale c. Richter Scale d. Coriolis Scale

6. An instrument that measures wind speed is a/an ____________________ .

a. anemometer b. wind vane c. multimeter d. aerometer

7. A device that uses electromagnetism to produce electricity is called a/an ____________________ .

a. motor b. generator c. electrometer d. turbine

8. A wind turbine converts ____________________ .

a. potential energy to electrical energy

b. kinetic energy to potential energy

c. chemical energy to kinetic energy

d. motion energy to electrical energy

9. A good place to site a wind turbine could be a ____________________ .

a. mountain top b. sea coast c. narrow valley d. all of the above

10. Wind energy produces how much of total electricity generation in the U.S. today?

a. 3-5% b. 6-8% c. 10-11% d. 25-26%

Wind Gauge

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

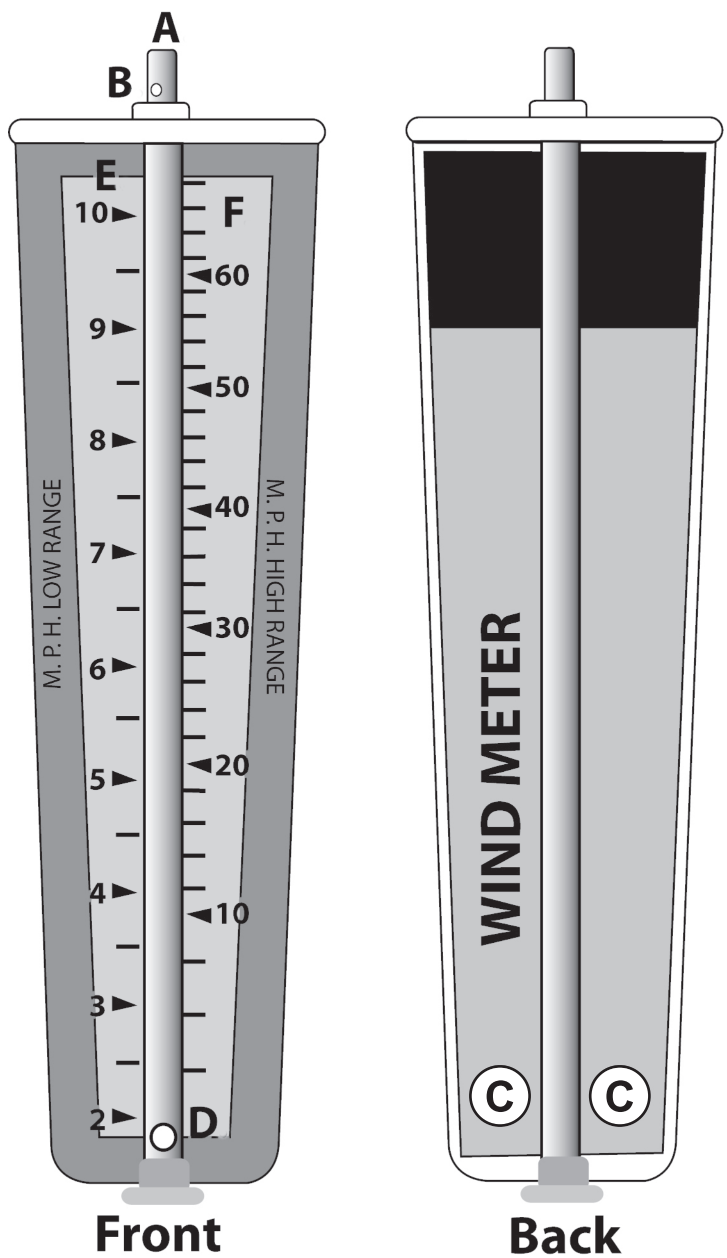
D. a very light ball at the bottom of the hollow stem that can move up and down the stem.

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.



Forms of Energy

All forms of energy fall under two categories:

POTENTIAL

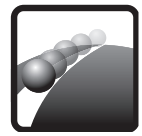
Stored energy and the energy of position (gravitational).

CHEMICAL ENERGY is the energy stored in the bonds between atoms in molecules. Gasoline and a piece of pizza are examples.

NUCLEAR ENERGY is the energy stored in the nucleus or center of an atom – the energy that holds the nucleus together. The energy in the nucleus of a plutonium atom is an example.

ELASTIC ENERGY is energy stored in objects by the application of force. Compressed springs and stretched rubber bands are examples.

GRAVITATIONAL POTENTIAL ENERGY is the energy of place or position. A child at the top of a slide is an example.



KINETIC

The motion of waves, electrons, atoms, molecules, and substances.

RADIANT ENERGY is electromagnetic energy that travels in transverse waves. Light and x-rays are examples.

THERMAL ENERGY or heat is the internal energy in substances – the vibration or movement of atoms and molecules in substances. The heat from a fire is an example.

MOTION is the movement of a substance from one place to another. Wind and moving water are examples.

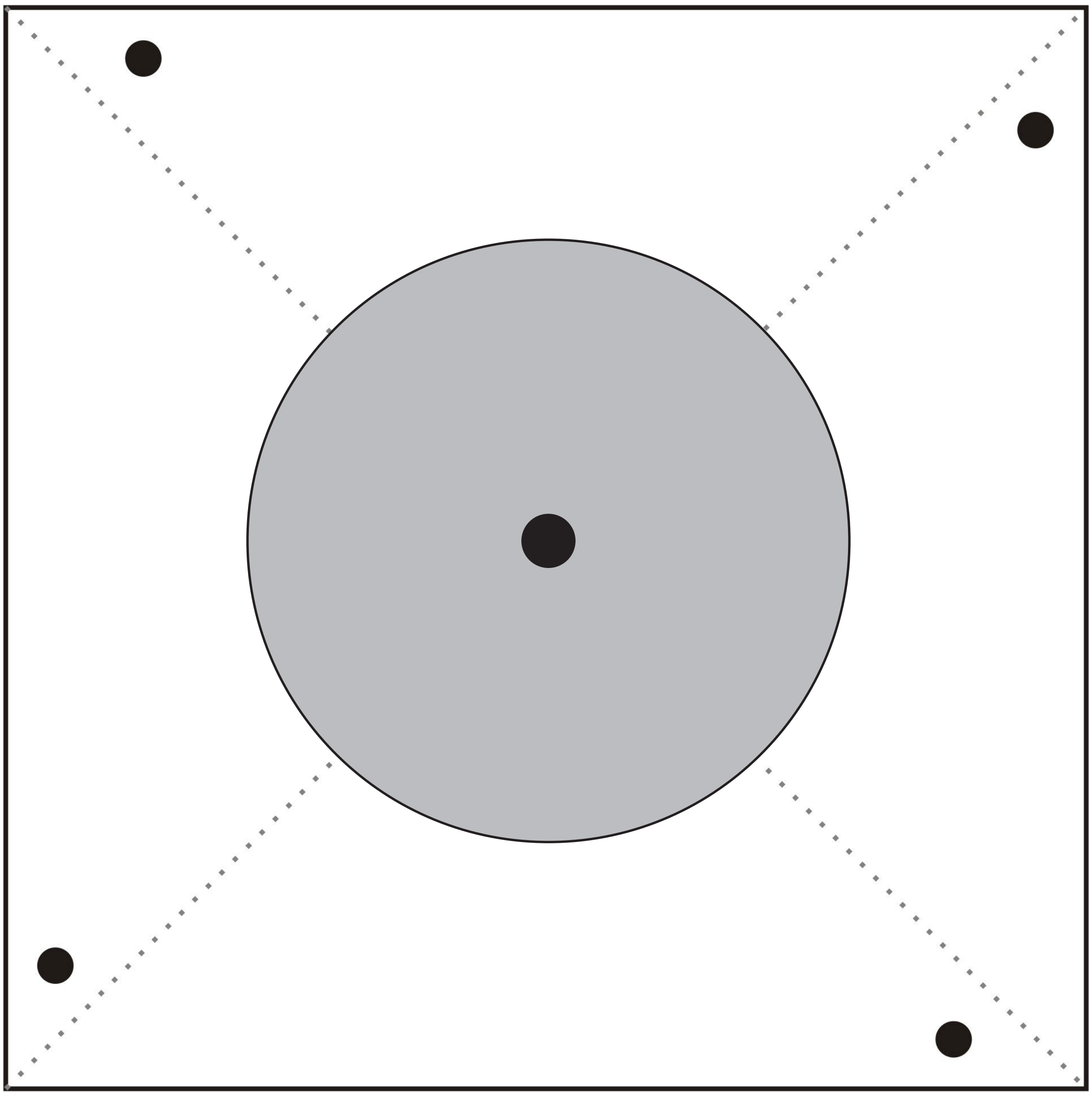
SOUND is the movement of energy through substances in longitudinal waves. Echoes and music are examples.

ELECTRICAL ENERGY is the movement of electrons. Lightning and electricity are examples.

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.



Genecon Activities

Teacher Demonstration: Generator vs. Motor

Activity used with permission from Adventures with the GENECON Hand Operated Generator, *by Gary W. Nahrstedt.*

✪ Objectives

- Students will be able to describe how a generator converts kinetic energy into electrical energy.
- Students will be able to describe how a motor converts electrical energy into kinetic energy.

Materials

- Genecon with output cord
- 1 Bulb (3.8V, 0.3A) in socket with alligator clips
- 1 Battery (any 1.5-volt AAA, AA, or D)
- 1 Turbine tower (see *Turbine Assembly Instructions* on pages 23-24 of the Teacher Guide)
- 1 Fan
- 2 Alligator clips
- Benchmark blades

✔ Procedure

PART ONE

1. Plug the output cord into the back of the Genecon. Connect the leads of the Genecon to one of the bulb sockets using the alligator clips provided in the kit.
2. Slowly turn the rotary handle of the Genecon with increasing force until the bulb lights. What do you notice about the bulb? How is it affected by the turning speed of the handle?
3. Rotate the handle in the opposite direction. What do you notice?
   Caution: excessively rotating the handle may burn out the bulb or strip the gears, damaging the unit.

PART TWO

1. Replace the light bulb with a dry cell battery, with the two alligator clips making contact with the opposite ends of the battery. Now what happens?

PART THREE

1. Attach alligator clips to the leads of the turbine. Then attach the clips to the leads of the Genecon.
2. Face the turbine blades into the fan and watch the Genecon as the turbine blades spin. What happens to the Genecon? Change the speed of the fan faster and slower. What do you notice?

Background Information: Why Does the Genecon Work?

In the first part of the demonstration, the Genecon acts as a generator. A generator is a device that converts kinetic energy into electrical energy. When the handle is turned, the bulb lights. You should notice that the bulb becomes brighter as the handle is turned more rapidly. In general, the brighter the bulb, the more voltage the Genecon is producing. The bulb will light when the handle turns in either direction, although the polarity is reversed (see Activity 17 in the Genecon PDF booklet listed on page 9 of this guide).

In the second part of the demonstration, the Genecon acts as a motor—a device that converts electrical energy into kinetic energy. The battery converts chemical energy into electrical energy to turn the handle (kinetic energy).

In the third part of the demonstration, the Genecon again acts as a motor. Electrical energy from the wall outlet powers the fan (kinetic energy). The wind (kinetic energy) is captured by the turbine blades and they spin (kinetic energy). The spinning motion generates electrical energy that flows through the leads from the turbine to the Genecon. This electrical energy provides the power to turn the handle (kinetic energy). Notice the speed of the turning handle corresponds to the speed of the power source—the spinning blades. A motor and a generator are essentially the same device—the direction of the electrical flow determines what the device is called. Motor: electrical energy in, kinetic energy out. Generator: kinetic energy in, electrical energy out.

☑ Assessment Questions

1. Lighting the bulb demonstrates a series of energy conversions. Describe as many as you can.
2. Write a paragraph describing how a motor works.

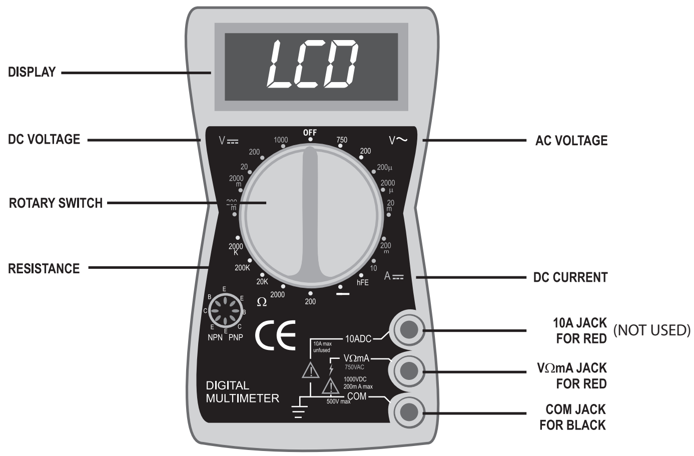
Measuring Electricity

Included in the kit are three tools to measure electricity—two multimeters and one voltmeter. The multimeter allows you to measure current, resistance, and voltage, and displays the reading numerically. The voltmeter measures voltage only, but displays a visual reading as higher electrical outputs illuminate more lights.

When using either meter 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 (megohm 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

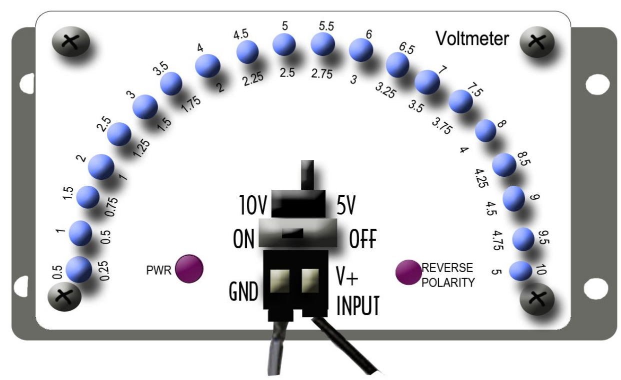
1. Connect RED lead to VΩmA jack and BLACK to COM.
2. Set ROTARY SWITCH to highest setting on DC VOLTAGE scale (1000).
3. Connect leads to the device to be tested using the alligator clips provided.
4. Adjust ROTARY SWITCH to lower settings until a satisfactory reading is obtained.
5. With the wind turbine,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

DC Current *(must include a load in the circuit)*

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.

Visual Voltmeter



Directions:

1. Switch the tab over to 5V.
2. Press down on the "GND" button. Insert one wire from the turbine into the hole on the bottom. Release the button to secure the wire in place.
3. Repeat step two with the other wire on the "V+ Input" side.
4. Turn on the voltmeter.
5. Place the turbine in front of the fan. The lights on the voltmeter will light indicating how much electricity is being generated.

Notes:

- *If the "Reverse Polarity" light flashes, switch the wires in the "GND" and "V+ Input" locations.*
- *The voltmeter's lowest reading is 0.25 volts. If you do not see any lights, connect the turbine to the multimeter for smaller readings.*

Basic Measurement Values in Electronics

SYMBOL	VALUE	METER	UNIT
V	Voltage (the force)	Voltmeter	Volt
I	Current (the flow)	Ammeter	Ampere
R	Resistance (the anti-flow)	Ohmmeter	Ohm

1 ampere = 1 coulomb/second

1 coulomb = 6.24 x 10^{18} electrons (about a triple axle dump truck full of sand where one grain of sand is one electron)

Prefixes for Units

- **Smaller**

  (m)illi x 1/1 000 or 0.001

  (μ) micro x 1/1 000 000 or 0.000 001

  (n)ano x 1/100 000 000 or 0.000 000 001

  (p)ico x 1/1 000 000 000 000 or 0.000 000 000 001

- **Bigger**

  (k)ilo x 1,000

  (M)ega x 1,000,000

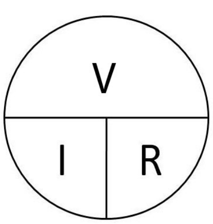
  (G)iga x 1,000,000,000

Formulas for Measuring Electricity

V = I x R

I = V/R

R = V/I



The formula pie works for any three variable equation. Put your finger on the variable you want to solve for and the operation you need is revealed.

- **Series Resistance (Resistance is additive)**

  $R_T = R_1 + R_2 + R_3 \ldots + R_n$

- **Parallel Resistance (Resistance is reciprocal)**

  $1/R_T = 1/R_1 + 1/R_2 + 1/R_3 \ldots + 1/R_n$

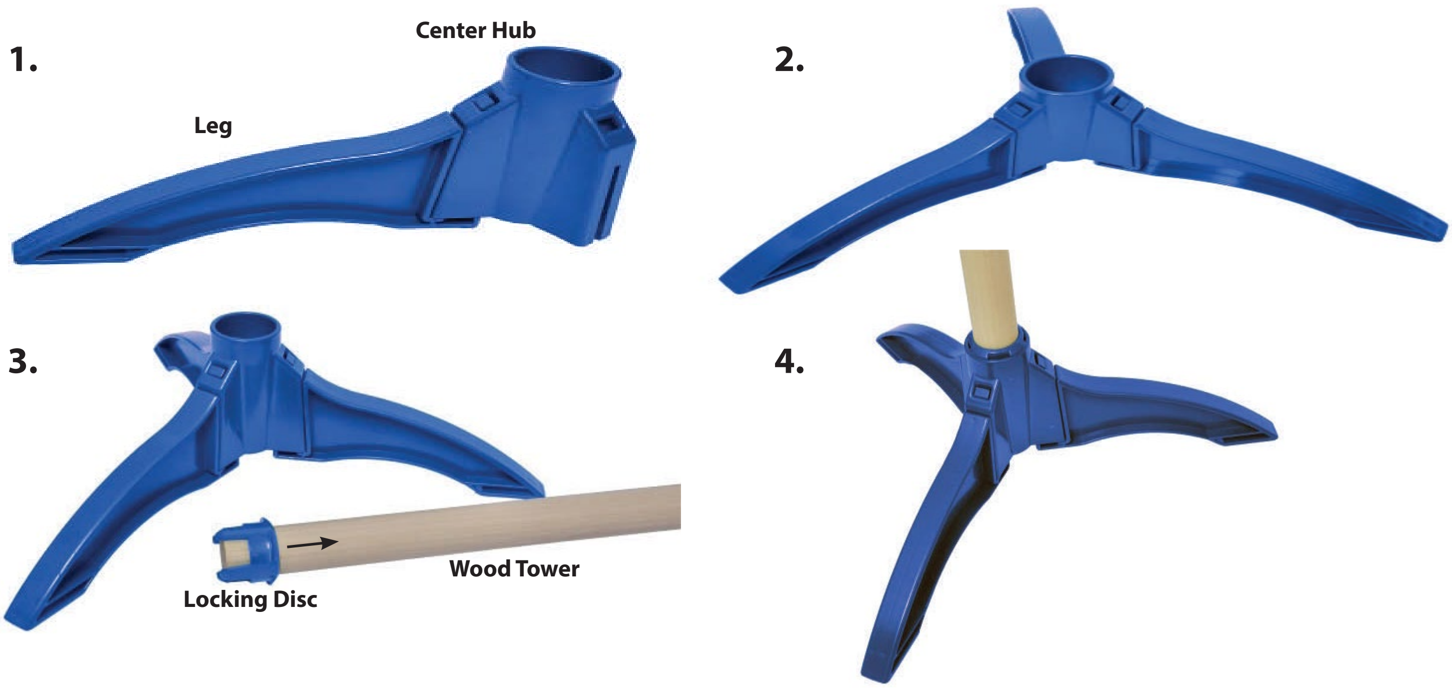
Note: ALWAYS convert the values you are working with to the "BASE unit." For example, don't plug kiloohms (kΩ) into the equation—convert the value to ohms first.

Turbine Assembly Instructions

You Will Need

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

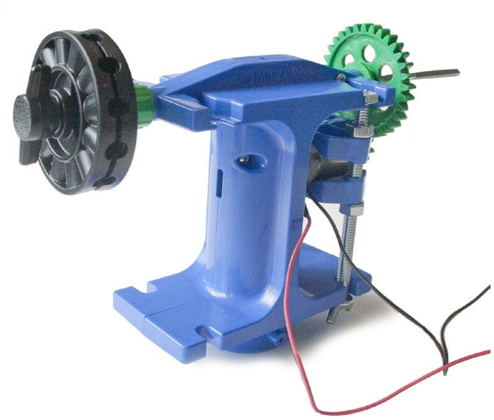
Tower Assembly



1. Lock one leg onto the center hub.
2. Attach the two other legs in the same way.
3. Slide the locking disc on to 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.

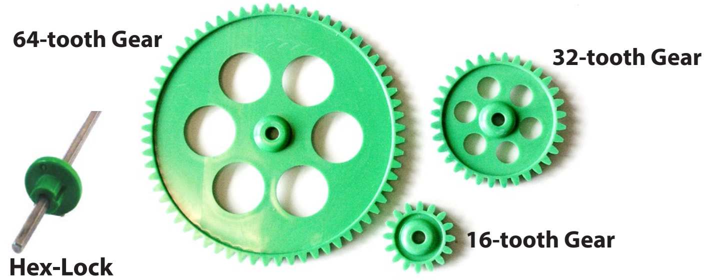
Turbine Nacelle

1. The turbine nacelle comes pre-assembled as part of the NEED wind kit. The hub, gears, and motor can be removed and rearranged, depending on the investigation See page 24 for directions on changing gears.

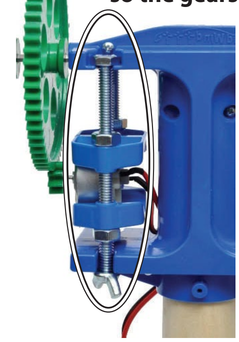

Turbine Nacelle

Turbine Gears and Motors

1. The 16-, 32-, or 64-tooth gear will lock into the small Hex-Lock. You can choose to mount the gear on either side of the nacelle, but we recommend mounting your gears on the side of the nacelle opposite from the hub. This makes it easier to interchange gears and manipulate your blade pitch.
2. You will now need to move your DC motor up or down so that the pinion gear (the smallest gear in a drive train) meshes with the gear on the hub.



NOTE: If you are using the largest gear size, you will notice that it will only fit with regular nuts under the motor mounts, as wing-nuts are too tall. If you are using the smallest gear size, you will have to use regular nuts above the motor mounts. Give the hub a spin to make sure that the gear turns and rotates the small pinion gear on the motor.

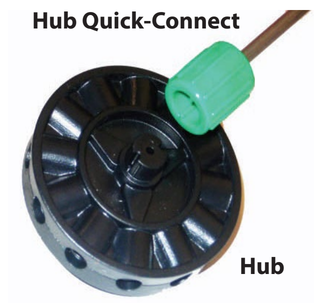


USING THE 16-TOOTH GEAR (SMALLEST RATIO)

- Since the 16-tooth gear is so small, it is challenging to get the generator high enough in the main body to mesh gears. In order to use this small ratio, you have to use the thinner generator. Remove the upper half of the motor mount and slide a small cardboard or folded paper shim in between the generator and the main body housing. You will have to adjust the width of this shim to get the gears to mesh perfectly. Tighten the nuts below the motor mount to secure the generator in place. If the gears do not mesh well, adjust your shim.

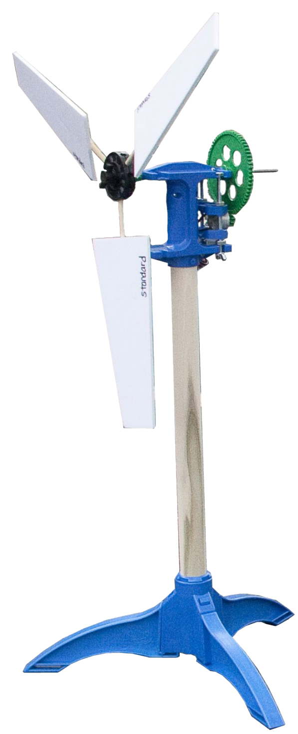
Adding the Hub and Blades

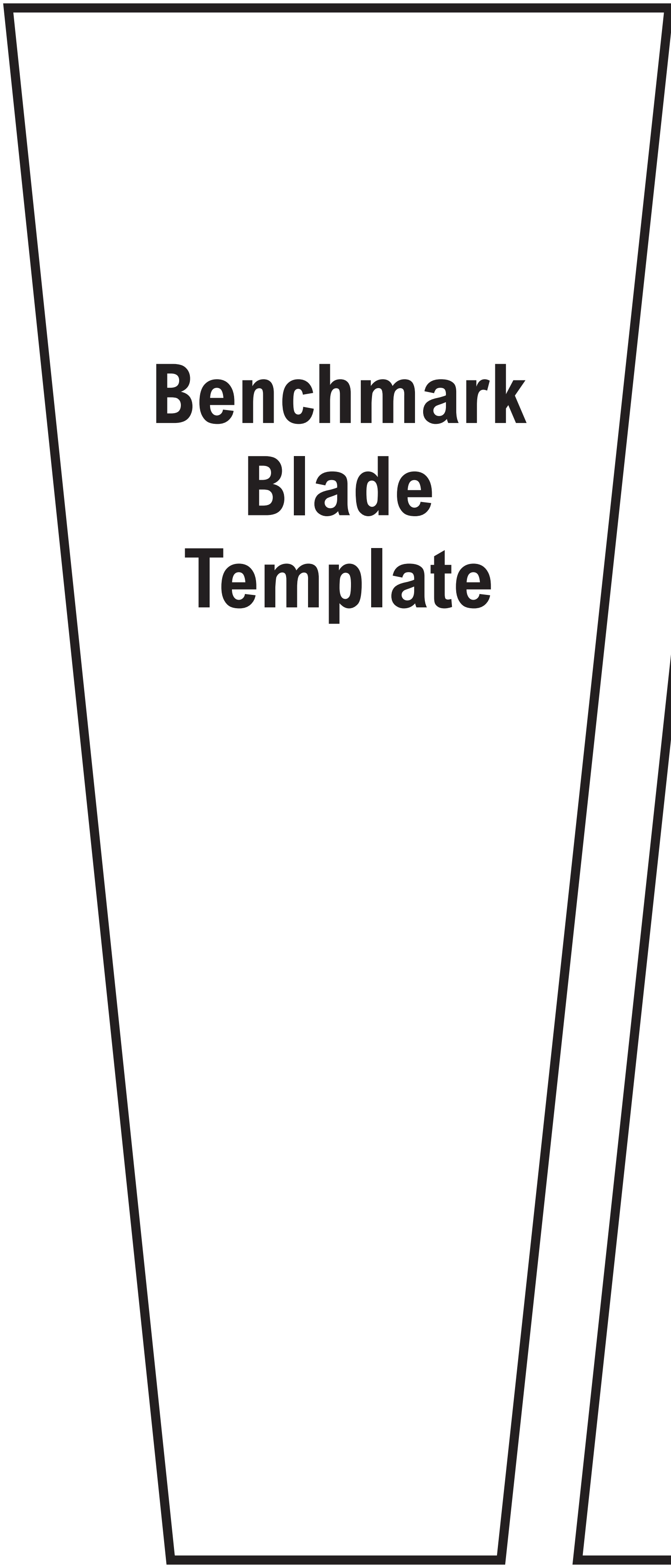
1. The HEX shaped driveshaft allows you to connect the Hex-Lock to the driveshaft. If you mount your gears or a weightlifting spool on the back of the nacelle, it will not slip on the driveshaft.
2. The Hex-Lock allows you to quickly interchange and lock gears in place on the driveshaft. Your gear will fit snugly onto this adapter. Slide the Hex-Lock and your gear up the driveshaft right behind the hub, as shown in the picture. Again, be sure to line up the main drive gear with the pinion attached to your DC motor.
3. The completed nacelle will slide right onto your 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.
4. 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.
5. Place the blades into the slots. Tighten the hub to hold the blades in place.

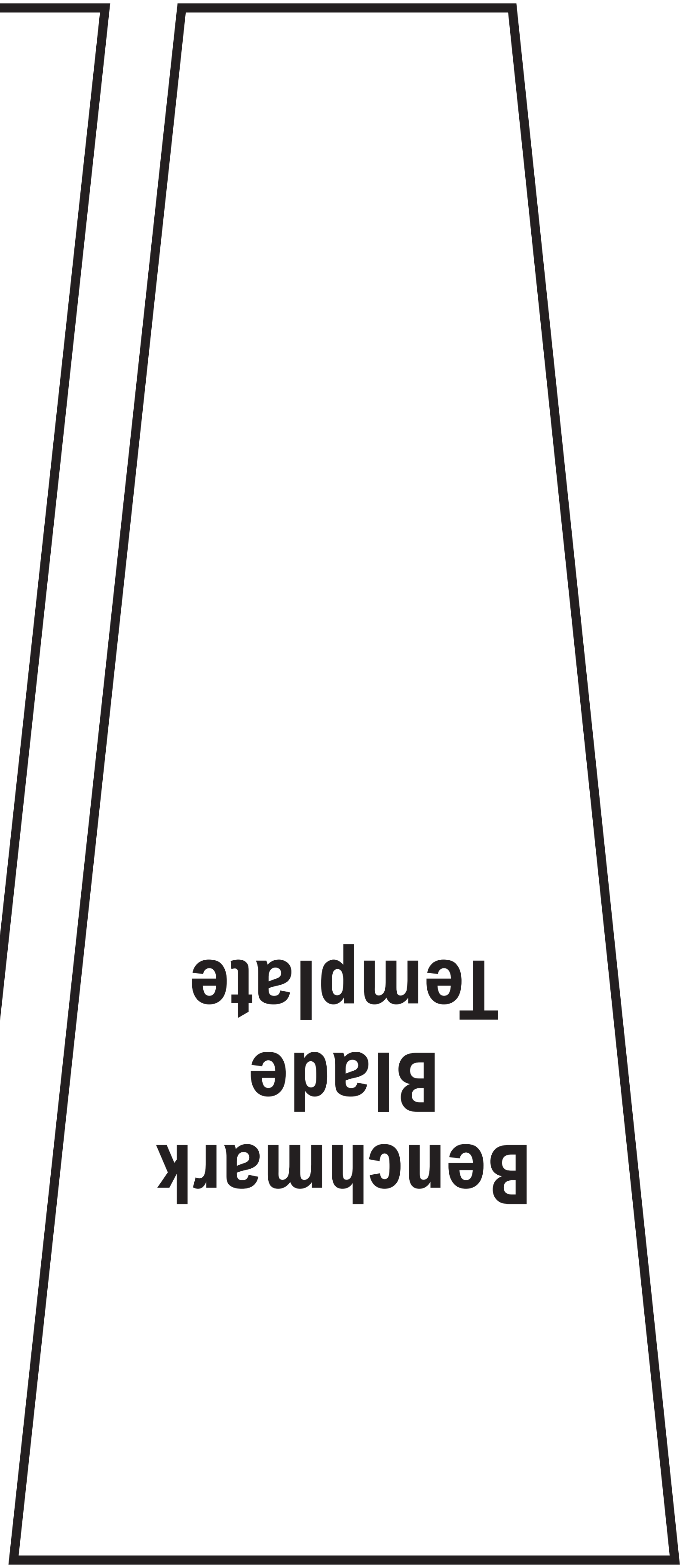


Video Assembly Instructions

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.




Benchmark
Blade
Template


Benchmark
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Template

Siting and Permitting a Wind Farm

ROLES AND KEY QUESTIONS

The Bureau of Land Management (BLM) has received a proposal from a developer to build a wind farm on public land in your community. You understand that developing renewable resources is a way to meet the growing electricity needs of your area, but you are curious about the impacts a wind farm might have on your community. You and other stakeholders have been invited to present your perspectives at a public forum. Based on your research, followed by your panel presentation, the community will vote on whether or not to support building the wind farm.

Governmental Agency Representative–BLM

The Bureau of Land Management is an agency in the Federal Government that is responsible for managing and conserving the resources that are on public land. The BLM has a policy of encouraging multiple uses of public lands. If a wind farm is built on the public land under your control, you will be responsible for overseeing and managing the project. The Federal Government would receive lease payments and/or royalties from the developer.

1. What are the advantages and disadvantages to the BLM of allowing the development of the wind farm?
2. What are the major issues that the BLM must consider before allowing the development of the wind farm?
3. One of the jobs of the BLM is to protect the public's interest in the land. Will allowing the development of the wind farm be in the best interest of the public?

Developer

As the developer of the wind farm project, you must create a plan that details the advantages of establishing a wind farm in your particular area. You must also be able to answer questions from those groups that might oppose the wind farm. It is important as the developer that you understand the "big picture" of the positive and negative impacts of developing the wind farm.

1. What are the economic and environmental benefits to the community of developing the wind farm?
2. What are the disadvantages? How will potential risks be minimized?
3. How will the environment be protected during the installation, operation, and maintenance of the wind farm?
4. How will the utility and its customers benefit from adding a wind farm?

Investor

An investor is someone who uses his or her money to finance a project, in order to make money later. A developer has approached you with a proposal to build a wind farm in a nearby community. As an investor, you are interested in paying money now to build a wind farm, with the idea that you will earn money later as the wind farm becomes productive. You need to determine the costs, risks, earning potential, and benefits of investing in the wind farm.

1. How much will it cost to build and maintain the wind farm? What costs do you need to consider?
2. How much return of income can you expect from your investment? Over how many years?
3. What are the biggest risks to investing in the wind farm?

Site Planner

The site planner of a wind farm considers many factors to determine the best location for a wind farm. You must take into consideration the important concerns that community members have. You need to determine the optimum areas for the turbines in regard to wind speed and weather. You must also take into consideration any other environmental factors that might affect the siting of the wind farm.

1. What information about local and global wind patterns and wind technology must you research before siting a wind farm?
2. What other weather information might be important besides wind speed?
3. What environmental factors must you consider before siting a wind farm?
4. What other factors must you consider? Are there roads and power lines nearby?

Farmer/Rancher

You are a farmer and rancher who leases the 10,000 acres of public land that you use to grow crops and graze your cattle. The Bureau of Land Management has informed you that it is considering a proposal to allow a wind farm to be built on part of the land. You think that using renewable energy and having multiple uses of the land are good ideas, but you are concerned about the impact of a wind farm on your crops and animals, as your lease is a long-term lease.

1. What impacts will siting, building, and operating a wind farm have on your crops and cattle?
2. Will you have to reduce the acres of crops you grow or the number of cattle that graze on the land?
3. Are there any financial benefits to you of building the wind farm on your leased land?

Consumer/Neighbor

You are a neighbor of the farmer/rancher on whose land the wind farm might be built. You have heard that large wind turbines generate a great deal of noise and that concerns you because the chinchillas you raise are very sensitive to noise. You are aware that there have been predictions of blackouts in the near future in your area because of a lack of electricity capacity. You are also wondering how the price of electricity in your area might be affected if a wind farm was installed.

1. How much noise do wind turbines generate? How much will shadows affect your land?
2. How would a wind farm affect the property values of the surrounding properties?
3. How would long-term local electricity rates be affected by the installation of a wind farm?

Environmentalist

You are very concerned with protecting the environment. You would like to know how wind energy impacts the environment during the manufacture, installation, maintenance, and removal of the wind turbines. Also, there have been reports in the past of wind turbines injuring birds and bats that fly into them. You would like to know how wind energy installations might affect birds and animals in your area. You are also concerned about pollution and climate change.

1. How would the manufacture and installation of wind turbines affect the local environment?
2. How would the operation of the wind turbines affect the surrounding environment and the plants and animals in the area?
3. Would the wind turbines produce pollution? Would they be better for air quality than other energy source facilities?
4. Would the amount of electricity generated by the wind turbines be enough to offset the "cost" to the environment?

Economist

An economist is a person who can analyze the financial impacts of actions. The community that will be affected by the development of the wind farm has consulted you. They have asked you to determine the costs of generating electricity from fossil fuels and wind energy and to do a comparison study. This includes comparing construction costs, transmission costs, generation costs, and potential tax credits available for using wind.

1. How does the cost of using wind to generate electricity compare to other sources?
2. What economic advantages/disadvantages would the wind farm bring to the area?
3. Will the wind farm impact the economy of the area by bringing more jobs to the area? How many jobs? Will the jobs be permanent and require training?

Utility Company Representative

You are an employee of the local utility company and are responsible for making sure that your utility has the necessary capacity to provide electricity to all of your customers. There is increased demand for electricity in your community and you know you must secure reliable sources of additional generation in the near future. You would be the main purchaser of electricity from the wind farm.

1. How expensive would the electricity be from the wind farm?
2. How predictable is the electricity generation from the wind farm?
3. How reliable is the wind farm equipment?
4. Will there be additional costs to the utility company that might be passed along to consumers?

Member of the County Commission

The County Commission manages the public services of the community and determines how they are paid for. The County Commission is a political group and must take into consideration all political sides of the issue (jobs, taxes, revenue, etc.). You must consider the impacts on the community if the BLM allows the wind farm to be developed in the area.

1. What impacts would the wind farm have on the need to provide local services?
2. What economic impacts would the wind farm have on the local community and taxes?
3. What political impact would supporting the wind farm have on your community?

Useful sites to visit when conducting research

American Wind Energy Association: www.awea.org

Energy Information Administration: www.eia.gov

Bureau of Land Management: www.blm.gov

U.S. Department of Energy - Wind: www.doe.gov/science-innovation/energy-sources/renewable-energy/wind

U.S. Department of Energy - Energy Efficiency: www.doe.gov/science-innovation/energy-efficiency

U.S. Department of Energy, Energy Efficiency and Renewable Energy, Wind Program: http://energy.gov/eere/wind/wind-energy-technologies-office

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

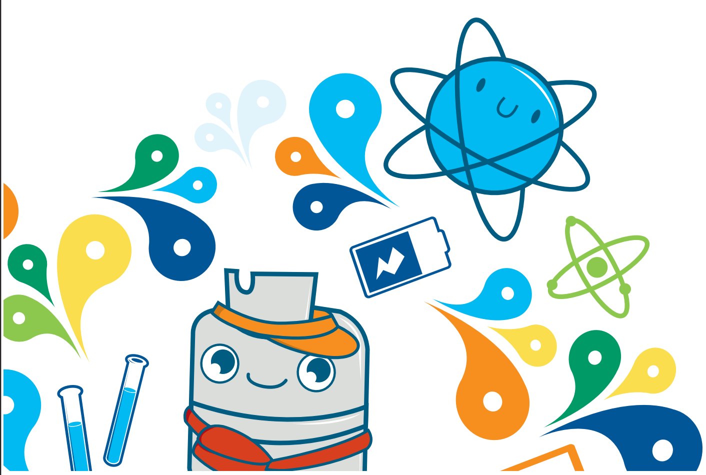
P. Knows what a gear box does

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

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?

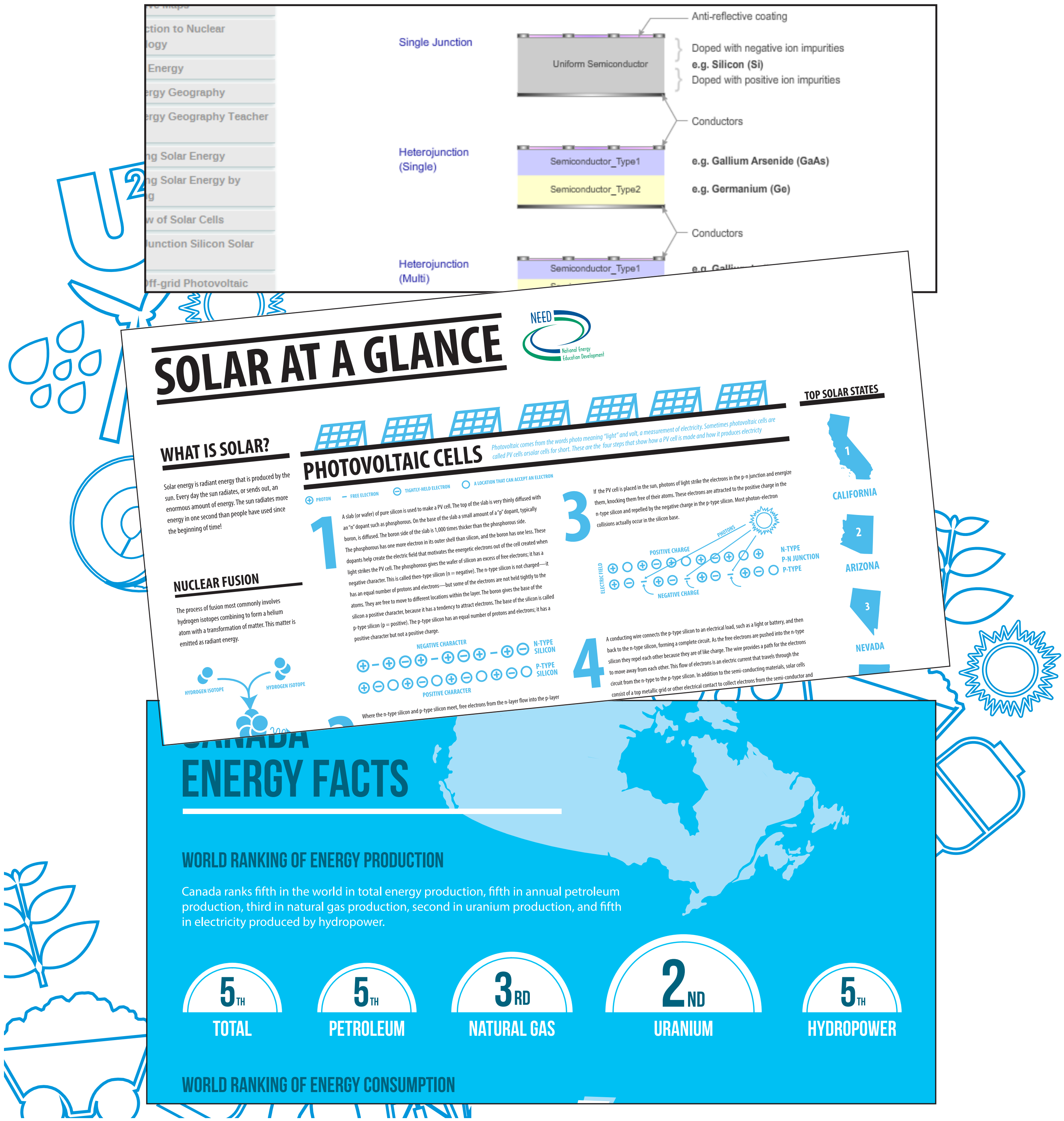
Students and teachers set goals and objectives and keep a record of their activities. Students create a digital project to submit for judging. In April, digital projects are uploaded to the online submission site.

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

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.



Energy From the 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?** *Please explain any "no" statements below*	❑ Yes	❑ No

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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NC Green Power
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Opterra Energy
Pacific Gas and Electric Company
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