Exploring Wind Energy
Teacher Guide

Hands-on, critical thinking activities that help secondary students to develop a comprehensive understanding of the scientific, economic, environmental, technological, and societal aspects of wind energy.

Grade Level:
[Sec] Secondary

Subject Areas:
- Science
- Social Studies
- Math
- Technology
- Language Arts

NEED
National Energy Education Development Project
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.

Teacher Advisory Board Statement

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

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Energy Data Used in NEED Materials

NEED believes in providing the most recently reported energy data available to our teachers and students. Most statistics and data are derived from the U.S. Energy Information Administration’s Annual Energy Review that is published yearly. Working in partnership with EIA, NEED includes easy to understand data in our curriculum materials. To do further research, visit the EIA website at www.eia.gov. EIA’s Energy Kids site has great lessons and activities for students at www.eia.gov/kids.
Exploring Wind Energy was developed by The NEED Project with funding from the American Wind Energy Association.

Exploring Wind Energy Kit
- 2 Alligator Clips
- 1 Anemometer
- 30 Binder clips
- 1 Compass
- 1 Genecon with booklet
- 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

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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.
## Exploring Wind Energy Materials

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<td><em>Large foam cups (approximately 14 cm tall)</em>&lt;br&gt;<em>Rulers</em>&lt;br&gt;<em>Hole punches</em>&lt;br&gt;<em>Markers</em>&lt;br&gt;<em>String or thread</em>&lt;br&gt;<em>Paper clips</em>&lt;br&gt;<em>Fan(s)</em>&lt;br&gt;<em>Scissors</em></td>
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<td><em>Poster board</em>&lt;br&gt;<em>Small light bulb (3.8V, 0.3A) in socket with leads</em>&lt;br&gt;<em>Battery (any 1.5-volt AAA, AA, or D)</em>&lt;br&gt;<em>Fan</em>&lt;br&gt;<em>Glue</em></td>
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*See pages 24-25 for turbine tower assembly instruction.*

Note: You can build your own turbine towers using PVC pipe. For directions, visit www.NEED.org.
Exploring Wind Energy 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.

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

Throughout this curriculum, science notebooks are referenced. If you currently use science notebooks or journals, you may have your students continue using these. A rubric to guide assessment of student notebooks can be found on page 16 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 worksheets 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. The rubric can also be used to evaluate student work in this format.

Activity 1: Introduction to Wind

Objective

Students practice making observations.

Procedure

1. If you wish, have students complete the Wind Energy Assessment (page 17 of the Teacher Guide) as a pre-test.
2. As an introductory activity or an alternative to the assessment, have students play Wind Energy Bingo. Instructions for the game are found on page 14-15, and student bingo sheets can be found on page 31.
3. Have students read Introduction to Wind on pages 2-6 in the Student Guide.
4. Take the class outside to make their own wind observations. In science notebooks, students should use objects in the environment to record visual cues in words and/or sketches.
5. Back inside the classroom, have students share their observations with each other and write a paragraph about their observations.
Activity 2: Measuring Wind Speed

**Objectives**

- Students will be able to measure wind direction and speed.
- Students will be able to explain wind speed's relation and importance when generating electricity from wind.

**Materials FOR EACH STUDENT OR PAIR**

- 5 Snow cone cups
- 1 Pencil
- 2 Extra-long straws
- 1 Straight pin
- Masking tape
- Hole punch
- Marker
- Watch with second hand or stopwatch
- Scissors
- Ruler
- *Build an Anemometer* worksheet, Student Guide page 22

**Materials FOR THE CLASS**

- Anemometer
- Wind gauge
- Wind vane
- Compass

**Preparation**

- Make copies of worksheets, as needed.
- Gather supplies for the activity, and assemble stations, if necessary.

**Procedure**

1. Students should review *Measuring Wind Direction and Speed* on page 6 in the Student Guide.
2. Students will build an anemometer using the directions on the *Build an Anemometer* worksheet.
3. Teach students how to use their anemometers and other wind measuring tools. Directions for the wind gauge can be found on page 18 of the Teacher Guide, project as necessary.
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. Students should record data and observations in their science notebooks.
5. Return to class and lead a discussion about class observations. Were there differences in wind speed around the school grounds? Why might that be? Were there any discrepancies in measured wind speed from different anemometers? Why might this be?

Activity 3: History of Wind Energy

**Objective**

- Students will be able to describe important events in the growth of wind energy use over time.

**Materials**

- *History of Harnessing the Wind's Energy* worksheet, Student Guide page 23

**Procedure**

1. Make copies of worksheets, as needed.

*CONTINUED ON NEXT PAGE*
CONTINUED FROM PAGE 7

3. Using the History of Harnessing the Wind’s Energy worksheet, students should choose five important events and analyze them.

4. Next, students should choose one event and write a more detailed paragraph about the event, what brought it about, and what impact it had.

Extension

- Students can work individually or in pairs to complete a more in-depth research report on a significant event.
- 1 Large foam cup approximately 14 cm tall
- 1 Extra-long straw*
- 1 Small straw
- 1 Binder clip

Activity 4: Wind Can Do Work

Objective

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

Materials FOR EACH STUDENT OR PAIR

- 1 Straight pin
- Ruler
- Hole punch
- Marker
- 50 cm String or thread
- Paper clips
- Masking tape
- Scissors
- Forms of Energy master, Teacher Guide page 19
- 4-Blade Windmill Template, Teacher Guide page 20
- Wind Can Do Work worksheet, Student Guide page 24

Materials FOR THE CLASS

- Fan(s)

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

Preparation

- Make copies of worksheets, as needed.
- Gather supplies for the activity, and assemble stations, if necessary.

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. Students should build windmills using the directions from the Wind Can Do Work worksheet.

4. Students should diagram their windmill assembly and trace the energy transformations that occur in this system in their science notebooks.

5. Encourage students to investigate the question, “What is the maximum load 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. Students can also think of their own question and design their own investigation based on the system.
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 set-up (see Preparation below)
- Genecon and booklet

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)
- 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 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 of the turbine set-up process can also be viewed by visiting https://vimeo.com/11469134 or by visiting www.vernier.com.
- Utilizing poster board, dowels, hubs, glue, and tape, create your own set of benchmark blades using the blade template.
- Familiarize yourself with the Genecon.
- Make copies of worksheets, as needed.

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 21 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. Demonstrate this by showing them your blades and the turbine. It is recommended that all of the students make blades out of poster board prior to experimenting with the blade materials in the Designing Optimum Blades investigation.

Extension

- For additional Genecon activities, please refer to your Genecon booklet.
Activity 6: Wind Blade Investigations

🎯 Objective

- Students will be able to identify the blade variables that impact the electrical output of a wind turbine.

🔍 Materials FOR INVESTIGATIONS

- Dowels
- Visual voltmeter
- Hubs
- Blade pitch protractor
- Sandpaper
- 2 Turbine tower set-ups (see Preparation below)
- Masking tape
- Multimeters
- Scissors
- Fan(s)
- Pennies or other masses
- Rulers
- Poster board
- Benchmark Blade Template, Teacher Guide page 26
- Blade investigations worksheets, Student Guide pages 28-31

🔍 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 24-25 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.
- Gather remaining materials and set up blade investigation stations.
- Make copies of worksheets, as needed.

✔ Procedure

1. Students should read Harnessing the Wind’s Energy on pages 12-13 and 18-19 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 22-23 in the Teacher Guide and pages 26-27 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 it is suggested that they be done in order in a gradual release model.
   - Blade Investigation #1 – Exploring Blade Pitch, Student Guide page 28
   - Blade Investigation #2 – Exploring Number of Blades, Student Guide page 29
   - Blade Investigation #3 – Exploring Surface Area, Student Guide page 30
   - Blade Investigation #4 – Exploring Mass, Student Guide page 31

**WIND TURBINE MANAGEMENT TIP:** NEED’s Exploring Wind Energy 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 investigation, 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.
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

- 1 Turbine tower set-up (assembled)
- Hub
- Dowels
- Airfoil blades
- Glue
- Masking tape
- Blade pitch protractor
- Multimeter
- Fan
- Blade Aerodynamics Graphic Organizer (optional), 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 24–25 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.
- Make copies of the worksheets, as needed.

Procedure

1. Have students read the insert on blade aerodynamics, found on pages 14-17 of the Student Guide.
2. Students should take notes as they read.
3. Place the benchmark blades into the hub and attach the hub to the tower.
4. Demonstrate how the blades are shaped, and experiment with the different variables that students may have experimented with in their wind blade investigations (pitch, number, surface area, and mass), as time allows.
5. Students should record observations and plan their optimal blade design in their small groups from the previous investigations.

NOTE: The graphic organizer is optional in steps 1 and 2 above. The reading can also be completed as a homework assignment or as a jigsaw activity within small groups.
Activity 8: Blade Design Challenge

Objectives

- Students will collaborate and create optimized wind turbine blades that generate the most electricity.
- Students will be able to identify variables that can affect the efficiency of a wind turbine.

Materials

- Dowels
- Flat balsa sheets
- Corrugated plastic sheets
- Extra alternative blade materials
- Hubs
- Glue
- Masking tape
- Multimeters
- Scissors
- Fans
- Rulers
- Stopwatches or watches with second hand
- Assembled turbine towers (with unused gears)
- Visual voltmeter
- Blade pitch protractor
- Sandpaper
- Designing Optimum Blades worksheet, Student Guide page 34
- Investigating Gear Ratios worksheet, Student Guide page 35

Preparation

- Assemble the turbine towers, if you have not done so already, using the Turbine Assembly Instructions on pages 24–25 of the Teacher Guide.
- Make copies of the worksheets, as needed.
- BLADE MATERIALS—The benchmark blades from previous activities were recommended to be made from poster board. Balsa and corrugated plastic sheets have been included in your kit, but anything can be used as blade material. You may want to gather your own materials, or have students bring in different materials for this investigation.

Procedure

1. Students should work in small groups from earlier investigations to compile data they recorded about different variables, and plan for designing the optimum blades. Students will follow the guidance of the Designing Optimum Blades worksheet to complete the activity.

2. Each group should have their own hub and any materials they would like to use to construct and build blades.

3. Decide on a time-frame for students to complete planning, testing, analysis, and redesigning phases, implementing checks on their work, as needed. Choose a time for final blade designs to be submitted.

4. Compare group designs as a class. Discuss what features and variables each group utilized and optimized to create their design. Discuss as a class what the most successful blade designs should incorporate.

5. Have students complete the Investigating Gear Ratios activity to examine how efficiency can also be tied to the construction of the tower. Discuss student observations.

NOTE: This activity may be framed as a competition or challenge between groups, with a reward. You may also choose to conduct the gear ratios activity as a demonstration with the winning design, or allow individual groups to experiment with gear ratios.

WIND TURBINE MANAGEMENT TIP: NEED’s Exploring Wind Energy 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 designs. 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 36 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 9: Siting a Wind Farm

Objective

• Students will be able to identify essential factors and challenges to be considered when siting a wind farm.

Materials

• Siting a Wind Farm activity, Teacher Guide pages 28-30
• Roll Group worksheet, Student Guide page 37

Procedure

1. Make copies of worksheets, as needed.
2. Assign students different roles to investigate their perspective. Decide how much time students will have for research and presentation.
   Be sure to investigate the web resources provided on page 30 of the Teacher Guide prior to the activity to best guide your students to relevant and appropriate information.
3. Students should research their roles, answer the questions, and assess the positives and negatives of the proposal based on their assigned roles.
4. Students will present their perspective to the class 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.

Assessment

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 17
• Copies of Wind Energy Bingo for each student, Teacher Guide page 31

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.
2. Discuss answers as needed.
3. Assess students responses and work using the rubrics on page 16.
4. Play Wind Energy Bingo with students as a formative assessment or vocabulary review. Instructions for this game are found on pages 14-15.
5. Evaluate the unit using the Evaluation Form on page 35 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 in younger grades. 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 Rock Performances
Get Ready
Duplicate as many Wind Energy Bingo sheets (found on page 31) 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**

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

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**ANSWERS**

A. Sailboat  
B. $0.12 national average for residential customers  
C. Biomass  
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

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## 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.

<table>
<thead>
<tr>
<th>SCIENTIFIC CONCEPTS</th>
<th>SCIENTIFIC INQUIRY</th>
<th>DATA/OBSERVATIONS</th>
<th>CONCLUSIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Written explanations illustrate accurate and thorough understanding of scientific concepts.</td>
<td>The student independently conducts investigations and designs and carries out his or her own investigations.</td>
<td>Comprehensive data is collected and thorough observations are made. Diagrams, charts, tables, and graphs are used and labeled appropriately. Data and observations are presented clearly and neatly with appropriate labels.</td>
<td>The student clearly communicates what was learned and uses strong evidence to support reasoning. The conclusion includes application to real life situations.</td>
</tr>
<tr>
<td>3 Written explanations illustrate an accurate understanding of most scientific concepts.</td>
<td>The student follows procedures accurately to conduct given investigations, begins to design his or her own investigations.</td>
<td>Necessary data is collected. Observations are recorded. Diagrams, charts, tables, and graphs are used appropriately most of the time. Data is presented clearly, and neatly.</td>
<td>The student communicates what was learned and uses some evidence to support reasoning.</td>
</tr>
<tr>
<td>2 Written explanations illustrate a limited understanding of scientific concepts.</td>
<td>The student may not conduct an investigation completely, parts of the inquiry process are missing.</td>
<td>Some data is collected. The student may lean more heavily on observations. Diagrams, charts, tables, and graphs may be used inappropriately, have some missing information, or are labeled without 100% accuracy.</td>
<td>The student communicates what was learned but is missing evidence to support reasoning.</td>
</tr>
<tr>
<td>1 Written explanations illustrate an inaccurate understanding of scientific concepts.</td>
<td>The student needs significant support to conduct an investigation.</td>
<td>Data and/or observations are missing or inaccurate.</td>
<td>The conclusion is missing or inaccurate.</td>
</tr>
</tbody>
</table>

## Culminating Project Rubric

This rubric may be used with the *Siting a Wind Farm* activity starting on page 28 of the Teacher Guide, or for any other group work you ask the students to complete.

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

**NUCLEAR ENERGY** is the energy stored in the nucleus 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 sides (being careful to not rip the edges) and the one 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 leads
• 1 Battery (any 1.5-volt AAA, AA, or D)
• 1 Turbine tower (see Turbine Assembly Instructions on pages 24-25 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 leads 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 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 tower. 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 booklet).

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.

<num> 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.
3. Compare and contrast motors and generators.
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).*

**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.

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.
## Basic Measurement Values in Electronics

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>VALUE</th>
<th>METER</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>Voltage (the force)</td>
<td>Voltmeter</td>
<td>volt</td>
</tr>
<tr>
<td>I</td>
<td>Current (the flow)</td>
<td>Ammeter</td>
<td>ampere</td>
</tr>
<tr>
<td>R</td>
<td>Resistance (the anti-flow)</td>
<td>Ohmmeter</td>
<td>Ohm</td>
</tr>
</tbody>
</table>

1 ampere = 1 coulomb/second

1 coulomb = $6.24 \times 10^{18}$ 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

- $V = I \times R$
- $I = \frac{V}{R}$
- $R = \frac{V}{I}$

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)**
  - $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots + \frac{1}{R_n}$

*Note: Always convert the values you are working with to the “BASE unit.” For example, don’t plug kilohms (kΩ) into the equation—convert the value to ohms first.*
### 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

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 25 for directions on changing gears.
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 Blade Template

Benchmark Blade Template
Calculating Wind Power

Question
How do you calculate wind power?

Materials
- Fan
- Wind gauge
- Turbine with benchmark blades
- Meter stick

Formula
Power = \( \frac{1}{2} \rho A V^3 \)
where \( \rho = \) air density (\( \rho = 1.2 \text{ kg/m}^3 \) at standard ambient temperature and pressure); \( A = \) swept area (\( A = \pi r^2 \); \( \pi = 3.1416 \)); \( V = \) velocity

Watts = \( \frac{1}{2} (\text{kg/m}^3) \times (\text{m}^2) \times (\text{m/s})^3 \)

Procedure
1. Measure the radius of the turbine blade assembly and calculate the area swept by the blades.
   \( A = \pi r^2 \)

2. Use the wind gauge to measure the wind velocity at a distance of 1 meter from the fan on low and high speeds. Convert the measurements from miles per hour to meters per second (m/s).
   \( 1 \text{ mile} = 1609.344 \text{ meters} \)
   Wind Velocity at Low Speed - 1 meter: _______ mph = _______ m/s
   Wind Velocity at High Speed - 1 meter: _______ mph = _______ m/s

3. Use the formula above to calculate the power of the wind in watts at both fan speeds.
   Wind Power at Low Speed - 1 meter: _______ W
   Wind Power at High Speed - 1 meter: _______ W

4. Vary the distance from the fan and calculate the power on low and high speeds.
   Wind Power at _______ m (distance A) on Low Speed: _______ W
   Wind Power at _______ m (distance A) on High Speed: _______ W
   Wind Power at _______ m (distance B) on Low Speed: _______ W
   Wind Power at _______ m (distance B) on High Speed: _______ W

Conclusion
1. Compare the power at different distances from the fan and on different fan speeds.
2. Explain the relationships between the different variables and the power produced.
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 concerned about the impact 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 long-term 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?

**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 local weather patterns. 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 weather patterns and wind technology must you research before siting a wind farm?
2. What environmental factors must you consider before siting a wind farm?
3. What other factors must you consider? Are there roads and power lines nearby?

Farmer/Rancher
You are a farmer and rancher who has a long-term lease of 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.
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 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?
2. How would a wind farm affect the property values of the surrounding properties?
3. How would 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.
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 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?

**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. Will the wind farm produce enough electricity with reliability to meet the growing needs of the community?
3. 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. You must consider the impacts on the community if the Bureau of Land Management 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 Websites 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
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
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:

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.

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.

SUPPLEMENTAL MATERIALS
Looking for more resources? Our supplemental materials 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

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 will have a link next to the relevant guide title on NEED’s curriculum resources page, www.NEED.org/curriculum.

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/maps to see energy production, consumption, and reserves all over the country!
Looking For More Resources?

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

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

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 should be 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.
Exploring Wind Energy 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
American Electric Power
Arizona Public Service
Arizona Science Center
Armstrong Energy Corporation
Association of Desk & Derrick Clubs
Audubon Society of Western Pennsylvania
Barnstable County, Massachusetts
Robert L. Bayless, Producer, LLC
BP America Inc.
Blue Grass Energy
Boulder Valley School District
Brady Trane
California State University
Cape Light Compact–Massachusetts
Chevron
Chugach Electric Association, Inc.
Colegio Rochester
Columbia Gas of Massachusetts
ComEd
ConEdison Solutions
ConocoPhillips
Constellation
Cuesta College
Daniel Math and Science Center
David Petroleum Corporation
Desk and Derrick of Roswell, NM
Dominion
DonorsChoose
Duke Energy
East Kentucky Power
Eastern Kentucky University
Elba Liquification Company
El Paso Corporation
E.M.G. Oil Properties
Encana
Encana Cares Foundation
Energy Education for Michigan
Energy Training Solutions
Eversource
Exelon Foundation
First Roswell Company
FJ Management, Inc.
Foundation for Environmental Education
FPL
The Franklin Institute
Frontier Associates
Government of Thailand–Energy Ministry
Green Power EMC
Gulf Power
Gerald Harrington, Geologist
Granite Education Foundation
Harvard Petroleum
Hawaii Energy
Houston Museum of Natural Science
Idaho Power
Idaho National Laboratory
Illinois Clean Energy Community Foundation
Independent Petroleum Association of America
Independent Petroleum Association of New Mexico
Indiana Michigan Power – An AEP Company
Interstate Renewable Energy Council
James Madison University
Kentucky Clean Fuels Coalition
Kentucky Department of Education
Kentucky Department of Energy Development and Independence
Kentucky Power – An AEP Company
Kentucky River Properties LLC
Kentucky Utilities Company
Kinder Morgan
Leidos
Linn County Rural Electric Cooperative
Llano Land and Exploration
Louisiana State University Cooperative Extension
Louisville Gas and Electric Company
Maine Energy Education Project
Massachusetts Division of Energy Resources
Michigan Oil and Gas Producers Education Foundation
Miller Energy
Mississippi Development Authority–Energy Division
Mojave Environmental Education Consortium
Mojave Unified School District
Montana Energy Education Council
NASA
National Association of State Energy Officials
National Fuel
National Grid
National Hydropower Association
National Ocean Industries Association
National Renewable Energy Laboratory
Nebraska Public Power District
New Mexico Oil Corporation
New Mexico Landman’s Association
Nicor Gas – An AGL Resources Company
Northern Rivers Family Services
North Shore Gas
NRG Energy, Inc.
Offshore Energy Center
Offshore Technology Conference
Ohio Energy Project
Opterra Energy
Oxnard School District
Pacific Gas and Electric Company
Paxton Resources
PECO
Pecos Valley Energy Committee
Peoples Gas
Petroleum Equipment and Services Association
Phillips 66
PNM
Providence Public Schools
Read & Stevens, Inc.
Renewable Energy Alaska Project
Rhode Island Office of Energy Resources
River Parishes Community College
RiverQuest
Robert Armstrong
Roswell Geologic Society
Salt River Project
Sandia National Laboratory
Saudi Aramco
Science Museum of Virginia
C.T. Seaver Trust
Shell
Shell Chemicals
Society of Petroleum Engineers
Society of Petroleum Engineers – Middle East, North Africa and South Asia
David Sorenson
Southern Company
Space Sciences Laboratory of the University of California Berkeley
Tennessee Department of Economic and Community Development–Energy Division
Tioga Energy
Toyota
Tri-State Generation and Transmission
TXU Energy
United States Energy Association
University of Georgia
United Way of Greater Philadelphia and Southern New Jersey
University of Nevada–Las Vegas, NV
University of North Carolina
University of Tennessee
University of Texas - Austin
University of Texas - Tyler
U.S. Department of Energy
U.S. Department of Energy–Wind for Schools
U.S. Department of the Interior–Bureau of Land Management
U.S. Energy Information Administration
West Bay Exploration
West Virginia State University
Yates Petroleum Corporation