

Wind Wisdom for School Power...Naturally

Elementary
K-4



This educational unit was developed by the Northeast Sustainable Energy Association (NESEA) for the New York State Energy Research and Development Authority (NYSERDA) to benefit educators and students in New York State and is part of NYSEERDA's School Power...NaturallySM program.

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The Northeast Sustainable Energy Association (NESEA) is a non-profit organization that seeks to motivate people to learn about, ask for and adopt sustainable energy processes and sources. NESEA connects ideas about whole systems thinking and integrated design to people who can help assimilate these ideas into the economy and the culture. The K-12 Education Department offers professional development opportunities, curriculum, and resources for teachers and non-formal educators on energy efficiency, energy conservation, and the science and applications of renewable energy.

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Wind Wisdom for School Power...NaturallySM

Unit Outline

Description

Wind is a renewable resource. Wind is here flowing around the planet, and it is free. Wind turbines harness the energy of the wind and generate power for human consumption. There is no smog, no chemical reaction, and no chemical pollution. There is small-scale wind, a turbine for a home or a small community; and there is large-scale wind, many turbines to add power to a region's electrical power grid. Engineers design turbines according to location and needs. Nowadays, siting wind turbines is quite a delicate process as we are more aware of our impacts on the ecosystems in which we reside. Wildlife flyways are taken into account as are viewsapes and noise issues. In order for humans to turn on a light, there will be impacts from the energy required. We need to carefully consider what these impacts are, who is affected, and how to best meet our needs while sharing this one precious world with all its other inhabitants.

Enrichment Program

Wind Wisdom for School Power...NaturallySM is intended to enrich existing scholastic programming. It is for teachers, non-formal educators, community mentors, and home-schooling parents who may not be completely familiar with concepts in wind energy and would like to learn along with their children. This curriculum is designed for and can be used as a certificate program for students, families, youth groups, and teachers interested in gaining a deeper understanding of the science, issues, and opportunities of wind energy as a renewable energy source. *Wind Wisdom for School Power...NaturallySM* can be downloaded from the New York State Energy and Research Development Authority (NYSERDA) and the Northeast Sustainable Energy (NESEA) websites. For more information go to either www.SchoolPowerNaturally.org or www.nesea.org/k12/solarsailsnewyork

Grade level

The unit is appropriate for the elementary level, kindergarten through fourth grade.

Rationale & Objectives

Wind Wisdom for School Power...NaturallySM offers an introduction to the technology involved in clean, renewable wind energy and makes a great starting point for in-depth studies in several related areas. It provides a context for teaching scientific principles related to energy transformations, chemical transformations, electricity, and light, which are central to many clean energy technologies. *Wind Wisdom for School Power...NaturallySM* also provides a natural segue to environmental, ecological, social, and human health studies in a variety of topics such as climate change, ecological foot-printing, and carbon foot-printing.

Goals of Unit

After completing the activities in this unit, students have a deeper understanding of how electricity is created from wind energy and the applications of this renewable energy source.

Activities

There are four basic steps in the structure of *Wind Wisdom for School Power...Naturally*SM:

1. **Learn:** Introductory activities that develop general background knowledge on wind, its definition, tools of measuring wind, and wind as a renewable energy source.
2. **Explore:** Field study opportunity that provides a context and concrete experience to help gain a basic understanding of wind energy.
3. **Integrate:** Follow-up activities that provide substantive exploration to develop a deeper understanding of wind turbine design and siting.
4. **Act:** Students share their learning experiences and explain the concepts they learned.

Glossary: Words that may be unfamiliar will be in bold the first time they are introduced in the unit. The definitions of these words are located in the glossary at the end of the unit.

Certificates of Completion

Students who complete all four steps—Learn, Explore, Integrate, Act—are eligible to receive a *Wind Wisdom for School Power...Naturally*SM award certificate from the teacher or mentor working with them on this unit. A copy of the certificate is available in this unit. A color copy Certificate is free and downloadable at www.nesea.org. Follow the links to the Solar Sail New York program. There is also a “Clean Green Power Champion” patch available through NESEA at \$5 per patch, while supplies last. An image of the patch is on the certificate.

New York State Curriculum Standards and Core Curriculum

An explicit list of State Standards and core curriculum with corresponding performance indicators are addressed in each lesson. This unit meets specific performance indicators in New York State Mathematics/Science/Technology Standards:

Standard 1: Analysis, Inquiry and Design

Standard 4: Science

Standard 5: Technology Education

Standard 6: Interconnectedness

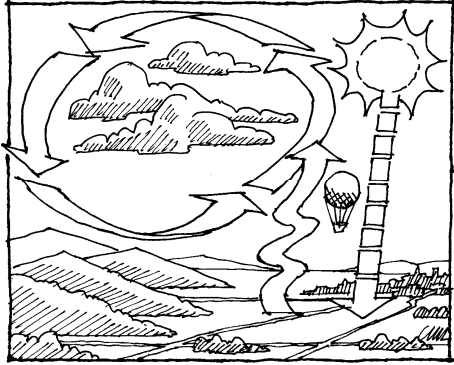
Standard 7: Interdisciplinary Problem Solving

Assessment

Model assessment activities are available at the end of the “Learn” and “Integrate” sections. Teachers are welcome to use the assessment tools as they are or as templates to create more grade appropriate assessment tools that are specific to what the class covered during the lessons.

CHAPTER 1: LEARN

Lesson 1 What Is Wind?



BACKGROUND: The Earth's **atmosphere** is made of air, which is composed of different gases. The sun shines on the Earth's atmosphere and heats its surfaces. As we know the Earth is not flat; it is a sphere, and so the sun does not reach all surface areas evenly or at the same time. As air heats it rises; the **molecules** in the air spread out because the air is light. Cooler air falls; its particles are denser and so the air is heavier. As the warm air rises, the cooler air fills in the space. This process of warming and cooling air placement is called **convection**, and this is what causes the air to move. This is wind.

LEARNING OUTCOME: Students state the definition of wind (knowledge level). Students explain the cause of moving air/wind. (comprehension level).

GRADE LEVEL APPROPRIATENESS: K-4

LINKS TO MST LEARNING STANDARDS AND CORE CURRICULA:

Standard 1: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

Scientific Inquiry:

Key Idea 1: The central purpose is to develop explanations of natural phenomena in a continuing creative process.

S1.1 Ask "why" questions in attempts to seek greater understanding concerning objects and events they have observed and heard about.

Standard 4 – Science: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Physical Setting (elementary)

Key Idea 4: Energy exists in many forms, and when these forms change, energy is conserved.

4.2 Observe the way one form of energy can be transformed into another form of energy present in common situations (e.g. mechanical to heat, mechanical to electrical, chemical to heat)

4.2 a Everyday events involve one form of energy being changed to another.

- The Sun's energy warms the air and water.

MATERIALS:

Part	Options to obtain it
Balloon, one for demonstration or enough to give each child one	Grocery store
Long flowy strips of a light weight fabric, 1 per student OR Long strips of surveyor’s tape	Used clothing/fabric store, linen closet Hardware store
Hair blow dryer, 1 OR A portable canned heating fuel such as Sterno, 1 container & a lighter OR A tea light set in a candle holder or 8oz can & a lighter	Home bathroom, pharmacy Grocery store, camping goods supply store Grocery store
Thin, light weight clear plastic bag that fits the size of a small waste basket, 1-3 OR A model hot air balloon	Grocery store Kits and models available through several online science stores.

SAFETY: Plastic bags melt with heat. If choosing to demonstrate with an open heat source, be mindful of the bag and your clothing so as not to catch on fire. When using an open flame it is always sensible to have a fire extinguisher on hand.

TEACHING THE LESSON: INSTRUCTIONS

1. Air is there: “As we look around we may not see the air, but it is there. How can we tell it is there? One way we can know that the air is there is that it takes up space.” Demonstrate by expanding your arms out as if you were holding an expanding balloon. This next part can be done as a teacher demonstration or a quick activity with students. Blow up a balloon. “What did I use to blow up this balloon?” Elicit responses. “I used my breath, the air in my lungs to blow up the balloon. The balloon now has air in it. How do we know it has something in it? Because when I release the tab, the air comes out and the balloon deflates.” Demonstrate. Then blow the balloon back up. “Again, air fills the balloon. So even if we cannot see it, air is there.” Release the air from the balloon or tie the end and leave the balloon full.
2. What is wind?: Can be taught inside but if not raining, go outside and stand in a circle. “How can you tell the wind is blowing?” Elicit responses. “The Earth has an atmosphere; think of it as a thin blanket around the Earth. The Earth’s atmosphere, this blanket, is made of air that includes different gases, such as oxygen. The sun shines on the Earth’s atmosphere and heats its surfaces and the air. Since the Earth is a sphere, like a ball, the sun does not reach all surface areas evenly or at the same time. When air heats it rises. The molecules in the air spread out. Cooler air falls. The molecules in cooler air are denser, and the air is heavier. As the warm air rises, the

cooler air fills in the space. This process of warming and cooling air placement is called convection, and this is what causes the air to move. This is wind.”

3. Wind Scarves: This activity will be more appreciated by younger students and is more appropriate for grades K-2. Hand out scarves, one to each student. “This is a do as I do, say as I say game. Hot air rises (raise scarf in hand), cool air falls (bring scarf down), and the wind moves all around (spin around with scarf).” Repeat and create a moving circle of wind scarves.

The next set of experiments will be more appreciated by older elementary level students and is more appropriate for 2-4 grades.

4. Hot Air Rises Demonstration: “How do we know that hot air rises? I am going to fill up this bag with hot air. What do you think will happen? Let’s make a prediction.” Elicit responses. If you are using a hair blow dryer you can have the students put their hands under the blower to feel the hot air. If you are using a sterno container or tea light, the students should recognize that a flame is hot and to keep a safe distance. Set up a graph of student responses.

Examples:

Prediction – EXAMPLES	How Many Agree
The bag will float straight up to the ceiling.	5
The bag will float straight only as long as the hot air is beneath it.	8
The bag will float up and then drift the right side because the vent is on and it is on the left side of the classroom.	3
The bag will hover over the hot air source but not float up.	2
The bag will fall on top of the hot air source.	2

Once the predictions are made, set the clear plastic bag above the heat source. Let the bag fill up with hot air and then let go. Assess accuracy of predictions and test results. Students may opt to request a repeat of experiment to see if the successful prediction(s) remain correct. Another bag may be needed depending on how hot the heat source was and if the bag melted in places and became more wrinkled and hard as a result. For optimal success, the bag needs to be free of rips and stiff, wrinkled spots.

5. Discuss results and confirm that hot air, even trapped hot air, rises.
6. Experiment’s Control: “If hot air rises and cool air falls, how would we know that cool air falls? What kind of experiment could we do to see cool air falling?” Elicit responses. Students may opt for another round of the bag experiment, this time with cool air. Ask students where they might get cold air. Suggestions they may come up with are: tray of ice cubes, a freezer, or the outside air on a cold day. Collect the cold air as closely as possible as the hot air was collected to keep the experiment similar. Make predictions and graph them as was done in the hot air experiment.
7. Discuss results and confirm that cold air, even trapped cold air, sinks or falls.

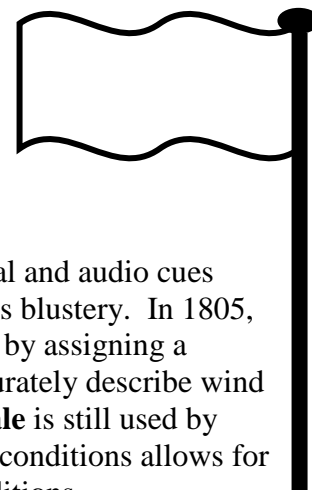
8. Convection: “Hot air rises and cool air falls. In the hot air experiment we could see that hot air rose with the bag, just like a hot air balloon. The rise and fall of air currents is called convection; it is a heat transfer process. Air takes up space, and when we trap it we can see that, such as when we saw the hot air bag rising. The heated air expands and becomes less dense; lighter, causing the bag to rise through the denser, cooler surrounding air. Cooler air will fill in the space where the warm air was. This movement of air placement on a larger scale is what makes wind.”

REFERENCES:

- The Hot Air Demonstration using portable canned heating fuel was inspired by wind activities taught by the staff at the Hitchcock Center for the Environment, Amherst, MA.

Lesson 2

Measurements Are a Breeze: Part 1: The Beaufort Scale



BACKGROUND: By using our senses we know the wind is blowing. Visual and audio cues help us to assess qualitatively the speed of the wind. The wind is calm or it is blustery. In 1805, Sir Francis Beaufort, a British naval officer, created a scale of measurement by assigning a quantitative numeric value to corresponding visual observation to more accurately describe wind condition on the sea and on the land. Over 200 years later, the **Beaufort Scale** is still used by ship officers and meteorologists to assess wind conditions. Assessing wind conditions allows for a deeper awareness of the surrounding environment and environmental conditions. Understanding wind force also provides a basic understanding of the types of wind conditions conducive to **wind energy** generation.

LEARNING OUTCOME: Students state the use of a Beaufort Scale (knowledge level).
Students explain the Beaufort Scale (comprehension level).

GRADE-LEVEL APPROPRIATENESS: K-4

LINKS TO MST LEARNING STANDARDS AND CORE CURRICULA:

Standard 1: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

Mathematical Analysis:

Key Idea 1: Abstraction and symbolic representation are used to communicate mathematically.

M1.1c: Apply mathematical skills to describe the natural world.

Scientific Inquiry:

Key Idea 1: The central purpose is to develop explanations of natural phenomena in a continuing creative process.

S1.1 Ask “why” questions in attempts to seek greater understanding concerning objects and events they have observed and heard about.

S1.1a Observe and discuss objects and events and record observations

S1.2 Question the explanations they hear from others and read about, seeking clarification and comparing them with their own observations and understandings.

S1.2a Identify similarities and differences between explanations received from others or in print and personal observations or understandings

S1.3 Develop relationships among observations to construct descriptions of objects and events and to form their own tentative explanations of what they have observed.

S1.3a Clearly express a tentative explanation or description which can be tested.

MATERIALS:

Part	Options to obtain it
Beaufort Scale Diagram	Included in <i>Wind Wisdom</i> unit

Long flowing strips of a light weight fabric, 1 per student OR Long strips of surveyors tape OR crepe paper ribbon and a stick or ruler and tape	Used clothing/fabric store, linen closet Hardware store Grocery store
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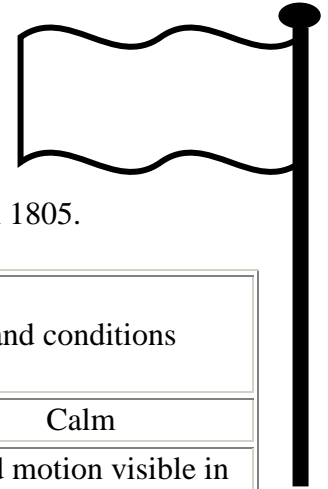
TEACHING THE LESSON: INSTRUCTIONS

1. Wind Speed: “The process of warming and cooling air placement is what causes air to move. How do we know there is wind?” Elicit responses. “We may see movement, the air pushing objects such as leaves or branches or debris. You may feel the wind pushing you when it’s strong.” Request that the students come up with words to describe moving air and write them on a board. Such descriptive words may include: gentle, light **breeze**, breezy, waft, blustery, gusty, windy, whipping, **gale**, **hurricane**, etc.
 “The Beaufort Scale, created by British naval commander Sir Francis Beaufort in 1805, assigns a value to wind strength and speed through visual cues. What are some visual cues you can think of to assess the wind’s strength? What types of things do you notice the wind push when it is gentle verses when it is strong?” Elicit responses and write them on the board. Hold up the diagram of the Beaufort Scale and state some of the visual cues from the Beaufort Scale that align with the students descriptive words of wind and what visual cues they came up with. This demonstrates to the students their success in first thinking of their own descriptive words and visual cues regarding wind. They then hear affirmation that Sir Francis Beaufort came up with similar descriptive words and visual cues as they did.
2. Visual Cue Measurements: Using the wind scarves from the “What is Wind” lesson, or constructing a “wind measurement tool” from 60 cm of crepe paper ribbon or thread and a stick or ruler, have the students assign values to the visual cues they are observing. For example, standing in a circle in the classroom will probably elicit a response of “no wind” or “calm”. Take the students outside in various safe weather conditions with their wind scarves or wind measurement tools and have them assess how windy it is outside. Discuss the values they assign to the visual cues. Do they differ from one another? Are they similar? Attempt to form a standard that the students can agree to naming different windy conditions.

EXTENSIONS

- Beaufort Scale Pictorial Diagram: Students draw pictures to correspond to the Beaufort Scale. Suggestions: Assign students each to a different “Beaufort number force” and have them draw it. Create a large poster of these drawings in the order of “Beaufort number force” and display.

The Beaufort Scale



The Beaufort scale is an empirical measure for the intensity of wind. The scale was created by the British naval commander Sir Francis Beaufort in 1805.

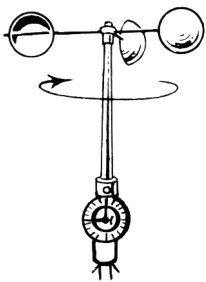
Beaufort number "Force"	Wind speed MPH	Wind Speed Knots	Description	Sea conditions	Land conditions
0	<1	<1	Calm	Flat	Calm
1	1-3	1-3	Light air	Ripples without crests	Wind motion visible in smoke
2	4-7	4-6	Light breeze	Small wavelets	Leaves rustle
3	8-12	7-10	Gentle breeze	Large wavelets	Smaller twigs in constant motion
4	13-18	11-16	Moderate breeze	Small waves	Small branches begin to move
5	19-24	17-21	Fresh breeze	Moderate longer waves	Smaller trees sway
6	25-31	22-27	Strong breeze	Large waves with foam crests	Large branches in motion
7	32-38	28-33	Near gale	Sea heaps up and foam begins to streak	Whole trees in motion
8	39-46	34-40	Gale	Moderately high waves with breaking crests	Twigs broken from trees
9	47-54	41-47	Severe gale	High waves with dense foam	Light structure damage
10	55-63	48-55	Storm	Very high waves. The sea surface is white	Trees uprooted. Considerable structural damage
11	64-72	56-63	Violent storm	Exceptionally high waves	Widespread structural damage
12	73-82	64-71	Hurricane	Sea completely white with driving spray.	Massive and widespread damage to structure

Lesson 3

Measurements Are a Breeze:

Part 2: Wind Vanes & Anemometers

BACKGROUND: We know the wind is blowing by using our senses. We can smell a scent on the breeze, see and hear objects move. These cues help us to assess qualitatively the speed and direction of the wind. To assess direction, **wind vanes** and **wind socks** provide visual observations of wind direction. The earliest record of a wind vane was in 48 B.C. in Athens Greece, and was created by the astronomer Andronicus in honor of the Greek deity Triton. Both the Vikings and the Christians affixed them to structures beginning in the 9th century. They appeared more ornamental and of some spiritual significance. Today, ornate wind vanes still decorate the tops of structures, while simpler wind vanes are used to assess wind direction and may be used in conjunction with other wind measuring devices. "Vane" comes from the Anglo-Saxon word "fane", meaning "flag". The wind sock is generally seen at airports and used as a visual cue of wind direction and force.



To assess speed, an **anemometer** is employed to determine revolutions per minute. The term anemometer is derived from the Greek word, *anemos*, meaning wind. The first anemometer was invented in 1450 by Italian architect Leon Battista Alberti. Robert Hooke, an English physicist, later reinvented the anemometer, and in 1846, John Thomas Romney Robinson, an Irish physicist, invented the spinning four-cup anemometer. In 1926, a three-cup anemometer was designed by Canadian inventor John Patterson. Three-cup anemometers are currently the industry standard in wind energy assessment studies because this design responds more quickly to gusts than the four cup anemometer and has a more constant **torque** (twisting force). Subsequent three-cup improvements were developed in 1935 by Americans Brevoort & Joiner and as recently as 1991 by Australian Derek Weston to measure both wind direction and wind speed.

LEARNING OUTCOME: Students state the purpose of a wind vane. (knowledge level).
Students explain how winds are named by their direction (comprehension level).
Students construct a simple anemometer (synthesis level). Students use a simple anemometer to calculate wind speed (application level).

GRADE-LEVEL APPROPRIATENESS: K-4

LINKS TO MST LEARNING STANDARDS AND CORE CURRICULA:

Standard 1: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

Mathematical Analysis:

Key Idea 1: Abstraction and symbolic representation are used to communicate mathematically.

M1.1c: Apply mathematical skills to describe the natural world.

Scientific Inquiry:

Key Idea 1: The central purpose is to develop explanations of natural phenomena in a continuing creative process.

S1.1 Ask “why” questions in attempts to seek greater understanding concerning objects and events they have observed and heard about.

Engineering Design:

Key Idea 1: Engineering design is an iterative process involving modeling and optimization (finding the best solution with given constraints); this process is used to develop technological solutions to problems within given constraints.

T1.4b: Build a model.

SAFETY: For the downwind activity, make sure you are using a tea or scent that will not cause an allergic reaction in your students. Have the students watch the direction of the water vapors as you pump the spray. Do not spray directly into anyone’s face. For safe use of the pins, tell the students that the pins must only go point first into the pencil eraser.

MATERIALS:

Part	Options to obtain it
Water spray bottle, 1	Garden store, hardware store, grocery store
Aromatic water for bottle, strong tea such as peppermint. OR Extract, small bottle added to spray bottle (peppermint or vanilla)	Grocery store
Directional Field Compass, 1	Sporting goods or camping store
Soap Bubbles, enough small containers for students to work in pairs	Grocery store
Images of a wind vane & wind sock	Included in <i>Wind Wisdom</i> unit
Image of an anemometer	Included in <i>Wind Wisdom</i> unit
Small, sturdy 2-4 oz. paper cups, 4 per student	Grocery store
Straws, 2 per student	Grocery store
Single hole punchers, 1 per student or 4-6 to share with entire class	School supplies
Pencils with eraser (new), 1 per student	School supplies, Office supply store
Pin with a beaded head, 1 per student	Fabric store, Grocery store
Markers, enough to share	School supplies

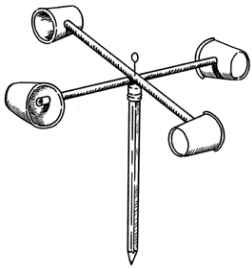
TEACHING THE LESSON: INSTRUCTIONS

1. Upwind-Downwind: “How can we tell if we are upwind or downwind? What does being upwind mean?” Elicit responses. “We may smell a scent on the breeze. If you

- can smell a scent on a breeze, that means the wind is coming toward you, and you are downwind of whatever is creating the scent. The scent may be a fragrant flower or a passerby's perfume or cologne or exhaust fumes from a car. When you are downwind of a scent, you can smell it. It also means that whatever is upwind of the scent cannot smell it. Let's see and smell which way the breeze is blowing." NOTE: This activity is best done outside. If that is not possible set up a fan on low setting and place it so the students will be downwind. Spray the spray bottle. "Watch the water vapor and sniff the breeze. Can you see which way the water vapor floated? Can you smell a scent? If you can smell the scent are you upwind or downwind?" The proper answer is downwind. To ascertain if the students indeed smell the scent, ask them what they smelled. You can then confirm the scent you used for the demonstration. IF your school has a "no scent" policy, this activity may be amended with a spray bottle filled with just water and focus on students' observations of the water vapor.
2. **Directional Wind:** "Learning to recognize whether you are upwind and downwind can help you to understand which way the wind is blowing. The next step is to learn which direction the wind is coming from to determine the directional wind. There are four basic directions, north, east, south, and west. The sun rises in the east. Do you remember where the sun was shining earlier?" Have students point the direction the sun rose in. Confirm with a compass. Go over each direction and have the students all face each one. For example, "The sun rose in this direction and this is east. Everyone face east. The sun sets in the opposite direction, the west. Everyone turn and face west, the opposite direction of east." Make sure all students know each direction. "To determine the directional wind, here is an example to think about - if the wind is going from north to south, what is the directional wind called?" Elicit responses. "A north wind. The wind is named the direction it is coming from."
 3. Bubbles Experiment: Facilitate outside. Hand out small containers of bubbles with a bubble wand. "I want you to blow the bubbles and observe the direction they float in." Have the students take turns blowing and closely observing where the bubbles are floating. Ask the observers which direction the bubbles are floating in. For example, "If the bubbles are floating west, then what is the directional wind?" Elicit responses to ascertain understanding of directional wind.
 4. Wind Vanes and Wind Socks: "Besides blowing bubbles, there are other tools that can be used to know the directional wind. Hold up an image of a wind vane. "A wind vane is a tool that is mounted in a high location such as a building. The arrow of the wind vane can spin in a breeze and the tip will face the direction the wind is coming from." Hold up an image of a windsock. "A windsock does very much the same. There is a wider end and a smaller end and the breeze flows through it. When it is windy, the sock will be blowing away from the directional wind. The directional wind is pushing or blowing the sock in the opposite direction. The windsock can also provide observational information about wind speed. If the sock is drooping there is little wind. If the wind is strong, the sock will be blowing straight out."
 5. The Anemometer: Hold up an image of an anemometer. "This invention, called an anemometer, turns in the wind and measures wind speed based on the revolutions per minute, the number of turns in a minute or sixty seconds. Today we are going to construct simple versions of an anemometer and see how accurate a reading we can

get outside.” Hold up the model students will then construct. (Be sure you have made one first.)

Note: Student models may not accurately measure the wind speed velocity, but students can get the general idea about wind speed by using this device.



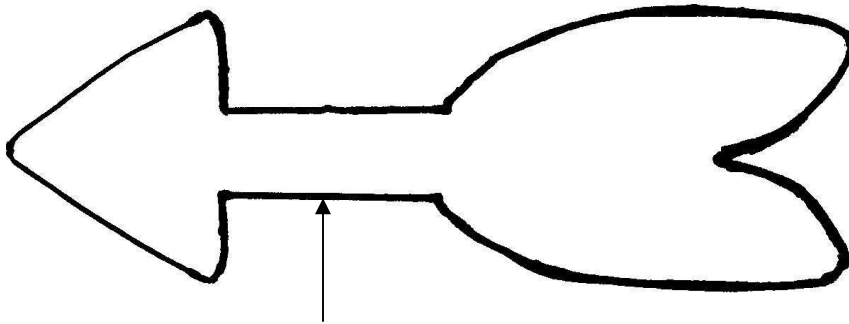
- a. Gather enough supplies so that every student can make one anemometer: one pencil, one pin, two straws, and four small paper cups.
 - b. Using a single hole-puncher have students hole-punch into one side of the paper cup. Express the importance of holes being in the same place on each cup. Adult help may be necessary for younger students.
 - c. Students will take one straw and put each end partly through a cup, thereby attaching two cups with a straw. Repeat so both (two) straws are attached to two cups (total four).
 - d. Cross the straws, making sure all four sides are equal and then using a push pin, push the pin through straws and into the pencil’s eraser.
 - e. Mark one cup with a marker, just one, for easier reading as the anemometer spins.
 - f. The anemometer is now ready to use.
6. For determining wind speed, at a most basic level, with student model anemometers, have the students count the number of times the marked cup passes a certain point in a minute. If there is no perceivable breeze outside a fan can be used. Have students create a paper fan to wave at the anemometer or use an electrical fan. It may be helpful for students to work with a partner so one can count to sixty while the other one focuses on how many times the marked cup goes around in a one minute period. Testing the wind speed in various windy conditions outside will give students a sense of how fast the wind is moving. These models, however, are unable to provide accurate miles-per-hour readings. For an accurate miles-per-hour reading, visit a local weather station either on site or via the internet.
 7. Ask students to state how many times the marked cup passed around in a one minute period. Ascertain the similarities in passes or revolutions in that one minute period to assess accuracy in counting. For example, how fast or slow are students counting? Is everyone stating a number every second and only providing one second per number? How long do students think a second is? Model if necessary.
NOTE: For young learners you may also consider lessening the time of the counting period to thirty seconds or work in small groups with an adult leading the counting so that students learn their numbers and how long it takes to count to 60; i.e. sixty seconds or one minute.
 8. Discuss the wind speed and compare to the Beaufort Scale in the prior lesson.

EXTENTIONS

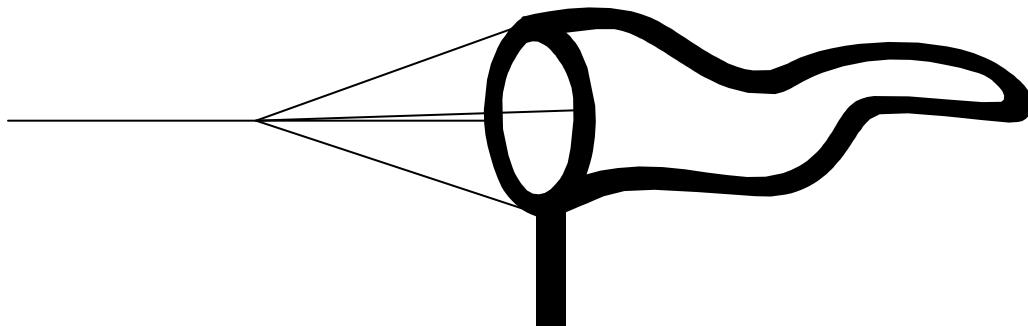
- Create a grid of anemometer readings with various wind conditions or fan settings in one column and a series of test counts. Working in small groups, have one person be the time keeper, another student be the counter, and another be the scribe and write down the windy condition or fan setting and the number of turns the anemometer makes in a one minute period. For older elementary students you can have them find the average of the three readings.

Wind or Fan Speed (define type)	Wind Speed in Revolutions per minute (RPM)		
	1 st reading	2 nd reading	3 rd reading
1			
2			
3			

- Calculate the **velocity** of the wind: Calculate the **circumference** (in meters) of the circle made by the rotating paper cups. Multiply your revolutions per minute (RPM) value by the circumference of the circle, and divide by 60. This will provide an approximation of the velocity of at which the model anemometer spins (in meters per second).
- Make a wind vane for mounting on the Anemometer: Make thick arrow shapes and have the students trace them on thick manila paper. Used manila file folders work well. Make sure students have two pieces of paper, so when they cut the traced arrow they will have two. Adult aid may be needed for cutting thick paper. Staple or glue the pieces together, except in the middle, though closer to the arrow tip. The arrow should be able to spin freely and evenly when propped on the beaded pin.

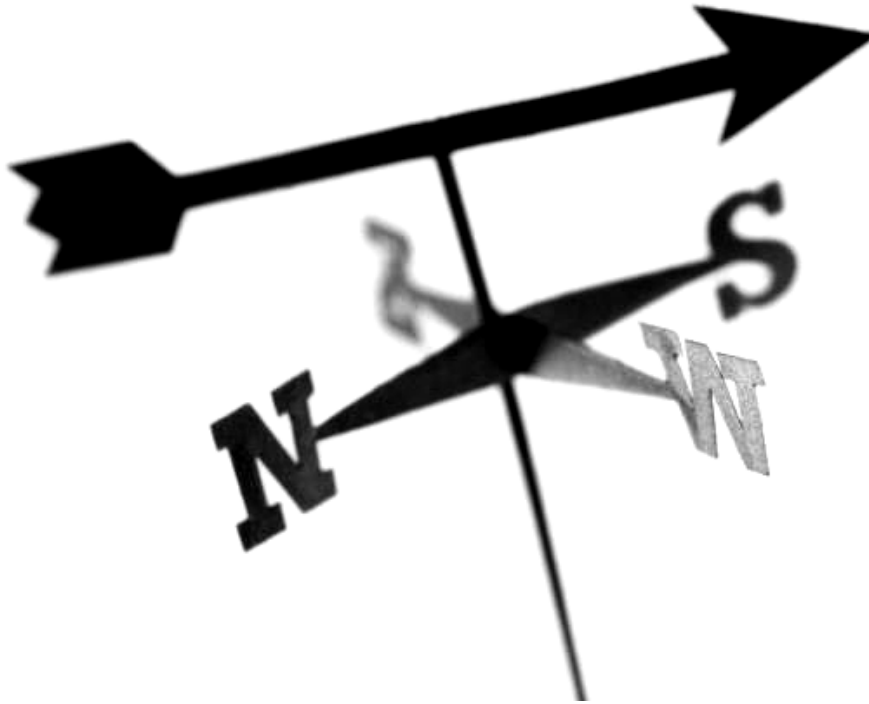


- Make a windsock: Windsocks can be constructed from a variety of light-weight fabrics. Students can get creative in the overall design as long as they keep the basic conical shape. Streamers, ribbons, or survey tape may be used to decorate the end. The wide end of the cone will need to be secured in 3-4 places with the string leading out and tied together. The remaining string can then be used to tie the windsock to a high place such as the flag pole. Several can be strung up along the rope and drawn up to the top of the pole.

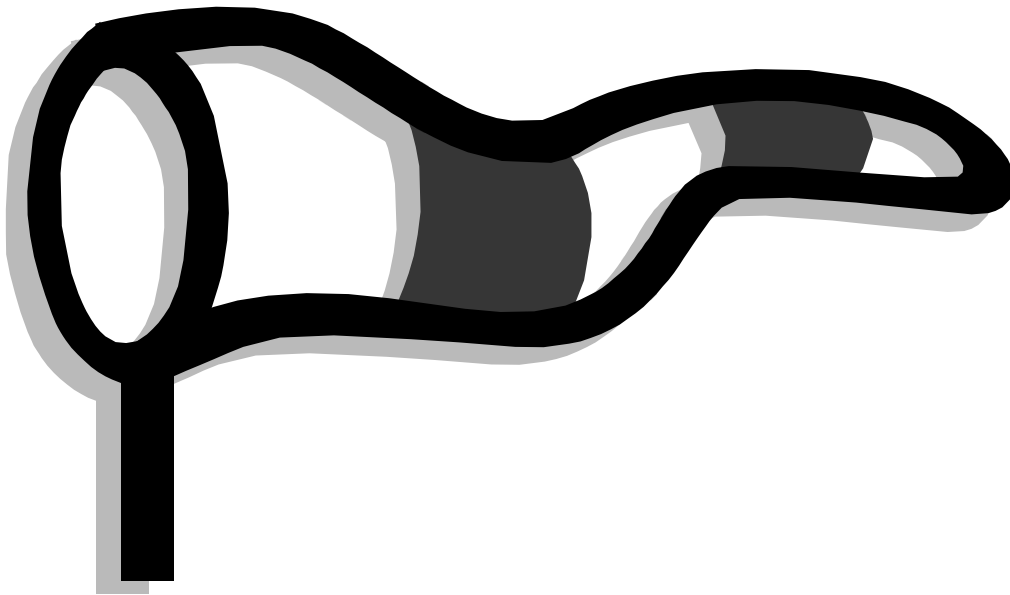


- Study the history and applications of weather instruments. Students in grades 3-4 are able to do simple research projects and may appreciate learning more about what they are creating and the applications of wind socks, wind vanes, and anemometers. Library and internet searches will facilitate the process.

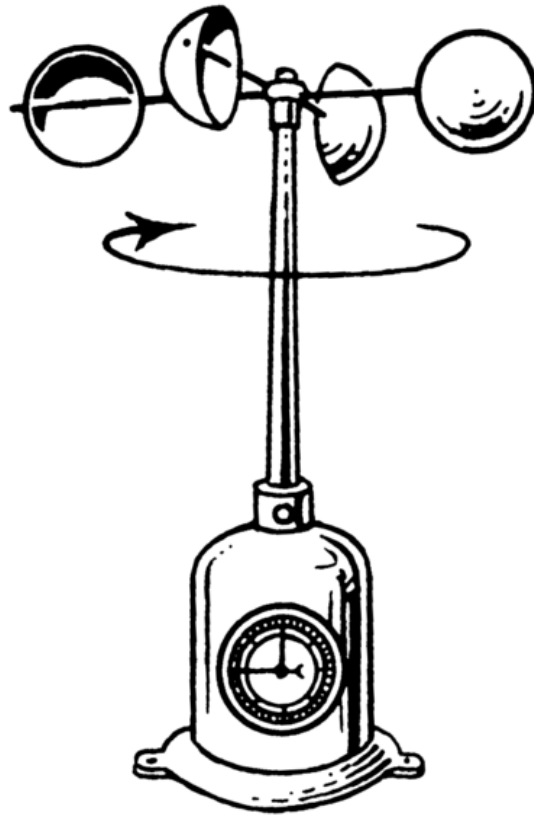
Wind Vane



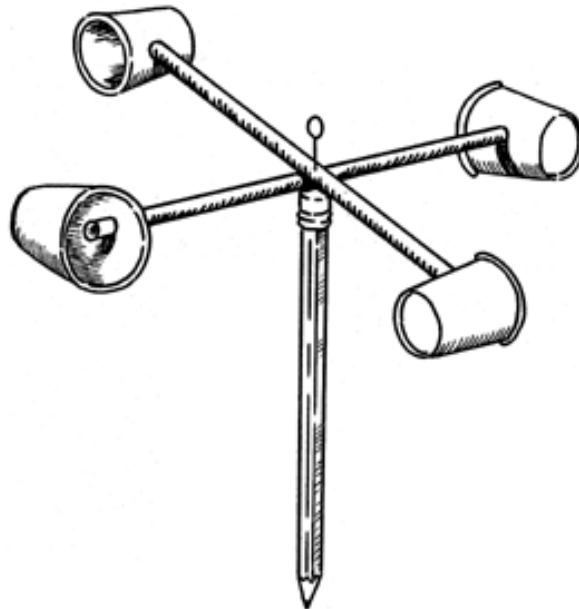
Windsock



Anemometer



Anemometer – Class Project



Lesson 4

Just Add Wind:

Lighting a Light Bulb with Wind

Adapted from *Energy Thinking*, © 2008, NESEA



BACKGROUND: According to the 2009 Pattern and Trends Report of New York State Energy Profiles for 1993-2007, about 13% of New York energy needs are met in-state. New York State operates thirteen coal plants and six nuclear power plants. In-state crude oil production is at 0.1% and natural gas is 4.7%. With regard to other in-state power sources, there are 28 large and 340 small hydro-electric projects contributing 6% and ten wind farms (less than 1%). Biofuels derived primarily from wood, wastes, and agricultural products contribute 5% to the in-state mix, and solar contributes less than 1% (NYSERDA, 2009). Whether New York's energy is produced from nuclear fission, natural gas, coal, water, oil, wood or other biomass (such as waste or landfill gas), or wind, all need an electric generator to produce **power**. The only exception is solar energy. The use of an electric generator is one way humans use the interaction between matter and energy. In a most basic sense, **energy** is the ability of a force to perform work or to organize or change matter. Energy occurs in many forms and is classified as either potential energy (stored) or kinetic energy (in motion) and is converted from one form to another.

A **generator** converts mechanical energy into electrical energy through **electromagnetic induction**. Electromagnetic induction occurs when a coil of wire experiences a changing magnetic field, which causes a **voltage** to be induced in the coil. This effect was discovered in 1830 by the English physicist Michael Faraday and is known as Faraday's Law. Faraday discovered that moving coils of wire and magnets past one another would generate an electric current in the wire. This ability to generate **electricity** from coils of wire and magnets is the basis for most modern electric power generation. In modern generators, coils of wire and a set of blades are connected to a common shaft. The wire coils, which are placed inside a ring of magnets, are spun when the blades are turned with an external energy source such as water heated by burning **fossil fuels**, high-pressure steam, falling water, or wind.

There are many ways a coil can experience a changing magnetic field. Electric generators accomplish this either by moving a magnet within a coil of wire or, as in most commercial electric generators, coils of wire are spun within a circle of large permanent magnets. Either way, a voltage is "induced" in the coils.

The coils of wire in a generator are attached to a central shaft that can be turned by an outside force. For electrical generation via the wind, the shaft is connected to a set of long narrow wing-shaped **turbine** blades that can be turned by wind.

In 1888, Charles Brush, an American inventor, built the first wind turbine for electrical generation. In 1891, Poul la Cour, a Danish inventor and scientist, expanded upon Brush's concept to develop the first electrical output wind turbine, incorporating aerodynamic design principles. Subsequent modifications and experiments have led to the modern day wind turbine designs, all with the single focus: how to generate electricity most efficiently using wind as the energy source.

LEARNING OUTCOME: Using a model wind turbine, generate electricity with breath and with wind. (application /synthesis level).

GRADE-LEVEL APPROPRIATENESS: K-4

LINKS TO MST LEARNING STANDARDS AND CORE CURRICULA:

Standard 4 – Science: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Physical Setting

Key Idea 4: Energy exists in many forms, and when these forms change, energy is conserved.

4.1 Describe a variety of forms of energy (e.g. heat, electrical, light) and the changes that occur in objects when they interact with those forms of energy.

4.1a Energy exists in various forms: heat, electric, sound, chemical, mechanical, light.

4.1b Energy can be transferred from one place to another.

4.1c. Some materials transfer energy better than others (heat and electricity).

4.1d Energy and matter interact: water is evaporated by the Sun’s heat; a bulb is lighted by means of electrical current; a musical instrument is played to produce sound; dark colors may absorb light, light colors may reflect light.

4.1 e Electricity travels in a closed circuit.

4.2 Observe the way one form of energy can be transformed into another form of energy present in common situations (e.g. mechanical to heat, mechanical to electrical, chemical to heat)

4.2 a Everyday events involve one form of energy being changed to another.

- The Sun’s energy warms the air and water.

4.2 b Humans utilize interactions between matter and energy:

- chemical to electrical, light, and heat: battery and bulb
- mechanical to sound (e.g., musical instruments, clapping)
- light to electrical (e.g., solar powered calculator).

Standard 6—Interconnectedness: Common Themes: Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

- Discover that a model of something is different from the real thing but can be used to study the real thing.

MATERIALS:

Part	Options to obtain it
Sources of Electricity visual aid	Included in <i>Wind Wisdom</i> unit
Wind Turbines Connected to Electricity Grid visual aid	Included in <i>Wind Wisdom</i> unit

DC hobby motor, 1-4 volts, 1 per pair	hobby stores, online at Pitsco, Solar World, KidWind
Mini-fan blades, 1 per pair	children's science store, online at KidWind
Alligator clip leads (2-ended), 2 per pair	electronics store
Breath	It's FREE! Just blow.
Fan	Classroom, Small appliances store
Light Emitting Diode (LED), 1 per pair	Electronics

SAFETY: If you are using Light Emitting Diodes (LEDs) keep bulbs away from the face. Always when working with glass, safety goggles are recommended. Be advised: Though **resistors** are not required with this lesson, as a fan will not spin the motor fast enough to develop the output that may destroy the LED, resistors are useful to maintaining a stable resistance when working with a **circuit**.

TEACHING THE LESSON: INSTRUCTIONS

1. Walk to the room's light switch and turn it off and on again. Ask the students if they have any ideas about how the lights are able to turn off and on. Most will have some understanding that electricity is responsible for a light being able to be turned on.
2. What is energy?: "Lighting homes, heating water, warming spaces, running machines, driving cars, and flying planes all require energy. Energy is all around us and appears in many forms. It can be either stored, called potential energy, or in motion, called kinetic energy. To learn a little bit about how energy works in our lives we are going to act out a few forms as they relate to our topic on wind energy. This is a repeat after me, do as I do game." Have the students rise and give themselves enough space to move around.

MODEL: "Kinetic energy" (student repeat) "is energy" (students repeat) "in motion". (Students repeat and mimic leader pretending to power walk.)

- "Kinetic energy is energy in motion." (Pretend to power walk.)
- "Potential energy is energy that is waiting." (Tap your foot and look at your wrist.)
- "Mechanical energy is energy that is a moving object." (Pretend to throw a ball.)
- "Wind energy is energy, a form of mechanical energy, (Pretend to throw a ball) which comes from wind turning big metal turbine blades in the sky. (Wave your arms in big slow circles and make a low and constant "woof" sound.)
- "Electrical energy is energy that is electrons moving through wires." (Put hands at sides and shuffle fast a few paces, turn and continue to shuffle as if you are moving inside a wire.) "It is also lightning!" (Do a pose with your hand raised at a diagonal, finger pointed up to the sky and then point down across your body to the ground. Repeat a few times. Think disco dancing.)

Have the students sit back down.

3. What is electricity? : "Electricity is the flow of electrical power or charge. Electricity is the flow of electrons moving through a wire. And they can do work when the wire is connected to a circuit. (Demonstrate this by turning on a light.) Electricity is a secondary energy source, which means that it is converted from other sources of energy, like coal, natural gas, oil, nuclear, wind, water, solar, and other natural resources. These are

primary (first) sources. (You may choose to use the visual aid “Energy Sources to Create Electricity”.) The energy sources we use to make electricity can be **renewable** or **non-renewable**. The primary source, wind, is a renewable resource. A renewable resource is something that is not only natural, such as any of the primary sources mentioned; a renewable resource is also naturally and continually replenished. It does not run out. The sun shines, the wind blows, water flows.”

4. Where does electricity come from? : “We can produce (make) electricity from a variety of sources; the sun, moving water, burning coal or gas, or wind. When we use the energy of the wind we use big turbine blades in the sky to catch the wind. The wind is a force in motion, a form of mechanical energy, and it can push the wind turbine blades. These spinning blades makes a generator, a big motor, spin and this creates - electrical energy - electricity. There is more to this motor or generator, but let us start with this one building block of knowledge.” (Can hold up visual, “Wind Turbines Connect to the Electric Grid to Generate Electricity”).
5. The motor: Hold up the hobby motor. “Here is a motor. Inside it, this little motor has parts that can make electricity, a magnet and a coil of wires. Working together, these parts have the ability to turn on a light bulb, but the motor needs help. First we will connect a bulb to the motor using metal wire. (Demonstrate; connect the LED bulb to the motor with the alligator clips and wire leads.) It needs an energy source. If we attach this miniature fan to the motor we can turn on the light. How might we do that?” Elicit responses.

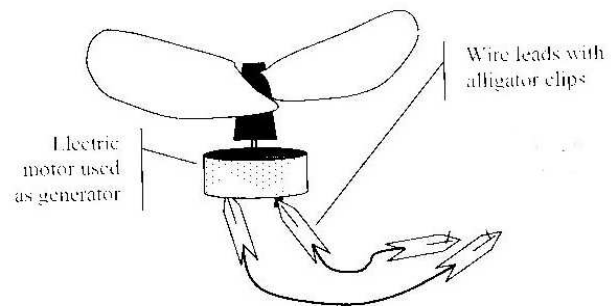
Students may suggest that the fan be put in front of another moving fan or to go outside if it is windy or to use their breath to make the fan blades turn.

Encourage all methods to assess effective methods to get the fan blades to turn.

6. Inquiry: Pass out enough supplies so that students can work in small groups. Attach the mini fan blades to a hobby motor. Allow time for student exploration of how to get the fan blades to spin and the light bulb to light.

- a) For students testing their lung power to see if they can push enough breath out to blow on the fan blades and make them spin, have an adult helper available to assist as younger students may not have the lung power to turn an LED with their breath. First allow them try. If they are meeting with failure let them know that they have smaller lungs and may not have the ability to push out as much air as is needed. They may need help, either with more students blowing on the fan blades in unison and blowing in the same direction, or with a bigger pair of lungs such as an adult. Ask if they would let you try too. Allow time for experimentation with “who has the strongest lungs?” There may be successful individuals and/or groups.
- b) If the LED does not light up, suggest to students to try reversing the leads.

7. Where is the wind coming from?: Have groups discuss their method of making the fan blades spin to get the light to turn on.

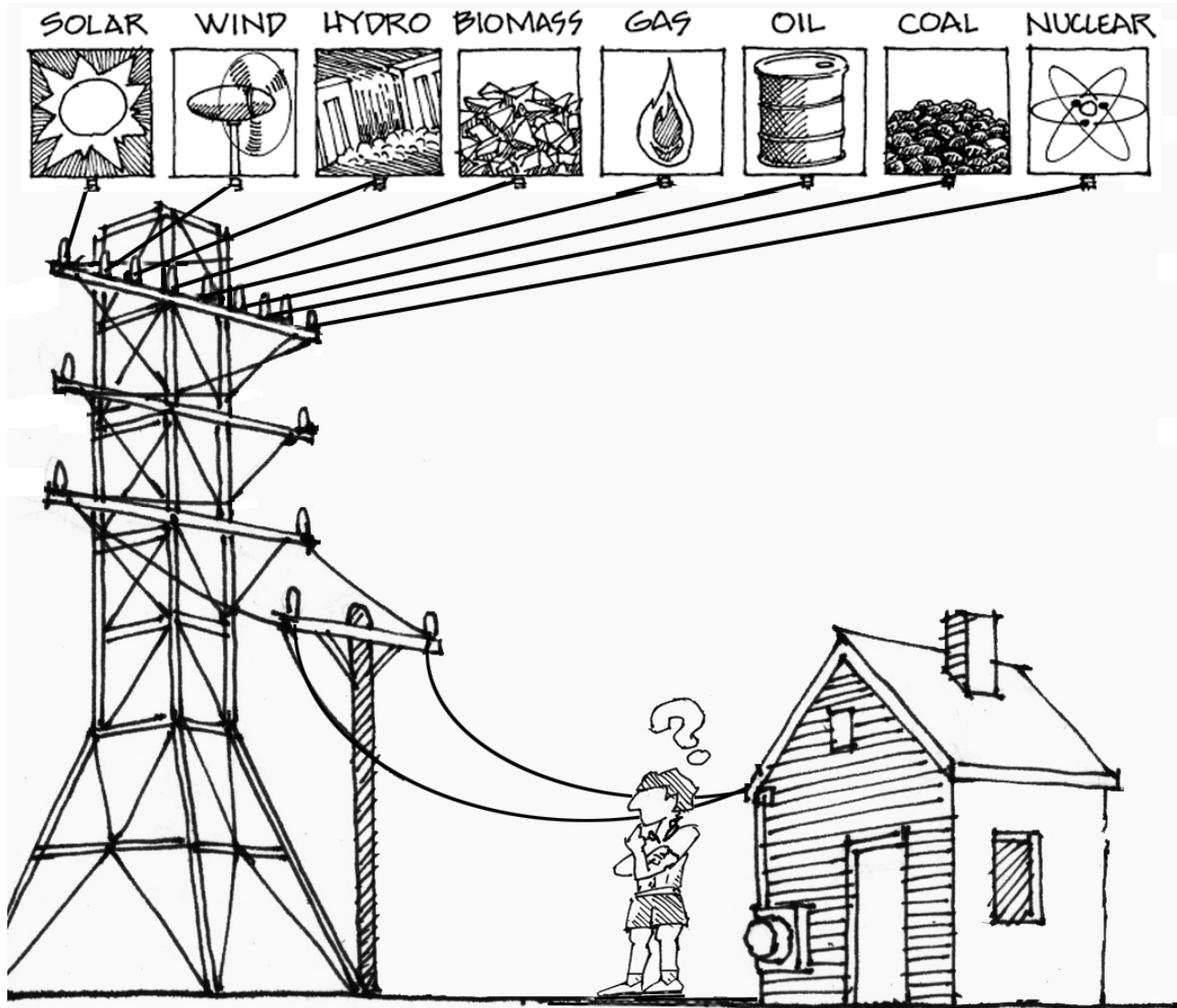


- a) For groups using their breath, ask, “Where is the wind coming from?” Answer is “my breath.” “Where were you blowing on the fan blade when you experienced success in making it spin?” If they are using mini turbine blades they will spin when air is forced on them from the front just as a full-size turbine will do.
 - b) If there are students have chosen to use a secondary source, such as another fan, ask them where the larger fan is getting its source of energy.
Appropriate response or teacher provided responses:
 - The fan is plugged into an outlet and electricity comes from there.
 - The larger fan is plugged in to an outlet that provides an electric current through wires that are connected to the power lines outside, which are connected to perhaps several energy sources, including water, wind, nuclear power plants, coal power plants, and gas power plants.
8. A Consistent Source: Students who used their lung power may have been able to turn on the light bulb. Could they keep the light bulb on? Why not? “To turn on the light bulb and keep it on, the light needs a consistent source of energy. Another fan can give it that, and that fan then also needs its own energy source.” Inquire if the students who went outside had luck in turning on the light bulb with the wind and keeping the light on. Discuss how their site may or may not have the appropriate conditions for generating electricity with the wind.
9. Conditions for a Wind Turbine: Ask the students to come up with conditions they think are needed for a big fan, a wind turbine, to be able to catch the wind and turn on many light bulbs. Appropriate responses include:
- a) The turbine would need a constant wind blowing on it.
 - b) The turbine would need to be placed in such a way for its blades to catch the wind in order to spin.
 - c) The turbine would need to be connected to the light bulbs in some way so that it could turn them on.

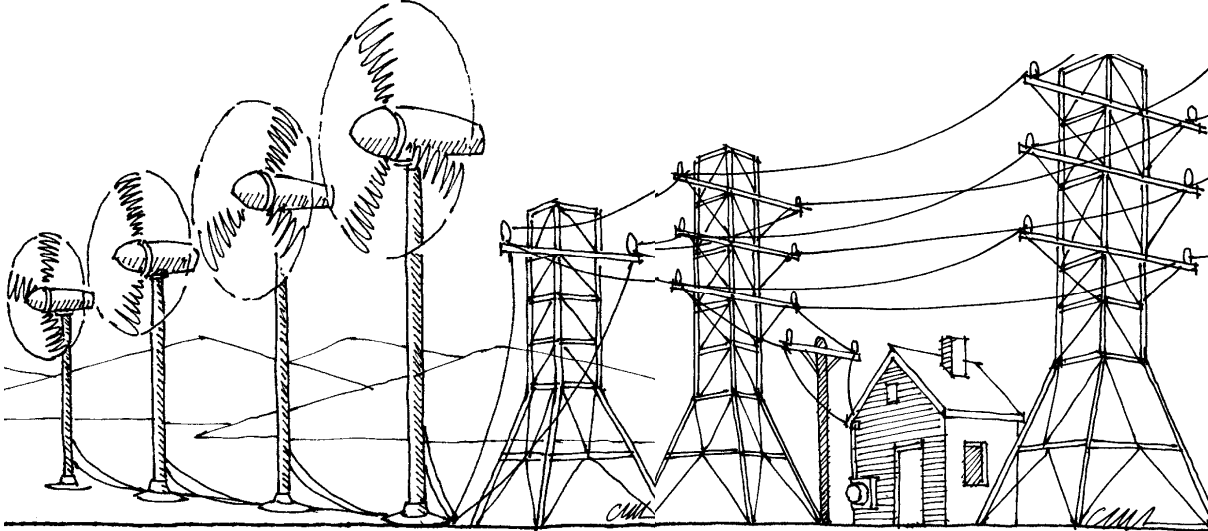
EXTENTIONS

- The Mini-Turbine: For 4th grade students interested in studying electromagnetism, refer to *Wind Wisdom for School Power...Naturally* for 5th-6th grade, lesson “How Can Wind Generate Electricity?: Part A: The Mini-Electrical Generator”
- Testing volts with a multi-meter: 4th grade students may be ready and interested in reading power outputs. Refer to *Wind Wisdom for School Power...Naturally* for 5th-6th grade for including use of a multi-meter with activity “How Can Wind Generate Electricity?: Part B: The Mini-Wind Turbine”

Energy Sources to Create Electricity



Wind Turbines Connect to the Electric Grid to Generate Electricity





What have you learned about wind energy?

Part 1



Please fill in the blanks of the following sentences.

The _____'s energy heats up the water and the _____.

_____ air rises and _____ air falls. This is what causes the

air to move and moving air is called _____.

Please circle the correct answer to the statement below.

If you smell a scent on the breeze you are _____ wind of the scent.

up down side below

A wind going from north to south is called a _____ wind.

north south up down

An anemometer is an instrument that measures the _____ of the wind.

direction force length speed

Draw a picture of a “light breeze”.

On the Beaufort Scale, what is the number value of “light breeze”? _



What have you learned about wind energy? Part 1 – TEACHER ANSWER SHEET



Please fill in the blanks of the following sentences.

The sun's energy heats up the water and the land.

Hot air rises and cool air falls. This is what causes the air to move and moving air is called wind.

If you smell a scent on the breeze you are downwind of the scent.

A wind going from north to south is called a north wind.

An anemometer is an instrument that measures the speed of the wind.

Draw a picture of a “light breeze”.

On the Beaufort Scale, what is the number value of “light breeze”? 2



Wind Wisdom for School Power...NaturallySM
Assessment Tool

CHAPTER 2: EXPLORE

Lesson 5

Exploring Wind Turbines and Wind Farms in New York State

BACKGROUND: The field trip provides a hands-on, cooperative learning experience. Field trips to local destination sites have the ability to impress upon students real life practices and applications of the subjects they are studying. Such outdoor pedagogical activities provide a context for understanding the interface between the natural and built environments while supporting enhancement initiatives such as the No Child Left Inside Act (NCLI) as well as place-based programs such as the EIC Model – Using the Environment as an Integrating Context.

LEARNING OUTCOME: Visit, analyze, and evaluate a facility that uses wind to generate electricity (application/analysis/evaluation).

GRADE-LEVEL APPROPRIATENESS: K-4

LINKS TO MST LEARNING STANDARDS AND CORE CURRICULA:

Standard 1—Analysis, Inquiry, and Design: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

Scientific Inquiry:

Key Idea 1: The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process.

S1.1 Ask “why” questions in attempts to seek greater understanding concerning objects and events they have observed and heard about.

S1.2 Question the explanations they hear from others and read about, seeking clarification and comparing them with their own observations and understandings.

S1.2a Identify similarities and differences between explanations received from others or in print and personal observations or understandings.

Standard 7: Interdisciplinary Problem Solving: Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

Key Idea 1: The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomena.

- 1.1 analyze science/technology/society problems and issues that affect their home, school, or community, and carry out a remedial course of action.

MATERIALS:

Part	Options to obtain it
Wind turbine image	Included in <i>Wind Wisdom</i> unit

SAFETY: Teachers, parents, and youth group leaders must assume responsibility for children in their care and use their own best judgment in each situation. Adults must accompany and directly supervise youngsters and teenagers during field trips and follow all reasonable safety guidelines. The New York State Energy Research and Development Authority and the Northeast Sustainable Energy Association assume no responsibility for safety.

TEACHING THE LESSON: INSTRUCTIONS

1. Find a wind project to visit as a destination site.

a. Possible Locations:

- American Wind Energy Association lists wind farms in New York. <http://www.awea.org/projects/> Click on New York State image for a listing of wind projects in New York.
- The KidWind Project is mapping wind farms across the US. Check locations in New York. <http://www.kidwind.org/>
- The Fenner Renewable Energy Center, Inc. (or "FREE Center"), Morrisville, NY, <http://www.fennerwind.com/>

b. Site Finding & Arrangement Tips:

- Sites by county (as of 2009):

Allegany County	Noble Allegany
Chautauqua County	Noble Ball Hill
Clinton County	Noble Altona, Noble Clinton, Noble Ellenburg
Erie County	Steel Winds
Franklin County	Noble Bellmont, Noble Chateaugay
Lewis County	Maple Ridge
Madison County	Fenner, Madison, Munnsville
Steuben County	Dutch Hill
Wyoming County	Noble Bliss, Noble Wethersfield
- Schedule the visit. Ask if there are any considerations and/or constraints the students need to be aware of when visiting the wind turbine or wind farm.
- For grades 3-4 consider pairing up the wind site visit with another energy resource site for comparison. Other options include natural gas plant, nuclear power plant, coal processing plant, or hydro-electric power plant. There may be security issues involved, so be sure to have scheduled permission for the visit.

2. Prepare students for the site visit:

NOTE: A stand alone field trip can suffice without the additional prep work for students, particularly for grades K-2.

- Ask: "Can we use wind to generate electricity, such as turning on a light?" Assess if students made the connection between turning on a light with breath in the earlier experiment "Just Add Wind" and turning on a LED light with wind.
- "A wind turbine uses the wind to make electricity." Hold up an image of a wind turbine. "Looking at a wind turbine, it may remind you of a gigantic fan. The blades spin in the wind and are connected to a generator, a much bigger version of the little hobby motors we were experimenting with. This generator then converts the mechanic energy of the blades spinning to electric energy so we can use it to turn on the lights.

- c. Make some predictions or hypotheses about the experience: “What are some things you have heard about wind turbines or wind farms, places that have many wind turbines?” Elicit responses. Based on the response create a list of student predictions of what they think the wind turbines will look like and sound like at various distances. For example:

Student Prediction / Hypothesis	How Many Students Think Is True
A fan makes noise. The wind turbine will also make noise. – Jesse	
The wind turbine is bigger than a fan. When we are close the wind turbine will sound loud. - Sam	
Wind turbines are big. We will see them from a distance. – Jose	
The hobby motor lit one small light bulb. A wind turbine can light many light bulbs. - Maya	

- i. After the site visit assess the predictions to see which ones were true and why.
3. Prepare students for the interview: Before you go to the site, work with students to prepare some interview questions and write them down. Questions may include:
 - How many light bulbs can this turbine (or this wind farm) light up at once?
 - Do the wind blades always spin?
 - If the blades are not spinning how can we have power to turn on the light?
 - What is it like to work here?
 - How did you get the turbine blades so high?

Give the site host the grade level and types of questions that will be asked, so she or he can best be prepared to answer questions.
 4. Site Visit Tips
 - Have students bring notebooks or clipboards to the interview and be prepared to jot down new questions to ask or possibly to follow-up on later.
 - Consider bringing a tape recorder, camera, or video camera to the interview as a way to record your visit. Ask the host ahead of time if it is okay to record images or voices and let him or her know how the information will be used.
 - Parents and adult mentors must accompany youngsters during all parts of site visits and take responsibility for all safety considerations.
 5. The Interview and Visit: Meet a renewable energy pioneer! See wind energy **technology** up close.
 6. Have the students write a thank you note to the person interviewed and to the people managing or owning the wind turbine site. Photos, drawings, and mention of specific things students learned and appreciated are the most meaningful to people who generously offered their time and knowledge.
 7. Hypotheses revisited: Have the students reflect on their visit and what they learned by discussing it in detail as a class and/or by writing about it in a journal. Review their hypotheses and what they think now about wind energy.

EXTENTION OR ALTERNATIVE OPTION A

When a field trip proves to be too far or too expensive, consider inviting an expert in the field of wind energy into the classroom for a presentation.

1. Find a wind energy expert to interview. Look up someone who works in the wind industry, such as a technician, engineer, or installer; someone who is a policy maker or public relations person for wind energy; or someone who is a researcher in wind energy, such as a biologist who studies impacts on wildlife. Make a request, asking if this expert would be willing to be interviewed about his or her career and what he or she does. To find an expert in the fields of wind energy, try:
 - a. Internet search by a wind energy job clearing house such as:
 - i. American Wind Energy Association: Careers in Wind <http://www.careersinwind.com/>
 - ii. WindJobs.org <http://www.windjobs.org/>
 - iii. The Wind Power Jobs Board <http://www.jobsinwindpower.com/>
 - b. The Northeast Sustainable Energy Association (NESEA) Sustainable Green Pages: <http://www.nesea.org/>
 - c. Alliance for Clean Energy New York, Inc. <http://www.aceny.org/>
 - d. Wind Developer in your state or region.
 - e. Scientist who researches wind energy.
2. Guest Speaker: Prepare students for the interview. Before the guest speaker arrives, work with students to prepare some interview questions and write them down. Questions may include:
 - What do you do? What does your day look like?
 - Why did you choose this as a career?
 - What did you study in school that helped you prepare for this job?
 - How long have you been doing this?
 - What do you enjoy most about your job?

Allow time for the guest speaker to discuss what he or she does in the wind energy field and then allow time for a question and answer period.

- Prior to the presentation, ask if the presenter has any wind energy props that she or he can bring in to show the students.
 - Tell the speaker that if he or she has any hands-on activities or demonstrations for the class that he or she is welcome to make the interview more participatory.
3. Have the students write a thank you note to the person(s) interviewed. Photos, drawings, and mention of specific things students learned and appreciated are the most meaningful to people who generously offered their time and knowledge.

EXTENTION OR ALTERNATIVE OPTION B

The On-School-Grounds Field Trip: Schedule a program with an environmental or energy educator who can facilitate age-appropriate activities at the school site. This could replace the interview and provide an entertaining set of hands-on activities on wind energy and/or energy concepts in general. Contact your local environmental education or energy education center for a programs listing. Non-formal educators at these facilities may also be able to specially create or tailor a program to suit the needs and interests of the class.

ADDITIONAL SUPPORT FOR TEACHERS

- Children’s Museums may offer interactive exhibits on energy for students to gain an understanding of the principles of energy pathways and transformations.
 - Children’s Museum of Science and Technology (CMOST), Troy, NY
<http://www.cmost.com/exhibits/Go%20Power.php>
- Placed-Based Education Evaluation Collaborative; “Quantifying a Relationship Between Place-based Learning and Environmental Quality Final Report.” This report outlines the merits of place-based environmental education using a student air-quality study to highlight findings.
http://www.peecworks.org/PEEC/PEEC_Research/S03CB4BC4-03CB558E
- No Child Left Inside provides information and references for place-based and community education in outdoor settings. <http://www.cbf.org/Page.aspx?pid=948>

Wind Turbine



A wind mill and a wind turbine.

CHAPTER 3: INTEGRATE

Lesson 6 Wind Turbine Orientation

BACKGROUND: What creates optimal conditions for siting a wind turbine or a wind farm at a particular location? It is the relationship between bodies of land and/or water and the air flowing over them. The wind responds to the contours of the land, creating places that are windier than others on a more consistent basis. Proper **orientation** of the wind turbines is very important to maximizing the turbines' ability to catch the wind. Engineers and developers investigate potential sites, studying the wind and its characteristics at each site. Information is gathered on prevailing winds or wind direction, wind speed, and turbulence. When a site is determined to be suitable for generating wind energy, the wind turbines need to be placed in such a way as to best catch the wind so that the turbine blades will spin.

LEARNING OUTCOME: Students observe the orientation of wind turbines. Students orient themselves to the prevailing wind.

GRADE-LEVEL APPROPRIATENESS: K-4

LINKS TO MST LEARNING STANDARDS AND CORE CURRICULA:

Standard 4 – Science: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Physical Setting

Key Idea 2. Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

- describe the relationships among air, water, and land on Earth.

SAFETY: Provide enough space between students so that everyone's arms can move freely and no one will accidentally hit one another.

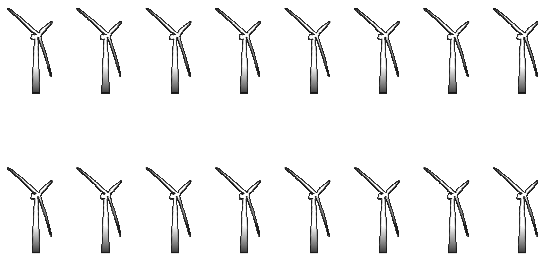
TEACHING THE LESSON: INSTRUCTIONS

1. This activity is preferably facilitated in an open space; outside is ideal. If there is time after the site tour and you have space to do this activity on site, it may help for the students to see the turbine blades as they mimic them with their bodies.
2. Blade orientation: "Orientation is the process by which you orient or position yourself in relation to something else such as a direction. In this activity we are going to mimic the turbine blades with our arms and orient our bodies to face the wind." Have everyone spread out and start spinning arms. Assess direction and have students face into the wind. Ask them to name the directional wind, the direction the wind is coming from. Assess wind speed and have the students rotate arms accordingly, faster or slower. "If there is no perceivable breeze, would our blades rotate?" Have the students study the blades to see if there is a special way they can hold their arms to mimic the shape of the turbine blade.

3. The Relationship between the Land and the Wind: “The lumps and bumps of the land and the trees and the houses where they stand can affect the way the wind flows. To generate electricity the wind turbines need to be situated where the wind is steady and fast. What features do you notice about the landscape that make this a good location? Elicit responses.
4. Wind Shadows: Form groups of three students. As teams, these groups will assess where a wind shadow falls. For the first part of the activity have students line up in threes. The front person is facing into the wind with the other two students behind them forming a line. Ask the front person if he or she feel a breeze on his or her face. It is best if they are lined up with the tallest person in front. Then ask the students standing behind if they can feel a breeze on their faces. Have them squat until their faces are level with the front person’s back. These students are less likely to feel much of a breeze. They are in the wind’s shadow. A wind shadow can be explained similarly to the sun’s shadow. When you are behind an object, it can be a shelter from the wind. The wind goes around the object you are behind and you do not feel the breeze. The point at which you are back in the wind and no longer sheltered by the object in front of you, is the end of the wind’s shadow. Have the students behind the front person continue to squat and walk backwards until they each feel the wind on their faces. This is the same concept an engineer will employ when spacing wind turbines to create a wind farm. They will ascertain where the wind shadow ends from one turbine to another, and this is the spot where the next turbine can be placed.

Example:

Wind turbines are set up in a series to effectively catch the maximum directional wind while spaced in rows to minimize the wind shadow of the turbine in front.



For photos, do an internet search, “wind farm, images” to see how wind turbines are in series and in rows for maximum effectiveness.

EXTENTION OR ALTERNATIVE OPTION

When a field trip proves to be too far or too expensive, and you are unable to visit a wind turbine, you can still do this activity. Conduct a web search on wind turbine blades and print several photos of wind turbines and the blades themselves up close. Pass around the photos and then facilitate the activity outside.

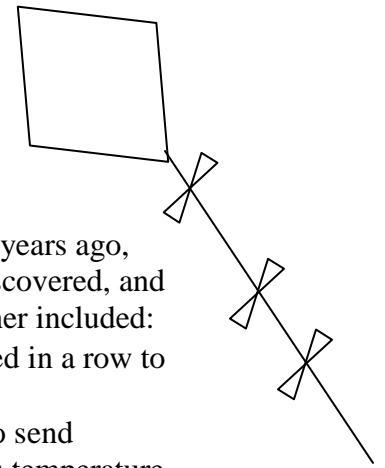
REFERENCES

- The concept for the Wind Shadow activity was inspired by Clayton Handleman, President of Heliotronics, Inc., a company that constructs and monitors solar and wind data acquisitions systems. <http://www.heliotronics.com/>

Lesson 7

Let's Go Fly a Kite:

Siting Investigations



BACKGROUND: The first kite recorded in history dates back three thousand years ago, in China and was made from bamboo and silk. Scientific applications were discovered, and kites were used as scientific instruments. Such research experiments on weather included:

- Scottish scientist Alexander Wilson, in 1749, used several kites attached in a row to measure and compare air temperature at different altitudes.
- Between approximately 1890 and 1930, box kites were implemented to send meteorological instruments aloft to gather various weather data such as temperature, barometric pressure, wind velocity, and humidity.
- Benjamin Franklin, an American electrical scientist, conducted a kite experiment in 1752 to prove that lightning is a form of electricity.

A wind turbine works best where the wind flow is straight, fast, and steady. Kite flying observations may help to assess windy conditions compatible with wind energy generation.

LEARNING OUTCOME: List the conditions necessary for wind to produce electricity (analysis level). Determine what site conditions are best for the production of electricity using wind (evaluation level).

GRADE-LEVEL APPROPRIATENESS: K - 4

LINKS TO MST LEARNING STANDARDS AND CORE CURRICULA:

Standard 4 – Science: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Physical Setting

Key Idea 2. Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

- describe the relationships among air, water, and land on Earth.

Key Idea 5. Energy and matter interact through forces that result in changes in motion.

- describe the effects of common forces (pushes and pulls) on objects, such as those caused by gravity, magnetism, and mechanical forces.

MATERIALS:

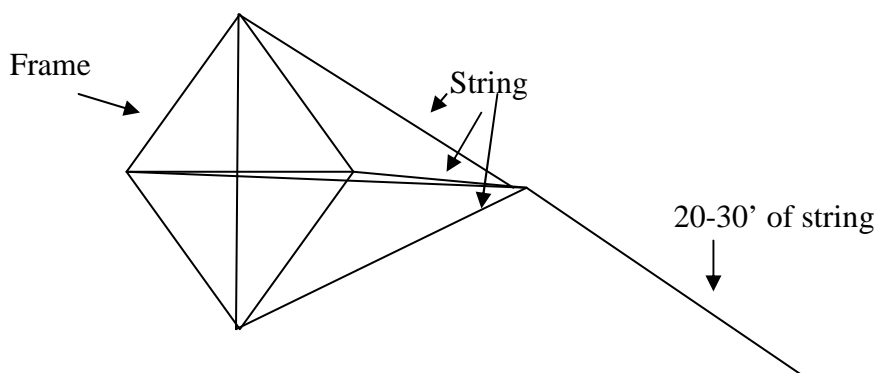
Part	Options to obtain it
Kites AND/OR	Children's science store
Kite Materials: Dowels, shishkabab sticks or expandable poles for frame, 2 per pair Tape Heavy plastic, paper bags, large sheet of heavy weight paper, or ripstop nylon, 1 per	hardware store classroom supplies, hardware store grocery store facility that has old parachutes for salvage

pair String, 50’-75’ per pair Spool or toilet paper roll, 1 per kite	hardware store, grocery store bathroom (save rolls) or fabric store
Beaufort Scale	Within <i>Wind Wisdom</i> unit
Wind	It’s FREE! Head outside

SAFETY: Be sure that the area where you fly a kite is safe from overhead wires or other obstacles.

TEACHING THE LESSON: INSTRUCTIONS

- Gather in a circle outside and tell the students to stand still and feel the air pushing or pulling them. Ask them to assess if there is a constant breeze, if it is blowing steady, and if it is coming from one direction. Discuss the wind conditions.
- Introduce the kite: “How does a kite stay aloft?” Elicit responses. Appropriate responses include:
 - The wind keeps it up.
 - When I pull on the string and run with it the kite will stay up.
 - When I pull on the string attached to the kite and the wind pushes against it.
- Studying the windiness of a location: “How can a kite help us determine if it is windy? Can a kite help us learn locations that are windy all the time?” Elicit responses. Appropriate responses include:
 - You can fly a kite on a windy day.
 - If the kite stays up then it is windy.
- Kite construction: Have students construct kites in pairs or have pre-fabricated ones, enough for students to work in pairs. There are several tutorials available to construct a kite. Basically:
 - Create a frame by forming a cross with two light, thin, rigid, and sturdy parts such as dowels, shishkabab sticks, or plastic or wooden toy parts. Tape together with a sturdy tape or glue.
 - Form and attach a plastic, paper, or fabric sheet to the frame.
 - Using a hole-punch, punch the sheet at all four tips where sheet meets frame.
 - Cut four pieces of thin light-weight string, long enough so that each piece can be tied at one hole, looped around the tip of the frame, and come together without folding the sheet.
 - Tie the strings together and attached one end of a very long, 20-30 feet, piece of string. Wind the other end around a toilet paper roll or spool.



5. Kite Flying: Allow the activity’s primary focus to be on kite flying on a variety of days to assess how to define windy conditions in a particular location. Discuss safety when sending the kite aloft and be aware of one’s surroundings. It is helpful to work in pairs. One student holds the kite up as high as his or her arm will reach and when the other student starts to run the student holding the kite should release it.
 - a) Discuss as a group the wind speed value on the Beaufort Scale. Chart it for a few days or weeks.

EXAMPLE

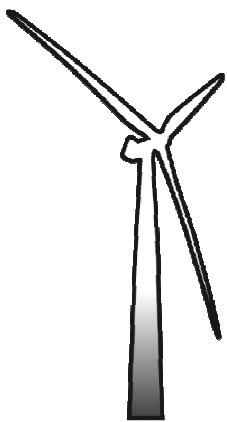
Date	Time	Wind Conditions –descriptive	Beaufort Scale Value
9/9/09	10:05 a.m.	Light breeze from southeast	2
9/16/09	10:10 a.m.	Breezy; twigs swaying, wind from south	4

6. Assessing the site:“Siting is the term given to describe the process of putting a wind turbine or wind farm in a location. There are several factors that need to be taken into consideration. How windy is the site? Is it consistently windy? What else is on the site that could affect putting a turbine there? Is the site in a migratory flyway for birds or bats? What is the site’s proximity to neighbors? All these things are taken into consideration when a wind turbine is being proposed. Before this conversation can even occur, it has to be known if the site has a fairly consistent wind. What does our research tell us about this site?” Bring out the chart that the class has been working on and discuss the windiness of the site. Ask students to interpret their observations and measurements, looking for patterns in windy conditions. If the site shows that it does have potential according to students, and the students are interested in further dialogue, then return to the above siting questions to discuss why it would be or would not be feasible to site a wind turbine at the location you studied.

EXTENSIONS

- Study the history of kites and how they were used to research the weather.
- Invite a wind energy engineer to present the siting process and how a specific location is determined to be an effective site for generating electricity from wind energy.
- Create more lyrics to the Mary Poppins song, “Let’s Go Fly A Kite” that include wind energy concepts. This can be used as an “Act” activity so that students can share what they have learned about wind energy.

Let's go fly a kite
 Up to the highest height!
 Let's go fly a kite and send it soaring
 Up through the atmosphere
 Up where the air is clear
 Oh, let's go fly a kite!
 “Let’s Go Fly a Kite”, Mary Poppins



Lesson 8

Spinning in the Wind: Wind Turbine Blade Design

BACKGROUND: Why are turbines designed the way they are? Designers consider a great many things during their design, such as economics, bird nesting, effects on wildlife, where the turbines will be located, balance, effects of weight, aerodynamics, and year-round weather conditions.

LEARNING OUTCOMES: Build, test, and evaluate wind turbine blades (application/synthesis/evaluation).

GRADE-LEVEL APPROPRIATENESS: 3-4

NOTE: This lesson is advanced for grades K-2. However, if you do have a working model then having the students see it, touch it, and watch it work will help students understand how a turbine works.

LINKS TO MST LEARNING STANDARDS AND CORE CURRICULA:

Standard 1: Analysis, Inquiry, and Design: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

Scientific Inquiry:

Key Idea 2. Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity.

- carry out their plans for exploring phenomena through direct observation and through the use of simple instruments that permit measurements of quantities

Engineering Design:

Key Idea 1. Engineering design is an iterative process involving modeling and optimization finding the best solution within given constraints which is used to develop technological solutions to problems within given constraints.

- describe objects, imaginary or real, that might be modeled or made differently and suggest ways in which the objects can be changed, fixed, or improved.
- generate ideas for possible solutions, individually and through group activity; apply age-appropriate mathematics and science skills; evaluate the ideas and determine the best solution; and explain reasons for the choices.
- plan and build, under supervision, a model of the solution using familiar materials, processes, and hand tools.
- discuss how best to test the solution; perform the test under teacher supervision; record and portray results through numerical and graphic means; discuss orally why things worked or didn't work; and summarize results in writing, suggesting ways to make the solution better.

Standard 4 – Science: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Physical Setting

Key Idea 3. Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

- observe and describe properties of materials using appropriate tools.

Standard 5—Technology Education: Students will apply technological knowledge and skills to design, construct, use, and evaluate products and systems to satisfy human and environmental needs.

Engineering Design

Key Idea 1. Engineering design is an iterative process involving *modeling* and *optimization* used to develop technological solutions to problems within given constraints.

- describe objects, imaginary or real, that might be modeled or made differently and suggest ways in which the objects can be changed, fixed, or improved.
- investigate prior solutions and ideas from books, magazines, family, friends, neighbors, and community members.
- generate ideas for possible solutions, individually and through group activity; apply age-appropriate mathematics and science skills; evaluate the ideas and determine the best solution; and explain reasons for the choices.
- plan and build, under supervision, a model of the solution using familiar materials, processes, and hand tools.
- discuss how best to test the solution; perform the test under teacher supervision; record and portray results through numerical and graphic means; discuss orally why things worked or didn't work; and summarize results in writing, suggesting ways to make the solution better.

Standard 6: Interconnectedness: Common Themes: Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

- Analyze, construct, and operate models in order to discover attributes of the real thing
- Discover that a model of something is different from the real thing but can be used to study the real thing.

MATERIALS:

Part	Options to obtain it
Working model wind turbine, 1 per class	www.KidWind.org (Recommended)
Large fan, 1-2 per class	hardware store, general supplies
Thin balsa wood or stiff thick cardboard or Coroplast (corrugated plastic sheets), 3-4 pieces pair	hardware store, craft store
Scissors, 1 per pair	office supplies
3/8”dowels, 3-4 per pair	hardware store
Glue or strong tape, 1 per pair	craft store, office supplies

Light Emitting Diode (LED), 1	electronics store
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SAFETY: Model Turbine: When the turbine is operating stand in front of or behind the turbine. Do not be in the plane of rotation. If the blades were to fly off, they would fly off to a side. Consider safety goggles. LED Safety: If you are using Light Emitting Diodes (LEDs) keep bulbs away from the face. When working with glass, safety goggles are always recommended. Be advised: Though resistors are not required with this lesson, as a fan will not spin the motor fast enough to develop the output that may destroy the LED, resistors are useful to maintaining a stable resistance when working with a circuit. Box Fan Safety: Do not stick anything into a box fan.

TEACHING THE LESSON: INSTRUCTIONS

1. Preparation: Assemble a working wind turbine model. For the purposes of this activity a model that can be handled will benefit student learning more than an image of a turbine.
2. Introduction: “Wind turbine blades need to be constructed in a shape that will best catch the wind and spin in a breeze. The materials also need to be durable and weather resistant.” Using a working model of a turbine (recommended) discuss the blades’ features. Ask the students what they notice about the blades’ shape and feel.
 - a. If you are unable to obtain a working model, conduct an internet search of wind turbines. The images will show the students the general shape of wind turbine blades.
3. The Best Blade Challenge: “To get a better idea how a wind turbine spins in the wind, we will now construct turbine blades and experiment with which ones can catch and spin in a breeze.” Hand out blade materials. Students will need pencils to draw the shape of their blades onto the blade material. Thin balsa wood, stiff cardboard, or a corrugated plastic (Coroplast) can all work. For younger students, an adult will need to cut the thick material. Adult help or supervision may be needed for the students to glue or tape their blades to dowels that will fit into the working wind turbine model. Use one or more large, strong box fans to create the wind needed to test the blades. Position the turbine hub, the front of the turbine where the blades are, in front of the fan. Run the tests on the working model to see which blade design catches a breeze most easily and spins in the wind.
 - a. Consider borrowing or purchasing a working model wind turbine such as one that can be found through the Kid Wind Project (www.KidWind.org). Kid Wind’s working model wind turbines are designed for experimentation and come with suggested experiments.
To fund a purchase, consider asking if there is money available from a local business, parent teacher organization funds, or the school, and follow up by donating the kit to the school or public library to loan out.
 - b. Students can also make their own working model wind turbine.
NOTE: This activity may be more appropriate for upper elementary.
Here are three web sites that can help guide design efforts.
Science Fair Wind Generators www.otherpower.com/toymill.html
The Penbina Institute www.re-energy.ca/t-i_windbuild-1.shtml
Vela Creations www.velacreations.com/chispito.html

4. If possible, compare the fan to wind outside. Bring the students outside with the model and their blade designs on a windy day and run the tests outside.
5. More than just spinning: Some model wind turbines come with a light that is attached and will light up when generating enough power, so the students can see that the spinning turbine blades have an effect and can generate electricity. You can also attach a small LED light with leads to connector wires on the motor and watch the LED light up when the blades are spinning fast enough.
6. Review: “What blade design or designs did you observe being the most effective to spin in a breeze?” Elicit responses. “What are the attributes of these designs? What made other designs less effective?” Elicit responses.

REFERENCES

- This lesson is based on KidWind’s lesson “Wind Turbine Blade Design” for middle to high school students. For more information and details on wind turbine blade design and lesson plans visit the KidWind Project at <http://www.kidwind.org>.



What have you learned about wind energy?

Part 2



Please circle the correct answer to the statement below.

Wind energy is _____ energy and can

electrical mechanical potential

be transferred to _____ energy.

electrical mechanical potential

The wind turbine is connected to a _____, which converts one form of energy into another.

Gird blade generator

When there is a closed circuit, you can turn on a light because now you have _____.

power electricity energy

Please fill in the blanks of the following sentences.

To generate electricity the wind turbines need to be placed where the wind is _____ and _____.

_____ : The process of putting a wind turbine or wind farm i in a location.

Draw a picture of a wind turbine catching the prevailing winds.

Draw an arrow to show the directional wind.



What have you learned about wind energy? Part 2 – TEACHER ANSWER SHEET



Wind energy is mechanical energy and can be transferred to electrical energy.

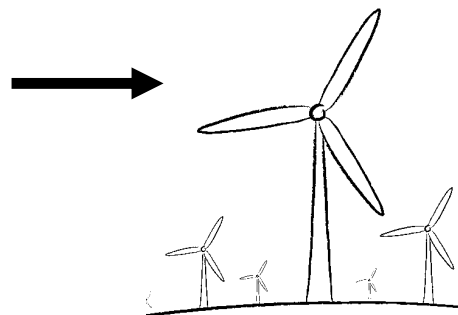
The wind turbine is connected to a generator, which converts one form of energy into another.

When there is a closed circuit, you can turn on a light because now you have electricity.

To generate electricity the wind turbines need to be placed where the wind is steady and straight. (Fast is also acceptable, as is other synonyms to any of these three words.)

Siting: The process of putting a wind turbine or wind farm in a location.

**Draw a picture of a wind turbine catching the prevailing winds.
Draw an arrow to show the directional wind.**



Wind Wisdom for School Power...NaturallySM
Assessment Tool

CHAPTER 4: ACT

Lesson 9 Students as Teachers

BACKGROUND: Sharing the learning experience deepens student understanding as they learn to be a teacher by explaining the concepts they learned.

Sometimes all a student needs is the time and space to reflect on what he or she has learned, and to the best of his or her ability, share his or her understanding of the concepts with others. In this activity students are asked to try out their thoughts on their teachers, peers, and the community at large and to learn how to most effectively and creatively communicate their ideas and their understanding of the concepts they have learned.

LEARNING OBJECTIVE: Students choose to educate the school and/or greater community about wind energy (Affective Domain: valuing and internalizing).

GRADE-LEVEL APPROPRIATENESS: K-4

LINKS TO MST LEARNING STANDARDS AND CORE CURRICULA:

Standard 4 – Science: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Living Environment:

Key Idea 7: Human decisions and activities have had a profound impact on the physical and living environment.

Standard 7—Interdisciplinary Problem Solving: Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

Key Idea 1: The knowledge and skills of mathematics, science, and technology are used to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomena.

Key Idea 2: Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.

LINKS TO AFFECTIVE DOMAIN:

Level	Trigger Words	Student Activities
Receiving	Recognizes, is aware of	Be aware, be willing to take notice, choose one over the other
Responding	Show concern, contributes, accepts	Comply with suggestions, voluntarily seek out activities,

		enjoys chosen activities
Valuing	Values, shows interest, appreciates, respects, chooses to	Accept a value and be willing to be identified with it, act consistently with, choose and seek out a position, attempt to convince others
Characterization	Internalizes	Act consistently with internalized, act with a new world view, develop a consistent philosophy of life.

TEACHING THE LESSON: INSTRUCTIONS

1. Students as Teachers: This activity gives the students an opportunity to be the teachers. Ask students to review what they have learned about wind energy. Tell them it is now their turn to teach what they have learned. By sharing information, students are able to retain what knowledge they have gained as they are now in the position to instruct.
2. Students can choose from a variety of formats on how to impart the facts about wind energy they have learned to others. First decide on who is the audience: family members, a school assembly, or the general public. As a class or in small groups, decide on the format of presentation.

Presentation format:

- a. Lecture: Individuals or small groups give 2-3 minute reports on what they learned to an audience of family members and peers.
 - b. Performance Artistry: Small groups perform a skit or song on what they have learned about wind energy.
 - i. Students may opt to sing a song such as “Let’s Go Fly a Kite” and add lyrics that teach about wind energy.
 - ii. Students may perform a skit such as the “Wind Turbine Orientation” activity with a student speaker describing what the group is acting out.
 - iii. Students may create a poem on wind energy and speak it out loud.
 - c. Public Display: The finished product should be of a quality high enough that the students would be proud to display it in a public setting such as the school’s foyer, their local library, environmental center, children’s museum, other public setting.

Options include:

 - i. Beaufort Scale drawings
 - ii. Poetry displayed within shapes of wind turbines.
 - iii. Folding kiosk board with information, photos, and drawings
3. Students present and share what they have learned about wind energy in the presentation format of choice.

Glossary of Terms

Anemometer: a device for measuring wind speed. Anemometers can be divided into two classes: those that measure the velocity of the wind, and those that measure the pressure of the wind, but as there is a close connection between the pressure and the velocity, a suitable anemometer of either class will give information about both these quantities.

Atmosphere: Layers of gases around the earth, including the air we breathe, which is mostly nitrogen (78%), about 21% oxygen, with the rest small but very important amounts of other gases including water vapor, argon, carbon dioxide, neon, helium, methane, hydrogen, nitrous oxide, and ozone.

Beaufort Scale: A scale of wind velocity ranging from 0 (calm) to 12 (hurricane).

Breeze: A light current of air; a gentle wind.

Circuit: An electrical device that provides a path for electrical current to flow.

Circumference: The distance around a closed curve; the length around a circle.

Conductor: A device or material designed to transmit electricity, heat, etc.

Convection: The transfer of heat by motion within the atmosphere.

Current: A flow of electricity through a conductor.

Decibel (dB): Logarithmic unit of measurement that expresses the magnitude of a physical quantity such as power or intensity, relative to a specified or implied reference level.

Directional Wind or Wind Direction: The direction from which the wind originates.

Electrical Circuit: An unbroken loop of material that electricity can flow through such as copper metal wires. If there is a break in the circuit, the electricity does not flow and cannot do work.

Electricity: A type of energy which exists when there is a difference in the number of electrons present at two different points, whether the result of static, generation, or magnetic field.

Electromagnetic Induction: The production of voltage across a conductor situated in a changing magnetic field or a conductor moving through a stationary magnetic field.

Energy: The capacity to do work; a resource for producing power.

Fuel: Anything we burn or can burn to get energy, such as wood, gasoline, coal, heating oil, propane, natural gas, etc. Note that some fuels are cleaner when they burn than others.

Fossil Fuels: Natural fuels such as oil, coal, and natural gas that took millions of years to form in the earth. They are rich in the elements carbon and hydrogen and come from the remains of ancient living things.

Gale: A very strong wind.

Generator: A machine that converts mechanical energy into electrical energy.

Hurricane: A wind with a speed greater than 74 miles (119 kilometers) per hour, according to the Beaufort scale.

Kilowatt-hour (kWh): A unit of electric energy often used to keep track of the amount of energy you buy from the electric company. It tells you how much electric power or rate of energy use (measured in kilowatts) was used over a given time (measured in hours).

Molecule: The smallest particle of a substance that retains the chemical and physical properties of the substance and is composed of two or more atoms; a group of like or different atoms held together by chemical forces. A small particle; a tiny bit.

Nonrenewable: Of or relating to an energy source, such as oil or natural gas, or a natural resource, such as a metallic ore, that is not replaceable after it has been used.

Orientation: The act of orienting or the state of being oriented. It is the location or position relative to the points of the compass.

Power: The rate at which work is accomplished.

Renewable: A resource that renews or replenishes itself on a short time scale. Examples include solar, wind, geothermal, hydropower, and biomass.

Resistor: a two-terminal electronic component that produces a voltage across its terminals that is proportional to the electric current through it in accordance with Ohm's law: $V = IR$. The current and voltage in a resistor are linearly related; that means that a change in voltage will produce a proportional change in current. Current versus voltage is a straight line for a resistor.

Siting: To situate or locate in a place.

Technology: The body of knowledge available to a society that is of use in fashioning implements, practicing manual arts and skills, and extracting or collecting materials.

Torque: A turning or twisting force. The moment of a force; the measure of a force's tendency to produce torsion and rotation about an axis, equal to the vector product of the radius vector from the axis of rotation to the point of application of the force and the force vector.

Turbine: Any of various machines in which the kinetic energy of a moving force is converted to mechanical power by the impulse or reaction of the force with a series of buckets, paddles, or blades arrayed about the circumference of a wheel or cylinder.

Velocity: The time rate of change of position of a body in a particular direction; the rapidity or speed of motion.

Volt: (Symbol V) the International System unit of electrical potential. The value of the across a conductor when a current of one ampere dissipates one watt of power in the conductor.

Voltage: The electrical potential difference, usually expressed in volts.

Watt: A watt is a measure of electric power; the rate, or how fast electric energy gets used. A 100-watt bulb can receive more energy per second than a 60-watt bulb, and so it is brighter and hotter. A kilowatt (kW) means 1000 watts, a megawatt (MW) means a million (1,000,000) watts, and a gigawatt (GW) is a billion (1,000,000,000) watts.

Wind Energy: Using blades attached to a turbine to convert wind energy into electric energy. It also refers to converting wind energy into mechanical energy.

Wind Sock - A cloth cone attached to a pole to show the direction of the wind.

Wind Vane - Mechanical device attached to an elevated structure that rotates freely to show the direction of the wind.

Wind Resources on the World Wide Web

Curriculum

American Wind Energy Association (AWEA)

Through the National Energy Education Development Project (NEED)

<http://www.need.org/curriculum.php> and in cooperation with the American Wind Energy Association (AWEA), the downloadable units *Wind Energy* for Kindergarten -12th grade. The material is organized by grade levels to ensure that the information is appropriate for each age group. <http://www.awea.org/education/curriculum/>

AWEA also provides background information, fact sheets, and reports on wind energy.

<http://www.awea.org/faq/>

Carol Hurst's Children's Literature Site: Wind in Children's Books

Offers information on children's books about wind. Also links to other educational wind sites.

<http://www.carolhurst.com/subjects/wind.html>

The Kennedy Center ArtsEdge: Lessons on Wind

Provides artistic and science literacy lessons on wind.

<http://artsedge.kennedy-center.org/teach/les.cfm?keywords=wind&x=0&y=0>

Kid Wind Project

Provides resources, lesson plans, and workshops on wind energy.

<http://www.kidwind.org/lessons/teachers.html>

Student-friendly site: <http://www.kidwind.org/lessons/students.html>

New York State Energy Research & Development Authority (NYSERDA)

*School Power...Naturally*SM offers a multitude of lessons on energy, particularly on photovoltaic energy. <http://www.powernaturally.org/programs/SchoolPowerNaturally/default.asp>

Northeast Sustainable Energy Association (NESEA)

The K-12 Education Department offers teacher training workshops and downloadable units on wind energy and related renewable energy topics. <http://www.nesea.org/k-12/>

Pandion Systems, Inc.

In partnership with KidWind, Pandion developed *WindWise Education*, lessons for 6-12th grade focusing on wind energy and wildlife. <http://www.pandionsystems.com/projects.htm>

The Penbina Institute

"Build Your Own Wind Turbine" (PDF). Step-by-step procedures on constructing a model wind turbine. <http://www.re-energy.ca/pdf/wind-turbine.pdf>

Curriculum Support – background information on wind energy

Energy Kids Page

Website supported by the Energy Information Administration of the U.S. Department of Energy. Student friendly site devoted to explaining history and applications of wind energy.

<http://www.eia.doe.gov/kids/energyfacts/sources/renewable/wind.html>

National Renewable Energy Laboratory: Wind Energy Basics

Explains the basics of wind energy. http://www.nrel.gov/learning/re_wind.html

New York Energy Research & Development Authority (NYSERDA)

Renewable Portfolio Standard – downloadable as a PDF.

Report providing information on renewable energy installations in the State, including wind.

<http://www.nysERDA.org/rps/projectgallery.asp>

Educational Online Data Monitoring

Heliotronics

Regional energy education business that installs online data monitoring systems to compliment on-site solar arrays on school grounds and is currently working on site monitoring for wind energy. <http://www.heliotronics.com/> Also visit Heliotronics collaboration with NYSERDA to monitor 50 schools within New York State. http://www.sunviewer.net/portals/NYSERDA_SPN/

Other Helpful Resources for NYS Educators

Alliance for Clean Energy New York, Inc.

Discussion of New York’s energy mix and expansion potential for renewable energy technologies, particularly wind.

<http://www.aceny.org/clean-technologies/wind-power.cfm/pageid/68235>

Energy Information Administration

Official energy statistics from the U.S. Government, New York State profile.

http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=NY

EnergyTeachers.org

A network of educators sharing ideas for teaching about energy production and use.

<http://energyteachers.org/>

New York Independent System Operator

“2009 Load and Capacity Data Gold Book.”

Complete inventory of generation plants in New York State, including fuel source, capacity (size), town, and county.

http://www.nyiso.com/public/webdocs/services/planning/planning_data_reference_documents/2009_LoadCapacityData_PUBLIC.pdf

New York State Energy Research and Development Authority (NYSERDA)

In January 2009, NYSEDA's Energy Analysis program published [*Patterns and Trends - New York State Energy Profiles: 1993-2007 \(523kb .pdf\)*](#), a comprehensive storehouse of energy statistics and data on energy consumption, supply sources, and price and expenditure information for New York State.

http://www.nyseda.org/Energy_Information/energy_facts.asp

New York State Public Service Commission

Find out more about New York State energy sources mix.

<http://www.askpsc.com/askpsc/page/?PageAction=renderPageById&PageId=a8022193f892947a1d26b67506005183#energymix>

New York State Small Wind Explorer

AWS Truewind's web-based prospecting and siting application for small wind users and installers, is an application commissioned by the New York State Energy Research and Development Authority (NYSERDA). This application offers public access to highly accurate, site-specific wind resource maps and reports.

<http://nyswe.awstruewind.com/>

Union of Concerned Scientists

Learn facts and figures about energy and human impacts and successes in the United States of America.

http://www.ucsusa.org/clean_energy/



*School Power... NaturallySM
Certificate of Recognition*



has been awarded the status of



WIND WISDOM CHAMPION

*For undertaking an in-depth exploration of wind as a renewable, clean green energy technology and
by making contributions toward the vision of a cleaner, healthier environment in your community.
Congratulations!*



NORTHEAST SUSTAINABLE ENERGY ASSOCIATION

www.nesea.org

NYSERDA

New York State
Energy Research and
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For a full size color copy go to <http://www.nesea.org/k-12/solarsailsnewyork/>