Wind Wisdom for School Power…Naturally

Intermediate Level
5-6

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 NYSERDA's School Power…Naturally[SM] program.

NESEA
NORTHEAST SUSTAINABLE ENERGY ASSOCIATION
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New York State Energy Research and Development Authority
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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.

For questions about this and other NYSERDA programs contact:
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Wind Wisdom for School Power…Naturally[sm]

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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 viewscapes 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…Naturally[SM] 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…Naturally*[SM] 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 program is appropriate for fifth through sixth grade.

Rationale & Objectives
Wind Wisdom for School Power…Naturally[SM] 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…Naturally*[SM] 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 on developing a deeper understanding of wind turbine design and siting.

4. **Act:** Students share their learning experiences and explain the concepts they learned.

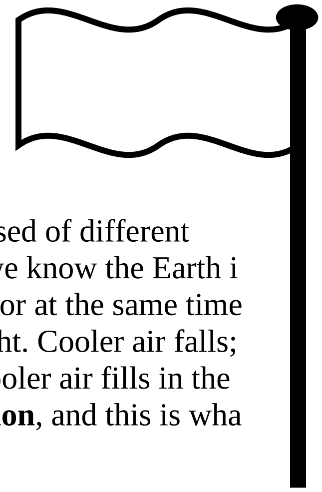
Glossary: Words that may be unfamiliar will be in bold the first time they are introduced in the unit. The definitions of these words are located in the glossary at the end of the unit.

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 2: Information Systems
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 the Wind Does

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 i 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 wha causes the air to move. This is wind.

By using our senses we know the wind is blowing. We can smell a scent on the breeze, see and hear object move. Visual and audial cues help us to assess qualitatively the speed of the wind. This 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, the **Beaufort Scale**. 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. Students explain the Beaufort Scale. Students use the Beaufort Scale to assess live data.

GRADE-LEVEL APPROPRIATENESS: 5-6

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 3. The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into phenomena.

- design charts, tables, graphs and other representations of observations in conventional and creative ways to help them address their research question or hypothesis.

Standard 2 - Information Systems: Students will access, generate, process, and transfer information using appropriate technologies.

Key Idea 1. Information technology is used to retrieve, process, and communicate information and as a tool to enhance learning.

- use spreadsheets and data-base software to collect, process, display, and analyze information. Students access needed information from electronic data bases and on-line telecommunication services.

MATERIALS:

Part	Options to obtain it
Beaufort Scale	Included in *Wind Wisdom* unit
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
LCD (Liquid Crystal Display) Projector and computer with internet access	School supplies

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.

TEACHING THE LESSON: INSTRUCTIONS

1. What is wind: Can be taught inside but if it is not raining, go outside and stand in a circle. "How can you tell the wind is blowing?" Elicit responses. "The Earth's atmosphere is made of air, which includes different gases. The sun shines on the Earth's atmosphere and heats its surfaces and the air. Since the Earth is a sphere, the sun does not reach all surface areas evenly or at the same time. When air heats it rises. The particles 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."
1. Upwind-Downwind: "How can 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 towards 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.
2. The Four Directions: "Name the four directions." Elicit responses. Correct response is: north, east, south, west. "Where does the sun rise?" Proper response: 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.”

3. Directional Wind “Upwind and downwind certainly help with understanding which way the wind is blowing. The next step is to know which direction the wind is coming from to determine the directional wind. For example, 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.”
4. Wind Speed: “We know 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 braches 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, strong, gale, 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 pushes when it is gentle verses when it is strong?” Elicit responses and write them up 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.
5. Applying the Beaufort Scale: With copies of the Beaufort Scale head outside and have students assess the wind conditions and assign a Beaufort Scale value to these conditions. Chart the wind conditions over the course a day.

EXAMPLE

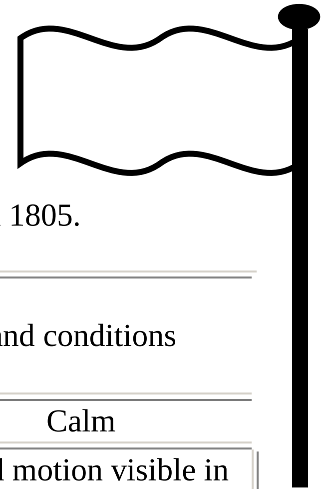
Date	**Time**	**Wind Conditions –descriptive**	**Beaufort Scale Value**
9/9/09	10:05 a.m.	Light breeze from southeast	2
	11:05 a.m.	Breezy; twigs swaying, wind from south	4
	12:05pm	Calm	0

6. Live Data Comparison: Conduct an internet search for the weather at or near the school’s location for the same day. Look for the directional wind and wind speed for confirmation on the students’ assessment of the wind conditions.
   a. Facilitate a comparative study on the school’s wind conditions versus the wind conditions at wind farms around the state on the same day.

ADDITIONAL SUPPORT FOR TEACHERS

- Heliotronics, in collaboration with the New York State Energy Research and Development Authority (NYSERDA) is developing a live wind data feed at selected schools throughout New York State. For more information on this option for live data studies contact Heliotronics at http://www.heliotronics.com/ or NYSERDA at http://www.powernaturally.org/

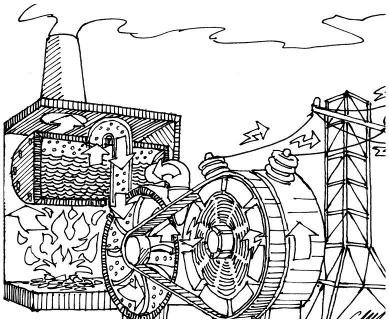
- Research and construct other wind measuring devices. There is basic information on the wind sock, wind vane, and anemometer in *Wind Wisdom for School Power…Naturally*^{SM} *K-4*.



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 2
The Electrical Generator

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 instate. New York State operates 13 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 10 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.

A **multimeter**, also called a multitester, is an electronic instrument that combines several functions into one hand-held unit. Most commonly, a multimeter can measure voltage, current, and electrical resistance. This device can be used to assess if the spinning generator is generating volts.

LEARNING OUTCOME: Design and construct an electricity generator. (application /synthesis level). Safely and accurately use the following measurement tools: voltmeter.

GRADE-LEVEL APPROPRIATENESS: Grades 5-6

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.

- Describe the sources and identify the transformations of energy in everyday life.
- Observe and describe energy changes as related to chemical reactions.
- Observe and describe the properties of sound, light, magnetism, and electricity.
- Describe situations that support the principle of conservation of energy.

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.

Key Idea 2. Technological tools, materials, and other resources should be selected on the basis of safety, cost, availability, appropriateness, and environmental impact; technological processes change energy, information, and material resources into more useful forms.

- process energy into other forms and information into more meaningful information.

Key Idea 4. Technological systems are designed to achieve specific results and produce outputs, such as products, structures, services, energy, or other systems.

- assemble, operate, and explain the operation of simple open- and closed-loop electrical, electronic, mechanical, and pneumatic systems.
- describe how subsystems and system elements (inputs, processes, outputs) interact within systems.
- describe how system control requires sensing information, processing it, and making changes.

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.

Models

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

- use models to study processes that cannot be studied directly (e.g., when the real process is too slow, too fast, or too dangerous for direct observation).

MATERIALS:

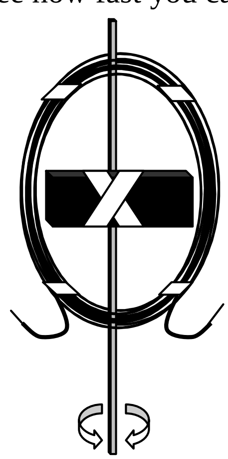
Part	Options to obtain it
Strong bar magnet, about 5 cm long, 1 per pair	electronics, hardware, toys, hobbies or science equipment, www.indigo.com
20 gauge stranded wire, 20’ per pair	electronics or hardware equipment

Multimeter, 1 per pair or share	electronics or hardware equipment
Duck tape, several strips per pair	hardware, electronics, general goods
Wire strippers, 1 per pair or share	electronics or hardware equipment
Thin wooden dowel 20-25cm long or a bamboo shish-kabob skewer, 1 per pair	hardware, general goods
Alligator clips, 2 per pair	hardware, electronics
Twist ties, 2 per pair	kitchen drawer, general goods

SAFETY: Request the students act responsibility with the equipment. Request the students keep their bodies safe by not placing fan blades close to their faces or inserting wire leads into outlets. Do not plug a multimeter into a wall outlet unless directed by someone experienced in using them. Shish-kabob skewers can be sharp. It is recommend that they sharp tips are cut off prior to the activity.

TEACHING THE LESSON: INSTRUCTIONS

1. Coil 20’ 20 gauge stranded wire in a loop shape through which you can move a strong bar magnet of about 5cm in size. This loop is oval shaped and approximately 4-5” in diameter. Make sure to leave a bit of wire hanging down from each end of the coil. Strip ½” off the ends of the wire. These stripped ends are where the alligator clips will be attached. Twist the stripped ends so that the wires are all together as a unit.
2. Attach the looped wire to a dowel or bamboo skewer. Use twist ties to hold the coils together and to fasten the wire coils to the skewer. Make sure the ties are loose enough for the skewer to turn freely.
3. Tape a 5cm bar magnet to the skewer in the middle of the looped wire without the magnet touching the wire.
4. Spin the dowel or skewer and see how fast you can get the magnet to spin.



5. Using alligator clips, connect one pointed probe to one end of the wire coil and the other probe to the other end. Make sure leads and probes are securely connected. Also make sure that the red test lead is connected to the “VΩmA” jack and the black lead is connected to the “COM” jack.

6. To test the generators, turn on the multimeter and set it to dc (direct current) millivolts; this is the lowest, most sensitive voltage setting. Spin the magnet by rubbing the dowel between your fingers. The multimeter will read zero volts when the magnet is still and should show that a voltage is being generated when the magnet is spinning. The meter may show a negative voltage depending on the direction it is spinning.

ADDITIONAL SUPPORT FOR TEACHERS

Gain a solid introduction to electromagnetism and electrical principles and see photos of some real items, including Faraday's models at the Virtual Museum of the Institute of Electronic and Electrical Engineers, Inc. (IEEE):
www.ieee-virtual-museum.org/exhibit/exhibit.php?id=159249&lid=1

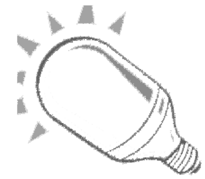
A child-friendly introduction to electricity can be found at the Department of Energy, Energy Information Administration: www.eia.doe.gov/kids/energyfacts/sources/electricity.html

Learn about Faraday's discovery of Electromagnetic induction at this Florida State University and National High Magnetic Field laboratory web site:
http://micro.magnet.fsu.edu/electromag/java/faraday2/index.html

Find out what is inside a wind turbine and how they work:

- A labeled diagram of a wind turbine with definitions from the United States Department of Energy: www.eere.energy.gov/windandhydro/wind_how.html#inside
- A clear, accurate, printable and concise fact sheet on wind turbines can be found at the UMASS Renewable Energy Research Laboratory:
www.ceere.org/rerl/about_wind/RERL_Fact_Sheet_1_Wind_Technology.pdf
- Details about the insides of a wind turbine and how they work.
Danish Wind Energy Association: www.windpower.org/en/tour/wtrb/electric.htm
- Fun and informative animated site that is child-friendly:
www.windpower.org/en/kids/index.htm?d=1

Lesson 3
Just Add Wind



Lighting a Light Bulb with Wind

Adapted from *Energy Thinking, © 2008, NESEA*

BACKGROUND: 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: 5-6

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.

- describe the sources and identify the transformations of energy observed in everyday life.
- observe and describe the properties of sound, light, magnetism, and electricity.

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

- describe different patterns of motion of objects.
- observe, describe, and compare effects of forces (gravity, electric current, and magnetism) on the motion of objects.

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.

Key Idea 2. Technological tools, materials, and other resources should be selected on the basis of safety, cost, availability, appropriateness, and environmental impact; technological processes change energy, information, and material resources into more useful forms.

- process energy into other forms and information into more meaningful information.

Key Idea 4. Technological systems are designed to achieve specific results and produce outputs, such as products, structures, services, energy, or other systems.

- assemble, operate, and explain the operation of simple open- and closed-loop electrical, electronic, mechanical, and pneumatic systems.
- describe how subsystems and system elements (inputs, processes, outputs) interact within systems.

- describe how system control requires sensing information, processing it, and making changes.

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.

- use models to study processes that cannot be studied directly (e.g., when the real process is too slow, too fast, or too dangerous for direct observation).

MATERIALS:

Part	**Options to obtain it**
Sources of Electricity visual aid	Included in *Wind Wisdom* unit
Wind Turbines Connected to Electricity Grid visual aid	Included in *Wind Wisdom* 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, 1 per pair	Electronics

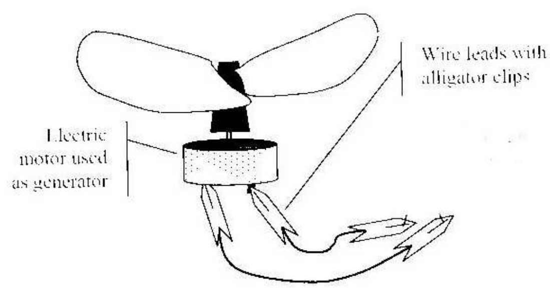
SAFETY: If you are using Light Emitting Diodes (LEDs) keep bulbs away from the face. Always when working with glass, safety goggles are recommended. Be advised: Though **resistors** are not required with this lesson, as a fan will not spin the motor fast enough to develop the output that may destroy 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.
3. What is electricity?: "Electricity is the flow of electrical power or charge. Electricity is a secondary energy source, which means that it is converted of 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, the water flows."

4. Where does electricity come from?: “We can produce electricity from a variety of sources; the sun, moving water, burning coal or gas, or the wind. When we use the wind we employ big turbine blades in the sky to catch the wind. The wind spins the blades and makes a generator, a big motor, spin and this creates electricity.” (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 generate a voltage reading on a multi-meter and with enough energy can turn on a light bulb; but the motor needs help. First we will connect a multi-meter to the motor using metal wire. (Demonstrate; connect the multi-meter to the motor with the alligator clips and wire leads.) It needs an energy source. If we attach a miniature fan to the motor we can get a reading but how?” Elicit responses. Proper responses include
    a. The multi-meter will show a volt reading, if we get the fan blades to spin.
    b. If we blow on the fan blades and they spin, the spinning blades will turn the magnet inside the motor, generating power, and the multi-meter will show that.

   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. To test the mini wind generators, tell the students to turn on the multimeter and set it to dc millivolts; this is the lowest, most sensitive voltage setting. The multimeter will read zero volts when the fan is not in motion and should show that a voltage is being generated when the fan is spinning.



7. 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 multi-meter to get a reading. Discuss and compare the readings the students got from the multi-meter.
8. Once the students recognize that the spinning fan, this mini wind turbine, is generating power the next part of the experiment is to disconnect the multi-meter and connect the motor to a small LED (light emitting diode).
    a. Note: Usually when placing an LED in a circuit a resistor is also placed in the circuit. LEDs are very sensitive to current charges and are easily damaged. However, the hobby motors in use develop their power at high RPMs, and a fan that fits onto the motor will not spin the motor fast enough to develop the output that may destroy the LED. Since LEDs are either off or on, changing the resistance will not change the brightness. If you choose to work with resistors start with a explanation of resistors and **Ohm’s Law**. An explanation of resistor color coding will be needed. Students can then check the resistance of the resistors using a multimeter. This may be an EXTENTION option.
9. Inquiry: 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 force enough breath out to blow on the fan blades and make them spin, allow time for experimentation with, "who has the strongest lungs?"
b. If the LED does not light up, suggest to students to try reversing the leads.

10. 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 who have chosen to use a secondary source, such as another fan, ask them where the larger fan is getting its source of energy. Appropriate responses or teacher provided responses are:
        - 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.
11. 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, yes, but 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.
12. Conditions for a Wind Turbine: Ask the students to come up with conditions they think are needed for a full-scale 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 to spin.
    c. The turbine would need to be connected to the light bulbs in some way so that it could turn them on.
    d. The turbine will need to have a working generator to change mechanical energy into electrical energy.

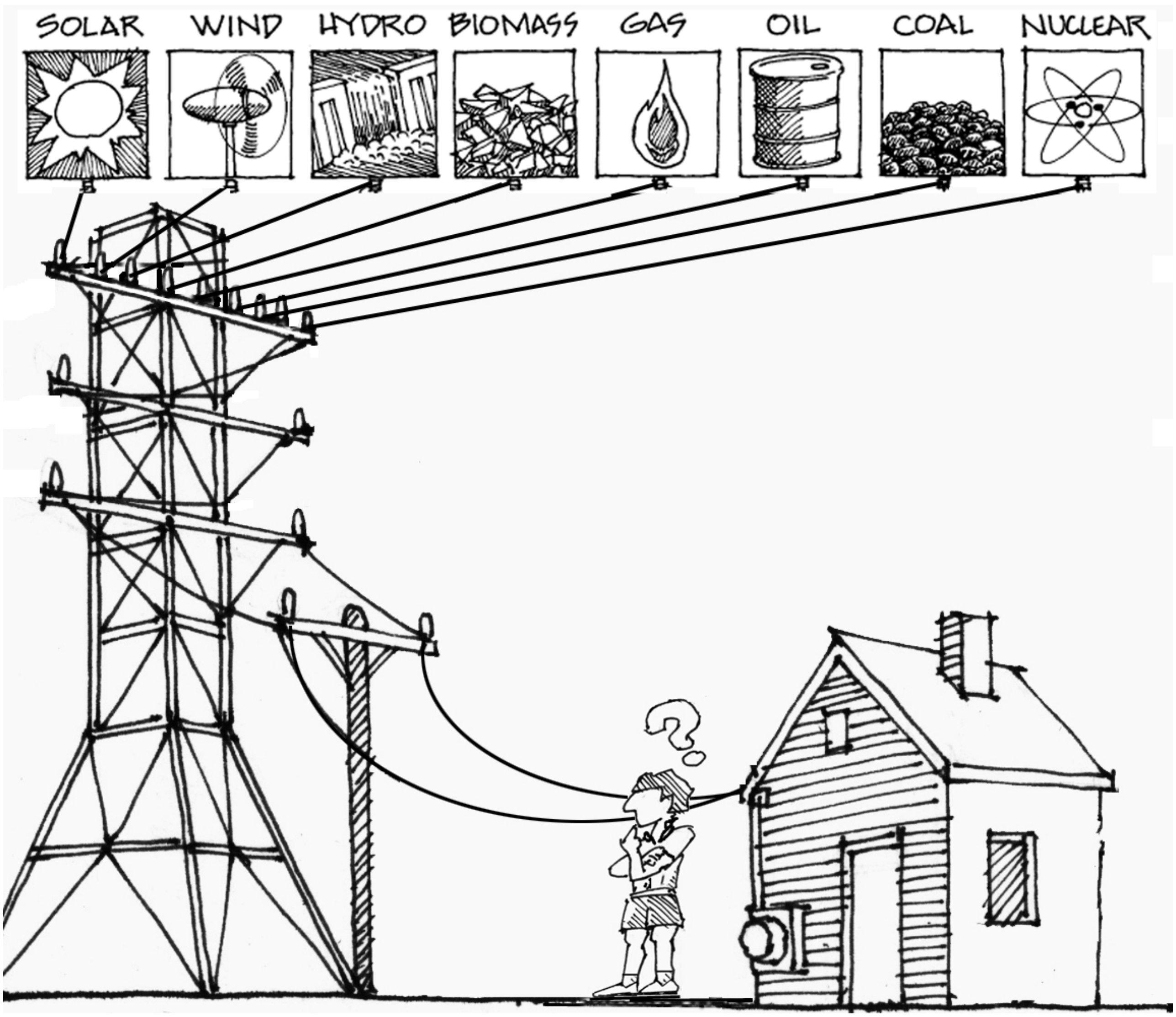
EXTENTIONS:

- Energy Transformations: Diagram the process of energy transformation from the above lesson. Beginning with the sun and radiant energy, a plant transformed the sun's energy into chemical energy and a human child ate the plant and that gave strength to make the child's muscles work – mechanical energy. The child blew on the fan blades, transforming the energy into motion - kinetic mechanical energy. This led to the transference of blades spinning to the generator operating – electrical energy, which turned the LED on.

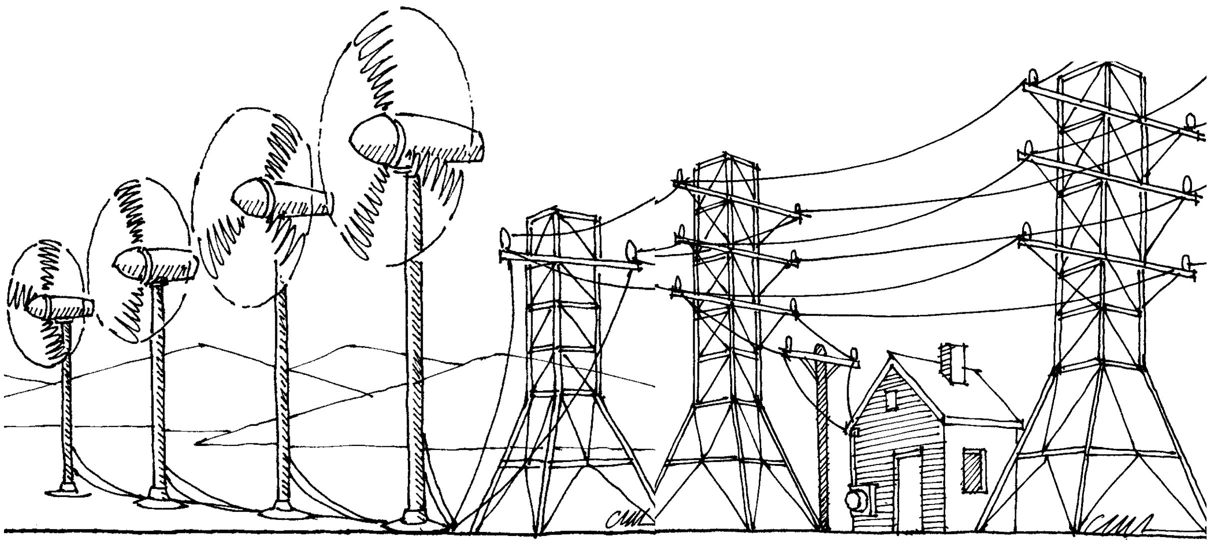
  EXAMPLE:

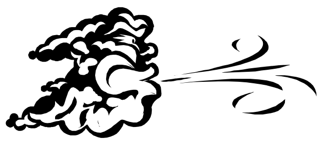
SUN →	kinetic →	kinetic →	electricity		
Light/heat	moving air	moving coil	flow of electrons		
SUN →	chemical →	mechanical →	mechanical →	kinetic →	electricity
Light/heat	food	muscles	moving air from blowing	moving coil	flow of electrons

Energy Sources to Create Electricity



Wind Turbines Connect to the Electric Grid to Generate Electricity





Lesson 4
Inheriting the Wind

BACKGROUND: Electricity is generated when there is a magnetic field moving relative to coils of wire. It induces electrons to flow creating electricity. All you need is something to cause the magnet or the coil to spin. Water turns turbines because it falls due to gravity. Nuclear, coal, oil, and gas are used to boil water to create steam, which can do the work of turning the turbines. Then there is wind. The power of the wind turns the turbines, which then forces the magnets (or the coils) in the generator to spin. Charles Brush, an inventor from Ohio, built the first wind turbine in the United States for electrical generation in 1888.

In 1891, Poul La Cour, a Dane inventor, capitalized on Brush's invention and developed the first electrical output wind machine incorporating the aerodynamic design principles used in European tower mills. Cour's four-blade design was faster than the "picket-fence" design of Brush. By the end of World War I, the use of Cour's 25 kilowatt wind turbines had spread throughout Denmark, only to be put of business by cheaper and larger scale fossil-fuel steam plants. Still, the concept of using the wind to generate electricity did not completely fall by the wayside. By 1920, and continuing into the present day, inventors have tweaked and tinkered to discover what wind turbine designs would generate significant enough amounts of electricity to compete in the marketplace with other types of energy. For example, as recently as between the late 1970s to early 1980s wind cost as much as forty cents per **kilowatt hour.** Today electricity generated from wind energy costs just four to six cents per kilowatt hour, which is competitive with other conventional technologies including coal at 5 cents, natural gas at between 5-6 cents, and nuclear at 6.5 cents.

Nationally and in New York State wind energy generation is at about 1%. The wind energy industry seeks a national standard for increasing renewable electricity, including increasing wind to 25% by 2025. Comparatively, New York State seeks to increase the use of in-state renewable energy, including wind, to 25% by 2013. "The New York State Energy Research and Development Authority (NYSERDA) has funded major projects to map New York's wind and encourage the development of wind power across the State. With assistance from NYSERDA, several large-scale wind farms have been developed in New York State, and several other projects are at various stages of development." (NYSERDA, "Large Turbines: Commercial Applications")

Through advancing technologies in wind energy engineering, wind energy is a viable option for generating electricity and is here to stay in the energy generation mix.

LEARNING OUTCOME: Students research wind as a power source (application level) Students create a timeline of wind as a power source. (synthesis level)

GRADE-LEVEL APPROPRIATENESS: 5-6

LINKS TO MST LEARNING STANDARDS AND CORE CURRICULA:
Standard 2: Information Systems: Students will access, generate, process, and transfer information using appropriate technologies.

Key Idea 1. Information technology is used to retrieve, process, and communicate information and as a tool to enhance learning.

- systematically obtain accurate and relevant information pertaining to a particular topic from a range of sources, including local and national media, libraries, museums, governmental agencies, industries, and individuals.

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 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.

Key Idea 5. Technology has been the driving force in the evolution of society from an agricultural to an industrial to an information base.

- describe how new technologies have evolved as a result of combining existing technologies (e.g., photography combined optics and chemistry; the airplane combined kite and glider technology with a lightweight gasoline engine).

LINKS TO SOCIAL STUDIES LEARNING STANDARDS & CORE CURRICULA:
Grade 5: History of the United States, Canada, and Latin America: Types and availability of resources are important to economic development; Science and technology have influenced the standard of living.

TEACHING THE LESSON: INSTRUCTIONS

1. Ask what the students know about wind energy or "wind power" and how humans discovered we could use the wind to create electricity.
    a. In science, the term "power" has a specific, mathematical relationship based on its definition, i.e. the rate at which work is done. Return to this definition when discussing the term "power." Note that the appropriate terminology is "wind energy" when discussing this subject.
2. Have the students research wind as an energy source. How has its use progressed through time into present use? Consider including research on wind industry growth. Ask students how big an industry they think wind is in New York and what they think is the percentage of wind energy used in New York State compared to the United States. Ask them what they are basing that number on. Is it a random guess? Have they heard statistics on wind energy use in New York or in the country? As they are researching wind energy usage in New York State they will asses how close they were to the actual percentage.
3. Students will then create a timeline of wind as an energy source. How was it used and in what contexts?
    a. This timeline can be done individually or in small groups. You may allow for creativity of pictorial timelines.
    b. You can also add complementary inventions, such as the anemometer, for inclusion in the timeline.

    c. You can also facilitate this activity as an introduction to subsequent activities by putting a timeline up on the board.
4. Students take turns presenting findings. What historical and scientific facts did they discover and what were their sources? Were they primary sources. i.e. source material that is closest to the person, information, period, or idea being studied such as original resource papers or historical records or documents? What and when were the scientific breakthroughs on wind energy technologies? Were there any interesting facts that they followed through history as an offshoot such as the development of anemometers to assess wind speed?
    a. If you provided the sources, then a comparative dialogue is not necessary to assess accuracy of student sources.

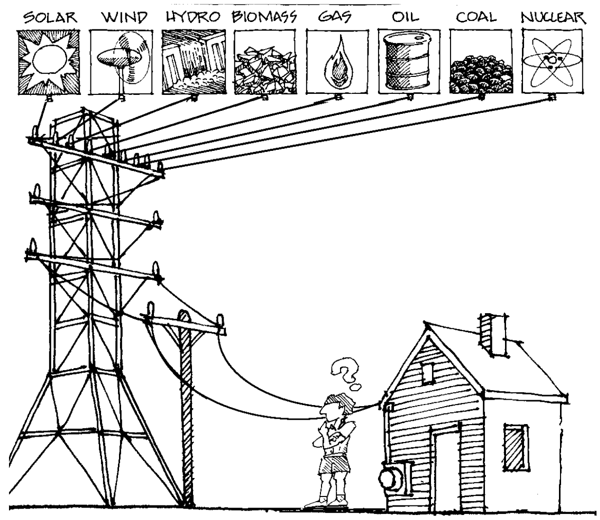
EXTENSIONS:

- Have students track an inventor through his or her life to study his or her contribution to advances in the field of wind energy technology.
- Compare costs of wind energy to other forms of energy used in New York State. Have them create a comparative chart to assess where wind power stands in relation to use and cost per cents per kilowatt hour.
  Research tips include:
    - Use web-based search key phrases: "cost of a kilowatt-hour", "cents per kilowatt hour", wind energy cost per kilowatt hour
    - Have students reference where they found the figures, and given the source, do they think the comparison is a fair assessment? If they do not know, ask them how they might find out.

RESOURCE & ADDITIONAL SUPPORT FOR TEACHERS:

- U.S. Department of Energy, Energy Information Administration: online monthly reporting of energy use by source.
  http://www.eia.doe.gov/cneaf/electricity/epm/epm_sum.html
- American Wind Energy Association: provides information on wind energy costs comparative to other forms of energy and fact sheets on applications of wind energy. Under Publications, see annual report. http://www.awea.org
- Pure Energy Systems: lists comparisons of cents per kilowatt hour
  http://peswiki.com/index.php/Directory:Cents_Per_Kilowatt-Hour
  As does their original reference Cold Energy http://www.coldenergy.com/difference.htm
- Illustrated History of Wind Power Development by Darrel M Dodge
  http://www.telosnet.com/wind/index.html
- New York State Energy Research and Development Authority (NYSERDA):
  "Large Turbines: Commercial Applications"
  http://www.nyserda.org/programs/pdfs/largewindturbines.pdf
  Wind Energy Toolkit: This website provides information on all the various aspects of wind energy development.
  http://www.powernaturally.org/programs/wind/toolkit.asp
  Patterns and Trends - New York State Energy Profiles: 1993-2007
  http://www.nyserda.org/energy_information/energy_facts.asp

Lesson 5
Why wind?



BACKGROUND: According to a 2009 report by the American Wind Energy Association (AWEA), "the U.S. wind energy industry brought online over 8,500 megawatts (MW) of new wind power capacity, increasing the nation's cumulative total by 50% to over 25,300 MW." Comparatively, New York State added 407 megawatts of new capacity in 2008 and currently (2009), generates 1260.8 MW, ranking New York seventh in the country for existing wind power generation and fifth for most capacity added in 2008. (AWEA, *Annual Wind Report*, 2009; "U.S. Wind Projects by State", 2009). Though wind adds only small percentage of New York's total energy portfolio, less then 1%, and comparatively all wind projects combined in the US comprise only about 1.25% of the total energy portfolio, a 2008 report by the New York State Energy Research and Development Authority (NYSERDA) appears hopeful. The report reminds New York citizens that, given the 2004 order of a Renewable Portfolio Standard (RPS) by the New York State Public Service Commission, the "…goal of increasing the proportion of renewable energy used by New York consumers from the then-current 19.3% (baseline resources) to at least 25% by the end of 2013" is within reach. (NYSERDA, *RPS Performance Report*, 2008) Interestingly, the new installations throughout the U.S. do project the country toward the U.S. Department of Energy's goal to generate 20% of the nation's electricity by 2030 from wind energy, strengthening the nation's electricity supply with a clean, inexhaustible, homegrown source of energy. For this goal to succeed, however, the wind industry must continue to garner long-term policy support. (DOE, *20% Wind Energy by 2030*, 2008).

To develop critical thinking, students need to analyze the information they are taking in whether it be from a scientific report, news article or other media source, or expert. Questions for students to consider while reading an article:

- What is the information's source?
- Has it proven to be reliable?
- What is the source's agenda?
- Does the source remain open to other facts or opinions?

Sources on the subject of wind energy to review:

- Local and regional news articles
- State and federal government reports and bulletins
- Expert periodicals, interviews, scientific research papers
- Opinion pieces, letters-to-the-editor, blogs
- Wind Industry and watch-dog groups' infomercials

LEARNING OUTCOME: Students collect news articles from various sources and assemble them categorically (synthesis level). Students, through presentation and discussion, analyze and evaluate the news information they have collected on wind power.

GRADE-LEVEL APPROPRIATENESS: 5-6

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.

- formulate questions independently with the aid of references appropriate for guiding the search for explanations of everyday observations.
- seek to clarify, to assess critically, and to reconcile with their own thinking the ideas presented by others, including peers, teachers, authors, and scientists.

Standard 2 – Information Systems: Students will access, generate, process, and transfer information using appropriate technologies.

Key Idea 1: Information technology is used to retrieve, process, and communicate information and as a tool to enhance learning.

- systematically obtain accurate and relevant information pertaining to a particular topic from a range of sources, including local and national media, libraries, museums, governmental agencies, industries, and individuals.

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.

Skills and Strategies for Interdisciplinary Problem Solving

Gathering and Processing Information: Accessing information from printed media, electronic data bases, and community resources and using the information to develop a definition of the problem and to research possible solutions.

LINKS TO SOCIAL STUDIES LEARNING STANDARDS & CORE CURRICULA:
Grade 5: History of the United States, Canada, and Latin America: Types and availability of resources are important to economic development; Science and technology have influenced the standard of living.

TEACHING THE LESSON: INSTRUCTIONS

1. Read the above background information and ask the questions listed above. This introduction will model the type of information you are requesting your students to gather and the questions on which to reflect.
2. Have your students research primary and secondary sources: periodicals, scientific research papers, newspapers, magazines, web sites, radio, television, and other news sources for mention of wind energy. They will need to clip, record, or print a few of their findings and be prepared to share them. They will need to address what their sources are and if they are primary, scientific research, or secondary, reports on the primary sources.
3. Create space for the students to post their findings for all to review. Provide time for small groups of students to review new postings.
   a. Option: Create a display of wind articles by category: pro, neutral, and con. Have the students decide where they think their articles belong. Prepare them to defend their reasoning.
4. Have students report their findings to the class. To get a discussion started, here are a few suggested questions to apply to articles your students find. See student handout.
   a. What caught your attention in this article?
   b. How reliable is the source, and what makes you think so?
   c. Does the author or publisher have something to gain from this view?
   d. What might the opposite point of view be and why?
   e. What additional information is needed, and what new questions are raised?
   f. If wind is not used to generate power, then what are the alternatives, both currently and in the future?
5. Generate a list of pros and cons for wind, based on student research.
   a. Ask: "How would we go about assessing the validity of the claims of both sides? What are actions we can take toward assessment?" Elicit responses and generate an action plan for further study. Students will generally decide the most effective way to ascertain the truth is to receive it firsthand. When possible, site visits will provide the most conclusive evidence along with interviews with experts in the fields and neighbors of the wind farms.

EXTENSIONS:

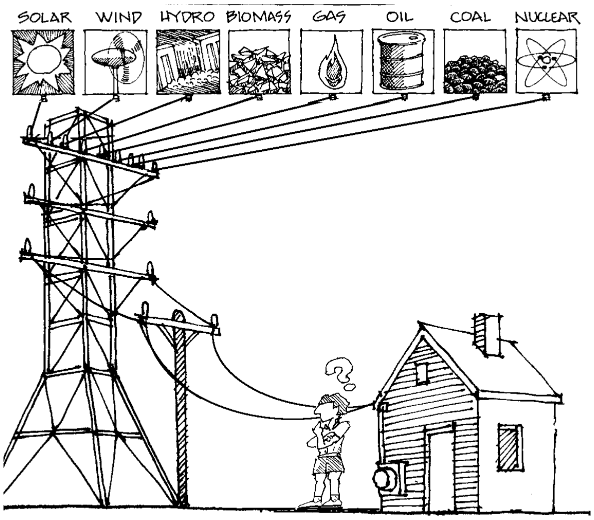
- Watch video clips, news reels, and infomercials on wind energy from a variety of sources to ascertain the message behind the footage.
  - Option: run an experiment by having half the class watch pro-wind first and the other half watch anti-wind first and then watch the opposite video clips second. After watching the videos, ascertain if there is difference between the pro-wind verses anti-wind sentiment from who watched which type of video clips first. Discuss the concept of propaganda with your students and the importance of keeping an open mind to all sides and making sure that all the facts are presented prior to forming an opinion.
    - When reviewing videos, keep in mind that any private citizen or town meeting video may have inappropriate and/or vulgar language. Discretion is advised.
  - Web-search key phrases: "New York Wind Power", "wind turbine sound."

REFERENCES & ADDITIONAL SUPPORT FOR TEACHERS

- Reports on wind energy
  - American Wind Energy Association http://www.awea.org
  - New York State Energy Research and Development Authority http://www.nyserda.org

Why wind?

Student Handout

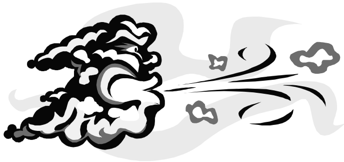


Instructions:
Examine newspapers, magazines, web sites, radio, television, and other news sources for mention of wind energy. Clip, record, or print a few of your findings and be prepared to share your findings and your reflections with the class. You will be assessed on your ability to:

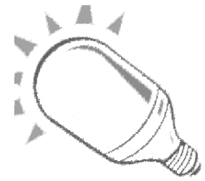
- Research the topic of wind and assess relevancy of each source for providing useful information on the topic;
- Present information and opinions and have the ability to distinguish between facts and opinions; and
- Defend your position on what makes an information source trustworthy.

Questions to consider throughout the process regarding each informational piece:

- What caught your attention in this article, report, opinion piece, etc?
- How reliable is the source, and what makes you think so?
- Does the author or publisher have something to gain from this view?
- What might be the opposite point of view and why?
- What additional information is needed, and what new questions are raised?
- If wind is not used to generate power, then what are the alternatives, both currently and in the future?



What have you learned about wind energy?



Part 1

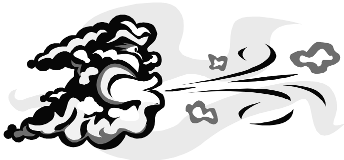
Describe how wind is created.

Who is Charles Brush and what did he do?

Describe how a generator works.

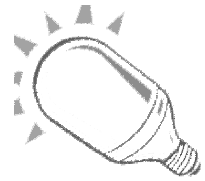
What is a primary source, both in terms of energy sources and information sources?

Label the Beaufort Scale number values and corresponding description and draw a picture of each (0-12).
You may the other side of this sheet.



What have you learned about wind energy?

Part 1 – TEACHER ANSWER SHEET



Describe how wind is created.

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 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.

Who is Charles Brush and what did he do?

Charles Brush was an American inventor who in 1888 built the first wind turbine for electrical generation.

Describe how a generator works.

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. The coils of wire in a generator are attached to a central shaft that can be turned by an outside force.

What is a primary source both in terms of energy sources and information sources?

Primary sources of energy include; coal, natural gas, oil, nuclear, wind, water, solar, and other natural resources.

Primary information sources include: historical records and documents, original research papers, or any source material that is closest to the information or idea being studied

Label the Beaufort Scale number values and corresponding description and draw a picture of each (0-12). You may the other side of this sheet.

Refer to the Beaufort Scale in *Wind Wisdom for School Power…Naturally*^{SM} for assessing students drawings and descriptions.

CHAPTER 2: EXPLORE

Lesson 6
Exploring 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: 5-6

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.

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.

- formulate questions independently with the aid of references appropriate for guiding the search for explanations of everyday observations.
- seek to clarify, to assess critically, and to reconcile with their own thinking the ideas presented by others, including peers, teachers, authors, and scientists.

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.

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

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.

Connections

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.

MATERIALS:

Part	**Options to obtain it**
Wind turbine image	Included in *Wind Wisdom* unit

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.
        - 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:
    a. "A wind turbine uses the wind to make electricity. The blades spin in the wind and are connected to a generator. This generator then converts the mechanic energy of the blades spinning to electric energy so that we can use it to turn on the lights."
    b. Make some predictions or hypotheses about the experience: "What are some things you have heard about wind turbines or wind farms?" Elicit responses. Based on the response create a list of student hypotheses of what they think the wind turbines will look like and sound like at various distances. For example:

Prediction / Hypothesis	How Many Students Think Is True
A fan makes noise. The wind turbine will also make noise.	
Wind turbines are big. We will see them from a distance. (Choose set distances in miles or kilometers.)	

i. After the site visit assess the hypotheses 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:
    - What is the power rating of this turbine (kilowatts or megawatts) and what does this mean?
    - What was the community response before and after installation? What were or are the primary concerns?
    - How many houses or businesses can be served by the output of this turbine or wind farm?
    - Is it part of a local power plant, independent, or grid tied to a regional power network?
    - Is there a cost saving or cost stabilization benefiting some customers directly?
    - Why did you choose this as a career?
    - What educational background do you apply to your work?
    - How long have you been doing this?
    - What skills and knowledge do you use the most in your daily work?
    - What are the most interesting and/or exciting aspects of your work?
    - What are the most challenging and/or tedious aspects of your work?

    Tell 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 or hostess ahead of time if it is okay to record images or voices and let them 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

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

1. Virtual Wind Generation Facilities Tour
   Site Options
   - Conduct an internet search on "virtual plant tour, wind energy" or "wind generators, virtual tour." You will need some form of media player to run tours.
   - *School Power…Naturally*^{sm} (SPN) has live data streaming from school sites the use wind energy. SPN also provides links and resources, such as the New York Wind Power video and NYSERDA sponsored wind power projects. http://www.powernaturally.org/programs/SchoolPowerNaturally/
   - Heliotronics, Inc. provides live data streaming from wind turbine sites and lessons to compliment observations. http://www.heliotronics.com/educators/teacherzone.html
2. 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. Web 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.
3. 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:
   a. What do you do? What does your day look like?
   b. Why did you choose this as a career?
   c. What did you study in school that helped you prepare for this job?
   d. How long have you been doing this?
   e. 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.

   f. Prior to the presentation, ask if the presenter has any wind energy props that she or he can bring in to show the students.

g. Prep 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.

4. 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.

ADDITIONAL SUPPORT FOR TEACHERS

- Virtual Solar Array Tour for Teachers, part of the "In the Classroom" of NYSERDA's *School Power…Naturally*^sm program. Background lessons on virtual tours using live data from New York State Schools who participate in "On the School Roof" solar array program. http://www.powernaturally.org/programs/SchoolPowerNaturally/
- Heliotronics offers Virtual Solar Array tours and lessons from live Solar Learning Labs^Tm. Use these data streams to compare wind as a renewable energy resource and gain greater understanding in environmental factors that can limit or enhance a particular energy resource. The lessons on the "On the Roof" from the School Power…Naturally^sm site are from this company. http://www.heliotronics.com/educators/educ_main.html
- Institute for the Applications of Geospatial Technology (IAGT)
  Creates maps for online use. Creates comparative maps of current wind projects and potential projects. Plots school sites for comparative studies between school districts.
  http://www.iagt.org/focusareas/edu.aspx
- 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 7
Creating Electricity with Wind Energy

BACKGROUND: Energy occurs in many forms and is classified as either potential energy (stored) or kinetic energy (in motion) and can be converted from one form to another. Wind energy is a form of kinetic energy, energy in motion. More specifically, wind energy is a form of mechanical energy. Wind has the ability to move wind turbine blades and in the act of making them spin, spin an electrical generator, thereby creating electrical energy, electricity.

Renewable energy sources are those that are naturally and continually replenished. They tend to be more environmentally sustainable and less damaging to our health, the health of wildlife, and the environment on which life depends. Wind is an example of a clean, green renewable energy source.

LEARNING OUTCOME: Students comprehend how wind acts through inter-active simulation of electrical generation by wind energy.

GRADE-LEVEL APPROPRIATENESS: 5-6

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

- observe, describe, and compare effects of forces (gravity, electric current, and magnetism) on the motion of objects.

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.

Systems Thinking

Key Idea 1. Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

- describe how the output from one part of a system (which can include material, energy, or information) can become the input to other parts.

Models

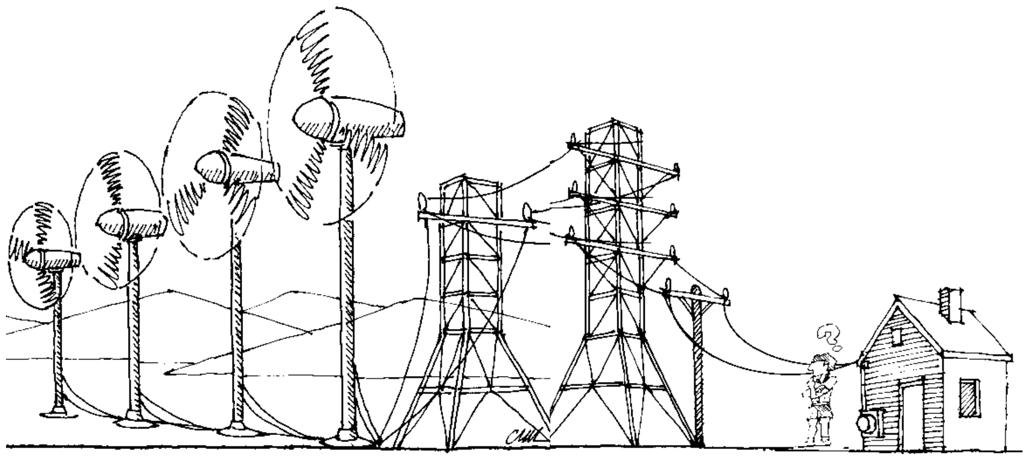
Key Idea 2. Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

- use models to study processes that cannot be studied directly (e.g., when the real process is too slow, too fast, or too dangerous for direct observation).

MATERIALS:

Part	Options to obtain it
Jump rope	Gym supply room, sporting goods
Chalk	Gym supply room, toy store

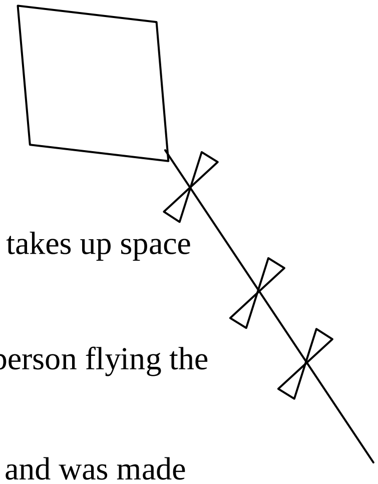
SAFETY: Use a flat playing area clear of debris.



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 real process as they mimic it with their bodies.
2. "In this activity we are going to simulate wind energy converting to electricity. I will call on a few of you to act out a piece of the process. Through our simulation, together we will reconstruct a wind energy system.
3. "I need a few people to represent the wind. You will stand facing this way (point to the direction you will set up the group) and blow." Get three to four students in the act blowing their hardest in one direction.
4. "The wind is blowing strongly here on this hilltop, a great spot to build a wind turbine to generate electricity. So now I need wind turbines that will spin in the wind." Bring in three to four students to act as wind turbines blades spinning in the wind. Students will stand, oriented to the directional wind (facing into the wind) and rotate one arm, their blades, on a vertical plane clockwise.
5. "We need a generator to convert this mechanical energy into electrical." Bring in four more students to act as the generator. One person will extend one arm towards the wind turbines and rotate one arm on a vertical plane clockwise. That student will then connect his or her other hand to the rest of the generator. The generator needs two people to form the coil of wires. Hand them a jumping rope. The forth person forming the generator is the magnet. He or she stands in between the students holding the coils (the jumping rope). Students with the coils start to spin the rope and the person who is the magnet jumps the rope. Tell the students that this represents a change in energy, mechanical energy, a force in motion to electrical energy. The coil of wire experiences a changing magnetic field as the magnet in the generator spins.

6. “So what do we do with this energy?” Ask a few remaining students to be power lines connecting the generator to a house. The house can be represented by drawing a square in chalk around the last student. The electrical energy travels through the wires to the house. The students acting as the power lines form a line holding hands and move their arms in a wavelike fashion to represent the energy moving through them. The energy or wave starts at the generator and moves towards the house. (Refer to the game “Pulse” whereby one person squeezes the hand of another then that person can squeeze the hand of the next person and so forth until all participants have felt a squeeze and given a hand squeeze in turn.) When the person inside the house sees the last arm wave – the one that is connected to the imaginary wall of the house - the person inside pretends to flip a switch imagining s/he has just turned on a light.
7. Now that all the pieces are together let the students practice working together, each part in turn moving until the person in the house turns on the light. Practice going slow and then fast.
8. Review the concept of electricity and how wind can make electricity while the students are still in formation. Ask each group what their purpose was in the demonstration.



Lesson 8
Let's Go Fly a Kite:
Siting Investigations

BACKGROUND: When kites fly, they change the air flow. The kite's surface takes up space and forces the air to go around the kite. Two factors keep kites aloft:

- the flow of air around and over the frame of the kite; and
- a kite's resistance to wind, which is provided by the string held by the person flying the kite.

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 sites are best for the production of electricity using wind. (Evaluation level).

GRADE-LEVEL APPROPRIATENESS: Grades 5-6

SAFETY: Be sure where you fly a kite is safe from overhead wires.

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.

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.

- locate and utilize a range of printed, electronic, and human information resources to obtain ideas.
- consider constraints and generate several ideas for alternative solutions, using group and individual ideation techniques (group discussion, brainstorming, forced connections, role play); defer judgment until a number of ideas have been

generated; evaluate (critique) ideas; and explain why the chosen solution is optimal.

- develop plans, including drawings with measurements and details of construction, and construct a model of the solution, exhibiting a degree of craftsmanship.
- in a group setting, test their solution against design specifications, present and evaluate results, describe how the solution might have been modified for different or better results, and discuss tradeoffs that might have to be made.

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.

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

- consider constraints and generate several ideas for alternative solutions, using group and individual ideation techniques (group discussion, brainstorming, forced connections, role play); defer judgment until a number of ideas have been generated; evaluate (critique) ideas; and explain why the chosen solution is optimal.
- develop plans, including drawings with measurements and details of construction, and construct a model of the solution, exhibiting a degree of craftsmanship.
- in a group setting, test their solution against design specifications, present and evaluate results, describe how the solution might have been modified for different or better results, and discuss tradeoffs that might have to be made.

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 or hot glue gun and glue sticks Heavy plastic, large sheet of heavy weight paper, or ripstop nylon, 1 per pair String, approximate 25 meters per pair Spool or toilet paper roll, 1 per kite Survey flagging tape 6 meters per pair plus 12cm lengths for ties, 5 per pair	hardware store classroom supplies, hardware store grocery store facility that has old parachutes for salvage hardware store, grocery store bathroom (save rolls) or fabric store hardware store
Beaufort Scale	Within *Wind Wisdom* unit
Wind	It's FREE! Head outside

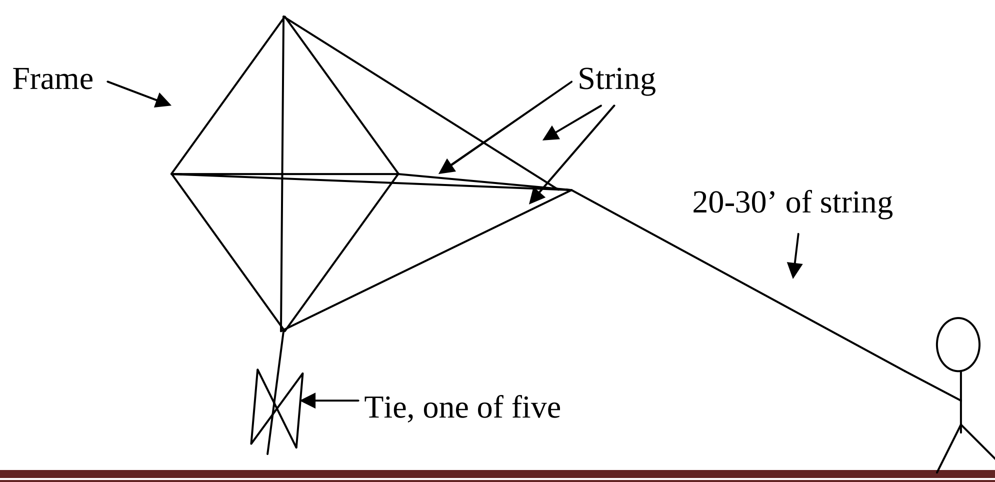
TEACHING THE LESSON: INSTRUCTIONS

1. "We saw and felt the conditions at the wind turbine site. What are ways we could assess if our school, or a site within walking distance, has conditions that might be suitable for a wind turbine to operate?" Elicit responses.

2. Introduce the kite: “How does a kite stay aloft?” Elicit responses. Appropriate responses include:
    a) The wind keeps it up.
    b) When I pull on the string and run with it the kite will stay up.
    c) When I pull on the string attached to the kite and the wind pushes against it.
3. 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:
    a) You can fly a kite on a windy day.
    b) If the kite stays up then it is windy.
4. Kite construction: This is a great opportunity for an inquiry lesson in aerodynamic design. Working individually or in small teams, have students design and construct a kite. Provide them with time for research and development.
    a) Parameters:
        i. Kite must have a long tail with one tie every meter and a total of five ties. Ties will be used to help determine air turbulence at various altitudes at the range where a wind turbine’s blades would be spinning.
        ii. Kite must be designed for ability to catch the wind and stay aloft. For this activity, steadiness in the air is more important than any ability to perform tricks such as diving or looping.

ALTERNATIVE OPTIONS

1. Purchase pre-fabricated kites, enough for students to work in small groups.
2. Have students construct a set design of one type of kite. There are several tutorials available to construct a kite. Basically:
    b) 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. Affix with a sturdy tape or hot glue.
    c) Form and attach a plastic, paper, or fabric sheet to the frame.
    d) Hole punch sheet at the tips where frame meets sheet at all four tips.
    e) 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 then come together without folding the sheet.
    f) 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.



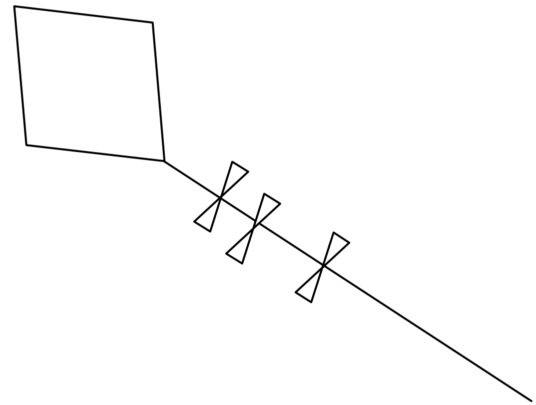
5. Kite Flying: Fly the kites on a variety of days to assess how to define windy conditions in a particular location. Discuss safety when sending the kite aloft and be aware of one's surroundings. It is helpful to work in pairs. One student holds the kite up as high as his or her arm will reach and when 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.
6.

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

   a) When the kite is up high, have the students note and record how their ribbons are flying. They are looking for an impression of the air turbulence at different heights based on what they are observing from the ribbons they tied to the string. See student handout "Let's Go Fly a Kite." Are the ribbons straight out and flowing smoothly or rippled? Are they all streaming in the same direction?
7. Assessing the kites: Upon completion of investigations, discuss with the class the following, if students made kites: "What kites designs had the most success staying in the air? Why do you think that?"
8. 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, but before this conversation can even occur, it has 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. Also, discuss results from student handout sheets. 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 site questions to discuss why it would or would not be feasible to site a wind turbine at the location you studied.

EXTENTIONS:

- Wildlife impact study: Assess the site based on potential impacts on wildlife ,both residents and migrants. For lesson plans on this topic visit the KidWind Project and look under "Lessons and Plans." http://www.kidwind.org/
- Wind Mapping: Have students make predictions of where they think it is the windiest in their school district and where they think it is the least windiest. Conduct an internet search and/or interview a local meteorologist about the windy conditions of the area. Review predictions. Map the school district and color area by windy conditions.



Let’s Go Fly a Kite:

Siting Investigations for Students

Use the table below to keep track of your observations.

____

Name/Group

Date	Time	Wind Conditions – descriptive	Beaufort Scale Value

Kite Ribbon Observations

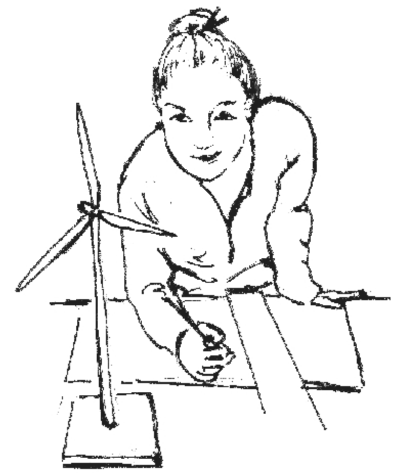
Ribbon 1 (Highest)	
Ribbon 2	
Ribbon 3	
Ribbon 4	
Ribbon 5	

<u>Questions</u>:

What might your observations say about wind speed and turbulence at the different heights?

What terrain features might affect the wind flow?

Lesson 9
From a Distance



BACKGROUND: When siting, or placing, a wind farm, accurate assessment of wind power potential and how the turbine will affect the landscape are vital. How do you get started before you begin building? Explore the various factors by building a model turbine and obtain a visual analysis of the siting potentials. When this analysis is done at the planning and development stages and prior to the installation stage, it will enable the student, as the aspiring wind power developer, to make a judicious choice regarding the site.

LEARNING OUTCOMES: Design and construct a scale model wind turbine (application/synthesis). Analyze and evaluate the effectiveness of their model wind turbine (analysis and evaluation).

GRADE-LEVEL APPROPRIATENESS: 5-6

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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.

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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.

Models

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

- select an appropriate model to begin the search for answers or solutions to a question or problem.
- use models to study processes that cannot be studied directly (e.g., when the real process is too slow, too fast, or too dangerous for direct observation).

MATERIALS:

Part	**Options to obtain it**
Dowels	Craft store
Spools	Craft store
Popsicle sticks	Craft store
Glue or hot glue gun w/glue sticks	Craft store
100’ measuring tape	Hardware store

SAFETY: If using a hot glue gun, remind students that both the nozzle and the glue are hot enough to blister the skin. Caution is recommended.

TEACHING THE LESSON: INSTRUCTIONS

1. Discuss the importance of scaled models. “Engineers use a scaled model to assess the feasibility of siting a wind turbine in a particular location. This research can help determine what the full-scale wind turbine will look like on the landscape.” Give students “From a Distance” Handout. Select a wind turbine size to model.
2. Construct a scale model wind turbine. Provide enough materials for all students to make at least one model turbine: one dowel, one spool, three popsicle sticks. Using the props and glue, students will construct a scale model wind turbine of the real turbine selected from the handout.
    a. For example, if students want to build a 40-centimeter (cm) tall scale model of a 40-meter (m) tall turbine, every centimeter of the model will represent one meter of the real one. This results in a 1 to 100 or 1:100 scale model.
3. If you and your students are interested in assessing a proposed turbine over which your community is deliberating, this exercise can be used to estimate how big proposed real turbine or wind farm will likely look from a distance. Be sure to obtain or have your students research the correct specifications to accurately assess the impact. Make sure your students ask for explanations of any unfamiliar terms, such as “rated capacity.”

4. Upon completion of the model, students will then assess how tall their turbine looks from a distance. They will select two distances away from a real turbine that that they wish to imitate and calculate how far away they need to be from their model turbine to imitate these distances.
    a. For instance, if the student wants to know what a full-size turbine would look like five kilometers away, they would need to look at a 1:100 scale model turbine from a distance of 50 meters.
    b. Math involved: Multiply the representational distance away, in this case 5,000 meters, by the scale ratio, in this case 1/100.

$$5{,}000 \times 1/100 = 50 \text{ meters}$$

    c. Make sure that the students are using the same measurement system, metric or English, and the same scale that they used to construct their model turbine to calculate these distances.
5. Have your students make a prediction about how tall their model will look from each distance. Let the students know that this is how tall a full-scale turbine would look at the full-scale distance.
    a. Tips for students: “You can do this by holding your hands apart from each other to demonstrate the height. To record your estimates, you can have someone take a picture of you, or you could hold a measuring tape between your hands and record the estimates.”
6. Bring your students with their models outside to a large flat open area such as a playing field. Have the students choose a location to place their wind turbine where they can see it while lying down on the ground from the scale distances they calculated. Taking turns with the measuring tape(s), have the students measure and walk out the distances. They can use sticks, hats, or whatever is available as distance markers.
7. Students will then lie down and observe the model turbine at the different chosen distances.
8. Ask the students observing, “Does it look larger, smaller, or the same as you imagined?” Elicit responses. “For those of you who are experiencing a variation from your hypothesis, what might attribute to this difference?” Elicit responses. “Do you see the importance of having an engineer to make these assessments? Elicit responses.

EXTENTIONS:

- Use a software program to incorporate a picture of a real turbine into a picture of a proposed wind-power site. You will need to know how far from the site the picture is taken and use the technique you just learned to determine how tall the turbine(s) will look at that distance.
- Prevailing Winds Investigations: Siting is more than assessing an average wind speed. Contact Heliotronics for a forthcoming lesson on cubing. http://www.heliotronics.com/
- Field Trip Opportunity for students to do with their family or as a class trip: For this activity, you will need to locate a wind-power site that can be seen from several locations at different distances, a map that includes the site, and a camera. The map should have a scale of between 1:62,500 and 1:126,720 and cover an area of at least five miles around the site. Once you have identified an appropriate site and found it on the map, take a

drive with your camera to photograph the wind turbine(s) from several locations at different distances. One picture should be from as close as you can reasonably get to the turbine(s), preferably on-site. Don't use a camera's wide angle or zoom features; you want the settings of your camera to be consistent and the photographs to best represent what you see with the naked eye. Note: You could use a handheld GPS device to aid in this activity; however, the process to do so is not described here. Tack the photographs you took onto your map indicating where each picture was taken to create a set of visual images of what the turbines look like from different perspectives. Include with each picture a label stating at what distance from the turbine(s) the picture was taken. Discuss anything that surprised you about how wind turbines look from a distance.

  - Add the exploration of wind turbine sound to your images, using a video recorder instead of a camera. You can also compare a noise we are familiar with, such as a lawnmower, to a turbine if you can get permission to take such an item to a site for your project. Fire it up and compare—document with the video recorder.

- Spacing Wind Turbines to Create a Wind Farm: Working with the model turbines, investigate how many turbines can be situated on an equally scaled model site to maximize the benefits of the prevailing winds. Asses directional wind and orient the model turbines. What would be the wind shadow for each turbine? A wind shadow can be explained similarly to the sun's shadow. At what point is the wind turbine out of the wind because it is too close to the one in front of it. At what point is the turbine back in the wind because the shelter is no longer effective? The point at which the next turbine is back in the wind is the end of the wind shadow, and this is the spot where you can place the next turbine. Space the turbine accordingly to create a model wind farm.

ADDITIONAL SUPPORT FOR TEACHERS
Factors in Siting Wind Turbines:
http://www.windpoweringamerica.gov/ne_siting.asp
http://www.ehow.com/how_2098621_site-wind-turbine.html
http://www.awea.org/pubs/factsheets/10stwf_fs.pdf
http://www.kidwind.org/lessons/LESSON_scalemodels.html

Actual Siting Work Facilitated in New York State:
http://www.greenbuildingsnyc.com/2009/02/11/wind-power-corning-tower-albany/

REFERENCES

- This model wind turbine construction lesson, "From a Distance", was inspired by the KidWind Project and Richard Lawrence, Instructor, Cape Cod Community College, and WindMaster, KidWind. http://www.kidwind.org/
- 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/

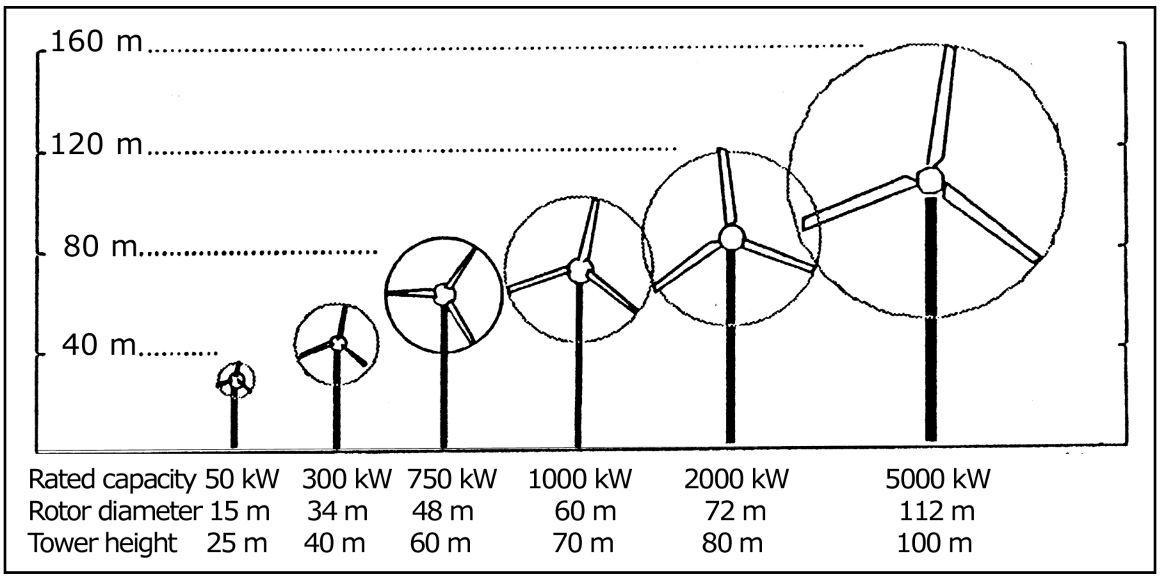
From a Distance

Student Handout

Construct a scale model wind turbine: For example, if you want to build a 40-centimeter (cm) tall scale model of a 40-meter (m) tall turbine, every centimeter of your model will represent one meter of the real one. This results in a 1 to 100 or 1:100 scale model.

You can use either the metric (meters, millimeters, etc.) system or the English system (inches, feet, etc.), but be sure to be consistent—use the same measurement system for the full-size and scale model versions.

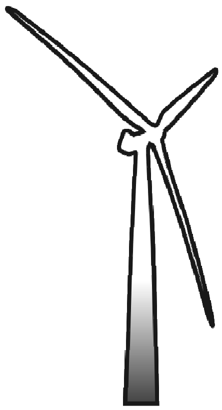
Note: This model turbine is not intended as a working turbine but to show scale.



Representative capacity, diameter, and height of wind turbines

See how tall your turbine looks from a distance. Select two distances away from a real turbine that you wish to imitate (consider double the distance for one, such as 5km and 10km), and calculate how far away you need to be from your model turbine to imitate these distances.

For instance, if you wanted to know what a full-size turbine would look like five kilometers away, you would need to look at your 1:100 scale model turbine from a distance of 50 meters. How did we get that, you ask? Multiply the distance away you wish to represent, in this case 5,000 meters, by your scale ratio, in this case 1/100. 5,000 x 1/100 = 50 meters



Lesson 10
Spinning in the Wind:
Wind Turbine Blade Design

BACKGROUND: Why are turbines designed the way they are? Wind turbines are mounted on a tower 30 meters (100 feet) or more aboveground to capture the wind's energy. Wind developers consider a great many things during their design, such as turbine height, economics, bird nesting, effects on wildlife, where the turbines will be located, balance, effects of weight, aerodynamics, and year-round weather conditions.

Turbines catch the wind's energy with propeller-like blades. Three blades are mounted on a shaft to form a rotor. The blade acts similar to an airplane wing and operates most effectively when mounted at a height at which the wind is swift with low turbulence. "When the wind blows, a pocket of low-pressure air forms on the downwind side of the blade. The low-pressure air pocket then pulls the blade toward it, causing the rotor to turn. This is called lift. The force of the lift is actually much stronger than the wind's force against the front side of the blade, which is called drag. The combination of lift and drag causes the rotor to spin like a propeller, and the turning shaft spins a generator to make electricity." (Bellis, "Introduction to Wind Turbines", 2009). Turbine blades need to be constructed of a material that will hold up in all weather conditions and maintain optimal function. They need to be designed to spin easily in a breeze. Other considerations may include color, blending in with the local landscape while at the same time being visible to migratory flying animals, weight of material, **decibel** of blades while spinning, or raw materials extraction, i.e. where the resources are coming from to make the turbine.

LEARNING OUTCOMES: Research and evaluate wind turbine blade designs. (Application/evaluation). Build, test, and evaluate wind turbine blades (Application/ Synthesis/Evaluation)

GRADE-LEVEL APPROPRIATENESS: 5-6

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.

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.

- consider constraints and generate several ideas for alternative solutions, using group and individual ideation techniques (group discussion, brainstorming, forced connections, role play); defer judgment until a number of ideas have been generated; evaluate (critique) ideas; and explain why the chosen solution is optimal.

- develop plans, including drawings with measurements and details of construction, and construct a model of the solution, exhibiting a degree of craftsmanship.
- in a group setting, test their solution against design specifications, present and evaluate results, describe how the solution might have been modified for different or better results, and discuss tradeoffs that might have to be made.

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.

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

- consider constraints and generate several ideas for alternative solutions, using group and individual ideation techniques (group discussion, brainstorming, forced connections, role play); defer judgment until a number of ideas have been generated; evaluate (critique) ideas; and explain why the chosen solution is optimal.
- develop plans, including drawings with measurements and details of construction, and construct a model of the solution, exhibiting a degree of craftsmanship.
- in a group setting, test their solution against design specifications, present and evaluate results, describe how the solution might have been modified for different or better results, and discuss tradeoffs that might have to be made.

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.

Models

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

- select an appropriate model to begin the search for answers or solutions to a question or problem.
- use models to study processes that cannot be studied directly (e.g., when the real process is too slow, too fast, or too dangerous for direct observation).

Optimization

Key Idea 6. In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs.

- determine the criteria and constraints and make tradeoffs to determine the best decision.

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 plastic, 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 hot glue gun w/glue sticks, 1 per	craft store, office supplies

pair or 4 to share	
Multimeter, 1 per pair or 4 to share	hardware store, electronics store
Light Emitting Diode (LED), 1-2 per pair	electronics store

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 then 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. 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.
   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.

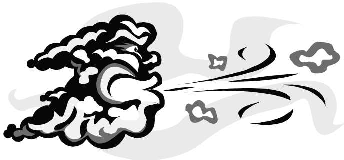
5. More than just spinning: Some model wind turbines come with a light that is attached and will light up when generating enough power ,so the students can see that the spinning turbine blades have an effect and can generate electricity. You can also attach a small LED light with leads to connecter wires 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.

EXTENTIONS

- Wind Turbine Materials Study: Conduct a research project on the process of design and construction of turbines. Investigate the raw materials used in constructing a wind turbine and their points of origin. Research New York State’s natural resources and their abundance. Question if there are resources in-state that could support the production of locally manufactured turbines. Are there materials that can be sustainably extracted at a more regional level in a way to support the state economy? Additionally, conduct a cost analysis of the construction of wind turbines. Consider a comparative study with other forms of energy and the resources used to manufacture the infrastructure and the energy resources used to generate the power.

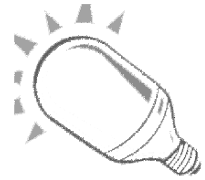
REFERENCES

- The “Spinning in the Wind” 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



Describe the process by which wind energy is converted into electricity.

Define “siting.”

Describe the physical conditions necessary for siting a wind turbine.

Draw a picture of a wind turbine catching the prevailing winds and label the parts of the turbine. Be sure to draw an arrow to show the directional wind.

What have you learned about wind energy?

Part 2 – TEACHER ANSWER SHEET

Describe the process by which wind energy is converted into electricity.

Wind forces wind turbine blades to spin, and in the act of making them spin, they spin an electrical generator, which converts the mechanical energy into electricity.

Define "siting."

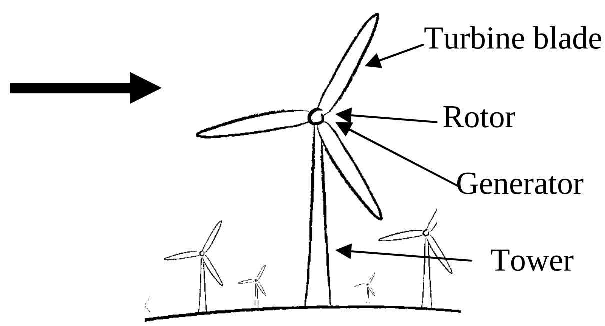
To situate or locate in a place.

Siting is the term given to describe the process of putting a wind turbine or wind farm in a location.

Describe the physical conditions necessary for siting a wind turbine.

A wind turbine works best where the wind flow is straight, fast, and steady.

Draw a picture of a wind turbine catching the prevailing winds and label the parts of the turbine. Be sure to draw an arrow to show the directional wind.



Wind Wisdom for School Power…Naturally^{SM}
Assessment Tool

CHAPTER 4: ACT

Lesson 11
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: 5-6

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.

Connections

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.

- analyze science/technology/society problems and issues that affect their home, school, or community, and carry out a remedial course of action.
- make informed consumer decisions by applying knowledge about the attributes of particular products and making cost/benefit tradeoffs to arrive at an optimal choice.

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 formats include:
   a. Lecture: Individuals or small groups give 5-10 minute reports on what they learned to an audience of family members and peers. Consider inviting community members at large to this reporting session.
   b. Documentary: Video or photo montage documentary on wind energy.
   c. Performance Artistry: Small groups perform a skit on what they have learned about wind energy.
      i. Students may perform a skit such as the “Creating Electricity with Wind” activity with student speakers describing what the group is acting out.
      ii. Students may create a poem on wind energy and speak it out loud.
   d. 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, or other public setting.
      Options include:
      i. Beaufort Scale drawings
      ii. Poetry displayed within shapes of wind turbines.
      iii. Folding kiosk board with information, graph comparisons of wind energy output and usage to other energy sources, photo documentation of the class’ visit to a wind farm, and drawings.

Please see more “Project Examples” on following pages.

3. Students present and share what they have learned about wind energy in the presentation format of choice.

ADDITIONAL SUPPORT FOR TEACHERS

- On the following pages are examples of student projects that can fulfill the “Act” activity. Some of these activities provide more than just opportunities for student sharing; they can also be used as a place-based service learning project where students develop citizen science skills.

Students as Teachers: Project Examples

Air Quality Comparative Study
Compare air quality in communities with one type of power generation plant. Ask students to formulate a hypothesis on which communities will have better or worse air quality, depending on the plant that is situated in their community. Include a wind farm as one of the power generation sites. Take sample readings from all sites in the study, and compare particulate matter and other air quality factors. What conclusions do your students draw from the research they conducted? What further research may be necessary to gain a deeper understanding of all the factors involved?

Biomimicry
Why was the first windmill invented? What was the inspiration? Have students research the history of the windmill and what led to its creation. Using nature as the model, have students brainstorm what the windmill mimics in nature. Are there models in nature that can help make the use of wind turbines more acceptable and safer? How might we better protect birds and bats from the turbines? Using nature as the model, have students explore other renewable energy technologies and what inspirations in nature lead or are leading the way to advances in the field of renewable energy: http://www.biomimicryinstitute.org/

Build an Anemometer
Construct an anemometer that will accurately measure the wind speed at your school. They may need school staff assistance in mounting the anemometer in an appropriately high location.

Create a Lesson or Activity on Wind Generation
Research wind generation to create an activity that they can facilitate for the class. Suggested topics for activities:

- New York State's current electricity source mix and potential for expanding wind energy for electrical generation;
- Take an electrical generator apart and put it back together.
- Have students videotape the above activity to show it a larger audience. Students can create a step by step power point presentation of how to construct an electrical generator.

Create a Model Wind Turbine
The web site www.KidWind.org has many great instructions on how to build model wind turbines that actually produce power when placed in a strong breeze or in front of a large fan. As part of the activity have students write up their experiences, their challenges, and their successes.

Create a Web Site on the Pros and Cons of Wind Energy
Having learned about wind energy; its attributes, possibilities, and applications; and its limitations, create a website that is fact-based and interesting that teaches the greater community about wind energy from a student's perspective.

Decibel Levels Study
Conduct a decibel level study at several wind turbine sites to determine loudness and intensity of sound at various ranges, from directly beneath the turbine out to a 3-5 mile radius. Have students post their findings with comparative values in the communities in which they conducted their study. Posting can be through flyers at community gathering areas and/or local cable television network and local newspapers.

Expressive Art Piece
Create and perform an original performance about wind energy. Perform at a community event.

Inheriting the Wind Video
Create a reenactment documentary on the history of wind power use and where we are today. Students may also conduct interviews with stakeholders in wind generation placement.

Property Values Study
Conduct a study on property values in communities with wind farms. Compare those to communities with other types of power plants such as coal, hydro-electric, and nuclear.
Is there evidence that demonstrates a marked increase or decrease in property values depending on the power plant that is situated in the community?

Research Finance Options to Incorporate Wind Energy into Your School
Is your school in a location that could support electrical generation with wind energy? Interested in having a wind turbine at your school to generate power for the school and operate as a learning laboratory? Have your students research options. Visit other institutions that already have wind turbines in operation and collect scientific data. Your students can also research options for homes and small businesses. Have your students also research town and state codes and zones to know how and in what context a wind turbine can be placed on a piece of land.
Getting started:

> New York State Energy Research & Development Authority, Wind Incentives
> http://www.nyserda.org/funding/funding.asp
> Silicon Solar, Inc, Wind Incentives through NYSERDA
> http://www.siliconsolar.com/nyserda-wind-incentives.html

Research Charles Brush
Charles Brush built the first wind turbine in the U.S.A. for electrical generation in 1888. What inspired his work? What other inventions did he produce?

- Option: create and perform a skit of his work on the wind turbine.
- Option: create an illustrated children's short story of his work and read it to younger students.

Research Michael Faraday
Michael Faraday discovered magnetic fields and magnetic induction. Research his work and correlate how it applies to a modern wind turbine.

- Option: Make a diagram on poster paper showing how a wind turbine generates electricity. Label all the key components of the system. If possible, observe the parts you can see in either a full-size or model working machine and be able to relate them to your

diagram.
- Option: Write a report on Michael Faraday and present the findings to the class.

Virtual Tour of a Wind Farm
Create a video tour of a wind farm after having visited one or more farms. Students can take their audience inside the turbine and show how it works and pan out to describe siting.

Wind Energy Information Exhibit
Design an information kiosk on wind energy, interactive if possible, and make handouts for visitors. Put on public display.

Wind Kinetic Sculpture
Once you know how electric circuits and wind powered generators work, you can play around and create some sculptures with parts that move by the power of the wind. Have students inquire with their city or town an appropriate place to stage their creations and then have an "open house" showing of their sculptures. Students will need to be on hand to field questions regarding their sculptures.

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).

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.

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

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.

Multi-meter: A multimeter or a multitester, also known as a volt/ohm meter or VOM, is an electronic measuring instrument that combines several measurement functions in one unit. A typical multimeter may include features such as the ability to measure voltage, current, and resistance.

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.

Ohm: The resistance between two points of a conductor when a constant potential difference of 1 volt, applied to these points, produces in the conductor a current of 1 ampere, the conductor not being the seat of any electromotive force.

Ohm's Law: The current through a conductor between two points is directly proportional to the potential difference or voltage across the two points, and inversely proportional to the resistance between them.

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.

Rotor: A rotating part of an electrical or mechanical device.

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 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 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 State 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

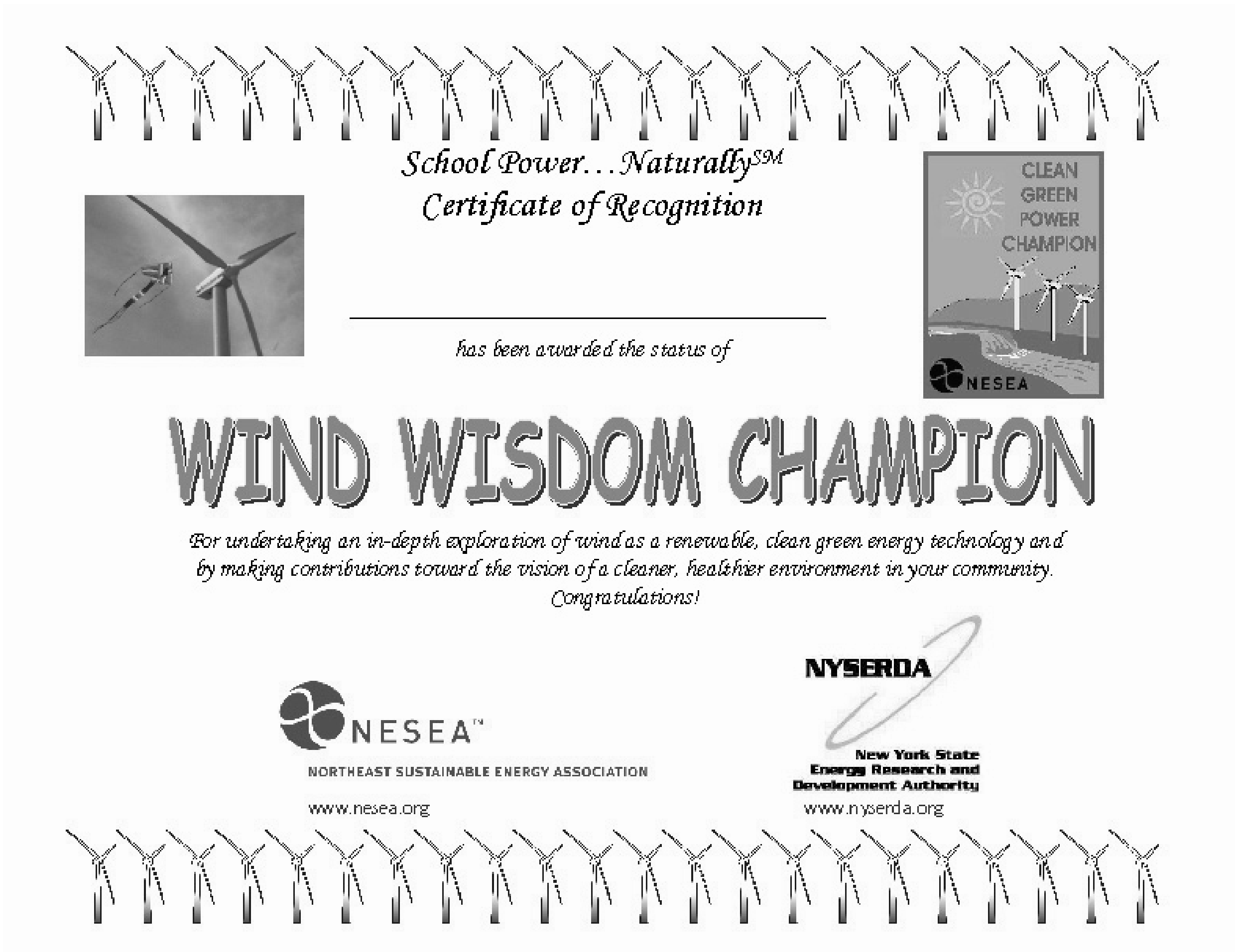
New York State Energy Research and Development Authority (NYSERDA)
In January 2009, NYSERDA's Energy Analysis program published *Patterns and Trends - New York State Energy Profiles: 1993-2007* (523kb .pdf), a comprehensive storehouse of energy

statistics and data on energy consumption, supply sources, and price and expenditure information for New York State.
http://www.nyserda.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/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