Wind Wisdom

Educator's Guide

Wind Energy Education Activities for Middle and High School Students

NESEA
Northeast Sustainable Energy Association
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WIND WISDOM EDUCATOR'S GUIDE

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Written by: Susan Reyes, Educator

The Northeast Sustainable Energy Association developed this unit based on a two-weekend Wind Wisdom program developed for Massachusetts Teen Girl Scouts in collaboration with the Girl Scouts of Western Massachusetts and with guidance from an advisory board of the following Girl Scout and community energy leaders:

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Emily Bedaw	Girl Scouts of Pioneer Valley
Sara E.Campbell, PE	Girl Scouts of Western Massachusetts
Dale Carnegie	Girl Scouts of Western Massachusetts
Walt Congdon	TRISTATE SOLAR
Wendy Garf-Lipp	Girl Scout Council Southeastern Massachusetts
Barbara Malinoski	Girl Scouts of Western Massachusetts
Ruth Morse	Girl Scouts of Western Massachusetts
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NESEA™

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NORTHEAST SUSTAINABLE ENERGY ASSOCIATION:
The Northeast Sustainable Energy Association (NESEA) is the nation's leading regional membership organization focused on promoting the understanding, development, and adoption of energy conservation and non-polluting, renewable energy technologies. NESEA has worked successfully for more than a quarter century in the fields of transportation, building construction, and renewable energy.

WIND WISDOM ACTIVITIES

The following eight activities offer youth an opportunity to explore wind energy. To attain an introductory experience with wind energy, it is recommended that each student complete at least four of the open-ended activities. Activities are addressed directly to students, with adult guidance and supervision expected. A certificate to acknowledge students' participation in the program is available to download. Girl Scouts can earn a patch for their work by documenting it on the Wind Wisdom Patch Requirements Worksheet and Patch Order Form on page 30.

Introduction to Wind Wisdom

Wind Wisdom means being knowledgeable about wind power as a renewable energy source and sharing that knowledge with others.

Middle and high school students participating in the Wind Wisdom activities go to the leading edge of technology as they learn about clean, renewable wind energy. The program is designed so that students can tailor the experience to their own desired interests and complete the program with a personalized, appropriate level of challenge.

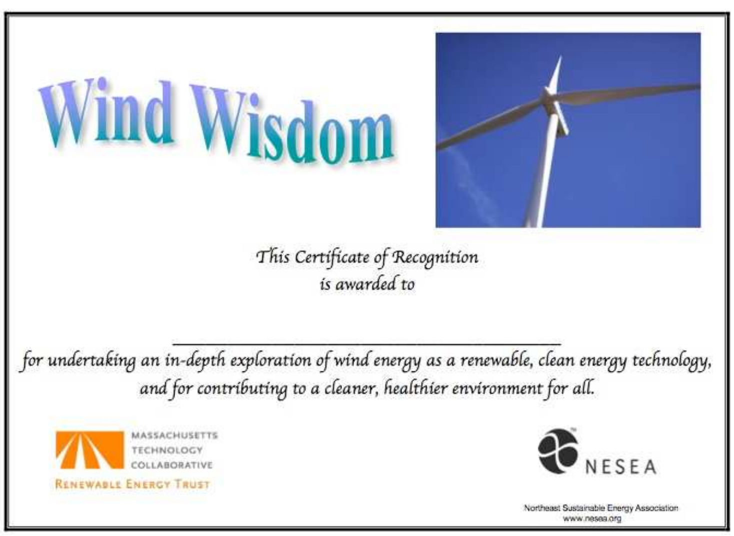
Among the opportunities offered through this program, you can:

- Learn how we convert wind energy into electrical energy through the technology of wind turbines.
- Explore the costs and benefits of using wind energy, including how it can help reduce global warming and pollution levels when used to offset the use of fossil fuels.
- Develop ideas for wind energy school projects, displays, and presentations.

Each activity includes specific suggestions, tips and resources to help complete the required tasks.

Through Wind Wisdom, students can take the lead in initiating conversations with their peers and their parents about environmental issues and the potential role of wind power as a clean green energy source.

Download certificates for students who have completed at least four activities at http://www.nesea.org/k-12/cleanenergyforacleanenvironment/windwisdom/



Activity 1: Why wind?

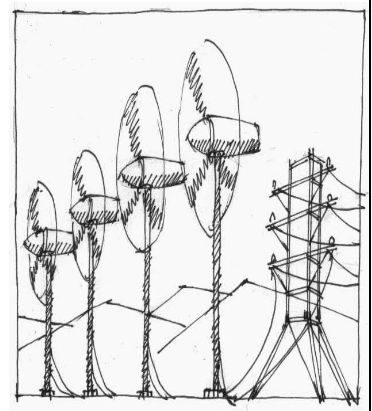
Analyze costs, benefits, and alternatives to wind energy and take a look at your own energy use.

Complete TWO from the following four choices, A, B, C, and D:

A. Make a poster of wind energy in the news to discuss with your class.

Spend a couple of weeks looking through newspapers, magazines, web sites, radio, television, and other news sources for mention of wind energy. Clip, record, or print a few and be prepared to share your findings. To get discussion started, here are a few suggested questions to apply to articles you find:

- What caught your attention in this article?
- 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 the opposite point of view be and why?
- What additional information is needed, and what new questions are raised?
- If not wind, then what are the alternatives, current and future?



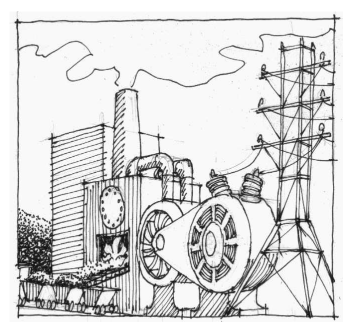
Producing electricity from the wind is the fastest growing electric power source in the United States and in the world.

B. Take a closer look at the damage to our health and the environment from burning fossil fuels for energy.

Find at least two good web sites, articles or books about one or more of these topics:

- global warming/climate change
- acid precipitation and acidification of waterways
- reduced visibility
- mercury pollution
- arsenic waste from coal ash
- destruction of forests through strip mining
- ozone pollution
- asthma and lung cancer

Share what you learned with someone else in a thoughtful, creative manner.



In the United States, the most common way to make electricity is with coal-powered electric power plants.

C. Write a letter to the editor or opinion piece.

Use your letter or opinion piece to evaluate at least one of the four main concerns people express about wind power—noise, visual impact, danger to birds or bats, or falling parts. Cite at least one reliable source for supporting information.

D. Consider your own energy consumption.

Look at your own energy consumption and potential contribution to global climate change by completing one or more of the following carbon calculators and make a commitment to at least three changes you will make to reduce your energy consumption.

- www.carbonfootprint.com/USA/calculator.html. Simple calculator using your electricity bills and travel mileage.
- www.climatecrisis.net/takeaction/carboncalculator/ This site includes an explanation of how the results are calculated.
- www.resurgence.org/carboncalculator/index.htm For optimal detail, accuracy and a challenge, try out this United Kingdom version.
- http://www.epa.gov/climatechange/wycd/school.html EPA site offers high school students an opportunity to calculate their carbon footprint and that of their school.

Activity 2: How can wind generate electricity?

Experiment with magnets, wire, and motion to generate your own electricity and learn how a wind turbine works.

In 1831, Michael Faraday, an English chemist and physicist, 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 power 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 power source.

Most modern power plants burn fossil fuels or use the heat of a nuclear reaction to boil water into high-pressure steam, which is then forced against a set of turbine blades. This action spins the blades, which spins the coils of wire inside the ring of magnets to generate electricity. Instead of steam, wind or moving water can also be forced against turbine blades to generate electricity.

Complete TWO from the following three choices A, B and C:

A. **Learn about Michael Faraday's discovery of magnetic fields and magnetic induction, and see how it applies to a modern wind turbine.** 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.

There are many web sites available that can help with your understanding of Michael Faraday's work, how electricity works, and how it is generated with a wind turbine. A few are offered at the end of this section to get you started.

B. **Generate your own electricity with coils of wire and a magnet.**

1. **Gather the following parts:**

Part	Find it at a place that sells:
Strong bar magnet, about 5 cm long	electronics, hardware, toys, hobbies or science equipment
10-20 ft. of thin insulated wire	electronics or hardware equipment
Multimeter	electronics or hardware equipment
Electrical or masking tape	hardware, electronics, general goods
Wire strippers	electronics or hardware equipment
Pencil or bamboo skewer	general goods

2. **Take the electricity challenge:**

Try to generate electricity by coiling some wire in a loop shape through which you can move the magnet. To see if you can do it, attach the two loose ends of wire to the multimeter probes (you can hold them together with your fingers), and see if you can get a voltage or current reading by moving the magnet through the coils of wire you made.
(See page 7 for instructions on how to use a multimeter).
Draw a diagram of what you did when you achieve success.

Hints: Be sure you have lots of loops in the coil. Hold the loops together with tape. Affix the magnet to the stick and then use the stick to spin the magnet inside the coil. Try moving the magnet faster inside the coil.

For more advanced students seeking an alternative, or those wishing an extension for activity B., read through "Science Fair Wind Generators" for a wealth of information on projects, materials, tips, important links, and how it all works: www.otherpower.com/toymill.html#vernvz

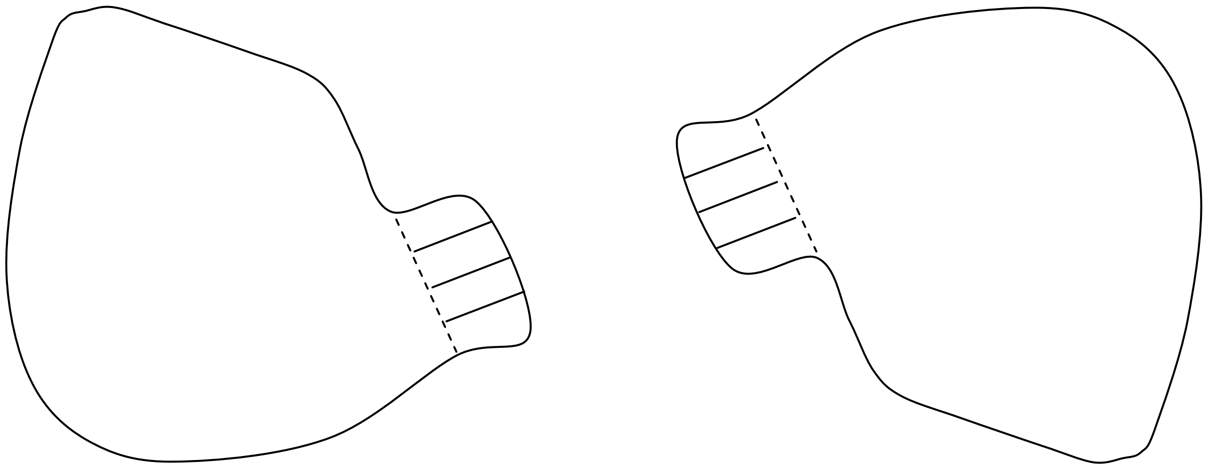
C. Put a motor to work with wind.

Materials: Besides a multimeter, you'll need the following:

- A hobby motor. A motor converts electricity into rotational motion. In this activity, you will use a motor as a generator, converting rotational motion into electricity. For a good generator, look for a hobby motor rated a relatively high 5 to 9 volts DC input voltage and a relatively low 1,500 to 2,500 RPMs (rotations per minute) output rotation speed. An ideal motor, the Wind Turbine Generator, is available at www.kidwind.org for $3.00 each.
- Wide short double propeller blades to catch wind from a fan and make the hobby motor turn. Contact Sharon at contactus@caframo.com to inquire about availability of part #827-01-GBG, fan blades for $2.50 each, or $1.25 each for four or more (or try making your own. See p.6).

Put your propeller blades on your motor and attach it with two wire leads to your multimeter, which should be on the lowest range setting available. Blow hard on the propeller. Can you generate electricity? Can you find some friends and see who can generate the most wind power through their breath? Hold a contest and see who is truly the windiest.

MINI WIND TURBINE BLADE CONSTRUCTION INSTRUCTIONS



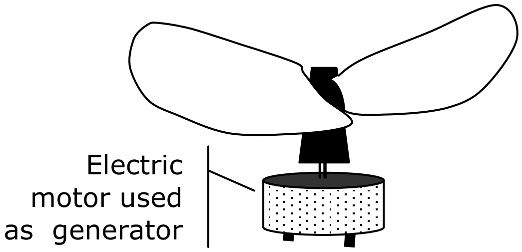
Materials
- Cardboard & other stiff materials
- #1 rubber stopper (from hardware store)
- hot glue
- strong tape
- hobby motor – 5-9 DC input volts & 1500 -2500 rpms
- fan
- multimeter

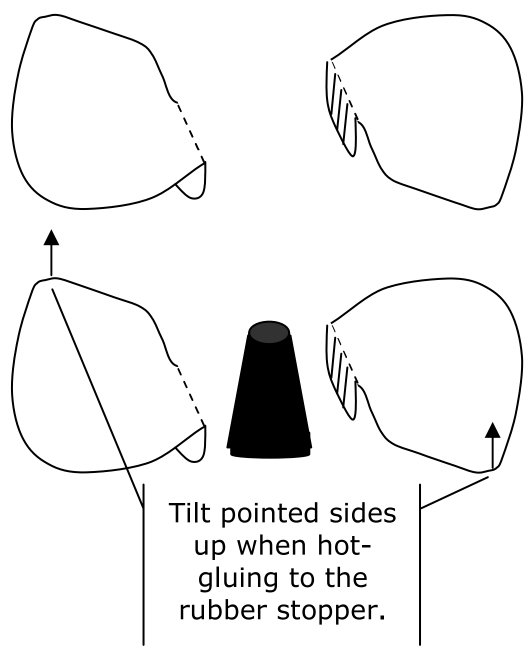
1. Cut out and trace the two turbine blades onto cardboard such as is used to back note pads. Cut out the cardboard turbine blades and cut along the three lines on each tab. Fold the tabs down as shown in the drawing.

2. Hot glue the tabs of the two blades to a rubber stopper. As you do this, tilt each blade about 15 to 20 degrees with the pointed sides tilted up to create a curve in the blades. Reinforce the hot glue by taping the tabs to the rubber stopper with electrical or duct tape.

3. Push the rubber stopper onto the shaft of the motor. You may need to start a hole with a pushpin.

4. Hook the motor leads up to a multimeter, and see if you can get some electrical current output. Try different materials or new blade designs for comparison.





HOW TO USE A MULTIMETER (MULTITESTER)

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. For the purpose of the Wind Wisdom program, we are using the multimeter to see if we can produce measurable DC (direct current) voltage or electric current from small electric generators.

KEEP SAFE: Do not use your multimeter in a wall outlet.

Most multimeters come with operating instructions that are more precise than the following, but these will help you get started.

1. Turn the meter on.
2. Turn the dial to measure either DC current or DC volts (often abbreviated DCA or DCV respectively).
3. Attach one pointed probe to one end of a wire lead from your motor or handmade generator, and the other probe to the other wire end. Make sure leads and probes are securely connected. Alligator clips on your leads help make a good connection, as well as electrical tape.
   Note: The connection must be made with the metal inside the wire leads, so you may have to strip away some of the plastic coating at the end.
4. Get your motor shaft turning with a wind source, or in the case of activity B., turn the magnet rapidly inside the coil by hand to see if the meter detects either voltage or current.

   Hint: you may need to experiment with range options on your multimeter to detect small output. If there are different range options, see what numbers, if any, you get by changing the dial to different settings. Some multimeters will adjust the range automatically, but most have settings for microvolts (μV), microamps (μA), millivolts (mV), milliamps (mA), volts (V), and amps (A). Play around with it.

   Hint: You can test your multimeter to see it working correctly by connecting its probes to either end of a fresh 1.5-volt battery, turning the dial to the appropriate direct current voltage (DCV) range, and check if you get a reading of around 1.5 volts.

Here are a few on-line sites to help you with multimeter usage:

- www.electronics-radio.com/articles/test-methods/meters/how-to-use-multimeter.php
- www.doctronics.co.uk/meter.htm
- View a podcast at: www.youtube.com/watch?v=KzjMIcER4EU

RESOURCES:

1. **Find definitions of energy terms with renewable energy glossaries found at the Clean Green Power project web site:** http://www.nesea.org/k-12/cleanenergyforacleanenvironment/cleangreenpowerproject/

2. **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) at www.ieee-virtual-museum.org/exhibit/exhibit.php?id=159249&lid=1

3. **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

4. **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

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

    a. **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

    b. **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

    c. **Details about the insides of a wind turbine and how they work geared to kids or adults** can be found at the Danish Wind Energy Association: www.windpower.org/en/tour/wtrb/electric.htm

        There is also a fun and informative animated site which is child-friendly: www.windpower.org/en/kids/index.htm?d=1

    d. **A source of wind energy model turbine materials** is available at KidWind www.kidwind.org/windshopfiles/partsbuildingmats.html

        Many items are available, including motors for wind turbines and interesting model turbine kits. Also find tips, explanations and experiments.

Activity 3: What makes a good site for wind turbines?

Find out by flying a kite, reading wind maps, and deciphering animal tracks and signs.

Complete ONE of the following, A or B:

A. Create an imaginary wind farm site on an 11" x 17" or larger poster paper.

1. **Do a little background research to find out about the many factors that need to be in place for a great wind farm site.**

   Here are two suggested sites to get started:

   - The Union for Concerned Scientists offers information on the important geography, human and environmental considerations: www.ucsusa.org/clean_energy/renewable_energy_basics/WPNE-Overview.html
   - New York State Energy Research Development Authority offers a colorful and easy to read guide on wind site development. See p.4, "What makes a good wind site?" www.powernaturally.org/Programs/Wind/WindGuide.pdf

2. **Apply what you have discovered as you create your own ideal, imaginary site.**
   Draw your map complete with icons to represent turbines and label the features of what makes this an optimal site based on your research. Share and discuss the details and thought you put into your site plan with at least one other person.

   These questions raise some of the considerations for a wind turbine site:

   - What qualities would you want in the wind flow at the location?
   - What terrain features would be good and bad and why?
   - What would make the project more or less costly?
   - What existing electrical power infrastructure is present?
   - What would the impact be on birds, bats, trees, or plants?
   - What would be some of the alternatives to wind energy?
   - Who would benefit from the wind farm?
   - How close are human dwellings and businesses located?
   - What are the impacts on humans (day and night)?
   - Who might benefit and who might not?

Required features to show on your map:

- Basic terrain features, such as hills, ridges, water bodies, and rivers
- Buildings and other man-made structures and alterations
- Power transmission lines and power station
- Six wind turbines
- Short explanations for the non-visible site features

B. Experiment with the wind.

1. Go fly a kite!

See what the wind is like down low and up high. A turbine works best where the wind flow is straight, fast, and steady. What can you say about the wind at two sites based on kite flying observations?

KEEP SAFE: Be sure where you fly a kite is safe from overhead wires and is not too close to an airport.

Preparation: You will need a reasonably good quality kite and some lightweight and highly visible ribbon material, such as the brightly colored plastic ribbon available at hardware stores.

Find at least two interesting and different wind sites to compare (e.g., along a coast, a field surrounded by trees or buildings, or an open hilltop). Plan to go to both sites under the same type weather conditions, perhaps on the same day one after the other. If you have a handheld wind-meter, bring it along to read the surface wind speed and direction in a few different ground locations nearby to compare with what you observe aloft.

If you don't have a wind meter, bring along a Beaufort Scale chart, which provides descriptive observations of wind effects on land or at sea and how to interpret them to estimate wind speed.
www.zetnet.co.uk/sigs/weather/Met_Codes/beaufort.htm

Procedure: Roll out some kite string and tie ribbons on at intervals of about 10 feet. Start with three ribbons and, if you are successful in getting your kite up off the ground, try more. Have a helper hold the kite to help get it aloft.

When the kite is up high, note and record how your ribbons are flying. Are the ribbons straight out and flowing smoothly or rippled? Are they all streaming in the same direction?

Keep track of your observations for both sites. You may want to use a table such as the one shown below to keep track of your observations.

KITE RIBBONS OBSERVATIONS		
	Site 1	Site 2
Ribbon 1 (highest)		
Ribbon 2		
Ribbon 3		
Ribbon 4		
Ribbon 5		

What might your observations say about wind speed and turbulence at the different heights? Were your observations at both sites the same? What terrain features might affect the wind flow?

2. Interpret wind resource maps.

At the Wind Powering America site, you can zoom in to see wind information in your state: http://www.windpoweringamerica.gov/wind_maps.asp, also review http://navigator.awstruewind.com/ AWS True Wind Navigator

You can find a Cape Cod, Massachusetts map if you visit the Cape and Islands Energy Clearinghouse a http://www.cirenew.info/windenergy.php

Looking at these maps:

- What is the wind like where you live compared to the ocean waters surrounding Massachusetts?
- Where are the good sites in Massachusetts for wind energy? Make sure to zoom into these online maps to view local conditions.

Activity 4: What is a wind turbine like up close?

Take a field trip and interview an expert.

To prepare for this activity, you will need to find a wind turbine or wind farm that you can visit and an individual knowledgeable about wind energy that you can interview. Visiting a wind-power site with a wind energy expert would be ideal and it is possible at several wind energy installations.

Keep Safe: Adult mentors must accompany youth during all parts of site visits and take responsibility for all safety considerations.

1. **Find a wind energy site to visit.**

   Here is a list of some of the wind turbine sites in Massachusetts and neighboring states. If you ask, some of these sites may have an expert available to join you for your field trip or be available for an off-site or phone interview. On the other hand, all of theses sites are not always open to visits but contacting them may help you develop leads on who to interview and you might discover some interesting new information.

   - **Barre, VT**: 100 kW turbine owned by Northern Power Systems http://www.northernpower.com/ or call 802-461-2955
   - **Beverly, MA**: 10 kW turbine at Beverly High School www.solarnow.org/beverly.htm or call 978-927-9786
   - **Holyoke, MA**: 250 kW turbine on Mount Tom in Holyoke run by the University of Massachusetts Renewable Energy Research Laboratory www.ecs.umass.edu/mie/labs/rerl or call 413-545-4359
   - **Hull, MA**: Two turbines, Hull Wind I, a 660 kW turbine at Hull High School, and Hull Wind II, a 1.8 MW turbine on the old landfill. www.hullwind.org or call 781-925-0051
   - **Newport, RI:** 1.5 kW turbine at Rose Island Lighthouse www.roseislandlighthouse.org or call 401-847-4242
   - **Princeton, MA**: Several turbines run by the Princeton Municipal Light Department www.pmld.com or call 978-464-2815
   - **Searsburg, VT**: Eleven 550 kW turbines owned by Green Mountain Power. Seasonal tours are offered by Vermont Environmental Research Associates. www.northeastwind.com/whatwevedone/searsburg.html or call 802-244-7522 or 413-498-2729

2. **Find a wind-power expert to interview.**

   If a wind-power expert is not available through your field trip to a wind turbine site, try contacting wind turbine installers, wind energy organizations, engineering and renewable energy departments at local universities and colleges, environmental centers, or local renewable energy organizations.

   To help your search, try NESEA's Sustainable Green Pages www.nesea.org or use the Internet and phone book to find local contacts. Through your search, you may also find additional wind-turbine sites near you.

3. **Plan your interview questions.**

   Before you go, consider what interview questions you will ask. Some specific questions you might ask about your wind turbine site 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?
   - Could you tell me the story of how you got involved in using clean power?

   Don't be afraid to ask about specific terms and for clarification of anything you hear!

On site tips for a successful and enjoyable visit:

- Be sure to go out of your way to show respect for people, plants, animals, and property.
- 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 of your visit. Just be sure to ask the host or hostess ahead of time if it's OK to record images or voices and let them know how the information will be used.

- To make your trip more meaningful, gain a deeper awareness of your own energy use. Do you know where energy comes from for your energy needs, where you use energy in your home, and how much you use for hot water, lighting, heating, travel, and appliances?

4. Follow up your visit.

Write a thank you note to the person you interviewed and also to the people managing or owning the wind turbine site. Photos, drawings and mention of specific things you learned and appreciated are the most meaningful to people who generously offered their time and knowledge.

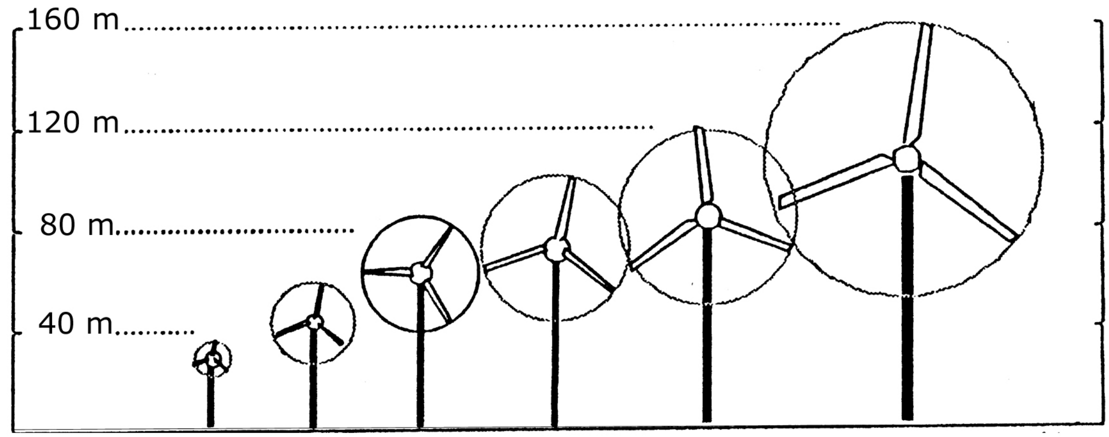
Reflect on your visit and what you learned by discussing it in detail with another person, with a group, or by writing about it in a journal. Another great way to follow up is to complete Activity 7, "How can I spread the word about wind energy?"

Activity 5: What does a turbine look like from a distance?

Set up a scale model activity or observe a real wind turbine.

Complete ONE of the following, A or B:
A. Build a scale model wind turbine and look at it from a distance.

1. **Select a wind turbine size to model.**
   Consider constructing a model of a turbine you have seen or one that is proposed for a site near you. From Figure 5.1, select a wind turbine size to model. Or, if you wish to model a specific wind turbine, look up that turbine's specifications on the Internet or call the manufacturer or turbine owner to find out the turbine's rated capacity, rotor diameter, and tower height.



Rated capacity	50 kW	300 kW	750 kW	1000 kW	2000 kW	5000 kW
Rotor diameter	15 m	34 m	48 m	60 m	72 m	112 m
Tower height	25 m	40 m	60 m	70 m	80 m	100 m

Figure 5.1 Representative capacity, diameter, and height of wind turbines

2. **Construct a scale model wind turbine.**
   Use simple materials such as a dowel, a spool, and Popsicle sticks glued together for blades to construct a scale model wind turbine of the real turbine you selected.
   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. If you would like to make a model that works, see Activity 2.

3. **See how tall your turbine looks from a distance.**

Select two distances away from a real turbine that you wish to imitate (for instance, you may wish to select 5 km and 10 km away from an offshore turbine), 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.

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

Be sure to use the same system, metric or English, and the same scale that you used to construct your model turbine to calculate these distances.

Make a prediction about how tall your model will look from each of these distances. Remember, this is how tall a full-scale turbine would look at the full-scale distance. 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.

Bring a lengthy measuring tape (at least 50 to 100 ft.) and your model wind turbine to a large, flat open area such as a playing field. Place your wind turbine where you will be able to see it while lying down on the ground from the scale distances away that you calculated.
Observe (or even photograph) your model turbine at the different distances you chose. Did it look larger, smaller, or the same as you imagined?
You can use this technique to estimate how big a proposed real turbine or wind farm will likely look from a distance. For example, how the Cape Wind Project (a proposed wind farm off of Cape Cod) would look from the nearest shore.

Extension: 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.

B. Explore what an existing wind turbine looks like from a distance.

1. **Find a wind-power site on a map.**

   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.

   Note: You could use a hand-held GPS device to aid in this activity, however, the process to do so is not described here.

   Locate your wind power site on the map.

2. **Take a drive with your camera.**

   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.

   Mark on your map where you take each photograph.

3. **Tack your pictures to your map.**

   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.

4. **Share what you learned.**

   Share your map with at least one other person and discuss anything that surprises you about how wind turbines look from a distance.

Extension: 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.

Activity 6: What makes a great wind turbine design?

Build your own working wind turbine model and experiment to see what yields the most power.

Complete the following and then complete EITHER A or B:

Review different wind-turbine designs and shapes in books, magazines, and on the Internet. Look for some close-up views, especially of the blades. Collect a few pictures or make a few sketches showing different designs that you find.

You can find photographs of wind turbines on the Internet at the following sites:

- National Renewable Energy Laboratory (NREL) Photographic Information Exchange web site; look under the topic "wind:" www.nrel.gov/data/pix/searchpix.cgi
- Search on terms such as "wind turbine," "wind turbine blade," or "small wind turbine" at commercial and amateur photograph image sites such as:
  www.flickr.com
  www.fotosearch.com
  www.inmagine.com
  Be aware that many of the photos at a commercial site require payment to be used.

Think about why the turbines might be designed the way they are. Consider the great many things designers think about during their design, such as economics, bird nesting, effects on wildlife, where the turbines will be located, balance, effects of weight, aerodynamics, and year-round weather conditions.

Why are the blades shaped the way they are? Why are the towers of many modern wind turbines smooth? Why are they painted certain colors? Keep your mind open to other questions that might arise. Can you see evidence of optimized features in the photographs you have reviewed?

Complete ONE of the following, A or B:

A. The Best Blade Challenge

For this activity you will need a working model wind turbine, a large, strong box fan, thin balsa wood with tools to cut and shape it, at least three 3/8" dowels, hot glue or wood glue, and a multimeter.

1. **Borrow or buy a working model wind turbine.**

   For this activity you will need a working model wind turbine such as can be found at the Kid Wind Project (www.KidWind.org). Kid Wind's working model wind turbines are designed for experimentation and come with suggested experiments. You can either borrow or buy a working model wind turbine.

To fund a purchase, you might consider asking if there is money available from your local library, a local business, parent teacher organization funds, or your school to buy the kit, and follow up by donating the kit to the school or pubic library to loan out.

2. **Test different blade designs.**

   Design, construct, and test different turbine blades on the working model turbine to see which blade design produces the most power. You make the blades by cutting and shaping them out of thin balsa wood and then gluing them onto wooden dowels so that they can be attached to the hub of the wind turbine.

   Use a large, strong box fan to create the wind needed to test the blades. Position the turbine a set distance in front of the fan with the hub of the turbine lined up with the hub of the fan blades. Measure the electrical output with a multimeter (see page x for how to use a multimeter) to see which blade design produces the highest DC current.

   This is also an opportunity for a competition in a larger group where teams design blades and get two or three trials to improve designs.

Optional: Can you light up? Low voltage LEDs (light emitting diode), such as red or green, or possibly a flashlight bulb may light up with some turbines in this guide. You can buy them at electronics suppliers such as Radio Shack. Note that LEDs only operate with current flowing in one direction, so switch the connections to LED leads before declaring defeat for a fair test. LED Safety: Though your electrical output is low in the projects detailed here, be aware that LEDs can overheat or burst if they receive too much electrical input, so ask your LED supplier about resistors needed for higher output projects.

Alternative or Extension Activity: Carry out any of the other experiments suggested in a Kid Wind model turbine kit.

B. The *Build Your Own Working Turbine* challenge

This activity is an open-ended challenge to build your own wind turbine, possibly even including the electric generator! It's not as hard as you might think at first, but this is not a trivial task. There are some miniature wind turbine designs available, complete with instructions on what to order for parts. Some of these include building your own simple generator and, for advanced crafters, one that is large enough to produce usable power.

If you use a hobby motor as a generator, the specifications of the motor are particularly important, as it must produce an adequate amount of power under relatively low RPMs (rotations per minute). To make a good generator, look for a hobby motor rated a relatively high 5 to 9 volts DC input voltage and a relatively low 1,500 to 2,500 RPMs output rotation speed. www.kidwind.org sells an ideal motor-generator for model wind turbines.

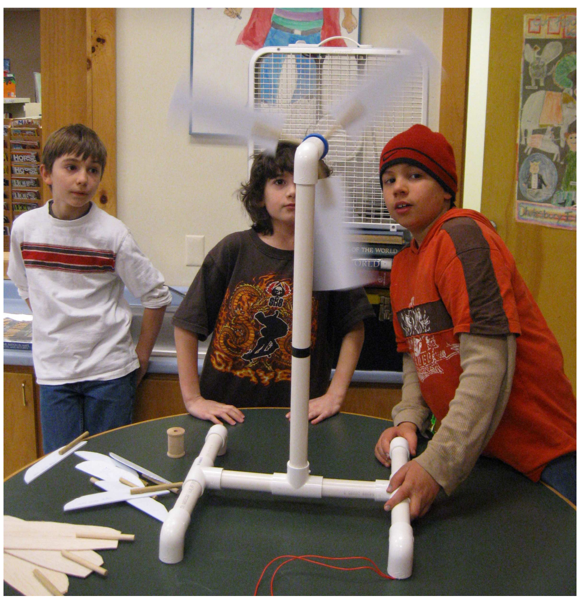
Here are three web sites to help guide your design efforts.

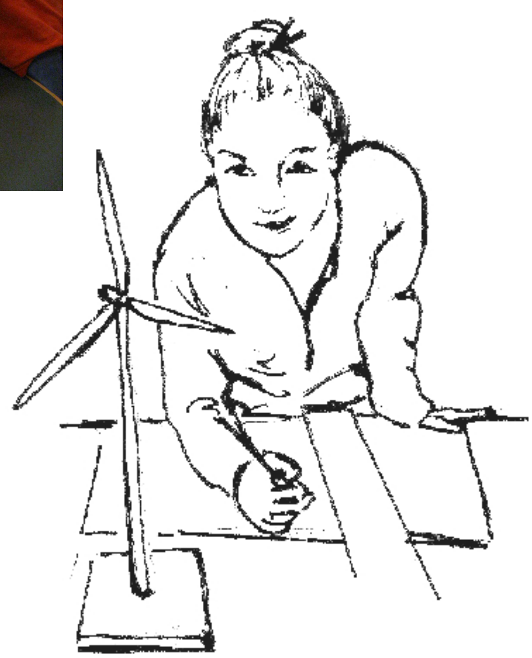
www.re-energy.ca/t-i_windbuild-1.shtml

www.otherpower.com/toymill.html

Here is a serious design only for teens with adult help and supervision www.velacreations.com/chispito.html

Keep a log of your experiments, successes and failures in this endeavor. Have fun!





Activity 7: How can I spread the word about wind energy?

Plant seeds of wind wisdom in your community with a project designed to educate others.

Share what you have learned about wind power. Use your creativity to engineer a way to do this. It can be an individual endeavor or a group effort. The challenge will be to provide accurate and well-supported information to as many people as possible.

Some examples of possible projects:

- Choose an activity you completed and lead a group through the activity in your school or community.
- Enter a wind energy science project in your local, regional or state science fair.
- Create a wind energy education lending kit for educators or youth at your local environmental education center, library, school or museum.
- Make an informative tri-fold display with some hands-on activities.
- Lead an ecological footprint or carbon calculator group activity and make some commitments to change your own energy usage – think about the role wind energy could play in reducing your carbon contribution.
- Create a question-and-answer brochure about the use of wind power and energy conservation to distribute at your library or other public places.
- Write a letter to the editor of your local newspaper(s). Make sure your information is well documented and supported.
- Create a slide show presentation for a community group on your wind site visit and patch project.
- Produce a video account of a patch activity and use it for a Girl Scout presentation or show it on your local community access TV station.

You will find additional ideas along with *How to Make Yourself a Star*—guidelines on how to write a news release—in the ACT section of the Clean Green Power Project at http://www.nesea.org/k-12/cleanenergyforacleanenvironment/cleangreenpowerproject/

Activity 8: What are some wind career options?

Explore wind and other renewable energy career opportunities.

To complete this activity, you will find and interview a renewable energy expert and then complete a fun follow-up activity that pertains to a career in the wind energy field. You may be surprised at the range of options!

1. **Find a renewable energy expert to interview.**

   Look up someone who works in a renewable energy field, preferably wind energy, who is willing to be interviewed about their career and path to their present position. Though this could be done over the phone, you could meet your interviewee in person if you are completing *Activity 4* as well. Be sure to follow all safety guidelines and always have a trusted adult accompany you. Follow up with a thank you note.

   To find an expert, try:

   - Northeast Sustainable Energy Association's Sustainable Green Pages www.nesea.org
   - The Destination Sites listed under the Clean Energy for a Clean Environment web site http://www.nesea.org/k-12/cleanenergyforacleanenvironment/cleangreenpowerproject/
   - The American Wind Association Career Center at www.awea.org/resources/career_center/

   You also can try contacting the wind-power organizations listed on page X in *Activity 4*.

   Also, see or look up profiles of people working at a wind energy firm such as Northeast Wind. www.northeastwind.com/whoweare/bios.html to find out what real jobs are like right now in the wind industry.

   From these sites you should find several suitable northeastern U.S. renewable energy businesses.

2. **Conduct your interview.**

   Here are some suggested questions you might ask:

   - Why did you choose renewable energy as a career?
   - What educational background do you apply to your work?
   - What previous work experiences have helped you in your current position?
   - 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, challenging, exciting, and/or tedious aspects of your work?
- What advice would you give to someone interested in a career in wind energy?
- What types of work are needed in the wind energy field?

3. **Complete a follow-up activity.**

   This is an open-ended assignment based on something inspired or learned through your interview with the wind energy expert. These are some examples of activities:

   - Wind power technicians wear harnesses and use clips and ropes as a safety measure when they climb inside towers. Don a rock climbing harness, and try your hand at a rock wall, being sure you have skilled help and always keep safety first in mind.

   - Biologists are hired to study signs of animal behavior at wind power sites. Bring a bag of dry Plaster of Paris, a bottle of water, a stirring stick and disposable plastic container to an animal track in the mud. Mix water slowly into the plaster till a thick batter consistency and then pour into the track. Let it set for a few hours before pulling out your track & identifying it. You may need to observe its relationship to other tracks nearby.

     Also look for other signs of animals—scat, fur, chewed branches, etc. Can you tell the difference between rabbit and deer chews and scat? Suggestion: Look for a tracking guide that offers a lot of detail about each animal, such as that of Massachusetts resident, Paul Rezendes: "Tracking and the Art of Seeing," Harper Collins Publishers, Inc., 1999, or consult Rick Curtis' Outdoor Action Guide to Animal Tracking on-line at www.princeton.edu/~oa/nature/tracking.shtml

   - Specially trained wind installers can lift a small tower using human power and cables. Larger towers involve different installation processes. Ask your wind turbine expert about how and why installation is done as it is and ask if you can observe the process for a couple hours. Take pictures or illustrate so you can share what you learned with others. You can see a simplified installation of a large turbine on-line at www.windpower.org/en/kids/choose/assemble/index.htm

   - Public relations people work with local communities to educate people about wind power projects. Write an article or an editorial, or develop a presentation about a wind project.

- Wildlife managers are consulted to make recommendations for habitat protection. Imagine you are trying to protect bears at a Massachusetts wind farm from human disturbance during their active seasons. Find out a bear’s seasonal activities and tell when the wind farm is open and closed to the public. (Hint: Learn about the Searsburg Wind Farm site in Vermont and take a tour if you can).

Wind Wisdom and the Massachusetts Science and Technology/Engineering Curriculum Framework

Applicable aspects of the Massachusetts Science and Technology/Engineering Framework:

Many Massachusetts Science and Technology/Engineering Learning Standards can be fulfilled through the eight Wind Wisdom activities. Furthermore, many Mathematical Skills, Scientific Inquiry Skills standards, and Massachusetts curriculum frameworks from other areas of study can be met through the Wind Wisdom program due to its interdisciplinary nature, but are not listed below. Meeting a particular set of standards depends on choices and adaptations to the Wind Wisdom program made by the individual.

Strand 1 Earth and Space Science
Grades 6-8
Heat Transfer in the Earth System
Standard 3. Differentiate among radiation, conduction, and convection, the three mechanisms by which heat is transferred through the earth's system.
Standard 4. Explain the relationship among the energy provided by the sun, the global patterns of atmospheric movement, and the temperature difference among water, land and atmosphere.

Grades 9-10
Content standard 1. Matter and Energy in the Earth System
Central Concepts: The entire Earth system and its various cycles are driven by energy. Earth has both internal and external sources of energy. Two fundamental energy concepts included in the Earth system are gravity and electromagnetism.
1.1 Identify Earth's principal sources of internal and external energy, such as radioactive decay, gravity and solar energy.
1.3 Explain how the transfer of energy through radiation, conduction, and convection contributes to global atmospheric processes, such as storms, winds, and currents.
1.4 Provide examples of how the unequal heating of Earth and the Coriolis effect influence global circulation patterns, and show how they impact Massachusetts weather and climate (e.g. global winds, convection cells, land/sea breezes, mountain/valley breezes).
1.8 Read, interpret, and analyze a combination of ground-based observations, satellite data, and computer models to demonstrate Earth systems and their interconnections.

Content Standard 2. Energy Resources in the Earth System
Central Concepts: Numerous earth resources are used to sustain human affairs. The abundance and accessibility of these resources can influence their use.

2.1 Recognize, describe, and compare renewable energy resources (e.g. solar, wind, water, biomass) and nonrenewable energy resources (e.g. fossil fuels, nuclear energy)
2.2 Describe the effects on the environment and on the carbon cycle of using both renewable and nonrenewable sources of energy.

Content Standard 3. Earth Processes and Cycles
Central Concepts: Earth is a dynamic interconnected system. The evolution of Earth has been driven by interactions between the lithosphere, hydrosphere, atmosphere, and biosphere. Over geologic time, the internal motions of Earth have continuously altered the

topography and geography of the continents and ocean basins by both constructive and destructive processes.

3.2 Describe the carbon cycle.

Strand 2 Life Science (Biology)
Grades 6-8
Changes in Ecosystems Over Time

Standard 17. Identify ways in which ecosystems have changed throughout geologic time in response to physical conditions, interactions among organisms, and the actions of humans. Describe how changes may be catastrophes such as volcanic eruptions or ice storms. Study changes in an area of the schoolyard or a local ecosystem over an extended period. Students might even compare their observations to those made by students in previous years.

Biology
High School
Learning Standard 6. Ecology

Central Concept: Ecology is the interaction among organisms and their environment.
6.4 Explain how water, carbon, and nitrogen cycle between abiotic resources and organic matter in an ecosystem, and how oxygen cycles through photosynthesis and respiration.

Strand 3 Physical Sciences (Chemistry and Physics)
Grades 6-8
Forms of Energy

13. Differentiate between potential and kinetic energy. Identify situations where kinetic energy is transformed into potential energy and vice versa.

Heat Energy

14. Recognize that heat is a form of energy and that temperature change results from adding or taking away heat from a system.
15. Explain the effect of heat on particle motion through a description of what happens to particles during a change in phase.
16. Give examples of how heat moves in predictable ways, moving from warmer objects to cooler ones until they reach equilibrium.

Grades 9-10
1. Motion and Forces

Central Concept: Newton's laws of motion and gravitation describe and predict the motion of most objects.
1.4 Interpret and apply Newton's three laws of motion.
1.6 Distinguish qualitatively between static and kinetic friction, and describe their effects on the motion of objects.
1.8 describe conceptually the forces involved in circular motion.

2. Conservation of Energy and Momentum

Central Concept: The laws of conservation of energy and momentum provide alternative approaches to predict and describe the movement of objects.
2.1 Interpret and provide examples that illustrate the law of conservation of energy.
2.2 Interpret and provide examples of how energy can be converted from gravitational potential energy to kinetic energy and vice versa.
2.3 Describe both qualitatively and quantitatively how work can be expressed as a change in mechanical energy.

2.4 Describe both qualitatively and quantitatively the concept of power as work done per unit time.

3. Heat and Heat Transfer
Central Concept: Heat is energy that is transferred by the processes of convection, conduction, and radiation between objects or regions that are at different temperatures.
3.1 Explain how heat energy is transferred by convection, conduction, and radiation.
3.2 Explain how heat energy will move from a higher temperature to a lower temperature until equilibrium is reached
3.3 Describe the relationship between average molecular kinetic energy and temperature. Recognize that energy is absorbed when a substance changes from a gas to a liquid to a solid. Explain the relationships among evaporation, condensation, cooling and warming.
3.4 Explain the relationships among temperature changes in a substance, the amount of heat transferred, the amount (mass) of the substance, and the specific heat of the substance.

5. Electromagnetism
Central Concept: Stationary and moving charged particles result in the phenomena known as electricity and magnetism.
5.1 Recognize that an electric charge tends to be static on insulators and can move on and in conductors. Explain that energy can produce a separation of charges.
5.2 Develop qualitative and quantitative understandings of current, voltage, resistance, and the connections among them (Ohm's law).
5.3 Analyze simple arrangements of electrical components in both series and parallel circuits. Recognize symbols and understand the functions of common circuit elements (battery, connecting wire, switch, fuse, resistance) in a schematic diagram.
5.4 Describe conceptually the attractive or repulsive forces between objects relative to their charges and the distance between them (Coulomb's law).
5.5 Explain how electric current is a flow of charge caused by a potential difference (voltage), and how power is equal to current multiplied by voltage.

6. Electromagnetic Radiation
Central Concept: Oscillating electric or magnetic fields can generate electromagnetic waves over a wide spectrum.
6.1 Recognize that electromagnetic waves are transverse waves and travel at the speed of light through a vacuum.
6.2 Describe the electromagnetic spectrum in terms of frequency and wavelength, and identify the locations of radio waves, microwaves, infrared radiation, visible light (red, orange, yellow, green blue, indigo, and violet), ultraviolet rays, x-rays, and gamma rays on the spectrum.

Strand 4 Technology/Engineering
Grades 6-8
2. Engineering Design

Central Concept: Engineering Design is an iterative process that involves modeling and optimizing to develop technological solutions to problems within given constraints.

2.1 Identify and explain the steps of the engineering design process, i.e., identify the need or problem, research the problem, develop possible solutions, select the best possible solution(s), construct a prototype, test and evaluate, communicate the solution(s), and redesign.

2.2 Demonstrate methods of representing solutions to a design problem, e.g. sketches, orthographic projections, multi-view drawings.
2.3 Describe and explain the purpose of a given prototype.
2.4 Identify appropriate materials, tools, and machines needed to construct a prototype of a given engineering design.
2.5 Explain how such design features as size, shape, weight, function, and cost limitations would affect the construction of a given prototype.
2.6 Identify the five elements of a universal systems model: goal, inputs, processes, outputs, and feedback.

Grades 9-10
1. Engineering Design
Central Concepts: Engineering design involves practical problem solving, research, development, and invention/innovation, and requires designing, drawing, building, testing and redesigning. Students should demonstrate the ability to use the engineering design process to solve a problem or meet a challenge.
1.1 Identify and explain the steps of the engineering design process: identify the problem, research the problem, develop possible solutions, select the best possible solution(s), construct prototypes and/or models, test and evaluate, communicate the solutions, and redesign.
1.2 Understand that the engineering design process is used in the solution of problems and the advancement of society. Identify examples of technologies, objects, and processes that have been modified to advance society, and explain how they were modified.
1.3 Produce and analyze multi-view drawings (orthographic projections) and pictorial drawings (isometric, oblique, perspective), using various techniques.
1.4 Interpret and apply scale and proportion to orthographic projections and pictorial drawings (e.g., ¼’ = 1’0”, 1 cm = 1 m).
1.5 Interpret plans, diagrams, and working drawings in the construction of prototypes or models.

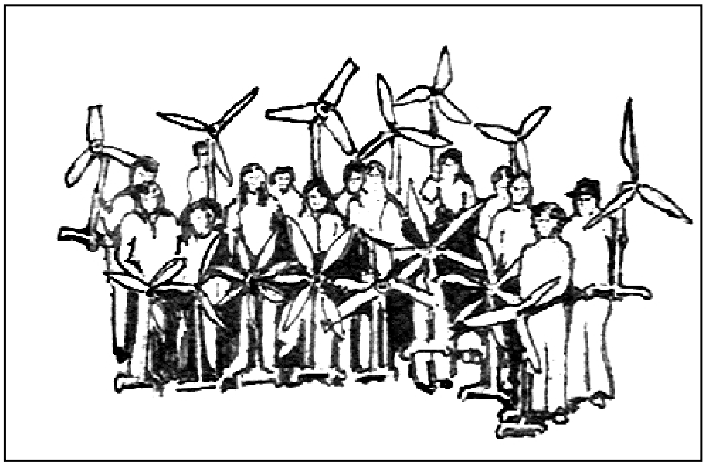
2. Construction Technologies
Central Concepts: The construction process is a series of actions taken to build a structure, including preparing a site, setting a foundation, erecting a structure, installing utilities, and finishing a site. Various materials, processes, and systems are used to build structures. Students should demonstrate and apply the concepts of construction technology through building and constructing either full-size models or scale models using various materials commonly used in construction. Students should demonstrate the ability to use the engineering design process to solve a problem or meet a challenge in construction technology.

2.1 Identify and explain the engineering properties of materials used in structures (e.g., elasticity, plasticity, R value, density, strength).
2.2 Distinguish among tension, compression, shear, and torsion, and explain how they relate to the selection of materials in structures.
2.3 Explain Bernoulli’s principle and its effect on structures such as buildings and bridges.

2.4 Calculate the resultant force(s) for a combination of live loads and dead loads.
2.5 Identify and demonstrate the safe and proper use of common hand tools, power tools, and measurement devices used in construction.
2.6 Recognize the purposes of zoning laws and building codes in the design and use of structures.

4. Energy and Power Technologies--Thermal Systems
Central Concepts: Thermal systems involve transfer of energy through conduction, convection, and radiation, and are used to control the environment. Students should demonstrate the ability to use the engineering design process to solve a problem or meet a challenge in a thermal system.
4.3 Explain how environmental conditions such as wind, solar angle, and temperature influence the design of buildings.
4.4 Identify and explain alternatives to nonrenewable energies (e.g., wind and solar energy conversion systems)

5. Energy and Power Technologies--Electrical Systems
Central Concepts: Electrical systems generate, transfer, and distribute electricity. Students should demonstrate the ability to use the engineering design process to solve a problem or meet a challenge in an electrical system.
5.1 Explain how to measure and calculate voltage, current, resistance, and power consumption in a series circuit and in a parallel circuit. Identify the instruments used to measure voltage, current, power consumption, and resistance.
5.2 Identify and explain the components of a circuit, including sources, conductors, circuit breakers, fuses, controllers, and loads. Examples of some controllers are switches, relays, diodes, and variable resistors.
5.3 Explain the relationships among voltage, current, and resistance in a simple circuit, using Ohm's law.
5.4 Recognize that resistance is affected by external factors (e.g., temperature)
5.5 Compare and contrast alternating current (AC) and direct current (DC), and give examples of each.



WIND WISDOM PATCH PROGRAM

Requirements Worksheet and Patch Order Form

For Teen Girl Scouts Ages 11 to 18

The patch is FREE for Massachusetts Girl Scouts due to grant funding from the Massachusetts Technology Collaborative, www.masstech.org

Patch Recipient(s): **Attach List if Needed**	**Mail patch(es) to:** Name: Address: City/Town: State: Zip Code: **Quick contact information:** Phone: Email:
Adult Mentor/Troop Leader:	
Troop:	
Council:	
# of Patches Ordered:	

How to Earn Your Wind Wisdom Patch:
Each Girl Scout completes at least FOUR of the eight activities offered to earn the patch. Explain what was done to complete each activity. Please be brief but include specific details such as locations of site visits and presentations; names and locations of people interviewed; news media coverage; resources you used, etc. We welcome your sharing of any videos or digital photos of your work.

Activity # _______

Completed with high quality work. Adult or troop leader's initials_________

Activity # _______

Completed with high quality work. Adult or troop leaders initials_________

Activity # ______

Completed with high quality work. Adult or troop leaders initials________

Activity # ______

Completed with high quality work. Adult or troop leaders initials________

Feedback: *Use additional paper if needed.*
What were the most rewarding parts of the patch program?

What suggestions would you have to change the program?

Other Comments:

Mail, FAX or Email This Form to:	Contact NESEA:
Wind Wisdom Patch Program NESEA 50 Miles Street, Suite 3 Greenfield, MA 01301 **FAX:** 413-774-6053 **Email:** nesea@nesea.org	NESEA K-12 Education Department 413-774-6051 Arianna Alexsandra Collins, Education Director x21 Susan Reyes, Science Educator x27

Safety Note:
Parents and troop leaders must assume responsibility for youth in their care and use their own best judgment in each situation. Adult mentors and or parents must accompany and directly supervise girls during field trips at all times and follow all Girl Scout safety guidelines. The Northeast Sustainable Energy Association or the Girl Scouts of Western Massachusetts assumes no responsibility for safety. Any photos offered to us during the project are assumed available for public display unless parent signs otherwise.