<u>**Wind Turbines**</u>

Essential Question: How can renewable resources be transformed into useful energy forms?

Enduring Understanding: Renewable, clean energy technologies can improve our quality of life, our future, and create significant economic opportunities.

Focus Question: How can I convert the energy of the wind?

Challenge (Problem):

Your challenge is to design a device that uses the power of the wind to generate electricity. Your group will build your prototype using the supplied materials.

(Engage)

You will research types of energy, renewable and non-renewable energy sources, electrical energy measurement & generation, and wind turbines & how they function. On completion of this project you will be able to explain the use of wind power as a renewable resource, and build a model wind turbines and experiment with the types of changes that will increase efficiency.

Your group will be will be assessed on the prototype's performance, use of the engineering design process, teamwork, and a group presentation.

Begin the Engineering Design Process

Let's Get Started!

GOAL: What is the problem your group must solve?

DEFINE THE PROBLEM:

Criteria: What must you do to solve the problem?

1.

2.

3.

4.

5.

6.

Constraints: What will limit you in solving the problem?

1.

2.

3.

4.

5.

6.

Focus Questions: What do you need to know in order to solve the problem?

1.

2.

3.

4.

5.

Build Background Knowledge:

Have you ever felt a strong wind? What could you do with a steady, strong wind? When we get wind to do something for us, we are making it work. Wind is air in motion. It is caused by the uneven heating of Earth's surface by the sun. Since the surface is made of very different types of land and water, it absorbs the sun's heat at different rates. During the day, the air above the land heats up more quickly than the air over water. The warm air over the land expands and rises, and the heavier, cooler air rushes in to take its place, creating winds. At night, the winds are reversed because the air cools more rapidly over land than over water. In the same way, the large atmospheric winds that circle Earth are created because the land near the Equator is heated more by the sun than the land near the North and South Poles.

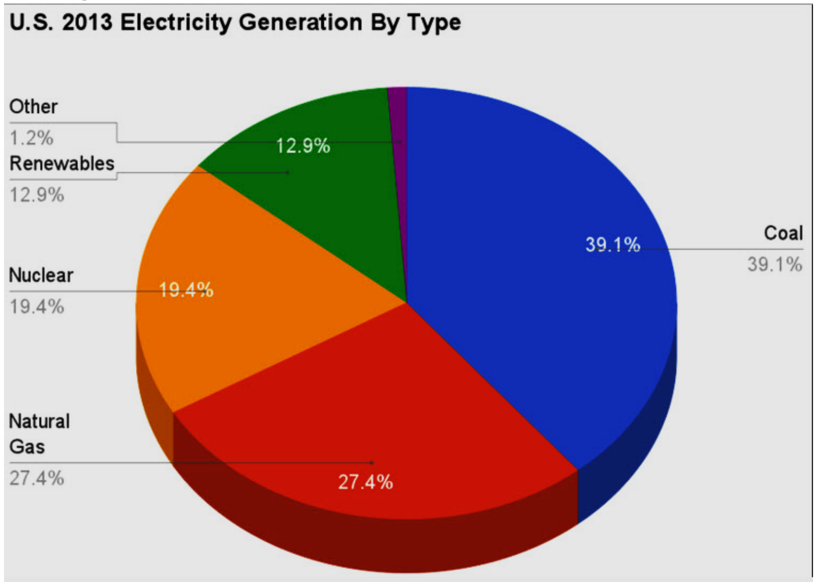
Wind is called a renewable energy source because the wind will blow as long as the sun shines. A renewable energy resource is one that is naturally regenerated over a short period of time (solar, wind, hydropower, geothermal and tidal energy). A non-renewable energy source is a resource for which there is a limited supply. The supply comes from the Earth itself and, as it typically takes millions of years to develop, is limited. Examples are coal, natural gas, petroleum and nuclear fuels.

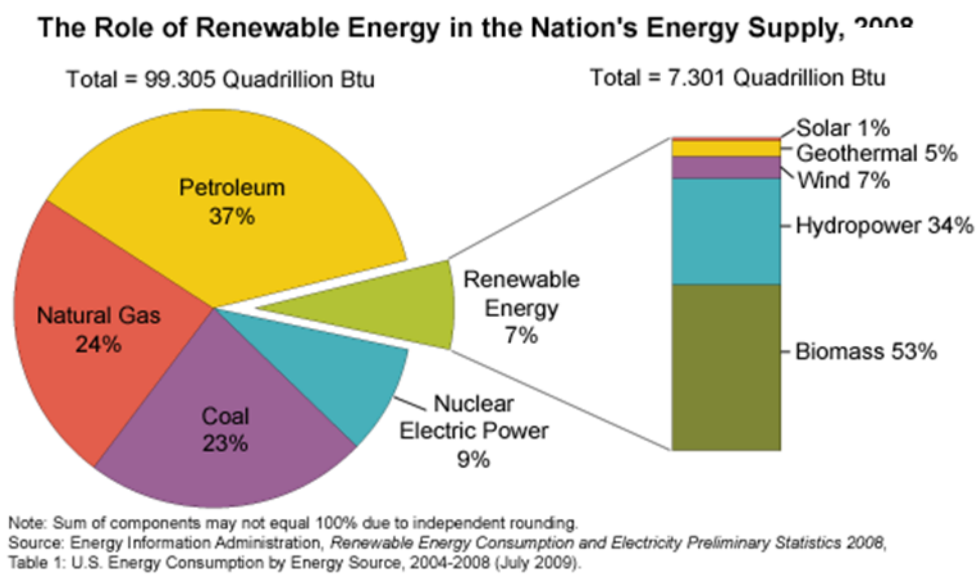
Over 5,000 years ago, the ancient Egyptians used wind to sail ships on the Nile River. Later, people built windmills to grind wheat and other grains. The earliest known windmills were in Persia (Iran). These early windmills looked like large paddle wheels. Centuries later, the people of Holland improved the basic design of the windmill. They gave it propeller-type blades, still made with sails. American colonists used windmills to grind wheat and corn, to pump water, and to cut wood at sawmills. As late as the 1920s, Americans used small windmills to generate electricity in rural areas that had no electric service. Today the wind is being put to work again. Have you seen those tall, modern, white windmills located in large groups on open hillsides? They are called wind turbines, and when there are several of them together, it is called a wind farm. These wind farms are how engineers convert wind energy into usable energy for people, in the form of electricity. A wind farm is a power plant that uses wind turbines to create electricity. Today, engineers continue to make improvements in wind power technology. Wind energy has several advantages. It is a renewable energy source and it does not pollute the environment.

As power companies install wind farms in more and more locations, engineers design turbines and generators that work under all weather conditions. Engineers must design turbines to work in severe weather conditions as well as typical windy days. Sometimes the force of the wind can be steady and sometimes it can cause a powerful repetitive force on the wind turbine, similar to a flag flapping in the wind. If the wind turbine is improperly designed, it might fall apart in a severe windstorm. Since the wind does not blow all of the time, electrical engineers devise ways to ensure that extra energy generated during windy periods can be stored for use during calmer times.

Engineers also design wind farms to protect wildlife. Laws, such as the Migratory Bird Treaty Act and the Endangered Species Act, prohibit the killing of a single bird if it is a protected species. An early 1990s wind farm in California's Altamont Pass caused the loss of so many golden eagles that concerns were raised about building more wind farms. Engineers are involved with research projects to address the bird-wind power problem in a variety of settings, so they can reduce bird deaths from wind plants.

You might not expect engineers to be concerned that wind turbines kill thousands of insects. But, dead bugs on the blades can significantly reduce how well the turbines work. Occasionally, utilities must stop the turbines and pressure-wash hundreds of blades. To reduce the problems caused by insects, engineers incorporate nonstick surfaces and different blade angles into their designs.





Vocabulary:

Collect definitions for vocabulary terms as you build background knowledge.

Anemometer:	
Beaufort scale:	
Constraint:	
Criteria:	
Electric Circuit:	
Energy:	

Generator:	
Machine:	
Motor:	
Nonrenewable energy:	
Potential Energy:	
Renewable energy:	
Rotor:	
Turbine:	
Wind energy:	
Wind farm:	
Wind turbine:	
Work:	

EXPLORE Wind Power & Electricity
Complete the activities on these webpages

WIND POWER NOW:
http://www.pbs.org/now/science/wind.html#turbine

What are some advantages and disadvantages of wind power?

Advantages	Disadvantages

Complete:
Wind Power * America / WIND & MAPS SECTIONS
http://www.pj-i.com/Interactive/WPA/

Describe how the energy of the wind is converted to electrical energy?

1.
2.
3.
4.
5.
6.
7.
8.

Summarize each component of the wind.

Origin:

Speed:

Distribution:

Direction:

Environment:

What is the *average annual wind speed* for Maryland (land)?

What is the average annual wind speed for Maryland (water)?

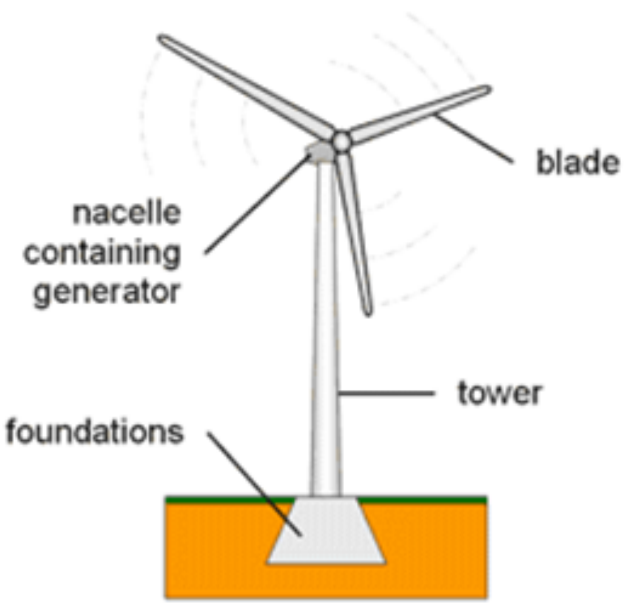
Complete the Wind Energy Virtual Lab:

http://scienceofeverydaylife.discoveryeducation.com /innovation/labs/wind-energy/wind.swf

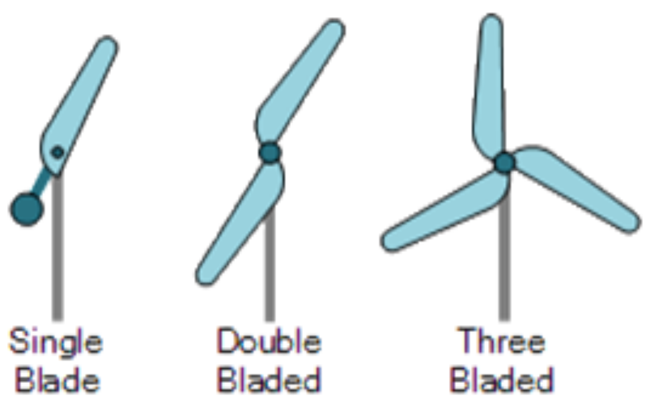
Find the most efficient blade design. *Attach the 3M Wind Energy Design Results to the opposite page*.

Draw the blade design below.

Diagram

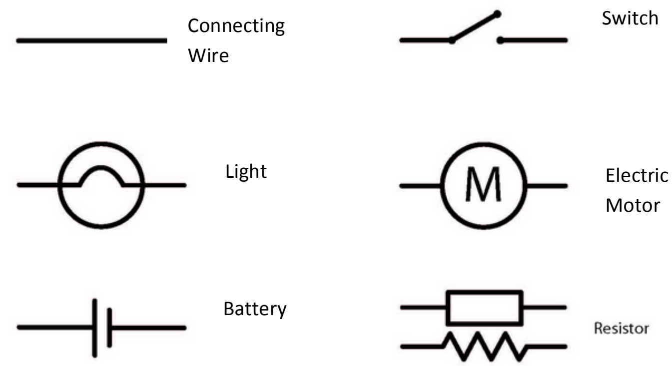


Blade Designs



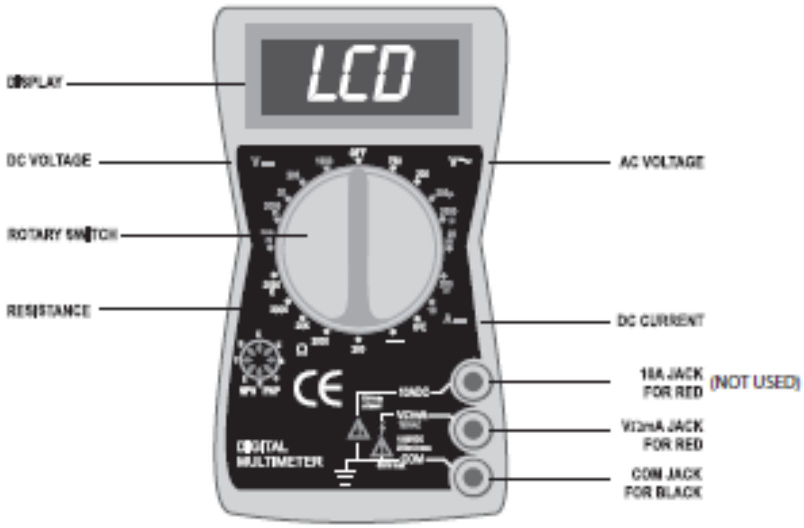
Electricity Lab Exploration

Complete each of the labs below.

<table>
<tr><th>Lab - Build a curcuit.</th><th>Completed</th></tr>
<tr><td>

Using these symbols draw a diagram of the curcuit.</td><td></td></tr>
<tr><td colspan="2">Convert Chemical energy to electrical energy:Describe the tranformations in energy.
____________ → ___________ → __________</td></tr>
<tr><td>Measure the electrical energy using the multi-meter.</td><td></td></tr>
</table>

Digital Multimeter



Directions:

DC Voltage

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

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

1. Connect RED lead to VΩmA jack and BLACK to COM.
2. Set ROTARY SWITCH to 10 ADC setting.
3. Connect leads to the device to be tested using the alligator clips provided.
   Note: The reading indicates DC AMPS; a reading of 0.25 amps equals 250 mA (milliamps).

Wind Gauge

This type of wind gauge is designed to measure wind speed based on Bernoulli's Principle, which states that energy is conserved in a moving fluid (liquid or gas). If the fluid is moving in a horizontal direction, the pressure decreases as the speed of the fluid increases. If the speed decreases, the pressure increases. This means that as the speed of the wind increases, its pressure decreases. Pressure moves from high to low.

The wind gauge has the following features:

A. one large hole in the top of the hollow stem;

B. one small hole on the side of the hollow stem;

C. two holes on the lower back; and

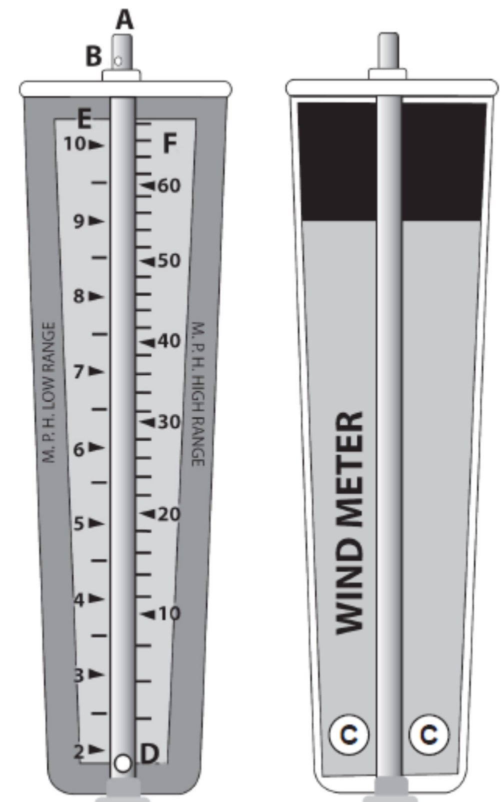
D. a very light ball at the bottom of the hollow stem that can move up and down the stem.

The wind gauge has two ranges:

E. low; and

F. high.

To operate the wind gauge, hold the wind gauge upright into the wind with the scale side facing you. Do not block the bottom holes on the back. As the wind flows across the top holes it creates lower pressure at the top of the stem. No wind flows across the bottom holes, so the pressure there remains the same (at a higher pressure than at the top). Air flows into the bottom holes, lifting the ball. The faster the wind blows, the lower the pressure at the top of the stem. If the wind is blowing faster than 10 mph and the ball is at the top of the stem, cover the large hole at the top of the stem with your finger. Be careful not to obstruct the smaller hole on the side of the stem. The wind will create lower pressure only at the smaller hole. Read the wind speed using the high range on the wind gauge when the top hole is covered.



Wind Lab Exploration

Complete each lab below.

Use the wind gauge to measure the wind speed outside. **________________ M.P.H.**	
Use the wind gauge to measure the wind speed of the fan at a distance of one meter. **________________ M.P.H.**	

<u>Do you have any questions about this challenge? Is there anything you need to know in order to solve this problem?</u>

IMAGINE: (Extend your learning)

***Brainstorm* several designs for your wind turbine prototype.**

Share your ideas with your group. Pick one as a group.

PLAN:

Draw a detailed diagram of your prototype on the opposite page. Draw a side and a front view. Label the parts. Include measurements of all the parts.

Write a description of your prototype:

List materials used in the prototype.

Material	Quanitity needed
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	

(Continue on adjacent page)

CREATE: ***Construct*** **your prototype.**

As you followed your plan, what worked well?

What did you change?

EXPERIMENT: ***Test*** **your prototype**

Quanitative-

Set-up your prototype 1 meter away from the fan.

_____________ M.P.H. – Fan Wind Speed

_____________volts of electricity generated

Qualitative – **Describe your prototype's performance.**
When you tested your prototype, did it generate electricity? Did it work the way you planned it to?

IMPROVE: *Troubleshoot* your prototype

What worked?	What didn't work?

How can you improve the performance of your prototype?
What will you change?

Draw a detailed diagram of your prototype on the opposite page. Draw a side and a front view. Label the parts. Include measurements of all the parts.

Describe the change/s you made to your prototype.

RE-EXPERIMENT:
Quanitative-
Set-up your prototype 1 meter away from the fan.

______________ M.P.H. – Wind Speed

______________volts of electricity generated

______________ % of increace or decrease of electricity generation

Qualitative **– Describe your prototype's performance**.
When you tested your prototype, did it generate the electricity?
Did it work the way you planned it to?

Name your prototype. -_________________________________

Evaluation:

PROTOTYPE RUBRIC:

CATEGORY	4	3	2	1
Function	Structure functions extraordinarily well, holding up under atypical stresses.	Structure functions well, holding up under typical stresses.	Structure functions pretty well, but deteriorates under typical stresses.	Fatal flaws in function with complete failure under typical stresses.
Construction - Materials	Appropriate materials were selected and creatively modified in ways that made them even better.	Appropriate materials were selected and there was an attempt at creative modification to make them even better.	Appropriate materials were selected.	Inappropriate materials were selected and contributed to a product that performed poorly.
Construction - Care Taken	Great care taken in construction process so that the structure is neat, attractive and follows plans accurately.	Construction was careful and accurate for the most part, but 1-2 details could have been refined for a more attractive product.	Construction accurately followed the plans, but 3-4 details could have been refined for a more attractive product.	Construction appears careless or haphazard. Many details need refinement for a strong or attractive product.

PRESENTATION RUBRIC:

As a group plan a presentation that shares your findings, design and prototype. You can use PowerPoint, a Flipchart, a video or a combination of these. Be prepared to present to the group. Your group's presentation will be scored using rubric below.

3	**2**	**1**
Completely describes the pros and cons of the design plan.	Somewhat describes the pros and cons of the design plan.	Fails to describe the pros and cons of the design plan.
Describes the task the prototype is designed to accomplish.	Somewhat describes the task the prototype is designed to accomplish.	Fails to describes the task the prototype is designed to accomplish.
Use the data for your design, to explain failures or successes of the prototype.	Somewhat uses the data for your design, to explain failures or successes of the prototype.	Fails to use the data for your design, to explain failures or successes of the prototype.
Discuss your team's final design plan. What changes did you make to the original design? What changes would you make to improve your prototype now?	Discussed two aspects of the design.	Discussed one or less aspects of the design.
Completely answers the questions: How can renewable resources be transformed into useful energy forms? How can I convert the energy of the wind?	Somewhat answers the questions: How can renewable resources be transformed into useful energy forms? How can I convert the energy of the wind?	Fails to answer the questions: How can renewable resources be transformed into useful energy forms? How can I convert the energy of the wind?
Shares information about the use of wind turbines in the world today, their pros and cons, and other relevant background information.	Somewhat shares information about the use of wind turbines in the world today, their pros and cons, and other relevant background information.	Fails to share information about the use of wind turbines in the world today, their pros and cons, and other relevant background information.
Collaboration is obvious. All members of the group participate in the presentation.	All members of the group participate in the presentation.	Single member of the group presents.
Effective use of vocabulary in presentation.	Some vocabulary used in presentation.	Vocabulary was not used in the presentation.

Scoring for Journal Entries (Individual)

Journals will be graded throughout the project.

3	2	1
Each step is dated and added to the table of contents.	Most steps are dated and added to the table of contents.	Each step is dated and added to the table of contents.
Each Table of Contents entry identifies the step by a **heading.**	Most entries identify the step by a heading.	Headings are not entered in the Table of Contents.
Drawing/prototype designs are clearly labeled with the parts and directional arrows for forces. Includes measurements of all the parts.	Two of the components are completed.	One of the components is completed.
Data collection is detailed. (quantitative, qualitative)	Data collection is incomplete. (quantitative, qualitative)	Failed to collect data. (quantitative, qualitative)
Accurate and labeled diagrams at each stage of development, with a side, top and front view. Label parts. Measurements of all the parts.	Two of the components are completed.	One of the components is completed.
Detailed collection of background information.	Minimal collection of background information.	No collection of background information.

Evidence the Engineering Design Process was used.

Details for each step are complete. 2	Details for each step are incomplete. 1	Details for each step not completed. 0
Goal	Goal	Goal
Ask	Ask	Ask
Imagine	Imagine	Imagine
Plan	Plan	Plan
Create	Create	Create
Experiment	Experiment	Experiment
Improve	Improve	Improve
Re-Experiment	Re-Experiment	Re-Experiment

__/__/__	Presentations
__/__/__	
__/__/__	
__/__/__	
__/__/__	
__/__/__	
__/__/__	
__/__/__	

will do it:

ADDITIONAL RESOURCES:

Beaufort Scale

Beaufort number	Wind Speed (mph)	Seaman's term		Effects on Land
0	Under 1	Calm		Calm; smoke rises vertically.
1	1-3	Light Air		Smoke drift indicates wind direction; vanes do not move.
2	4-7	Light Breeze		Wind felt on face; leaves rustle; vanes begin to move.
3	8-12	Gentle Breeze		Leaves, small twigs in constant motion; light flags extended.
4	13-18	Moderate Breeze		Dust, leaves and loose paper raised up; small branches move.
5	19-24	Fresh Breeze		Small trees begin to sway.
6	25-31	Strong Breeze		Large branches of trees in motion; whistling heard in wires.
7	32-38	Moderate Gale		Whole trees in motion; resistance felt in walking against the wind.
8	39-46	Fresh Gale		Twigs and small branches broken off trees.
9	47-54	Strong Gale		Slight structural damage occurs; slate blown from roofs.
10	55-63	Whole Gale		Seldom experienced on land; trees broken; structural damage occurs.
11	64-72	Storm		Very rarely experienced on land; usually with widespread damage.
12	73 or higher	Hurricane Force		Violence and destruction.