UTAH OFFICE OF
ENERGY DEVELOPMENT

Exploring Energy Conversions with Wind Power

Grade/Subject: Physics

Strand/Standard: Physics.2.4 Design a solution by constructing a device that converts one form of energy into another form of energy to solve a complex real-life problem. *Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution*. Examples of energy transformation could include electrical energy to mechanical energy, mechanical energy to electrical energy, or electromagnetic radiation to thermal energy. (PS3.A, PS3.B, ETS1.A, ETS1.B, ETS1.C)

Lesson Performance Expectations:

- Students will create a device that converts kinetic wind energy into electricity.
- Students will evaluate their design compared to other designs with the same materials and pick out the best design.

Materials: A group of 4 needs:

- 1- small room/desk fan (for every 2-3 groups)
- 1- ⅜ " wooden dowel 16"
- 4-8 index cards
- 4 wooden skewers
- 4 ft of string
- 1 1" PVC tee joint
- 1 cork
- 4 pins
- 18" clear scotch tape
- Clay/ playdough
- 1- 3V mini generator motor

Access to a stapler and simple tools (plyers, screwdriver), shared between the class.

Time: 80 minutes

Teacher Background Information:

- OED Wind Energy Video (3.04 min)
- DOE How do Wind Turbines Work?
- How to Use a Multimeter
- DOE Building, the Basic PVC Wind Turbine
- Students can make their wind turbines without needing the entire PVC base structure.

- Energy is the ability to do work. It exists in many forms, and some forms are more useful than others. Kinetic energy and potential energy are the main categories of energy under which most energy forms fall. Energy can be provided by natural resources such as wind, solar, and hydrocarbons.
- The Law of Conservation of Energy states that energy cannot be created or destroyed but only changed from one form to another. Electricity generated with wind involves the following energy conversions:
- Wind is kinetic energy caused by the sun's thermal energy when it is radiated to the earth and heats the surface unevenly.
- The kinetic energy of wind turns the blades of a wind turbine.
- The mechanical energy in the rotating turbine blades and shaft is converted to electrical energy in the turbine generator.
- Electricity may be transformed into another type of energy by the end-user. For example, the used electricity to power a toaster changes back to thermal energy to toast the bread.
- How does wind generate electricity? Energy from wind is utilized using a wind turbine, sometimes called a wind generator that harnesses the energy that is then converted into electricity (EIA).
- Wind energy is one of the oldest methods of utilizing a natural fuel source to produce power, dating back thousands of years. From moving large boats to food production. In the 1930s, wind development for electricity was developed as the transmission systems were built. Over the last 50 years, the wind has been developed more extensively to mitigate the risk of other fuel shortages (petroleum) and to address environmental concerns (EIA).
- Two wind turbines are regularly used to create energy on a large scale and work on the same basic principles. As the wind travels into and through the blades, they rotate and turn a shaft. In turn, this shaft connects to a generator that will create electricity. A two-blade turbine typically faces away from the wind, and a three-blade turbine normally faces into the wind. Typically, many turbines are combined to create wind farms capable of powering a large number of buildings. Some smaller single turbines are available to place on residential roofs or gardens to power certain aspects of a home. The large wind turbines used by electric utilities are typically horizontal axis machines that resemble airplane propellers. However, many small wind turbines are vertical axis machines with swirling blades connected at the top and bottom.

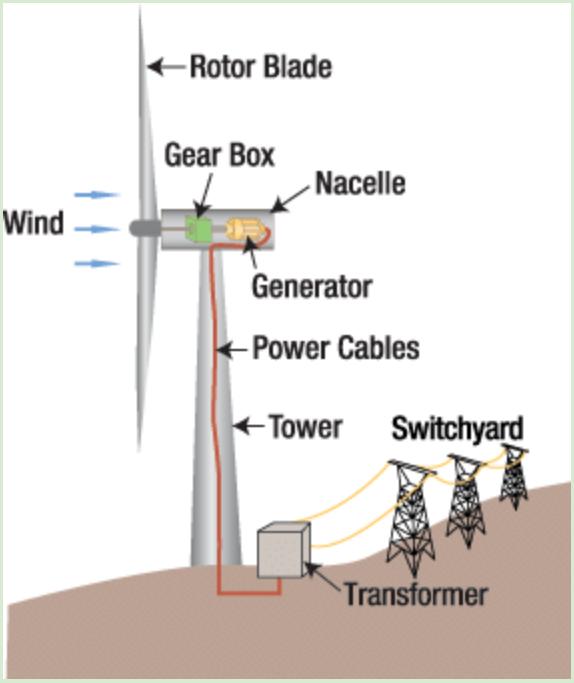
Student Background Knowledge:

- Students need to understand the different types of energy and how energy can change from one form to another.
- Students need a basic understanding of electrical circuits.
- Students need to know how to use a multimeter. (Or be given an explanation and support during the activity)

Teacher Step by Step: A 3-d lesson should insist students do the thinking. Provide time and space for the students to experience phenomenon and ask questions. The student sheet provided below provides guidance but is only an example of how students might respond.

1. **Introduce *Problem:*** Show the animation/video at the following link. This video has many thinking questions that students can start considering that relate to energy generation from wind. *Wind Turbine Animation (:39 min) (this 2:16 min) (this 2:13)*
2. Have students pick out a couple of the questions about wind turbines that they are most curious about and write them down. They may also add questions that they wondered about from the video. Examples- Why/How does the outside of the blade spin faster than the wind? What are the parts of a wind turbine? What factors affect the efficiency of a wind turbine? (# blades/ angle of blades/ wind speed etc)? What factors help decide where a wind farm should go?
3. Using a diagram of a wind turbine, label the energy transformations that occur.

4. Give students the materials and have them create a machine that will rotate in the wind. Once they create a design that will rotate in the wind, they should connect a multimeter to the generator's wires to see how much energy is produced by the wind turbine they have created.
5. Have them draw their wind turbine and explain how it works, especially anything they learned that differed from their original sketch. During this sketch, ask probing questions such as
    a. How did you attach your blades and adjust their pitch/angle?
    b. Does your wind turbine have friction/ what did you do to reduce friction
    c. Does the wind turbine work better with the fan on one side or the other?
    d. How was energy changing form during the process?
6. Together as a class, build one or two wind turbines using the 'best' materials and designs.
7. Answers to questions



1. Wind energy is converted into kinetic energy
2. Kinetic energy converts to electrical energy
3. Electrical energy converts to energy in your home

Assessment of Student Learning.

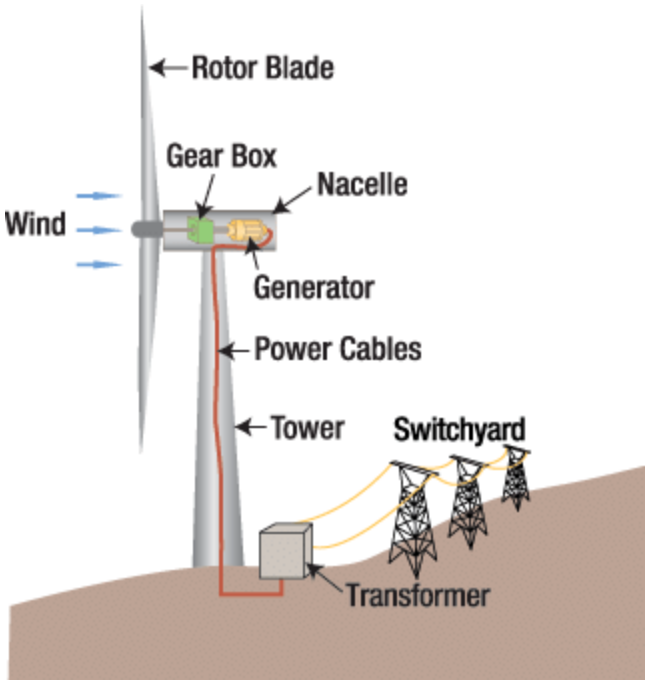
What **claim** can you make about the conversion of energy? *Energy can change form multiple times.* What **evidence** do you have to support it? *The wind turning the turbine's blade produces kinetic energy, which is then turned into electrical energy.* What **reasoning** did you use? *The wind did not have any electricity in it, yet by converting the energy of the wind, we can get electrical energy to power our homes.*

Standardized Test Preparation:

Exploring Energy Conversions with Wind Power

1. What variables determine the output of a wind generator? Choose all that apply:
    a. The speed of the wind.*
    b. The size of the blades.*

c. The size of the generator*
d. The direction the windmill faces.*



2. What variables affect the ability of the blades to produce electricity? Choose all that apply.
   a. Their length*
   b. Their shape*
   c. Their weight*
   d. Their number*

3. What are the criteria for a city today to add a windmill to its energy grid? Choose all that apply.
   a. The wind must be adequate to produce electricity.*
   b. The windmill must create affordable electricity.*
   c. The windmill must replace the other energy sources currently used.
   d. The windmill must produce enough energy to sell to other cities.

4. What constraints does a city have when adding windmills to their energy grid? Choose all that apply.
   a. The windmills must fit in a budget.*.
   b. The city must have a place to put windmills.*
   c. The windmills must be taller than the tallest building.
   d. The windmills must have backup storage or an alternative energy source.*

Extension of lesson: Write a compare/contrast paragraph on the following videos about wind energy technicians and about them: **A Day in the life of a Wind turbine technician** and **Wind Energy Technicians Fast-Growing Jobs**

Career Connections: Wind turbine technician, heavy equipment operator, and electrician.

Exploring Energy Conversions with Wind Power

Name_____

Problem: Globally, environmental concerns, including climate change, are challenging people to examine and search for new energy sources. Wind power is a potential source. Write down three questions that interest you as you watch the video.

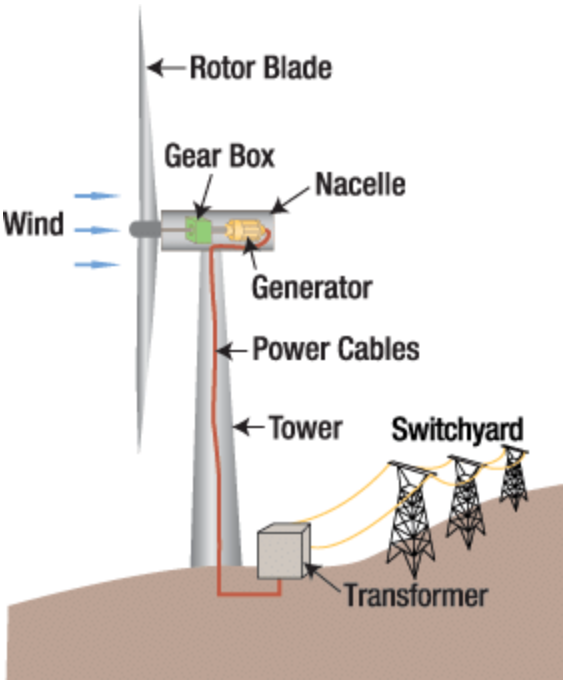
1.

2.

3.

Background:

Below is a picture of a wind turbine. Explain the energy conversions you see in this picture. Add more steps if you want to/can.



1. Wind energy is converted into _____
2. _____ energy converts to _____
3. _____ energy converts to _____

Design and Build

1. Look at the materials available. Sketch how you think you can make the best wind turbine with those materials.

2. Now create the wind turbine. Be sure to check with your instructor before attaching anything permanently. Keep experimenting with your materials until you have something attached to your generator that will spin when placed in front of a fan.

3. Once your wind turbine seems to be working, use a multimeter to measure the voltage being produced by your wind turbine.
   Voltage:_____

4. Try a couple of different designs to see what works best. What is the best voltage you can get?
   Voltage _____

5. Sketch your wind turbine below and explain what you learned during the building process about what is necessary to create a working wind turbine. Make sure to explain any differences from your original sketch.

Comparisons:

Have each group share how they created their wind turbine and the features that make it successful.

	# Blades	Blade shape/size	Fan Speed	Voltage
Group 1				
Group 2				
Group 3				
Group 4				
Group 5				
Group 6				
Group 7				
Group 8				
Group 9				
Group 10				

Although there are many variables tested above, decide what you think the best answer is to each question below.

5. What number of blades produced the most electricity?

6. What fan speed produced the most electricity?

7. What is the best size and shape for making blades?

8. Together as a class, build one or two wind turbines with the answers to questions 5-7. Did either of these wind turbines outperform all of the original designs?

9. Look back at your three questions from the intro video. Can you answer at least one of them now? Please do so here.

10. Scientists accept a law that says energy is converted from one form to another.

    What **claim** can you make about the conversion of energy?

    What **evidence** do you have to support it?

    What **reasoning** did you use?