UTAH OFFICE OF
ENERGY DEVELOPMENT

The Power of Wind

Grade/Subject: 4th Grade

Strand/Standard 4.2.4 Design a device that converts energy from one form to another. *Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data from testing solutions, and propose modifications for optimizing a solution.* Emphasize identifying the initial and final forms of energy. Examples could include solar ovens that convert light energy to heat energy or a simple alarm system that converts motion energy into sound energy. (PS3.B, PS3.D, ETS1.A, ETS1.B, ETS1.C)

Lesson Performance Expectations:

- Identify wind power as a source of energy
- Engineer a windmill to create enough power to light an LED light bulb
- Using the engineering process, students will determine the construction of the blades, the housing unit, and wind power enough volts to light one LED light bulb
- Students will understand why we can't rely solely on this resource for energy

Materials: Materials listed are enough for one group of 3-4 students.

- 20 - 30 small wooden craft sticks
- Small hobby motor, 6 - 12 volts -- Can be purchased in most model stores or on Amazon
- Low-temperature glue gun and glue sticks
- Different types of paper (examples: construction, copy, cardstock, color copy paper, newspaper, or recipe cards)
- Hair Dryer, fan, or windy day
- Drill (for teacher use) and drill bit that matches the same size as the motor shaft
- Alligator clips with copper wire
- 2- 3 Voltmeters for the testing area.-- available at most hardware stores or on Amazon.
- Optional: LED light bulbs Amazon

Time: 3-4 days 45 - 60 mins each day

Day 1 Introduction and research
Day 2 Building the prototype
Day 3 Testing prototype and Redesign
Day 4 Test redesign and record the data

Teacher Background Information:

- Wind is the air that moves between regions of different pressure. Temperature differences between regions, which result from variations in the solar energy received at the surface of the Earth, cause the pressure differences that drive winds. The rotation of the Earth also affects the direction of the winds.

- OED Wind Energy Video

- Wind is a powerful force that can be used to produce energy. It is a renewable energy source, which means we can use it repeatedly without ever using it up. Wind power is also an emissions-free energy source. Challenges to wind energy are finding ways to capture its power. Engineers designed wind turbines that look little like windmills to do just that. You may have seen wind farms or groups of wind turbines in certain parts of Utah. They often resemble tall, white pinwheels on a large "stick."

- A typical wind turbine contains numerous components, many of which are made from steel, cast iron, and concrete. Some parts of the wind turbine require materials mined here in Utah, like copper, iron, and zinc, so an increase in the number of wind turbines manufactured also generates an increased need for mining.

- How does a wind turbine work? The turbine blades connect to a gearbox, which spins it faster and connects to the generator. As the wind blows, the blades of the turbines spin, which turns into a generator that creates electricity for our use. A turbine also has a brake in case the wind starts blowing too fast.

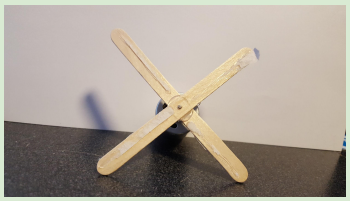
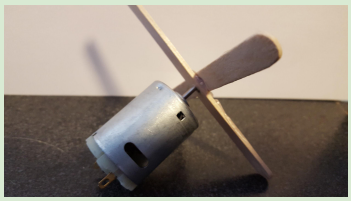
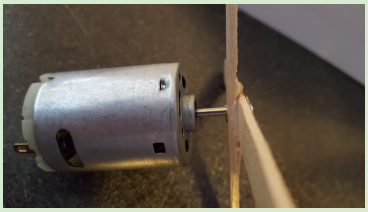
- Wind turbines may also slow or stop, producing little or no electricity when the wind blows slowly or not at all.

- Utah Geological Survey identified wind development zones covering approximately 1838 square miles in Utah or about 2% of the state's surface area. These zones can produce up to 9145 MW of wind generating capacity. Currently, there are three wind farms in Utah: Spanish Fork Wind Park in Utah County, Latigo Wind Park in San Juan County, and Utah's largest wind energy project, Milford Wind, in Millard and Beaver Counties.

Student Background Knowledge:
Students need to know how to read a voltmeter. Video on How to read a voltmeter: The Best Multimeter Tutorial (4:35 min)

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

Teacher Preparation:

To prep the windmill portion, glue two craft sticks together in the middle. Once the glue sets, drill a hole in the middle. It should fit tightly around the drive shaft on the mini motor. A drill could be useful during the project in case students need to make some changes. It is also suggested to make extra cross pieces. You will need to divide the students into groups of 3-4 students.

Day 1: Introduction and Research
Introduce the Problem to the students on page 1. Allow students to discuss (3-5 mins) their knowledge of windmills, where they have seen them, and how they work. After the discussion, let the students come up with some questions they may need to know before they create a windmill. Have them write down their questions

and draw a model of their knowledge of what a windmill will look like on the outside and how it functions on the inside. As a class, look at each groups' questions but do not answer the questions.

Research: The student worksheet has links to videos on turbines and energy production. Students will need to take notes and look at the previous model they drew. Have students work quietly on their notes and designs.

Bring the students together in their groups. Ask: How would you change your model to make it more effective and efficient? Decide within your group what design to use that creates an energy-generating windmill.

The student groups will use their research to create a model that will meet the criteria and constraints. Make sure they know that time to build their prototype is limited. Students will also need to look at what supplies are available to use. (You can make some changes to some of the building supplies.) Groups must make a list of supplies that they will be using. They will also need to have a detailed model with notes of the length of blades, the height of the windmill, etc.

Day two: Building your Prototype
Students build their original prototype

Day three: Testing, Analyzing, and Redesign
Teacher prep: Set up an area where the students can test their prototype by setting up a hairdryer or fan. Place the voltmeters nearby so students can test their prototypes.
Video on How to read a voltmeter: The Best Multimeter Tutorial (4:35 minutes)

Student groups can test their prototype, writing down the amount of energy they have created using wind. They will record the volts on the voltmeter and any additional observations (for example, blades not long enough, blades hitting the base, etc.)

Once the group has tested their prototype, the students need to answer the analysis questions. Students will then get an opportunity to redesign and adjust their prototypes. Explain that they don't need to start over but can use this redesign to look at the problems and use different ideas to develop a solution. Allow time for the students to make the changes to their prototype.

Day four: Testing Redesign and analyzing data
Have students test their redesigns and analyze the data. Once the groups have discussed their data, have students complete the Interpretation and conclusion portion of the worksheet.

Assessment of Student Learning. Students will complete the Interpretation or Conclusion page. The following questions are asked:

1) Did your prototype meet the Criteria? Why or why not?
2) Did your group succeed in creating wind power? How did the redesign changes help your project?
3) What other changes in the design could you make in the prototype?
4) What did you learn in the process of designing and testing your project?

Standardized Test Preparation:

The Power of Wind

1. What are the advantages of wind power? Choose all that apply.
    a. Wind energy is mostly free.*
    b. Wind energy produces fewer emissions.*
    c. Wind energy does not require expensive machinery.
    d. Wind is always blowing to create a steady source of energy.

2. What are the criteria for a city that wishes to design a system to capture wind energy in a city today? Choose all that apply.
    a. The energy produced must supplement the energy sources currently used.*
    b. The energy must be transformed into usable electricity.*
    c. The energy must allow for enough extra to sell to the electric company.
    d. The energy must replace all other sources of electricity for the household.

3. What are the constraints for the city as it designs a system to capture wind energy? Choose all that apply.
    a. Cost of the windmills.*
    b. Amount of electricity the windmills can produce.*
    c. The number of days of adequate wind.*
    d. The size of the area available for windmills.*

4. Why is wind energy attractive to people living in Utah? Choose all that apply.
    a. The energy source is mostly free.*
    b. Wind energy produces little or no emissions.*
    c. Current energy sources produce emissions.*
    d. Wind energy costs less than other sources.

Extension of lesson and Career Connections:
Have students look up different careers in wind power. The following are some websites to find research. DOE Wind Career Map shows various career opportunities. DOE Wind Career Map with Descriptions gives students definitions of the careers.

The Power of the Wind

Name_____

The mayor of a small town needs your help. The town will be growing quickly in the next few years. The city council would like to see this growing city use renewable energy as an energy source. Many on the city council would like to look into wind energy. Your job is to create a prototype using wind to generate electricity for the town. A "prototype" is a physical model of a machine that can be adjusted and changed to meet needs.

The mayor has assigned you and your partners to create an efficient windmill prototype to see if it can generate at least 1.0 volts of electricity.

Together with your group, discuss three main questions you will need to research before building.

1.

2.

3.

Research: Research is important to the engineering process. Watch the following videos and write down what you learned in them.

Energy 101: Wind Power (2:13 minutes)

What did you learn from the video?

Energy 101: wind turbines (3:16 minutes)

What did you learn from the video?

https://www.energy.gov/eere/wind/animation-how-wind-turbine-works

What does this animation show?

Criteria: Create a windmill that can generate at least 1.0 volts of electricity on a voltmeter.

Constraints: Limited supplies-- Craft Sticks, low-temperature glue gun, glue sticks, different types of paper, Time: You have 1 hour to construct the windmill
Blade Size

_____

_____

Windmill Height_____

Based on your research, draw a model of your windmill. Include dimensions of the blade, height of the windmill, location of the motor, and wires.

List of supplies your group chose.

Testing: Place your windmill in front of the fan. Record the number of volts created (the data) on the table below.

	Fan Test #1	Fan Test #2	Fan Test #3	Observations
Low-Speed				
Medium-Speed				
High-Speed				

Analysis: Answer the following questions.

1) How did your windmill perform? Give some examples from your observations.

2) What changes do you need to make to the windmill to make it more efficient or fix issues during testing?

Redesign: Redesign your windmill by making changes to improve or reach the criteria. Then retest your design and record the results in the table below.

	Fan Test #1	Fan Test #2	Fan Test #3	Observations
Low-Speed				
Medium-Speed				
High-Speed				

Analysis: Answer the questions below.

1) Did your redesign meet the criteria? Why or Why not? Describe your observations.

2) What changes do you need to make to the windmill to make it more efficient or fix issues during testing? Use the space below to show any redesigns.

Interpretation or Conclusion: Answer the following questions about your project.

1) Did your prototype meet the Criteria? Why or why not? Did your group succeed in creating wind power? How did the redesign changes help your project?

2) Did your group work together successfully? What is your evidence?

3) What other changes in the design could you make in the project?

4) What did you learn in the process of designing and testing your project?