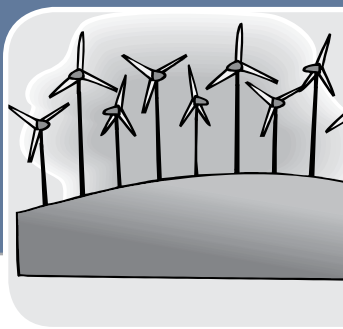
Summary:
Students construct simple turbines to investigate how the energy in wind and water can be harnessed to do work.

Waterwheels, Windmills, and Turbines



Grade Level: K–4 (5–8)

Subject Areas: Language Arts, Science, Social Studies

Setting: Classroom

Time:
Preparation: 50 minutes
Activity: 50 minutes

Vocabulary: Dam, Generator, Hydroelectric power, Kinetic energy, Mechanical energy, Potential energy, Turbine

Major Concept Areas:

- Natural laws that govern energy
- Development of energy resources

Standards Addressed:

Common Core ELA: L.K-5.4, L.3-5.3, L.4-5.6, RI.K-5.4, RI.1.1, RI.2.2, RI.2-4.3, RI.2-5.10, RI.3.1, RI.3.5, RI.3-4.7, RI.5.1, RL.K.4, RL.K.10, RL.1.1, RL.3-5.1, RL.2-4.4, RL.4.7, RL.5.7, SL.K-2.1, SL.K.2, SL.K-2.3, SL.K-1.6, SL.2-5.2, W.K-1.5, W.3-5.7

NGSS: K-PS2-1, K-PS2-2, K-2-ETS1-2, K2-ETS1-3, 2-PS1-2, 3-PS2-2, 4-ESS3-1, 4-PS3-1, 4-PS3-3, 4PS3-4
SEP: Analyzing and Interpreting Data, Asking Questions and Defining Problems, Constructing Explanations and Designing Solutions, Developing and Using Models, Obtaining, Evaluating, and Communicating, Planning and Carrying Out Investigations
DCI: ESS3.A: Natural Resources, ETS1.B: Developing Possible Solutions, ETS1.C: Optimizing the Design Solution, PS1.A: Structure and Properties of

Continued on next page

Objectives

Students will be able to

- demonstrate how wind and water can move a simple turbine; and
- recount the role of turbines in electricity generation.

Rationale
Understanding how turbines operate helps students explain how humans have developed technology to further their ability to use energy resources.

Materials

- A pinwheel (see ***Getting Ready***)
- Tea kettle (electric or with a heat source such as a hot plate)
- Aluminum foil
- Masking tape
- Photographs of windmills and waterwheels (optional)
- Each group will need a copy of and materials listed on ***Waterwheels, Windmills, and Turbines Activity Sheet,*** *Student Book*, page 95

Background

See the following resources in the *Student Book* for background information:

- ***Facts about Hydropower***, page 305
- ***Facts about Wind Energy***, page 328
- ***Electricity from Falling Water***, page 335
- ***Electricity from Fossil Fuels***, page 336
- ***Electricity from Uranium***, page 337

The wind gently blows across the surface of a lake. This is a calming sight, but who would think that wind and water are both sources of energy that can power all the electrical appliances in our home?

Wind is a form of energy created in part by the sun. The heating and cooling of Earth's surface and Earth's rotation help form wind. The sun heats Earth's surfaces. This heat is then radiated, warming the surrounding air. About two percent of the sun's energy that reaches Earth is converted to wind energy.

Wind energy has been used for hundreds of years. Farmers and ranchers have used windmills to pump water to fields and livestock in remote locations. Today wind machines still use mechanical energy to pump water but more and more they are used to provide electricity for operating lights and appliances. Although only a small amount of electricity in Wisconsin is generated through wind power (less than one percent), electricity generated by wind energy is steadily growing in the state. Wind machines that generate electricity can be small or large scale systems. Wisconsin utilities operate 55 large wind turbines in five sites in Wisconsin. The rotation diameter of these blades can be over 150 feet (46 meters)! Home-sized (small scale) systems have rotation diameters that range from 10 to 20 feet (3 to 6 meters).

Similar to wind energy, water power has been used for many years to do work. Many people have seen grist mills located by streams. The flowing stream causes a waterwheel to rotate that turns gears within the grist mill to grind flour. Waterwheels also lift objects (including water) and power machinery.

Humans use flowing water to generate electricity (hydroelectricity). Dam operators regulate the flow of water through the dam (see ***Electricity from Falling Water***). There are around 70 utility-operated and about 50 privately-owned hydroelectric sites in Wisconsin. These sites produce about 2,500 million kilowatt hours of electricity.

Another form of water, steam, can be used to generate electricity as well. Burning fossil fuels (coal, oil, or natural gas) or the heat from nuclear fission converts water to steam. (see ***Electric Power from Fossil Fuels and Electricity from Uranium***).

Although there are variations in how wind, water, and steam generate electricity, all involve spinning blades. The blades spin a shaft that in turn causes a wire coil in a generator to spin. The generator converts the mechanical energy of the spinning coil into electrical energy. The spinning wire coil is surrounded by magnets that produce an electric current (see the activity "Electric Motors and Generators"). The electricity produced by the generator is transmitted through power lines to homes and businesses in the surrounding community. To make sure that enough water is available to spin the turbine, humans build dams to store water and release it as needed. The dams prevent the water from flowing down stream, creating a reservoir. The stored water behind the dam has a large amount of potential energy.

So, the next time you dip your toes in a babbling brook or feel a cool breeze on your face, remember: these resources also have the energy to generate electricity for appliances we use every day.

Procedure

Orientation

Show students a pinwheel and ask if they think it can do work. Remind them of the definition of work (applying a force—a push or a pull—that moves something a distance). Blow on the pinwheel to show students that it moves. Ask students to think of situations where a wheel similar to this can do work. Show students photographs or describe windmills and waterwheels.

Discuss what sources of energy make the windmills and waterwheels turn. Explain that the wheels are tools or simple machines that convert the kinetic energy in the wind or water to mechanical energy. Tell them that another word for this working wheel is a turbine, a wheel with blades joined to a shaft. Inform them they will make their own model turbine and experiment with different ways to make it turn.

Steps

1. Divide the class into small groups and provide each group with a copy of ***Waterwheels, Windmills, and Turbines Activity Sheet***. One student in the group can be responsible for getting materials, another student for reading directions and providing guidance, and another for constructing the turbine.

2. Have students read the Introduction and Making a Turbine sections of the activity sheet. Go over each step with students to make sure they understand the procedure. NOTE: For younger students, it might suffice to make simple pinwheels to demonstrate how wind energy spins

Water turbine for Unit #1 at Grandfather Falls Hydroelectric plant. Courtesy Wisconsin Public Service Corporation.

Matter, PS2.A: Forces and Motion, PS2.B: Types of Interactions, PS3.A: Definitions of Energy, PS3.B: Conservation of Energy and Energy Transfer, PS3.C: Relationship Between Energy and Forces
CCC: Cause and Effect, Connections to Engineering, Energy and Matter, Patterns, Structure and Function, Technology

Getting Ready: Construct a turbine prior to the class and use this as a model. This turbine can also serve as the pinwheel used in the **Orientation**.

Young hands may lack the dexterity to make these turbines. Consider making a class set for these students. Students can make a simple pinwheel to demonstrate wind energy.

To prepare for Part C in the ***Waterwheels, Windmills, and Turbines Activity Sheet***, cover the spout of an electric kettle with a piece of aluminum foil and secure with tape. Poke a pencil hole in the foil near the tip of the spout.

Resources:

For a list of additional resources related to this activity, visit the KEEP website at keepprogram.org and click on Curriculum & Resources.

Woelfle, Gretchen. *The Wind at Work: An Activity Guide to Windmills.* Chicago: Chicago Review Press, 1997.

Related KEEP Activities:

This activity could be preceded with investigations found in K–5 Energy Sparks for Theme II: "Sunvestigations," "Windy Wonders," and "Water Fun." Help students appreciate their dependence on electricity through K-5 Energy Sparks for Theme II: "Electricity in Our Lives." Students identify energy sources used to generate electricity in "Fueling Around." Have students learn more about electricity with the activity "Circuit Circus."

Credits:

Activity adapted from NMSU Cooperative Extension Service and the New Mexico Energy, Minerals, and Natural Resources Department, Energy Conservation and Management Division. "Blowin and Flowin" pp. 11–17 in *Power Pack: Science and Energy SERIES Supplement for New Mexico*. Las Cruces, N. Mex.: New Mexico State University Cooperative Extension Service, n.d. Used with permission. All rights reserved.

Waterwheels, Windmills, and Turbines Activity Sheet adapted from Society, Environment and Energy Development Studies Foundation. SEEDS 5: *The Energy Literacy Series Teacher's Guide.* Edmonton, Alberta: Society, Environment and Energy Development Studies Foundation, 1981. Used with permission. All rights reserved.

the blades. Use the water resistant pie plate to illustrate how the flow of water or steam is used to spin the blades. ***CAUTION: Warn students to be careful when using scissors and that the edges of the cut pie plate may be sharp.***

3. Tell students to make their model turbines. It is important to check to see that the shaft fits snugly in the hole in the pie plate. You may need to glue the shaft to the pie plate. The turbine should not rotate around the shaft.

4. When the students have finished their turbines, tell them to follow the instructions for conducting the experiments described in Using the Turbine, Parts A, B, and C on the ***Waterwheels, Windmills, and Turbines Activity Sheet*** and record answers to the questions on the activity sheet. ***CAUTION: Supervise the kettle at all times to make sure no one gets burned.*** Students will be able to answer most of the questions based on their observations.

Closure

When everyone has finished, discuss their answers to the questions posed in the ***Waterwheels, Windmills, and Turbines Activity Sheet.*** Stress to students that the turbine caused a change in the direction of the energy of motion. The wind, water, and steam moved in a straight line until they hit the blades of the turbine. Then the turbine moved in a circle. Point out that because the turbine caused a change, we can call it an energy converter. Tell students that turbines are an important part of the machinery we use to make electricity. Discuss information about windmills, dams, and generators in power plants (see the **Background**).

Assessment

Formative

- Did students follow directions and successfully build model turbines?
- To what extent did students make careful observations and respond thoughtfully to the questions?
- Were students able to make the turbines spin using wind and water?

Summative

Have students build or sketch a simple power plant, including a turbine, and trace the flow of energy from the turbine to their homes.

Extension

Challenge students to design a different model for a waterwheel or turbine. For example, cut flaps in plastic jar and skewer the jar on a doweling rod.

Answers to Activity Sheet Questions

Part A: The Windmill

1. The windmill spins gently when you blow on it lightly.
2. The windmill spins more quickly when you blow harder. You supply more energy when you blow harder.

Part B: The Waterwheel

1. The water has stored energy.
2. When the water strikes the blades of the turbine, the turbine spins.
3. To make the turbine turn the fastest, you should hold it as far from the cup as possible because the farther the water falls, the more kinetic energy it has and the more work it can do on the turbine.

Part C: The Steam Engine

1. Yes. The turbine turned as the steam hit it.
2. The steam was produced by boiling water in a kettle.