Testing a Windmill Generator

RENEWABLE ENERGY
THE INFINITE POWER OF TEXAS

FOR USE WITH FACT SHEET NO. 13: WIND POWER BASICS

TEXAS ESSENTIAL KNOWLEDGE AND SKILLS

TEKS utilized include **SCI.**(3) All systems…can be described in terms of...energy; change and consistency…can be observed and measured as patterns; 2(C) make inferences and predict trends from data; 6(C) analyze the efficiency of energy conversions…for the production of electricity...from...the movement of...wind; 6(D) analyze the effects of heating and cooling processes in systems such as weather…and mechanical. **ALG.** 1(B) gather and record data; 1(D) represent relationships...using...tables; **ENG.** 2(B) develop drafts; 2(E) use technology for revising, editing; 4(C) compile information from primary and secondary sources...using available technology; 4(D) represent information in a variety of ways such as graphics; 7(D) construct...graphic organizers; **WORLD GEO.** (c) 3(B) describe physical environments of regions; 4(A) explain the distribution of different types of climate in terms of patterns of temperature, wind...and the factors that influence climate regions.

OVERVIEW

Students will learn the best locations in Texas for utilizing wind power. Students will construct and test a windmill to observe how design and position affect the electrical energy produced. Appreciation for the benefits of renewable energy sources is a focus.

TIME FRAME:

Two 1-hour periods

TEACHER GUIDE

Background Information

Wind is caused by warm air rising, with cooler air rushing in (or sinking) to fill the space. Cooler air sinking causes warm air to rise. The turbines change this wind energy into mechanical power. Turbines require a minimum wind speed of about 15 miles per hour to generate electricity economically.

Teaching Instructions

The teacher should read the student activity first. This activity presumes that students can connect a small DC motor and volt meter (an electrical connector clamp can be used). Emphasize to the class safety precautions when taking current and voltage readings using volt- and ammeters. Use either meter leads that have alligator clips on the ends, or attach insulated alligator clips to the wire ends that come into contact with the meter leads. Students should never touch any bare or exposed metal in a circuit that is generating electricity (i.e. meter leads, bare wire, etc.). Students should read Students should read Fact Sheet #13, *Wind Power Basics*, before reviewing the activity. Safety instructions should be reviewed. Voltmeter readings should be taken safely. For example, attach insulated alligator clips on the ends of the wire to safely clip on to the voltmeter leads. Discuss safety procedures for using the fan.

Basic concepts of electricity, such as current flow, operation of a magnetic coil motor and generation of electricity can be discussed. Discuss the diagram of the major components for generating electricity in the Fact Sheet. Students can draw a concept map for the wind turbine and the functions of its parts.

Students should outline the instructions, before class, using very few words to summarize. Before performing the experiment, students should plan some of the variations they will change in the design. Extra cardboard will be needed for altering blade sizes. Discuss the advantages of using a

renewable energy source, rather than fossil fuels. Point out (from the Fact Sheet) the results of doubling wind speed (which increases power output eight times) and where to locate wind turbines. Using the Internet for more information, students can research wind turbines as to what they are, where they are found, what uses they have, when they are most effective, and how they work.

Once the instructions to the initial lab exercise have been completed, experimenting with the variables provides students with opportunities to enhance their understanding. Variables can include changing length and width of blades, using different weights of cardboard for the blades, changing wind velocity, and using different angles for the blades. Students should record their variables and results in a data chart they create during the activity. As students change blade length, width, weight or angle, they should predict whether the amount of voltage will increase or decrease.

Students can share and compare the variables they used and the effects on electricity generation. Research on historical uses of wind power will enrich their understanding. How wind develops from sunshine is a major concept. Students can keep track of wind speed in your area for 2 weeks and consider if wind power would be beneficial as an investment there.

GLOSSARY

convection – transport of heat by the movement of parts of a fluid (air or water); cool air is denser than warm air and as it settles the cool air pushes the warm air upward

electricity – created when a metal wire is moved through a magnetic field; a flow of energy involving electrons and other subatomic particles

fossil fuel – the remains of a plant or animal below ground (from a former geographical period, usually prehistoric,) that has changed into oil or natural gas.

kinetic energy – energy resulting from motion

renewable energy – forms of energy that derive and quickly replenish from the natural movements and mechanisms of the environment, such as sunshine, wind, movement of the seas and the heat of the earth

variable – a value liable to change, as in size, number, degrees, etc.; one can manipulate variables in an experiment.

voltmeter – instrument for measuring electric potential; voltage = resistance (ohms) × current (amperes)

ASSESSMENT ANSWERS

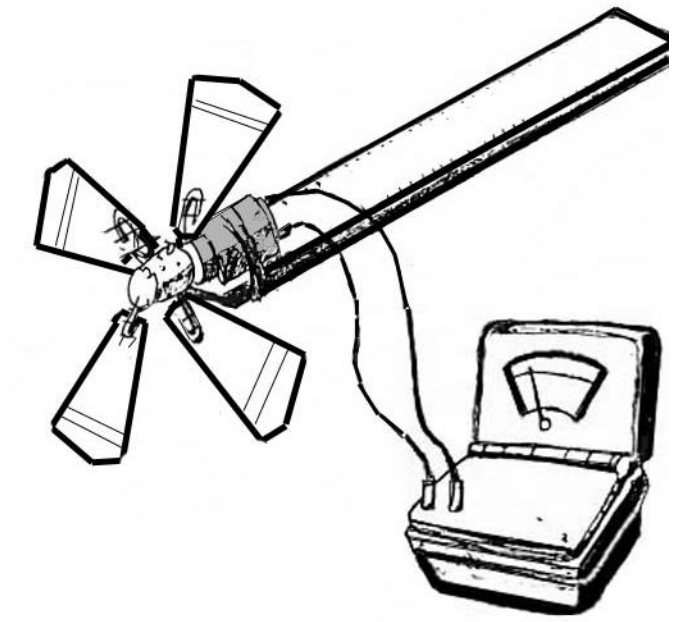
Short Answer Questions

1. Improving efficiency can be accomplished by changing length and/or width of the blades, changing the angle of the blades, altering blade weight and also insuring that the windmill is positioned on an optimum site where the wind is quite constant.
2. Students can practice drawing a map of Texas from memory, which also aids their ability to locate major Texas cities. The areas in the Panhandle and West Texas as well as part of the coast should be shaded. Students can describe the kinds of environments they have shaded by doing some research, using a variety of sources.
3. Wind power is renewable, cost effective to use, will reduce our consumption of imported energy, does not pollute the environment and can be delivered through the existing power grid.

Mulitiple Choice Questions

1 c 2 d 3 d 4 d 5 b
6 d 7 d 8 d 9 d 10 b

#13 STUDENT ACTIVITY: TESTING A WINDMILL GENERATOR



Key Vocabulary
define the following terms:
convection, electricity, fossil fuel, kinetic energy, renewable energy, variable, volt meter

Materials
- small electric fan or hair dryer
- small DC toy motor (from a science or electronic supply company)
- cork (at least 2 cm in diameter)
- DC volt meter
- stiff ruler
- 50 cm of thin electrical wire with alligator clips
- rubber band
- scotch tape
- paper clips
- wire cutters
- scissors
- piece of cardboard (thicker than an index card)
- goggles

Constructing the Windmill Generator (wear goggles)
1. Use the rubber band to attach the small electric motor to the flat end of the ruler with the motor shaft extending towards the edge of the ruler.
2. If the motor doesn't already have wires attached, cut the piece of wire into 2 pieces and add these 2 wires to each of the motor's outlets.
3. Follow your teacher's safety instructions and attach the 2 wires to a DC voltmeter using the alligator clips.
4. Take four paper clips and straighten out the lower part of each clip. Clip off enough of this straight part, so that only 1 cm sticks out.
5. Cut out 4 pieces of cardboard 2 cm $\times$ 5 cm. Tape these 4 blades onto the central part of each paper clip.
6. Using the 1 cm part of the paper clip that sticks out, insert the blades into the sides of the cork, .5 cm from the small end of the cork. Be sure to space the blades equally around the circumference of the small end of the cork.
7. Place the large cork end, which is furthest away from the wind blades, into the motor shaft. Make sure the shaft goes into the exact center of the cork.

Performing the Experiment (wear goggles)
1. Rotate the blade in the cork so that it is at a 45° angle to the flat plane of the edge of the ruler. Place the windmill 30 cm away from the fan or hair dryer (your distance may vary depending on the strength of the wind source). Turn on the fan or hair dryer. Measure the voltage produced. Try rotating the blades of the windmill to see which angle produces the greatest voltage.
2. Design your own set of wind blades, discussing with your lab partner(s) which size and shape, and what number of blades, will work best. Attach these new blades to the motor and try adjusting them at various angles to produce the greatest voltage. Place the windmill at the same distance from the wind source. Measure the voltage again. Place all of your measurements in a data chart.
3. Determine the most efficient blade size and shape (sketch and record the dimensions). Next explore how wind velocity affects the amount of electricity produced by changing the fan speeds. (Be sure to keep the windmill at the same distance each time.) Record your measurements in a data chart. Discuss with your teacher other variables you might use.

ASSESSMENT

Short Answer Questions

1. What changes to a windmill can improve its efficiency?
2. Draw a rough map of Texas and shade in the areas where wind power is best generated.
3. Cite 3 reasons for using wind power, now and in the future.

Multiple Choice Questions

1. As an engineer working with renewable energies you would:
   a) place wind farms in valleys and low lying areas
   b) place wind farms where weather fronts are calm
   c) place wind farms on elevated sites
   d) build wind farms everywhere

2. Wind power turns the kinetic energy of wind into:
   a) direct heat
   b) solar energy
   c) hydroelectric power
   d) both mechanical and electrical power

3. Wind power:
   a) is one of the oldest renewable technologies
   b) was used by early sailors
   c) is used to pump water
   d) all answers a, b, & c

4. Wind:
   a) is moving air
   b) is created by the sun's energy
   c) has power proportional to the cube of its speed
   d) all answers a, b, and c

5. You will likely most often see wind turbines:
   a) on rivers
   b) on hilltops
   c) on lakes
   d) in cities

6. Learning about renewable energy sources:
   a) is necessary for the future
   b) will help future decision making
   c) shows you other ways to create electricity
   d) all answers a, b, and c

7. Wind energy is:
   a) an important energy source
   b) kinetic energy
   c) movement of energy from the air
   d) all answers a, b, and c

8. Some of the devices used in wind power are:
   a) turbines
   b) sails
   c) windmills
   d) all answers a, b, and c

9. Wind is:
   a) caused by convection
   b) a determiner of weather
   c) a form of fossil energy
   d) a and b

10. Hot air:
    a) is heavier than cold air
    b) rises
    c) sinks
    d) a and c

InfinitePower.org

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