Making a "Wet Cell" Battery

RENEWABLE ENERGY
THE INFINITE POWER OF TEXAS

FOR USE WITH FACT SHEET NO. 18: RURAL RENEWABLE APPLICATIONS

TEXAS ESSENTIAL KNOWLEDGE AND SKILLS

TEKS utilized include: **SCI.** (c) 1(A) demonstrate safe practices during...laboratory investigations; 1(B) make wise choices in the use and conservation of resources; 2(B) collect data and make measurements with precision; 6(D) compare...environmental impacts of using various energy sources such as rechargeable or disposable batteries and solar cells; **ENG.** 6(A) expand vocabulary through wide reading, listening, discussing; 8(B) read...varied resources as...journals, newspapers...electronic texts; 13(B) locate...information using... technical resources, periodicals...and the Internet; 13(D) adapt researched material for presentation; **WORLD GEO.** 7(D) develop... hypotheses on...population patterns for the future; 8(B) compare ways that humans depend on...and modify the physical environment...and technical contexts; 16(A) describe distinctive...landscapes associated with different places in Texas; 19(C) evaluate the significance of major technological innovations...including electricity, that have been used to modify the physical environment.

OVERVIEW

Students will learn a variety of rural applications using renewable energy sources. Students will review the renewable energy sources available in rural settings. Photovoltaic systems will be the focus in an activity. Students will study the storage mechanism (the battery) for a stand-alone PV system by making a wet cell battery. Learning about circuits, electrolytes, and battery storage will enhance student's understanding of photovoltaic system components.

TIME FRAME

One 1-hour period

TEACHER GUIDE

Background Information

The battery created in this activity is called a wet cell, or voltaic cell, because a liquid (citric acid) is involved. Car batteries are usually wet cells. Aluminum foil and copper wire are the electrodes in this battery and a citric acid solution is the electrolyte. The aluminum foil oxidizes and positive aluminum ions go into solution, leaving an excess of electrons on the aluminum electrode. The citric acid electrolyte facilitates the electron flow. The electrolyte is needed to get a transfer of electrons. Without an electrolyte, the electrons cannot move and current (amps) would not be produced. In this activity the electrons flow from the aluminum to the copper or from areas with excess free electrons to areas with fewer electrons.

In rural locations with stand-alone photovoltaic systems, batteries are needed to store the energy that is generated for use when the sun is not shining. There are many new kinds of batteries on the market today, including some without liquid electrolytes that are sealed so that no maintenance is required.

Teaching Instructions

Teacher should read the student activity first. Before performing the experiment, students should first read Fact Sheet #18, *Rural Renewable Applications,* and understand the role of a battery in rural photovoltaic electricity applications. Appropriate safety guidelines should be reviewed.

A variety of citric solutions can be used, such as lemon, lime, orange or grapefruit juice. The electrodes are 2 different metals. One of the metals loses electrons more easily than the other (aluminum loses electrons easily). Touching the electrodes to the positive and negative ends of the ammeter closes the circuit and allows the electrons to flow and thus produce a current. Students can try different electrolytes (juices) to observe if changes in current occur.

Expected Observations
Students should recognize the essential parts of a voltaic (wet) cell. These include two pieces of different metals and a solution to assist in conducting electricity. The solution is called an electrolyte, which can be an acid, a base or a salt. Fruit juices and vinegar are acids, ammonia is a base and baking soda is a salt.

ASSESSMENT ANSWERS

Short Answer Questions

1. The cell has 2 electrodes, aluminum and copper, and a liquid electrolyte, citric acid. The aluminum foil releases aluminum ions (A1+++) into the citric acid solution, leaving an excess of electrons around the aluminum. Many of these electrons travel in the electrolyte, creating a current.
2. Cleaning the electrodes, so current can flow, and keeping enough water or electrolyte in the battery will keep it working longer.
3. If there is no current, first check the connections on the meter and the levels of electrolytes.
4. When a car battery "dies," there is no electrolyte for the movement of electrons to the electrodes.
5. Plans to test smaller batteries could include testing the life of a battery by keeping a flashlight or other mechanism on continuously and recording the number of hours the battery functions before it dies out.
6. The mapping or webbing of rural applications will vary by student, but terms in the Fact Sheet should be utilized.
7. Problems with using batteries are: initial cost, quality or life span of the battery; keeping the level of the electrolyte high enough to function properly for batteries with liquid electrolytes; the corrosiveness of the electrolyte in some batteries; proper and safe disposal of old batteries in keeping with hazardous waste regulations.
8. The presentations will vary. Preparing an outline helps the student organize his/her thoughts.
9. This answer is opinion. Factors that indicate increased rural population include some people's desire to leave large cities to raise children with technology (computers) providing them with a way to work at home, outside of the city. Reducing energy costs in these rural areas by using renewables would be very attractive, as well as living without the transportation problems of large cities.

GLOSSARY

acid – a sour substance; substance containing hydrogen replaceable by metals; vinegar, for example has the positive hydrogen ion (h+)

ammeter – instrument for measuring electrical current in amperes

base – any substance capable of combining with an acid to form a salt; substance capable of accepting protons; the (oh-) negative ion is an example; soap is basic or alkaline

battery – a device consisting of one or more cells in which chemical energy is converted to electricity

biofuel producer – farmers growing crops, such as trees, grasses or other fast growing crops, specifically for energy uses

biomass – plant and animal materials (trees, hay, shrubs, food scraps) that have chemical energy stored in their organic (carbon based) materials

electricity – a flow of energy of electrons

electrode – a conductor through which electricity enters or leaves

electrolyte – a liquid used as a battery fluid; a liquid which contains ions (charged particles positive and negative)

kinetic energy – energy resulting from motion

photosynthetic energy – the energy of light that is absorbed by chlorophyll in plants and involves the production of oxygen from water to form organic (carbon based) compounds; leaves, grass (green plants) have chlorophyll and produce food through photosynthesis

photovoltaics – comes from "photo" meaning light and "voltaic" referring to producing electricity

potential energy – energy that a body possesses by virtue of its state, not its 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

solar cell – (also called photovoltaic cell) converts sunlight into electricity

wind turbine – any rotary machine with revolving vanes (like a pin wheel) driven by wind

The cost of homes in rural areas tends to be less, as well as property taxes.

10. The rural areas of Texas, such as the Panhandle, West Texas, and parts of the Rio Grande Valley would be affected. Lands existing away from the major cities are the areas where ranches and farms are found.

Multiple Choice Questions

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

STUDENT ACTIVITY #18: MAKING A "WET CELL" BATTERY

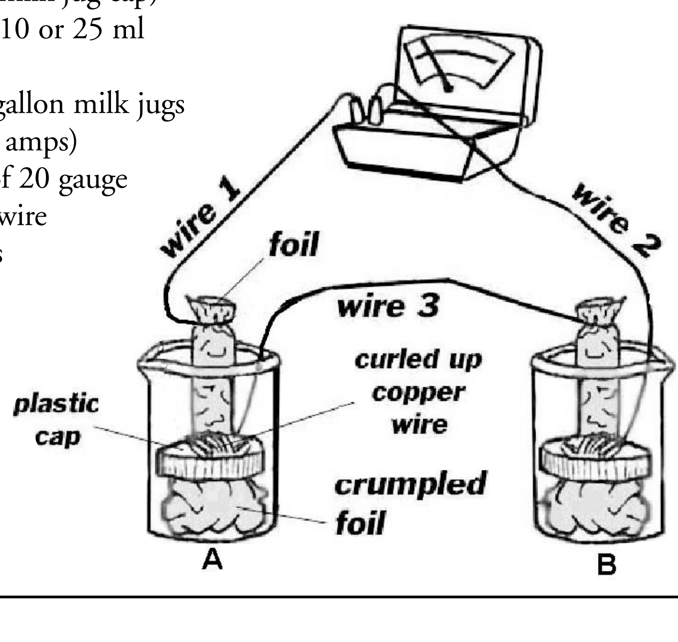
Key Vocabulary
define the following terms:
acid, ammeter, base, battery, biofuel producer, biomass, electricity, electrodes, electrolyte, kinetic energy, photosynthetic energy, photovoltaics, potential energy, renewable energy, solar cell, wind turbine

Materials

- wire cutters
- aluminum foil
- 2 ea. 150 ml beakers (w/diameter that accommodates milk jug cap)
- graduated cylinder (10 or 25 ml size range)
- 2 plastic caps from gallon milk jugs
- DC ammeter (reads amps)
- 3 ea. 80 cm pieces of 20 gauge uninsulated copper wire
- electrolytic solutions (vinegar, lime juice, or any type of citrus solution, as teacher directs)
- scissors
- goggles
- baking soda

Constructing the Wet Cell Battery
(wear goggles)

1. Using scissors, cut 2 pieces of aluminum foil 20 cm by 30 cm. Roll up each piece of foil so the roll is on the longer 30 cm side. Crumple one end of each roll (about 1/4th of the roll).
2. Obtain two 150 ml beakers and place the crumpled ends of the aluminum rolls into a beaker. You now have 2 beakers, each holding one crumpled end of an aluminum roll.
3. Obtain 2 milk caps and place one milk cap on top of the crumpled aluminum foil in each beaker. (The milk caps will act as insulation.)
4. Take one piece of the 20 gauge uninsulated copper wire and wind it around the top of the aluminum foil in one of the beakers, which we will now call Beaker A. Attach the other end of this copper wire in Beaker A to one of the ammeter probes.
5. Take the second piece of 20 gauge uninsulated copper wire and attach one end to the other ammeter probe. Curl the rest of this wire on the other end into a ball and place the ball on the milk lid in the second beaker, which we will call Beaker B.
6. Take the third piece of wire and wind one end around the aluminum foil in Beaker B. Curl the rest of the wire at the other end into a ball and place it on top of the milk cap in Beaker A.
7. Make sure the coiled wires on top of the milk caps do not touch the aluminum foil or each other, or a short circuit will occur.



Performing the Activity
(wear goggles)

1. Obtain the electrolyte(s) you are using (about 100 ml of each) in separate containers. Electrolytes can be vinegar, lime juice (diluted), lemon juice or other citrus juices. Number and name the electrolyte(s).
2. Pour approximately 50 ml of electrolyte #1, vinegar (or your chosen electrolyte) into Beaker A and 50 ml of the same electrolyte into Beaker B, until the electrolyte covers the curled up copper wire (on both milk lids) completely. Record the amp reading on the ammeter for #1 electrolyte.
3. Pour out the electrolyte #1 as directed by your teacher for reuse.
4. Gently rinse Beaker A and B with water.
5. As the teacher directs, pour electrolyte #2 into Beakers A and B, just as you did with electrolyte #1, and repeat taking the amp reading. Do this for as many different samples of electrolyte as you are testing by taking an amp reading each time and recording your reading next to the correct electrolyte with its number and name.
6. On your very last sample, after you have recorded the amp reading, add a teaspoon of baking soda, which is a base, to one of the beakers. Record what happens to the amp reading.

ASSESSMENT

Short Answer Questions

1. How does a wet (voltaic) cell work?
2. What can you do to keep a battery working for a longer period of time?
3. If the battery stops working (no reading on the ammeter) what would you do?
4. Why does a car battery "die" when there is no water surrounding its lead plates (electrodes)?
5. Use newspapers, magazines, or the Internet to review claims made by battery manufacturers and create a plan as to how someone could test these claims in a lab activity.
6. Create a graphic organizer, such as a concept map or web, to outline all the possible rural applications for photovoltaic electricity you can recall.
7. What are some problems with using batteries?
8. Prepare a five-minute presentation on the use of renewable energies in rural areas and include the need for battery storage with stand-alone photovoltaic systems. Outline the presentation.
9. Do you think renewable energy sources in rural areas will attract more population to those areas in the future?
10. Where in Texas would you expect to find the use of windmills, PV gate openers, water tank de-icers and electric fences? Use a map of Texas, or create one, to shade in the areas you believe are affected.

Multiple Choice Questions

1. The best locations for wind and stand-alone PV applications are:
   a) inner city — c) suburbia
   b) rural — d) none of the answers

2. Solar energy is the key to:
   a) wind energy — c) photovoltaic power
   b) photosynthetic energy (plants) — d) all answers a, b, and c

3. Water pumping is performed by:
   a) mechanical windmill pumps — c) wind turbine powered pumps
   b) photovoltaic pumps — d) all answers a, b, and c

4. Some applications of PV and wind power systems are:
   a) water tank deicers — c) gate openers
   b) electric fences — d) all answers a, b, and c

5. Nut shells, cotton gin husks, rice hulls are examples of:
   a) zoology — c) biomass fuels
   b) electricity — d) none of the above

6. Vinegar is:
   a) an electrolyte — c) a base
   b) an acid — d) a and b

7. A biofuel producer is:
   a) a gas company — c) a propane business
   b) an electric company — d) a farmer

8. Batteries are used for
   a) storage of electricity — c) LFG (landfill gas)
   b) passive solar systems — d) a and b

9. Stand-alone photovoltaic systems often require:
   a) wind — c) batteries
   b) turbines — d) biomass

10. Stand alone photovoltaic power applications are ideal for:
    a) farms — c) remote islands
    b) mountain cabins — d) all answers a, b, and c

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