Rural Renewable Applications

RENEWABLE ENERGY
THE INFINITE POWER
OF TEXAS

For High School

OVERVIEW

This unit introduces students to the renewable and sustainable technologies used by agricultural producers for over a thousand years. Around 500 to 900 CE (Common Era), Persian farmers used wind power to grind grain. For hundreds of years after that, farmers and other agricultural producers used wind power to pump water and grind grain. More recently, agricultural producers have started converting sunlight to electricity with photovoltaic cells and began using wind power to generate electricity. Students will familiarize themselves with these concepts through the Reading Passage, answering Assessment Questions, and by conducting a Lab Activity to model how energy can be produced by a chemical device and could be used as a storage mechanism.

OBJECTIVES

See High School Teacher Resource Guide for TEKS objectives and additional information regarding this and other high school units.

SUGGESTED TIMEFRAME

Teacher will need to determine how many class periods to devote to each activity, based on the suggested timeframe and length of classes.

Time	Activity Description	Content Area
60 minutes	**1** – Introduction and Reading Passage	Science Language Arts
60 minutes total 30 minutes 30 minutes	**2** – Lab Activity – Wet Cell Battery a) Constructing the experiment b) Performing the activity	Science Mathematics
45 minutes	**3** – Assessment	Science Vocabulary
60 minutes	**4** – Follow Up Lab Activity – Energy from the Sun	Science Mathematics Reading

REQUIRED MATERIALS

- ➤ copy of Reading Passage and Student Data Sheets for each student
- ➤ a Lab Activity equipment kit for each group containing:
    - wire cutters
    - aluminum foil
    - 2 150-ml beakers (w/diameter that accommodates the plastic cap selected)
    - 2 plastic caps that are slightly smaller than the beakers used
    - graduated cylinder (10 or 25 ml size range)
    - DC ammeter (reads amps)
    - 3 80-cm pieces of 20 gauge uninsulated copper wire
    - electrolytic solutions (vinegar, lemon lime juice, sports drink with electrolytes or any type of citrus solution)
    - scissors
    - goggles
    - baking soda
- ➤ a Follow Up Lab equipment kit for each group containing:
    - cardboard box approximately 15 × 15 × 45 cm (a large shoe box would work)
    - strip of aluminum foil 20 × 60 cm
    - large strip of poster board 20 × 60 cm
    - 2 small strips of cardboard (lid to box can be used) 30 × 6 cm
    - parabolic curve template (included, use copier to enlarge or reduce if necessary)
    - scissors
    - white glue
    - hole punch
    - food quality bamboo skewer
    - hot dogs, buns, condiments

BACKGROUND INFORMATION

As the population of the United States spread west, windmills were essential because electricity was not available and surface water was scarce. Wind power was used to pump water from underground aquifers. This water was used for growing crops and watering livestock. It was not until the 1930s that most of rural America received low cost electrical power through massive federal programs. Even today, in many areas windmills are still used to pump water because they are reliable and mechanically simple. At Big Bend National Park in far west Texas, there is an old windmill on the site of the abandoned Sam Nail ranch that has been steadily pumping water from a well for over 60 years.

In rural locations with stand-alone photovoltaic systems, storage batteries are needed to store the energy that is generated for use when the sun is not shining. Like car batteries, batteries used in PV systems are often lead-acid storage batteries. They can store energy and be recharged many times. Lead-acid storage batteries use an electrolyte (sulfuric acid) that may be in the form of a liquid, a gel, or absorbed into a glass mat. Cleaning the electrodes, so current can flow, and keeping enough water or electrolyte in the battery will keep it working longer. 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.

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.

The battery created in the first Lab Activity is called a wet cell or voltaic cell, because a liquid (citric acid) is involved. 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.

SUMMARY OF ACTIVITIES

Activity 1 – Introduction and Reading Passage

Teachers should read the entire sequence of activities first, before starting the lab. Explain to the class that they will learn about a variety of rural applications that use renewable energy sources. Teachers can include material from the teacher background information section, especially the details on how a wet (voltaic) cell battery works. Have students consider the following quote:

"This 'telephone' has too many shortcomings to be seriously considered as a means of communication. The device is inherently of no value to us." – *Unnamed Telecommunications Company, internal memo, 1876*

Obviously, the shortcoming was the lack of vision on the telecommunications company part. However, a similar lack of vision can often be present when it comes to rural energy. After all, how much energy does a farm need, especially when they are so few and far between each other in rural areas? This can lead to a discussion of what rural energy needs exist and how those needs could be met by using some imagination and vision.

Each student will need a copy of the Reading Passage and the Student Data Sheet (includes reading comprehension questions and vocabulary words). Instruct students to study the Reading Passage and complete the questions and vocabulary on the Student Data Sheet. This activity will help them understand the role of storage batteries in rural photovoltaic electricity applications. Key vocabulary words in the Reading Passage will assist them in understanding the Lab Activity instructions. For students who wish to learn more of the detailed physics principles behind the operation of wind generators, solar heaters, windmills, and other similar rural renewable energy systems, direct them to the appropriate resources. Suggested resources are included in the Teacher Resource Guide. Appropriate safety guidelines should also be reviewed.

Activity 2 – Lab Activity – Making a "Wet" Cell

1. Students will study the storage mechanism (the battery) for a stand-alone PV system by constructing a wet cell. Learning about circuits, electrolytes, and storage batteries will enhance student's understanding of photovoltaic system components.
2. Distribute copies of the Lab Activity to each student but have students work in groups (as determined by the teacher). Before beginning the lab, students should review the instructions so they will understand the purpose and the goals. To enhance the class' scientific inquiry in this lab, instruct each student to develop statements for the following: hypothesis, predictions, conclusions and finally significance/implications. Note that the hypothesis and predictions should be made before beginning the Lab Activity. Refer to the Teacher Resource Guide for more information. Ask students to obtain an equipment kit. Students should record their amp readings on the Data Table provided in the Lab Activity. After students have completed their Data Tables, students should complete the data analysis questions listed in the Lab Activity. Review lab results with the entire class and their implications for battery usage in the students' lives, such as extending the life of a battery, why a car battery dies and problems associated with using batteries.

Expected Observations

Students should recognize the essential parts of a voltaic (wet) cell. These include pieces of two 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, and baking soda is a base. The use of a sports drink as an electrolyte may or may not generate current that can be measured.

Activity 3 – Assessment

Distribute a copy of the Assessment Questions to each student. Instruct each student to work alone and answer the short answer and multiple-choice questions. Collect the handouts, grade and return them to the students.

Activity 4 – Follow Up Lab

In the Follow Up Lab students will construct a small, simple solar cooker. This activity expands on several concepts involved with solar energy including the idea of its portability and that it is the basis of all agriculture, which is both a vital aspect of rural living and one of the main applications of solar energy for rural uses. Students will work in small groups. Teachers will need to assemble a materials kit for each group and prepare a parabolic curve template for each kit.

ADDITIONAL ACTIVITIES

1 – Creative Writing: comparing contemporary life with life before modern conveniences existed

Read Additional Activity 1 before beginning this activity. Students will read the student activity handout, "Mrs. Morgan's Morning," a one page story about a morning in a modern woman's life. As they read, the students will list modern electrical conveniences found in the story. They will then create a similar story about a rural Texas woman in the 1930s. Distribute a copy of "Mrs. Morgan's Story" to students and tell them to follow the instructions provided in the activity.

2 – Internet or library research

Students can learn about the uses of PV systems that use battery storage in countries of the Caribbean, in Mexico, and in South America and compare their findings with usage in the United States. The advantages for PV are self-evident where no power grid exists. With increasing costs for electricity and potential blackouts, PV systems on U.S. homes may be part of the answer to our energy problem.

3 – Battery Research

Using newspapers, magazines, or the Internet, instruct students to review claims made by battery manufacturers (such as the longest battery life) and create a plan as to how someone could test these claims in a lab activity.

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HIGHLIGHTS

- **Agricultural producers have long been on the forefront of renewable energy use**
- **Rural locations are ideal for wind and photovoltaic power applications**
- **Agricultural waste and energy crops may become a new source of farm revenue**

SOURCE: CENTRAL & SOUTH WEST SERVICES

SOLAR POWERED WATER PUMP *West Texas ranchers inspect a PV powered water pump. These reliable systems are quickly gaining popularity throughout the state.*

INTRODUCTION

From the 200-foot tall windmills in Holland to those of west Texas, agricultural producers have long relied on renewable energy for their livelihoods. Whether the task was pumping water, drying crops or cooking, farmers have always relied on three things: the sun, the wind, and the rain. In fact, solar energy is the key that allows farmers to unlock the Earth's potential, whether it is the kinetic energy captured by the windmill or the photosynthetic energy captured by plants.

WATER PUMPING

Water pumping may be the most common use of renewable energy in agriculture. Three basic types of water pumps use renewable energy.

Mechanical Windmill Pumps

These simple devices have allowed farmers and ranchers to obtain the water they need for more than a century. Today, millions of farmers around the world rely on mechanical windmills for their water needs.

Photovoltaic-Powered Pumps

Submersible electric water pumps powered by photovoltaic (PV) modules are suitable for small to medium scale pumping needs up to about 2 horsepower depending on the depth of the water well. Given their simplicity, lack of moving parts and long life, these systems are growing in popularity.

MECHANICAL WINDMILL *Used by generations of Texas ranchers, water pumping windmills continue to be placed in service for the benefit of thirsty livestock.*

Wind Turbine-Powered Pumps

A relatively new type of pump system, this method uses the electricity generated by a small wind turbine to directly power a submersible or centrifugal pump. U.S. Department of Agriculture tests here in Texas have compared this newer technology with mechanical windmills. While costing about the same as mechanical systems, the USDA found that the wind turbine systems produced almost twice the volume of water. Larger wind turbines can pump enough water for small-scale irrigation. Solar/wind hybrid pumping systems are also available.

ELECTRIC APPLICATIONS

With the cost of extending a power line as high as $30,000 a mile, reliable PV and wind power systems offer farmers and ranchers many uses they otherwise could not afford.

Electric Generation

PV systems are simple, reliable and require little maintenance. While relatively expensive at about $6,000 per kilowatt, PV systems costing as little as $50 can be a perfect fit for providing small amounts of power around the ranch. In rural areas where the wind is fierce, wind turbine systems costing about $2,500 per kilowatt are usually a better investment than PV, especially for applications needing a lot of energy. In some cases, large wind turbines may even provide electricity more cheaply than the local electric company.

Water Tank De-Icers

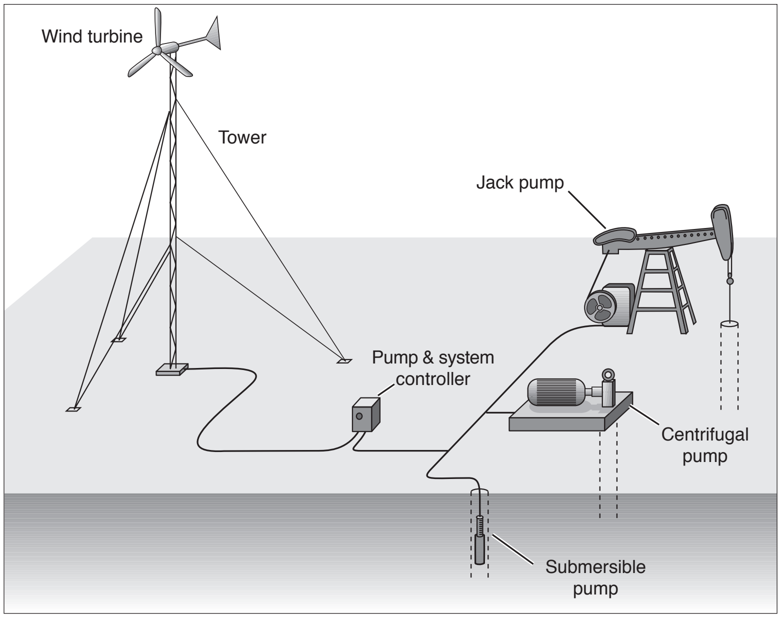
An essential technology for ranchers in cold climates, water tank de-icers are powered by a PV module that provides power to a small compressor that generates air bubbles on the bottom of the water tank. The movement of the water prevents ice from forming on the top of the tank. Performance of these units is best on tanks that are sheltered or insulated.

Electric Fences

Powered by PV modules, commercially available units can keep a fence electrified day and night. These units can deliver brief shocks with small pulses of low current at around 8,000 to 12,000 volts potential – more than enough to keep livestock contained.

Gate Openers

Gate openers are an ideal candidate for PV power because they are often located far from available power lines. Some models are brawny enough to open gates 16 feet wide and weighing up to 250



ELECTRIC-POWERED WATER PUMPING OPTIONS *Different types of electric water pumps, each suitable for different ranges of well depth and flow rate, can be driven directly by the wind turbine.*

pounds. These gate openers can utilize wireless remote control mechanisms or digital keypads, both of which offer convenience and security.

BIOMASS OPPORTUNITIES

Many farmers used to burn or plow under farm wastes. The advent of new technologies that convert biomass material from plants or animals into valuable energy may give farmers and ranchers moneymaking alternatives to such practices.

Agriculture Wastes

In many cases, troublesome waste products from agricultural cultivation and processing can be effectively used as a low cost fuel for making electricity or process heat. One cogeneration operation near Houston burns rice hulls from a local mill to make electricity that is sold to the local utility. Other candidates for agricultural waste feed stocks in Texas include cotton gin trash, sugarcane pulp, and peanut shells. Commercial development of small biomass gasification systems may soon assist this market. On dairies and large feedlots, manure can be processed to make electricity. Doing so reduces odor and potential pollution problems while adding a revenue source.

Farming Fuel: Biofuels & Energy Crops

While Texas refineries are among the nation's leading producers of ethanol-based automotive fuels, the ethanol feed stocks used in these blending operations come almost exclusively from grain produced in mid-western states. Texas farmers growing corn or grain sorghum would have another market for their products if local biofuel producers considered shopping locally. Over the next few years, markets may develop for the cultivation of dedicated energy crops such as switch grass, poplar trees or other fast-growing crops grown specifically for energy uses. Before long, growing our own fuel could become a reality in Texas.

SOURCE: CIELO WIND

ELECTRICITY GENERATING WIND TURBINE *Rural landowners now have opportunities to earn energy royalties by leasing their land to utility-scale wind farm developers.*

Understanding The Reading Passage

Based on the information from the Reading Passage, answer the following questions:

1. Even when electrical power is available, what are some advantages of using off-grid PV systems for gate openers, water pumps, or feeders?

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2. What is one advantage of mechanical windmills? What is one advantage of wind turbine powered pumps?

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3. A 5 kilowatt PV system provides enough power to run a small farm and costs around $50,000. How far would the farm have to be from existing power lines before the PV system is cheaper than extending the power line? ______________________

4. Many livestock operations are faced with difficult problems dealing with manure and manure run-off. What alternatives could you offer to simple disposal?

____

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Vocabulary

Write down your understanding of these words or word pairs and verify your definitions in a dictionary, on the Internet if available or with your teacher:

acid ____

ammeter ____

base ____

STUDENT DATA SHEET
No. 21

battery ______________________________

biofuel producer ______________________________

biomass ______________________________

cell ______________________________

centrifugal pump ______________________________

cogeneration ______________________________

electricity ______________________________

electrodes ______________________________

electrolyte ______________________________

ethanol ______________________________

gasification ______________________________

kinetic energy ______________________________

photosynthetic energy ______________________________

photovoltaics ______________________________

potential energy ______________________________

refineries ______________________________

renewable energy ______________________________

royalties ______________________________

solar cell ______________________________

submersible ______________________________

wind turbine ______________________________

LAB ACTIVITY – MAKING A WET CELL BATTERY

INTRODUCTION

The purpose of this activity is to construct a wet cell battery and learn about its basic components using simple materials. You will take current measurements from the output of your battery set up, using different electrolytes.

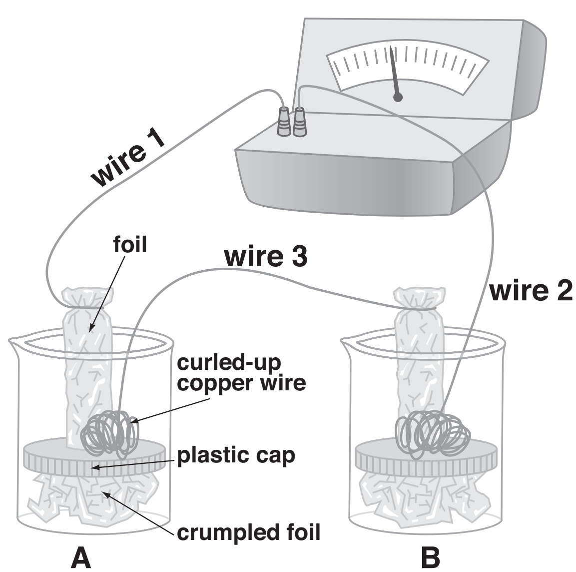
BEFORE YOU START

Review the vocabulary words from the Reading Passage. Ask your teacher if you are unsure of any of the meanings.

MATERIALS

Obtain an equipment kit from your teacher. Check that it contains the following materials:

- wire cutters
- aluminum foil
- 2 150-ml beakers
- graduated cylinder
- 2 plastic caps that are slightly smaller than the beakers used
- DC ammeter (reads amps)
- 3 80-cm pieces of 20 gauge uninsulated copper wire



- a sample of each electrolytic solutions prepared by your teacher
- scissors
- goggles
- baking soda

Step I. 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. Loosely crumple one end of each roll (about 1/4th of the roll).
2. Obtain 2 150-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 plastic caps and place one cap on top of the crumpled aluminum foil in each beaker. (The 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 cap 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 cap in Beaker A.
7. Make sure the coiled wires on top of the caps do not touch the aluminum foil or each other, or a short circuit will occur.

Step II. Performing the Activity

(wear goggles)

1. Obtain about 100 ml of each of the electrolytes you are using in separate containers. Electrolytes can be vinegar, lime juice (diluted), lemon juice, other citrus juices or sports drink with electrolytes. Number and name the electrolyte(s).

2. Pour approximately 50 ml of electrolyte #1 into Beaker A and 50 ml of the same electrolyte into Beaker B, until the electrolyte completely covers the curled up copper wire on both caps.. Record the amp reading on the ammeter for electrolyte #1.
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 current reading, add a teaspoon of baking soda, which is a base, to one of the beakers. Record what happens to the current reading.

DATA TABLE 1. Current produced from wet cell battery using different electrolyte solutions.

Electrolyte	Solution description	Current (amps)
1		
2		
3		
4		
	BAKING SODA	

DATA RESULTS

1. Which electrolyte sample produced the largest current? ____________________

2. What happened to the current after the baking soda was added?

____

____

3. Did any of the solutions not generate a current? If yes, why?

____

____

____

Assessment Questions

1. How does a wet (voltaic) cell work?

____

____

2. Why does a car battery “die” when there is no water surrounding its lead plates (electrodes)?

____

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3. On a separate piece of paper, create a graphic organizer, such as a concept map or web, to outline all the possible rural applications for photovoltaic electricity you can recall.

4. Think about preparing a five-minute presentation on the use of renewable energies in rural areas, including the need for battery storage with stand-alone photovoltaic systems. Outline your imagined presentation on the reverse side of this paper or on a separate sheet of paper.

5. Do you think renewable energy sources in rural areas will attract more population to those areas in the future? Why or why not?

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____

6. Where in Texas would you expect to find the use of windmills, PV gate openers, water tank de-icers and electric fences? Draw a simple outline map of Texas and 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
   b) rural
   c) suburbia
   d) none of the answers

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

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

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

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

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

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

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

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

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

STUDENT DATA SHEET

FOLLOW UP LAB: Finding Energy Solutions for a Texas Cattle Ranch

The illustration on the preceding page depicts a working Texas cattle ranch. Because many rural ranches are miles from the utility grid, some ranchers seek to find alternative energy solutions to electricity from their utility provider or fuel from the gas station. The rancher in this picture decided not to spend the thousands of dollars required to extend the grid power out to his ranch. He wants to be totally independent. He has had to come up with alternative ways to power all his ranch needs.

With your group, identify all the items in the picture that will require energy. Think about the rancher's family and their needs in the ranch house. Notice the vehicles and cattle that will also have needs requiring power. Then determine alternative methods for supplying the needed energy, right on the ranch.

Make a table that lists the energy needs in one column and your alternative energy solutions in the next column. You can also draw your solutions onto the picture itself.

ADDITIONAL ACTIVITY 1

Rural Texas Women

by Carol Schlenk for the
Humanities Texas traveling exhibit,
Rural Texas Women at Work, 1930 – 1960

Introduction

Students will read the activity handout, "Mrs. Morgan's Morning," a one page story about a morning in a modern woman's life. As they read, the students will list modern electrical conveniences found in the story. They will then create a similar story about a rural Texas woman in the 1930s.

Background Information for Teacher

Texas women living out in the country in the 1930's had a very difficult life. Although electricity inside buildings was common in the cities by that time, rural women did without that convenience. During President Franklin D. Roosevelt's New Deal, Lyndon B. Johnson helped legislate the Texas Rural Electrification Project in 1932.

As students read the story, "Mrs. Morgan's Morning," have them list the 20 items they find in the story that need some form of electricity (including batteries) to operate. After they have compiled their lists, inform them that if Mrs. Morgan had lived in rural Texas in the early 1930s, nothing on their lists would have been available to help her with her work. Energy in her home would have been almost solely from burning wood or from performing tasks by hand with hand tools. Then have students rewrite the story, replacing all electrical tools and appliances with wood-burning power or physical labor.

Mrs. Morgan's Morning

Directions: As you read the following story, underline every modern convenience that might require electricity (including batteries) and list 20 of them here. Then rewrite the story as if Mrs. Morgan lived in the 1930s with none of the items on your list available to her. In your story, replace all the items on your list such as electrical tools and appliances with physical labor or wood-burning power.

On Friday, March 24, 2005, at exactly 6:00 am, Mrs. Mary Morgan woke up to the music of Mozart on her radio alarm clock. She switched the alarm off, turned her bedside lamp on and pulled on her robe as she climbed out of bed. Because it seemed a bit chilly in the house, she turned up the central heat thermostat and went into the bathroom to get ready for a day of work.

After a quick shower, she plugged in her hair curlers and began blow-drying her hair. Then, after getting dressed and putting on her make-up, she headed downstairs for breakfast.

When she entered the kitchen, her husband, Stuart, already had the automatic coffeepot going, and the brewing coffee smelled wonderful. Because her family was always in something of a hurry in the mornings, she asked her 14-year-old daughter, Alicia, to put some bread in the toaster and get the orange juice out of the refrigerator. Joel, her 12-year-old son, whose job it was to get his one-year-old brother dressed, was still in his room, listening to his stereo. "Joel," Mrs. Morgan called up the stairs, "please turn off that music now and get little Andy dressed for daycare."

Fifteen minutes later, Joel was at the kitchen table, and Andy was in his highchair, both ready to eat. Mr. Morgan heated the water for instant oatmeal in the microwave, and everyone but Andy made their own hot cereal. Mrs. Morgan opened a can of applesauce, entertaining Andy with the "whirring" sound of the automatic can opener. Just before she sat down to feed the baby, she turned on the portable TV to watch the morning news on the "Today" show and put some sweet rolls into the toaster oven.

Unfortunately, Andy wasn't as interested in the news as Mrs. Morgan was, and as his mother tried to spoon oatmeal into his mouth, he spit it right back out, onto Mrs. Morgan's clean white blouse. Then he threw his graham crackers on the floor. "Alicia," Mrs. Morgan called out, "please finish feeding your little brother. I have to go change out of this oatmeal outfit into something I can wear to work. And after you finish feeding him, please, please vacuum up the mess he makes." Alicia, who was finishing up some last minute homework on the computer, turned it off and began feeding Andy the rest of his oatmeal.

Back upstairs, Mrs. Morgan hurriedly searched her closet for something to match the blue skirt she was wearing. The best choice, a gray cotton blouse, was still sitting in the washing machine, clean but wet. She tossed it into the dryer and plugged in the iron. It would be difficult getting to work on time today at this rate!

Downstairs again in a clean blouse, Mrs. Morgan kissed her husband and Alicia goodbye and told Joel to please switch on the crock pot to cook that night's dinner. She got Joel and Andy into the car and safely buckled the baby into his car seat. Mr. Morgan had left the garage door open, so as Mrs. Morgan left for work, she closed it with the remote control. Pulling out of the driveway she thought, "What a hectic morning! I feel like I've already done a day's work!"

1 ____________________
2 ____________________
3 ____________________
4 ____________________
5 ____________________
6 ____________________
7 ____________________
8 ____________________
9 ____________________
10 ____________________
11 ____________________
12 ____________________
13 ____________________
14 ____________________
15 ____________________
16 ____________________
17 ____________________
18 ____________________
19 ____________________
20 ____________________

Understanding the Reading Passage

1. In the event of a power failure, the devices would still work; eliminate the need to run power lines.
2. Mechanical windmills are simpler and work in all weather. Wind turbine powered systems produce more water, but require a minimum wind speed to be cost effective.
3. At $30,000 per mile, the farm would break even at a distance of 1 2/3 miles and would be ahead if the distance was farther.
4. A small biomass gasification could solve the problem. The gas could be sold or burned on site to generate electricity.

Lab Activity Data Results

1. Answers will vary, because the concentration of citric or acetic acid will vary in the different samples.
2. The current may reduce, drop to zero, or even reverse, depending on the amount of baking soda and concentration of the acid.
3. Answers will vary depending on the electrolyte strength in the solutions used.

Assessment 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. When a car battery "dies," there is no electrolyte for the movement of electrons to the electrodes.
3. The mapping or webbing of rural applications will vary by student, but terms in the Reading Passage should be utilized.
4. The presentations will vary. Preparing an outline helps the student organize his/her thoughts.
5. 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. The cost of homes in rural areas tends to be less, as well as property taxes.
6. 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

Vocabulary Definitions

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 that stores electrical energy using electrochemical cells
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
cell – an electric device that generates electricity through the conversion of chemical to electrical energy
centrifugal pump – a water pump using a rotating element or screw to move water; the faster the rotation, the greater the flow
cogeneration – the simultaneous production of electrical energy and another form of useful thermal energy (such as heat or steam) from the same fuel source
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)
ethanol – an alcohol (CH5OH) distilled from renewable sources, such as grain, sugar crops or almost any starchy plant, that can be used as an alternative fuel
gasification – waste treatment process where waste is heated to produce a combustible gas that can be burned in excess air to generate heat
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
refineries – plants used to separate the various components present in crude oil and convert them into usable fuel products or feedstock for other processes
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
royalties – amount of money paid for the use of a copyrighted or patented item
solar cell – (also called photovoltaic cell) converts sunlight into electricity
submersible – capable of being immersed and functioning underwater
wind turbine – any rotary machine with revolving vanes (like a pin wheel) driven by wind

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