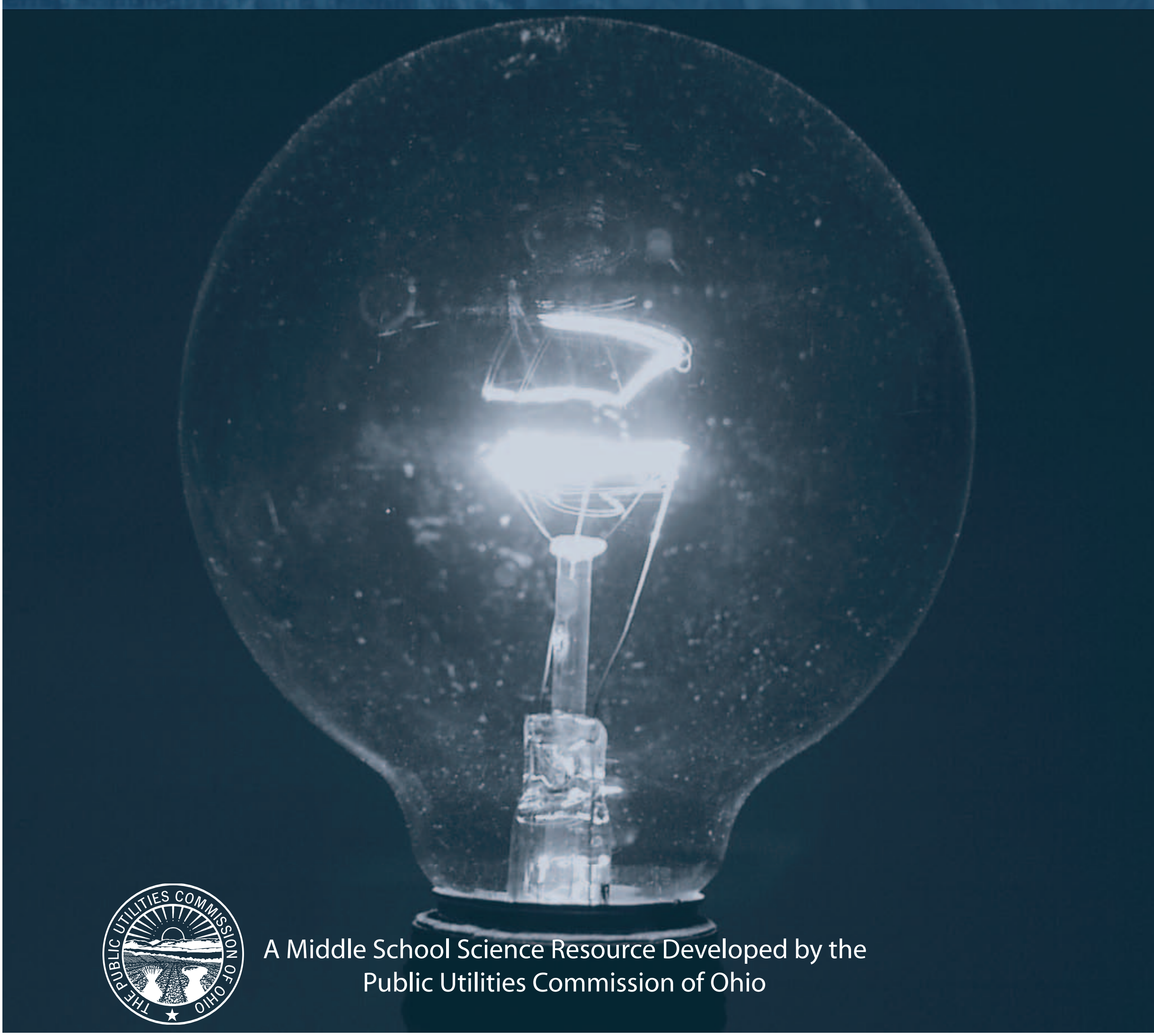
The Science of Energy



A Middle School Science Resource Developed by the
Public Utilities Commission of Ohio

The Science of Energy

A Middle School Science Resource Developed by the
Public Utilities Commission of Ohio

The Public Utilities Commission of Ohio

Monitoring marketplaces and enforcing rules to assure safe, adequate, and reliable utility services

Ted Strickland, Governor
Alan R. Schriber, Chairman

Commissioners

Ronda Hartman Fergus
Judy A. Jones
Valerie A. Lemmie
Donald L. Mason

Dear Educator:

The Public Utilities Commission of Ohio (PUCO) affects nearly every household in Ohio, because we regulate providers of utility services, including electric and natural gas companies. As a former educator, I believe it is increasingly valuable for students to learn about energy at a young age. It is for this reason that we developed *The Science of Energy*, a comprehensive teachers resource for grades 6 8 that provides discussion topics, activities, and sample test questions on the following subjects:

- Electricity
- Natural Gas
- Renewable Energy
- Energy Conservation

The Science of Energy was developed with Ohio Academic Content Standards and testing indicators in mind. Teachers can use the section overviews and discussion topics to develop lesson plans and then distribute copies of the activities to students to reinforce the concepts learned. The glossary of terms at the back is an additional resource for teachers and students alike.

Please share *The Science of Energy* with your middle school science teachers. If they choose to implement this resource into their curriculum and would like to receive additional copies, please contact the PUCO Office of Public Affairs at (614) 466 7750.

Sincerely,

Alan R. Schriber,
Chairman

180 East Broad Street Columbus, OH 43215 3793 (614) 466 3016 www.PUCO.ohio.gov

Electricity: Powering Our World

Objectives

- Learn the basic principles of electricity and energy
- Learn about the makeup of atoms and how atoms generate electric charges
- Learn how electricity is generated and transported to homes

Overview: Electricity as Energy

Electricity affects virtually every aspect of modern life. It allows people to turn on lights at the flip of a switch, use computers, watch TV, and keep food cold in the refrigerator. As easy as it is to use electricity, it can be very hard to understand how electricity works, and how it gets into homes. This lesson will explain some basic concepts about electricity, how it is made, and how it is delivered to homes, schools, and businesses throughout the United States.

Energy means the capability of doing work, or what makes things work. Food is the source of energy that people need so their bodies work. Electricity is the type of energy that makes technology work.

In the United States, electricity makes up 39 percent of all the energy consumed. Electricity is considered **secondary energy**, because other forms of energy are needed to produce electricity. **Primary energy** sources such as coal, oil, and hydropower are some of the resources commonly used to make electricity.

Discussion Questions

1. What is energy? What are other forms of energy besides electricity?
2. What are some of the energy sources that are used to make up electricity?
3. Why do you think electricity makes up such a large percentage of the energy used in the U.S.?
4. What is the difference between primary energy sources and secondary energy sources? What are examples of each?

Electric Charges

If a person walks across carpet and then touches a metal object, he or she will probably feel an electric shock. In the winter, a person's hair will stand up after taking off a wool hat. These shocks people feel are caused by electric charges in objects. A bolt of lightning is also an **electric charge**, but much larger and stronger than the ones normally felt by humans.

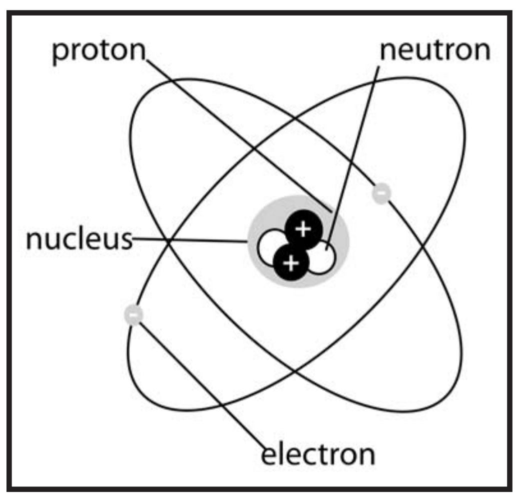
Fun Fact

U.S. consumers pay more than $212 billion in electric bills every year.

Where do electric charges come from? First, it is important to understand a little bit about the objects that carry electric charges. All physical objects are made up of **matter**, and all matter is made up of tiny **atoms** that are too small to be seen. Inside these atoms are even smaller particles that have positive and negative charges. The **nucleus** is the center of the atom, and inside the nucleus are **protons**, which have a positive charge, and **neutrons**, that are neutral and have no charge. **Electrons** carry a negative charge and orbit around the nucleus.

"Opposites attract" is a popular saying, and this idea is true for protons and electrons. Because protons and electrons have opposite charges, they are attracted to each other and are held together by an electric charge. Atoms in an object usually have the same amount of protons and electrons, so the opposite charges cancel each other out, leaving the object with an overall neutral charge.

Electrons are located outside of the nucleus, and it is easy for them to move around. If two objects are rubbed together, the electrons will "jump" from one object to the other. The object with more electrons now has a negative charge, and the object with fewer electrons has a positive charge. If the electrons continue to move to the other object, eventually the atom will become crowded with all the extra electrons. When this happens, the extra electrons will "jump" again to a nearby object, which creates an electric spark.



Discussion Questions

1. What is all matter made of?
2. What are the three particles that make up an atom?
3. Why do electrons move more easily than protons?
4. How is a spark created?

Electric Current: Electricity on the Move

Just as a bolt of lightning moves through the sky, electricity travels from **power plants** to homes, schools, and businesses. **Electric current** is this flow of charged particles that can travel over distances.

> **Fun Fact**
>
> **Electricity travels 186,000 miles per second. If you had a light on the moon connected to a switch in your bedroom (238,857 miles away), it would take only 1.26 seconds for the light to turn on.**

The wires and cords used to plug appliances in electric outlets carry electric currents. Electricity also travels through the large power lines seen on the side of the road. When electricity travels, it passes through some things more easily than others. **Resistance** measures how easy or hard it is for electricity to pass through a certain material. Electricity can easily travel through materials with low resistance, such as metal. These materials are known as **conductors**. Materials with high resistance do not allow electric currents to easily travel through them. Things like rubber and plastic have high resistance and are known as **insulators**.

Conductors and insulators make it possible for people to use electricity safely. Metal wires allow electricity to travel quickly and provide energy for our appliances, while the plastic coating on the wires insulates the electric current so it travels only to where it is needed.

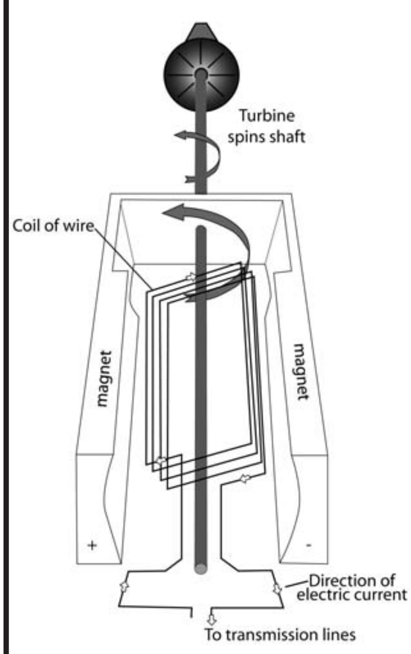
Discussion Questions

1. What is electric current?
2. What does electricity travel through so we can use it?
3. What are conductors and insulators? Give examples of each.
4. Why are conductors and insulators important in using electricity safely?

Producing Electricity

In the United States, electricity is generated by power plants that use various energy sources to produce the electricity. The majority of our electricity is generated by **nonrenewable resources** such as coal, natural gas, and oil. While these resources are found naturally in the earth and efficiently produce large amounts of electricity, nonrenewable resources take a long time to form, and there is a limited supply available for people to use for power generation. Because of this, electric usage needs to be monitored to make sure that these resources do not run out. **Renewable resources** including hydropower, wind, biomass, and solar energy are also used to produce electricity. These resources are readily available in nature and can be replenished relatively quickly. However, they are not as efficient in producing electricity as other resources, so their usage is limited.

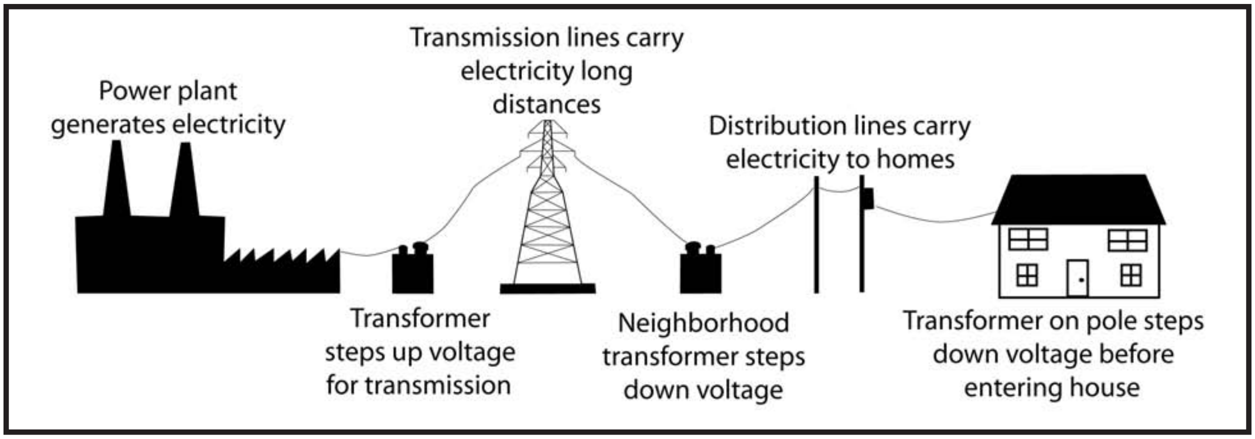
Most power plants use these energy sources to generate electricity through a steam **turbine**. The energy sources are burned to produce heat, which converts water into high-pressure steam. This steam is then used to turn the blades of a turbine, similar to a windmill, which is connected to a generator. The generator spins and converts the mechanical energy of spinning to electrical energy.



A basic generator

In order to get from the power plant to homes, electricity must travel long distances. **Transformers** are devices that change the voltage of electricity to help it travel more efficiently. When the electricity is ready to leave the power plant, it goes through a **step-up transformer** to increase the **voltage** of the electricity.

Voltage is the amount of pressure that pushes the electricity through wires. When the voltage is increased, less electricity is lost as it travels through the power lines. Electricity travels through **transmission lines**, the big power lines that can be seen from the highway. Once the electricity gets closer to homes, it goes through a **step-down transformer** that decreases the voltage to a safe level. Amazingly, it takes only a fraction of a second for electricity to travel from a power plant to the light bulb in a home.



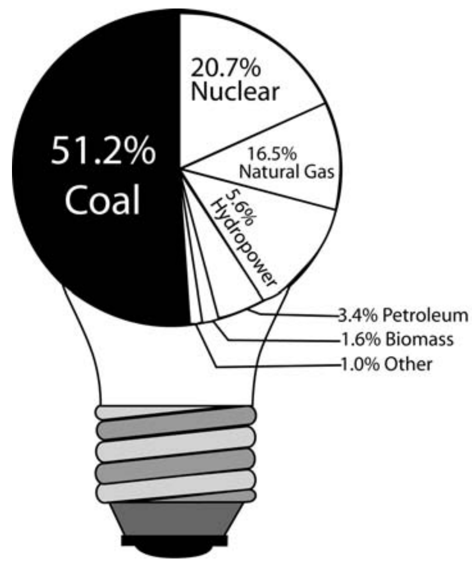
Electricity is measured in power units called **watts**. When electric companies measure how much electricity people use, it is measured in the form of **kilowatt-hours** (kWh), or the amount of electricity used in one hour. Electric companies set an amount to charge for each kilowatt-hour of power used, and that rate is used to determine the amount people pay for their electric bill each month.

Overview of Sources Used to Generate Electricity

Coal, a nonrenewable resource, is used to generate 51 percent, of the electricity in the United States. Coal is burned to heat water and make steam to push the blades of a turbine.

Nuclear power involves a process called fission in which the atoms of the element uranium split, releasing heat to turn water into steam and rotate the turbine blades. Nuclear power is nonrenewable and is used to generate 21 percent of U.S. electricity.

Natural gas can either be burned to produce steam or to produce hot combustion gas that passes through the turbine blades. Natural gas is a nonrenewable resource. Approximately 17 percent of the electricity in the U.S. is produced using natural gas.



Sources of U.S. Energy Production (from Energy Information Administration, U.S. Dept. of Energy)

In hydropower generation, flowing water is used to spin the turbine connected to the generator. Hydropower plants can use a current from a river or falling water that has accumulated in a dam to create the force needed to turn the turbine blades. Hydropower is a renewable resource and accounts for 6 percent of electric generation in the U.S.

Petroleum, a nonrenewable resource, is burned to create steam to turn the turbine. The most common form of petroleum used to make electricity is fuel oil, a type of oil that is refined from crude oil. Petroleum generates approximately 3 percent of U.S. electricity.

Biomass energy resources include wood, garbage, and crop waste such as corn and wheat that can be used to produce electricity. These renewable resources can replace fossil fuels like coal and natural gas in power plants. Currently, biomass energy is only used to generate one percent of U.S. electricity.

Other renewable resources, including wind, solar, and geothermal power generate the remaining one percent of electricity in the United States. Windmills harness the force of the natural wind to turn the generator turbine. Solar power uses photovoltaic cells to harness the energy of the sun to produce energy. Geothermal energy involves the heat buried beneath the surface of the earth. This heat transforms water into steam, which is then tapped to be used at steam-turbine plants.

Discussion Questions

1. What are the sources used in the United States to produce electricity?
2. How is electricity produced in power plants?
3. What does electricity travel through to get to homes, schools, and businesses?
4. What are the purposes of step-up and step-down transformers in transporting electricity?

5. What is the difference between a nonrenewable and renewable resource?
6. What energy source produces the most electricity?
7. What unit is electricity measured in for consumers?

Electric Reliability

Electricity is necessary to perform many everyday tasks. Because of this, electric companies work hard to make sure that they produce enough electricity to meet the needs of all the consumers who use it. **Reliability** is a term that refers to an electric company's ability to produce enough electricity so that all customers will have electricity at all times.

While power plants produce large quantities of electricity, the electricity cannot be stored in these large quantities. Because of this, electric companies generate the electricity to be supplied to consumers for immediate use. When people turn on lights, they use electricity that was produced at the power plant and transported to their homes just a moment earlier.

In order to meet the electricity demands of customers, electric companies must maintain a certain **capacity** of electricity, or the amount of electricity the company has ready to deliver to households. Usually electric companies make 15 to 20 percent more electricity than is needed to meet peak demands. **Peak demand** is the time of day when people use the most electricity, and when electric companies must produce the most electricity. Usually, peak demand at homes, schools, and businesses occurs during the day between noon and 6 p.m.

To make sure that enough electricity is always available, electric companies that are close together link their electric supplies together through **power pools**, and these power pools make up the **power grid** for North America. That way if one system has a problem, another power company can provide electricity to those customers until the problem is fixed. Even though power companies work together, power outages can still occur, many times because of thunderstorms or random occurrences such as a tree or car hitting an electric pole.

Fun Fact

An average American household uses about 866 kilowatt-hours of electricity each month.

Discussion Questions

1. What is electric reliability? Why is it important for electricity to be reliable?
2. Why does electricity have to be produced for immediate use?
3. Because electricity cannot be stored, what challenges do electric companies have in making sure electricity is always available?
4. What is peak demand? Why does it occur during the day?
5. What is a power pool?
6. How do power pools increase the reliability of our electricity?

Key Terms (defined in glossary)

Electricity	Resistance	Transmission lines
Primary energy	Conductors	Step-down transformer
Secondary energy	Insulators	Watts
Matter	Power plants	Kilowatt-hours
Atoms	Nonrenewable resources	Reliability
Nucleus	Renewable resources	Capacity
Protons	Generator	Peak demand
Neutrons	Transformers	Power Pool
Electrons	Turbine	Power grid
Electric charge	Step-up transformer	
Electric current	Voltage	

Activity 1: Powering with Fruit

Overview

Observe how chemical reactions in fruit can create an electric current.

Objectives

1. Learn how to build a simple electric circuit using a variety of objects.
2. Observe how chemical reactions in fruit work to create an electric current similar to a battery.
3. Demonstrate the properties of electric currents and electric charges in objects.

Materials

- 2 pieces of a variety of fruits (2 lemons, 2 apples, 2 bananas, 2 potatoes, etc.)
- 3 copper wires
- 2 large paper clips
- 2 pennies
- Digital clock or small light bulb
- Scissors
- Knife

Procedure

1. Attach one paper clip to the end of one of the wires.
2. Attach a penny to the end of the second wire.
3. Attach the second penny and paper clip to the ends of the third wire.
4. Pick the two lemons to start with.
5. Squeeze and roll the lemons slightly on the table to loosen the pulp on the inside.
6. Using the knife carefully, make two small cuts approximately one inch apart in the skin of both lemons.
7. Take the third wire (with the paper clip and penny attached to the ends) and stick the paper clip into one of the cuts until it is sunk into the inside of the lemon.

8. Take the penny from the same wire and insert it into the other lemon, using the same method.
9. Insert the paper clip attached to the first wire into the other hole of the lemon with the penny.
10. Insert the penny attached to the second wire into the other hole of the lemon with the paper clip.
11. Take the free ends of the wires and attach them to the terminals of the digital clock.
12. The energy from the lemons should create enough electricity to turn on the clock. If the clock does not work, check to make sure you have attached the wires correctly.
13. Repeat the procedure using other kinds of fruit.
14. Compare the results to determine which fruit produces the best electricity. Have a class discussion about the findings of the experiment.

Activity adapted from the PBS kids organization. More information can be found at http://www.pbskids.org.

Activity 2: Reading Your Electric Meter

Overview

Participate in the activity of reading a home electric meter.

Objective:

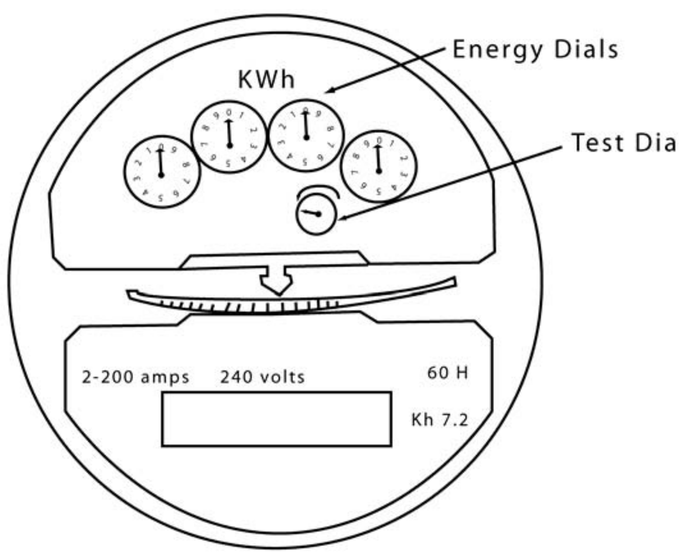
1. Understand that electric companies use home meters to measure the amount of electricity used in each residence.
2. Learn how electric companies measure the meters to determine how much energy was used.
3. Learn how to calculate how much electricity costs with the electric meter reading and the rate from the electric company.
4. Understand that electricity costs money, and the meter reading determines how much a person will pay for their monthly electric bill.

Materials

- Diagram of an electric meter
- Copies of a recent electric bill

Procedure

1. Electric companies use electric meters to measure how much electricity each household uses in a given period of time. This amount then is used to determine how much people will pay for their electric bill.
2. Refer to the diagram of the electric meter to see what one looks like.



3. There are four dials that make up an electric meter. The first and third dials read counterclockwise; the second and fourth dials read clockwise.
4. When reading an electric meter, always read the dials going from farthest left to farthest right.
5. Each dial on the meter represents a number place. The dial farthest to the right represents the ones; the next dial to the left is the tens; the third dial to the left is the hundreds; and the furthest dial to the left represents the thousands.
6. If the arm of one of the dials falls in between two numbers, the number it just passed should be recorded.
7. Observe the dials on the electric meter of your home, or arrange to look at the electric meter of the school with the class. Record the dials of the electric meter on a Monday, and then again on the following Monday to see the electric usage for one week.
8. Use the electric meter recordings from both Mondays to find out how much electricity their family or the school used in one week.
9. Take the meter reading number from the second Monday and subtract the reading from the first Monday. This will give you the amount of electricity used during the week in kilowatt-hours, the unit used by electric companies to measure electric usage.

Second Monday recording - first Monday recording = amount of electricity used for week

10. Look at a copy of an electric bill, or contact a local electric company to find out the current electric rate. This will give the amount charged by the electric company for each kilowatt hour of electricity used.
11. Multiply the amount of electricity used in the week by the rate charged per kilowatt-hour to determine how much the electricity for one week will cost.

Total electricity for week (kilowatt-hours) x electric rate = total cost of electricity for one week

12. Conduct a discussion about why electric companies use meters. What would happen if you used less electric appliances? What if you used more? What would happen if the electric company raised the rate they charge for electricity? How does the cost of electricity affect the budget for a family or a school district?

Activity adapted from NASA kids activity. For more information, please visit http://whyfiles.larc.nasa.gov.

Current Events: Electric Power Outages

The following news articles discuss power outages. Discuss the different reasons power outages occur and ways people can prepare for weather-related power outages.

Power outages linger in soggy parts of Ohio

The Columbus Dispatch 5-23-04

Thousands of Ohioans remained without power after two days of punishing thunderstorms, and the National Weather Service said more rain that was expected to hit already soaked soil could worsen flooding in parts of northeastern Ohio.

More showers were developing in hot, humid air, and another line of storms was to hit central and northern parts of the state late yesterday, the weather service said. Many counties remained under a flood watch.

Waves of thunderstorms packing heavy rain, hail, lightning and damaging wind yesterday and Friday closed roads, flooded basements and toppled trees into homes and cars.

"The soil over much of northern Ohio just cannot handle any more rainfall," meteorologist Mike Dutter of the agency's Cleveland office said yesterday.

Power was restored yesterday to most of the 44,000 American Electric Power customers who lost service in Columbus, Cambridge, Lancaster, Mount Vernon and Newark.

AEP spokeswoman Terri Flora said a few scattered customers in northeaster and southeastern Columbus will have their electricity restored today.

Service should also return to normal in hard-hit Mount Vernon by today, Flora said. Yesterday, 3,700 Mount Vernon-area customers remained without power, down from 8,000 after Friday's storm.

"This is the slow part," Flora said. "Some customers get a little frustrated. We can't restore individual customers before the main line is repaired."

In the Columbiana County village of Leetonia, crews packed sandbags around downtown yesterday as streets flooded with water from Little Beaver Creek. The barrier helped limit the damage mainly to muddy floors, Fire Chief Kenneth Garlough said.

Firefighters rescued at least two motorists from fast-rising water, Garlough said.

Columbiana County residents were advised to boil water as two wastewater treatment plants were overwhelmed.

About 140,000 northeastern Ohio homes and businesses were still without power yesterday, down from a peak of 400,000 customers, FirstEnergy Corp. spokeswoman Ellen Raines said.

More than half were in the Akron, Kent, Warren and Youngstown areas, and they might not have power restored until Monday or Tuesday, she said. About 65,000 Cleveland-area customers could have power back by late today.

FirstEnergy was working with the American Red Cross to distribute drinking water and ice in Cuyahoga, Trumbull and Mercer counties, said Rob Glenn, spokesman for the Ohio Emergency Management Agency.

About 30 businesses along the flooding Cuyahoga River had to close because of the rising, Glenn said.

Calls help track power outages: FirstEnergy encourages residents, businesses to report any problems

By Betty Lin-Fisher
Akron Beacon Journal 5-25-04

If your neighborhood's electricity is out, is there a point in every neighbor calling the power company to report it? Absolutely, said FirstEnergy spokeswoman Ellen Raines. FirstEnergy and its operating companies, including Ohio Edison, rely heavily on calls from affected residents and businesses to gauge the extent of a power outage, Raines said.

"The more calls we get, the more information we have to get as detailed a picture as possible of the outage," she said.

Raines said FirstEnergy's monitoring systems may be able to predict which areas are affected by a downed power line, but until customers call, there is no confirmation.

Ohio Edison has two phone numbers you can call to report an outage or downed wire: an automated line, 1-888-LIGHTSS (544-4877), is quicker than the customer-call center at 1-800-O-EDISON (633-4766).

John Falvy, director of contact centers for all of FirstEnergy's call centers, said the only difference between calling the automated system and the call center is talking to a real person. However, both phone numbers operate on the same system, so a live operator is not going to be able to give you any more details than the automated line.

The automated line is able to handle 3,000 calls at once, while the call center has 300 lines. This weekend, 325 customer service representatives were handling calls, Falvy said. That's significantly higher than the typical staff of 190, he said.

Most of the calls are handled at a center in Fairlawn that houses 150 customer service representatives. An additional 30 representatives are in Stow, 36 in Toledo and 13 in Warren. There is also a call center in Reading, Pa., with 230 agents. For this weekend's storms, about 50 agents from Pennsylvania fielded calls from Ohio customers reporting outages. Falvy said with computers, it doesn't matter where an agent is located; calls can be routed to his or her desk.

This weekend, when 430,000 customers in FirstEnergy's Ohio Edison and Cleveland Electric Illuminating Co. lost power because of severe thunderstorms, the call centers took 168,000 calls, said Falvy.

Raines said the company recognizes that customers often want to talk to a "real person," but the automated system will also have recorded updates and is the fastest way to report an outage. For instance, this weekend, a message on the automated system gave average estimates on power restoration for the hardest-hit areas.

However, Falvy said the average wait time for people calling the customer service representatives was 18 seconds. Raines said if the lines into the call center are busy, customer calls are rerouted to the automated line.

Raines said the company does not discourage customers from calling multiple times, but it doesn't move you up in the priority list. Sometimes after more time has passed after an outage, a customer service representative might be able to give a customer more updated information about the estimated restoration time, she said.

However, Raines said it's important for a customer to call if the other houses in the neighborhood have gotten electricity restored and yours hasn't. That may mean there's a problem with the service going into your house. FirstEnergy brought in 133 extra crews from other FirstEnergy companies to work with the 135 local crews to restore power after this weekend's storms, said Raines.

The company also offered free water and ice over the weekend to Ohio Edison customers at three local Acmes -- Acme No. 2 in Ellet, No. 4 in Hudson and No. 7 in Kent, said Raines, who said the company would continue to offer the free ice and water as long as the power was out in certain areas. However, FirstEnergy expected all of the areas to be restored by last night.

Questions

Name ____ Date ______________

Circle the correct answer. There may be more than one.

Multiple Choice

1. What is energy?
   a. The ability to move
   b. The ability to do work
   c. A Power Bar

2. What type of charge do neutrons have?
   a. Positive
   b. Negative
   c. Neutral

3. Where are protons and neutrons located inside of an atom?
   a. The nucleus
   b. The core
   c. The center

4. Which of these is not a major source of energy used to produce electricity in the U.S.?
   a. Coal
   b. Natural gas
   c. Limestone

5. When does the peak demand occur for electricity usage?
   a. Between midnight and 6 a.m.
   b. Between 6 a.m. to noon
   c. Between noon to 6 p.m.

True or False

6. All matter is made up of atoms.
   a. True
   b. False

7. Because protons and electrons have opposite charges, they repel each other.
   a. True
   b. False

8. Metal is considered an insulator of electricity.
    a. True
    b. False
9. Hydropower is a renewable resource for generating electricity.
    a. True
    b. False
10. Electricity cannot be stored in large quantities.
    a. True
    b. False

Short Answer

Answer the following questions with a few short sentences.

11. Explain why electricity is considered a secondary form of energy.

12. What is the difference between a conductor and an insulator? Why are they important in our use of electricity?

13. Describe the path electricity takes as it travels from the power plant to homes, schools, and businesses.

14. Explain the difference between a renewable and nonrenewable resource. Include examples of each.

15. Why is electric reliability so important?

Answer Key

Multiple Choice

1. What is energy?
   a. The ability to move
   b. The ability to do work
   c. A Power Bar
2. What type of charge do neutrons have?
   a. Positive
   b. Negative
   c. Neutral
3. Where are protons and neutrons located inside of an atom?
   a. The nucleus
   b. The core
   c. The center
4. Which of these is not a major source of energy used to produce electricity in the U.S.?
   a. Coal
   b. Natural gas
   c. Limestone
5. When does the peak demand occur for electricity usage?
   a. Between midnight and 6 a.m.
   b. Between 6 a.m. to noon
   c. Between noon to 6 p.m.

True or False

6. All matter is made up of atoms.
   a. True
   b. False
7. Because protons and electrons have opposite charges, they repel each other.
   a. True
   b. False
8. Metal is considered an insulator of electricity.
   a. True
   b. False

9. Hydropower is a renewable resource for generating electricity.
   a. True
   b. False

10. Electricity cannot be stored in large quantities.
    a. True
    b. False

Short Answer

11. Explain why electricity is considered a secondary form of energy.

Other sources of energy (i.e. coal, natural gas, hydropower) are needed in order to generate electricity.

12. What is the difference between a conductor and an insulator? Why are they important in our use of electricity?

A conductor is a material that electricity can easily travel through, while an insulator is a material that does not allow electricity to easily pass. Metal wires are conductors and help electricity to quickly travel and provide energy for us to use, while the plastic coating on wires acts as an insulator to protect us from the electricity.

13. Describe the path electricity takes as it travels from the power plant to homes, schools, and businesses.

Electricity is generated at a power plant. It goes through a step-up transformer to increase the voltage of the electricity so it travels more efficiently. The electricity travels over transmission lines from the power plant to homes, schools, and businesses. Before it enters a residence, the electricity goes through a step-down transformer to decrease the voltage to a safe level so it can be used.

14. Explain the difference between a renewable and nonrenewable resource. Include examples of each.

Nonrenewable resources supply most of the electricity we use. They occur naturally in nature, but it takes many years for these resources to form so they are only available in a limited amount. Coal, natural gas, and oil are nonrenewable resources. Renewable resources are readily available in nature and can be quickly replenished. Hydropower, wind, biomass, and solar energy are examples of renewable resources. Renewable resources, however, are not as efficient in producing electricity.

15. Why is electric reliability so important?

Electric reliability, or the ability of electric companies to provide power to customers 100 percent of the time, is important because of the reliance that our society has on electricity to perform necessary, everyday tasks.

Additional Information

Information from the following organizations was used in the creation of this section. For more information about electricity generation and energy sources, please visit these Web sites:

http://www.exeloncorp.com/peco/regulatory_extaffairs_communications/epr_elec_educ.shtml#energyterms

http://www.need.org/infobooks.htm

http://www.eia.doe.gov/kids/

http://www.earth.uni.edu/EECP/

http://www.southerncompany.com/learningpower/

http://www.forteelectric.com/Funfacts.html

Natural Gas: Delivering Clean Energy

Objectives

- Learn how natural gas forms in the ground, is explored and drilled for.
- Learn how natural gas is distributed to homes, schools, and businesses.

Overview: How Natural Gas is Formed

Millions of years ago, even before dinosaurs roamed the Earth, the remains of dead plants and animals began to decay under the surface. These remains, known as **organic material**, were covered by more and more layers of dirt, rock, and other debris deposited by wind, floods, and volcanic eruptions until they were buried deep in the ground.

Fun Fact

The first use of natural gas in the United States was in 1816, when gaslights were used on the streets of Baltimore, Maryland.

Over time, the organic material was squeezed by the pressure of the layers of rock above and cooked by heat deep in the ground until it gradually changed into **fossil fuels** (coal, a solid; oil, a liquid; and natural gas) in a process known as **anaerobic decay**. Fossil fuels are nonrenewable resources, energy sources available in a limited supply that cannot be easily replaced.

Natural gas can be formed from almost any organic material, under a wide variety of temperatures and pressures. Due to the force of gravity and pressure created by the overlying rock layers, natural gas seldom stays in the rock in which it is formed. Instead, it moves through underground layers of rocks until it escapes at the surface.

Discussion Questions

1. How do natural gas and other fossil fuels form? Are there ways to speed up this process?
2. What are the differences between natural gas, oil, and coal? Is one of these fossil fuels better to use than the others? If so, why?

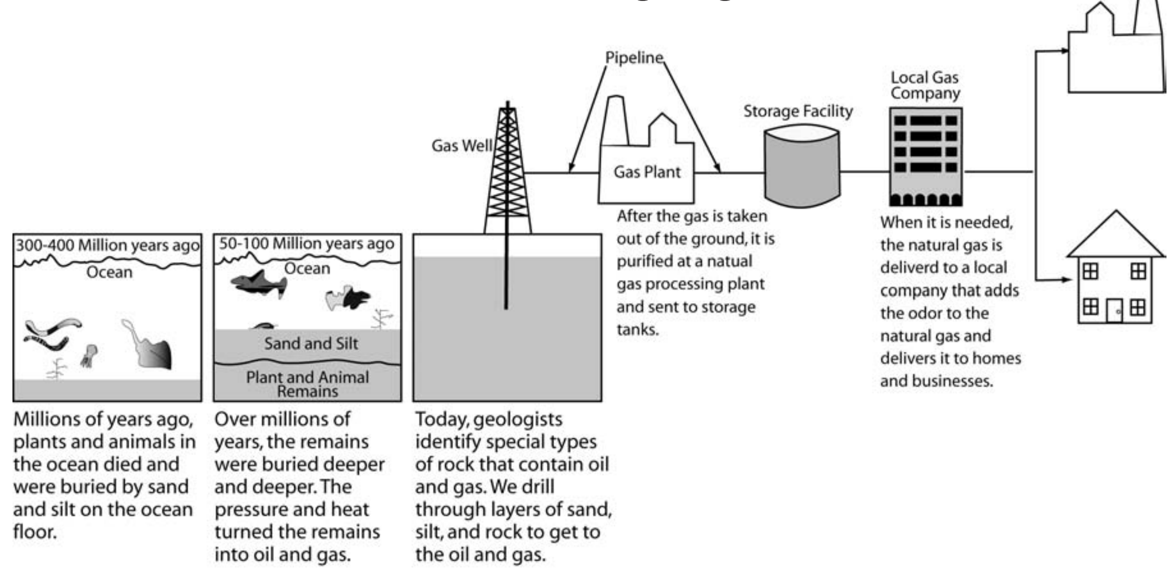
How Natural Gas Gets From the Ground to Homes and Businesses

Production

The search for natural gas begins with **geologists**, scientists who study the Earth, locating the types of rock that are usually found near gas and oil deposits. Geologists study rock samples, take measurements, and conduct seismic surveys to collect information about the rocks beneath to find the best places to drill gas wells. Seismic surveys use echoes from a vibration source at the earth's surface to collect information about the rocks underneath.

Natural gas is found in rock formations, known as **reservoirs**, throughout the world, often right alongside oil deposits. These rock formations hold natural gas like a sponge holds water. Some of these areas are on land but many are underwater, deep in the ocean. If a site seems promising, natural gas production companies drill wells. The colorless and odorless natural gas flows up through the **well** to the surface of the ground where it is collected in huge storage tanks or underground in old gas wells. About 90 percent of the gas used in Ohio comes from the Gulf of Mexico region and the rest comes from private wells within the state.

Natural Gas: From Beginning to End



Transportation

Transmission companies transport the natural gas from wells and storage tanks through interstate pipelines, big pipes that transport natural gas over long distances. There are more than 285,000 miles of **pipeline** that link major producing areas to consumers throughout the United States. Local gas companies contract with transmission companies to reserve space in the pipelines, so that the gas they purchase for their customers can be transported to the area where it is needed.

When chilled to -260 degrees Fahrenheit, natural gas changes from a gas into a liquid. In this liquid state, natural gas can be loaded onto large ships with several tanks and moved across the ocean to deliver gas to other countries. Liquefied natural gas takes up only 1/600 of the space that it does as a gas. That is like fitting all of the people in Ohio into an area the size of Cleveland.

Distribution

After a long trip through the pipeline, natural gas arrives at the local gas company and is passed through a metering system that measures the amount delivered. It then enters a pressure control station that reduces the gas pressure to a level that is safe for the smaller natural gas lines used by the local gas company. Since natural gas is colorless and odorless, a rotten egg odor is added to it before it is delivered to homes and businesses so that dangerous gas leaks can be detected.

Fun Fact

According to the Guinness Book of World Records, the familiar rotten egg odor added to natural gas is the smelliest molecule on Earth.

Measuring Natural Gas

Natural gas is measured by volume in cubic feet or by heat content in British thermal units (Btu).

One Btu is the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit. One Btu is equal to the heat released by a burning match. One cubic foot of natural gas contains about 1,000 Btu and is roughly equal to the amount of air it take to inflate a basketball. An average household in Columbus, Ohio, uses nearly 1,000 cubic feet of natural gas in one year.

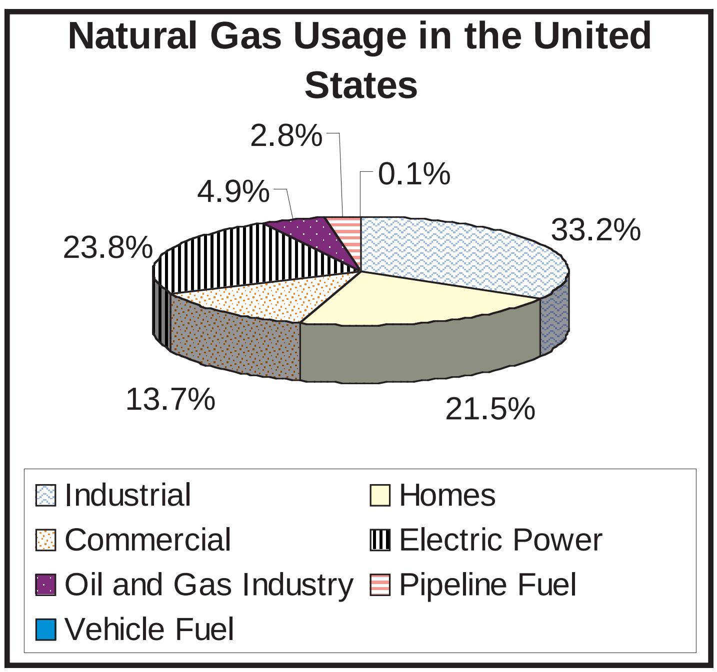
Discussion Questions

1. Where does the natural gas used in Ohio come from? In what other parts of the world might natural gas be found?
2. What are the different ways to transport natural gas?

How Natural Gas is Used

Natural gas is the cleanest of all fossil fuels. The main products of the **combustion**, or burning, of natural gas are **carbon dioxide** and water vapor, the same things we exhale when we breathe. Because it burns clean, natural gas has many practical uses.

Natural gas makes up about 23 percent of the energy consumed in the U.S. More than one-half of the homes in the U.S. use natural gas as their main heating fuel, and it is also used to fuel stoves, water heaters, clothes dryers, and other household appliances. Natural gas is an important raw material for many common products including paints, fertilizers, plastics, antifreeze, dyes, photographic film, medicines, and explosives.



Natural gas can be used to generate electricity through the use of a gas turbine, an engine that burns natural gas to produce steam or hot combustion gas. That steam or gas is passed through blades that spin to generate electricity.

It is important to know that natural gas is not the same thing as the gasoline used to fuel cars and trucks. Natural gas is a fossil fuel found inside the earth. Gasoline is a fuel refined from oil, another fossil fuel. However, natural gas can also be used in automobiles as a cleaner-burning alternative to gasoline.

Discussion Questions

1. What are some of the ways natural gas is used at home? At school?
2. How is natural gas different from gasoline?

Key Terms (defined in glossary)

Organic material	Seismic survey	Combustion
Fossil fuels	Reservoir	Carbon dioxide
Anaerobic decay	Well	
Permeable	Pipeline	
Geologist	British thermal unit (Btu)	

Activity 1: How Natural Gas Forms

Overview

Conduct a simulation of the formation of natural gas and other fossil fuels and practice the essential laboratory skills of hypothesizing, observing, and explaining their findings.

Objectives

1. Observe change over time through the simulation of forming natural gas and other fossil fuels through fossilizing plant materials; and
2. Practice the skills of hypothesizing, observing, and describing the process and results of an experiment.

Materials

- One small aquarium for classroom setup, or several 2-liter soda bottles with the tops cut off, for multiple small-group experiments
- Enough fine to medium-grain sand to cover 2 inches of each aquarium
- Fern fronds (leaves)
- Twigs
- Plant leaves
- Screen(s) or sifter(s)
- Fine silt or mud

Procedure

1. Review the definition of a simulation. To simulate a process is to imitate it or create a model that shows how that process occurs. When a process like natural gas formation is simulated, for example, we study what conditions exist for fossil fuels to form from decayed plant and animal materials. A simulation does not need to be an exact replication of a process for it to demonstrate how something happens in the natural world.
2. In this activity, we will create a "fossil" over the course of the next four weeks and will observe how that fossil forms.

3. Natural gas is an example of a fossil fuel. A fossil fuel is a fuel that has formed in the earth from the remains of plants or animals that lived millions of years ago. Can you think of other fossil fuels (e.g., oil, coal)? Fossil fuels are formed from a combination of plant material, heat, pressure, and time. The process of fossil fuel formation takes millions of years to complete and is still taking place today. Although we will not actually create fossil fuels in this activity, we will see how the fossilization process occurs.

4. In small groups or as a class, line the aquarium(s) with plastic wrap so that you can lift the entire formation out when it is dry. Next, pour water into each aquarium to a depth of 4 to 6 inches. Then spread about 2 inches of sand on the bottom, followed by small leaves, sticks, and pieces of fern.

5. Once each aquarium is set up, record your observations. Describe what the aquarium looks like, and the textures and colors you notice in the sand and foliage. What changes might occur over a few weeks if the aquarium is left untouched? Watch the aquarium change over the course of the next four weeks and continue to record any changes in color and water level.

6. After two weeks, use the screen or sifter to gently sift fine silt or mud on top of the plant layer to a depth of 2 inches. This replicates the natural fossilizing process of contributing heat and pressure to the vegetation. Continue to document any changes you see and adjust your hypotheses if necessary.

7. Wait another two weeks and drain any water that remains. Let the formation sit and dry for another week or two. Once it is dry, carefully lift the entire formation out of the container(s). You have simulated the early stages of fossil fuel formation. Gently break the formation into layers to reveal the fossil-like imprints from the plants.

Activity modified from Coal Formation Lesson Plan (American Coal Foundation)

Activity 2: Exploring for Fossil Fuels

Overview

Conduct a simulated exploration of fossil fuels and discuss the relationship between supply and demand of fossil fuels.

Objectives

1. Participate in a simulated exploration of fossil fuels; and
2. Understand the relationship between supply and demand of fossil fuels and how both conditions affect the cost of energy.

Materials

- Blackboard or overhead projector
- Pencil and paper
- Three different colors of M&Ms or jelly beans (Note: Approximate percentages of beans or beads):
    - 40 percent red
    - 35 percent yellow
    - 25 percent blue
- Clock, timer, or stopwatch
- Rice

Procedure

1. Review the definition of simulation. To simulate a process is to imitate it or create a model that shows how that process occurs. A simulation does not need to be an exact replication of a process for it to demonstrate how something happens in the natural world.
2. As a class, compile a list of natural fossil fuels. The list should include natural gas, coal, and oil. Which of these energy sources is the most plentiful, and which is the most expensive? You will be participating in a mock exploration for fossil fuels that will illustrate the supply of each of those energies.

3. Your teacher will toss the M&M's or jelly beans into the air , letting them scatter over the classroom. (Your teachers may also choose to hide groups of beans or beads around the room before class.)
4. Divide into three exploration companies. Each company is assigned a specific fossil fuel to recover:

Company #1	red M&M's or jelly beans = coal
Company #2	blue M&M's or jelly beans = oil
Company #3	white M&M's or jelly beans = natural gas

5. Take one minute to search and recover your group's fossil fuel. After one minute, count how many of the resources you collected. Record your totals on the chalkboard or overhead projector.
6. Your teacher will now total the number of each energy source found from all three searches. Work with your company to prepare a graph (bar, circle, line, etc.) illustrating the quantities of each resource recovered, then calculate the percentages of each resource. (This is done by dividing the number of each colored bead or bean retrieved by the total number of beads/beans recovered.)
7. Display your company's graphs and share your calculations. Review the calculations with your teacher to come up with accurate percentages.
8. Discuss as a class which energy sources were easier to collect. Why? Which were the most difficult to find? Why? Which energy source do you think would be the most expensive. Why? What do you think happens to the price of energy sources as they become scarcer?
9. The percentages you calculated should represent the actual percentages of fossil fuel resources in the United States. Coal is the least expensive and most abundant fossil fuel resource in the United States. Next is natural gas and then oil.

Activity modified from Coal Supply and Demand Lesson Plan (American Coal Foundation)

Current Events: Lake Erie Natural Gas Drilling

Read the following news articles about drilling for natural gas on Lake Erie, and then discuss the pros and cons of each side of the issue.

Taft order bans drilling under Ohio waters of Erie through 06

Cleveland Plain Dealer 8/21/2003

Columbus - Gov. Bob Taft, following up on an earlier promise, has signed an executive order banning drilling for oil or gas under the Ohio waters of Lake Erie.

Taft has been under pressure to act from environmental groups concerned that the activity could begin after a federal ban on drilling in the Great Lakes expires in September 2005.

The governor signed the order last month without fanfare, spokesman Orest Holubec said Tuesday.

The move didn't sit well with critics who contend Ohioans need the energy and cash the drilling would provide.

"They [Canadians] have drilled right up to the border," said Thomas Stewart, executive vice president of the Ohio Oil and Gas Association. "They are out there today drilling in Lake Erie."

The Canadian side of Lake Erie has 550 gas-producing wells.

Stewart said Ohioans would benefit from the millions of dollars in royalties the oil and gas production would generate, and from having a large source of natural gas so close.

But Bryan M. Clark, conservation program coordinator for the Ohio Sierra Club, called the governor's action "fantastic."

"Gov. Taft has hit a home run for Ohio's environment," Clark said.

The order prohibits the Ohio Department of Natural Resources from issuing any permit, license or lease for removing oil or gas from or under the lake bed through 2006, the end of Taft's second term.

The Ohio Geological Survey estimates that the Lake Erie Ohio zone has more than 1.1 trillion cubic feet of natural gas - equal to all the state's onshore reserves.

Last year, Ohio produced 98 billion cubic feet of gas, or 11 percent of the state's needs.

Great Choice

Akron Beacon Journal 8/26/2003

Bob Taft pledged to sign an executive order banning oil-and-gas drilling in the Ohio waters of Lake Erie. In July, the governor kept his word. He issued the order with such little fanfare the news did not surface until last week.

A federal ban on drilling in the Great Lakes expires in 2005. The Taft order would extend the prohibition for another year, until the end of the governor's term. That may not seem a substantial gain. Actually, it bolsters a growing consensus. Taft acted with the strong support of officials in the state departments of natural resources and environmental protection.

Sen. George Voinovich has been a particularly ardent and influential supporter of a drilling ban. The Cleveland Republican has made the revival of Lake Erie a cornerstone of his public career. He and others are deservedly proud of the lake's recovery. They recognize problems and challenges remain. They warn that drilling will jeopardize progress, especially the role Erie plays in the tourist industry.

The Ohio Oil and Gas Association criticized the Taft order, citing revenues that would flow to its members and the state. The governor smartly weighed the costs and benefits.

Drilling for oil and gas would not add significantly to the state's energy sources. Ohioans consume more than a trillion cubic feet of natural gas per year. Recent estimates are tapping Lake Erie would generate a tiny fraction of that amount.

The state has numerous alternative sources. A modest conservation program would quickly make up the difference, and it would do so without harming a signal achievement of the past three decades, the steady return of Lake Erie to greatness, a pursuit wisely reinforced by Bob Taft.

Lake Erie drilling makes economic sense

Cleveland Plain Dealer 9/10/2003

What irony. A week after more than 50 million people lost electricity, The Plain Dealer reported that Gov. Bob Taft has signed a bill prohibiting drilling for oil and natural gas in Lake Erie, and of course the Sierra Club applauds the governor's approach. Presumably, it also applauded as the Northeast went without power.

As The Plain Dealer's Aug. 21 article indicated, Canada is already drilling in Lake Erie, and we have yet to hear of any environmental disasters. Ohio, however, refuses to tap into one of the few resources that could help revitalize the state's economy. Instead of showing real leadership, Taft has kowtowed to a special-interest group that still will not support him.

Advances in technology have made drilling for oil and natural gas far more productive and environmentally friendly than it was 30 or 40 years ago (when environmentalists were busy predicting a new Ice Age). For example, according to the Department of Energy, new seismic and remote-sensing technologies now increase the likelihood that an oil or gas well will be successful, and there will be fewer dry holes to disturb the environment.

If Gov. Taft were willing to step to the forefront, he could have made a compelling case to the people of Ohio as to why permitting drilling would have been beneficial to the region and not cause harm to the environment.

With an ever-growing economy and population, conservation alone is not a responsible course of action. Yes, the environment should be taken care of, but there are ways to protect the environment while still increasing the United States' power supply. Failure to do so will result, eventually, in more power outages down the road. While the Sierra Club may enjoy blackouts, the majority of the people do not.

Questions

Name ____ Date _______________

Circle the correct answer. There may be more than one.

Multiple Choice

1. Fossil fuel refers to:
   a. Coal
   b. Oil
   c. Natural gas
   d. All of the above
2. Methods of natural gas transportation include:
   a. Tankers
   b. Truck
   c. Pipeline
   d. Both B and C
3. Coal, petroleum, natural gas, and propane are fossil fuels. They are called fossil fuels because:
   a. They are burned to release energy and they cause air pollution
   b. They were formed from the buried remains of plants and animals that lived millions of years ago
   c. They are nonrenewable and will run out
   d. They are mixed with fossils to provide energy

True or False

1. Natural gas and gasoline are the same thing.
   a. True
   b. False
2. When burned, coal and oil typically release more pollutants than natural gas.
   a. True
   b. False

Matching Terms

Match the terms on the left with their definitions on the right by writing the correct letter in the blank.

1. British thermal unit (Btu) ____
2. Fossil fuels ____
3. Sedimentary rocks ____
4. Combustion ____
5. Reservoir ____
6. Well ____
7. Organic material ____
8. Tanker ____
9. Seismic survey ____
10. Geologist ____
11. Pipeline ____

A. A scientist who studies the Earth and its processes.

B. The process of burning.

C. A large ship with several tanks that is used to transport liquefied natural gas across oceans.

D. Rocks formed by the accumulation of sediment or organic materials and therefore likely to contain fossil fuels.

E. A scientific tool that use echoes from a vibration source at the earth©s surface to collect information about the rocks beneath.

F. A unit of measurement used to measure heat content; the amount of energy required to raise the temperature of 1 pound of water 1 degree Fahrenheit.

G. A pipe that transports natural gas and oil long distances.

H. A hole drilled to obtain natural gas or oil.

I. An underground rock formation containing natural gas or oil that is confined by less permeable rock or water barriers.

J. Decayed matter from plants and animals.

K. Fuels that come from organic material that lived millions of years ago; includes natural gas, oil, and coal.

Short Answer

Answer the following questions with a few short sentences.

1. Name at least three things can be powered by natural gas.

2. Why is the rotten egg odor added to natural gas?

3. How do geologists locate the best places to drill natural gas wells?

4. What is the main way natural gas and other fossil fuels form?

Answers

Multiple Choice

1. Fossil fuel refers to:
   a. Coal
   b. Oil
   c. Natural gas
   d. All of the above

2. Methods of natural gas transportation include:
   a. Tankers
   b. Truck
   c. Pipeline
   d. Both B and C

3. Coal, petroleum, natural gas, and propane are fossil fuels. They are called fossil fuels because:
   a. They are burned to release energy and they cause air pollution
   b. They were formed from the buried remains of plants and animals that lived millions of years ago
   c. They are nonrenewable and will run out
   d. They are mixed with fossils to provide energy

True or False

1. Natural gas and gasoline are the same thing.
   a. True
   b. False

2. When burned, coal and oil typically release more pollutants than natural gas.
   a. True
   b. False

Matching Terms

(Answers: 1-F, 2-K, 3-D, 4-B, 5-I, 6-H, 7-J, 8-C, 9-E, 10-A, 11-G)

Short Answer

1. Name at least three things can be powered by natural gas.

Furnace, stove, water heater, clothes dryer, gas turbine, automobile

2. Why is the rotten egg odor added to natural gas?

The rotten egg odor is added to natural gas so that leaks can be detected by the smell before an explosion occurs.

3. How do geologists locate the best places to drill natural gas wells?

Geologists study rock samples, take measurements, and use seismic surveys to find the best places to drill natural gas wells.

4. What is the main way natural gas and other fossil fuels form?

The remains of dead plants and animals, known as organic material, began to decay under the earth millions of years ago. Over time, this organic material was squeezed by pressure and cooked by heat deep in the ground until it gradually changed into fossil fuels. This process is called anaerobic decay.

Additional Information

Information from the following organizations was used in the creation of this section. For more information about electricity generation and energy sources, please visit these Web sites:

http://www.need.org/guides.htm
http://www.eia.doe.gov/kids/
http://www.fe.doe.gov/education/
http://www.nef1.org/
http://www.nsta.org/Energy/find/primer/index.html
http://www.rebuild.org/sectors/ess/index.asp
http://energy.gov/engine/content.do?BT_CODE=KIDS

Renewable and Alternative Energy Sources: The Changing Faces of Energy Production

Objectives

- Students should be able to identify alternative energy sources and have a basic understanding of how each resource is used to provide electricity.
- Students should also learn about the differences between each of the alternative sources of energy and their benefits and drawbacks.

Overview: Renewable Energy Options

As the demand for electricity increases, the demand for the resources used to produce the electricity we use every day increases as well. Coal and other fossil fuels are burned to produce steam, which is then harnessed to create electricity. However, burning materials is not the only way to create electricity.

Ohioans use a lot of energy. In 2000, Ohio ranked 6^{th} in the nation in total energy consumption. Consumers in Ohio spent a total of $2.9 billion on energy in 2000, which was 7^{th} in the nation.

Most of the energy produced in Ohio comes from coal. Nearly 87 percent of the electricity used in the state is generated using coal. Less than 1 percent of our electricity is produced through **renewable energy resources**, which are sources of energy that can be replaced naturally in the near future, so they can be used again. Examples of renewable energy resources include:

- **Biomass** - power produced from agricultural or industrial organic waste materials;
- **Wind Power** - power generated by harnessing the energy of the wind;
- **Hydroelectric** - electricity generated by water;
- **Solar** - electricity generated by the sun; and
- **Geothermal Power** - electricity generated by using heat from the Earth.

Coal and oil take millions of years to become a usable source of energy, while quick-growing trees and grasses only take a few years to mature to the point where they can be used as a biomass fuel source.

While very little of Ohio's electricity comes from these renewable sources, there are many opportunities for Ohioans to take advantage of them. Each of these alternative power supplies is being used in Ohio, either on a large scale by power companies, or by private homeowners who want to reduce their electric bills.

Solar Energy

Most people have probably seen calculators or other small electronic devices that use **solar cells**. Instead of batteries, there is a thin black strip on the top of the calculator. If the strip is uncovered and in the light, the calculator will turn on, but if the strip is covered up or there is not enough light, the calculator will not work. Just like a calculator, homes too can be powered by solar cells, but those solar cells are much larger and much more expensive.

Throughout the world, solar energy is used to heat water for showers and to cook food. In these examples, the sun's heat supplies all of the energy needed to complete the task. If you have ever gotten into a car on a sunny day (even when it is not hot outside) the inside of the car can be very warm. Warm enough to melt candy and make things very uncomfortable. The light that comes through the car windows gets trapped on the inside of the car. The fabric of the car absorbs the energy from the light and converts it into heat. Since the fabric and the widows are good insulators, the heat is held in. As more and more light comes in, the heat continues to build.

Some people, like campers or those living in remote areas of the world, use the same idea when it comes to cooking food. They use devices called solar ovens, made of pieces of glass and insulation, that get hot enough to bake loaves of bread. This type of energy, using light directly from the sun, is called **passive solar energy**.

The sun does more work than just making the days warmer. Plants use sunlight for food. The sun heats air high in the atmosphere, which causes the wind to blow. Energy from the sun evaporates water, which causes clouds to form and eventually makes it rain. Sunlight does many things for the planet that humans cannot control, but humans have figured out another way to use the sun that can be controlled◎ solar power.

Scientists have learned to harness the energy of the sun through the use of **photovoltaic cells (PV)**. PV cells are used in calculators, but they can also be used to provide electricity to homes and other electrical equipment. They are made of an element called **silicon**. Silicon is an element, which means it is something that cannot be made by man. Silicon atoms have an **atomic structure**, or the arrangement of the nucleus, protons, and electrons, that makes them very good at combining with other atoms. In nature, silicon atoms always combine with another element to make a compound, or **silicate**, which is a compound that contains silicon. The most common form silicon takes is quartz minerals. The grains that make up the sand on most beaches are tiny pieces of quartz or other silicates. The atomic structure of silicon has some interesting features that make it good for harnessing the sun's energy. The silicon used in solar cells is in a special form called crystalline silicon. The atoms in crystalline silicon share electrons in their outer layer which is important to its use in PV cells.

In order for current to flow through something, there must be positive and negative parts to the material. Think of a battery. One end is positive and the other is negative. When the two sides are not connected, no electricity flows through the battery. Once the battery is put into something that connects both ends, or **terminals**, current begins to flow. The same idea applies to PV cells. In order for a current to be produced, there has to be both negative and positive parts to the PV cell. Scientists can make both types of silicon for the PV cells by adding certain minerals to the silicon in a laboratory.

Fun Fact

More than 10,000 homes in the United States are powered entirely by solar energy.

The addition of phosphorous and boron helps current flow through the cells. Adding phosphorous to the silicon gives the silicon atoms an extra electron to latch onto. These extra electrons in the silicon allow a negative electrical current to flow. By adding boron, there is one less electron in the outer layer, and this gives the silicon atoms another place to fit in, helping the silicon carry a positive charge. These two types of silicon are made into sheets, and when the cell is made, they are placed on top of each other. The typical PV cell consists of six layers of material.

Everyday, enough energy from the sun makes it to the ground surface of the United States to power the country for a year and a half. However, 15 percent of that energy is reflected back into space, 30 percent evaporates water in oceans, lakes, and rivers, two percent creates wind, and another small percentage is used by plants for photosynthesis. The remaining sunlight has the potential to be converted into solar power. In areas where the sun shines longer during the day and is located more directly overhead, the potential energy from the sun is greater than in areas where the days are short and the sun is not directly overhead. In Ohio there is the potential to produce more than 1,000 kWh of electricity per year through a PV system and eliminate over 2,500 pounds of CO_2 emissions.

Researchers have been working on ways to maximize energy use from the sun by using **solar collectors**, or **solar troughs**. These two devices work by taking the sunlight and focusing it onto a small area. This increases the amount of energy delivered to that area. Solar collectors are similar to a car on a sunny day. They absorb energy from the sun and convert it to heat using insulation. Solar troughs go one step further. They use mirrors to focus the energy of the sun on a particular point. Much higher temperatures can be achieved by using solar troughs. A simple experiment found at the end of this section can demonstrate the effects of solar troughs.

Discussion Questions

1. What types of "work" does sunlight do for the Earth?
2. How can people use sunlight to complete their daily chores?
3. Is there anyway to convert sunlight into another form of energy instead of just using the heat from the sun?

Wind Power

Wind has the power to do many things. It can be used to fly a kite, cool homes on a warm day, and even provide electricity to homes using the right equipment. For centuries, windmills have been used to capture wind power to perform many tasks such as grinding grain, sawing wood, and pumping water. These are all examples of using the wind for its **kinetic energy**, or the direct use of the wind©s power to do work. Kinetic energy is energy in motion. The blowing wind or a spinning wheel would be an example of kinetic energy. Another way to use wind power is to convert it to **mechanical energy** through the use of machinery, like **wind turbines**. Wind turbines are special windmills that convert wind power into electricity.

As wind passes over the blades of the turbine, they spin. The blades are attached to a long metal rod called a shaft. At the end of the shaft is a gearbox that, through a series of gears, speeds up the rate at which the shaft is spinning. This energy is transferred to another shaft with a gear on it. That gear is used to turn the motor of a generator. As magnets in the generator spin, they create electricity that is carried out to the electric grid, or to a home, through wires.

Other parts of the wind turbine help improve the efficiency of the wind turbine. The brake stops the blades if they turn too fast for the windmill to safely operate. The anemometer and the shaft motor help turn the windmill into the wind, so the windmill can function even if the wind changes directions.

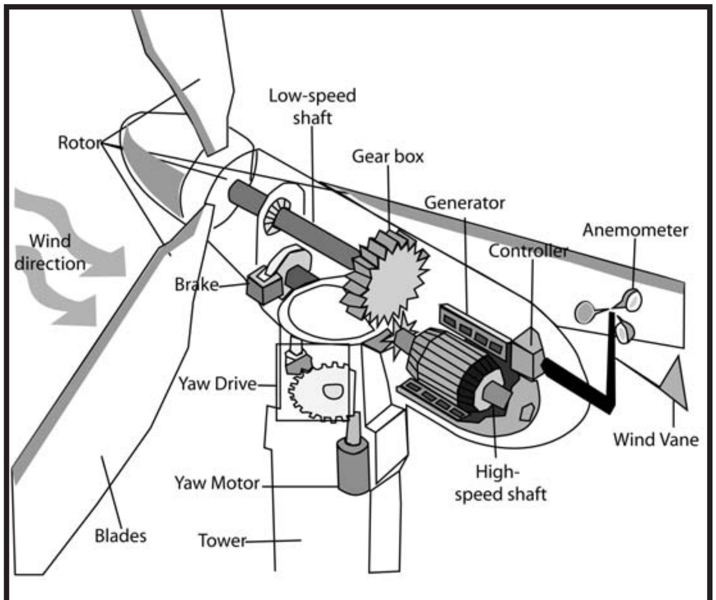
In most instances, the bigger the wind turbine, the more power it is capable of producing. Larger wind turbines can turn larger motors, which create more electricity. However, most of the wind turbines used in Ohio are small compared to those used to produce power in other states throughout the Midwest and in California.

In 2003 the first utility-scale wind turbines in Ohio were installed in Bowling Green, and in September 2004 two more wind turbines were installed at the same location. Utility-scale simply means that these wind turbines are connected to the same electric grid that delivers the electricity produced in conventional power plants to homes. Most of the wind turbines in Ohio are not hooked into this grid. They supply electricity only to the people that have built them, usually farmers and other private citizens.

Each of the four wind turbines has a 257-foot tall tower and three blades that are each 132 feet long. Combined, these two machines can produce enough electricity to power more than 1,500 homes for one year.

There is one problem with wind power. Although it is clean and relatively cheap in the long run, it is not always available. If the wind is not blowing, then the blades of the wind turbine cannot turn, and if they cannot turn, no electricity is produced. Most areas of the United States have the potential to produce wind power throughout the year, but there are times when many areas would not have enough wind to produce all of the electricity needed. Ohio is no exception to this rule.

Most wind turbines need the air to be moving at least five miles per hour before they can begin to produce electricity. This is known as **cut-in speed**, or the minimum wind speed that will turn the blades of the rotors. However, this is only the minimum wind speed needed to produce electricity. The amount of electricity produced by a wind turbine is a cubic function, which means that if wind speed is doubled the power output increases eight times.



A basic wind turbine.

Complete the following exercise to see just how much difference a little wind can make.

In any situation where energy is involved, the amount of energy produced or used (power) is a result of time and the amount of energy used or produced by an object. When wind turbines are concerned, the energy produced is measured in terms of watts (w). The amount of energy put into the windmill is the wind speed (V). In order to convert kinetic energy measurements, known as joules, into watts the wind speed must be multiplied by 0.5. The equation looks like this:

$$w = 0.5 \times V^3$$

Using a cut-in speed of 5 mph, determine how much power is produced.

$w = 0.5 \times 5^3$

$w = 0.5 \times 125$

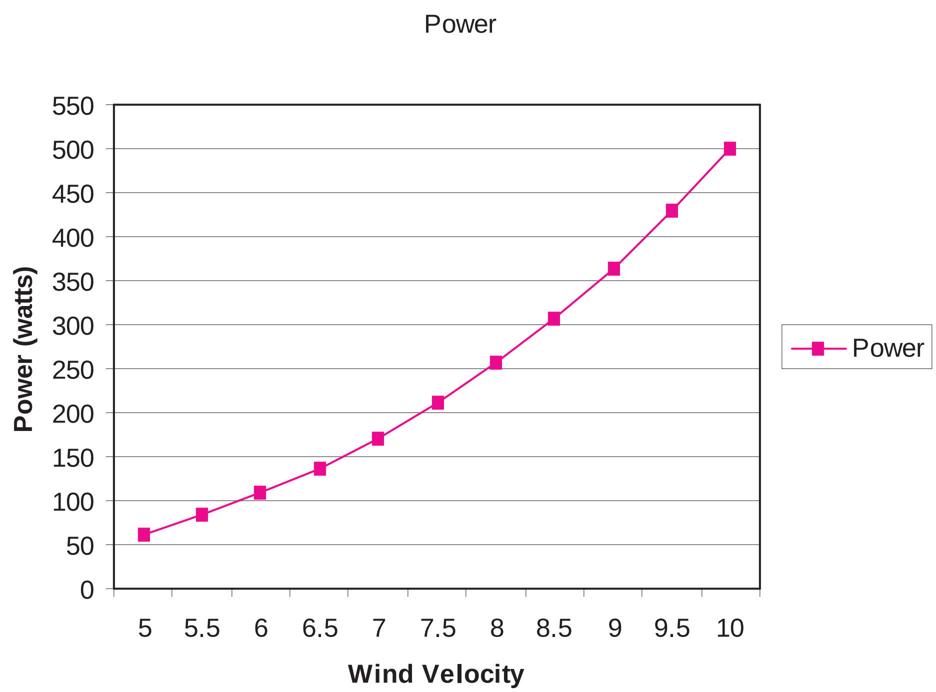
$w = 62.5$

So, at 5 mph, a wind turbine would be capable of producing 62.5 watts of power. Using the same method, figure out how much power a wind turbine could produce at the following speeds:

V = 5.5	V = 7.0	V = 8.5	V = 10
V = 6.0	V = 7.5	V = 9.0	
V = 6.5	V = 8.0	V = 9.5	

Graph the results of the equations.

The graph should show a curve similar to this one:



Notice at the bottom of the curve, there is little difference between the power output at 5 mph and 6 mph. It is a difference of about 75 watts. However, the difference in output between 9 mph and 10 mph is 135.5 watts.

Take the power produced at 10 mph and divide it by the amount of power produced at 5 mph. 500/62.5=8

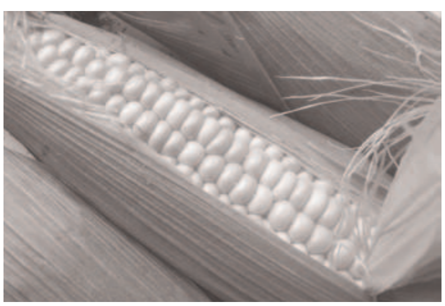
By doubling the wind speed from 5 mph to 10 mph there is 8 times more electricity produced. This is why wind speed is critical to all wind turbine projects. Most wind turbines can operate at wind speeds up to 25 mph. Any wind speed faster than that has the potential to cause damage to the generator, so a brake slows down the rotors.

As wind turbine design technology improves, lower wind speeds will be able to produce more power, and generators will become more efficient. Currently, about 80 percent of the energy taken in by a wind generator is turned into electricity. This is more efficient than most other forms of electricity production, but in most areas of the world, the wind does not blow constantly, which would be a necessity for wind power to be the only means of electric production. Limited amounts of wind-generated electricity can be stored in batteries, but there are limitations to how much electricity a battery can store.

Discussion Questions

1. Would wind power be a good alternative energy source in Ohio? Why or Why not?
2. If there is no wind, what do you think happens to the windmill? Can it still produce power?
3. How is wind turned into electricity? Is electricity produced by windmills the same as other electricity?

Biomass Energy



Until recently, many of the appliances taken for granted today were not available to most people. Items like stoves, furnaces, and space heaters simply did not exist 150 years ago. Most Americans had to burn wood to heat their homes and cook. Wood is a form of biomass energy, which is an organic energy source available on a renewable basis for conversion to energy. As settlers began to move to the western part of the United States in the late 1800s, they learned that often there were not enough trees to cut down for firewood. However, there was a source of biomass fuel in abundant supply.

Buffalo roamed the plains of the United States in great numbers, and they left behind buffalo chips wherever they grazed. These are dried pieces of buffalo manure that could be burned, just like wood, and used for heating and cooking.

This same principle is applied today in many agricultural regions of the United States. In Ohio, the University of Findlay used a special furnace designed to generate heat from burning horse manure from one of its veterinary programs. The heat generated by the furnace was used to dry out the horse manure so it can be used as an energy source in the furnace. Enough excess heat was generated that the school was able to heat their sports arena.

Before they began using the horse manure as a fuel source, the school was paying $30-40,000 a year to have the manure hauled away. Not only were they saving money by getting rid of the horse manure themselves, they were also saving on their heating bill.

Manure and other animal waste comprise a basic form of biomass. The dried manure can be burned for a variety of uses and often avoids much of the mess and smell associated with getting rid of animal waste. One of the major problems with using animal waste as a fuel source is that a lot of manure is needed to produce the energy necessary to heat large spaces. Additionally, the manure needs to be dried before it can be burned, which uses some of the heat produced by burning the manure.

Animal waste is just one form of biomass, and it is a pretty basic form. Little needs to be done to the manure to make it a viable energy source. Other forms of biomass are not so simple.

Ethanol is a **biofuel** produced from corn, wheat, and some wood-waste products. Biofuels are fuels produced from organic substances, such as corn and in some cases, old vegetable oils, like those used to cook French fries at fast-food restaurants. Ethanol is produced through a process known as fermentation. Commonly, the grain or corn is ground up and added to water with yeast in it. This mixture is then heated and cooked. The yeast has an enzyme that combines with the sugars in the ground material and causes a chemical reaction. Carbon dioxide is produced and the liquid left over is ethyl alcohol, or grain alcohol. This alcohol is clear, has a faint smell and burns very cleanly. Most commonly, the alcohol is combined with gasoline and used to power automobiles.

Most of the automobiles today have an internal combustion engine as a power source. In this type of engine, a fuel is combusted, or burned. The burning creates gasses that are used to turn parts of the engine that power the wheels.

When used as a fuel additive for cars, ethanol is mixed with unleaded gasoline to create a 10 percent ethanol/90 percent gasoline mixture. The addition of ethanol increases the octane, or amount of combustible fuel, in the gasoline, which improves combustion in the engine. Ethanol contains oxygen molecules that promote combustion and results in a cleaner-burning gasoline. This helps lower the emission levels of cars that burn ethanol blended fuels.

Ethanol is also used in higher concentrations in some large fleets of vehicles, like cars used by state governments. The state of Ohio uses cars that run on ethanol as part of a test program. Many of these specially equipped vehicles run on a blend of 85 percent ethanol and 15 percent gasoline. In situations where the blended gasoline is not available, these engines can run on regular unleaded gasoline. Availability is a major issue with ethanol, as it is with many biofuels. Most gas stations do not have an 85 percent ethanol pump, and since not many cars use them, not many gas stations are willing to install them. Since availability of the fuel is low, most automakers only produce these specially equipped vehicles in limited quantities for large fleets.

Other uses

- In the 1800s, ethanol was used as a fuel for lamps and had yearly sales of nearly 25 million gallons in the United States.
- Currently, Brazil uses ethanol produced from sugar cane. Brazilians use about 4 billion gallons of ethanol a year in their cars.
- In France, ethanol is made from grapes that are not good enough to use in making wine.

Ethanol is a source of fuel that is clean, powerful, and readily available in many parts of the world. However, many of the devices used today are not designed to use pure ethanol, so while it can help stretch the gasoline used today, it will not be able to replace it as a fuel source in the near future.

Discussion Question

1. What are some other food sources that might be able to be used as a fuel?

Landfill Gas Recovery

The average American produces 3 pounds of trash each day. It is hauled away from the street and taken to a landfill where it is dumped and left to decompose. Most **organic materials**, or materials created from living organisms, will biodegrade naturally if given proper amounts of air, moisture, and light. In a landfill, however, this usually does not happen. Piles of trash are dumped on top of one another until the mounds reach several stories high and take up acres of ground. This means that the decomposition process is slowed significantly, but it also means that the gasses produced during decomposition are trapped in the mounds of trash.

These gasses, comprised mostly of methane and carbon dioxide, are extremely flammable. In some old landfills, explosions occurred when the gasses were not vented properly. New regulations concerning landfills require the venting of these gasses into the atmosphere. Often, they are burned off as well, so the amount of explosive gas put into the air is minimized.

Some industrious people thought this gas might be something they could use to create electricity. Much like a power plant that runs on natural gas, methane is piped from landfills into power plants, burned, and used to heat water. The steam from the water is used to turn a turbine and generate electricity. Often, the methane coming from the landfill will not produce enough heat to create the necessary amount of steam, so it is combined with natural gas. This mixture creates the heat necessary for the steam and reduces the amount of natural gas that would be needed by a traditional natural gas power plant. Rather than simply burning the gas off to prevent it from being released into the atmosphere, these power plants use it to create something useful.

Currently, Ohio has five power plants that use landfill gas as a fuel for their electricity generation. The largest plant, located at the Carbon Limestone Landfill in Lowellville, has a capacity of 14.9 megawatts (MW). It uses landfill gas created from more than 18 million tons of garbage to produce electricity. The plant is capable of producing enough electricity to power 12,000 households per year from trash those same households throw away.

Fun Fact

Landfills in Ohio produce 36.3 MW of electricity from landfill gas.

While landfill gas is not technically a renewable source of energy (it cannot be regrown), there will certainly be a supply of the gas as long as there is trash. Machines called **digesters** can help to speed up the production of the methane used in these power plants. This helps make sure that the power plants have enough methane to produce electricity. While using the methane in the power plant does not eliminate CO_2 and other pollutants from being released into the atmosphere, studies show that the harmful emissions from landfill-gas power plants contain lower levels of pollutants than if the methane were released into the atmosphere.

Discussion Question

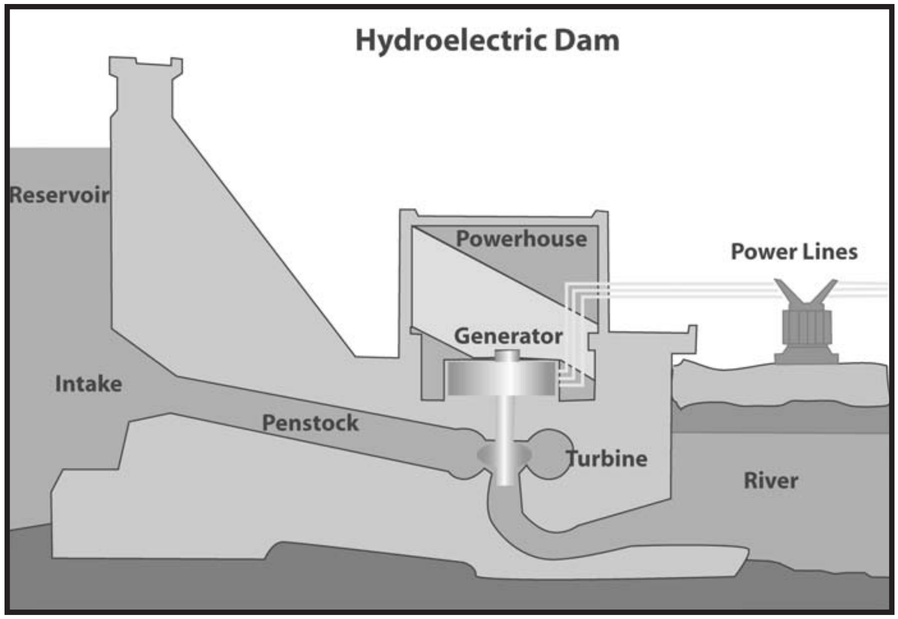
1. What happens to the things put in the trash? Where do they go? Can that trash be turned into a source of energy to produce electricity?

Hydropower

Water is one of the most abundant resources on the Earth. There are many uses for water, and one of them is the generation of electricity. Many of the first sawmills in the United States used waterwheels to power saw blades. Large wheels were connected to cranks, and as the water pushed the wheel, a shaft would turn and move the cranks. These cranks could be connected to saw blades or milling equipment. The saw blades could then be used to cut lumber, or the milling equipment could grind grains. The same concept, known as hydropower, is used today to produce electricity.

Hydroelectric plants produce power using water pressure to spin a turbine attached to a generator. The water on one side of a hydroelectric plant is held back by a dam into a reservoir. An opening near the bottom of the dam, called an intake, allows water to flow into a tunnel called a penstock. The penstock is usually smaller in diameter than the intake, so the pressure of the water is increased. This water then passes through the turbine blades. The turbine rotates a shaft attached to a generator, which creates the electricity.

Hydropower is the most widely used renewable energy source in the U.S. In 2000, hydropower was used to generate six percent of the energy used in the United States. The most famous example of a hydroelectric plant is Hoover Dam. The electricity generated there is used to power all of Las Vegas, Nevada. Anyone who has seen photographs of Las Vegas knows that it has a lot of lights.



There are two utility-scale hydroelectric facilities that provide electric to Ohio consumers. A plant in Belleville, West Virginia uses water from the Ohio River to produce 42 MW of electricity, and can provide electricity to about 35,000 homes with very little emissions. Another hydroelectric facility in Stockport, Ohio uses the Muskingum River to produce 800,000 kilowatt hours of electricity per year. The Stockport hydroelectric facility is known as a "run of the river" electric generator. This means that there is no dam needed to hold back water and feed it into the turbines. The natural flow of the river does all the work.

Hydroelectric plants do not produce greenhouse gasses like traditional power plants, but there are some environmental impacts associated with hydroelectric plants. When a new dam is constructed, there is usually some flooding of the upstream part of the river.

There are a few hydroelectric plants that do not operate in conjunction with a dam. These plants use the natural flow of the river to produce electricity. Even with the flooding issues, hydroelectric power is still the most widely used alternative energy source in the United States. Greater concern for environmental problems has led to design features that aim to minimize the environmental impact of the dam.

Fuel Cells

Another way to produce electricity is through the use of fuel cells. Much like solar cells, fuel cells use a chemical reaction to generate an electrical current. A fuel cell works like a battery, but it can be recharged while it is being used. In a normal battery, a chemical reaction between a metal and a liquid (usually an acid) creates the current used as a power source.

In the earliest batteries, the metal used was lead, and the chemical used was an acid, usually hydrochloric acid. These are known as wet cell batteries, because they use a liquid. As the chemical reaction takes place, the metal is eaten away by the acid, the current flows through the lead and powers the object attached to the battery. Wet cell batteries are most commonly used in automobiles because they can produce a lot of power and are easily recharged.

Just as current flowing out of the battery eats away at the metal in the battery, current flowing into the battery can "recreate" the metal. Automobiles have alternators that are used to charge batteries this way. The first fuel cells used in electric cars worked in the same manner. Batteries in the cars used metals that would be eaten away, and the only way to recharge the battery was to have electricity flow back through it. These cars had to be plugged into an outlet to be recharged. The recharging process was slow, the electricity used to charge the car was added to the electric bill of the customer, and the range (how far the car could travel on a single charge) was limited.

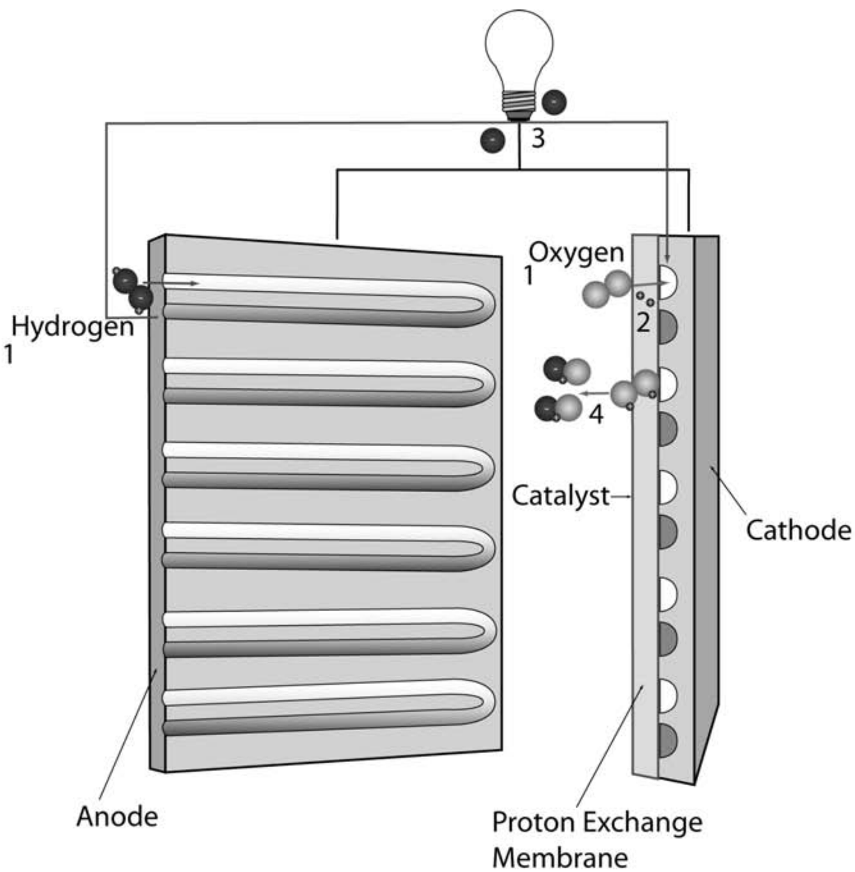
In an attempt to solve the problems of range and the need for faster recharging, engineers began working on ways power the fuel cells without the need for electricity. One promising technology is the hydrogen fuel cell. This type of fuel cell uses hydrogen and oxygen to produce a current.

One side of a hydrogen fuel cell produces the electrons necessary for the current. This is called the anode. The other side produces the positive current. This is called the cathode. Hydrogen is forced through the anode side of the cell. As it passes over the membrane between the two sides, the hydrogen is split into two hydrogen ions and two electrons.

The membrane in these fuel cells is coated with platinum. The platinum produces a positive charge that is used to split the hydrogen atoms. The cathode side of the cell has oxygen flowing through grooves in it. The oxygen produces electrons that feed the platinum membrane. The two gasses, hydrogen and oxygen, combine after passing through the cell to produce two water molecules.

This type of reaction typically produces 0.7 volts of electricity. This is not enough current to run most objects, so the fuel cells are arranged in fuel-cell stacks. In the stacks, the cells are linked together, and their combined voltage is enough to run cars, busses, and most household objects.

In theory, hydrogen fuel cells are a great alternative to fossil fuels. However, problems do exist. For example, there are no hydrogen pipelines running to homes, and there are no hydrogen refueling stations for automobiles. In addition, since hydrogen is a gas, a very small amount of hydrogen can take up a lot of space. In order to effectively store hydrogen gas, the hydrogen would have to be cooled to reduce its volume. It would take a lot of energy to keep the hydrogen as cold as it would need to be, so much of the energy produced by the fuel cells would need to be used to cool the fuel source.



Fuel Cell Basics

1. Hydrogen is forced into the anode side of the fuel cell while oxygen is forced into the cathode side.

2. The catalyst causes the hydrogen atom to seperate into positive and negative parts. The positive part passes through the proton exchange membrane and joins the oxygen atoms on the cathode side.

3. The electrons give the anode a negative charge. The protons on the cathode side give the cathode a positive charge. The electrons flow through wires attached to both side and cause a direct current, which can power objects like a light bulb.

4. The electrons flow to the cathode side through the wires, combine with the oxygen atoms and the protons from the hydrogen, and form water molecules. Water is the exhaust from a hydrogen fuel cell.

An alternative to the use of pure hydrogen in fuel cells is to use another source of fuel capable of producing hydrogen. Fuels like gasoline, natural gas, and methanol have the properties necessary for producing hydrogen. Of these alternatives, methanol is being explored as a renewable source of fuel for fuel cells. The drawback to this is that while the efficiency of a fuel cell running on pure hydrogen is about 70 percent, the efficiency of a fuel cell running on methanol drops to about 25 percent, which is the same as a car that uses a regular engine and gasoline. Unlike hydrogen fuel cells which only produce water as exhaust, methanol produces other exhaust such as carbon dioxide. While pure fuel cells seem to be problematic for powering a car, alternative hydrogen sources and improving design add to the promise of fuel cell power.

Fuel cells not only have the potential to power cars, they can also be used to generate electricity. Molten carbonate fuel cells use a different form of gas to initiate the reaction that produces electricity. The main problem with these fuel cells is their size and the heat they generate. Molten carbonate fuel cells are large, and capable of producing enough electricity to power 50-60 average homes. However, they operate at more than 1,100 degrees Fahrenheit. This makes them impractical for most applications, and the efficiency of the cell is decreased due to the heat generated by the reaction. Any energy that is not being used to create electricity, in this case, is considered wasted energy.

In an attempt to increase the efficiency of molten carbonate fuel cells, some researchers have used the heat they emit to create steam, which is then used to power a generator. While this is not a perfectly efficient method, it does prevent a total loss to the heat. These fuel cells do require fossil fuels to create the hydrogen they use, however they use the fuels more efficiently than conventional power plants.

Like many of the other alternative energy sources described in this section, the big hurdles for fuel cells to overcome are cost and availability of fuel. Most fuel cells produced are handmade, which increases cost, and separating hydrogen from water or other fuels, through a process known as reforming, uses a lot of energy. Storing the hydrogen once it has been separated is also a problem. However, as technology advances and fuel cells become more efficient, the cost will likely decrease. Many people believe fuel cells are the energy source for the future. Only time will tell.

Summary

All of the alternative energy sources described in this section produce the same type of electricity that power plants using coal or natural gas produce. A person sitting in their home cannot tell the difference between electricity generated by a hydroelectric plant, or a plant that burns coal, or one that uses landfill gas. The biggest difference comes in the form of environmental impact and cost.

Most fossil fuels produce electricity at a cheaper cost per kilowatt hour, but they also release chemicals into the air. Alternative sources of energy like solar cells or wind turbines are expensive to set up and maintain, but it has been argued that their environmental impact is less than that of power plants that burn fossil fuels. Still, fossil fuels remain the main fuel source for electricity generation in Ohio.

Alternative energy sources can be used to reduce the amount of fossil fuels used to generate electricity. In the near future, they will probably not replace fossil fuels. The only way to reduce the amount of fossil fuels needed to generate the electricity used every day is through conservation efforts. Reducing the amount of electricity used is the only sure way to reduce the effects both renewable and nonrenewable resources have on the environment.

Discussion Questions

1. What types of alternative energy sources are available? How might these energy sources help Ohio?
2. What are some possible negative results of using alternative energy resources?

Key Terms (defined in glossary)

renewable energy resources

biomass

wind power

hydroelectric

solar energy

geothermal power

solar cells

passive solar energy

photovoltaic cells (PV)

silicon

atomic structure

silicate

terminals

solar collectors, or solar troughs

kinetic energy

mechanical energy

wind turbines

cut-in speed

ethanol

biofuel

organic materials

digesters

Activity 1: Exploring Solar Energy

Overview

See how simple technologies can be used to increase the energy of renewable resources.

Objective

1. Witness the effects of concentrating light onto a small area.
2. See how the amount of sunlight on a surface effects the amount of energy available on that surface.

Materials

- 3 Thermometers (per experiment group)
- 150 Watt light or sunlamp on a stand
- Convex magnifying lens

Procedure

1. Place the three thermometers in a circle (spread out from one another) so that one is in a shadow (from a book or even your hand) and one is in the normal lighted area. For the third thermometer, use the magnifying lens to concentrate the light on to the thermometer.
2. Record the temperature readings of each thermometer before you begin. Turn on the light and then read the temperatures every minute for five minutes.
3. Once the results have been recorded, turn the lamp off and have the students graph the results.

Questions

1. Why did the thermometer with the lens above it got warmer faster?
2. What else could the light focused by the magnifying glass for be used for? Would this work with something in the shade?
3. What would happen if we focused the light into a smaller point?

Adapted from an experiment developed by www.schoolresult.com/experiments/science_experiments28.htm.

Activity 2: A Resource Debate

Overview

Research and debate the pros and cons of using different resources to produce electricity.

Objectives

1. Use a variety of resources (Internet, books, etc.) to research an energy source used to generate electricity.
2. Make a presentation to the class about your energy source and participate in a debate to examine the pros and cons.

Procedure

1. Divide into five groups. Each group researches a different resource, including coal, natural gas, nuclear energy, hydropower, and biomass/alternative energy resources.
2. Each group conducts research on their resource using a variety of materials. The Internet, textbooks, newspapers, and magazines are useful reference materials. Look for information such as the amount required for electricity production, whether or not the energy source is renewable or nonrenewable, the environmental effects of using the resource for electricity generation, and economic or cost factors associated with the resource.
3. Each group prepares a presentation on their energy resource to give to the class. A visual aid, such as a power-point presentation or posterboard, can be included in the presentations.
4. Set aside time for each group to present their research on the energy source.
5. After all the groups have presented, conduct a class discussion or debate about the pros and cons of each resource.

Current Events: Renewable Energy in Ohio

Read the following news articles about renewable energy in Ohio, and then discuss the pros and cons of each side of the issue.

Ice here is now being made from sunlight. Say what?

By: Tom Henry
Toldeo Blade September 11, 2004

Bowling Green State University's 37-year-old ice arena now is partially powered by solar energy. A bank of 572 solar panels on the building's roof became operational at noon yesterday.

In a nutshell, here's how the $238,000 project works: Sunlight collected by the solar panels causes a chemical reaction that creates direct-current electricity, the kind found in ordinary batteries.

That electricity is sent to an inverter, a device that converts DC power into alternating-current electricity, or AC power. That's the kind people use when they plug appliances into the walls of their homes and businesses.

Here's how the ice is made from sunlight: Three compressors, each 100 horsepower, provide the coolant to keep the skating surface from melting. They're by far the biggest draw on the building's electricity. So by partially powering the arena with solar energy, the university is essentially making some of the arena's ice from sunlight.

Daryl Stockburger, Bowling Green utilities director, said the arena's rooftop has enough solar panels to generate 30 kilowatts of electricity, with plans to install enough for the system to put out 300 kilowatts. "We'll be adding panels. My expectation is annually," he said.

The panels were manufactured by First Solar LLC, of Perrysburg Township.

It was not immediately known what percentage of the ice arena's power needs were being met yesterday by solar energy because BGSU buildings aren't metered individually. The campus is metered as a whole, Mr. Stockburger said.

He and others, though, conceded the initial output is a fraction of the building's needs. Even 300 kilowatts probably won't supply all the power for one of the compressors, they said.

But they're enthusiastic by the project because it is another step in Bowling Green's commitment to having a portion of its energy needs met by nonpolluting, renewable sources.

The city also gets a portion of its electricity from the AMP-Ohio/Green Mountain Energy Wind Farm, west of Bowling Green.

"Every kilowatt hour here is [power] they don't have to buy from a utility," said R. Scott Sullivan, business development manager for Ballard Power Systems.

The company, in Fairfield, Calif., contributed $60,000 to the project by donating the AC/DC inverter and engineering services, he said.

"We want to see more universities use [solar] as a research tool," Mr. Sullivan said.

Other assistance came from a $35,000 Ohio Department of Development energy efficiency grant.

The city's general tax dollars weren't used because Bowling Green has a separate stream of revenue for such projects, in part because of agreements with AMP-Ohio.

Three percent of the city's customers contribute up to 10 percent of their monthly bills to support non-polluting sources of energy, Mr. Stockburger said.

Photovoltaic panels were installed on the arena roof by Advanced Distributed Generation of Maumee, one of the state's few contractors licensed to do such work. The company will install a smaller system at the University of Toledo, spokesman John Witte said.

Alvin Compaan, UT physics professor, said UT still is deciding which building to supplement with solar power.

That project, to consist of a 12-kilowatt array of panels, likely will occur in the spring at a cost of $100,000.

Half is being paid by an Ohio Department of Development grant, he said.

A National Science Foundation grant awarded to UT will be used next year to have small, 1-kilowatt solar demonstration project installed at UT, COSI, and the Toledo Zoo, he said.

In a breeze, wind power meets electricity-output goal

By: Tom Henry
Toledo Blade September 15, 2004

They have been two of the biggest conversation pieces along rural U.S. 6 for 10 months now, a rotating pair of renewable-energy symbols that stand above a bean field that Wood County leases out to farmers.

But the American Municipal Power-Ohio/Green Mountain Energy Wind Farm southwest of Bowling Green has moved beyond symbolism since going online in November, having met its first-year goal for electrical output at the end of July - four months ahead of schedule.

Oh, sure, they're still a peculiar, spinning sight to many northwest Ohioans, even though wind power is the fastest-growing segment of the U.S. energy industry, and the latest generation of turbines is quickly rising from the nation's landscapes.

Daryl Stockburger, Bowling Green utilities director, notes how the two southwest of Bowling Green are adjacent to the Wood County landfill. "We've had people ask us if they were put there to blow air off the landfill," he mused.

By the end of this month, the two-turbine facility is to have four turbines in operation, each producing 1.8 megawatts.

Those four are expected to generate enough electricity to power a village of 1,560 homes, twice the current average of 780. The $4 million price tag to install them will be about $400,000 less than the $4.4 million cost to put up the first pair, because there won't be a need for another power line and all the infrastructure that was installed when the project started, said Mr. Stockburger, who represents Bowling Green on the AMP-Ohio board.

He also is chairman of a joint venture at the wind farm for the Ohio Municipal Electric Generating Agency, a consortium that includes

Bowling Green and several other Ohio communities, including Edgerton, Montpelier, Elmore, Pioneer, Napoleon, Cuyahoga Falls, Wadsworth, and Monroeville.

There isn't enough land to put up more than four turbines at the site. But officials are starting to look for other locations for the next step in the expansion process, he said.

The only known casualties so far: seven bats.

Commercial wind farms have been a paradox to many environmental groups. On the one hand, they're nonpolluting. But on the other, they can kill raptors such as hawks and eagles as they swoop down to capture prey.

Several campaigns have been targeted at getting federal officials to assess potential wildlife impacts on mountain ridges. One last year for the Appalachian mountain ridges included more than 25 national and regional conservation groups. Among them were the Defenders of Wildlife, National Audubon Society, Humane Society of the United States, and the Endangered Species Coalition.

Bowling Green obviously isn't on a mountain ridge. But in an interview with The Blade yesterday, one of the nation's leading bat conservationists said a number of bats end up being killed in areas that are seemingly remote and far removed from densely-forested areas where bats would be expected to congregate.

"Some bats are killed at virtually every turbine site in the country. We don't know of any where no bats are killed," said Merlin D. Tuttle, founder and president of Bat Conservation International of Austin, Tex.

"We've got a lot to learn about bats. We're finding kills even in the most remote turbines out in the middle of prairies, where bats don't feed," he said.

His group and others support wind power but want officials to adopt stronger siting requirements to protect wildlife.

"I am just very disturbed that we're building and then seeing what happens later," Mr. Tuttle said.

No evidence of bird carcasses have been found at the Bowling Green wind farm. Mr. Stockburger said that could be because the tips of the blades - even as impressive as they are when they rise to their maximum height of 390 feet - are still low enough to avoid most birds. But he didn't rule out the possibility that some birds might have been killed and picked up by predators in the bean field before anyone found evidence.

Mr. Tuttle said the same thing can happen with bats. Kill rates range from two bats per turbine a year on the low end, usually in prairie and farm settings, to 100 bats per turbine a year in mountains. He said he could give no immediate assessment of Bowling Green's program until he learned more about it.

Small Wind Turbine Keeps Ohio Local Business Afloat

Credit: Green Energy Ohio

Victory Farm, Ohio - Robert Howard, CEO of a chemical processing business, is also a creative entrepreneur who put wind power to work for his sideline businesses.

The Jacobs wind turbine he put up in 1993 on a 135-foot tower provides electricity for his state-of-the-art shrimp farm. "The small wind turbine powers the whole site, which includes a 10,000 square-foot barn. We were located at the end of the power grid and our power was down a lot," says Howard.

The winds in central Ohio pick up in September and blow through May, a period when electricity demand is high at the shrimp farm. The wind turbine, originally a stand-alone unit now connected to the grid, is the perfect solution.

Howard began studying wind power while in China in the 1980's. "I kept reading about advances in renewable energy. I realized I had to get into the field. This was my dream. And once I got married, my wife told me to go play while I still could."

His wind turbine went up without a hitch. But six months later, a resident upset about his turbine sued the township. When Howard found out the individual lived two miles away, he let the naysayer know in no uncertain terms that he thought the suit ridiculous. It was soon dropped.

During the first year of operation a hunter shot holes in the blades. Howard was not deterred. Relying upon his original tower, he boosted the turbine's generating capacity from 12 to 18 kilowatts while retrofitting it. His insurance covered the cost of replacing the parts. He then refurbished the 12 kW turbine and donated it to Glacier Ridge Metro Park, where it now powers a restroom and information center.

Howard eventually sold his shrimp farm, but he still uses the 18 kW wind turbine, as well as a solar photovoltaic array and an 18kW fuel cell, to power his own home and Victory Farm, which produces perch, shiitake mushrooms and eggs. Howard's neighborhood has evolved from a rural area to one of the most upscale communities in central Ohio. "The fellow who owns the local Limited is my neighbor. He thinks the small wind turbine is totally cool," reports Howard.

Howard©s claim to fame among local energy activists is that he was the first small wind turbine owner in American Electric Power's Ohio service territory to take advantage of net metering. It took a couple of lawsuits, but he now receives a credit of 10 cents per kilowatt-hour for the wind-generated electricity he puts on the grid.

Howard is so enamored with renewable energy that he donated a 400 Watt Southwest Windpower turbine to the Columbus Academy, a K-12 prep school his daughter attends. The turbine is just one of several renewable energy technologies that power the school's science department.

"My interest in wind power was driven by my heart," he concludes. "I wanted to do the right thing. Now, when my kids flip the switch, they know where their power comes from. It's homegrown!"

http://www.awea.org/smallwind/success_stories/success_stories_028.html

Questions

Name ____ Date _______________

Circle the correct answer. There may be more than one.

Multiple Choice

1. What was the biomass energy source used by settlers moving west in the late 1800s?
    a. Grass
    b. Manure
    c. Bones
    d. Natural gas
2. Which of the following materials are used to make photovoltaic cells? (May be more than one answer circled)
    a. Glass
    b. Silicon
    c. Gellinium
    d. Photoplasma
    e. Copper
3. What is the source of power at a hydroelectric plant?
    a. Landfill gas
    b. Wind
    c. Water
    d. Steam
4. What alternative energy source creates the most electricity used in Ohio?
    a. Coal
    b. Water (Hydroelectric)
    c. Solar Energy
    d. Wind Power
5. What plant(s) is most ethanol made from in the United States?
    a. Tomatoes
    b. Corn
    c. Spinach
    d. Apples

6. Most fuel cells run on which gas:
   a. Argon
   b. Hydrogen
   c. Helium
   d. Oline
7. How many utility-scale windmills are there in Ohio?
   a. 6
   b. 45
   c. 108
   d. 4
8. How much electricity does the average home use in a month?
   a. 866 kWh
   b. 790 mWh
   c. 866 mWh
   d. 1,000 kWh
9. What are the three main parts of a fuel cell
   a. Anode, cathode, and catalyst
   b. Hydrogen, oxygen, and water
   c. Positive, negative, and neutral
   d. Metal, liquid, and gas
10. Which energy source might power automobiles in the future?
    a. Solar
    b. Wind
    c. Fuel Cells (hydrogen)
    d. Hydroelectric

Short Answer

Answer the following questions with a few short sentences.

1. Name three benefits of using alternative energy sources. Name three drawbacks.

2. What are some (3) reasons that alternative fuels are not used more than they currently are?

Answers

Multiple Choice

1. What was the biomass energy source used by settlers moving west in the late 1800s?
   a. Grass
   b. Manure
   c. Bones
   d. Natural gas
2. Which of the following materials are used to make photovoltaic cells? (May be more than one answer circled)
   a. Glass
   b. Silicon
   c. Gellinium
   d. Photoplasma
   e. Copper
3. What is the source of power at a hydroelectric plant?
   a. Landfill gas
   b. Wind
   c. Water
   d. Steam
4. What alternative energy source creates the most electricity used in Ohio?
   a. Coal
   b. Water (Hydroelectric)
   c. Solar Energy
   d. Wind Power
5. What plant(s) is most ethanol made from in the United States?
   a. Tomatoes
   b. Corn
   c. Spinach
   d. Apples
6. Most fuel cells run on which gas:
   a. Argon
   b. Hydrogen
   c. Helium
   d. Oline

7. How many utility-scale windmills are there in Ohio?
    a. 6
    b. 45
    c. 108
    d. 4
8. How much electricity does the average home use in a month?
    a. 866 kWh
    b. 790 mWh
    c. 866 mWh
    d. 1,000 kWh
9. What are the three main parts of a fuel cell
    a. Anode, cathode, and catalyst
    b. Hydrogen, oxygen, and water
    c. Positive, negative, and neutral
    d. Metal, liquid, and gas
10. Which energy source might power automobiles in the future?
    a. Solar
    b. Wind
    c. Fuel Cells (hydrogen)
    d. Hydroelectric

Short Answer

1. Name three benefits of using alternative energy sources. Name three drawbacks.

Less pollution, energy independence, lower energy costs (in the long run), they are cleaner, use waste materials as fuel (land fill gas, biomass), allow people in remote areas to have access to electricity

Expensive to start, availability problems with solar and wind energy, environmental concerns with hydroelectric dams, not yet operating at peak efficiency

2. What are some (3) reasons that alternative fuels are not used more than they currently are?

They are expensive to install (solar system for one home can cost $30,000)

They are not always available. If the sun isn't shining solar systems won't work, if the wind doesn't blow, wind turbines won't work.

Some people don't trust the technology - there is some skepticism about alternative energy

It's hard for a single homeowner to install a stand alone system

Additional Resources

Information from the following organizations was used in the creation of this section. For more information about electricity generation and energy sources, please visit these Web sites:

Alternative and Renewable Energy Information

http://www.eia.doe.gov/kids/

www.eere.org

Clean Energy Program Information

http://www.eere.energy.gov/cleancities/afdc/tools/curr_68.html

Solar Power Information

http://www.solarelectricpower.org/

http://science.howstuffworks.com/solar-cell.htm

Wind Power Information

http://www.awea.org

Fuel Cells

http://science.howstuffworks.com/fuel-cell.htm

Energy Conservation and Safety: Making Smart Decisions

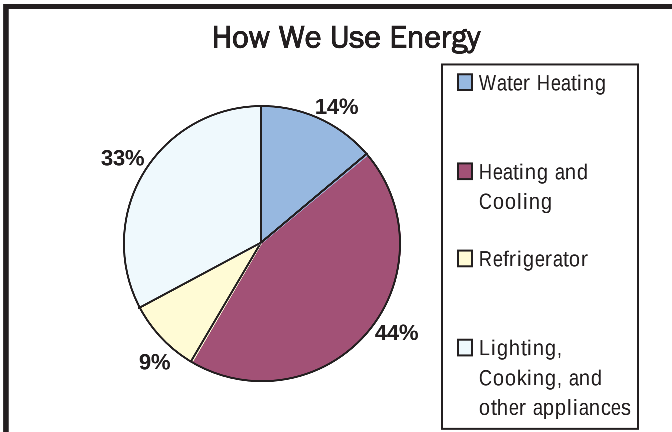
Objectives

- Know how to conserve energy in your home
- Understand why energy conservation is important
- Learn the importance of using energy safely

Overview: Energy Conservation

Energy conservation is any action that results in using less energy. **Energy efficiency** is the use of special technology, equipment, and material that requires less energy to perform the same function. Energy efficiency improvements and conservation tips are easy ways for Americans to save energy and money in their homes and communities. Conserving energy saves consumers money today while also helping to ensure abundant energy supplies for the future.

Did you know that the typical U.S. family spends close to $1,300 a year on utility bills? We use energy everyday for transportation, heating, cooling, cooking, lighting, and entertainment. Nearly $1 million dollars worth of energy is used everyday in the U.S. Unfortunately, a large portion of that energy is wasted. Electricity generated by **fossil fuels** for a single home puts more **carbon dioxide** into the air than two average cars. By using a few inexpensive energy-efficiency measures, energy bills can be reduced by 10 to 50 percent, and at the same time, help reduce **air pollution**, and extend our energy resources.



This chart provided by the U.S. Department of Energy, shows how Americans use energy in their homes based on the national average.

Conservation Tips

You can help manage energy use at home by working with your parents to follow the energy tips below. If everyone works together to conserve, our energy resources will extend well into the future.

Tips for Energy Conservation

1. Turn off the lights when a room is not in use.
2. Keep the refrigerator door closed as much as possible.
3. Wash clothes with the washer at full capacity.
4. Operate the dishwasher with a full load and use the energy-saving cycle whenever possible.
5. Take shorter showers.
6. Walk or ride your bike whenever possible instead of riding in a car.
7. Use a blanket instead of turning on the heat.
8. Open the windows instead of turning on the air conditioner.
9. Set the thermostat to 68 degrees or lower when you are not at home.
10. Check the furnace filter monthly and change it when necessary.
11. Keep all heat registers and air ducts clear from obstructions.
12. When brushing your teeth, turn the water off until you need to rinse.
13. Turn off the television, radio, computer and other electronic devices when they are not in use.
14. Use cold water instead of hot water whenever possible.
15. Add insulation in the attic and basement.

Discussion Questions

1. How can you conserve energy at home, school, and in the community?
2. Why is energy conservation important?
3. Describe the activities you participate in that are dependent on electricity and natural gas?

Overview: Natural Gas Safety

While natural gas is a very useful fuel, it can be dangerous if handled incorrectly. Natural gas is explosive, especially when it builds up in large quantities from a gas line leak. For safety reasons, a rotten egg odor is added to natural gas, so that leaks can be detected by the smell before an explosion occurs. If you smell natural gas in your house, call the local gas company immediately.

Another danger associated with the use of natural gas is **carbon monoxide** poisoning. Carbon monoxide is a colorless and odorless gas produced when people burn natural gas or other fuels without enough oxygen. Natural gas furnaces and water heaters with improper venting can lead to a build-up of carbon monoxide in the air. If you breathe carbon monoxide, it enters your bloodstream and makes you feel like you have the flu, but without the fever. In severe cases, carbon monoxide poisoning can be deadly. If you or someone else has these symptoms, get out of the house and call 9-1-1, the fire department, or emergency medical services immediately.

To stay safe around natural gas and avoid the effects of carbon monoxide follow these simple tips:

1. Do not play with natural gas appliances or pipes.
2. If the burners on top of a gas stove have a blue flame, they are working correctly. If the flame is large, yellow, and flickering, ask a parent to have it checked by a repairperson.
3. Keep paper and toys away from the furnace and water heater. Do not store gasoline, paint thinner, or aerosol cans near them either. The vapors could be ignited by the appliance flames.
4. Remind a parent to have the furnace, vents, and chimney inspected. Blockages or cracks can make it hard for heating equipment to work properly and can lead to carbon monoxide buildup.

5. Never run any fuel-burning equipment in an enclosed space.
6. Install a carbon monoxide alarm. Carbon monoxide alarms are similar to smoke detectors.

Overview: Electric Safety

Electricity makes life easier in many ways, and allows people to efficiently use a variety of technologies. However, electricity is a very powerful force, and it can be extremely dangerous and even deadly if it is handled incorrectly. A bolt of lightning has a very strong electric charge, and a person who is struck by lightning can be severely injured. Electric appliances have an electric charge just like a lightning bolt, and can be just as dangerous if people are not careful when using them.

Accidents can be prevented by practicing safety around electric objects. Here are some safety tips to keep in mind when using electricity:

1. Unplug all appliances when they are not in use.
2. Do not play with electric cords.
3. Make sure that electric cords you use are free of any fraying or cracking. If a cord seems to be fraying or coming apart, let a parent or another adult know so they can replace the cord.
4. When unplugging an electric appliance, pull from the plastic plug instead of pulling from the cord.
5. Keep all electric appliances away from sinks, baths, and other areas with water. If an electric object falls into water, never reach in to get it. Find a parent or adult to help.
6. Never use a metal object to dislodge or try to fix an electric appliance.
7. Do not plug too many appliances into one electric outlet.

Outdoor electric safety is especially important, because the overhead power lines that carry electricity to homes, schools, and businesses transport electricity at extremely high voltages. That means that the electricity traveling through the overhead power lines outside is much more powerful and dangerous than the electricity in appliances.

Here are some outdoor electric safety tips to keep in mind:

1. A thunderstorm or severe weather may knock down overhead power lines. If you see an overhead power line on the ground, stay far away and do not touch it or any objects near it. Tell a parent or adult to call the police or fire department for help.
2. Never climb trees that may be growing near overhead power lines.
3. Do not fly kites, balloons, or other flying toys around overhead power lines. If a toy becomes tangled in a power line, do not try to get it out. Have an adult call the local electric company to get it out.
4. Electric transformers are the big metal boxes that may be found in yards. Do not play around these transformer boxes.

Key Terms (defined in glossary)

Conservation	Fossil fuels	Carbon dioxide
Energy Efficiency	Air pollution	Carbon monoxide

Activity 1: Conserving With Cookies

Overview

Participate in two experiments in which you will (1) gain an appreciation for your dependency on electricity and (2) learn how regulating the rate of energy consumption makes the energy source last longer.

Materials

- Pen and paper
- Cookies or crackers (two per student)
- Overhead projector or blackboard

Procedure

1. Discuss the nation's dependence on electricity. More than half of the United States' electricity is generated by coal; far more than any other energy source. Our country's demand for electricity is on the rise as the use of electronic equipment increases.
2. Do you think you could live in your home without electricity for just two hours? What would life be like? For homework, try to survive without using any electricity for two hours. Discuss as a class the items that you will have to avoid using. The list may include the following:

Radio or stereo	Computer	Microwave	Electric Stove
Hairdryer	Dishwasher	Washing machine	Clothes dryer
Lighting	Video gamer	TV/VCR/DVD	Can opener
Toaster	Coffeemaker	Refrigerator	Freezer
Alarm clock	Water heater		

3. Document which hours you spend without using electricity and how you altered your daily routine to avoid using electricity. During the next class period, discuss how it felt to not use electricity for that period of time. Did you realize how dependent you are on electricity? How would it affect people if the nation ran out of the energy resources needed to produce electricity?

4. Fossil fuels, such as coal, oil, and natural gas, are called nonrenewable energy because they are limited in supply. It is important to conserve these natural resources so that they will last longer. You will now participate in a brief and tasty activity to demonstrate the impact that regulating the consumption of a resource has on making it last.

5. Take a cookie or cracker. Your teacher will give you a signal to begin eating. Raise your hand when you are finished eating. Your teacher will count the hands raised every 15 seconds until all the cookies or crackers are eaten. As a class, create a graph indicating how many students finished eating every 15 seconds.

6. Take a second cookie or cracker. This time, you can only take a bite when your teacher says, "Take a bite." Raise your hand when you have finished eating. Your teacher will count the hands raised after every 15 seconds. As a class, create a second graph to indicate the consumption rates. This graph usually shows that the overall cookie resources last longer.

7. Discuss the two graphs. How are they the same? How are they different? Why did the cookies last longer when their consumption was regulated? Can we, or should we, conserve nonrenewable sources of energy, such as coal? Do individuals have a responsibility to conserve energy? Why or why not?

8. Write a paragraph explaining your opinion about conserving energy resources. What measures do you think individuals can (or should) take to conserve energy? What, if any, measures should the government take to regulate energy consumption?

Activity 2: Home Energy Use and Safety Audit

Overview

Conduct a home energy audit can help you find ways that your home could be more energy efficient.

Materials

- Pen and Paper
- Ruler

Procedure

Working with an adult at home, answer the following questions and tally up the points to determine your home's energy efficiency and safety rating. Ignore any sections that do not apply to your home.

1. Attic Insulation: Use a ruler to measure how much insulation you have in the attic area.
   ❒ 6 inches or less (2 pts)
   ❒ 7 to 11 inches (4 pts)
   ❒ 12 inches or more (6 pts)
2. Furnace filters: How often were your furnace filters cleaned or changed in the last year?
   ❒ not at all (2 pts)
   ❒ 1-3 times (4 pts)
   ❒ 4 or more times (6 pts)
3. Lighting: Count the number of fluorescent light bulbs you have in high-use areas such as hallways, living rooms, and kitchens.
   ❒ No fluorescents (2 pts)
   ❒ 1-4 fluorescents (4 pts)
   ❒ 5 or more fluorescents (6 pts)
4. Refrigerator: Close the door over a dollar bill so it is half in and half out of the refrigerator.
   ❒ The dollar is easy to pull out (2 pts)
   ❒ The dollar is hard to pull out (4 pts)
   ❒ The dollar doesn't pull out (6 pts)

5. Thermostat: Is the temperature setting on your thermostat above or below the following levels?

Winter

- ❐ 74 or higher (2 pts)
- ❐ 71 - 73 (4 pts)
- ❐ 70 or lower (6 pts)

Summer

- ❐ 74 or low er (2 pts)
- ❐ 75 - 77 (4 pts)
- ❐ 78 or higher (6 pts)

6. Water Heater: Locate the EnergyGuide label to determine your water heater's energy-efficiency rating. How much energy does it use compared to similar models?

Tip: If you can't locate the EnergyGuide label, ask an adult to touch the water heater tank. If the tank is warm to the touch, it probably uses the maximum amount of energy.

- ❐ Uses the most energy (2 pts)
- ❐ Uses an average amount of energy (4pts)
- ❐ Uses the least energy (6pts)

7. Weather Stripping: Open your front or back door and check the condition of the weather stripping between the door and the door frame.

- ❐ None (2 pts)
- ❐ Worn out (4 pts)
- ❐ Good condition (6 pts)

8. Windows: How many layers of glass do your windows consist of? Is there a special label on the glass? Do you also have storm windows?

- ❐ Single-pane with no storm windows (2 pts)
- ❐ Single-pane with storm windows (4 pts)
- ❐ Double-pane windows (4 pts)
- ❐ Double-pane, either gas-filled or with reflective coating (6 pts)

9. Carbon Monoxide Alarms: How many carbon monoxide alarms are in your home?

- ❐ None (2 pts)
- ❐ At least 1 (4 pts)
- ❐ One on each floor (6 pts)

10. Appliances: Appliances in the house:

- ❒ Stay plugged in at all times (2 pts)
- ❒ Are unplugged sometimes (4 pts)
- ❒ Are always unplugged when not in use (6 pts)

Assessment

Calculate your total score. If your score is:

2-24: Your home needs major improvements. Look for ways to improve areas that scored low on your test. After making these changes, take the test again to see how simple improvements have increased your home's energy efficiency.

26-42: Your home is getting close. Review the quiz and energy conservation and safety tips to see how to make your home more energy efficient. Look for ways to improve areas of the audit that scored low. After making the improvements, conduct another audit to see how simple improvements have increased your home's energy efficiency and safety rating.

44-60: Congratulations! Your home is very energy efficient and safe.

Current Events

Read the following news articles about energy conservation and efficiency, and then discuss the things students can do to conserve energy.

Alliance Seeks Strong Energy-Efficiency Standards in Upcoming Regulations

The SEER 13 air conditioner standard was obtained this year will save consumers $1 Billion annually.

After delays of up to 12 years, the U.S. Department of Energy (DOE) has begun the formal process for issuing energy-efficiency standards for three important residential and commercial appliances and equipment. The Alliance urged DOE to follow through with prompt publication of proposed regulations that will take maximum advantage of energy-efficiency technologies, so that the nation can reap the multiple benefits for our economy, environment, and energy security. "The wasted energy and money and the unnecessary environmental degradation during the years of delay cannot be recouped," said Kateri Callahan, president of the Alliance to Save Energy.

The DOE's actions come just a week after two U.S. senators - Government Affairs Committee Chair Sen. Susan Collins (R-ME) and Ranking Member Sen. Joseph Lieberman (D-CT) - sent a letter to Energy Secretary Spencer Abraham sharply criticizing the department's foot-dragging and quantifying the eventual energy savings from the new standards. After multiple postponements, DOE has begun an 18-month process to publish regulations setting minimum energy-efficiency standards for the three categories of equipment.

Article published at
http://www.ase.org/content/article/detail/1759

Earth Day Network and Starbucks Team to Promote Environmental Awareness - One Coffee Cup at a Time

Washington, DC and Seattle, WA (March 29, 2004) - Earth Day Network (EDN) and Starbucks Coffee Company (Nasdaq: SBUX) are teaming together for the third straight year to promote environmental awareness and encourage citizens to create positive change for the environment.

For the six weeks leading up to Earth Day, April 22, 2004, Starbucks will feature five different environmental messages on their coffee cup sleeves. The messages, developed by EDN and Starbucks, encourage customers to protect the environment by making energy-saving decisions on a daily basis. With more than 5,400 stores throughout the United States, Starbucks offers a broad reach for communicating environmental messages.

"Earth Day Network is proud to once again have Starbucks as a major partner in our campaign to reach out to a broad-based coalition of citizens," said Kathleen Rogers, President of Earth Day Network. "Thanks to their creativity and commitment, we are able to reach millions of people in this country and encourage them to get involved in the issues that impact the environment. Starbucks leadership and commitment to environmental activism is a model for all corporate citizens and consumers, and is an integral part of our success."

Cup sleeve messaging includes the following five tips: (1) factor in fuel efficiency when shopping for a new car; (2) make your environmental voice heard by registering to vote; (3) measure your environmental footprint at earthday.org; (4) equip your home with Energy Star certified products; (5) use an energy efficient showerhead.

"As an environmental leader, Starbucks is proud to support Earth Day Network's efforts to promote environmental stewardship," said Ben Packard, director of Environmental Affairs for Starbucks. "Our goal is to minimize our environmental footprint on the planet and help to ensure a healthy environment for future generations."

The cup sleeve messaging is a component of Starbucks ongoing support of Earth Day Network's "Campaign for Communities," which creates alliances between organizations representing people of color and low income communities. Starbucks is making a financial contribution of $25,000 to Earth Day Network in 2004 to help support the organization©s efforts to engage these communities in environmental education and activism. This contribution marks the third consecutive year of Starbucks financial support of Earth Day Network.

Earth Day Network and Starbucks have also teamed up through the Starbucks Card Duetto® Visa. As part of the Duetto® Card philanthropy program, $5 will be donated to the Earth Day Network after each new cardmember makes their first purchase using the Visa Account of the Duetto® Card from March 1, through May 31, 2004.

About Earth Day Network

Earth Day Network was founded by the organizers of the first Earth Day in 1970, Earth Day Network (EDN) promotes environmental citizenship and year round progressive action worldwide. Our mission is to build broad-based citizen support for sound, workable and effective environmental and sustainable development policies for all. EDN is a driving force steering environmental awareness around the world. EDN's global network reaches over 12,000 organizations in 174 countries. As a result, Earth Day is the most celebrated non-secular holiday in the world with more than a half billion people participating every year.

About Starbucks Coffee Company

Starbucks Coffee Company is the leading retailer, roaster and brand of specialty coffee in the world, with more than 7,500 retail locations in North America, Latin America, Europe, the Middle East and the Pacific Rim. The Company is committed to offering the highest quality coffee and the Starbucks Experience while conducting its business in ways that produce social, environmental and economic benefits for communities in which it does business.

Questions

Name ____ **Date** _______________
Circle the correct answer. There may be more than one correct answer for each question.

Multiple Choice

1. Typically, American households use the most energy on:
   a. Water heating
   b. Heating and cooling
   c. Refrigerator
   d. Lighting, cooking, and other appliances

2. Any action that results in using less energy is called:
   a. Energy performance
   b. Energy wasting
   c. Energy efficiency
   d. Energy conservation

3. A good way to conserve energy is to:
   a. Turn off the lights when you leave a room
   b. Take shorter showers
   c. Ride a bike or walk short distances, instead of asking parents for a ride
   d. All of the above

4. The use of special technology, equipment, and material that requires less energy to perform the same function is called:
   a. Energy performance
   b. Energy wasting
   c. Energy efficiency
   d. Energy conservation

5. Natural gas is:
   a. Dangerous
   b. Explosive
   c. None of the above
   d. Both A&B

Short Answer

Answer the following questions with a few short sentences.

1. How can you save energy this week?

2. How does conserving energy help parents?

3. How does conserving energy help the environment?

4. How do you stay safe around natural gas?

5. How do you stay safe around electricity?

Answers

Multiple Choice

1. Typically, American households use the most energy on:
   a. Water heating
   b. Heating and cooling
   c. Refrigerator
   d. Lighting, cooking, and other appliances

2. Any action that results in using less energy is called:
   a. Energy performance
   b. Energy wasting
   c. Energy efficiency
   d. Energy conservation

3. A good way to conserve energy is to:
   a. Turn off the lights when you leave a room
   b. Take shorter showers
   c. Ride a bike or walk short distances, instead of asking parents for a ride
   d. All of the above

4. The use of special technology, equipment, and material that requires less energy to perform the same function is called:
   a. Energy performance
   b. Energy wasting
   c. Energy efficiency
   d. Energy conservation

5. Natural gas is:
   a. Dangerous
   b. Explosive
   c. None of the above
   d. Both A&B

Short Answer

1. How can you save energy this week?

Take shorter showers. Walk to a friend's house instead of have your parents drive you. Turn off water while brushing your teeth.

2. How does conserving energy help parents?

It can help them save money on their utility bills.

3. How does conserving energy help the environment?

Conserving energy can reduce pollution by reducing the amount of fossil fuels that have to be burned to create energy.

4. How do you stay safe around natural gas?

Do not play with natural gas lines. If you smell natural gas, leave the area and call the gas company and the fire department. Never use an oven to heat a home. Have all natural gas appliances checked by a repair person every year.

5. How do you stay safe around electricity?

Never put anything other than an electric plug into an electric outlet. If something like a kite gets stuck in power lines, have an adult call the power company to get it down.

Additional Information

Information from the following organizations was used in the creation of this section. For more information about electricity generation and energy sources, please visit these Web sites:

http://www.eia.doe.gov/kids

http://www.ase.org/section/_audience/consumers/kids

http://www.eere.energy.gov/kids/help.html

GLOSSARY

Air pollution: Contamination of air by smoke and harmful gases, mainly oxides of carbon, sulfur, and nitrogen.

Alternative fuel: Any fuel for vehicles other than petroleum-based fuels - examples: solar, electric, compressed natural gas, propane, alcohol, and hydrogen.

Anaerobic decay: The process by which heat and pressure deep inside the Earth turns *organic material* into fossil fuels.

Atom: The microscopic particle that makes up all forms of matter, containing *protons*, *neutrons*, and *electrons*.

Atomic structure: The arrangement of the nucleus, protons, and electrons in an atom.

Biofuel: A fuel source which is made from organic materials.

Biomass: A renewable source of energy that has been stored as plant and animal material; producing fuels from living materials or decayed waste materials; examples: manure, wood, compost, ethanol from corn, methane from landfills.

British thermal unit (Btu): A unit of measurement used to measure heat content; the amount of energy required to raise the temperature of 1 pound of water 1 degree Fahrenheit.

Capacity: The total amount of *electricity* a utility company has ready to send to homes, schools, and businesses at any given time.

Carbon dioxide: A colorless, odorless gas that forms when natural gas is *combusted*. It is used in food refrigeration, carbonated beverages, fire extinguishers, and spray cans.

Carbon monoxide: A colorless and odorless gas produced when people burn natural gas or other fuels without enough oxygen.

Coal: A dark brown to black solid *fossil fuel*.

Combustion: The process of burning.

Conductor: A material with low *resistance* that electricity can easily flow through; example: metals.

Current: Flow of electric charge.

Cut-in speed: The wind speed that a *wind turbine* needs to begin producing electricity.

Digester: A machine that turns organic material into natural gas, replacing the need to wait for thousands of years for the gas to form naturally.

Electric charge: Formed by attraction between *protons* and *electrons* in an atom.

Electric current: The flow of charged particles that allows *electricity* to travel over distances.

Electricity: A type of energy that makes technology work, created when an object has an uneven number of *protons* and *electrons*.

Electrochemical reaction: A process caused by the passage of an electric current that involves the transfer of electrons between a solid and the other a liquid.

Electron: A negatively charged particle in an atom that circles the *nucleus*.

Energy: The ability to do work; a term used to describe the amount of electricity supplied over time, measured in kilowatt-hours.

Energy conservation: The preservation and careful management of the environment and of natural resources; any action that results in using less energy.

Energy efficiency: The use of special technology, equipment, and material that requires less energy to perform the same function.

Ethanol: A type of alcohol made by fermenting corn, grain, or other organic substances used in rocket fuel; proposed as a renewable clean-burning additive to gasoline.

Fermentation: The anaerobic conversion of sugar to carbon dioxide and alcohol by yeast.

Fossil fuels: nonrenewable energy sources that come from fossilized plants and animals and cannot be replenished; examples: *coal, oil, natural gas*.

Fuel cell: A new technology that uses electrochemical reactions to generate electricity.

Generator: The device used in power plants to convert mechanical energy to electrical energy.

Geologist: A scientist who studies the Earth.

Geothermal energy: A renewable source of energy from the internal heat in the core of the earth; examples: hot springs, steam, volcanoes.

Hydropower: A renewable source of energy that comes from water and is harnessed to produce electricity.

Insulate: To prevent the passage of heat, electricity, or sound into or out of, especially by surrounding with a nonconducting material.

Insulator: A material with high *resistance* that is hard for *electricity* to travel through; example: plastic.

Kilowatt-hours: The unit that consumers buy *electricity* in from electric companies; measures the amount of electricity used in one hour.

Kinetic energy: Energy in motion.

Matter: The scientific term to describe what makes up all physical objects; includes tiny *atoms* that are made up of *protons*, *neutrons*, and *electrons*.

Mechanical energy: Energy acquired by the objects upon which work is done is known as mechanical energy.

Microorganism: An animal or plant so small that it is invisible to the naked eye.

Molecule: The smallest particle of a substance that retains the properties of the substance and is composed of one or more atoms.

Natural gas: An abundant, clean burning fossil fuel that is found in deposits around the world.

Neutron: The neutral particle inside the *nucleus* of an *atom*.

Nonrenewable energy resource: Energy sources that occur naturally in nature, but in a limited supply that cannot be easily replaced. *Coal*, *natural gas*, and *oil* are examples of nonrenewable resources.

Nucleus: The center of an *atom* that contains protons and neutrons.

Oil: Petroleum; A liquid *fossil fuel* that is processed to produced gasoline, kerosene, and plastic products.

Organic material: Decayed matter from plants and animals.

Passive solar design: A construction technique using structural elements of a building to bring in heat in cold weather and deflect or vent heat in hot weather through the use of materials, coating, eaves, windows, landscape; examples: north, south, east, west orientation, sun/shade, insulation.

Passive solar energy: Using the light energy of the sun without converting it to another form of energy; examples: using a solar water heater to heat water.

Peak demand: The time of day when people use the most *electricity* and electric companies must produce the most *electricity*; usually peak demand is from noon to 6 p.m.

Permeable: Allowing the passage of gas or liquid.

Photovoltaic (PV): The effect of producing electric current using light -- *photo* = light; *voltaic* = producing direct electric current by chemical action.

Photovoltaic (PV) cell: A device that converts solar energy directly into electricity.

Pipeline: A pipe that transports natural gas and oil long distances.

Power grid: A system used by electric companies that are close together to make sure *electricity* is always available for customers; companies link together *transmission lines* and combine electric resources in the event of a power outage.

Power plant: A facility that generates *electricity* using a particular energy source; *fossil fuel*, nuclear, and hydropower plants are the three types of power plants that produce most of the electricity in the United States.

Power pool: Two or more electric systems that are operated on a coordinated basis to supply power in the most economical manner for their combined load requirements and maintenance program.

Primary energy sources: Sources of *energy* found or stored in nature; examples: biomass, coal, oil, natural gas, the sun, wind, water, nuclear power from radioactive substances, thermal power stored in the earth©s core and oceans, and potential energy from the earth©s gravity.

Proton: The positively charged particles inside the *nucleus* of an *atom*.

Reflection: Return of light from a shiny surface at an angle.

Reflector: A shiny device used to alter the path of light; a mirror is a reflector.

Reliability: The ability of an electric company to produce enough *electricity* to meet the needs of customers at all times.

Renewable energy resource: A source of energy that is virtually inexhaustible and is naturally and quickly replenished; examples: solar, wind, hydropower (water), geothermal, and biomass.

Reservoir: An underground rock formation containing natural gas or oil that is confined by less permeable rock or water barriers.

Resistance: The measure of how well *electricity* flows through a substance.

Secondary energy sources: Sources of *energy* produced from *primary energy* sources using technology; examples: production of electricity by burning coal, using photovoltaic cells to harness solar energy, producing alcohol/methane fuel from corn and other crops.

Seismic survey: A scientific tool that uses echoes from a vibration source at the earth's surface to collect information about the rocks beneath.

Silicate: A compound containing silicon.

Silicon: A nonmetallic element; in nature is always combined with another element; when combined with oxygen it forms silica, or common quartz, and in this form, the second most abundant element of the earth's crust.

Solar (electric) cell: Photovoltaic (PV) cell.

Solar collectors, or **Solar troughs**: Devices used to concentrate the energy of the sun.

Solar energy: Energy derived from the sun.

Solar oven: A solar-powered device that is able to cook food.

Step-down transformers: Devices that reduce the *voltage*, or pressure, of *electricity* to a safe level of 120 volts before it enters homes.

Step-up transformers: Devices that increase the *voltage*, or pressure, of *electricity* as it travels through *transmission lines* from the *power plan*t in order to decrease the amount of energy lost as it travels.

Tanker: A large ship with several tanks that is used to transport liquefied natural gas across oceans.

Terminals: The points on a battery from which electrons flow; a position in a circuit or device at which a connection is normally established or broken.

Thermostat: A device, as in a home heating system, a refrigerator, or an air conditioner, that automatically responds to temperature changes and activates switches controlling the equipment.

Transformer: A device that increases or decreases the voltage of electricity as it travels from the power plant through *transmission lines*.

Transmission lines: Large power lines that transport *electricity*.

Turbine: A device with blades attached to a central rod that spins when a force hits the blades; used to produce *electricity*.

Ultraviolet (UV) light: Invisible radiation or light just beyond violet in the visible spectrum.

Voltage: The amount of pressure that pushes the *electric current*; measured in units known as volts.

Watt: A unit of power used to measure *electricity*.

Well: A hole drilled to obtain *natural gas* or *oil*.

Wind energy: A renewable source of energy that uses wind to turn a wind turbine and generate electricity.

Wind turbine: A mechanical device used to transform wind into electricity.

The Public Utilities Commission of Ohio

www.PUCO.ohio.gov