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ABSTRACT

The purpose of this unit is to investigate a simple energy network and to make an analogy with similar mutually supporting networks in the natural and man-made worlds. The lessons in this unit develop the network idea around a simple electrical distribution system that we depend on and also into further consideration of electrical energy itself. The network idea in the later lessons emphasizes the interdependence of the man-made network for producing and distributing electrical energy and the natural ecological network. In the final lesson, the consuming end of the network is examined and some strategies for consuming electrical energy are examined. Students should learn that energy networks such as the electrical circuits are a necessary part of modern life. They are also expected to learn about sources, conversions, and uses of electrical energy. There are six lessons in this fourth- and fifth-grade unit. Complete teacher and student materials are provided. (BB)

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HCP/U3841-0005

Interdisciplinary Student/Teacher Materials in Energy, the Environment, and the Economy

Networks:

How Energy Links People, Goods and Services

Grades 4, 5

February 1978

National Science Teachers Association

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"Networks: How Energy Links People, Goods and Services" is the product of a writing session held at the University of Maryland during Summer 1977. The following teachers were the main contributors to this unit:

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January 1978
John M. Fowler
Project Director

NETWORKS:

How Energy Links People, Goods and Services

Introduction

The purpose of this unit is to investigate a simple energy network and to make an analogy with similar mutually supporting networks in the natural and man-made worlds.

The lessons in this unit develop the network idea around a simple electrical distribution system that we depend on and also into further consideration of electrical energy itself. The network idea in the later lessons emphasizes the interdependence of the man-made network for producing and distributing electrical energy and the natural ecological network. In the final lesson the consuming end of the network is examined and some strategies for consuming electrical energy are examined.

Students should learn that energy networks such as the electrical circuits are a necessary part of modern life. We also expect them to learn about sources, conversions, and uses of electrical energy.

Lesson Title	Target Classes
1. A Working Electrical Circuit	Science
2. Networks Underground	Science, Social Studies
3. How Does Nature Help Us Get Electricity?	Science, Social Studies
4. Here's Energy Changing	Science
5. It's Energy You Pay For	Social Studies
6. How Our Need for Coal Affects the Environment	Social Studies

Lesson 1: A WORKING ELECTRICAL CIRCUIT

Overview

This lesson gives students an opportunity to construct a simple energy network: a working electrical circuit.

Objectives

Students should be able to:

1. Make a circuit with wires, dry cells, and bulbs.
2. Recognize open and closed circuits.
3. Arrange bulbs in series and parallel circuits and distinguish between the two.

Time Allotment

One-three class periods.

Materials

Dry cells (size D)
Bell wire (uninsulated)
Flashlight bulbs
Switches
Christmas tree lights (two sets, series and parallel wired).
Sockets for bulbs

Background Information (Teacher Use Only)

An electrical circuit is an arrangement of components which provides a path around which electrical charges can flow. When this flow takes place, we speak of a closed circuit. When an air gap or some other non-conducting segment prevents the flow, it becomes an open circuit. (A short circuit is a path through which potentially damaging large currents can flow.)

The simplest electrical circuit consists of a source (in the present case, a battery), the conducting wires which link the various components together, and a conversion device, such as a bell, light, heating element, etc.

The idea of a circuit emphasizes that electricity is a flow of electrical charge that must be continuous from source through conversion back to source. Electrons, in simple circuits such as the one we look at first, leave the battery with some kinetic energy, flow through the wires (losing some kinetic energy in heating up the wires), give up most of their kinetic energy in the form of light and heat in the light bulb and finally return, with very little energy lost, to the battery. Energy has been converted but the same number of electrons that leave the battery re-enter it each second.

Electrical devices (bulbs, dry cells) may be connected in two basic connections: series or parallel. In a series connection, each bulb must be working in order for the others to work. In a parallel connection, the electricity is divided and flows through each bulb. Each bulb, therefore, is part of a separate circuit, independent of the other bulbs.

Teaching Strategies.

Open the lesson by asking the class to list as many ways as possible in which they use electricity. *(Accept all suggestions. Students will probably mention flicking on a light, playing a radio or TV, record player, etc.)* Write the list on the board.

Ask students to describe where the electricity comes from and how it gets to each of these examples. *(Accept all answers, for example, plug in the wall, from a battery, etc., but make sure they recognize that conducting paths such as wires are involved.)*

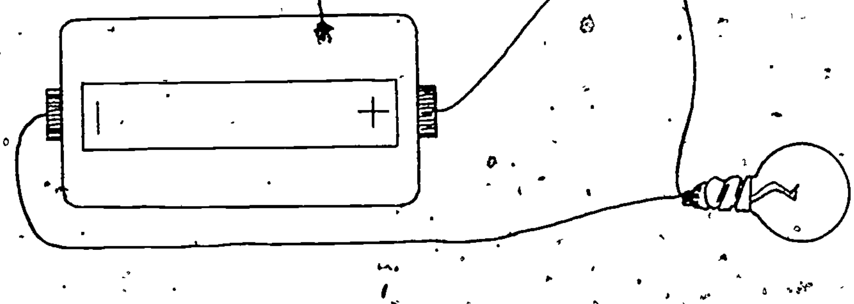
Developing the Lesson

Distribute the materials for making a model of an electrical system:

Student Activity 1

Flashlight bulb
Wire (uninsulated, or at least bare at both ends)
Flashlight battery or dry cell

Wind one end of bare wire tightly around the threaded part of the flashlight bulb. Tape the other end to the metal contact at the bottom of the bulb. Then give students the wired bulb and battery and ask them to make the bulb light up.



They should recognize that both wires have to be connected separately to the top and bottom terminals of the battery. Discuss the concept of a circuit, tracing the path of the electrical current out of the battery, through the bulb and back into the battery. (If you have a burned out bulb available, you might give it to a student to see if he/she can discover that the filament inside the bulb is broken, making the path through the bulb incomplete. Note: Be sure to use a bulb in which the broken filament is visible.)

Let the students experiment with the electrical systems:

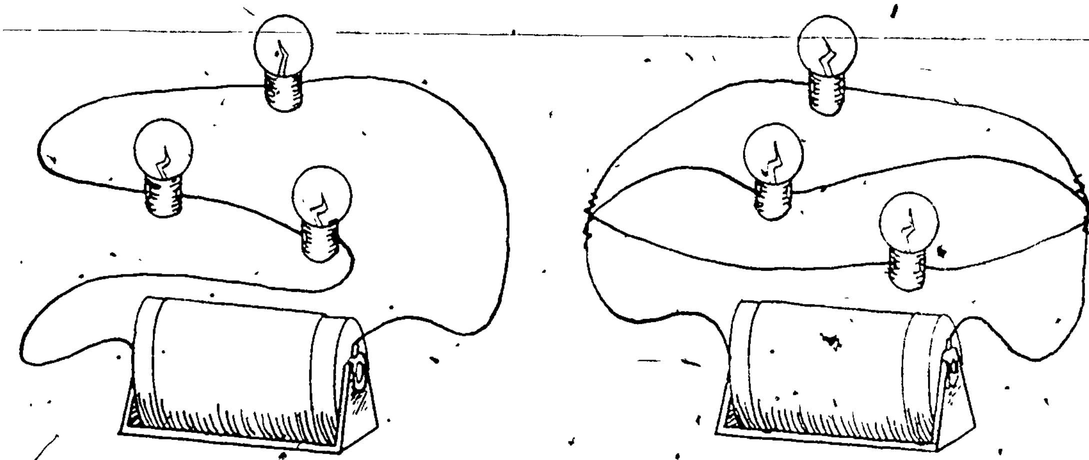
1) by seeing if it makes any difference which wire is connected to the positive end of the battery and which to the negative end.
2) by adding two pieces of wire.
3) by adding pieces of string. "Why doesn't it work with string?"
4) by seeing if they can connect additional batteries or bulbs to the system.

The difference between an open and closed circuit can be illustrated by adding a switch to the circuit. An old fashioned switch with a metal strip that moves in and out of the contact is best. The switch controls the electric flow. Ask: "How can you tell when you have a closed circuit?" *(Bulbs light.)* "What shows that you have an open circuit?" *(Bulbs do not light.)*

Ask: "What kinds of things do you need for an electric circuit?" Lead them to the idea of a source, an energy conversion device, like the bulb, and the connecting wire. Help them to find out that each of these has a different use by experimenting, trying to build a working circuit without one of the three components (two batteries and no bulbs, for instance). "Can you make a complete circuit without the bulb? How would you know if it is complete?" *(The wire gets hot, so electricity must be flowing through it.)* Note: Be careful. The wire gets very hot! The students should be able to generalize that without the bulb the wire is both a conductor and the energy-connecting device. You always need all three types of components to make a complete circuit.

Student Activity 2

Choose students to make up two teams. Have two or three students per team. Give each team three bulbs, lengths of wire, and batteries. Have one team connect these components in a series circuit. The other team should connect the bulbs in a parallel circuit as shown in diagram below.



Have the students disconnect one of the bulbs from the series set. "What happens?" *(All the bulbs go out.)* Have the students disconnect a bulb from the parallel set. "What happens?" *(The other bulbs do not go out.)*

Student Activity 3

Materials:
- Hand crank generator (borrow from high school)
- Flashlight bulbs
- Sockets for bulbs
- Five pieces of insulated wire (lengths of six feet each)

Choose five or six students from the class to represent some parts of a city. Have the students locate in different places in the room. Have a student represent the power plant, and turn the generator. Have the other students place their bulbs in a socket and connect their socket with wire to the next student's socket. In this way they will make a series circuit.

Have the student playing the power plant turn the crank of the generator. If all components are working, the "city" should light up.

Dry cells may be used instead of a hand-cranked generator. An interested student might be persuaded to make a cardboard box set-up to demonstrate his/her electrical circuit.

Ask the following questions:

1. What does the generator do? *(It produces the current in the wire which lights the bulbs.)*

2. What will happen to different parts of the "city" if the generator does not do its job? [*Have students disconnect one of the wires leading from the generator. The light in that part of the "city" (Student X) would go out.*]

Note: It might prove interesting to tell the students that they now have to supply the city with electricity, but without using wires you can see. What would each of you suggest? Try it.

Concluding the Lesson: Student Activity 4

Have students work the crossword puzzle and fill in the blanks in the sentences with the proper word.

Student
Activity 4

BULBS AND BATTERIES CROSSWORD PUZZLE

```
                                              8E    9S
                                               L     E
                         7O                    E     R      10S
                   6S     P                    C     I        H
             1D  R  Y  C  E  L  L              T     E        O
                    S     N                    R     S        R
                    T    2C  L  O  S  E  D  C  I  R  C  U  I  T
                    E     I                    C     O        C
                    M     R                    I     N        I
                    S     C                    T     N        R
                      3B  U  L  B  S           Y     E        C
                          I                          C        U
                4S  W  I  T  C  H  E  S              T        I
                                                     I        T
                                                     O
 5P  A  R  A  L  L  E  L  C  O  N  N  E  C  T  I  O  N
```

Across

1. The source of electric energy used in this lesson.
2. Current flows in a ______ ______.
3. One way to change an electrical system is to add more ________.
4. ________ are used to open and close a circuit.
5. In a ______ ______ the current can flow through more than one path.

Down

6. Electrical ______ are very useful.
7. Current does not flow when we have an ______ ______.
8. __________ is a very useful form of energy.
9. In a ______ ______ the current has only one path.
10. A ______ ______ is the term used to explain the flow of large amounts of current that damage the system.

Answers

Across
1. *DRY CELL*
2. *CLOSED CIRCUIT*
3. *BULBS*
4. *SWITCHES*
5. *PARALLEL CONNECTION*

Down
6. *SYSTEMS*
7. *OPEN CIRCUIT*
8. *ELECTRICITY*
9. *SERIES CONNECTION*
10. *SHORT CIRCUIT*

Extended Activity 1

You may want to allow time to do the extended activity. It is suggested that this be a small group activity.

Make an electric quiz board.

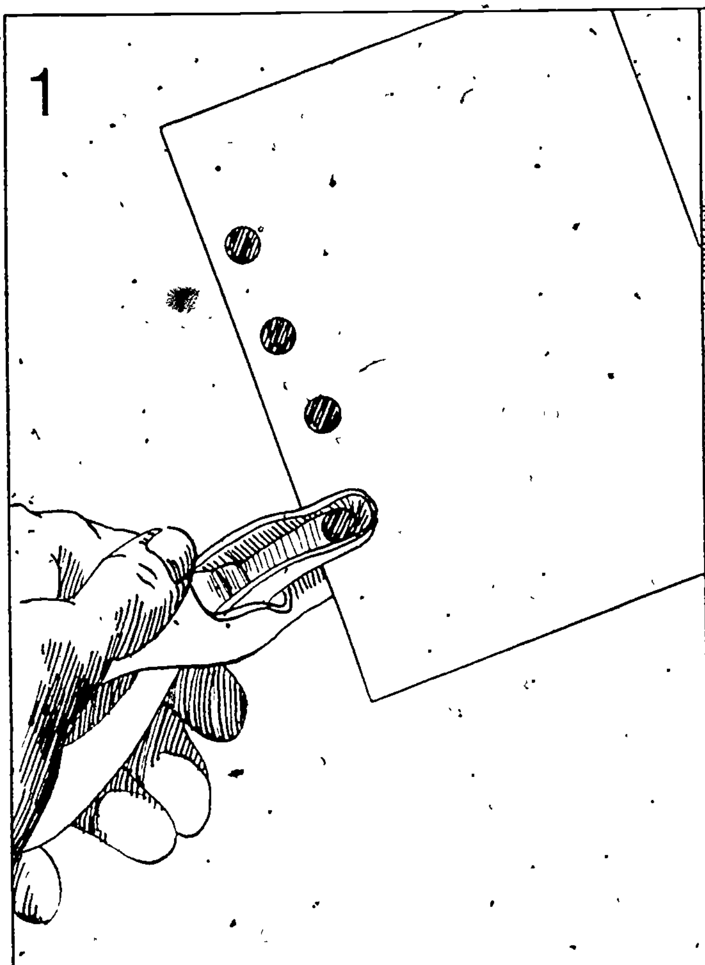
Materials:

- Tape
- Hole puncher
- Aluminum foil strips
- Thin cardboard
- Paper fasteners
- Paper

<u>Note</u>: The students can design the electric quiz board on any subject, using questions or pictures.

<u>Directions</u>

Punch two rows of holes in a sheet of thin cardboard. Put questions or pictures next to one row of holes. Write the names or answers next to the other, but do not put them in the same order. On the back of the thin cardboard, connect the holes that match. Use strips of aluminum foil for the connections. Use a light circuit with an opening in it. Use this circuit to check each part of the test. The light should go on when you hold the wires in any two holes that match. If the answer is right, the light will come on. (See diagram next page.)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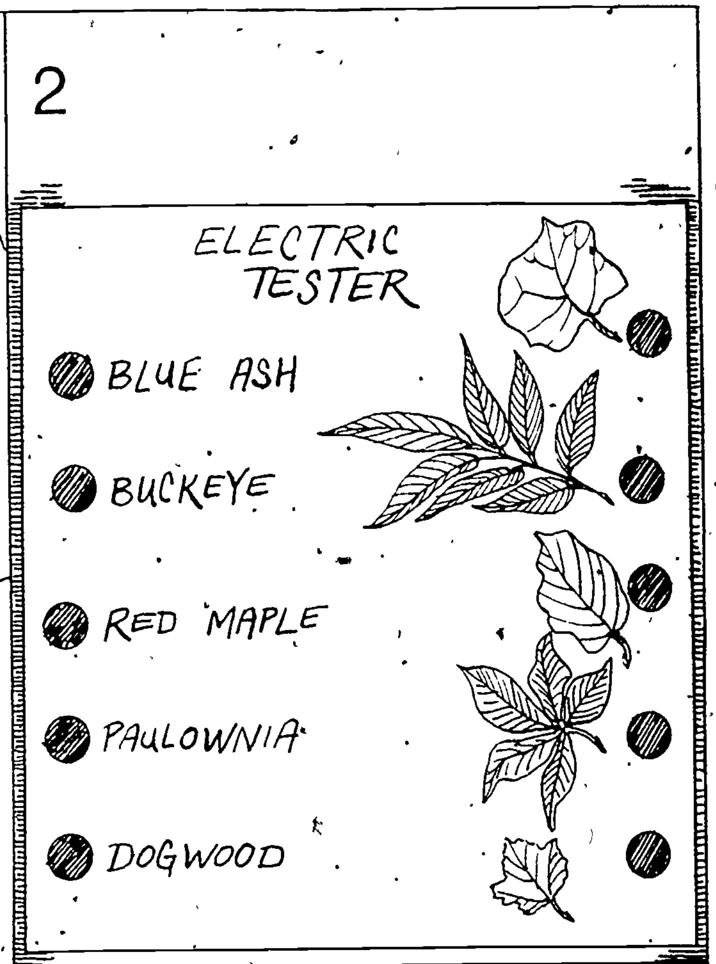
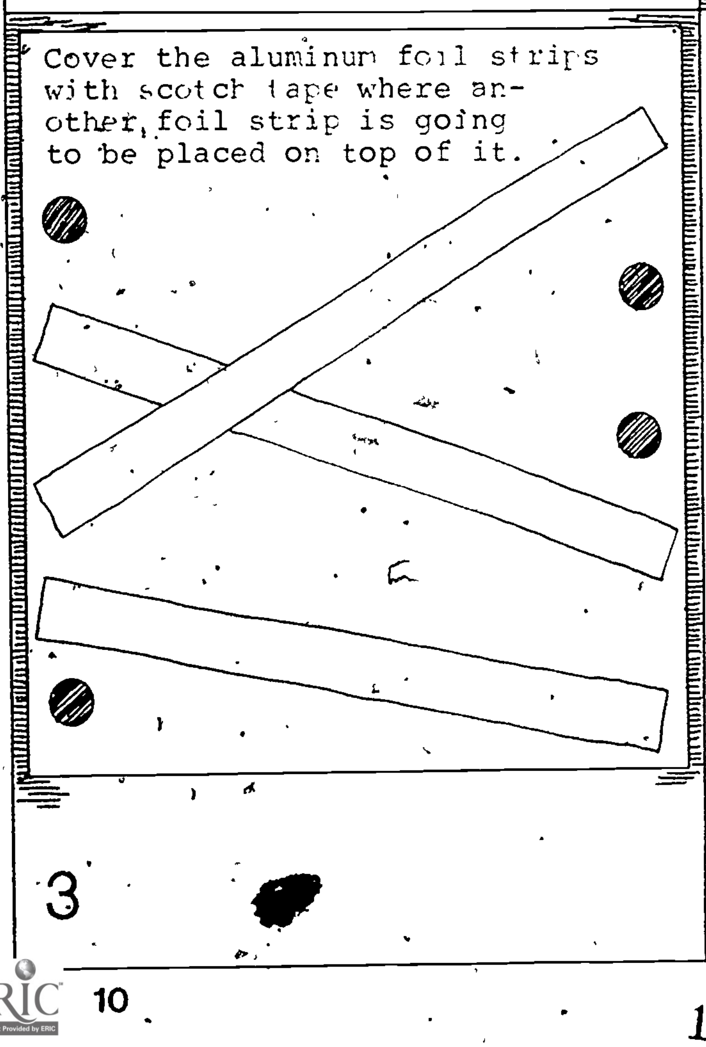
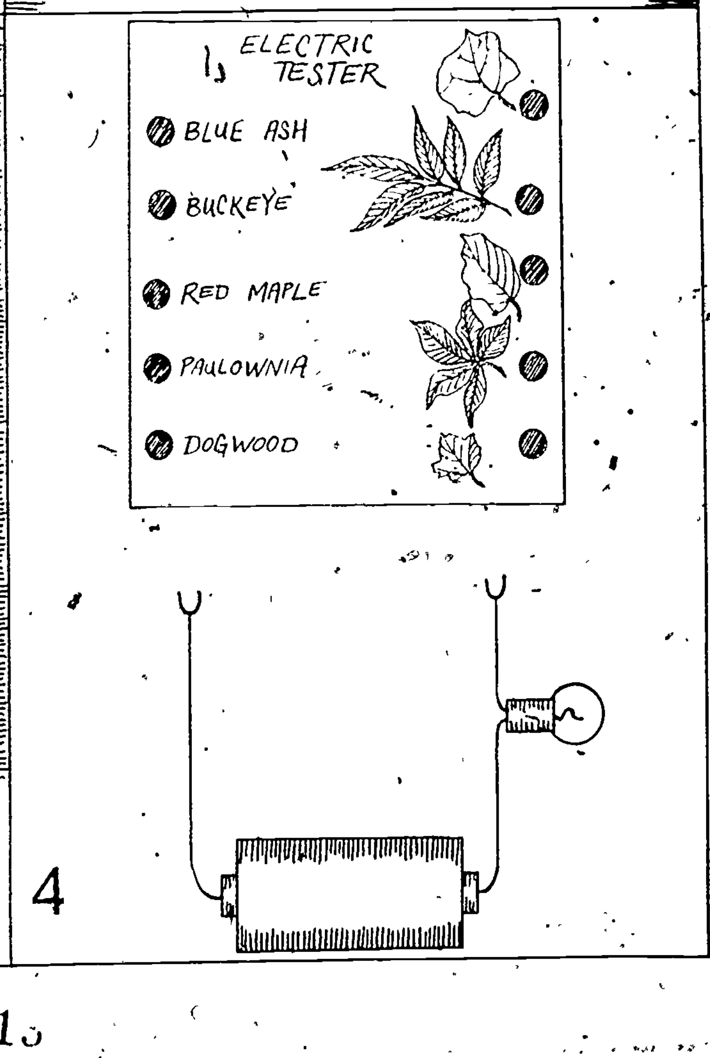

2
ELECTRIC TESTER
BLUE ASH
BUCKEYE
RED MAPLE
PAULOWNIA
DOGWOOD


Cover the aluminum foil strips with scotch tape where another foil strip is going to be placed on top of it.
3


ELECTRIC TESTER
BLUE ASH
BUCKEYE
RED MAPLE
PAULOWNIA
DOGWOOD
4

Lesson 2: NETWORKS UNDERGROUND

Overview — Much of the energy being transported in a city each day lies buried beneath the pavement. Yet it is in these hidden wires and circuits that people and their goods and services are linked together. In this lesson we offer students a glimpse into this underground world of energy distribution. We also offer a look at our dependency on our electrical energy networks.

Objectives — Students should be able to:

1. Recognize a simple network of distribution of electrical power within a community.
2. Relate how he/she might be affected by an electrical power failure.
3. Explain how we depend on electricity.

Time Allotment — Two-three class periods.

Materials — (The quantity you will need of each item will vary according to the number of students you have in your class or the number of students who choose to participate, individually or in a group.)

Picture of a power plant
Picture of a city
Strings of Christmas lights
Wooden dowels (or sturdy tree branches)
Story: New York City Blackout
Map: New York City Blackout
Oak tag paper
Paper
Scissors
Copies of Student Worksheet
Tape
Crayons
Glue

Background Information (Teacher Use Only)

We consider "turning on the switch" an ordinary event. It is the most common device that provides us with electricity. Tracing the origin of the electricity in the switch uncovers an energy network as the diagram on the next page shows. This network transfers energy from the water power of a dam through turbines and generators in the power plant, through power lines and into a home or building.

Contact your city or community planning office for information about the network of electrical power in your own community. Invite someone from this office to visit your class to give a short talk about electricity and electrical service in the community.

Teaching Strategies

Open this lesson by asking questions similar to those in Lesson 1. "Where does electricity come from, and how does it get to the things we use (radio, TV, etc.)?" Remind students of their answers: "from the plug", "wire in the wall", etc.

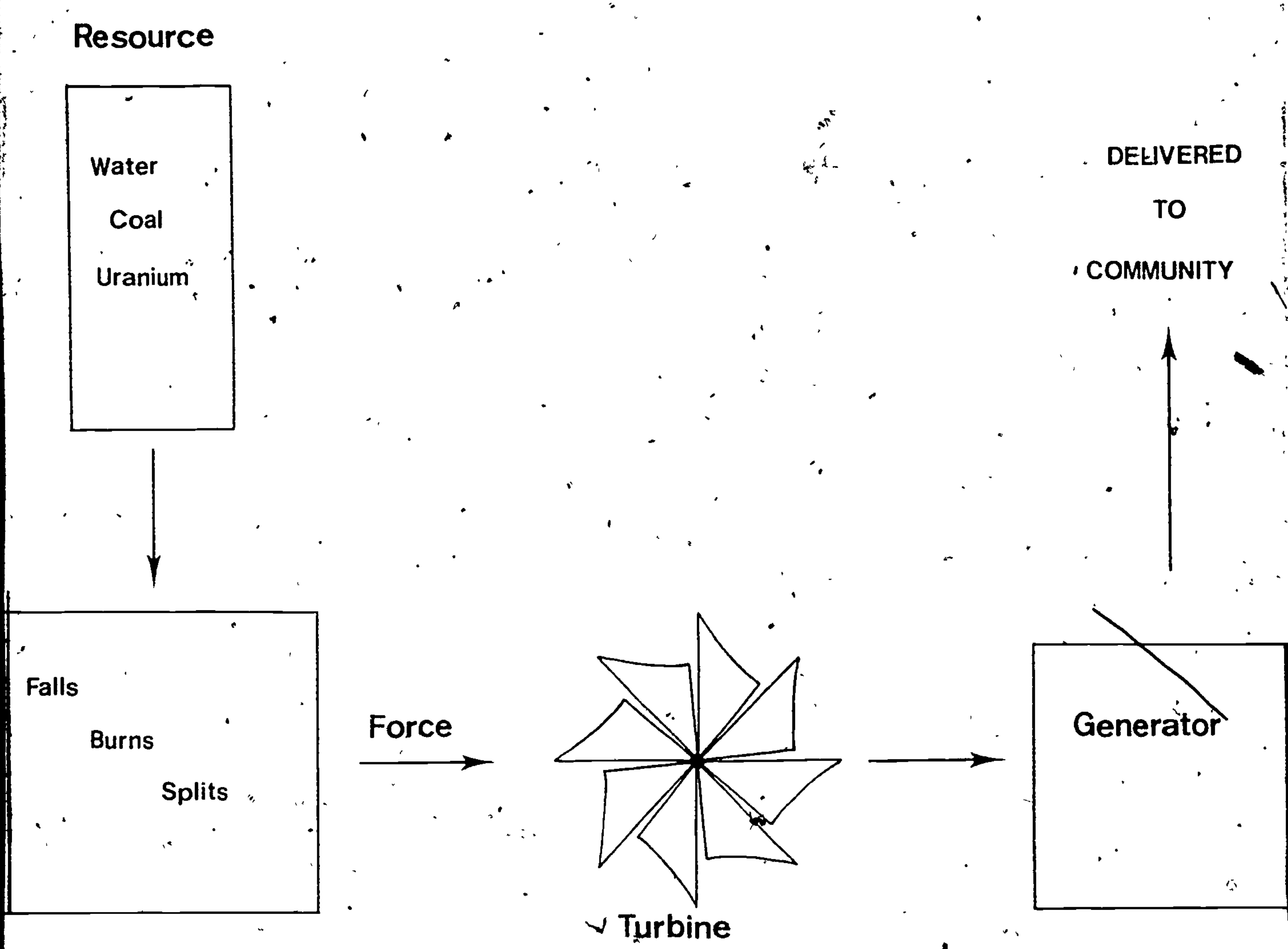
Ask: "How does the electricity get to your house?" *(Accept responses such as: on utility poles; on wires.)* "How does the electricity get to the wires?" *(From a power plant.)*

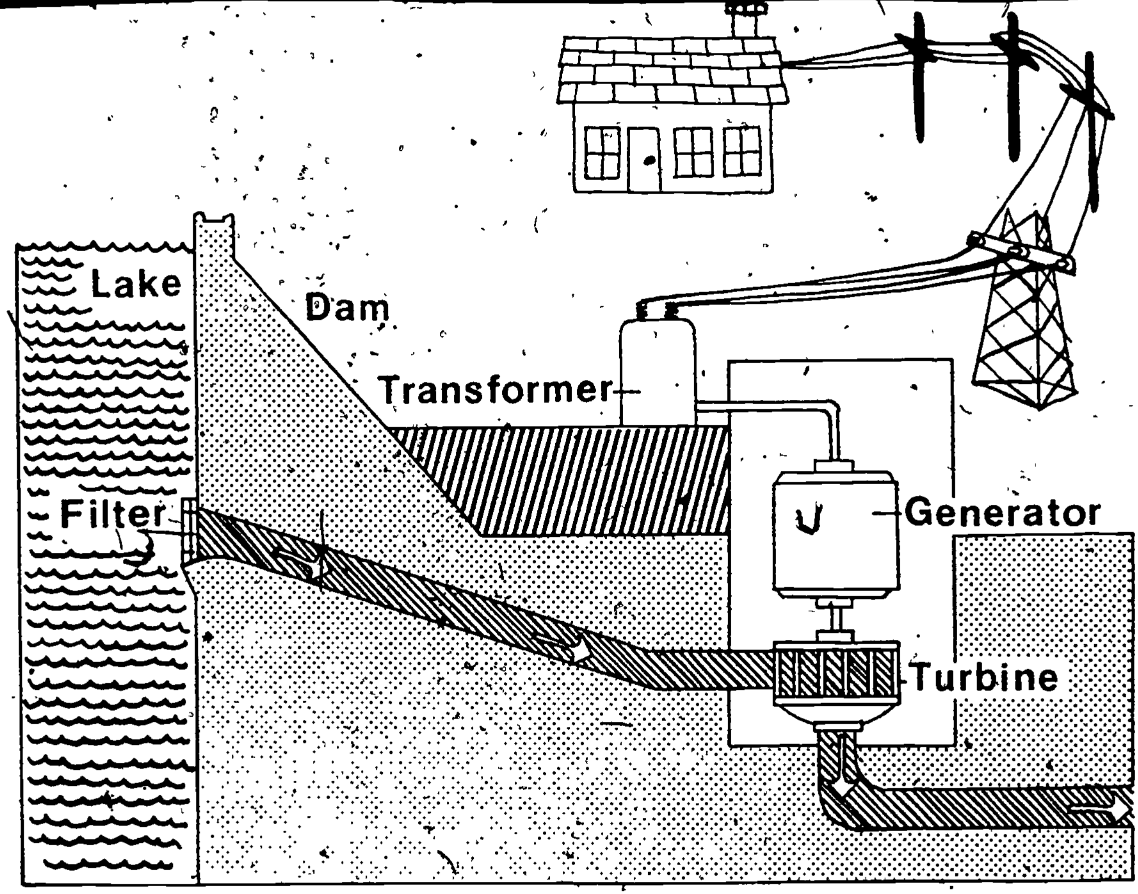
Developing the Lesson

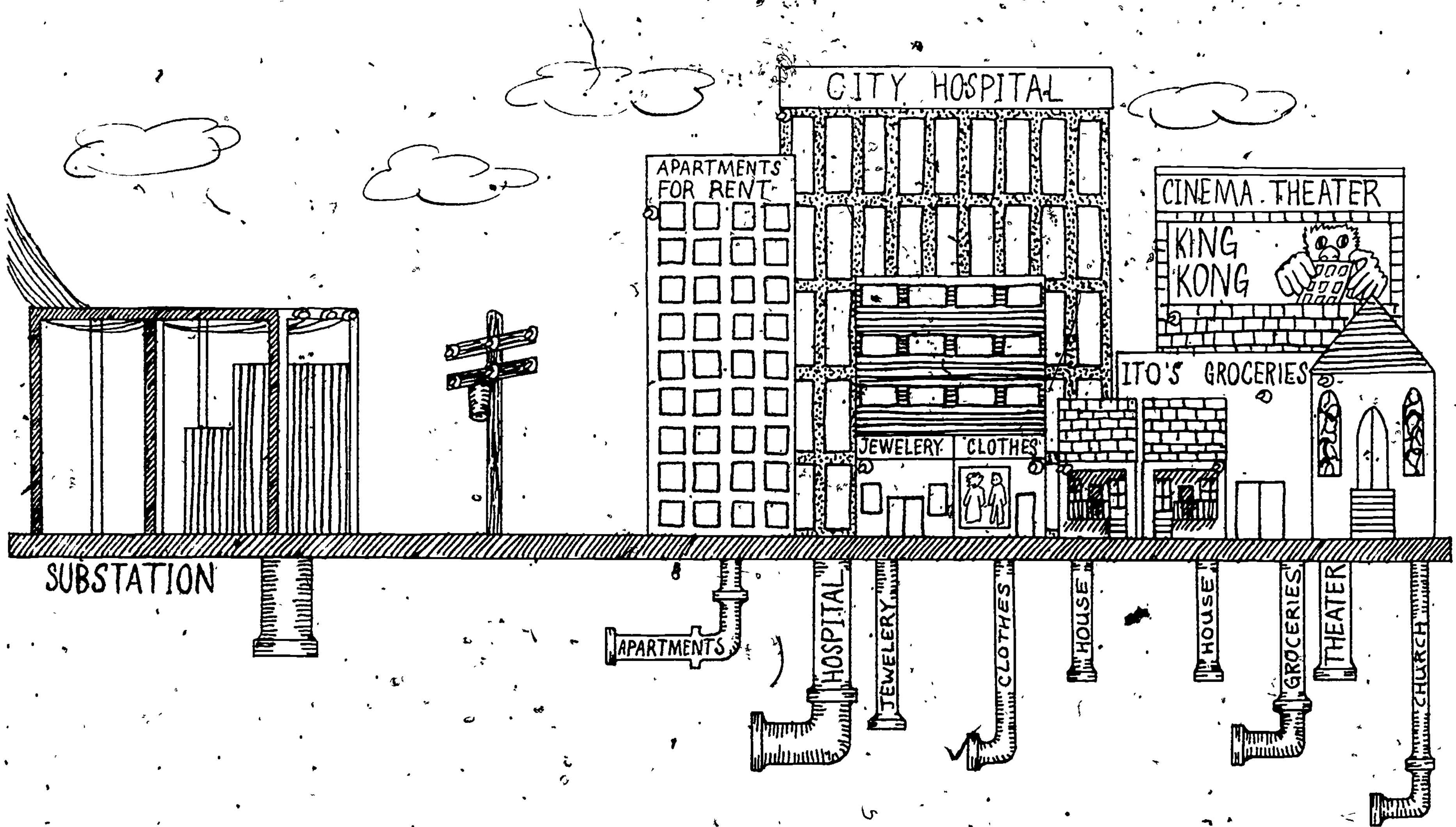
Distribute the picture of a power plant. Have students point to the building. "What is this building called?" *(Power plant; hydro-electric plant.)* "Where might you go to see a plant like this?" *(Answers will vary.)* "What is the purpose of this plant?" *(Produces electricity.)* "Where is the electricity sent?" *(To my house; to the town, etc.)* "How is the electricity 'sent' to these places?" *(Through wires.)*

Distribute the picture of a City Without Electric Wires. Tell students it is their job to get electrical power to each building in the city. Start with the substation. Point to each place shown in the picture as the activity develops. Have students draw power lines on their pictures, but anticipate that most will draw lines above ground, connecting the buildings with the substation.

Ask students to describe what their lines look like. *(Roads, webs and nets will be mentioned among other likenesses.)*


Resource
Water
Coal
Uranium
Falls
Burns
Splits
Force
Turbine
Generator
DELIVERED
TO
COMMUNITY


Lake
Dam
Transformer
Filter
Generator
Turbine


CITY HOSPITAL
APARTMENTS FOR RENT
CINEMA THEATER
KING KONG
ITO'S GROCERIES
JEWELERY
CLOTHES
SUBSTATION
APARTMENTS
HOSPITAL
JEWELERY
CLOTHES
HOUSE
HOUSE
GROCERIES
THEATER
CHURCH

Tell students that the word "network" describes one manner in which numerous things can be connected. All the houses and buildings in a community need to be connected with a source of electrical power. Tell the students they have drawn a network when they have provided each building with a line representing electrical wires.

Ask students if they can think of another way to distribute electricity to the city. Draw lines this way. (This time students will probably draw the wires underground.) Explain that much of what ties the parts of a city together is underground and that most of the newer cities, or new sections of old cities, have their electric wires placed underground. Give students an opportunity to discuss the reasons for underground wires.

Class Activity

Students may wish to construct a community focusing on the electrical power network. Have students use the general pattern for cut, fold, and paste blocks to represent community buildings and homes. All of these can be modified to represent whatever building they are making. Use oak tag paper, and cut out holes for windows and doors, and a hole in the "floor" for the light bulb. Lay out the community using strings of Christmas lights to simulate the power lines and lights for buildings.

Students may have their power lines above ground or place them underground. Wooden dowels or tree branches can serve as above-ground poles, but will probably need to be taped in place or propped up.

Ask: "Have you ever seen a sign reading: BEFORE YOU DIG, CALL YOUR ELECTRIC COMPANY? Why do you think this sign was posted?" *(Answers will vary, but some student may suggest that underground cables could be damaged if a shovel digs into them.)* "What would happen then?" *(Local electrical power failure.)* "What are some advantages of having cables (wires) underground?" *(Answers will vary. Likely responses are: too many wires showing; you could not see the sky; they take up too much space.)*

"If electricity was shut off in the school, what wouldn't run anymore?" *(Put list on chalkboard.)*

Then ask: "What wouldn't work in our homes? What things would still work?" Assign class members to address one of these two categories. Assign a recorder to each group to list the suggestions from the group. Call the class together in a few minutes and have the recorders report to the whole class.

Concluding the Lesson

Call on members of the class to tell their experiences when electrical power went out in their homes. Talk about "blackouts" and explore feelings and attitudes during this time.

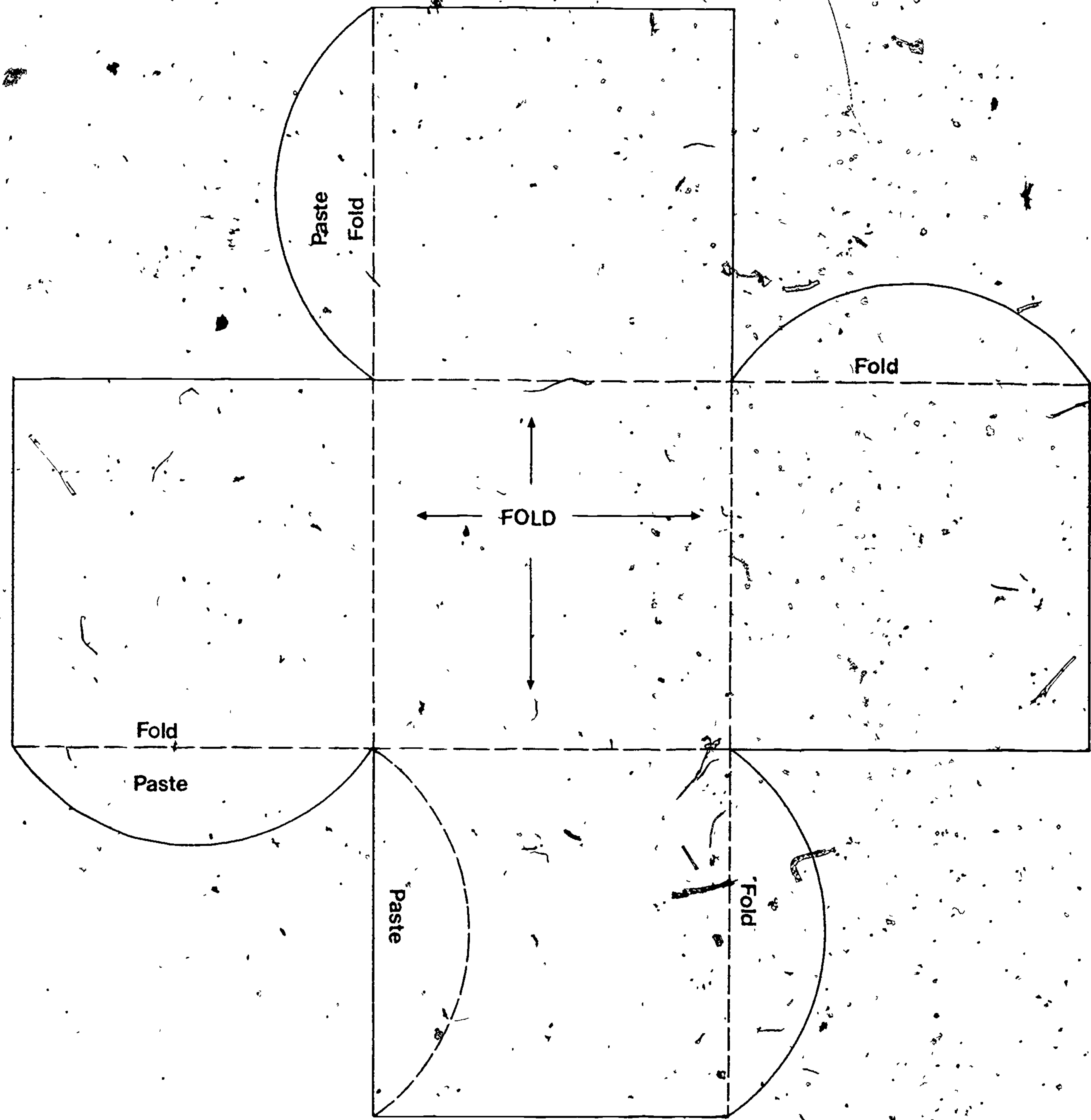
Distribute copies of the story of the New York City Blackout, 1977. Have students read the story and answer the questions. Discuss the questions after sufficient time has passed.

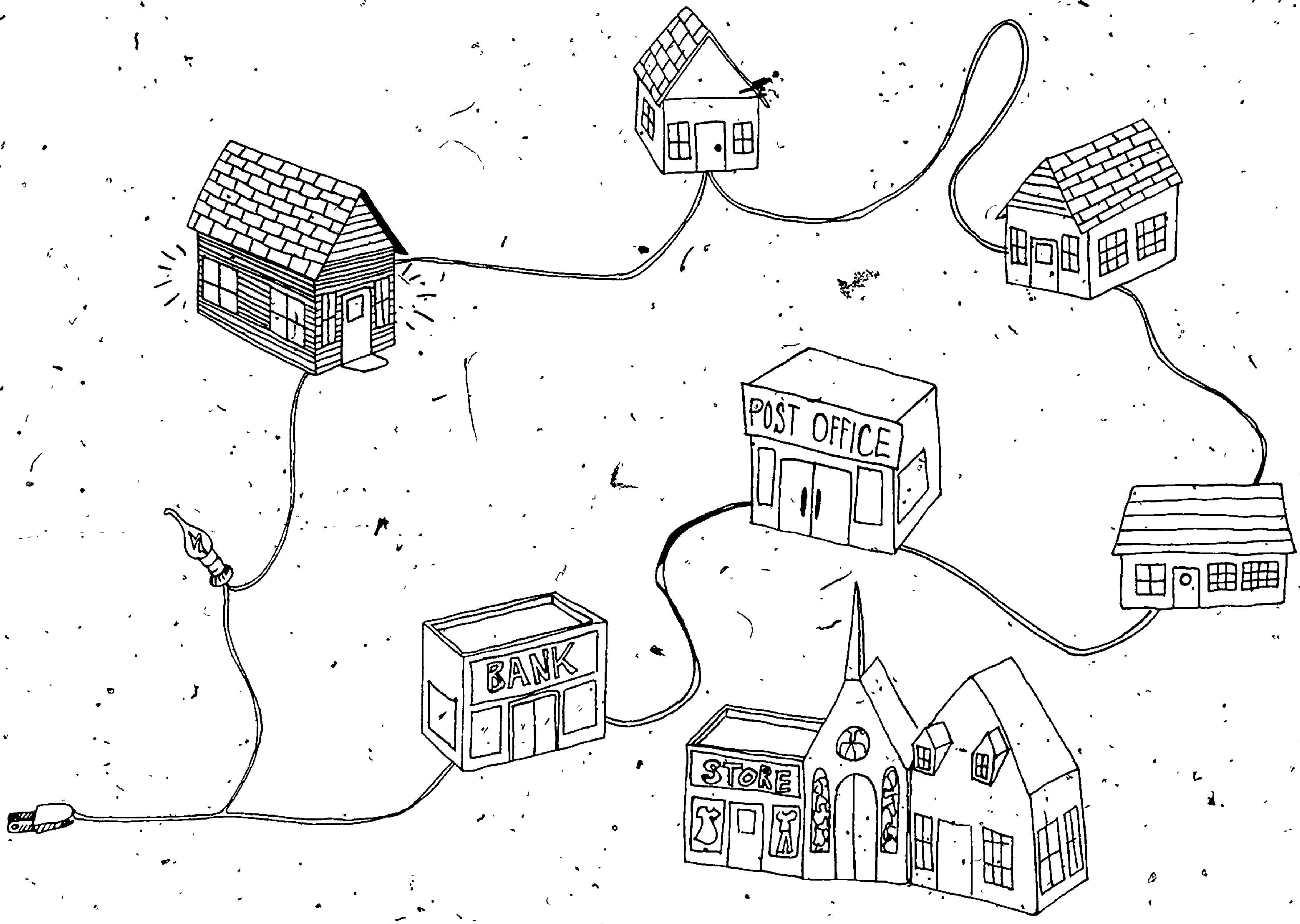
Have the students choose a season of the year, day of the week and time of day and write a "What If?..." story about the day the lights went out in the students' community.

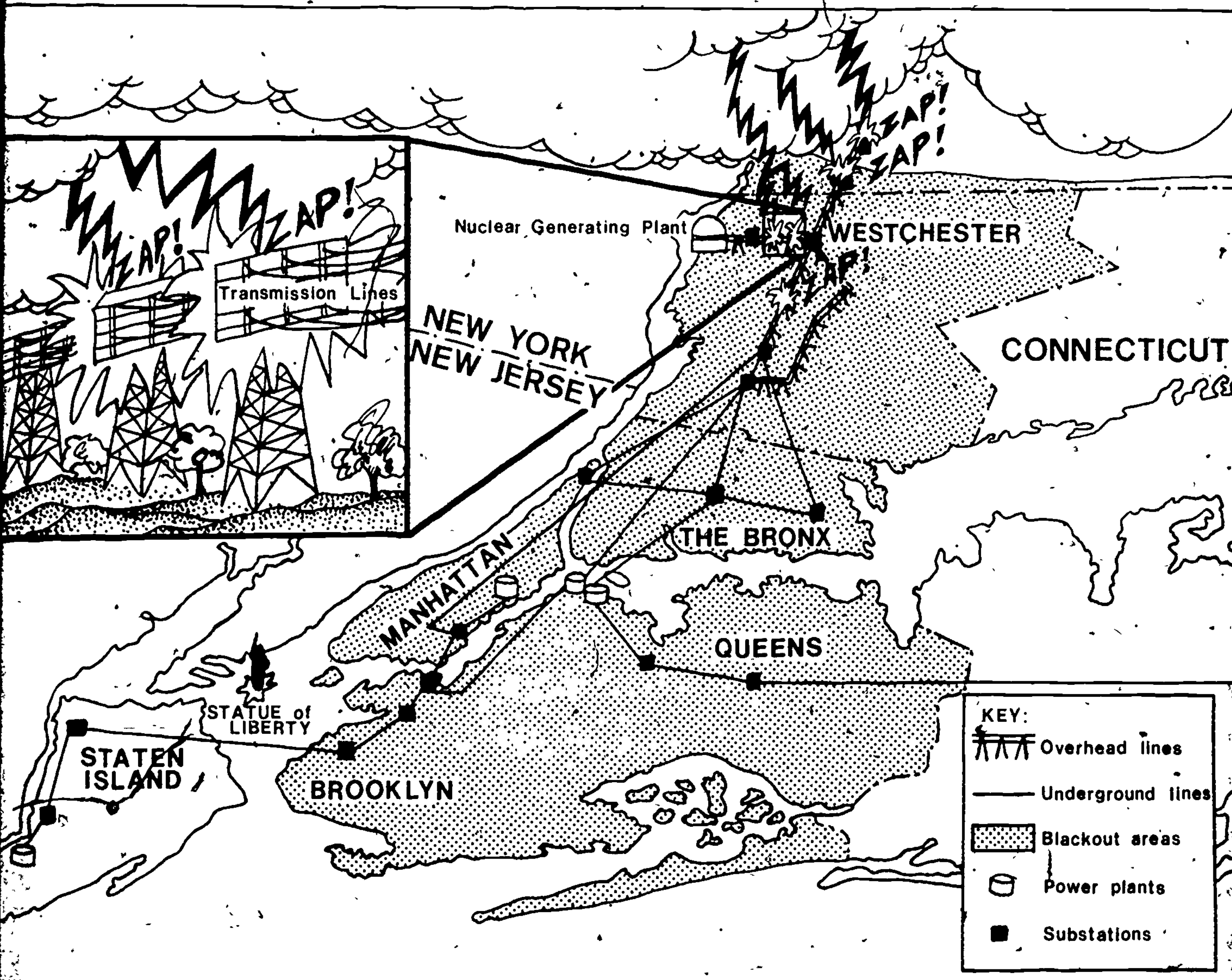
Have students answer the questions below before they begin writing. Then suggest that they write their story.

1. What - happened?
2. Where - did it happen?
3. When - did it happen (time, day, week, year)?
4. Why - did it happen?
5. What things would be affected?
6. How would they feel about it?

Block Building




POST OFFICE
BANK
STORE


ZAP!
ZAP!
Transmission Lines
ZAP!
ZAP!
ZAP!
Nuclear Generating Plant
WESTCHESTER
NEW YORK
NEW JERSEY
CONNECTICUT
THE BRONX
MANHATTAN
QUEENS
STATUE of LIBERTY
STATEN ISLAND
BROOKLYN
KEY:
Overhead lines
Underground lines
Blackout areas
Power plants
Substations

New York City Blackout, July 13, 1977

New York City stopped at about 9:30 on a hot summer night. The television screen went blank. And lights went out all over the giant city. Over in the amusement park the "Wonder Wheel" stopped with people at the top. It took a long time for workmen to crank the wonder wheel down by hand and let the frightened people get on the ground again.

Trains stopped running. Airports closed down. All airplanes had to go to airports in Newark, New Jersey or Philadelphia, Pennsylvania where the lights were still on. There were no more red and green traffic lights. It became so dangerous to drive with traffic going in every direction that some people left their cars and began their long trip home on foot. Other people had to walk home in the dark when the subways and the in-city electric trains had no more electric power. When the people got to their apartment buildings, they found they had to walk up to their apartments using the stairs. The elevators didn't work either! Inside, the apartment air was hot and stuffy because fans and air conditioners quit running. People opened their windows to get some air and shook their heads in amazement at the darkness all around. Some people laughed at the darkness, but most grew very worried. All of a sudden the neighborhood seemed so different. So many dark places. What if they should get sick? Who could help them if the lights went out in the hospital?

As a matter of fact, in Bellevue Hospital, the city's largest hospital, doctors completed knee surgery on a patient by candlelight. And candles burned in nearly every room of the giant hospital.

They were used in theatres and restaurants, too. But in some places there were no candles that could be lighted. The actors and the audience had to leave dark theatres and go out into the dark streets.

"What's wrong?" everyone asked everyone else.

What went wrong was caused by lightning. During an electrical storm--which means lots of thunder and lightning--way over in Westchester County, lightning hit important power lines. These power lines connected the major power plant and the smaller power plants around New York. These power plants shared the electrical system.

Then lightning hit a large transformer near the Nuclear Generating Plant, starting a fire. The fire caused the transformer to explode and the nuclear power plant had to shut down. Engineers tried to get power from the substation to get the electricity to run the city, but they overloaded the system. The whole electrical system broke down, and blacked out a city of 10 million people!

When the electrical system didn't work, New York didn't work.

Questions about the Story

1. Think back over the story. Find the place on the map where lightning first hit the power lines. *(Westchester.)*

2. Tell in your own words why the system didn't work. Point to places on the map that show the chain of events that caused the blackout. *(Student answers will vary. You might help them to see that the power lines, main and substation power plants, etc. are interconnected parts of an electrical system. A small break in the system may cause an interruption to a neighborhood, but a series of big breaks can make a whole system collapse.)*

3. List some of the ways people in the story depended on electricity. *(Student answers will vary. They should point out that electricity makes the following things run: traffic lights, elevators, trains, subways, lights, movies, rides at an amusement park, etc.)*

4. Are these the same ways you use electricity? *(Urban students will probably agree that they use electricity in much the same way and with the same degree of dependence. Rural children may mention the many ways electricity is used on the farm.)*

5. How important is electricity in your life? *(Student answers will vary. Most will probably agree that electricity has become a basic need.)*

6. What could you use instead of electricity to...

   a. Heat your home?
      (Students may mention wood stoves, coal and gas furnaces, fireplaces, etc.)
   b. Have light to see by?
      (Battery lights, gas lights, candles, kerosene lamps, firelight, etc.)
   c. Cook your food?
      (Natural gas, kerosene stoves; propane stoves, wood-burning stoves, fireplaces, etc.)

7. How well do you think your ideas will work?

(Student answers will vary. Point out the dependence of modern life on electricity and on systems that bring it to us. At this point you may want to clinch the idea that the source of electric power is the burning of fossil fuels at the power station should the student discussion take this turn.)

8. What things that you do now could you do even if you didn't have electricity?
   (Answers will vary.)

Lesson 3: HOW DOES NATURE HELP US GET ELECTRICITY?

Overview The activities and discussions in this lesson address the topic of the sources of electrical energy.

Objectives Students should be able to:

1. List several sources of electrical energy.
2. Describe in a drawing the network of energy, which includes the resource for producing electrical energy through the energy changes to reaching the house by wires.

Time Allotment One-five class periods (if all activities are used).

Materials

Camera
Buckets (plastic, scrub buckets)
Coffee cans
Tin snips
Dowels (1/2 in. x 3 in., or use a straightened coat hanger)
Awl or other sharp tool
Hammer
Can of Sterno (or another suitable flame source)
Wire screening, 4" x 4" (trivet will do)
Five Student Activity Sheets
Map of Fuel Resources
Crossword Puzzle
Blue Crayons

Background Information (Teacher Use Only)

The generation of electricity begins with a natural energy such as water, coal, oil, gas, or nuclear energy, as shown in the Student Activities.

Hydroelectric (water) power is provided by the motion of falling water. When the water trapped behind a dam is released it can be made to flow through turbines. As the turbines turn they activate generators which produce electricity by moving wires through a magnetic field.

Turbines can be turned by forced steam. Steam is produced when water is heated. The water is heated by burning one of the fossil fuels: coal, oil, natural gas; or by causing a controlled nuclear reaction which releases great amounts of heat energy.

Further information can be found in the Energy-Environment Source Book by John M. Fowler (Washington, D.C.: NSTA) 1975.

Teaching Strategies

The very best way to introduce this lesson would be to take the class to see a hydroelectric power plant. However, this will not be possible for many classrooms. A film about water power would make a good second choice. These are available in most school libraries.

Ask students: "How does electricity get into the wires that bring it to your house? Where is electricity made?"

Developing the Lesson

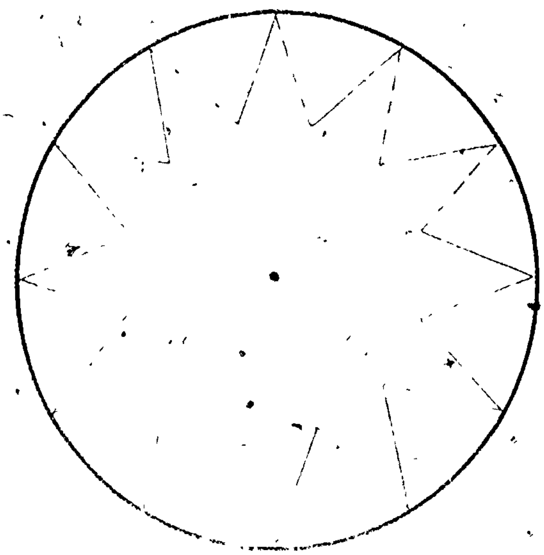
Distribute Activity 1 handout. Have a student read the paragraphs aloud and then have the class discuss the information.

Student Activity 1
Go outside!

Take the students out on the school grounds to see how a turbine wheel turns. Prepare ahead of time 4 or 5 buckets of water and a model turbine wheel. The wheel can be constructed from a metal coffee can lid. Punch a hole in the middle of the lid with an awl and hammer. Cut the lid with tin snips. Use a wooden dowel rod or straightened coat hanger for the axle. See picture below. Have students pour water over the wheel. Have students answer the following:

- Does the wheel turn faster if you pour the water faster?
- Does the wheel turn faster if there is more water poured? What happens when there is only a trickle of water poured?
- How does this demonstration help us understand the picture we just looked at? Can anyone explain the drawing now?

Cut on solid lines.
Fold on dotted lines.
Place axle through hole in middle.



Activity 2
Try it!

Have students return to the classroom and read and discuss Activity 2 handout. (You may wish to demonstrate the force of steam. The following activity may make the drawing less abstract.)

Place a large tin can with both ends removed over a can of Sterno. Set a piece of wire screening or non-flammable substitute over the top end of the can. Then place a small aluminum can, such as the kind sandwich spreads come in, on the wire screen. Fill the can half full of water and place a piece of cardboard on top of the can.

Light the Sterno and wait till the water boils. (While they are waiting, students might like to <u>predict</u> what they think will happen. Look for predictions that state the steam will move the cardboard. If no students suggest this, tell them to watch closely and to look for movement.) When the cardboard begins to move, ask: "What caused the cardboard to move? How is this like the turbine wheel moving?"

Activity 3
Map it!

Distribute Activity 3 handout. Have students read it. Invite the class to discuss the information on the sheet. Explain that human beings are only beginning to be able to split atoms and use the resulting energy. On the sun and other stars this process is continually producing the light and heat given off from them.

Ask: "Where on earth, and in particular, the United States, can we find stored energy?" *(Student answers will vary widely. Help them discover that energy is stored in the ground in the forms of coal, oil, uranium and natural gas. It is also stored in the falling water of rivers.)*

Activity 4

Distribute Activity 4 handout and have students complete the worksheet, working in small groups. Later each group can present their findings to the whole class.

Concluding the Lesson

Activity 5
Reading a Graph

Distribute Activity 5 handout. Anticipate some student difficulty in interpreting the graph. Pre-teaching may be necessary. Have students make a trial graph using the numbers of boys and girls in the class. For example, if there are 30 students, 30 = 100%. Fourteen boys would equal 43% of the total class membership. Twenty girls, 67%. Draw a circle on the board. Divide the circle in half. Show students that each half is equal to 50%. Have the class estimate where the boys' side should be divided to show 43%. Shade that part in. Ask if the remaining portion is greater than 50%. Ask: "Is it close to 67%?" Write Boys in the shaded portion; Girls in the unshaded portion.

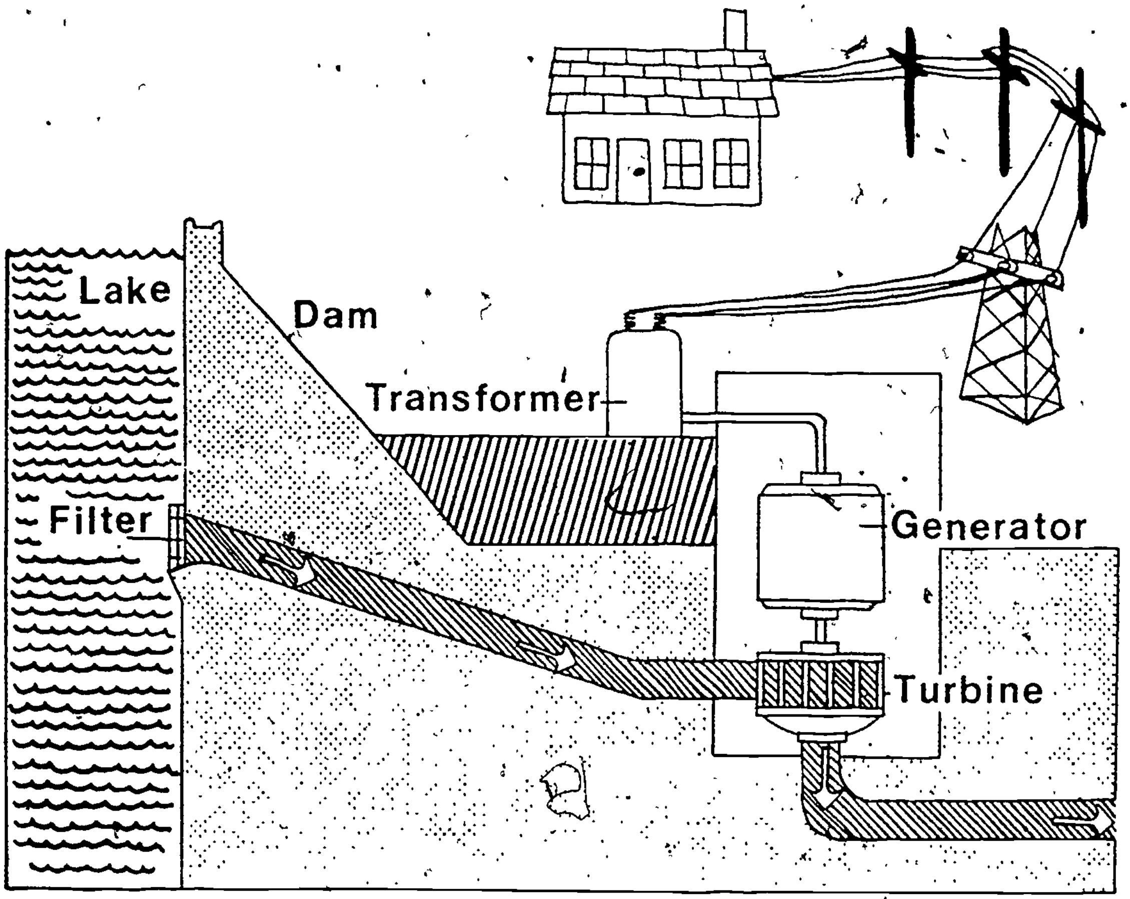
Direct the students' attention to the circle graph on the handout. Help students complete the questions. Sum up by telling students that the fuels on the graph are the major sources we use to produce the electricity we use.

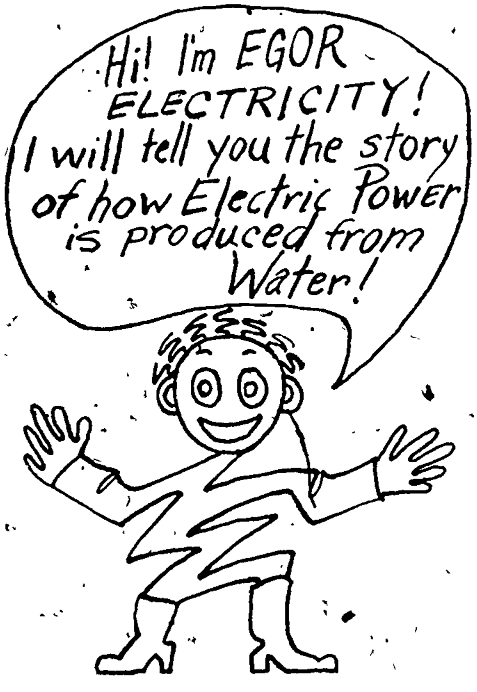
Activity 6
Evaluating the Lesson

Distribute the puzzle. Have students fill in the answers. Use the puzzle as an informal evaluation.

Lesson 3

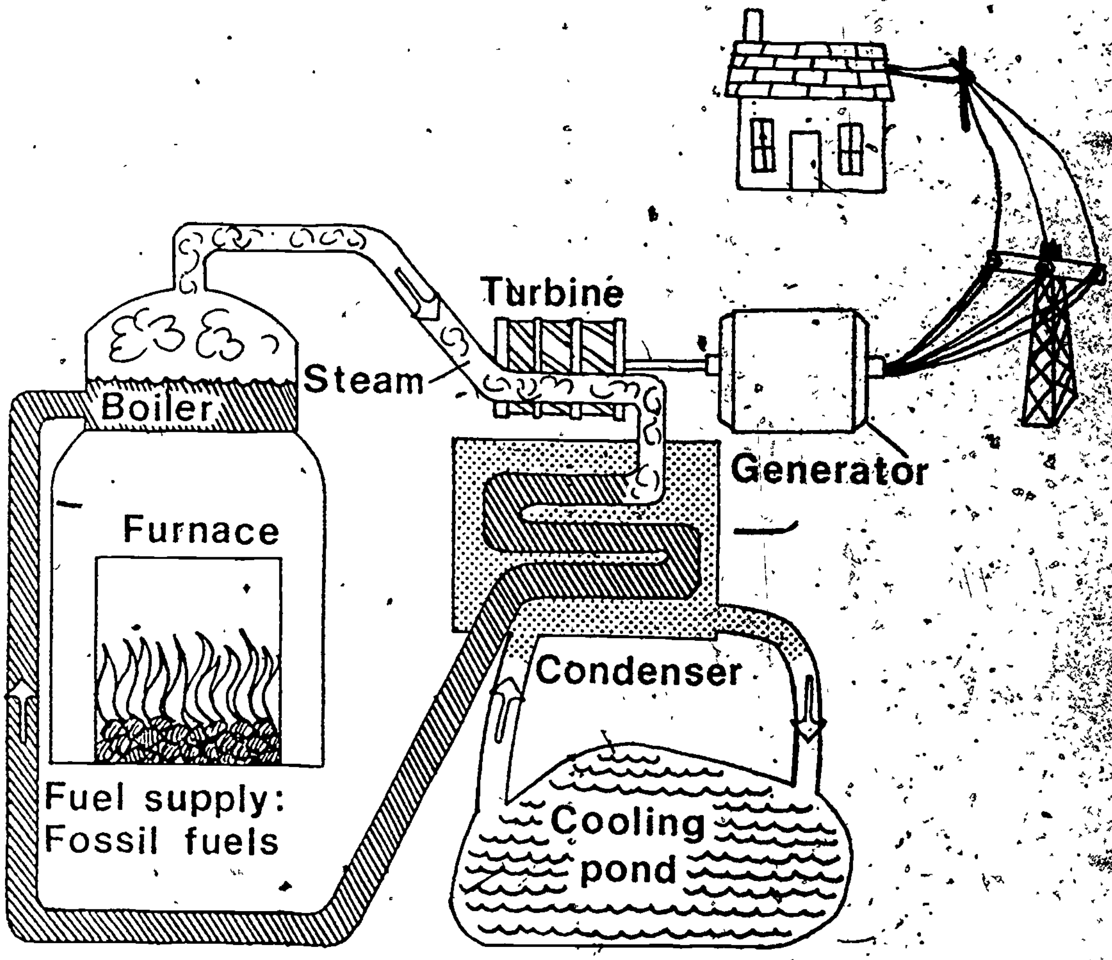
Student Activity 1 — Electricity from Falling Water

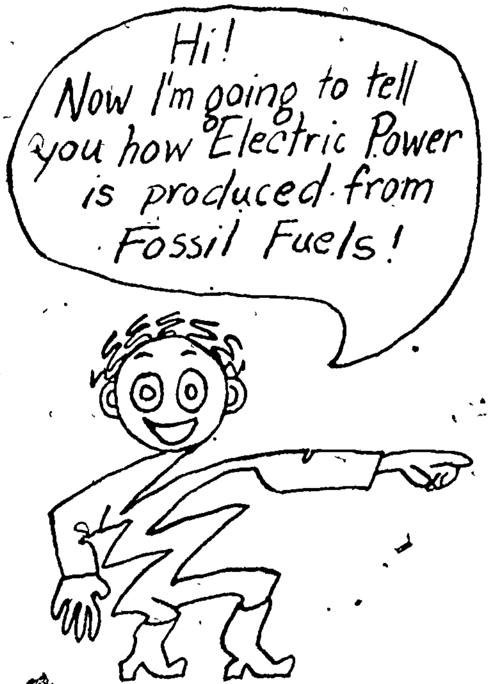




Hydroelectric power is provided by the motion of falling water. When water which has been trapped in a lake behind a dam is released as needed, it can be made to flow through the turbines which activate generators that make electricity.

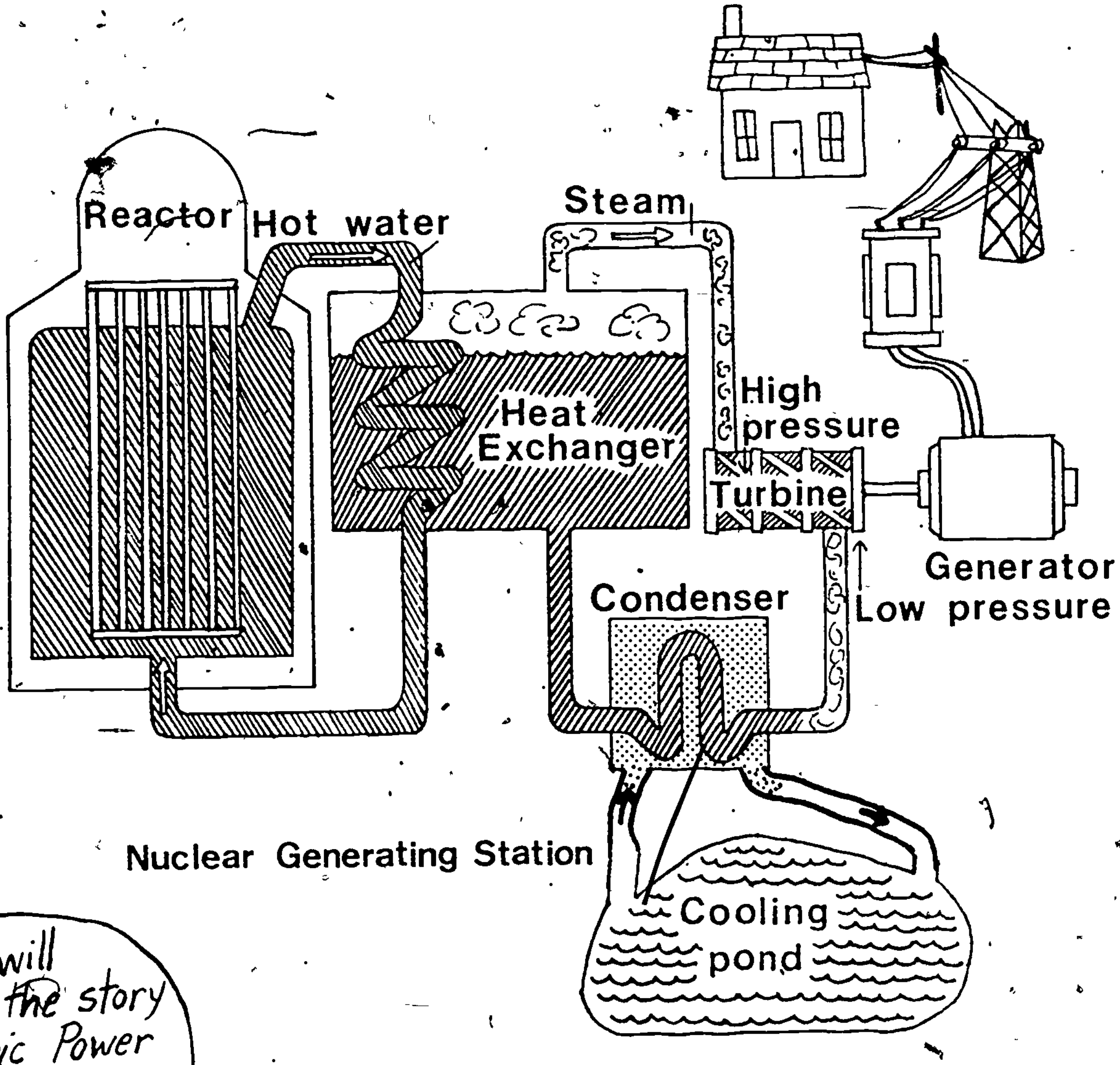
Student Activity 2 — Electric Power from Fossil Fuels



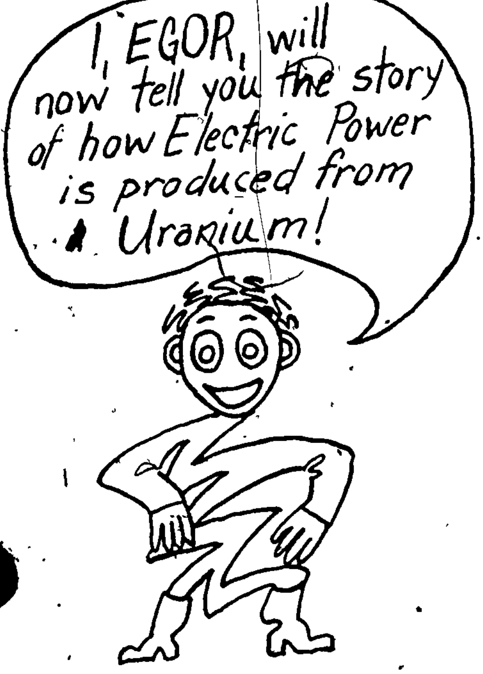


Fossil fuels (oil, gas, coal) produce electrical power by burning in a furnace to heat boilers that make steam. The steam turns a wheel called a turbine. The turbine drives a generator that makes electricity.

Student Activity 3 — Electricity from Uranium



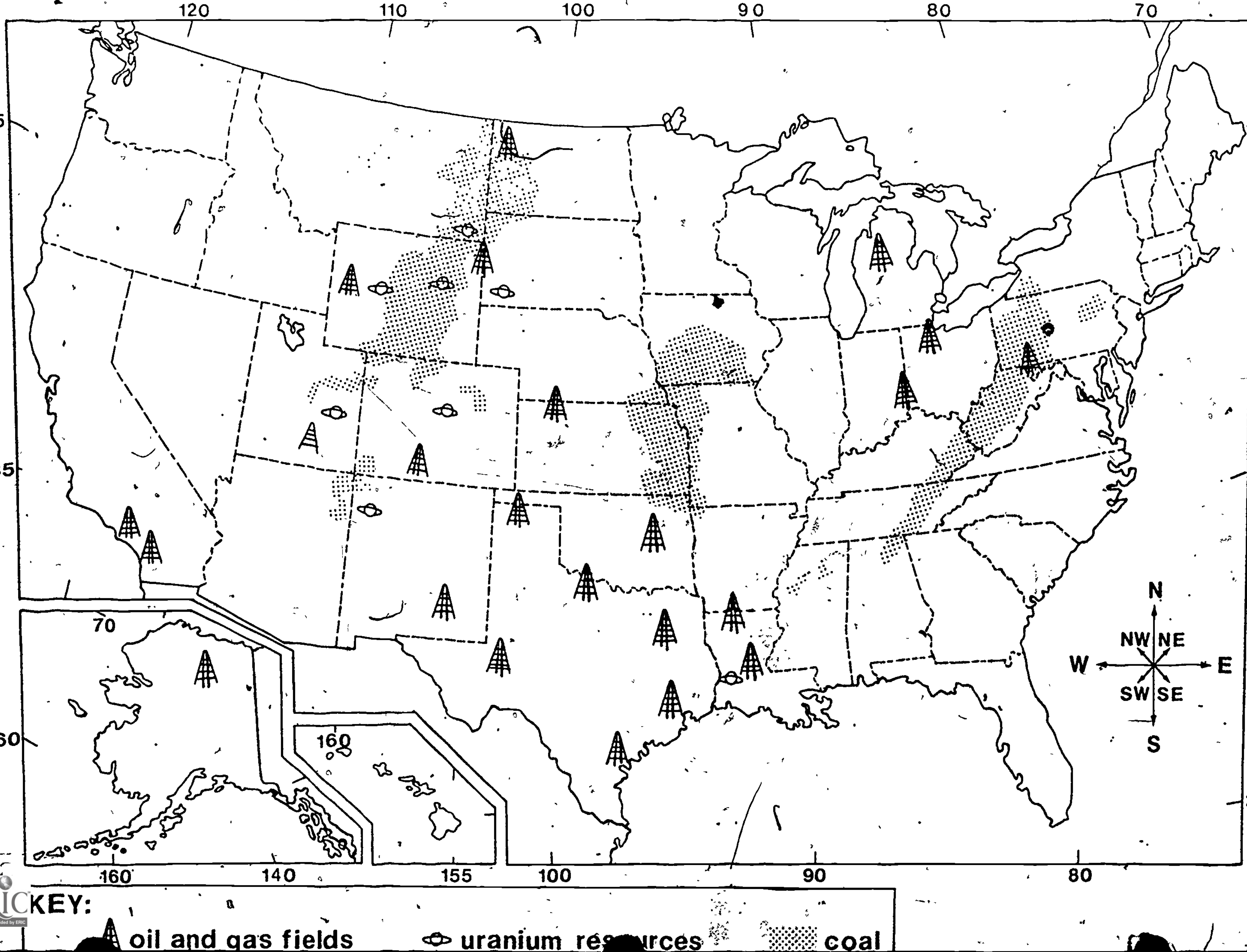
Nuclear Generating Station



Uranium is used in a nuclear reactor to produce electrical power. The uranium is split and gives off heat which makes steam from the water. The steam turns a turbine which drives a generator. The generator makes electricity.

SOURCES OF FUEL USED TO PRODUCE ELECTRICITY

Student Activity 4



Student Activity 4

Map Study Questions

Study the map, Sources of Fuel Used to Produce Electricity. Answer these sentences Yes or No.

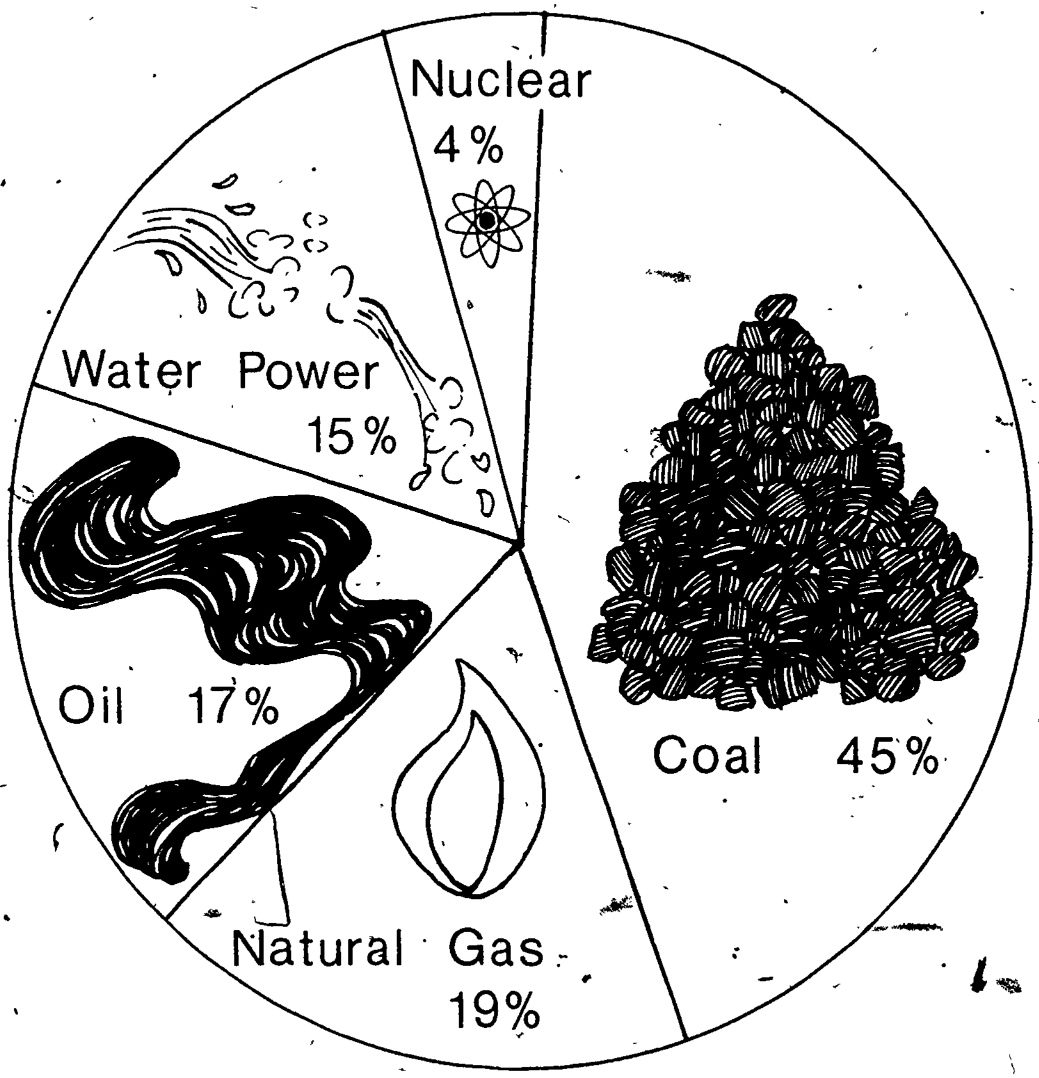
Part A

1. Is coal found in the East? *(Yes.)*
2. Are there oil fields in the West? *(Yes.)*
3. Are uranium resources found in the Southwest? *(Yes.)*
4. Is oil found near the Great Lakes? *(No.)*
5. Do all of the states have gas and oil fields? *(No.)*
6. Can a coal miner find a job in West Virginia? *(Yes.)*
7. Are there uranium resources in New York? *(No.)*
8. Does the Southwest have many oil and gas fields? *(Yes.)*
9. Can uranium miners find work in California? *(No.)*
10. Are coal and oil found in Montana? *(Yes.)*
11. Where would you expect to find water sources for hydroelectric plants? Mark them in blue on the map.

Part B

Find your state on the map. Answer this question: Are there any fuel deposits in your state? Name it or them.

Student
Activity 5



Look at the circle graph. Then answer these questions.

1. What does the graph show? *(Fuels used to produce electricity.)*
2. How many kinds of fuel are on the graph? *(Five.)*
3. Which fuel is used the most? *(Coal.)*
4. Which fuel is used the <u>least</u>? *(Nuclear.)*
5. Write the name of the fuel or the amount used in the chart.

(Nuclear)	Oil	*(Water Power)*	Natural Gas	Coal
4%	*(17%)*	15%	*(19%)*	*(45%)*

6. What is the total amount of fuel used? Add the percentages. *(15 + 19 + 17 + 45 + 4 = 100)*

Student Activity 6 (Teacher)

Crossword Puzzle Using Vocabulary Words from Lesson 3

```
              2O
         1F    I
       6C O  A L
          S
     7G A S
          I
    8N U C L E A R   4U
          F           R
          U           A
          E      3S   N       5H
       9E L E C T R I C I T Y
          S      E    U       D
                 A    M       R
                 M            O
                              E
                              L
            10T U R B I N E
                              C
                              T
                              R
                              I
                              C
```

Words to choose from:

1. Coal
2. Electricity
3. Fossil Fuels
4. Gas
5. Uranium
6. Hydroelectric
7. Nuclear
8. Oil
9. Steam
10. Turbine

<u>Down</u>

1. Coal, oil and natural gas are _____ ______.
2. The fossil fuel we use the most.
3. Boiling water makes _____.
4. The material used in nuclear reactors is _________.
5. The production of electricity by running water.

<u>Across</u>

6. A black, solid fossil fuel.
7. Air-like fuel.
8. Another name for atomic.
9. Used by people for heat and light.
10. A wheel that is made to turn a generator by water or steam.

Lesson 4: HERE'S ENERGY CHANGING

Overview

In this lesson students are encouraged to demonstrate the conversion of electrical energy into heat, light, and motion energy.

Objectives

Students should be able to:

1. Describe one method of changing electrical energy into another kind of energy--to heat, light or to move something.
2. Identify the major steps in energy conversion; for example, from coal to electric light.
3. Put together a basic generator and test it.

Time Allotment

Three-four class periods.

Materials

Student Activity 1 Handout
Insulated wire, 6 to 8 feet
Compass
Bar magnet
Iron bar
Dry cells, size D
Nichrome wire, 6 to 10 inches
Copper wire, insulated, 3 feet
2 dry cell batteries, 6 volt, put in series
Bell or buzzer
Light bulbs, flashlight size

Background Information (Teacher Use Only)

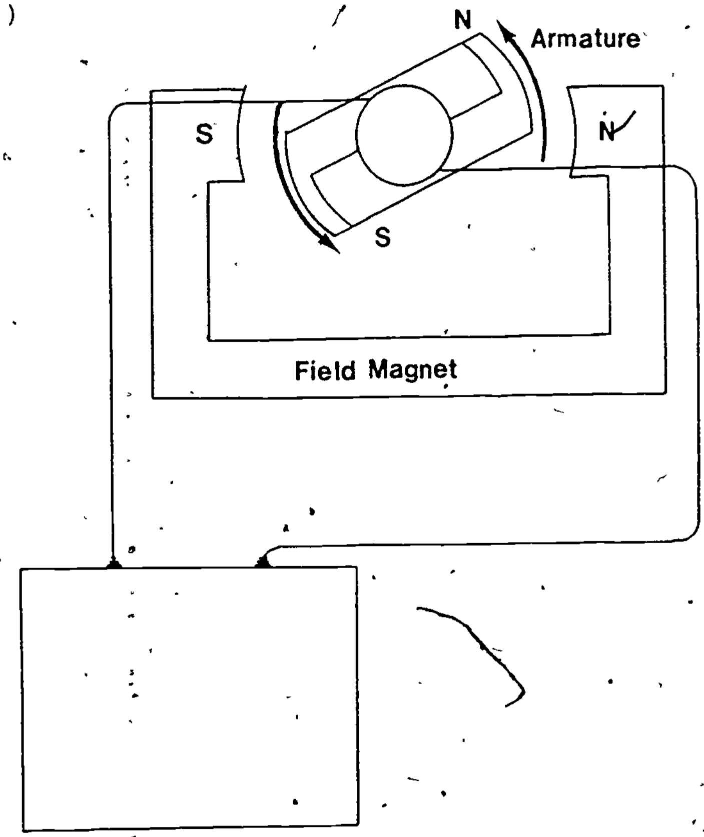
Energy conversion is the change of energy from one kind to another. For example, in a boiler furnace the energy released from the burning coal is in the form of heat. Heat is used to change water into steam. The steam is then forced to turn a wheel in a turbine which activates a generator to make electricity. This is a conversion from heat energy to mechanical energy (turning the wheel) to electrical energy. This is a simplified version of an energy chain.

A generator produces electrical energy from the energy of motion. A magnet moved through a coil of insulated wire will produce an electric current. The lines of force in the magnetic field are cut (interrupted). A generator is a machine which cuts the lines of force very quickly and produces an electric current.

Electrical energy can be used to produce heat energy, light energy, and the energy of motion. In an appliance such as a toaster, iron, coffee pot, there is a conductor. The conductor may be a coil of wire or a solid rod. The conductor will offer resistance to the flow of electricity that goes through the appliance when you turn it on. Heat is produced from this resistance.

Where electricity is used to produce light, the conductor gets hot enough to give off light. Conductors may be long, thin wires as in light bulbs or gases as in neon lights.

The production of motion from electricity may be seen as the reverse of the process of a generator. Parts of a motor may be two electromagnets. One is fixed; the other is in the armature and it rotates inside the field magnet. If current is furnished to these magnets, they then have north and south poles. The opposite poles will attract each other. The armature moves free and the opposite poles of the two magnets attract. The motor doesn't stop here because the current in the armature is then reversed which reverses the poles. This means like poles will repel each other. These two events of attracting and repelling keep the motor turning. (See diagram below.)



Teaching Strategies	Distribute duplicated class sets of Student Activity 1. Have students read the paragraph about the production of electricity. Then label each part of the diagram and cut each out. Place the pictures in the proper order. *(Boiler turbine . generator)*
Developing the Lesson	Turn the class attention to Activity 2. Tell the class that they will make a generator and describe how it works. (Discuss each question upon the completion of the activity.)
	"How can electrical energy be converted to other energy forms--heat, light, and motion?" Distribute the materials for Activities 3, 4, and 5, following the directions printed on each paper. At the end of each activity, sum up the learning in a short discussion session.
Extending the Lesson	Have the class make a list of the appliances in their homes that convert electrical energy to heat, light, and motion energy. Make a large chart for the classroom. Have students find pictures of the appliances to place under each category to make a more eye-catching display.

ELECTRICAL ENERGY CHANGED TO:

HEAT	LIGHT	MOTION
Stove	Lamps - all varieties	Doorbell
Iron		Mixer
Toaster	Flashlight	Typewriter

etc.

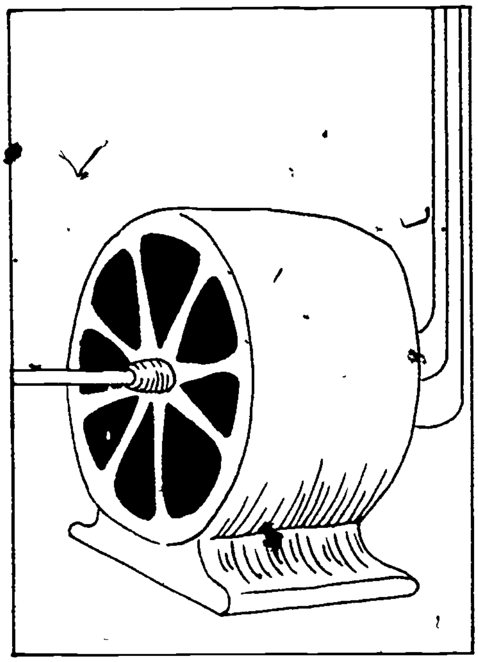
Lesson 4

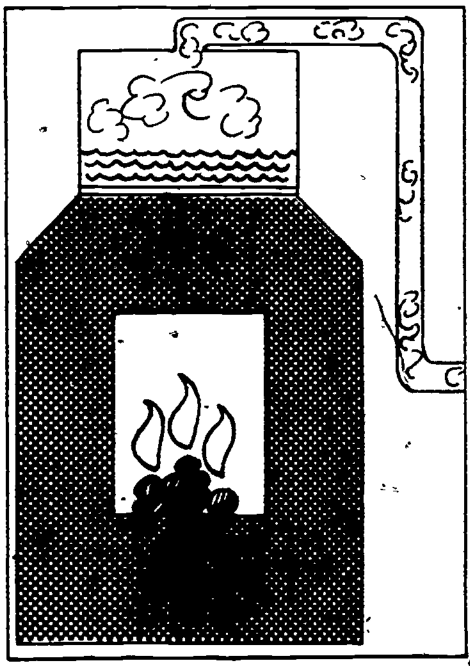
Student Activity 1

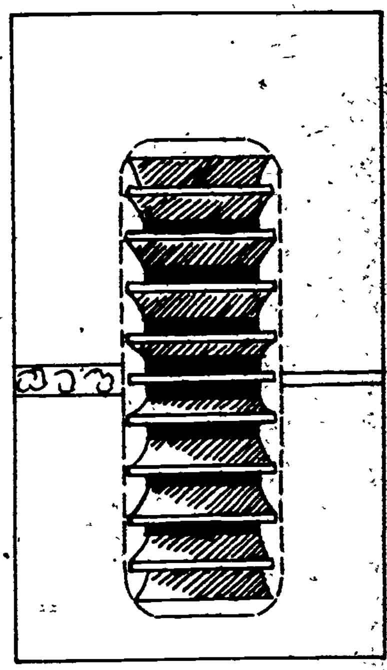
The Flow of Energy from Coal to Electricity

One way of producing electricity is to burn coal in a boiler furnace. The heat of the burning coal creates steam in the boiler. The steam turns the turbine and causes it to spin the moving part of the electrical generator. The generator changes this energy of motion into electrical energy.

Label each part. Then cut each part out and paste in the correct order in your notebook.







Student Activity 2

Materials:

1. Coil of wire (50 loops)
2. Compass.
3. One bar magnet
4. Paper tube or piece of iron

Procedure:

Arrange the materials as shown, making sure that the coil of wire is parallel to the needle of the compass. (See place marked A.) Move the magnet back and forth through the coil of wire. Observe the compass needle. You have made a model of a generator.

Questions:

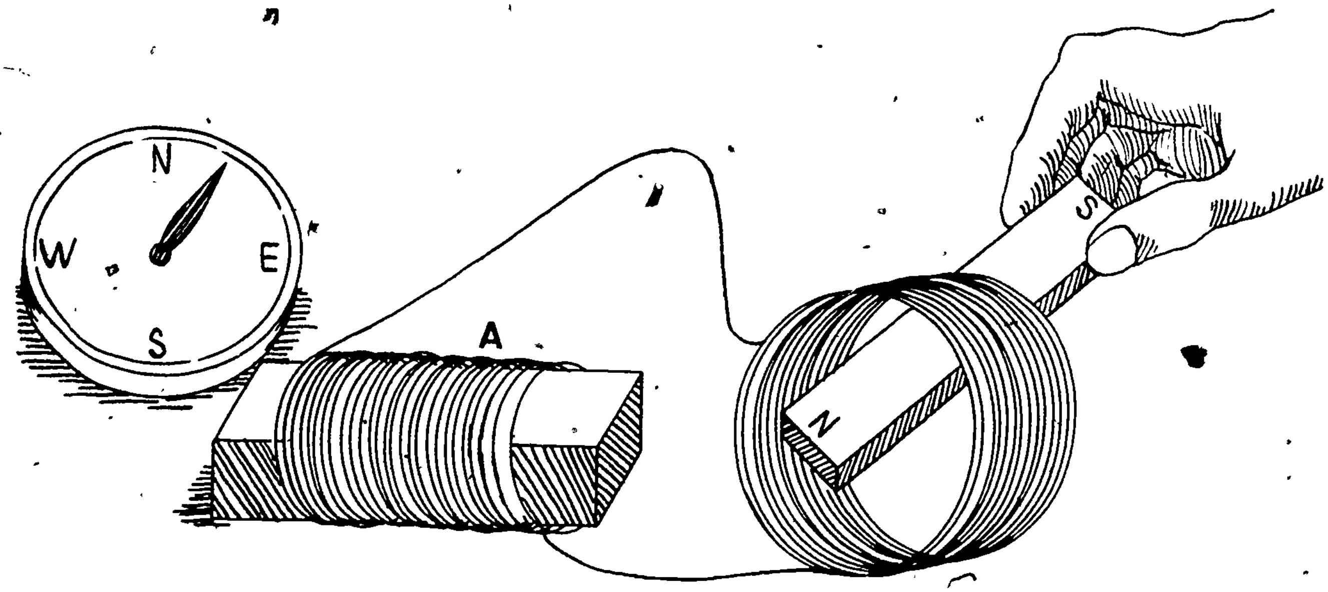
1. What happens to the compass needle when the magnet is moved in and out of the coil?
   (Compass needle moves.)

2. What happens to the compass needle when you don't move the magnet in and out of the coil?
   (Compass needle doesn't move. It points north.)

3. Point to these parts in the picture:

   magnet   wire   compass   compass needle

   (Check student responses informally.)



Student Activity 3 — Electrical Energy to Heat Energy

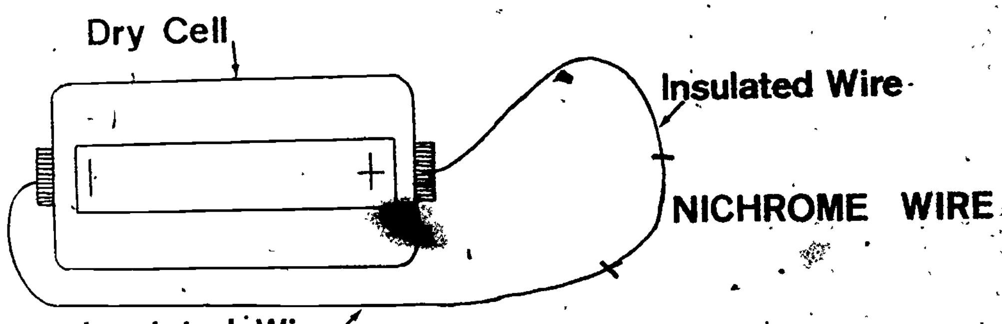
Materials:

1. Dry cell, size D
2. Length of insulated wire
3. Nichrome wire

Procedure:

Divide the class into small groups. Distribute the materials. Name each material as it is being distributed. Have students connect the nichrome wire to bared ends of the insulated wire, attached to the dry cell. "How does this make a circuit? What happens? Why did the wire become hot? If the dry cell contains electrical energy, what did this electrical energy get changed into?" *(Heat energy.)*

Special Note: Perhaps you should warn students not to touch the nichrome wire too long. It becomes hot!



Student Activity 4

Electrical Energy to Light Energy

Materials:

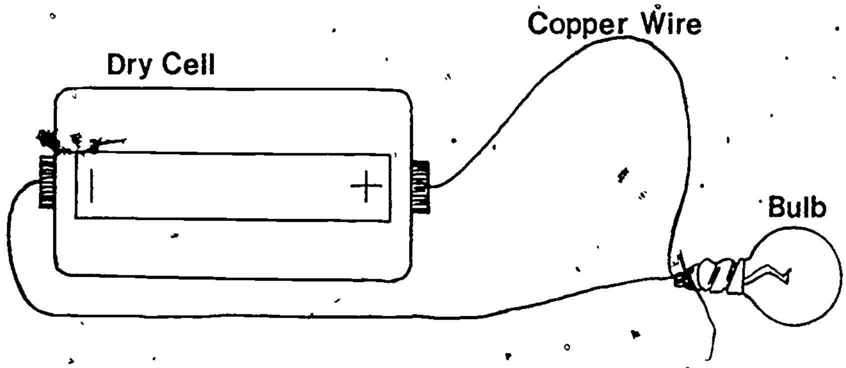
1. Dry cell, size D
2. Flashlight bulbs
3. Insulated copper wire

Procedure:

Divide the class into small groups. Refer them to the circuits they constructed in Lesson 2. Distribute lengths of wire, a bulb, a dry cell battery to each group. Have students connect these materials in such a way as to light the bulb. See diagram below.

This experiment should demonstrate electrical energy changing into light energy. The electrical energy is stored in the dry cell's chemicals. Light energy is represented by the lighting of the flashlight bulb.

Special Note: You may wish to challenge the students by offering a special ribbon to the groups with the speediest times in lighting and keeping their bulbs lit.



Student Activity 5

Electrical Energy to Energy of Motion

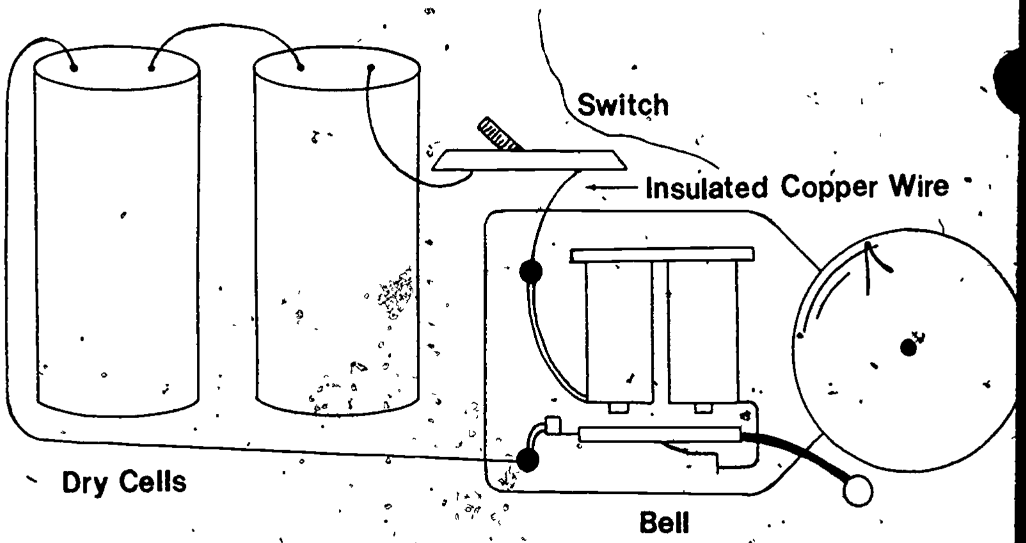
Materials:

1. Two dry cells, 6 volts each
2. Insulated copper wire
3. Bell or buzzer (borrow from high school)

Procedure:

Divide students into small groups. Have one group do the activity at a time. You will then need less materials. Distribute these to the first group. Name the materials as you do so. Suggest that the students connect the bell to the insulated wire and to the dry cells as shown.

"What happened?" *(The bell rang.)* "What did you change electrical energy into?" *(Changed into sound energy, which is a form of motion.)* Discuss why sound is a form of motion. *(Sound is carried by the motion of molecules.)*



Lesson 5: IT'S ENERGY YOU PAY FOR

Overview

This lesson is designed to give your students experiences that show them the role of the consumer in the energy network. They will examine some of the relationship between the use of electric appliances and an electric bill. The importance of conserving electrical energy will be stressed in the lesson.

Objectives

Students should be able to:

1. Read an electric meter.
2. Identify home and school appliances that affect the electric bill the most--and the least.
3. Make suggestions for saving electrical energy in the home and school.

Time Allotment

Three-five class periods.

Materials

Read-A-Meter Handout (Activity 1)
Home Inventory Checklist of Electrical Appliances
Save-A-Watt Tips
Old magazines
Large sheets of mural paper
Crayons or paints

Background Information (Teacher Use Only)

We are some of the consumers of electrical energy. Our use of electricity is part of the reason for the entire network. We need to examine our part in the network to see if we "play" wisely.

Learning to read electric meters can help in identifying ways to save energy. A watt is a measure of electric power. It measures the rate at which electricity is used. We buy electricity by the kilowatt hour. The KWH tells us how much work is being done by electrical energy.

The four dials on the electric meter record kilowatt hours by units of 10,000, 1,000, 100 and 10. If the pointer is between two numbers, read the lower number unless the pointer is between 0 and 9. Then read it as 9 because in this case 0 stands for 10.

To find how much electrical energy has been used in one month, take two meter readings one month apart. The difference (found by subtracting) will give the number of kilowatts used.

Example	8268	Reading May 1
	- 7628	Reading April 1
	640	kilowatts at .04¢ each.

640 x .04 = $25.60

To approximate how much electrical energy is used to heat or cool your home, read the meter in the evening and again in the morning. These readings should be taken before and after all appliances are in use. For example, take a reading at 10 pm and eight hours later, take a 6 am reading. Subtract the evening reading from the morning one. The final figure will give you the approximate number of kilowatt hours used in an eight-hour period. To get the approximate kilowatt hours for a 24-hour period, multiply the above answer by three.

Teaching Strategies

Ask: "How does the Electric Company know how much to charge your family for electricity each month? How often does the meter reader come to your house? Have you ever seen him/her? Can you read a meter?"

Developing the Lesson

Activity 1

Tell the students that their electric meters should look like the house meter itself. Distribute Activity Sheet 1. Help students understand that the kilowatt is the measure of the amount of electricity used. Assist students in answering the questions on meter reading.

Tell the students that when the pointer is between two numbers, they should write down the smaller number. (Be sure they read 0 as meaning 10.) Allow ample time for students to answer questions 1 and 2.

Answers: *1. 7628*
2. 640 KW $24.60

Special Note: You may wish to do more meter readings with the students. If so, have students answer questions 3 and 4.

Activity 2 — Have students do this activity for homework. It will help prepare them to think about ways to save energy.

Activity 3 — Have students complete this activity in class. Suggest that a "Save Electricity" poster contest might be fun. Students can do individual designs or cooperate with some of their classmates in making a large poster for a hallway bulletin board.

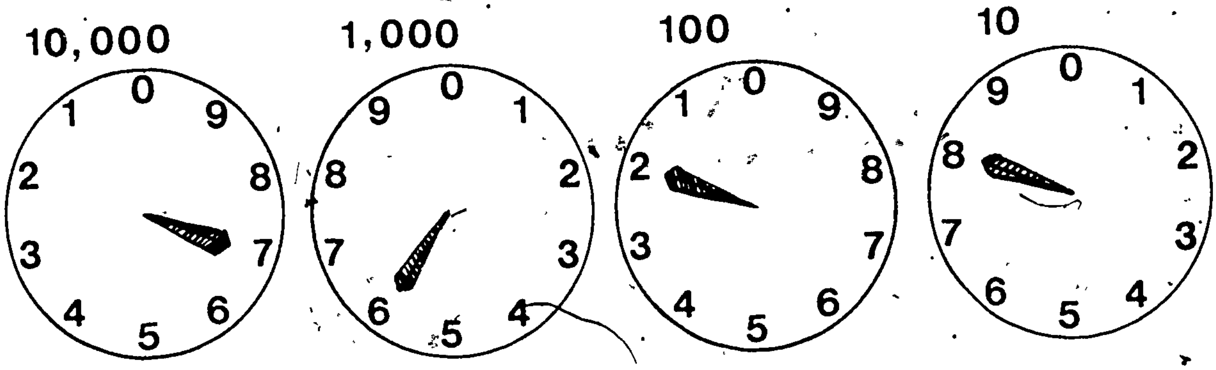
Activity 4 — Ask students to bring magazines and newspapers to class. Divide the class into small working groups and have them classify pictures under one of the topics. Encourage students to find other pictures for the appropriate headings, if they choose to do so.

Extending the Learning — Make an Energy Network Mural using large sheets of roll paper, paints and crayons. Have them use their own ideas on some or all of the following:

- Sources of Energy
- How Energy is Used
- Conversion of Energy
- Power Plants
- Transporting Electrical Energy in the City
- How We Use Energy in Our Homes and in Our School
- Pollution (Effects on the Environment)

Lesson 5

Student Activity 1 Read-A-Meter Exercise Sheet



LEARNING TO READ METERS CAN HELP YOU LEARN TO SAVE ENERGY

The four dials on your meter record kilowatt hours. Steps to follow:

1. Write down the number the pointer is pointing to. Your answer for reading the meter above is __________.

2. To find how much electrical energy you've used in one month you must take two readings one month apart. Then you subtract.

   Example: November 1 reading: 8268
   October 1 reading: - 7628
   Difference: ______ kilowatts used.

   One kilowatt costs 4¢. Multiply your answer x 4¢ to find the cost.

3. What would you do to find out the amount of electrical energy used in a day?

4. To find out about how much is used to heat or cool your home in a 24 hour period, read the meter at bedtime and again in the morning before other appliances are turned on.

   Example: 6 am reading......
   10 pm reading...... ______ Subtract
   Wattage used in 8 hours:

5. Find the meter in the school. Compare school and home meter readings. Subtract. Which uses more energy? Can you think of some reasons why? List them.

Student Activity 2

Checklist for an Inventory of Home Electrical Appliances

Directions:

1. Take this checklist home and put a checkmark by each appliance you find there.
2. Which appliances use the most energy in your home? Circle them.

	Est. kw-hr[(a)] Consumed Annually
FOOD PREPARATION	
Blender	15
Broiler	100
Carving Knife	8
Coffee Maker	106
Deep Fryer	83
Dishwasher	363
Egg Cooker	14
Frying Pan	186
Hot Plate	90
Mixer	13
Oven, Microwave (only)	190
Range	
with Oven	1,175
with Self-cleaning Oven	1,205
Roaster	205
Sandwich Grill	33
Toaster	39
Trash Compactor	50
Waffle Iron	22
Waste Disposer	30
FOOD PRESERVATION	
Freezer	1,195
frostless	1,761
Refrigerator	728
frostless	1,217
Refrigerator/Freezer	1,137
frostless	1,829
LAUNDRY	
Clothes Dryer	993
Iron (hand)	144
Washing Machine (automatic)	103
Washing Machine (non-automatic)	76
Water Heater	4,219
Quick Recovery	4,811

	Est. kw-hr[a] Consumed Annually
COMFORT CONDITIONING	
Air Cleaner	216
Air Conditioner (room)	860
Bed Covering	147
Dehumidifier	377
Fan (attic)	291
Fan (circulating)	43
Fan (rollaway)	138
Fan (window)	170
Heater (portable)	176
Heating Pad	10
Humidifier	163
Heater (portable)	170
Heating Pad	10
HEALTH & BEAUTY	
Hair Dryer	14
Heat Lamp (infrared)	13
Shaver	1.8
Sun Lamp	16
Tooth Brush	0.5
Vibrator	2
HOME ENTERTAINMENT	
Radio	86
Radio/Record Player	109
Television	
Black-&-White	
Tube Type	350
Solid State	120
Color	
Tube Type	660
Solid State	440
HOUSEWARES	
Clock	17
Floor Polisher	15
Sewing Machine	11
Vacuum Cleaner	46

(a) kw-hr = kilowatt-hour

The checklist is from the <u>Energy-Environment Source Book</u>, by John Fowler, published by National Science Teachers Association, 1975.

Student Activity 3

Tips for How to Save-A-Watt

Here are some energy-saving tips. Can you think of some other ways to save energy in the following categories?

A. Plug-ins/Other
   1. Turn off lights when not in use.
   2. *Be sure office machines, appliances, radios and T.V.'s are turned off when not in use.*
   3. *Small appliances often do jobs more easily and cheaper than an electric range.*
   4. *Operate the clothes dryer with a full load, but don't overload it.*

B. Water Heating
   1. Wash dishes by hand or use the dishwasher when it is full.
   2. *Operate your washing machine with a full load. Remember many fabrics wash better in cold water.*
   3. *Save water too. Showers use much less water than baths. Don't let water run needlessly, especially while brushing teeth.*
   4. *Check and repair all leaky faucets.*

C. Heating/Cooling
   1. Lower the thermostat at night and when leaving on a trip.
   2. *The outside door lets hot air in in the summer and cold air in in the winter. Be sure it closes tightly after you use it.*
   3. *Insulate your attic to use less energy for heating in the winter.*
   4. *Wear a sweater in the house in the winter and set your thermostat a little lower.*

Note: Accept all reasonable "Tips" from your students!

Student Activity 4

Save-A-Watt Ideas for a Scrapbook or Display (small murals, collage, etc.)

Students can collect pictures of appliances which use electricity. These pictures can be classified any number of ways:

a. Those which use more energy vs. those which use less.
b. Those which we can turn down or turn off in an effort to conserve energy.
c. Battery-operated vs. plug-ins
d. Those which are most necessary vs. those which are "convenience" or "luxury" appliances.

Lesson 6: HOW OUR NEED FOR COAL EFFECTS THE ENVIRONMENT

Overview

This lesson deals with some of the problems created when humans make changes in the environment. In this lesson the students study the changes made by the mining and burning of coal to produce electricity.

Objectives

Students should be able to:

1. Identify some of the environmental changes caused by the mining and burning of coal.
2. Suggest alternatives to present-day practices in coal production which would lessen the damages to our air, soil, water.

Time Allotment

Two-three class periods.

Materials

Classroom set of court trial script
Pictures showing positive and negative sides of coal mining
Costumes (optional)

Background Information (Teacher Use Only)

Coal is abundant in the United States. About half of our electricity is generated from this energy source. The environmental problems created from the mining and burning of coal should not be overlooked.

Coal is mined in various ways. Strip mining and underground mining are just two ways. Strip mining has the most obvious devastating environmental effect. Coal mining can be hazardous to the miners. For example, black lung disease has been costly to the miners in both misery and money. Mine accidents pose another threat to the miners.

There are other problems associated with generating electrical energy. Burning coal releases harmful pollutants which affect the land, water, and air. For example, sulfur creates acid water.

Sulfur is also discharged into the air forming smog which is dangerous to animals (including humans) and crops. Carbon dioxide given off into the atmosphere has created climatic problems. Hot water from the power plants is dumped into rivers. This dumping affects the aquatic life. Another problem to be addressed is that of the high power lines and towers used in transporting the electricity. Millions of acres of land are used for the purpose of putting these lines up. They are unattractive and potentially dangerous.

Congress has passed legislation which regulates the activities of the utility companies relative to the environment. The Clean Air Act establishes guidelines to bring about more control of utility emissions. The Water Quality Act sets the standards for water quality.

Electrical energy is needed. Our society functions at its present level only with the vital assistance of electrical energy. As other sources of energy are employed to generate electricity, it is found that they too create environmental problems. The question becomes: How can we reduce the amount of environmental damage without making electrical energy too expensive?

From Energy-Environment Source Book, John M. Fowler (Washington, D.C.: NSTA) 1975. pp. 13-15.

Teaching Strategies

One Day Ahead

Ask: "How many of you have been inside a courtroom or have watched a trial on television?"
"Why do people have trials?"
"Is a trial a fair way to decide something? Why or why not?"

Allow enough time for the class to decide why trials are important and to share what they know about courtroom procedure. Then suggest that the class could have a trial, but instead of trying a criminal they could try coal. The case would decide whether or not coal should continue to be used to produce electricity. Prior to assigning students to roles, be sure to list and explain them.

Have students claim the roles they would like to take in the simulation, or assign them to roles. The trial will need:

Judge (1)	
Lawyers (4)	Two Environmentalist lawyers, a Coal Company lawyer, and a Utility Company lawyer.
Jurors (12)	You may prefer to have less than twelve, since civil cases do not require the full twelve; or you may prefer to use a large portion of the class.
Witnesses	(Optional) If witnesses are used, have these students write their own parts.
Reporters (4)	Two newspaper; two T.V.
Spectators	Remaining class members, or another interested class may be invited to the classroom to watch the proceedings.
Court Reporter	Played by the teacher. Duties are to keep a record of key points made by both sides.

Point out that in real trials the jury does not hear evidence ahead of time. They must make their decision when the case is presented for the first time. Tell the class members who are jurors that they are now excused until both the prosecution and the defense have prepared their cases. Have the jurors do Activity 2 in the meantime.

Give each lawyer a copy of the case to be tried and the pictures each will introduce as evidence. The other participants may be assigned small research topics while the lawyers put their cases together.

Students should examine such topics as:

- Black Lung Disease
- Different Kinds of Coal
- Coal Mining Methods
- How Coal Pollutes
- How Coal is Used
- How Coal Helps to Make Electricity
- Where Coal is Located in the United States

Day of the Trial

Set up the classroom furniture to imitate a typical courtroom. You will need a desk for the judge, the court reporter, and one each for the four lawyers. Twelve desks could be placed in an arrangement that would suggest a jury box. The rest of the chairs should be set aside for the spectators. Put the classroom flag near the judge's desk. The judge should wear a robe, if possible, and have a gavel.

After the Verdict

Discuss the learnings that grew out of the courtroom. Use questions such as the following:

1. Which side--prosecution or defense--made the best presentation? How did the use of <u>facts</u> help?
2. Can you think of any evidence that was not used (by either side) that <u>should</u> have been presented?
3. Why was it hard to decide right or wrong in this case?
4. Do you think there should be a re-trial, this time with more <u>facts</u> in mind?

Extending the Lesson

Conduct a field trip to one or more of the following: power plant, strip mine, deep mine, transmission substation.

Have students prepare and present reports to the class on alternative sources of electricity.

Have an electric company representative come to class and discuss:

a. How their local generating station operates.
b. How an electrical transmission system works.
c. How they try to solve their environmental problems.

Lesson 6 -

POWER SUPPLY VS. THE PEOPLE AND THE LAND

Judge	Serious-minded person, wears a dark robe and carries a gavel. Very fair.
Lawyers	Four courtroom lawyers wear coats and ties (or dressy pants or dress), carry briefcases with evidence in them. They have name tags such as Mr. Lopez, Esq.
Witnesses	We have several coughing witnesses with dirty smudges on their faces. They wear caps with lights on them.
Reporters	They always ask a lot of questions and write things down in notebooks. Some use portable tape recorders. They wear name tags with things like KWXY-TV NEWS or Super City Herald on them. They write articles for the Class Newspaper. Some only write important headlines on the chalkboard.

Proceedings

Court Reporter	(Banging a gavel) All rise for the entrance of the judge. This is the case of ------(suggested name: Save-Our-Land Citizens vs. the Many-County Coal Company).
	You may be seated.
Judge	Coal is a dependable source for making electricity, but we use coal at great risk to our environment and health. Let's look at the environmentalists' side of the story and then we shall listen to the coal mining and utility companies. Lawyers for the environmentalists, would you stand and state your case?

Lawyer 1, Environmentalist: Getting the coal from the ground hurts the environment. Strip mining damages large areas of land. A huge machine removes the soil to get the coal. This kind of mining causes erosion of the land. Often there are landslides and falling rocks.

I would like to introduce Exhibit A. (Hold up picture of strip mining.) Underground mining is damaging also. Water seeps into the abandoned mines. The water mixes with sulfur--that's something that smells like rotten eggs--which makes the water unfit to use. Yeech!

Ladies and Gentlemen of the jury, coal mining is also dangerous to the miner's health. Black lung disease has cost the miners the loss of their money and their lives. Many miners get hurt in mine accidents, too.

Lawyer 2, Environmentalist: You just heard about mining the coal. Making electricity with coal is another problem. Burning coal in the power plant gives off hot gases and sulfur which form smog.

Carbon dioxide, another substance, is given off and changes the climate. Hot water, when it is dumped into nearby rivers and lakes, changes the environment of the plants and animals that live there.

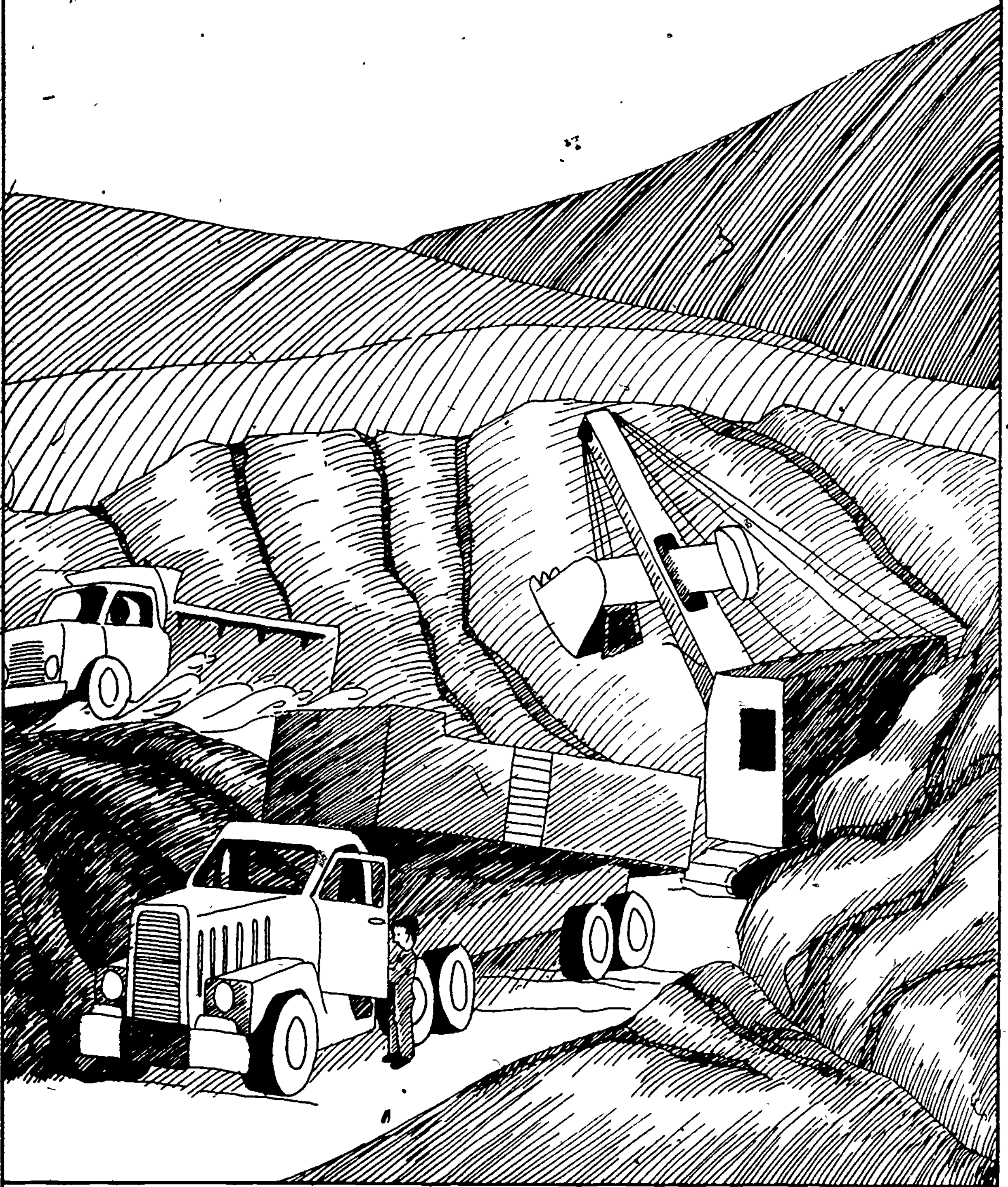
I would like to introduce Exhibit B. (Hold up and describe picture of smoke stacks.) Even after the electricity is made there are environmental problems. Ladies and Gentlemen of the jury, you have seen utility poles carrying high tension lines. You know how ugly they are! These utility poles and miles of cables need a lot of land. When these high tension lines interfere with your favorite television program, then, members of the jury, something must be done! Ladies and Gentlemen, (looking meaningfully at the jury) I rest my case.

Judge: Members of the jury, you have heard the case for the environmentalists. Since this is a special case, I will now open the court to questions from the jury. Are there any questions? (Answer questions.) Could we hear a summary of the environmentalists' case please?

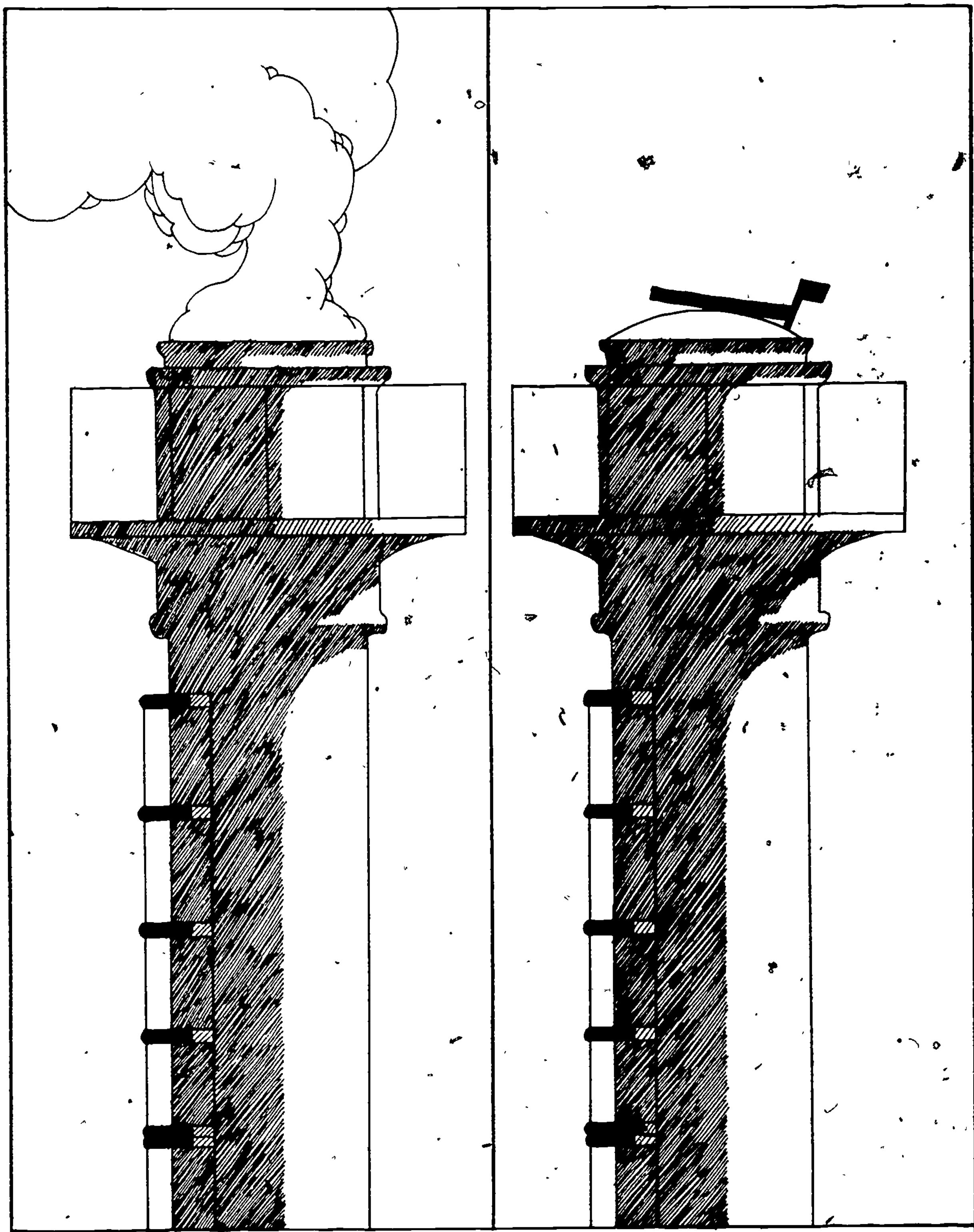
Court Reporter: (Read notes on the environmentalists' presentation.)

Judge	Now we will hear the case for the coal mining and utility companies. First we will hear from the Many-County Coal Company. Lawyer, would you state your case?
Lawyer 3 Coal Company	Ladies and Gentlemen of the jury, I am here to show you and the people that coal mining is different today. We need coal. Coal is used to make electricity for your TV. Without coal you couldn't watch TV at all. Without coal many people would not have electricity for light. We know that strip mining leaves ugly scars on the land. The coal mining companies now are bound by state law to restore land to its natural and usable state. I would like to introduce Exhibits C and D. (Show and describe picture of replanted land and recreation area.) Also, in 1970 the United States Congress passed the Coal Mine Health and Safety Act. Ladies and Gentlemen, all coal mining companies today spend a lot of time and money improving the working conditions of their miners. Safety records are much, much better. Members of the jury, I rest my case.
Judge	Now we will hear from the lawyer for the Utility Company.
Lawyer 4 Utility Company	Our companies are now following guidelines which were passed by Congress. The Water Quality Act sets the standards for water quality. The Clean Air Act gives guidelines for air pollution. Utility companies are building air cleaner plants to clean the air before it is put back into the atmosphere. Protecting the environment costs a lot of money, but we do it. I would like to introduce Exhibit E. (Show picture and describe it.) Now, many cities are placing the high tension lines underground. This way the land can be used for better things. The land is pretty without the utility poles. But, Ladies and Gentlemen, please remember that with any source of fuel used to generate electricity, there will be environmental problems.

Judge	Do the members of the jury have any questions for these lawyers? (Answer questions.) Could we have a summary of the case for the coal and power companies?
Court Reporter	(Read notes of the coal company and power company presentations.)
Judge	The jury is excused to deliberate. The court will recess for a few minutes. (Judge raps gavel; all rise as judge leaves.)
Jury	(Debate and vote by show of hands. A majority vote decides the case. One juror should knock on the door and tell the court reporter when the jury has reached a verdict.)
Court Reporter	All rise. (Spectators rise for judge and jury who re-enter the courtroom.)
Judge	Jury, do you have a verdict?
Jury Spokesperson	We have, Your Honor. (Give verdict.)
Judge	(Sum up the verdict again, then excuse the spectators and everyone else.) Court is adjourned.
Court Reporter	All rise. (Judge leaves.) You are excused.



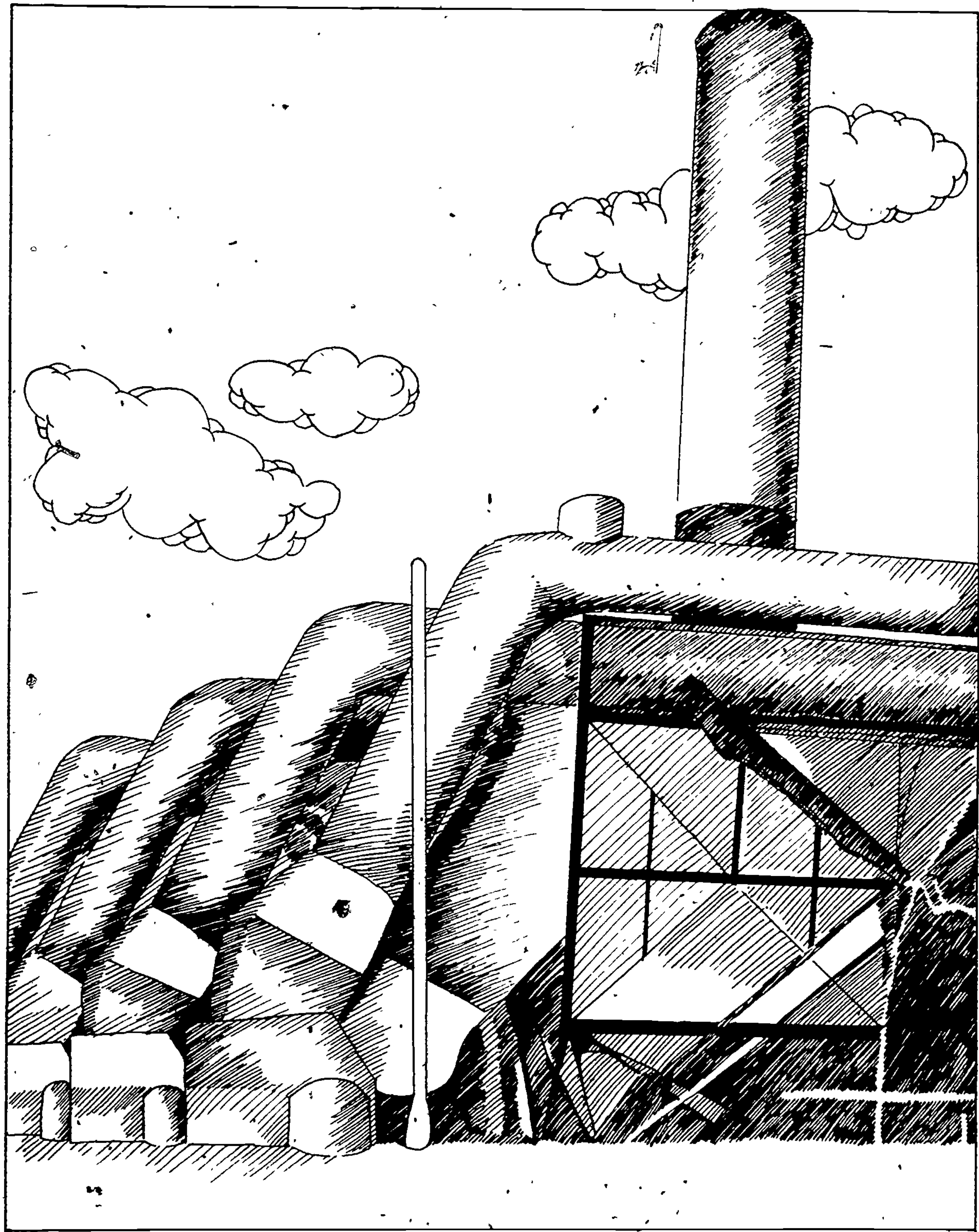
Digging for coal is noisy. It spoils the land.



Furnace stacks poured dirty smoke into the air before filters were used.

Hillside of a coal mine is being planted with trees and grass.

Watery hole where coal was taken out is being filled in to make a park.



Keeping the air clean can cost millions of dollars.

Student Activity 2 — Sources of Electrical Power

	PROBLEMS	BENEFITS
Coal	1. *Hard to get from mine*	1. *Large supply*
	2. *Causes erosion, air pollution*	2. *Relatively inexpensive*
	3. *Can be dangerous to miners*	3. *Safe to transport*
	4. *Strip mining can erode soil*	
Nuclear Power	1. *Nuclear pollution*	1. *Large supply*
	2. *Difficult to store*	2. *Clean at the power plant*
	3. *Expensive to build reactors*	
Water	1. *Expensive to build dams*	1. *Clean air*
	2. *Dams use up farm land*	2. *Constant supply*
	3. *Possibility of flood*	
	4. *Has to be transported to user*	
Natural Gas	1. *Limited supply*	1. *Efficient conversion*
	2. *Must be transported from site of production*	2. *Doesn't pollute air*
Solar/Wind	1. *Varies widely in different climates*	1. *Doesn't pollute*
	2. *Limited technology*	2. *Unlimited source*
		3. *Source is available without charge*

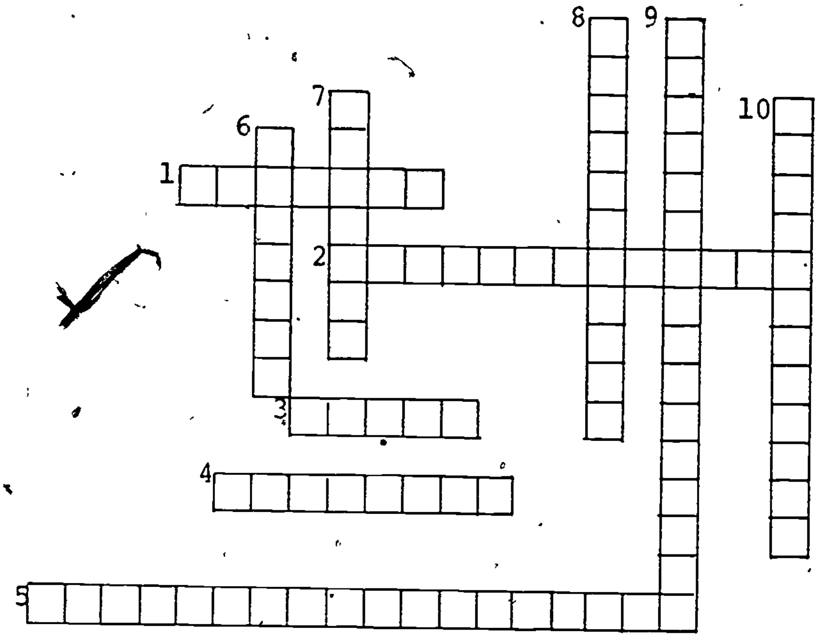
(Accept other reasonable responses.)

Student Guide

Lesson 1

Student Activity 4

BULBS AND BATTERIES CROSSWORD PUZZLE



Across

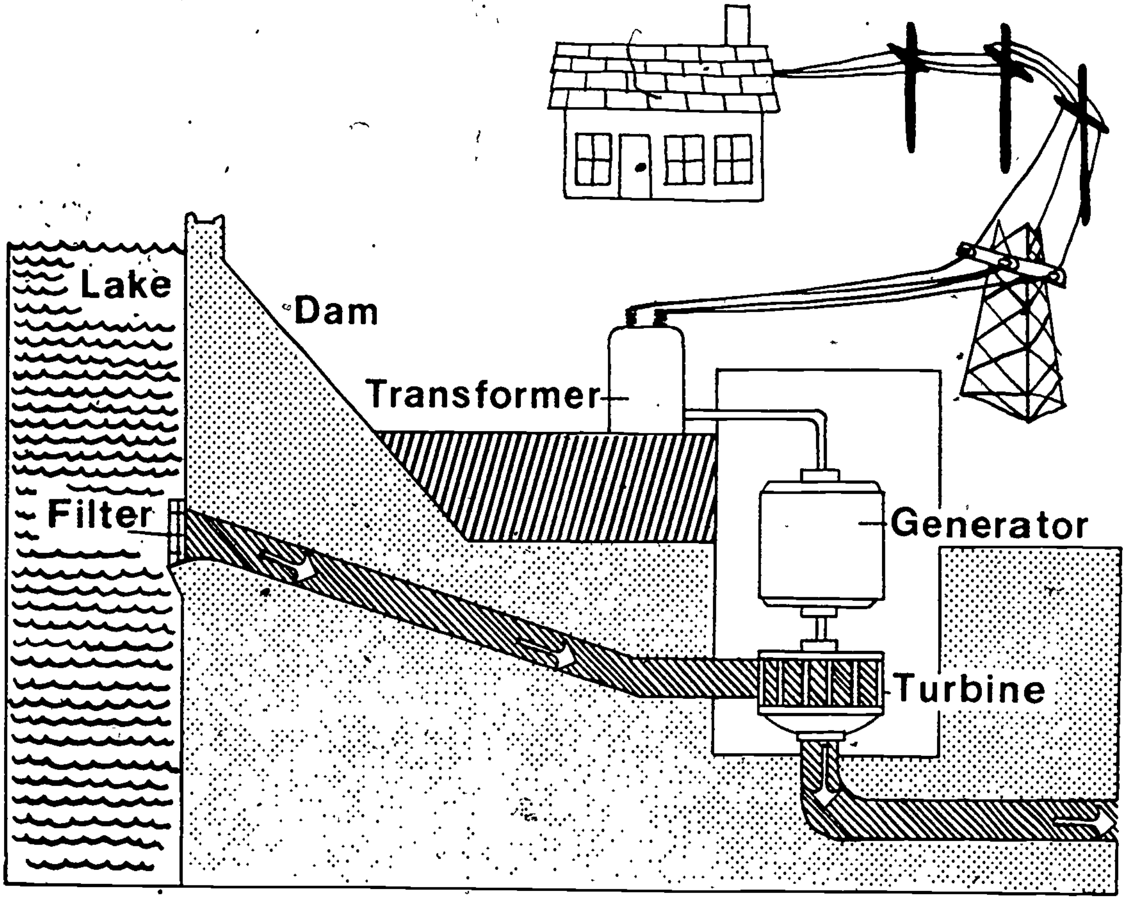
1. The source of electric energy used in this lesson.
2. Current flows in a ______ ______.
3. One way to change an electrical system is to add more ______.
4. ______ are used to open and close a circuit.
5. In a ______ ______ the current can flow through more than one path.

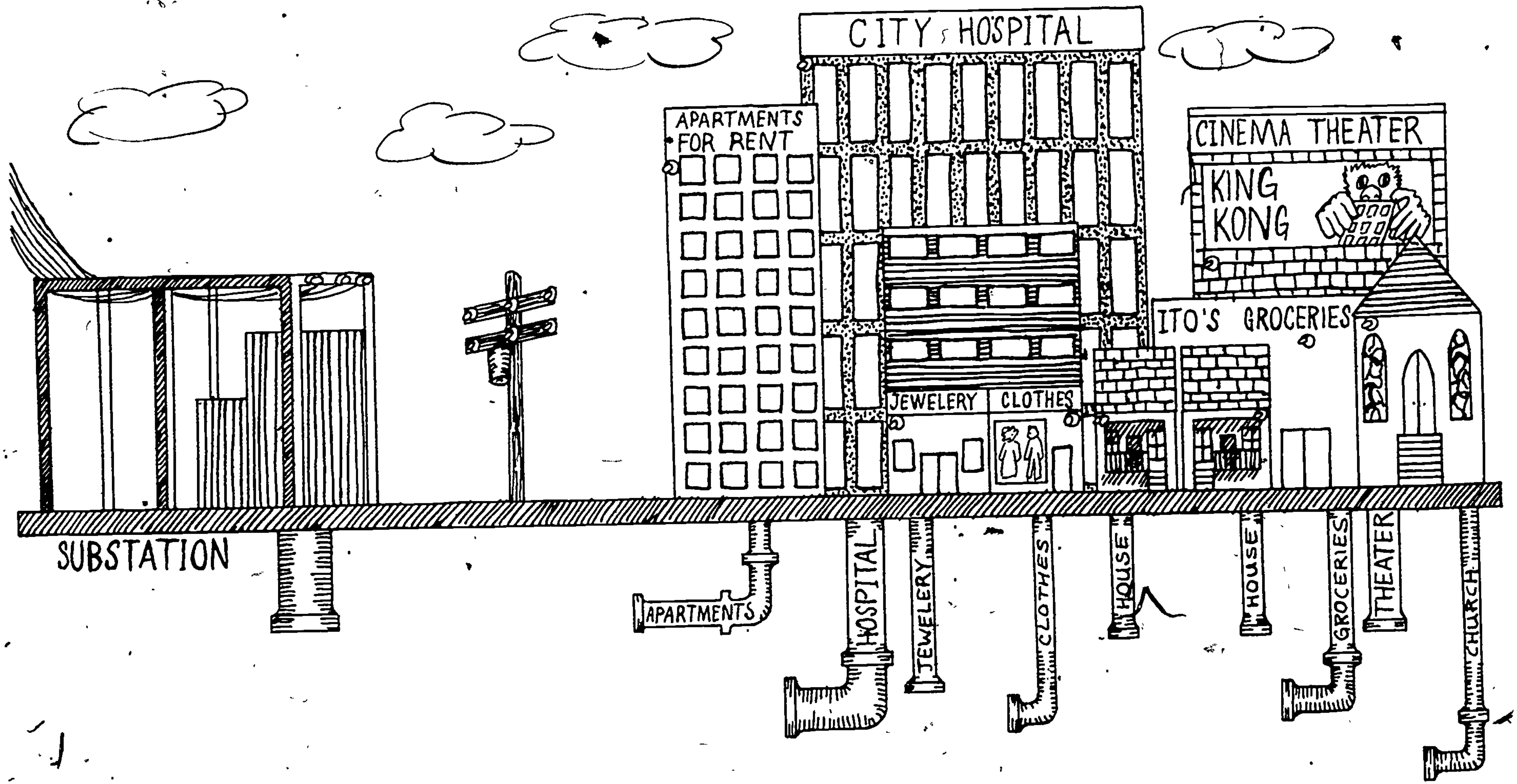
Down

6. Electrical ______ are very useful.
7. Current does not flow when we have an ______ ______.
8. ______ is a very useful form of energy.
9. In a ______ ______ the current has only one path.
10. A ______ ______ is used to explain the flow of large amounts of current that damage the system.

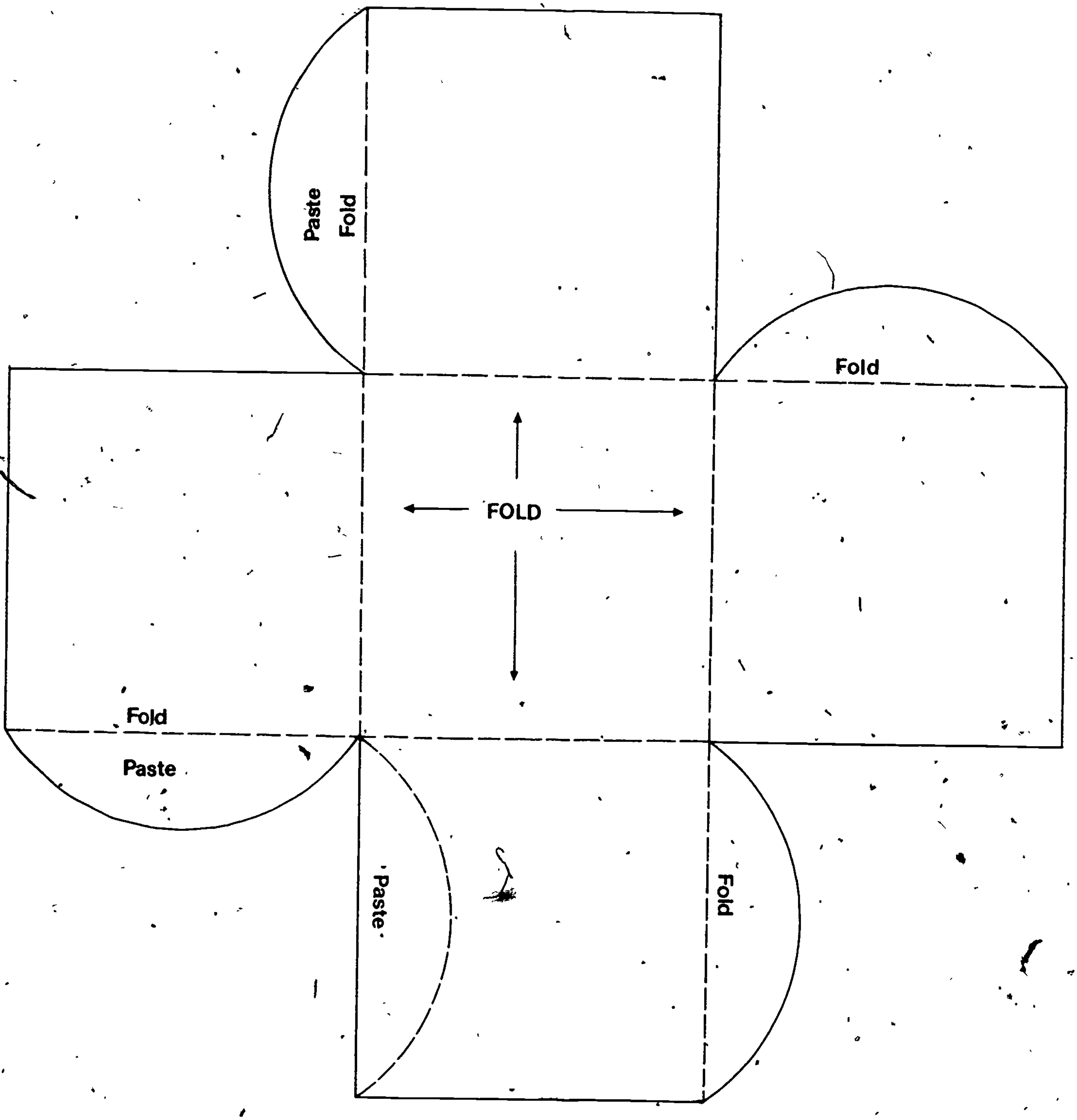
Word Box

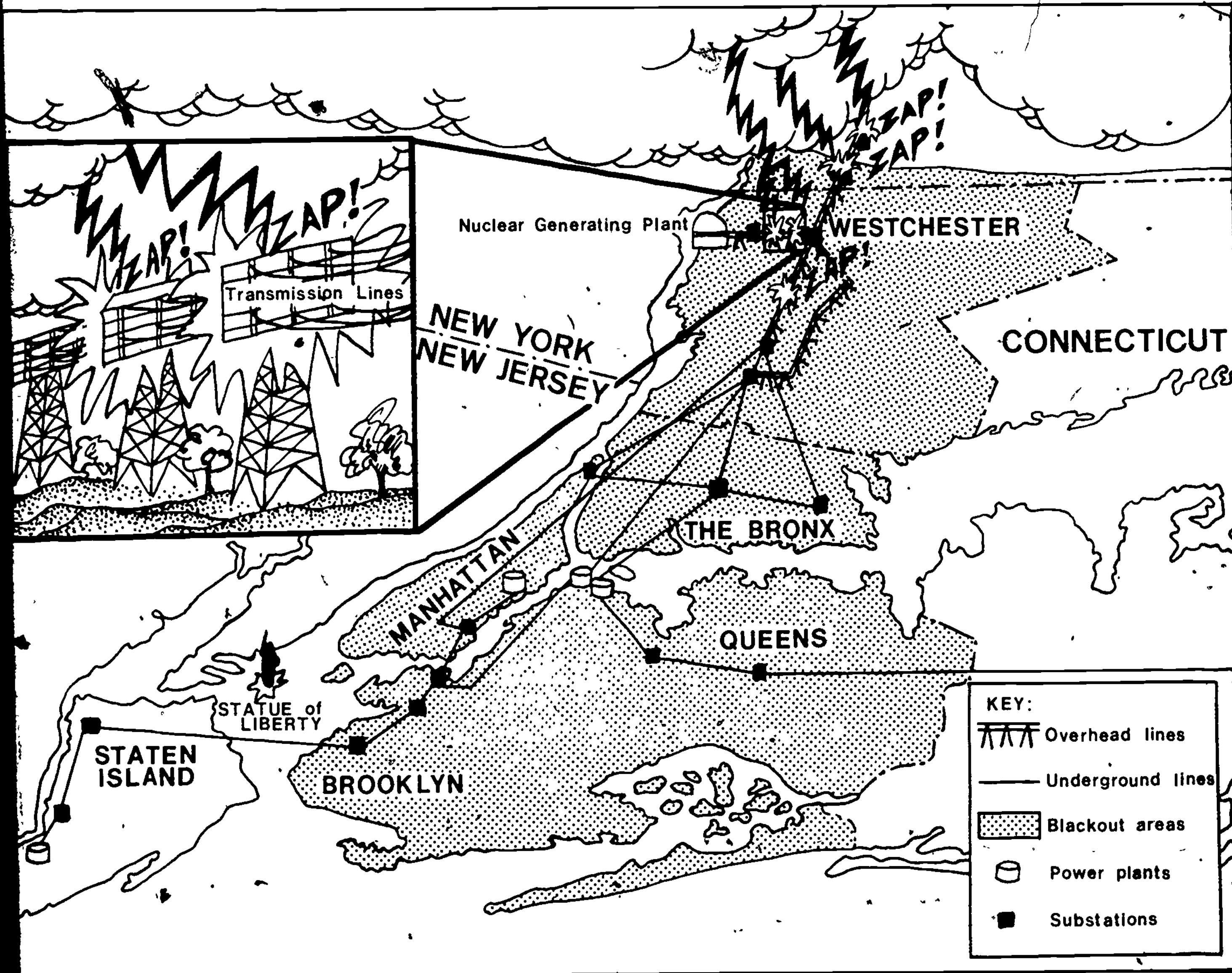
CLOSED CIRCUIT	ELECTRICITY
SERIES CONNECTION	SWITCHES
OPEN CIRCUIT	DRY CELL
SYSTEM	PARALLEL CONNECTION
SHORT CIRCUIT	BULBS

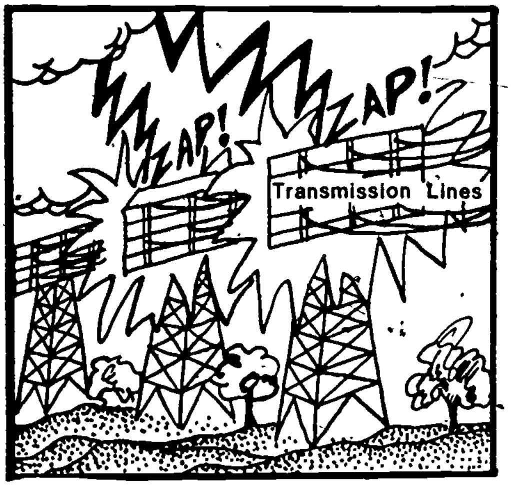

Lake
Dam
Transformer
Filter
Generator
Turbine


CITY HOSPITAL
APARTMENTS FOR RENT
CINEMA THEATER
KING KONG
ITO'S GROCERIES
JEWELERY
CLOTHES
SUBSTATION
APARTMENTS
HOSPITAL
JEWELERY
CLOTHES
HOUSE
HOUSE
GROCERIES
THEATER
CHURCH

Block Building




ZAP!
ZAP!
ZAP!
ZAP!
ZAP!
Transmission Lines
Nuclear Generating Plant
WESTCHESTER
NEW YORK
NEW JERSEY
CONNECTICUT
THE BRONX
MANHATTAN
QUEENS
STATUE of LIBERTY
STATEN ISLAND
BROOKLYN
KEY:
Overhead lines
Underground lines
Blackout areas
Power plants
Substations



New York City Blackout, July 13, 1977

New York City stopped at about 9:30 on a hot summer night. The television screen went blank. And lights went out all over the giant city. Over in the amusement park the "Wonder Wheel" stopped with people at the top. It took a long time for workmen to crank the wonder wheel down by hand and let the frightened people get on the ground again.

Trains stopped running. Airports closed down. All airplanes had to go to airports in Newark, New Jersey or Philadelphia, Pennsylvania where the lights were still on. There were no more red and green traffic lights. It became so dangerous to drive with traffic going in every direction that some people left their cars and began their long trip home on foot. Other people had to walk home in the dark when the subways and the in-city electric trains had no more electric power. When the people got to their apartment buildings, they found they had to walk up to their apartments using the stairs. The elevators didn't work either! Inside, the apartment air was hot and stuffy because fans and air conditioners quit running. People opened their windows to get some air and shook their heads in amazement at the darkness all around. Some people laughed at the darkness, but most grew very worried. All of a sudden the neighborhood seemed so different. So many dark places. What if they should get sick? Who could help them if the lights went out in the hospital?

As a matter of fact, in Bellevue Hospital, the city's largest hospital, doctors completed knee surgery on a patient by candlelight. And candles burned in nearly every room of the giant hospital.

They were used in theatres and restaurants, too. But in some places there were no candles that could be lighted. The actors and the audience had to leave dark theatres and go out into the dark streets.

"What's wrong?" everyone asked everyone else.

What went wrong was caused by lightning. During an electrical storm--which means lots of thunder and lightning--way over in Westchester County, lightning hit important power lines. These power lines connected the major power plant and the smaller power plants around New York. These power plants shared the electrical system.

Then lightning hit a large transformer near the Nuclear Generating Plant, starting a fire. The fire caused the transformer to explode and the nuclear power plant had to shut down. Engineers tried to get power from the substation to get the electricity to run the city, but they overloaded the system. The whole electrical system broke down, and blacked out a city of 10 million people!

When the electrical system didn't work, New York didn't work.

Questions about the Story

1. Think back over the story. Find the place on the map where lightning first hit the power lines.

2. Tell in your own words why the system didn't work. Point to places on the map that show the chain of events that caused the blackout.

3. List some of the ways people in the story depended on electricity.

4. Are these the same ways you use electricity?

5. How important is electricity in your life?

6. What could you use instead of electricity to...

   a. Heat your home?

   b. Have light to see by?

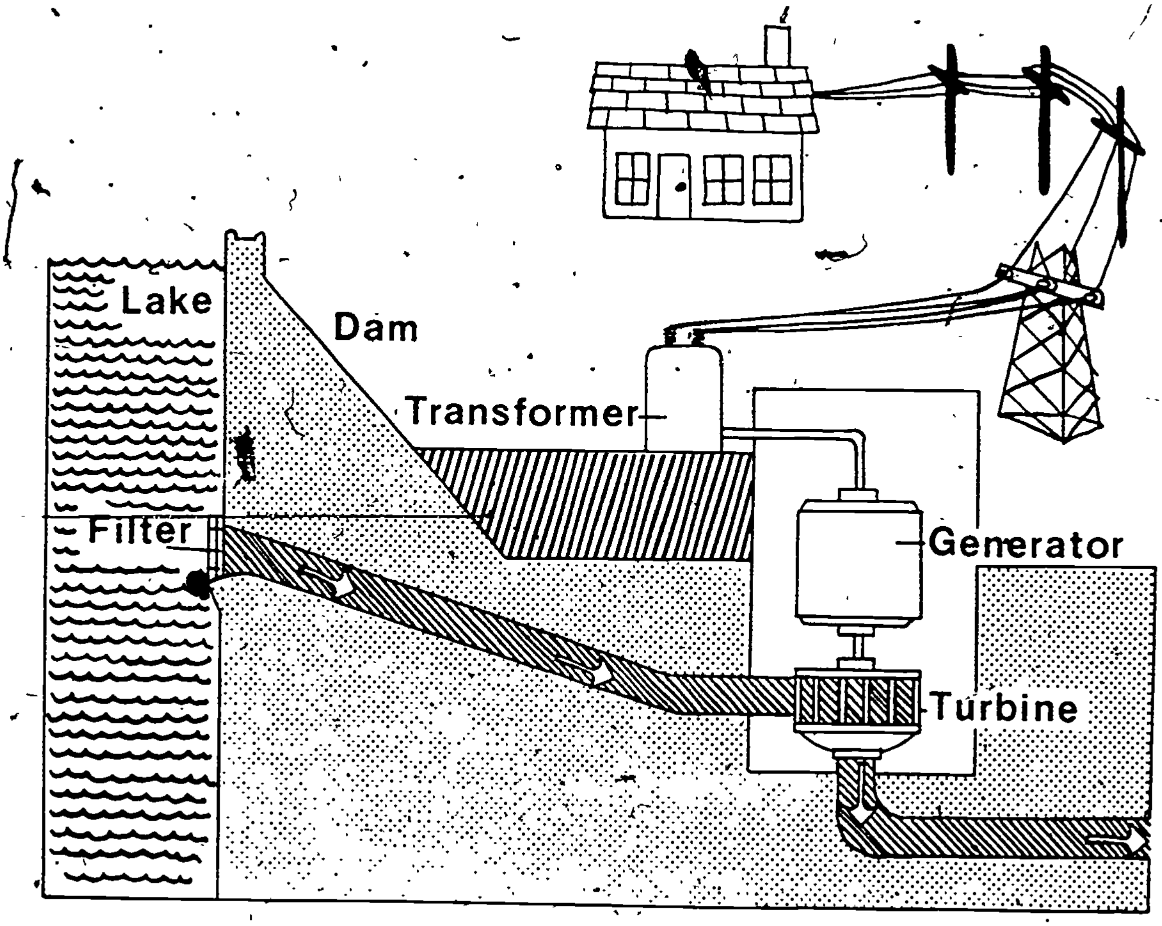
   c. Cook your food?

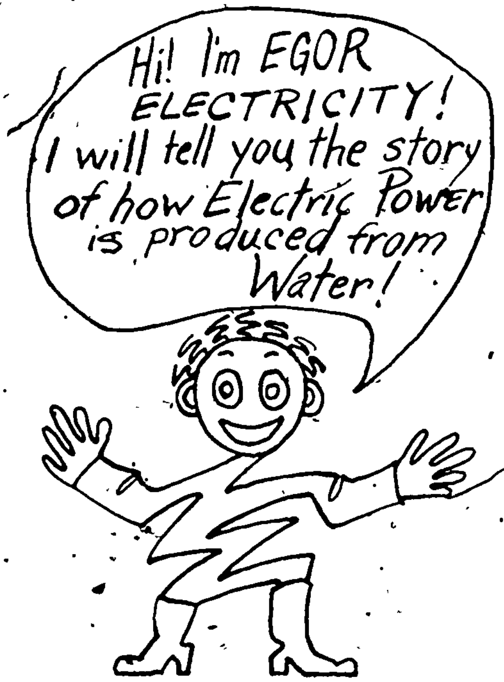
7. How well do you think your ideas will work?

8. What things that you do now could you do even if you didn't have electricity?

Lesson 3

Student Activity 1. Electricity from Falling Water

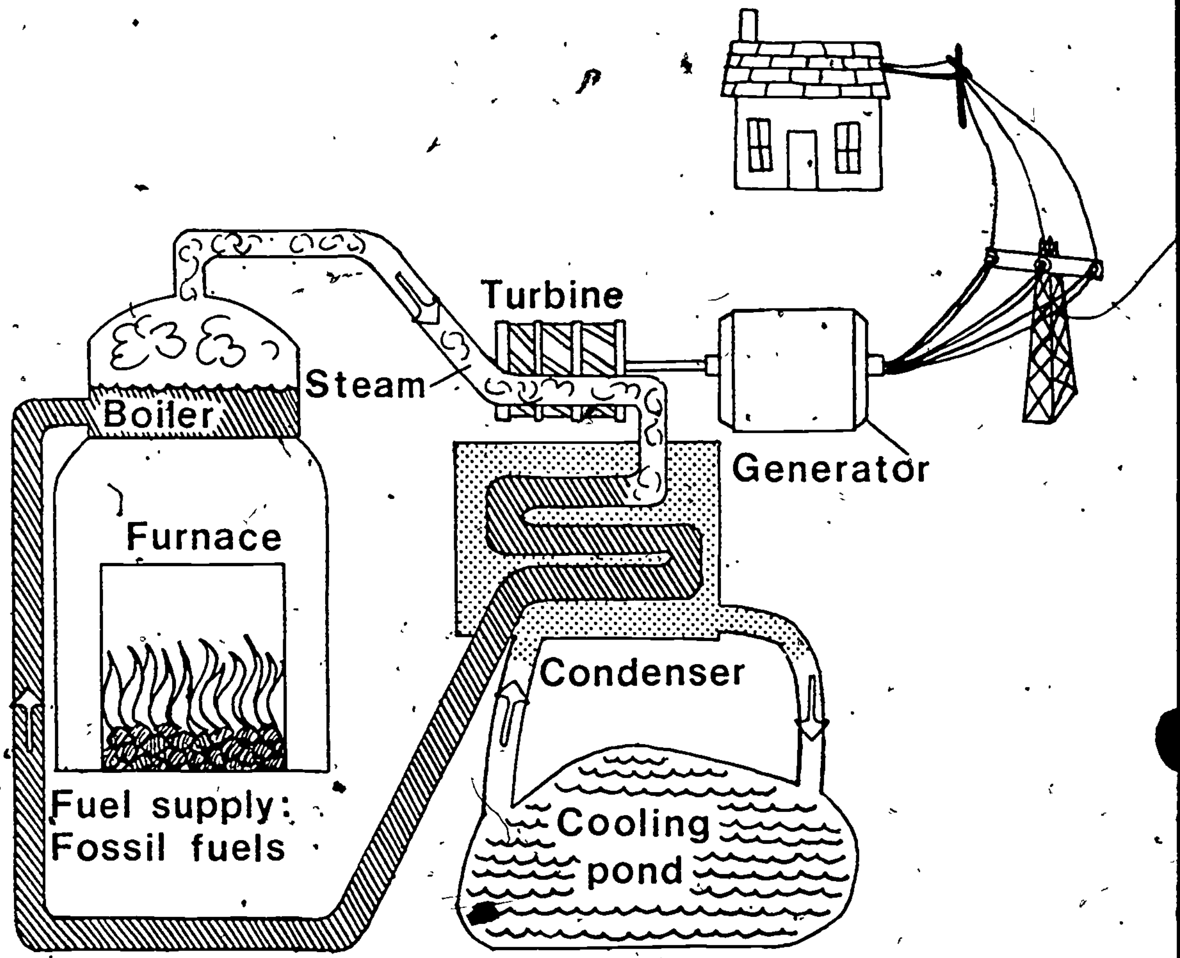


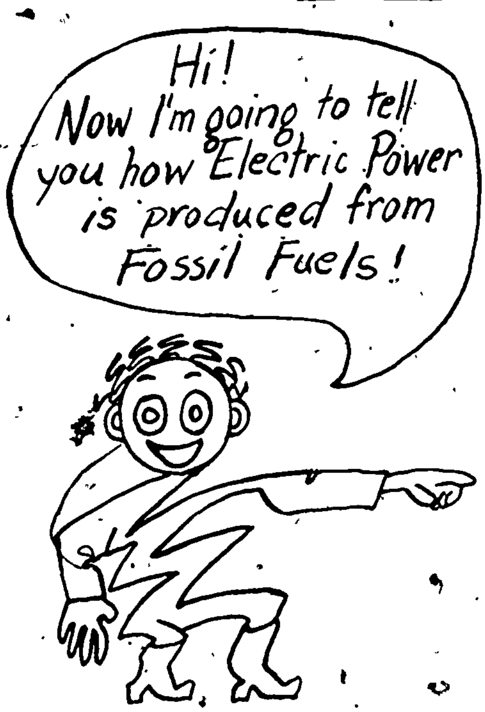


Hydroelectric power is provided by the motion of falling water. When water which has been trapped in a lake behind a dam is released as needed, it can be made to flow through the turbines which activate generators that make electricity.

Student Activity 2

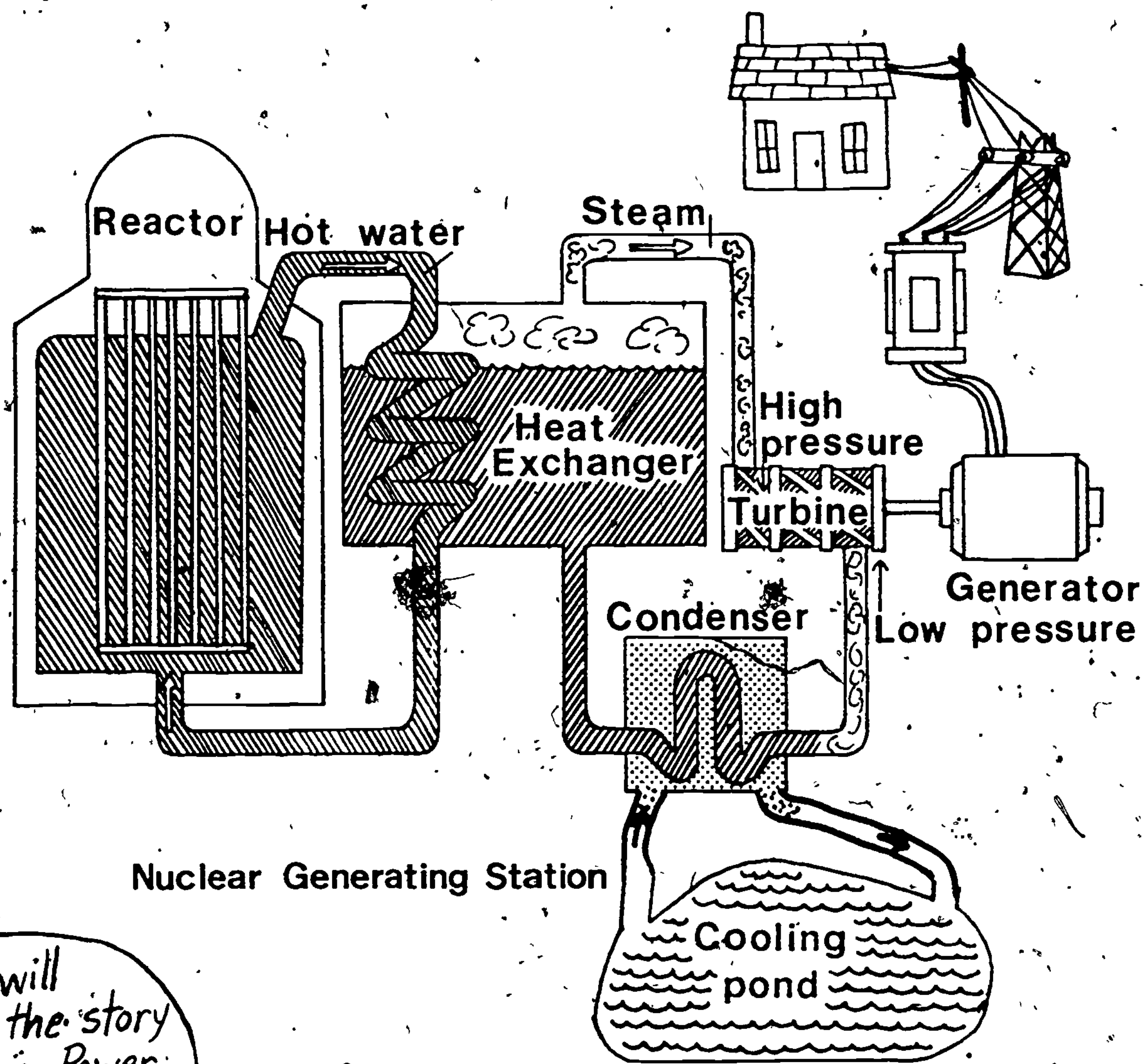
Electric Power from Fossil Fuels



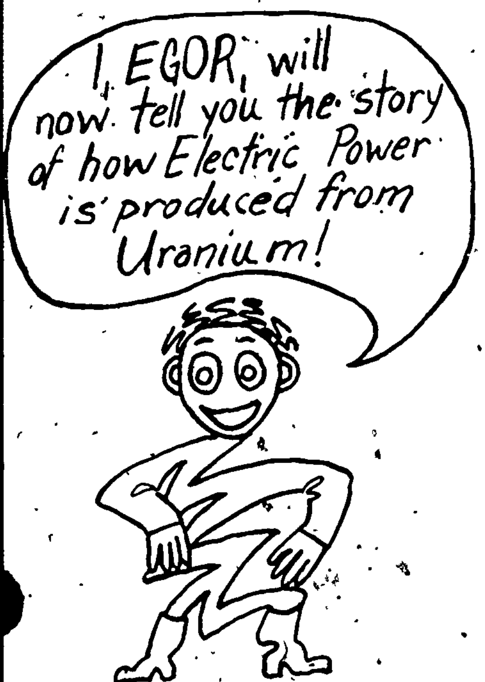


Fossil fuels (oil, gas, coal) produce electrical power by burning in a furnace to heat boilers that make steam. The steam turns a wheel called a turbine. The turbine drives a generator that makes electricity.

Student Activity 3 — Electricity from Uranium

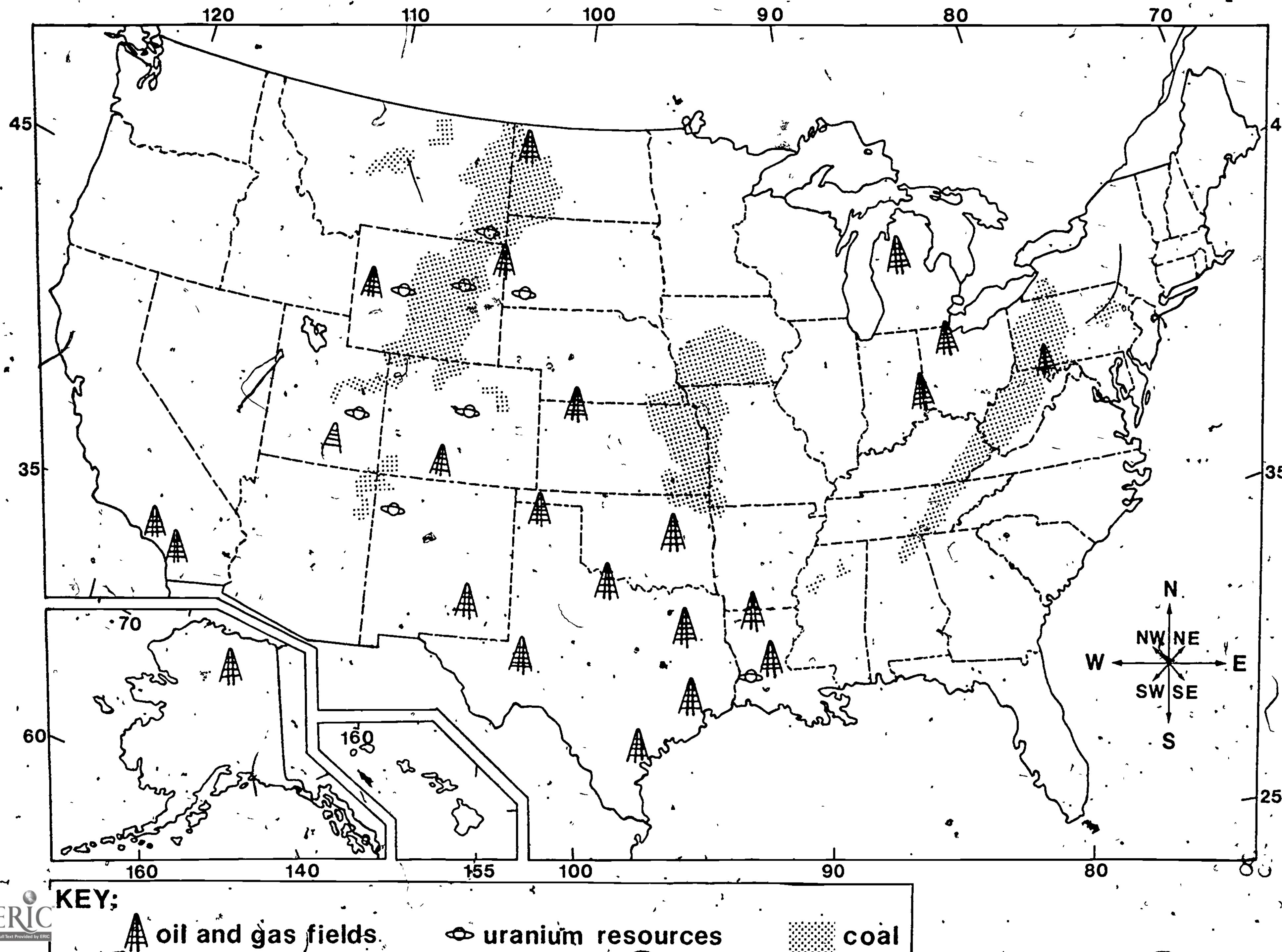


Nuclear Generating Station



Uranium is used in a nuclear reactor to produce electrical power. The uranium is split and gives off heat which makes steam from the water. The steam turns a turbine which drives a generator. The generator makes electricity.

SOURCES OF FUEL USED TO PRODUCE ELECTRICITY



Student Activity 4. Map Study Questions

Study the map, Sources of Fuel Used to Produce Electricity. Answer these sentences Yes or No.

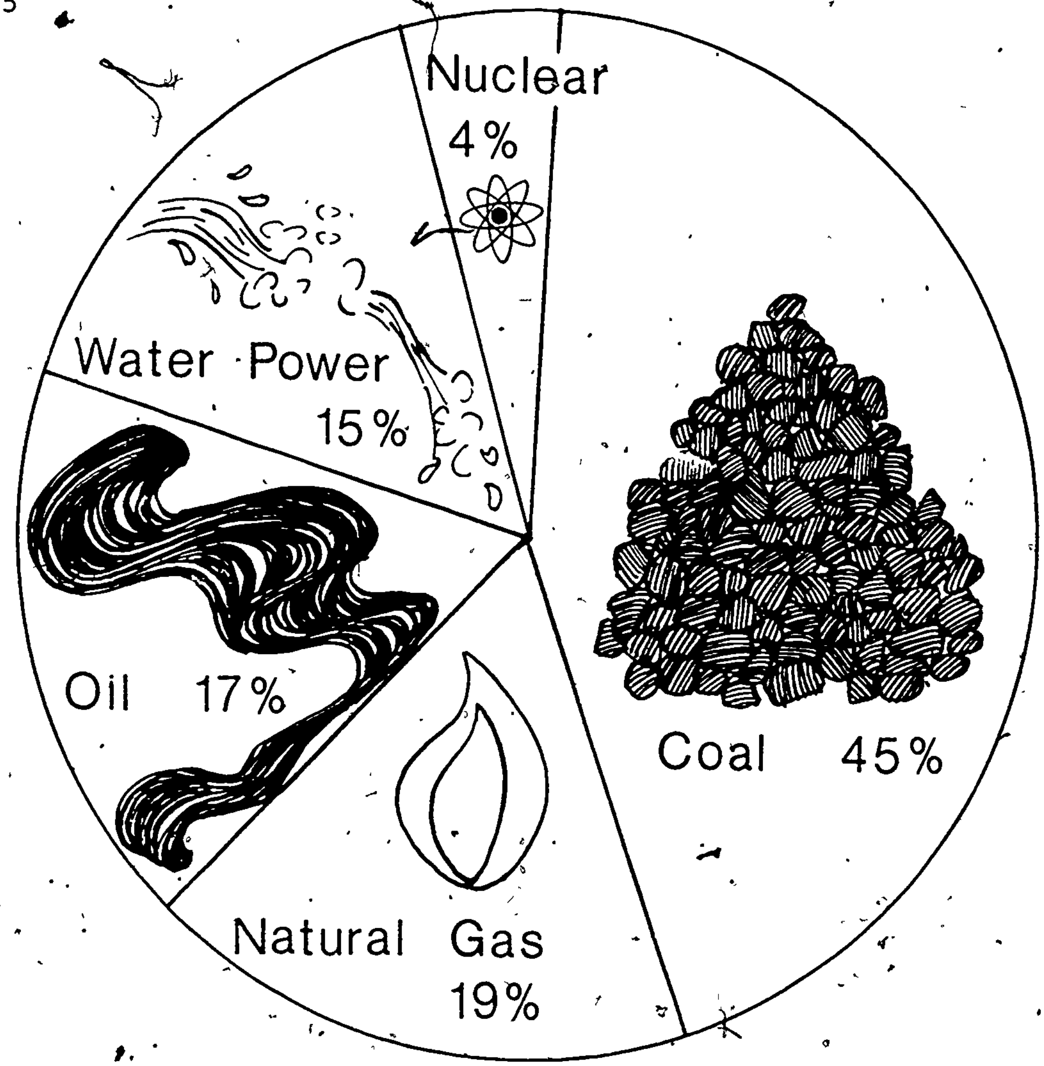
Part A

1. Is coal found in the East?
2. Are there oil fields in the West?
3. Are uranium resources found in the Southwest?
4. Is oil found near the Great Lakes?
5. Do all of the states have gas and oil fields?
6. Can a coal miner find a job in West Virginia?
7. Are there uranium resources in New York?
8. Does the Southwest have many oil and gas fields?
9. Can uranium miners find work in California?
10. Are coal and oil found in Montana?
11. Where would you expect to find water sources for hydroelectric plants? Mark them in blue on the map.

Part B

Find your state on the map. Answer this question: Are there any fuel deposits in your state? Name it or them.

Student
Activity 5



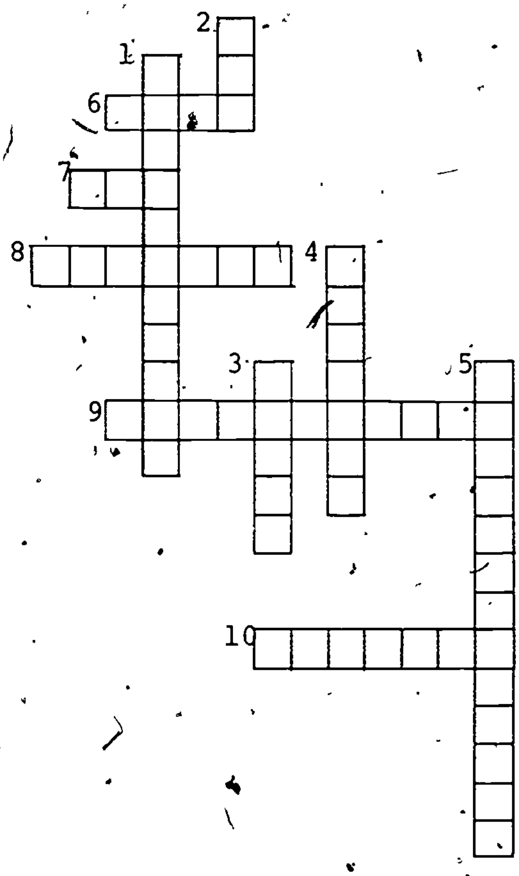
Look at the circle graph. Then answer these questions.

1. What does the graph show?
2. How many kinds of fuel are on the graph?
3. Which fuel is used the most?
4. Which fuel is used the least?
5. Write the name of the fuel or the amount used in the chart.

________	Oil	______	Natural Gas	Coal
4%	____	15%	______	______

6. What is the total amount of fuel used? Add the percentages.

Student Activity 6 — Crossword Puzzle Using Vocabulary Words from Lesson 3



Words to choose from:

1. Coal
2. Electricity
3. Fossil Fuels
4. Gas
5. Uranium
6. Hydroelectric
7. Nuclear
8. Oil
9. Steam
10. Turbine

Down

1. Coal, oil and natural gas are _______ _______.
2. The fossil fuel we use the most.
3. Boiling water makes _________.
4. The material used in nuclear reactors is _______.
5. The production of electricity by running water.

Across

6. A black, solid fossil fuel.
7. Air-like fuel.
8. Another name for atomic.
9. Used by people for heat and light.
10. A wheel that is made to turn a generator by water or steam.

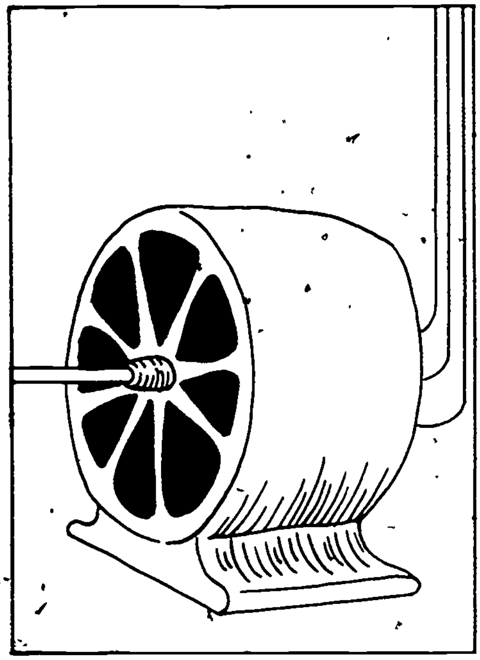
Lesson 4

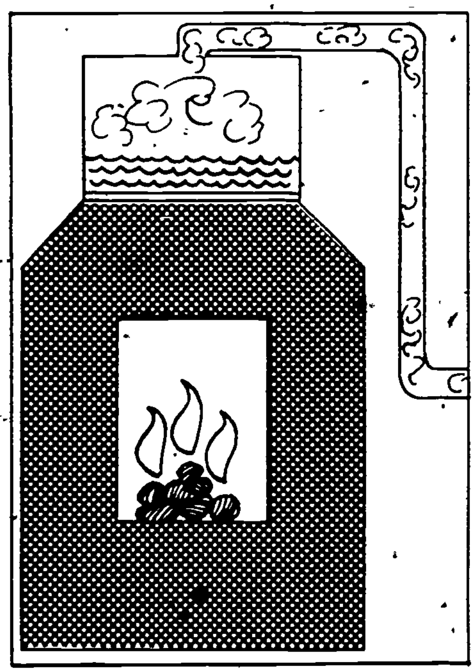
Student Activity 1

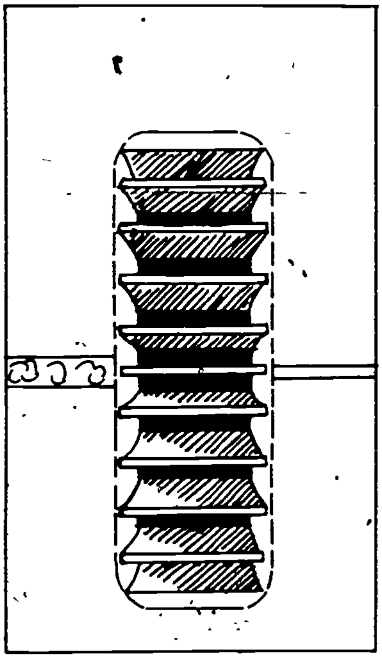
The Flow of Energy from Coal to Electricity

One way of producing electricity is to burn coal in a boiler furnace. The heat of the burning coal creates steam in the boiler. The steam turns the turbine and causes it to spin the moving part of the electrical generator. The generator changes this energy of motion into electrical energy.

Label each part. Then cut each part out and paste in the correct order in your notebook.







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Student Activity 2

Materials:

1. Coil of wire (50 loops)
2. Compass
3. One bar magnet
4. Paper tube or piece of iron

Procedure:

Arrange the materials as shown, making sure that the coil of wire is parallel to the needle of the compass. (See place marked A.) Move the magnet back and forth through the coil of wire. Observe the compass needle. You have made a model of a generator.

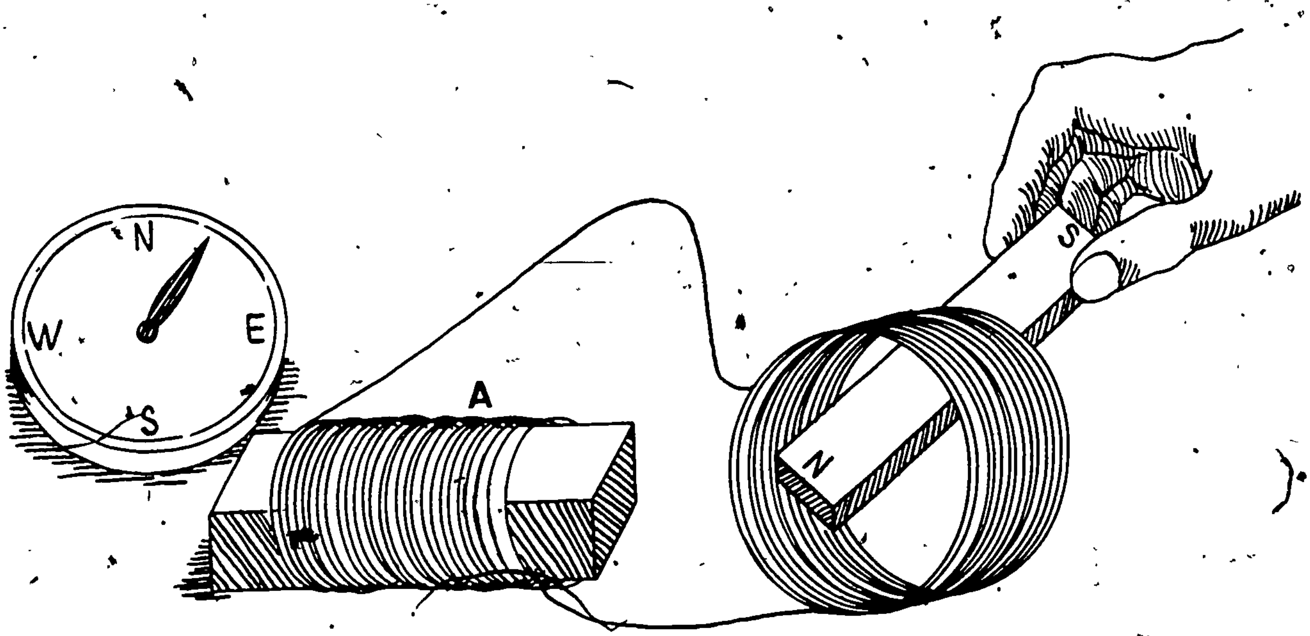
Questions:

1. What happens to the compass needle when the magnet is moved in and out of the coil?

2. What happens to the compass needle when you don't move the magnet in and out of the coil? ____________

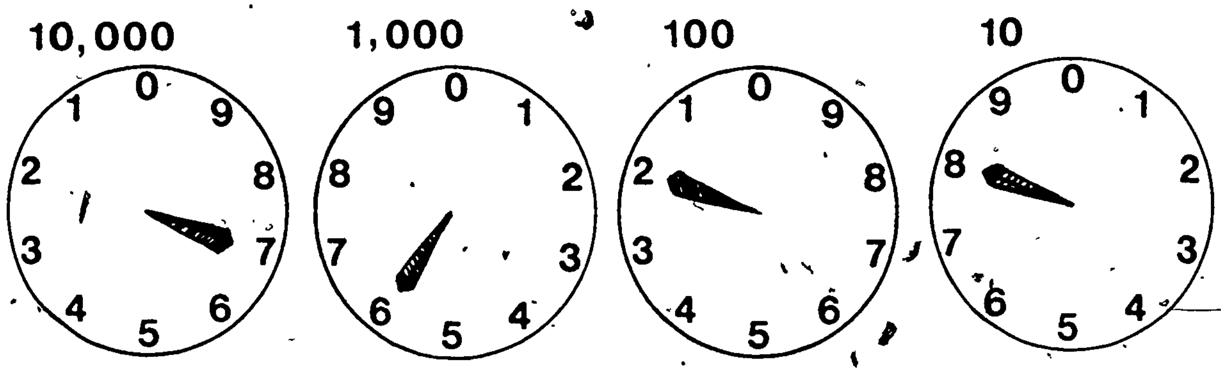
3. Point to these parts in the picture:

magnet   wire   compass   compass needle



Lesson 5

Student Activity 1 — Read-A-Meter Exercise Sheet



LEARNING TO READ METERS CAN HELP YOU LEARN TO SAVE ENERGY

The four dials on your meter record kilowatt hours. Steps to follow:

1. Write down the number the pointer is pointing to. Your answer for reading the meter above is ________.

2. To find how much electrical energy you've used in one month you must take two readings one month apart. Then you subtract.

   Example: November 1 reading: 8268
   October 1 reading: - 7628
   Difference: ______ kilowatts used

   One kilowatt costs 4¢. Multiply your answer x 4¢ to find the cost.

3. What would you do to find out the amount of electrical energy used in a day?

4. To find out about how much is used to heat or cool your home in a 24 hour period, read the meter at bedtime and again in the morning before other appliances are turned on.

   Example: 6 am reading......
   10 pm reading...... ______ Subtract
   Wattage used in 8 hours:

5. Find the meter in the school. Compare school and home meter readings. Subtract. Which uses more energy? Can you think of some reasons why? List them.

Student Activity 2

Checklist for an Inventory of Home Electrical Appliances

Directions:

1. Take this checklist home and put a checkmark by each appliance you find there.
2. Which appliances use the most energy in your home? Circle them.

	Est. kw-hr[a] Consumed Annually
FOOD PREPARATION	
Blender	15
Broiler	100
Carving Knife	8
Coffee Maker	106
Deep Fryer	83
Dishwasher	363
Egg Cooker	14
Frying Pan	186
Hot Plate	90
Mixer	13
Oven, Microwave (only)	190
Range	
with Oven	1,175
with Self-cleaning Oven	1,205
Roaster	205
Sandwich Grill	33
Toaster	39
Trash Compactor	50
Waffle Iron	22
Waste Disposer	30
FOOD PRESERVATION	
Freezer	1,195
frostless	1,761
Refrigerator	728
frostless	1,217
Refrigerator/Freezer	1,137
frostless	1,829
LAUNDRY	
Clothes Dryer	993
Iron (hand)	144
Washing Machine (automatic)	103
Washing Machine (non-automatic)	76
Water Heater	4,219
Quick Recovery	4,811

	Est. kw-hr[a] Consumed Annually
COMFORT CONDITIONING	
Air Cleaner	216
Air Conditioner (room)	860
Bed Covering	147
Dehumidifier	377
Fan (attic)	291
Fan (circulating)	43
Fan (rollaway)	138
Fan (window)	170
Heater (portable)	176
Heating Pad	10
Humidifier	163
Heater (portable)	170
Heating Pad	10
HEALTH & BEAUTY	
Hair Dryer	14
Heat Lamp (infrared)	13
Shaver	1.8
Sun Lamp	16
Tooth Brush	0.5
Vibrator	2
HOME ENTERTAINMENT	
Radio	86
Radio/Record Player	109
Television	
Black-&-White	
Tube Type	350
Solid State	120
Color	
Tube Type	660
Solid State	440
HOUSEWARES	
Clock	17
Floor Polisher	15
Sewing Machine	11
Vacuum Cleaner	46

(a) kw-hr = kilowatt-hour

The checklist is from the Energy-Environment Source Book, by John Fowler, published by National Science Teachers Association, 1975.

Student Activity 3

Tips for How to Save-A-Watt

Here are some energy-saving tips. Can you think of other ways to save energy in the following categories?

A. Plug-ins/Other
   1. Turn off lights when not in use.
   2.
   3.
   4.

B. Water Heating
   1. Wash dishes by hand or use the dishwasher when it is full.
   2.
   3.
   4.

C. Heating/Cooling
   1. Lower the thermostat at night and when leaving on a trip.
   2.
   3.
   4.

POWER SUPPLY VS. THE PEOPLE AND THE LAND

Judge Serious-minded person, wears a dark robe and carries a gavel. Very fair.

Lawyers Four courtroom lawyers wear coats and ties (or dressy pants or dress), carry briefcases with evidence in them. They have name tags such as Mr. Lopez, Esq.

Witnesses We have several coughing witnesses with dirty smudges on their faces. They wear caps with lights on them.

Reporters They always ask a lot of questions and write things down in notebooks. Some use portable tape recorders. They wear name tags with things like KWXY-TV NEWS or Super City Herald on them. They write articles for the Class Newspaper. Some only write important headlines on the chalkboard.

Proceedings

Court Reporter (Banging a gavel) All rise for the entrance of the judge. This is the case of -----(suggested name: Save-Our-Land Citizens vs. the Many-County Coal Company).

You may be seated.

Judge Coal is a dependable source for making electricity, but we use coal at great risk to our environment and health. Let's look at the environmentalists' side of the story and then we shall listen to the coal mining and utility companies. Lawyers for the environmentalists, would you stand and state your case?

Lawyer 1, Environmentalist

Getting the coal from the ground hurts the environment. Strip mining damages large areas of land. A huge machine removes the soil to get the coal. This kind of mining causes erosion of the land. Often there are landslides and falling rocks.

I would like to introduce Exhibit A. (Hold up picture of strip mining.) Underground mining is damaging also. Water seeps into the abandoned mines. The water mixes with sulfur--that's something that smells like rotten eggs--which makes the water unfit to use. Yeech!

Ladies and Gentlemen of the jury, coal mining is also dangerous to the miner's health, Black lung disease has cost the miners the loss of their money and their lives. Many miners get hurt in mine accidents, too.

Lawyer 2, Environmentalist

You just heard about mining the coal. Making electricity with coal is another problem. Burning coal in the power plant gives off hot gases and sulfur which form smog.

Carbon dioxide, another substance, is given off and changes the climate. Hot water, when it is dumped into nearby rivers and lakes, changes the environment of the plants and animals that live there.

I would like to introduce Exhibit B. (Hold up and describe picture of smoke stacks.) Even after the electricity is made there are environmental problems. Ladies and Gentlemen of the jury, you have seen utility poles carrying high tension lines. You know how ugly they are! These utility poles and miles of cables need a lot of land. When these high tension lines interfere with your favorite television program, then, members of the jury, something must be done! Ladies and Gentlemen, (looking meaningfully at the jury) I rest my case.

Judge

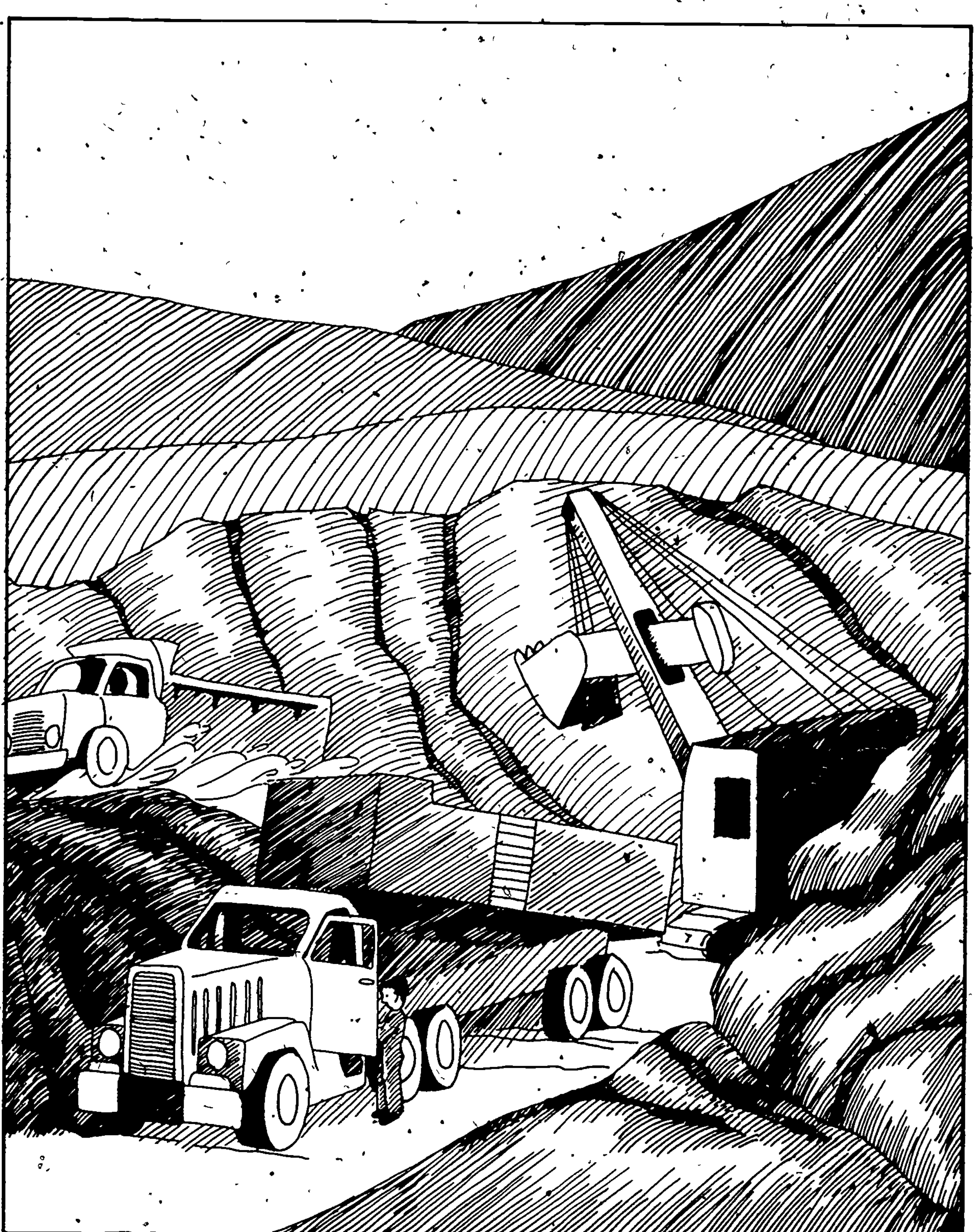
Members of the jury, you have heard the case for the environmentalists. Since this is a special case, I will now open the court to questions from the jury. Are there any questions? (Answer questions.) Could we hear a summary of the environmentalists' case please?

Court Reporter

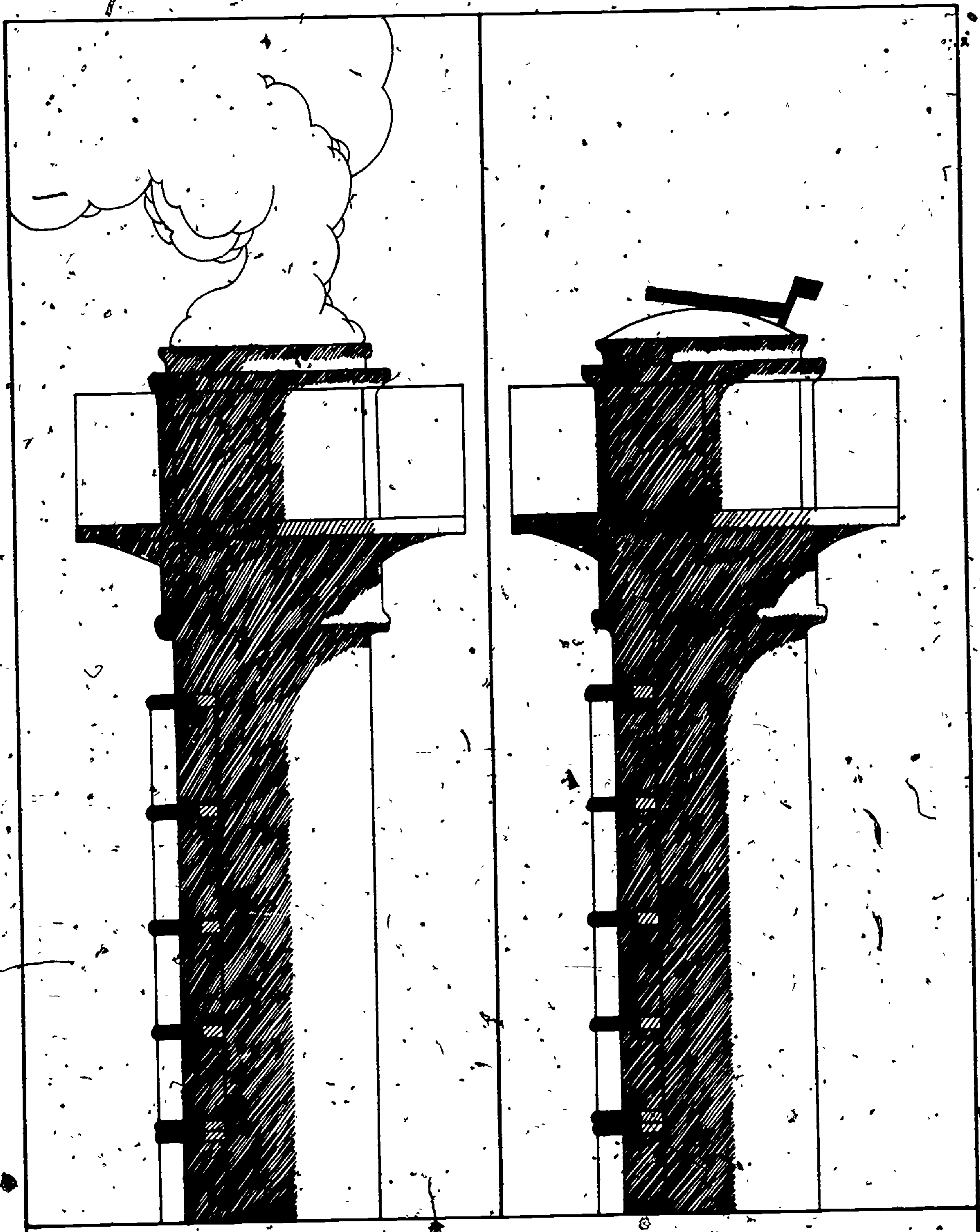
(Read notes on the environmentalists' presentation.)

Judge	Now we will hear the case for the coal mining and utility companies. First we will hear from the Many-County Coal Company. Lawyer, would you state your case?
Lawyer 3 Coal Company	Ladies and Gentlemen of the jury, I am here to show you and the people that coal mining is different today.
	We need coal. Coal is used to make electricity for your TV. Without coal you couldn't watch TV at all. Without coal many people would not have electricity for light.
	We know that strip mining leaves ugly scars on the land. The coal mining companies now are bound by state law to restore land to its natural and usable state.
	I would like to introduce Exhibits C and D. (Show and describe picture of replanted land and recreation area.) Also, in 1970 the United States Congress passed the Coal Mine Health and Safety Act. Ladies and Gentlemen, all coal mining companies today spend a lot of time and money improving the working conditions of their miners. Safety records are much, much better. Members of the jury, I rest my case.
Judge	Now we will hear from the lawyer for the Utility Company.
Lawyer 4 Utility Company	Our companies are now following guidelines which were passed by Congress. The Water Quality Act sets the standards for water quality. The Clean Air Act gives guidelines for air pollution. Utility companies are building air cleaner plants to clean the air before it is put back into the atmosphere. Protecting the environment costs a lot of money, but we do it.
	I would like to introduce Exhibit E. (Show picture and describe it.)
	Now, many cities are placing the high tension lines underground. This way the land can be used for better things. The land is pretty without the utility poles. But, Ladies and Gentlemen, please remember that with any source of fuel used to generate electricity, there will be environmental problems.

Judge	Do the members of the jury have any questions for these lawyers? (Answer questions.) Could we have a summary of the case for the coal and power companies?
Court Reporter	(Read notes of the coal company and power company presentations.)
Judge	The jury is excused to deliberate. The court will recess for a few minutes. (Judge raps gavel; all rise as judge leaves.)
Jury	(Debate and vote by show of hands. A majority vote decides the case. One juror should knock on the door and tell the court reporter when the jury has reached a verdict.)
Court Reporter	All rise. (Spectators rise for judge and jury who re-enter the courtroom.)
Judge	Jury, do you have a verdict?
Jury Spokesperson	We have, Your Honor. (Give verdict.)
Judge	(Sum up the verdict again, then excuse the spectators and everyone else.) Court is adjourned.
Court Reporter	All rise. (Judge leaves.) You are excused.



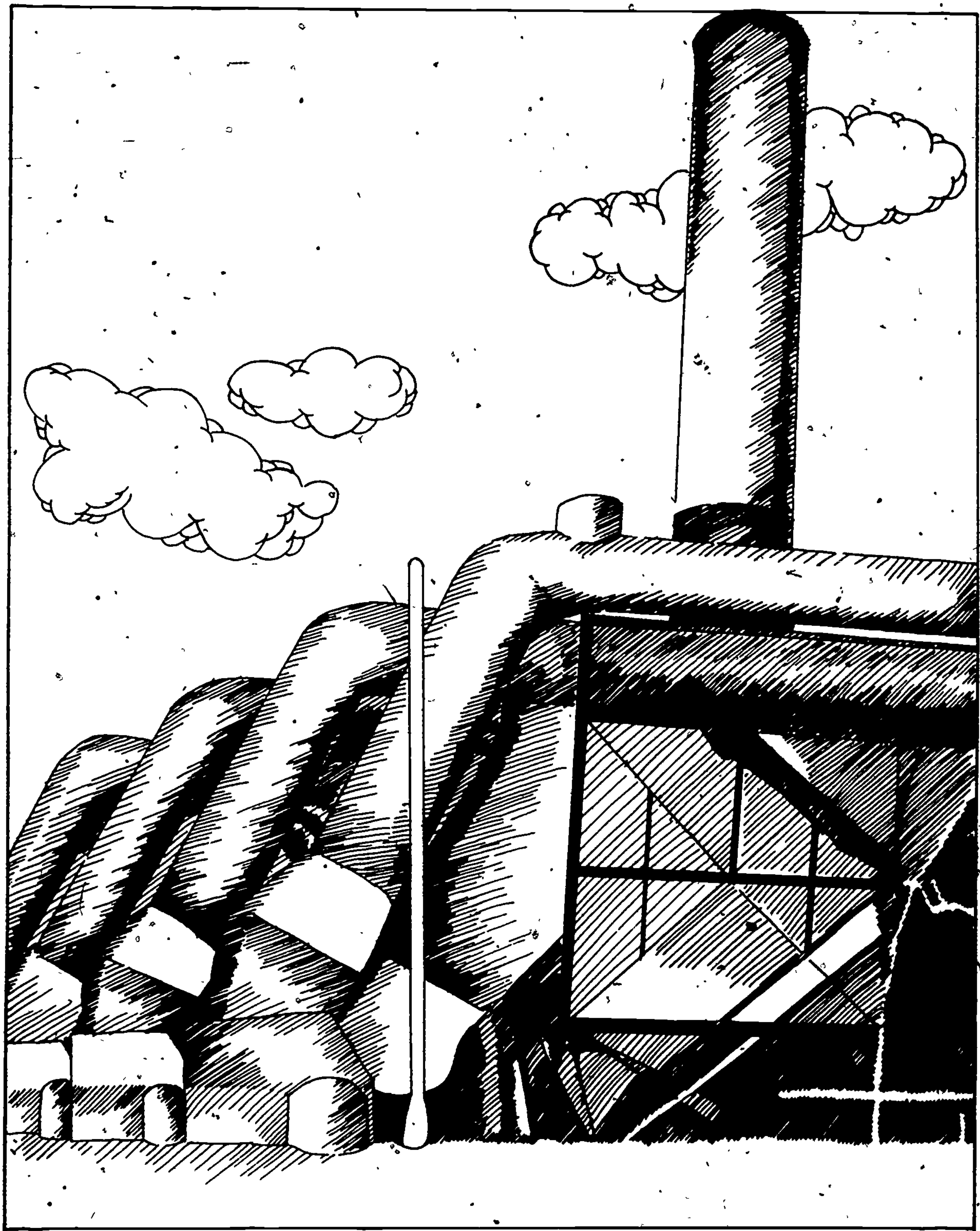
Digging for coal is noisy. It spoils the land.



Furnace stacks poured dirty smoke into the air before filters were used.

Hillside of a coal mine is being planted with trees and grass.

Watery hole where coal was taken out is being filled in to make a park.



Keeping the air clean can cost millions of dollars.

Student Activity 2

Sources of Electrical Power

	PROBLEMS	BENEFITS
Coal	1.	1.
	2.	2.
	3.	3.
Nuclear Power	1.	1.
	2.	2.
	3.	3.
Water	1.	1.
	2.	2.
	3.	3.
Natural Gas	1.	1.
	2.	2.
	3.	3.
Solar/Wind	1.	1.
	2.	2.
	3.	3.

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