DOCUMENT RESUME

ED 182 180 SE 029 975

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TITLE	Networks: How Energy Links People, Goods and Services, Grades 4, 5. Interdisciplinary Student/Teacher Materials in Energy, the Environment, and the Economy.
INSTITUTION	National Science Teachers Association, Washington, D.C.
SPONS AGENCY	Department of Energy, Washington, D.C. Office of Education, Business and Labor Affairs.
REPORT NO	HCP/U3841-0005
PUB DATE	Jun 79
CONTRACT	EY-76-C-10-3841
NOTE	94p.; For related document, see ED 153 859
AVAILABLE FROM	U.S. Department of Energy, Technical Information Office, P.O. Box 62, Oak Ridge, TN 37830 (no price quoted)
EDRS PRICE	MF01/PC04 Plus Postage.
DESCRIPTORS	Electricity; *Elementary Education; *Energy; Grade 4; Grade 5; *Instructional Materials; Integrated Curriculum; *Science Education; *Social Studies; *Teaching Guides

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)

ED182180

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

Networks:

How Energy Links People, Goods and Services

Grades 4, 5

June 1979

National Science
Teachers Association

Prepared for
U.S. Department of Energy
Office of Education, Business
and Labor Affairs

Under Contract No. EX-76C-10-3841

Copies of this unit may be obtained from:

U.S. Department of Energy
Technical Information Center
P.O. Box 62
Oak Ridge, Tennessee 37830

Teacher Manual

To the Teacher

The purpose of the Teacher Manual is to help you use Networks: How Energy Links People, Goods and Services to best advantage when infusing energy-related topics into your Social Studies, Science or Math course. The Teacher Manual consists of two parts: (1) an introduction (see table of contents on the previous page), and (2) the main ideas, strategies, materials, and attainable goals for each classroom lesson.

You will find the students' material printed on white stock behind this Teacher Manual. These exercises and activities can be easily duplicated into classroom sets. Complete student material for each lesson has been provided (see table of contents).

Project for an Energy-Enriched Curriculum contract #EX-76C-10-3841, U.S. Department of Energy, Office of Education, Business and Labor Affairs.

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<u>Networks: How Energy Links People, Goods, and Services</u> 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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The PEEC staff also wishes to acknowledge the cooperation of the National Council for the Social Studies (NCSS). The NCSS has suggested teachers and consultants to us and has assisted in evaluation and review of the social studies aspects of this unit.

June 1979
John M. Fowler
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Project for an Energy-
Enriched Curriculum
NSTA

NETWORKS:

How Energy Links People, Goods, and Services

Introduction

The purpose of this unit is to investigate a simple energy network and to make analogies with similar mutually supporting networks.

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

The lessons in this unit develop the network idea around a simple electrical distribution system upon which we depend, as well as consideration of electrical energy itself. The network idea in the later lessons emphasizes the interdependence of the man-made network for producing and distribution electrical energy. In the final lesson, additional student activities are used to examine the concept of a network.

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T - Teacher Manual

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. Connect together a working electrical current with wires, batteries and bulbs.
2. Identify and describe the function of different circuit components (source, conducting connectors, conversion device).
3. Connect and distinguish between series and parallel circuits.

Target Audience

Science.

e Allotment

One-three class periods.

Materials

(The quantity you will need of each item will vary according to the number of students in the class or the number of groups.)

Student Handout 1, A Working Electrical Circuit, p 53

desk lamp	nichrome wire
paper	five pieces of insulated wire lengths of 2 meters (6 ft) each
pencils	plastic covered wire
D batteries	scissors or wire strippers
tape	

sockets for bulbs
flashlight bulbs
hand crank generator (borrow from high school) or use 1½ volt dry cell

Background Information

An electric current, in the simple cases which are being studied here, is composed of moving electrons. They move because of the force provided by a battery, or a generator, or a similar source of electrical energy. They move only when a complete conducting path from and back to the source exists. They flow through materials which will conduct them such as copper wire. The amount of the flow (the size of the current) is determined by the strength of the source (its "voltage") and the resistance to the electron's motion in the circuit. In an open circuit, which occurs if a switch is opened, a wire is broken, or a nonconducting connection is made (with a piece of string instead of a wire for example) there is no current. In a "short circuit," a low resistance conductor connects the input and output terminals of the source and a lot of current flows (sometimes too much; a short circuit usually destroys the source).

Although there are many, many different functions served by different circuit components, the basic categories are a source, conducting connections (wires for instance) and a converting device - something like a light, a heater, or a motor which converts the electrical energy to light, heat, motion, etc.

The source provides the energy. In a crude analogy it is like a pump which lifts water up and lets it run through a network of pipes. This energy is then lost to resistance in the circuits or is converted to another form in the conversion device.

The whole process is continuous as long as the source is connected and the circuit is complete. Electrons move through the circuit, as many leaving the source as arrive back at it, and energy is converted and dissipated, "lost" as far as the circuit is concerned.

Although there are many ways that different circuit elements can be connected, there are two basic strategies, series connections and parallel connections. In a series connection, all the elements are in line (see illustration on page 6), and therefore, all the current must flow through each element. The resistances are additive. In a parallel connection (illustration on page 6) there are several paths available and the current divides according to the resistance in each path (it "follows the path of least resistance"). It is clear that the failure of one element (an open circuit) has more far-reaching consequences in a series connection than in a parallel connection.

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 the students to describe where the electricity comes from, how it gets to each of these converting devices (listed above), what happens to it, where it goes. *(Accept all reasonable answers, e.g. it comes from a wall outlet, it is changed into light, it disappears, etc.)*

Student Activity 1

Take a simple experiment, a desk lamp if it is available, and ask the students to draw a map of the path of the electric current. Lead them to the concept of a closed path. Check the maps. Make sure the students have drawn a closed path, one with the flow of electrons returning from the bulb to the source.

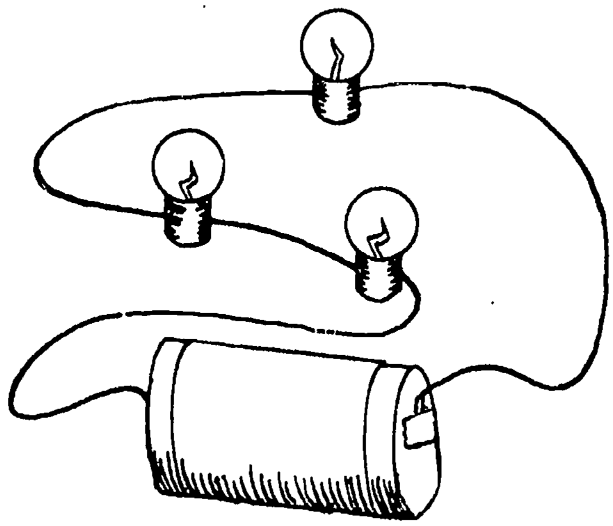
It is useful here, if the students are completely unfamiliar with electrical circuits, to do the beginning "batteries and bulbs" experiments. Batteries and Bulbs, Elementary Science Study, Webster Division, McGraw-Hill Book Co., New York, 1968.

Have the students connect a simple battery and bulb circuit together and compare it with the map they drew. In what ways is it similar? *(A closed circuit, a converter - the light.)* Help them to discover what is missing in their map by asking them to consider the difference between the wall outlet and the battery. Have them label the three basic circuit components on the desk lamp map. *{1) wall plug-source, 2) wire-conductor, 3) light bulb-converter}* To test their understanding have them take the bulb out and connect the two battery terminals together with a long nichrome wire. How can they determine that the circuit is complete, that there is an electric current? *(The wire gets warm, this indicates that the electricity must be flowing through it.)*

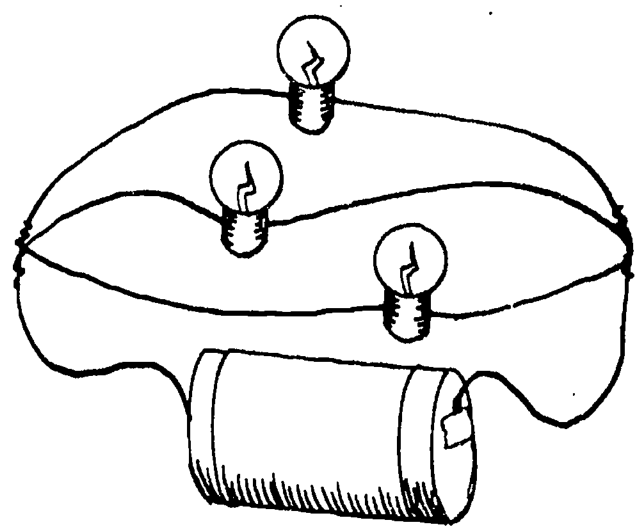
The students should be able to generalize that, without the bulb, the wire is both a conductor and the energy-connecting device. You always need all three components to make a complete circuit.

Student Activity 2

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



Series Circuit



Parallel Circuit

Have the students investigate the difference between the two circuits. Remove one bulb from each circuit. What evidence is there of differences between the two circuits? *(In the series circuit all other bulbs go out because the circuit is broken. In the parallel connection, one path may be broken but the other paths still work so those bulbs remain lit.)*

Also ask students to compare the brightness of the bulbs in the two different circuits with all the bulbs replaced. What might be the cause of the difference? *(The resistance is greater in the series circuit - all the electricity goes through one "pipe" so to speak, therefore the bulbs do not give as much light. In the parallel circuit there are several "pipes" so the flow is easier and the bulbs can give more light.)*

How would a house or a city be wired; in series or in parallel? *(Parallel.)* Ask for examples of series wiring. *(Some Christmas tree lights.)*

Student Activity 3

Choose five or six students from the class to represent some parts of a city with bulbs. Have the students stand in different places in the room. Have a student represent the power plant by turning the generator or connecting the batteries. Have the other students place their bulbs in a socket and connect their socket with wire in a parallel to the generator (batteries).

Have the student operating the power plant turn the crank of the generator (make final wire connection to batteries). If all the components are working, the entire "city" should light up.

(You may want to have them connect the bulbs in series first to emphasize the inappropriateness of this connection in a city.)

Keep on adding bulbs in parallel. This is equivalent to adding more "load." How does the "power house" respond? *(The generator gets harder and harder to turn. If batteries are used you will have to add more in order to keep the light at the same brightness. Both of these responses suggest that you have to provide more energy.)*

Concluding the Lesson

Have students draw a map which includes the school, utility poles, power lines to the school and the adjacent roads. Then supply the students with information obtained from your power company about where the power plant is that supplies power to your school, what type of plant it is, etc. Point out that the school and its connections to the power plant are only a part of a large energy network.

"Name some other parts of your city's energy network." *(Some responses may include homes, stores, hospitals, factories, street lights and traffic lights. There are many more.)*

Have students work the crossword puzzle.

Extending the Lesson

CROSSWORD PUZZLE: A Working Electrical Circuit

Across

1. One source of electric energy used in this lesson. *battery*
2. Current flows in a *closed circuit*.
3. A device that converts electrical energy into light energy is a *bulb*.
4. The energy network you have made a model of. *city*
5. *Switches* may be a way to open and close a circuit.
6. A "burned out" bulb may have a broken *filament*.
7. If a bulb in a *parallel connection* goes out, the other bulbs stay lit.

Down

8. *Electricity* is a very useful form of energy.
9. If a bulb in a *series connection* goes out, all the bulbs go out.
10. A light, a motor, a toaster are *converting* devices.
11. A battery is a *source* of electric energy.
12. An electrical system is an example of a *network*.
13. Current does not flow when we have an *open circuit*.
14. *Wire* was used to connect the source of electrical energy to the bulbs.

2. Networks Underground

Overview

Much of the energy being transported each day in a city lies buried beneath the pavement. Yet it is through 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 network of energy distribution. We also offer a look at our dependency on these electrical energy networks.

Objectives

Students should be able to:

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

Target Audience

Science, Social Studies.

Time Allotment

Two-three class periods.

Materials

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

Diagrams: Student Handout 1, Electrical Power, p 55
Student Handout 2, Power Plant, p 56
Student Handout 3, City Without Electrical Wires, p 57
Student Handout 4, Block Building, p 58
Story: Student Handout 5, New York City Blackout, pp 59-61
Map: Student Handout 6, New York City Blackout, p 62
Student Handout 7, Questions: New York City Blackout, pp 63-64
oak tag paper
scissors
paper
tape
crayons
glue

Background Information

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 uncovers an energy network as the diagram Electrical Power shows.

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 outlet, wire in the wall, etc.)*

Ask: "How does electricity get to your house?" *(Accept responses such as: by utility poles; by wires.)* "Where is the electricity put into the wires?" *(At a power plant.)*

Teaching Strategies

Student Activity 1

Distribute duplicated copies of the diagram found on page of the Student Guide to each student. Discuss how the energy is transfered 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 that office or your local electric power company to visit your class to give a short talk about electricity and electrical service in the community.

Student Activity 2

Distribute the diagram Power Plant. "What is this place called?" *(Power plant; hydroelectric 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 houses, to the town, etc.)* "How is the electricity 'sent' to these places?" *(Through wires.)*

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Student Activity 3

Distribute the diagram on page 57 of the Student Handout, City Without Electrical 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 probably be mentioned, among others.)*

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. *(This time the students will probably draw lines underground.)* Explain that much of what ties the parts of the city together is underground and that most newer cities, or new sections of old cities, have their electric wires placed underground. Give students an opportunity to d scuss the reasons for underground wires.

Student Activity 4

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. (See Block Building on page 58 for example. All of these can be modified to represent whatever building they are making.) Use oak tag paper, and cut 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 put power lines aboveground or place them underground. Wooden dowels or tree branches can serve as aboveground 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 is 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 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; they can be damaged in storms.)*

"If the electricity was shut off in the school, what would probably happen?" *(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.

Student Activity 5

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

Distribute copies of Student Handout 5, New York City Blackout. Have students read the story and answer the questions. After sufficient time has passed, discuss the questions.

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Concluding the Lesson

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

Have students answer the questions below before they begin writing.

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?

Story: New York City Blackout

Questions About the Story

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

2. Tell in your own words why the system didn't work. Point to the 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 and power plants are interconnected parts of an electrical system. Con Ed is also tied into other power systems from which it can buy electricity. 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 the 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. Provide 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, should the student discussion take this turn, you may want to clinch the idea that the source of electric power is the burning of fossil fuels at the power station.)*

8. What things you do now could still be done if you didn't have electricity? *(Student answers will vary.)*

3. Where Does Electrical Energy Come From?

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, from the resource for producing electrical energy, through the energy changes, to finally reaching the house by wires.

Target Audience

Science, Social Studies.

Time Allotment

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

Materials

Diagrams: Student Handout 1, Electricity From Falling Water, p 65
Student Handout 2, Electric Power From Fossil Fuels, p 66
Student Handout 3, Electricity From Uranium, p 67
Map: Student Handout 4, Sources of Fuel Used to Produce Electricity and Accompanying Student Questions, pp 68-69
Student Handout 5, Major Sources of Electricity in the United States and Accompanying Student Questions, pp 70-71
Student Handout 6, Network Word Puzzle, p 72
camera
buckets (plastic scrub buckets)
coffee can
tin snips
dowels (2 cm x 6 cm, or use a straightened coat hanger)
awl or other sharp tool
hammer
can of sterno (or another suitable flame source)
Note: Read warning label!!
wire screening, 10 cm x 10 cm (trivet will do)
blue crayons

Background Information

The generation of electricity begins with a natural source of energy such as water, coal, oil, gas, or nuclear material 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. The turbines turn generators which produce electricity by moving wires through a magnetic field.

Turbines can also be turned by 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) 1979.

Teaching Strategies

One way to introduce this lesson would be to take the class to see a power plant. A film about water power would make a good second choice. Most utility companies have such films available.

Developing the Lesson

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

Student Activity 1

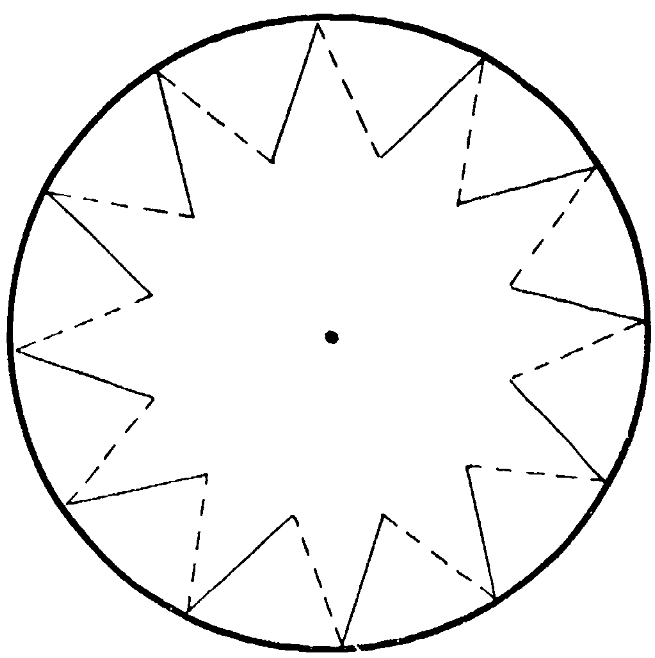
Distribute Handout 1, Electricity From Falling Water. Have a student read the sheet aloud and then have the class discuss the information.

Take the students out on the school grounds to see how the 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. Then ask the following questions:

- 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?
- Does the wheel turn faster when the water is poured from a bucket high above it or from one just above it?
- 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.



Student Activity 2

Have students return to the classroom and read and discuss Student Handout 2, Electric Power from Fossil Fuels. (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 predict 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?"

Student Activity 3

Distribute Student Handout 3, Electricity from Uranium. Have students read it and discuss the information on the sheet. Explain that human beings are able to split the nuclei of atoms, but only in the past couple of decades have they applied this to the production of electric energy.

Student Activity 4

Distribute Student Handout 4, Sources of Fuel Used to Produce Electricity and have students complete the accompanying worksheet, working in small groups. Later each group can present their findings to the whole class.

Student Activity 4

Map Study Questions

Study the map, Sources of Fuel Used to Produce Electricity. Answer these questions either 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? *(Yes)*
5. Do all of the states have gas and oil fields? *(No)*
6. Could a coal miner probably find work in West Virginia? *(Yes)*
7. Are there large coal deposits west of the Mississippi River? *(Yes)*
8. Does the Southwest have many oil and gas fields? *(Yes)*
9. Is either coal or oil found in Montana? *(Yes)*

Part B

Find your state on the map. Are there any fuel deposits in your state? Name them. *(Answers will vary.)*

Part C

Draw a network. Start with the source of the energy and get electricity to your home; to a neighbor's home; to a friend's home in another town. *(Network should show these components: energy source (coal, oil, gas, uranium, hydroelectric, in some cases geothermal); boiler (except for water power); turbine; generator transformer; power lines.)*

Student Handout 5

Distribute Student Handout 5, Major Sources of Electricity in the United States. Before students complete the reading of the circle graph for this part of the lesson, as well as the questions, try to find out what ideas they already have about percentages. Have students make a trial graph using the number of boys and girls in the class. For example, the total number of all students would equal 100%. What percentage would, say, 14 boys equal? *(46%)* Sixteen girls? *(54%)* 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 46%. Shade that part in. Ask if the remaining portion is greater than 50%. Ask: "Is it close to 54%?" Write Boys in the shaded portion; Girls in the unshaded portion.

Concluding the Lesson

Now discuss the circle graph. 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.

Look at the circle graph, Major Sources of Electricity in the United States. Then answer these questions.

1. What does the graph show? *{Fuels used to produce electricity and how much of each is used (relatively).}*
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 least? *(Nuclear and water power.)*
5. Write the name of the fuel or the amount used in the chart.

(Nuclear)	Oil	*(Water Power)*	Natural Gas	Coal
13%	*(17%)*	13%	*(14%)*	*(43%)*

6. What is the total amount of fuel used? Add the percentages.
(13 + 17 + 13 + 14 + 43 = 100)

Student Activity 6 — Distribute the Network Word Puzzle. Have students fill in the answers. Use the puzzle as an information evaluation.

Answer Key — Network Word Puzzle

Across

2. A black, solid fossil fuel. *(coal)*
3. Air-like fuel. *(gas)*
4. Source of energy in hydroelectric plants. *(water)*
5. Another name for atomic. *(nuclear)*
7. Fossil fuels may be found in the *(ground)*.
11. Used by people to produce heat and light. *(electricity)*
12. An *(atom)* is split in a nuclear reactor.
13. A wheel that turns a generator through use of water or steam. *(turbine)*
15. A *(generator)* produces electricity by moving wires through a magnetic field.

Down

1. Coal, oil and natural gas are *(fossil fuels)*.
4. Electricity flows through *(wire)* s to get to your home.
6. The material used in nuclear reactors is *(uranium)*.
8. Boiling water makes *(steam)*.
9. A black, liquid fossil fuel. *(oil)*
10. The production of electricity by running water. *(hydroelectric)*.
13. A turbine *(turn)* s the generator.
14. Sound of the water falling near the hydroelectric plant. *(roar)*

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. Identify the major steps in energy conversion, for example, from coal to electric light. 2. Put together a basic generator and test it. 3. Describe one method of changing electrical energy into another kind of energy--to heat, light or to move something.
Target Audience	Science.
Time Allotment	Three-four class periods.
Materials	Student Handout 1, Flow of Energy From Coal to Electricity, p 73 Student Handout 2, Primitive Electric Generator, p 74 insulated wire, 2 meters (6 feet) compass bar magnet iron bar dry cells, size D nichrome wire, 15-25 cm (6-10 inches) copper wire, insulated, 1 meter 2 dry cell batteries, 6 volt, put in series bell or buzzer flashlight bulbs

Background Information

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 interrupted. A generator is a machine which cuts the lines of force very quickly and produces an electric current. A complete description of a generator may be found on pages 256-258, Energy-Environment Source Book by John M. Fowler (Washington, D.C.: NSTA) 1979.

Electrical energy can be used to produce heat energy, light energy, and the energy of motion. In an appliance such as a toaster, iron, or coffee pot, there is a conductor. The conductor may be a coil of wire or a solid rod. The conductor will offer some 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 circuit element gets hot enough to give off light. Circuit elements may be long, thin wires as in light bulbs or gases as in fluorescent lights.

Teaching Strategies

Student Activity 1

Distribute duplicated class sets of Student Handout 1, The Flow of Energy from Coal to Electricity. Have students read the paragraph about the production of electricity. Then label each part of the diagram and cut each out. Have them place the pictures in the proper order.

Student Activity 2

Turn the class attention to Student Handout 2, Primitive Electric Generator. Tell the class that they will make a primitive electric generator and describe how it works. (Discuss each question upon the completion of the activity.)

Procedure:

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

Student Handout 2

Primitive Electric Generator

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

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.)

"How can electrical energy be converted to other energy forms--heat, light, and motion?" Distribute the materials for Activities 3 and 4, following the directions printed on each paper. At the end of each activity, sum up the learning in a short discussion session.

Student Activity 3

Electrical Energy to Light Energy

Materials:

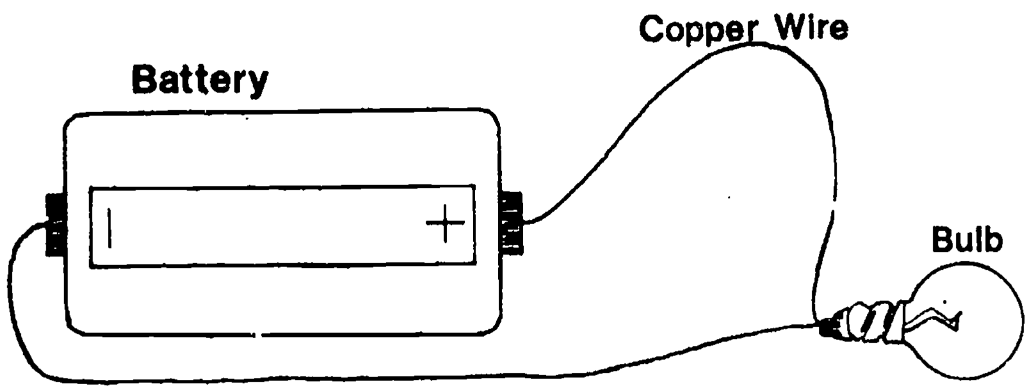
1. D battery
2. Flashlight bulbs
3. Insulated copper wire
4. Tape

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.

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



Student Activity 4

Electrical Energy to Energy of Motion

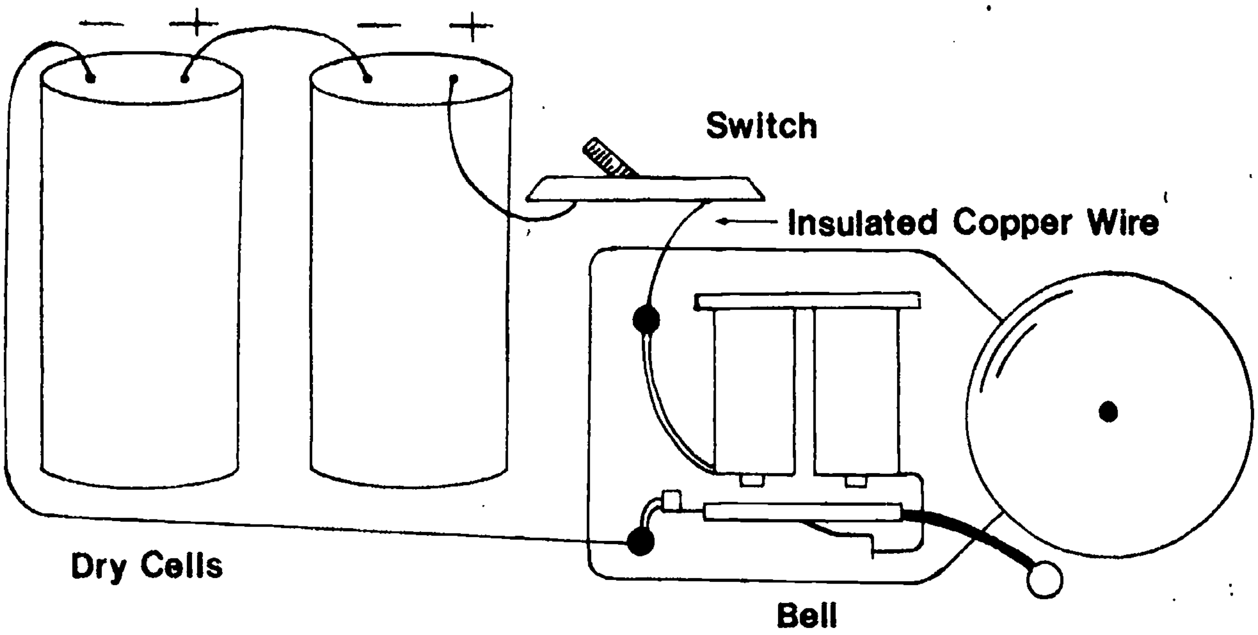
Materials:

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 the motion of an arm striking a bell. This mechanical movement causes a sound which is also a form of motion.)*
Discuss why sound is a form of motion. *(Sound is carried by the motion of molecules.)*



Concluding 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	flashlight	mixer
toaster		typewriter

etc.

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 relationships 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.

Target Audience

Social Studies, Math.

Time Allotment

Three-five class periods.

Materials

Student Handout 1, Read-A-Meter Exercise Sheet, p 7
Student Handout 2, Checklist for an Inventory of Home Electrical Appliances, pp 76-77
Student Handout 3, Tips fcr How to Save-A-Watt, p 7
old magazines
large sheets of mural paper
crayons or paints

Background Information

We are consumers of electrical energy. Our use of electricity is part of the reason for the entire network. Wise use of electricity is a conservation measure.

Learning to read an electric meter can help identify ways to save energy. A watt is a measure of electric power. It measures the rate at which electricity is used. Electricity is sold by the kilowatt hour. The KWH tells us how much electrical energy is being used.

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?"
Student Activity 1	Distribute Student Handout 1, <u>Read-A-Meter Exercise Sheet</u>. Help students understand that the kilowatt is used to measure electric power. 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 the 0 digit on the dial as 10, 100, 1000 or 10,000.) Allow ample time for students to answer questions 1 and 2.

Answer Key ad-A-Meter Exercise Sheet

LEARNING TO READ METER 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 *(7628)*.

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
   (640) kilowatts used

   One kilowatt costs 4¢. Multiply your answer x 4¢ to find the cost. *($25.60)*

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.
   (Answers will vary, e.g. larger building, more people, more machines and lights.)

Student Activity 2 — Have students to the Checklist for an Inventory of Home Electrical Appliances activity for homework. It will help prepare them to think about ways to save energy.

Student Activity 3 — Have students complete Student Handout 3, Tips for How to Save-A-Watt 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.

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 cheaply 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 only 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. Short showers use much less water than baths. Don't let water run needlessly, for example, while brushing teeth.*
   4. *Check and repair all leaky faucets.*

C. Heating/Cooling
   1. In the winter 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 to close it tightly after you use it.*
   3. *Insulate your attic to use less energy for heating in the winter.*
   4. *Close curtains or shades in the summer to keep out the hot sun, and keep in the cool air.*

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.

Concluding the Lesson

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

Sources of Energy
How Energy is Used
Conversions 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)

41

6. How Our Need for Coal Affects the Environment

Overview

The need for coal affects the environment. Coal is a vital part of a network which supplies electricity to communities. The environment represents a network of the living and non-living.

This lesson deals with some of the problems created when changes are made in the environmental network. 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. Discuss coal companies' and utilities' current measures to protect the environment.
3. Suggest alternatives to present-day practices in coal production which would lessen the damages to our air, soil, and water.

Target Audience

Social Studies.

Time Allotment

Two-three class periods.

Materials

Student Handout 1, <u>Power Supply vs. The People and the Land</u>, pp 79-82
Student Handout 2, <u>Exhibits A-E</u>, pp 83-87
Student Handout 3, <u>Sources of Electrical Power</u>, p 88-89
costumes (optional)

Background Information

A rapidly increasing demand for electricity has put an emphasis on coal. 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 visible 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 and rain.

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 may create climatic problems. Hot water from the power plants is dumped into rivers. This dumping affects the aquatic life. Another problem is the high power lines and towers used to transport the electricity. Millions of acres of land are used for the purpose of constructing these lines.

Congress has passed legislation which attempts to regulate 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 control of 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 questions 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) 1979, 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 be used to produce electricity. Prior to assigning students to roles, be sure to list and explain them. Distribute Student Handout 1, Power Supply vs. The People and the Land.

Student Activity 1

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 (Coal Miners)	(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 or a student. Duties are to keep a record of key points made by both sides.

Give each lawyer a copy of the case to be tried (pages 79-82) and the pictures each will introduce as evidence (pages 83-87). The other participants may be assigned small research topics while the lawyers put their cases together.

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 Student Handout 3, Sources of Electrical Supply in the meantime.

(This Handout can be found on pages 88-89.) Review their findings at an appropriate time during the lesson.

Students should research such topics as:

Coal Products	Different Kinds of Coal
Black Lung Disease	How Coal is Used
Coal Mining Methods	How Coal Pollutes
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 facts help?

2. Can you think of any evidence that was not used (by either side) that should 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 facts 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.

d. How the electrical system is like a network.

Student Handout 3

Sources of Electrical Power

	PROBLEMS	BENEFITS
Coal	1. *Hard to get from mine.*	1. *Large supply.*
	2. *Causes air pollution.*	2. *Relatively inexpensive to use.*
	3. *Mining can be dangerous work.*	3. *Safe to transport.*
	4. *Strip mining can erode soil.*	
	5. *Expensive to restore land and water to the condition they were in before mining.*	
Nuclear Power	1. *Produces dangerous radioactive materials.*	1. *Large supply.*
	2. *Waste products must be isolated and stored.*	2. *Clean at the power plant.*
	3. *Some products can be used to build atom bombs.*	3. *"Burns" material which has no other use at the time.*
Water	1. *Expensive to build dams.*	1. *Doesn't pollute the air.*
	2. *Dams use up farm land.*	2. *Provides fairly inexpensive electric power.*
	3. *Good places already used.*	
	4. *Always a possibility of dam collapse.*	

Natural Gas	1. *Limited supply.*	1. *Efficient.*
	2. *Must be transported from site of production.*	2. *Doesn't pollute the air much.*
Solar/Wind	1. *Erratic and will need to be stored.*	1. *Doesn't pollute.*
	2. *Present technology produces expensive electricity.*	2. *Large.*
		3. *Continuous source.*
	3. *Energy must be collected over large area.*	4. *Free to users.*
Oil	1. *Limited U.S. supply.*	1. *Efficient.*
	2. *Growing dependency on imported oil.*	2. *Doesn't pollute the air much.*
	3. *Increasingly expensive.*	3. *Has many uses.*
	4. *When we use it as a fuel, we destroy its many other uses.*	4. *Clean at the power plant.*

(Accept all reasonable responses.)

7. Energy Networks

Overview	This lesson is a culmination for the entire packet on energy networks. It offers a variety of activities which review the network concept.
Objectives	Students should be able to: 1. Describe the mechanics of a network. 2. Describe the importance of energy in a given network.
Target Audience	Social Studies.
Time Allotment	Two-three class periods.
Materials	Student Handout 1, Air Routes of the United States and Southern Canada, pp 91-92 map of your local community map of your state and/or neighboring states map of railway service in your state and/or neighboring states yarn or string tape or pins crayons or colored paper paper pencils
Background Information	The concept of network is defined as a system of lines, channels or pathways, interlocking like the cords in a net, which may allow the delivery of some thing or some service. Have the students do some of the following activities as a basis for discussions of various aspects of networks. The activities lend themselves to the whole class and/or small group participation.

Student Activity 1

Materials:

1. Map of local community
2. Yarn or string
3. Tape or pins

Procedure:

Have students locate on the local community map: a power plant, their school, city hall, home. Using the yarn to represent the means by which energy is transported, have students get electricity from the power plant to each of the above places. The "yarn" network representing the real network which supplies and delivers power may be as simple or as complicated as time allows. How does the energy get to each place? Do the yarn lines show all of the wires needed to transport the energy? If not, tell what others may be needed. What may happen to the network if a line is broken?

Student Activity 2

Materials:

1. Map of your state and/or neighboring states
2. Crayons or colored paper and pins.

Procedure:

On the map identify places where students in the class have travelled. Draw lines from your home town to show the routes travelled. How far was the longest trip? How many miles? What forms of energy were used in these travels? Where was the energy obtained which enabled this network to work?

Student Activity 3

Materials:

1. Student Handout 1, Air Routes in U.S. and Canada
2. Crayons

Procedure:

Ask students how this map represents a network. What does each line represent? Are all the lines necessary? Why or why not? What route would you fly to get to Atlanta, Georgia from Mobile, Alabama? What route would you take to get from Great Falls, Montana to Minneapolis, Minnesota? Ask other similar questions. What does this network deliver? How is energy necessary in this network? Plan a trip through this network and have students draw their itinerary on the map.

Student Activity 4

Materials:

1. Map of railway service in your state or a neighboring state.

Procedure:

Have students pretend to have cargo delivered from your town by rail to a destination across the U.S. Have students map the part of the rail network most likely to be used in such a delivery. Ask what energy is needed in this network. How is this network doing something that you (the student) may not be able to do? If you could do it how would you? What energy would be needed? What things does the rail network offer that you as one person cannot do?

Student Activity 5

Materials:

1. Paper and pencil
2. Students' telephone numbers

Procedure:

Have students construct an emergency telephone network with your assistance. For example:

Teacher calls: Sally, Joe, Tom

Sally calls: ________, ________, ________

Joe calls: ________, ________, ________

Tom calls: ________, ________, ________

and so on until every member of the class has been telephoned.

Pick a day after school, unannounced to the class to try out your network. The next day in class discuss the successes and failures in the operation of your network. How was energy a part of this network? Could the network operate without energy? Why or why not?

Extending the Activity

Procedure:

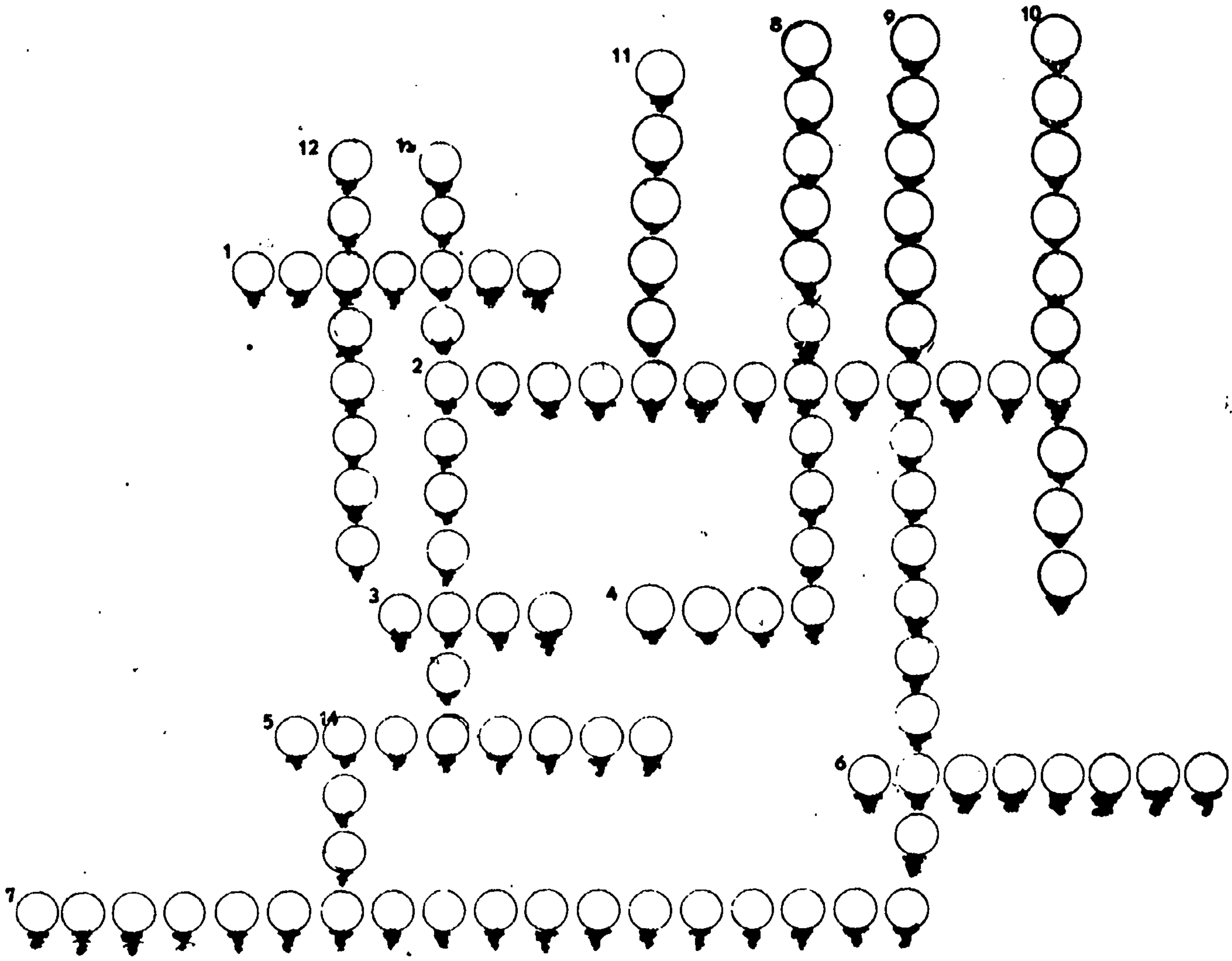
Do the above except using the "gossip" game. Teacher tells Sally, Joe, Tom, "We will have an extra recess at 1:00 today." The word is then passed on around the class. Afterwards hold a discussion as described in Student Activity 5.

Student Guide

Lesson 1

Student Handout 1

CROSSWORD PUZZLE:
A Working Electrical Circuit



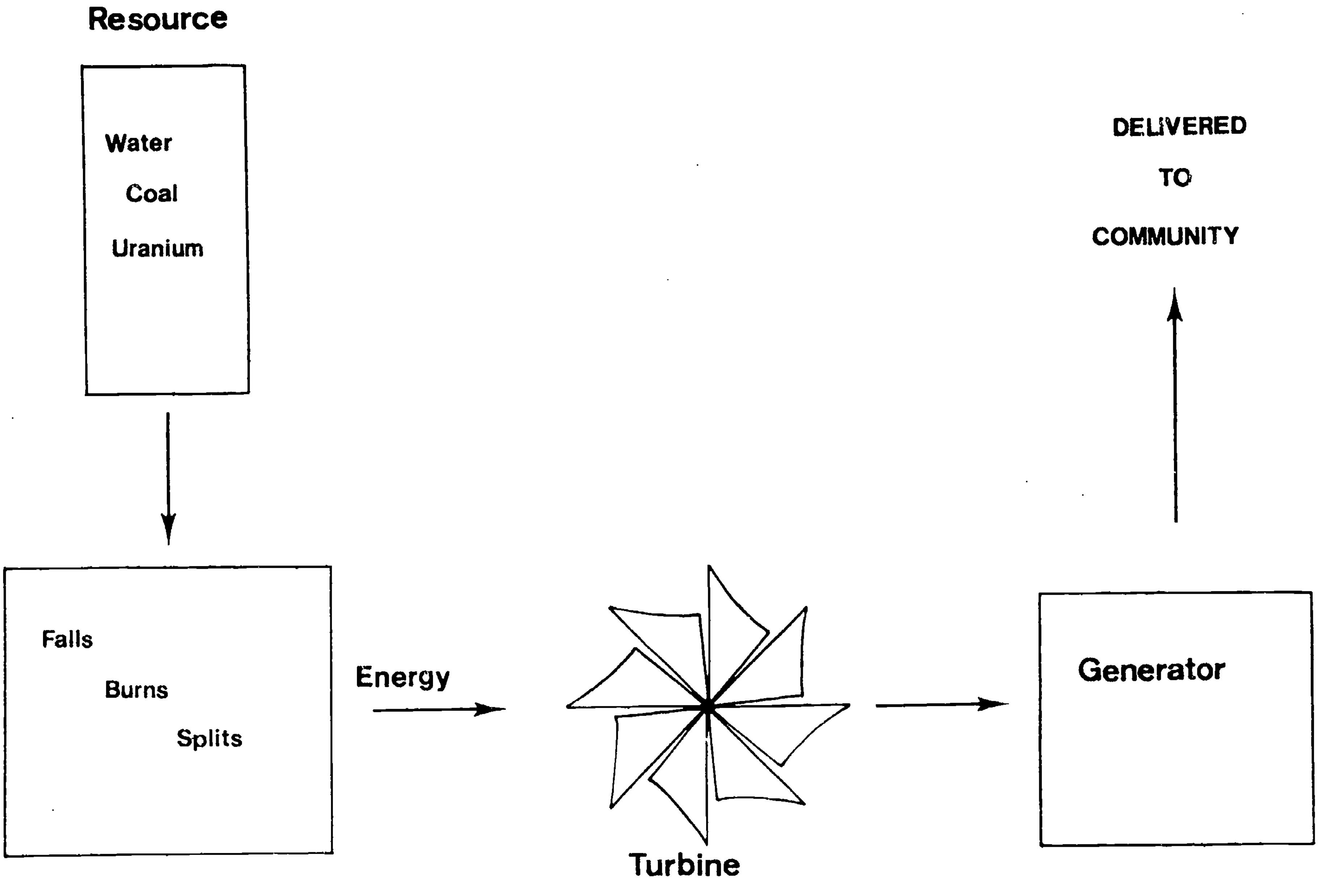
Across

1. One source of electric energy used in this lesson.
2. Current flows in a _______ ________.
3. A device that converts electrical energy into light energy is a ____.
4. The energy network you made a model of.
5. _________ may be a way to open and close a circuit.
6. A "burned out" bulb may have a broken ________.
7. If a bulb in a ________ __________ goes out, the other bulbs stay lit.

Down

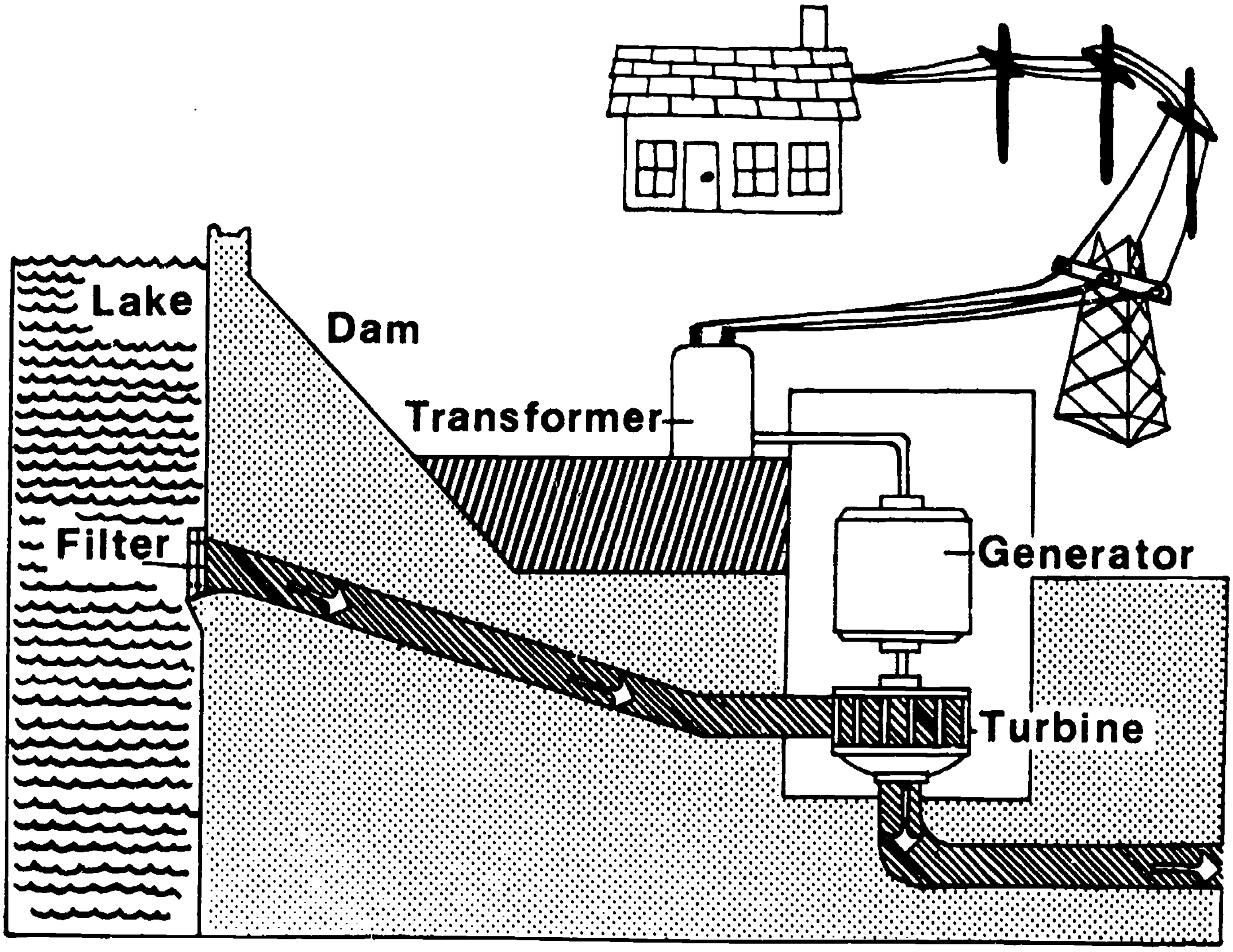
8. ___________ is a very useful form of energy.
9. If a bulb in a _________ ________ ___ goes out, all the bulbs go out.
10. A light, a motor, a toaster are ____________ devices.
11. A battery is a ______ of electric energy.
12. An electrical system is an example of a ________.
13. Current does not flow when we have an _____ __________.
14. ______ was used to connect the source of electrical energy to the bulbs.

Electrical Power



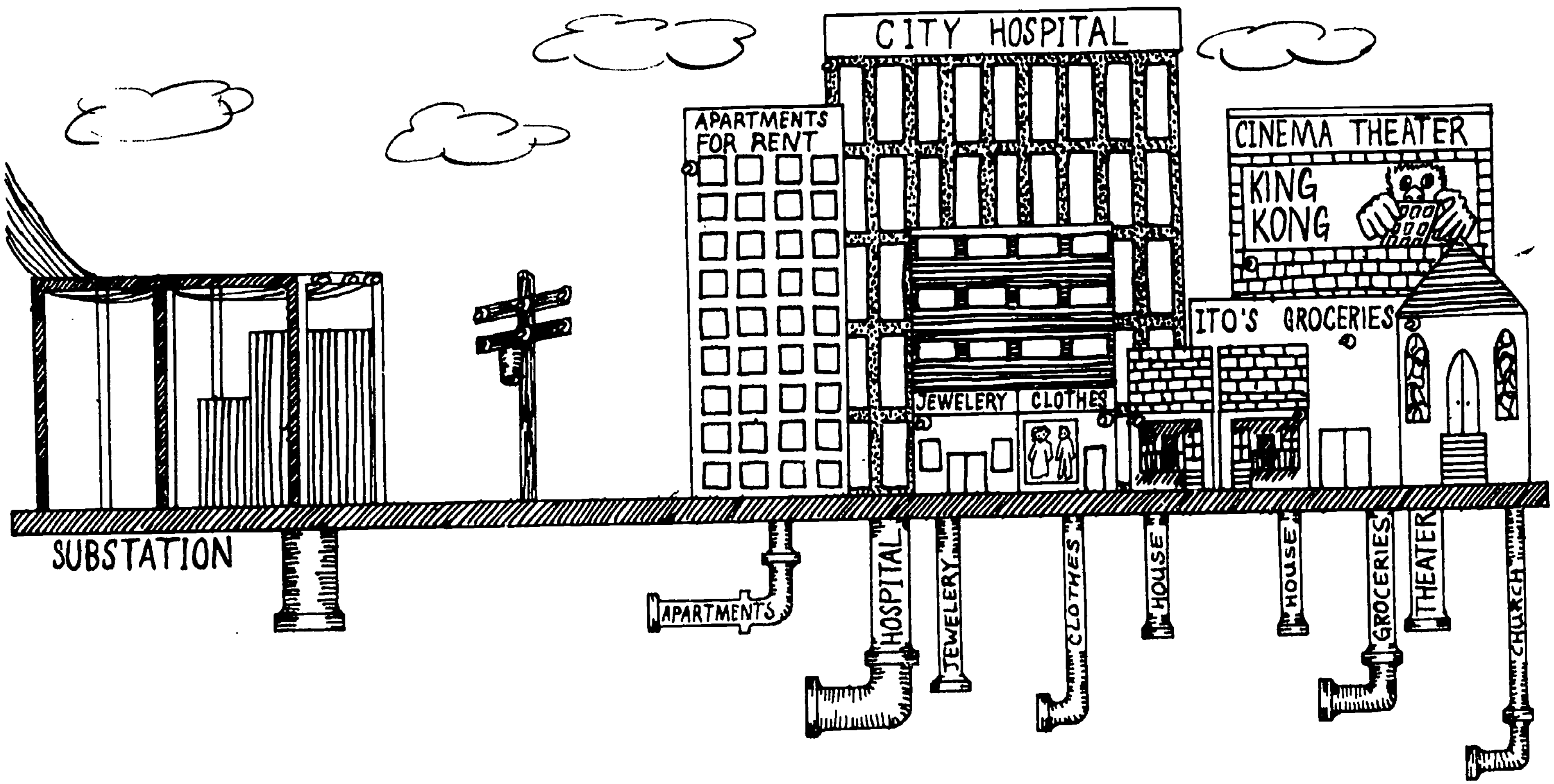
Lesson 2
Student Handout 2

Power Plant

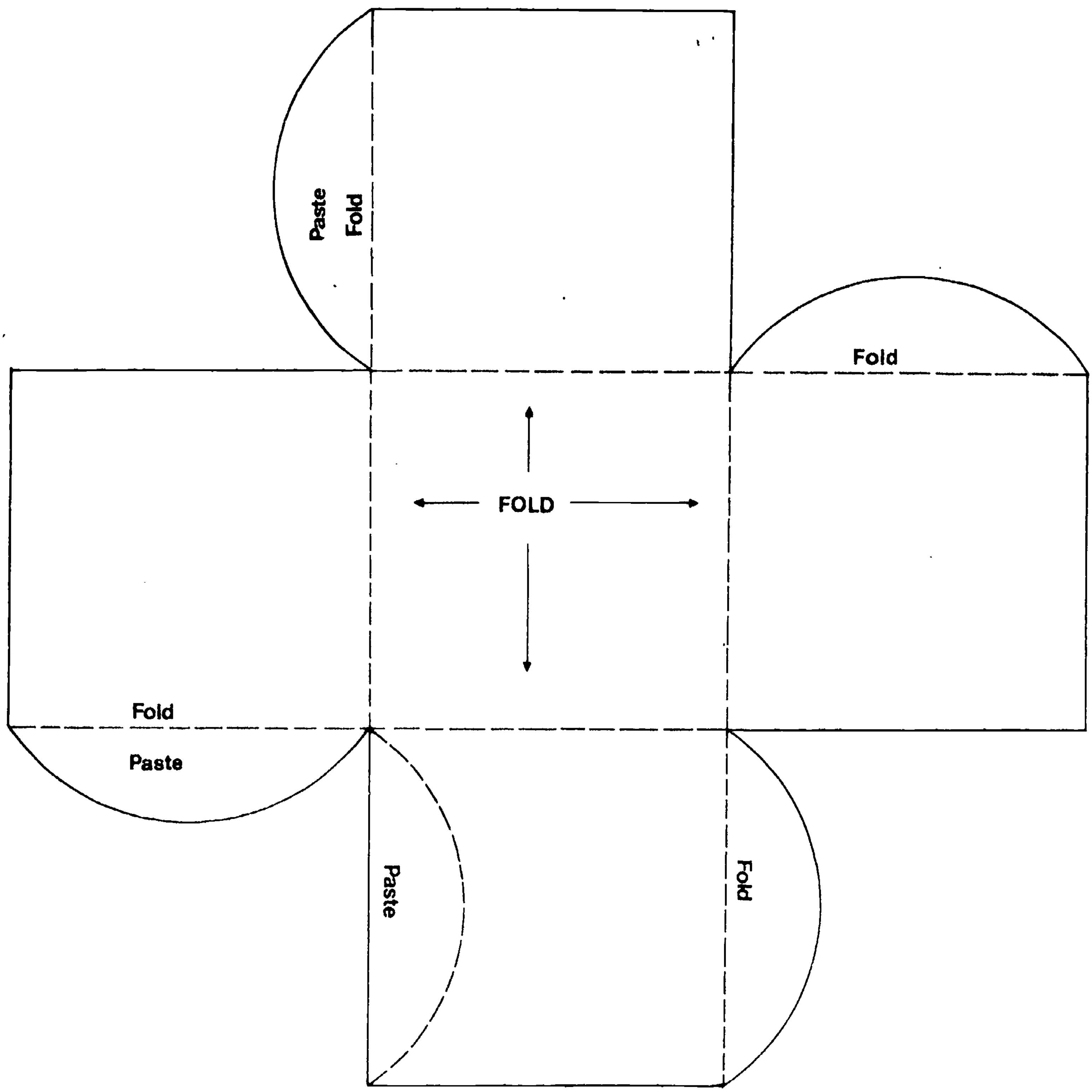


Lesson 2
Student Handout 3

City Without Electrical Wires

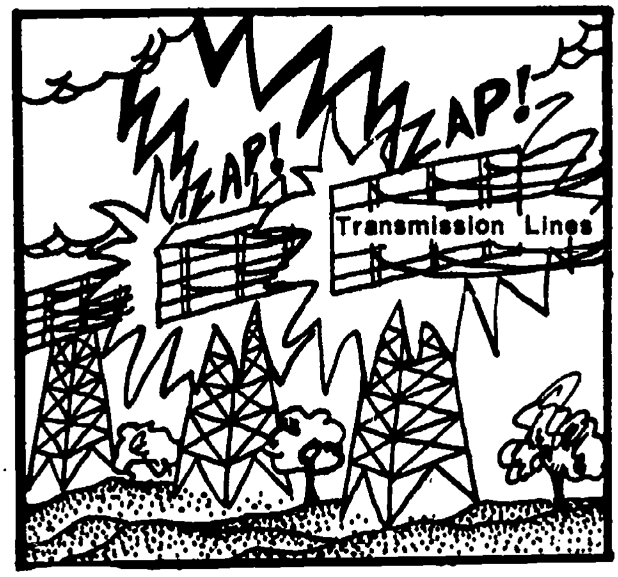


Lesson 2
Student Handout 4 Block Building



Story: 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. 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 back on the ground.

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 stopped 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 someone 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. Candles burned in nearly every room of the large hospital.

Candles 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.

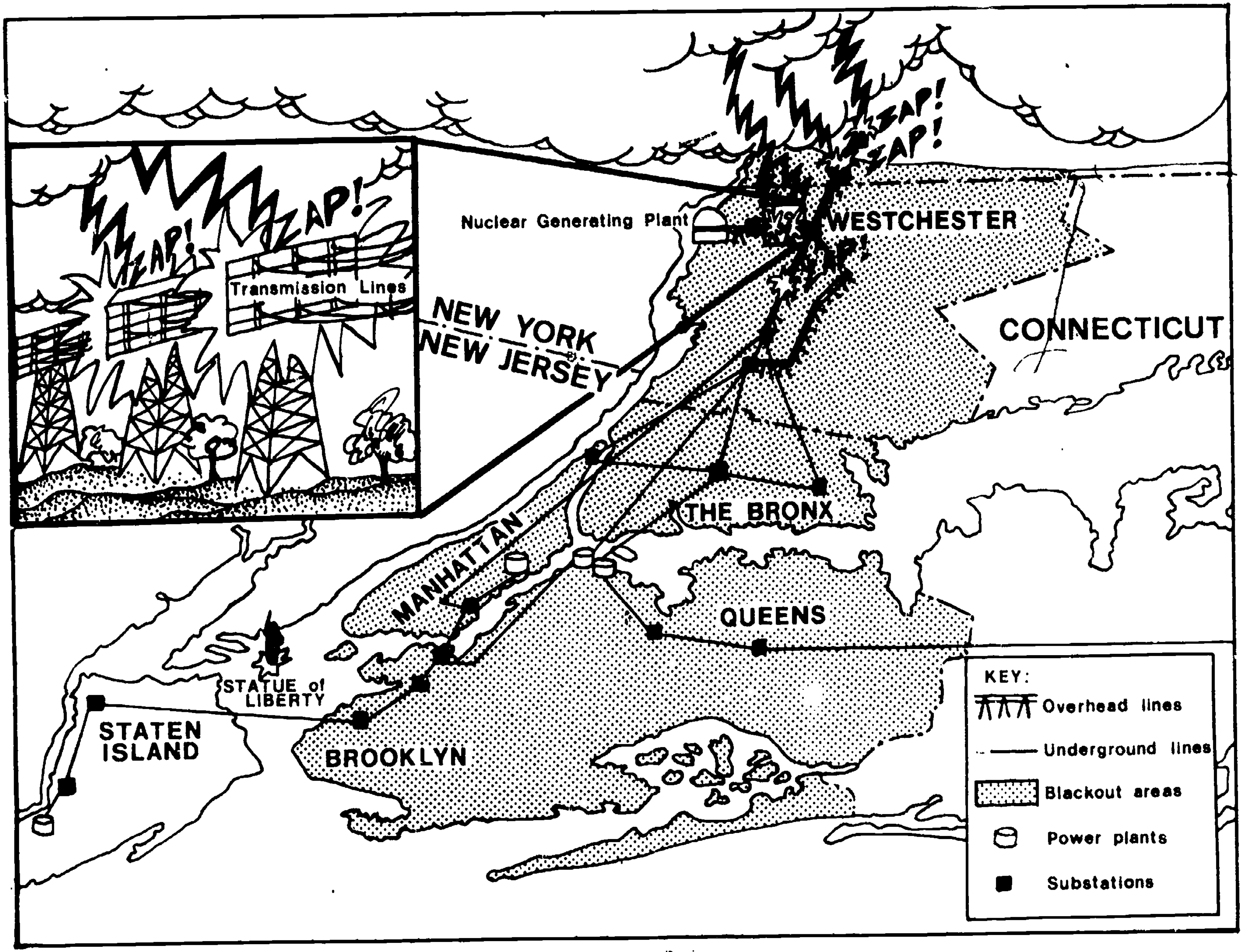
"What's wrong?' everyone asked everyone else.

What went wrong was caused by lightning. The utility, Consolidated Edison, which provides New York's electricity, was on this day buying about one third of the electricity it needed from other utility companies. The first lightning strike, at about 8:30, knocked out a big transmission line. By generating more power at other Con Ed stations and buying a little more power from outside utility companies, service was continued. But 18 minutes later a second transmission line was knocked out by lightning.

Now Con Ed was unable to generate enough energy itself and was left with only two transmission lines to the outside. These became overloaded as more power was demanded than they could carry. After one of them was shut down by protection devices, due to this overload, the second was shut down by the other utility to keep it from burning out. Now Con Edison faced a demand for electricity which was greater than their whole generating system could supply and they had to turn their whole system off to keep it from burning out.

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

Map: New York City Blackout



Lesson 2
Student Handout 7

Questions: New York City Blackout

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

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

3. List some of the ways the 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?

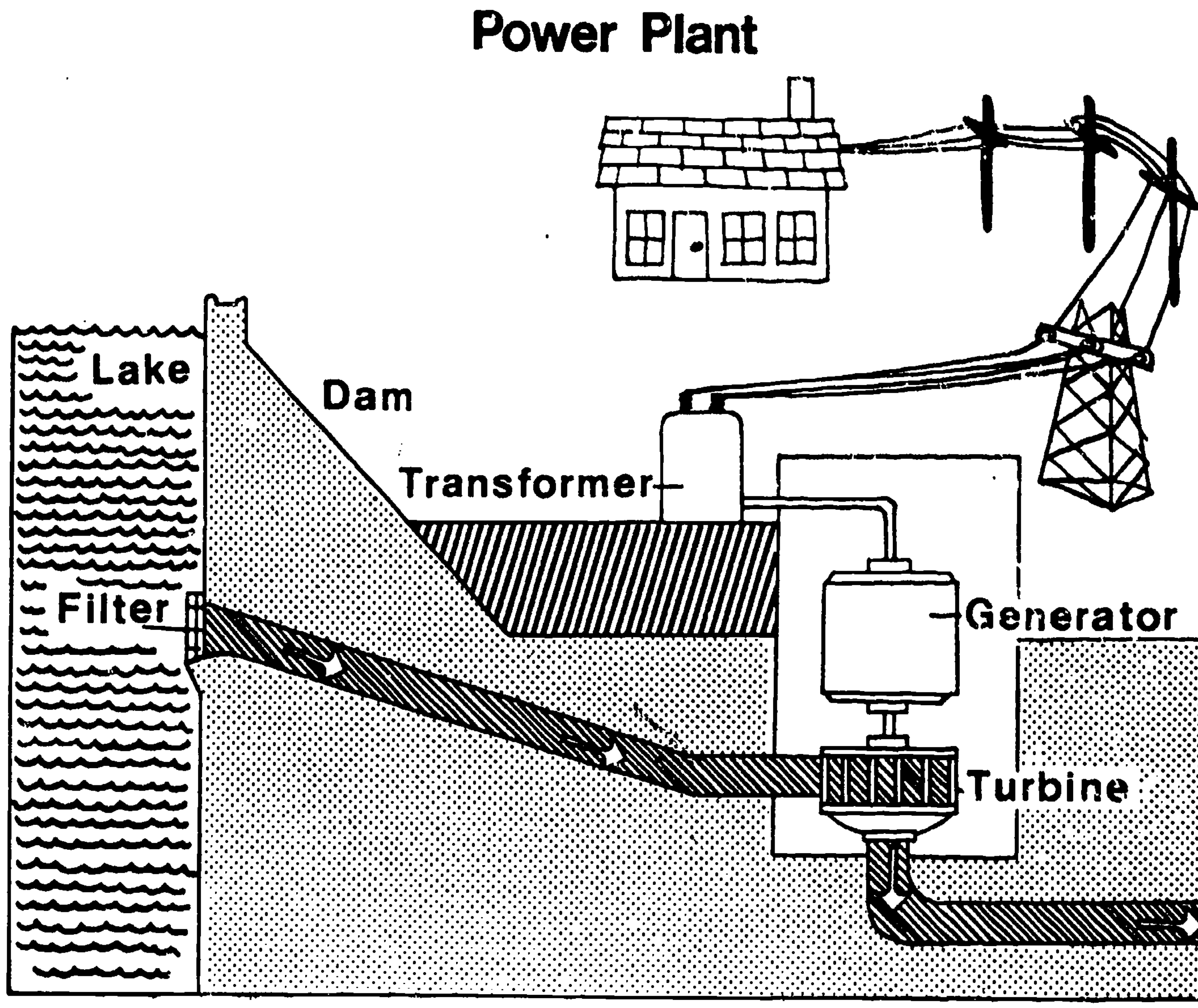
   b. Provide light to see by?

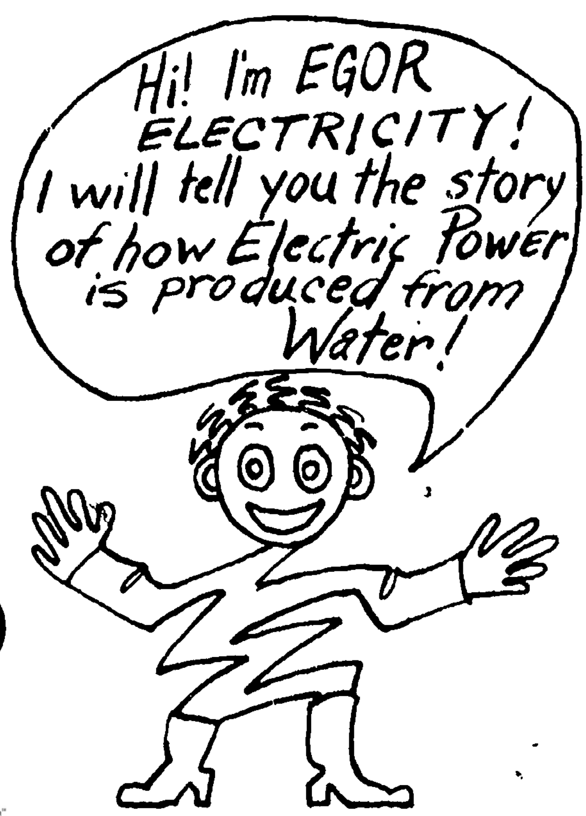
   c. Cook your food?

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

8. What things do you do now could still be done if you didn't have electricity?

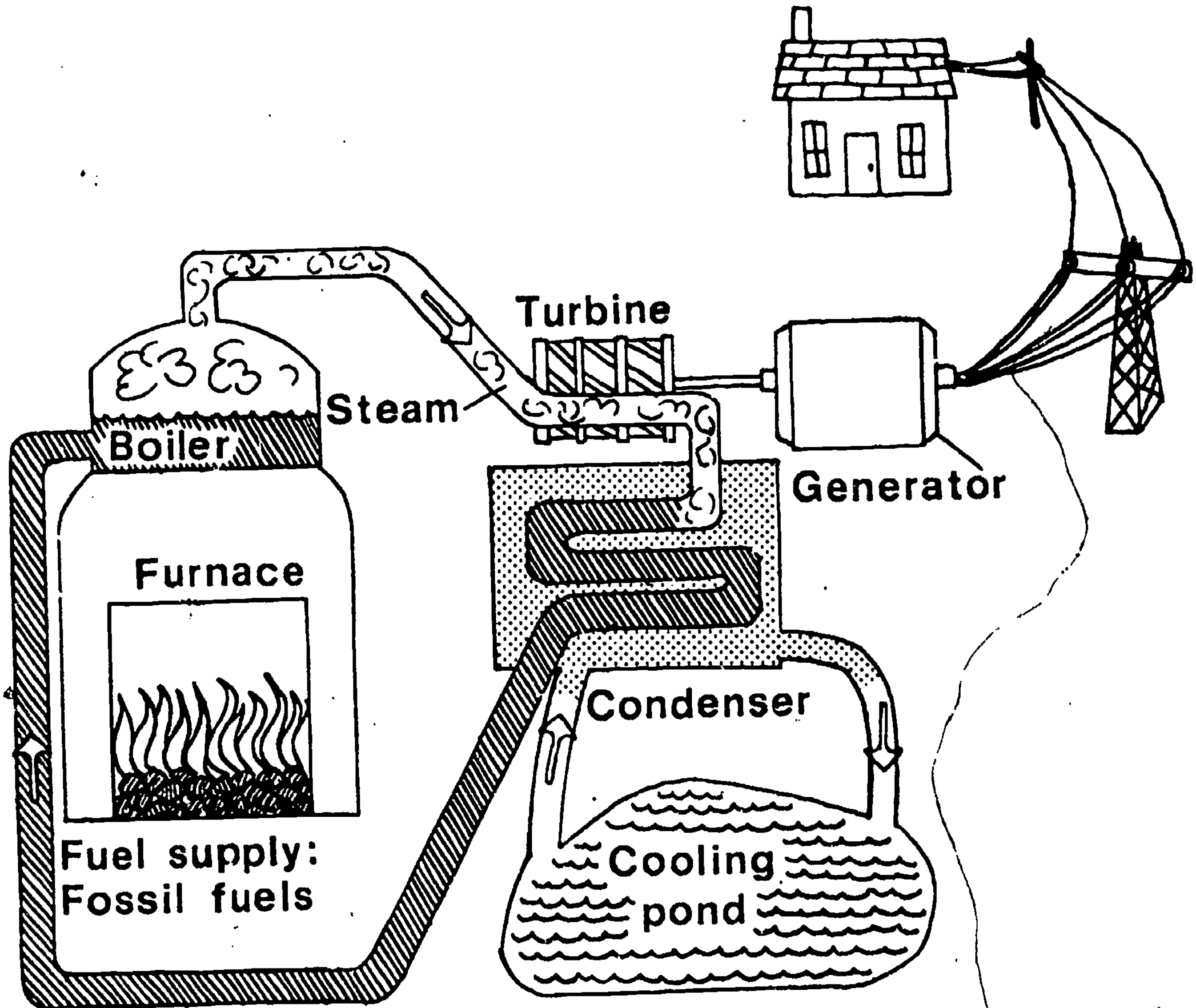
Electricity from Falling Water





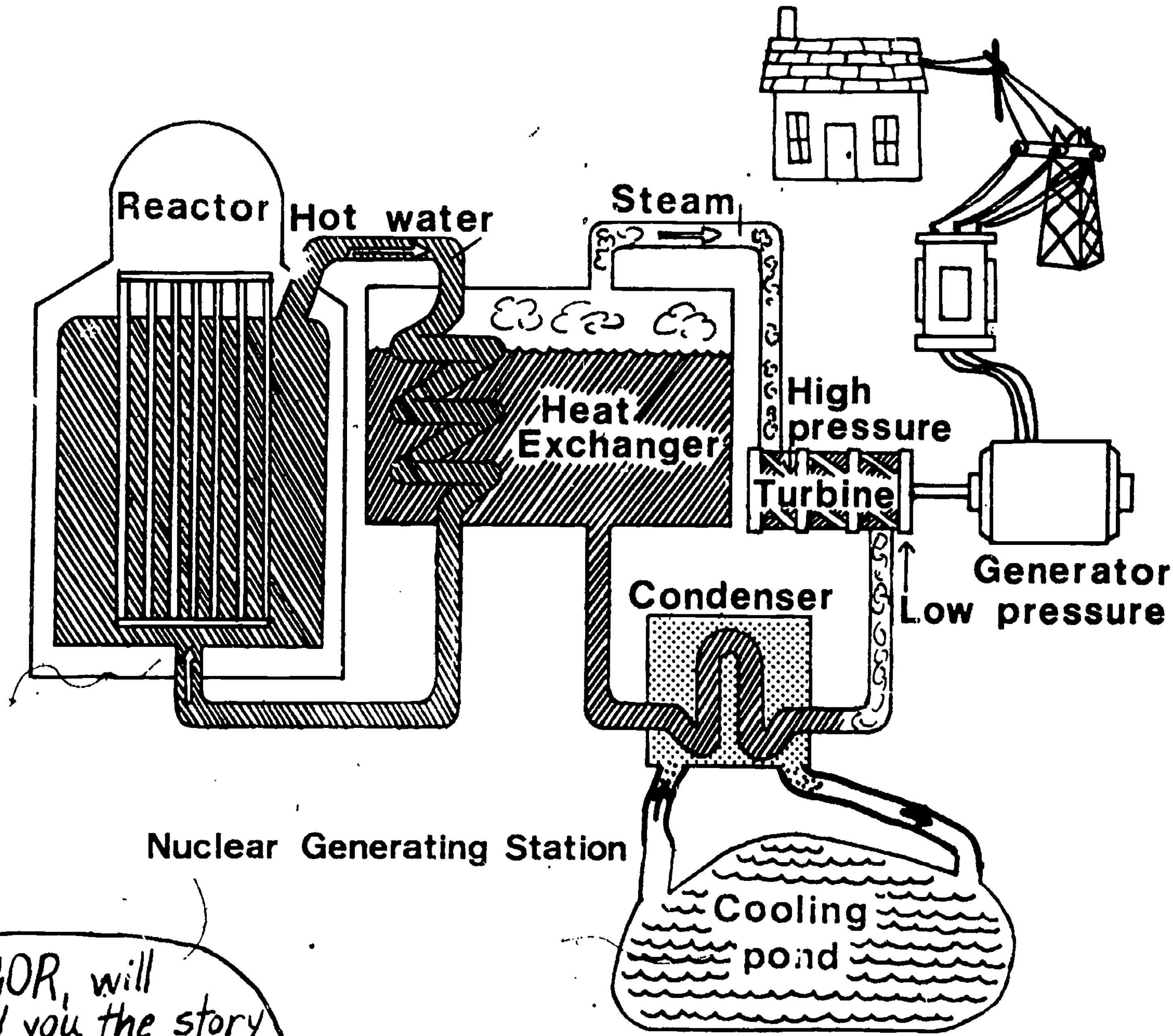
Hydroelectric power is provided by the motion of falling water. When water which has been trapped in a lake behind a dam is released as needed, it can be made to flow through the turbines which activate generators that make electricity.

Electric Power from Fossil Fuels



Fossil fuels (oil, gas, coal) produce electrical power by burning it 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.

Electricity from Uranium

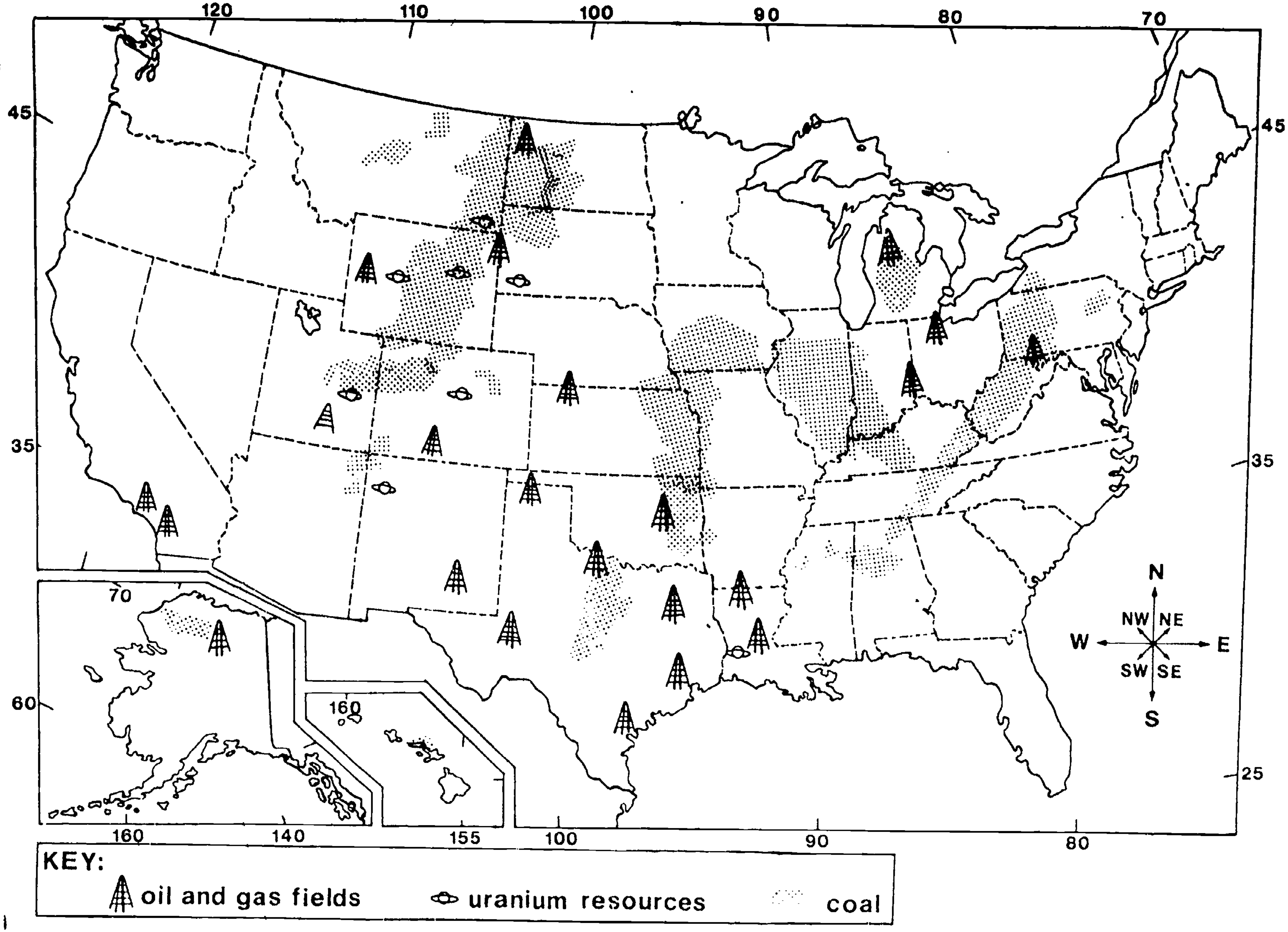


Nuclear Generating Station

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

Lesson 3
Student Handout 4

Map: Sources of Fuel Used to Produce Electricity



Student Handout 4

Map Study Questions

Study the map, Sources of Fuel Used to Produce Electricity. Answer these questions either 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 coal found near the Great Lakes?

5. Do all of the states have gas and oil fields?

6. Could a coal miner probably find work in West Virginia?

7. Are there large coal deposits west of the Mississippi River?

8. Does the Southwest have many oil and gas fields?

9. Is either coal or oil found in Montana?

Part B

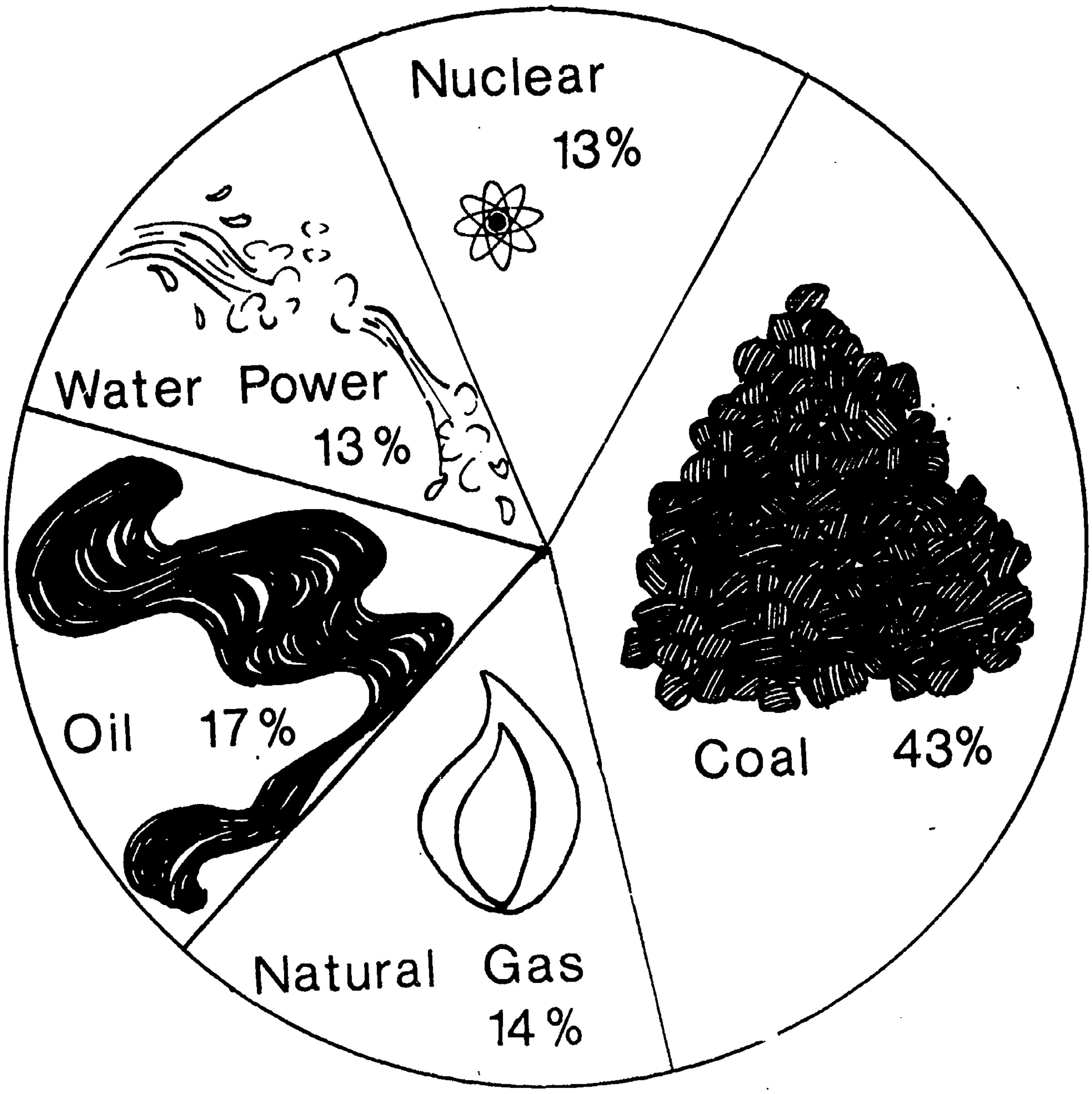
Find your state on the map. Are there any fuel deposits in your state? Name them.

Part C

Draw a network. Start with the source of the energy and get electricity to your home; to a neighbor's home; to a friend's home in another town.

Lesson 3
Student Handout 5

Major Sources of Electricity in the United States



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?

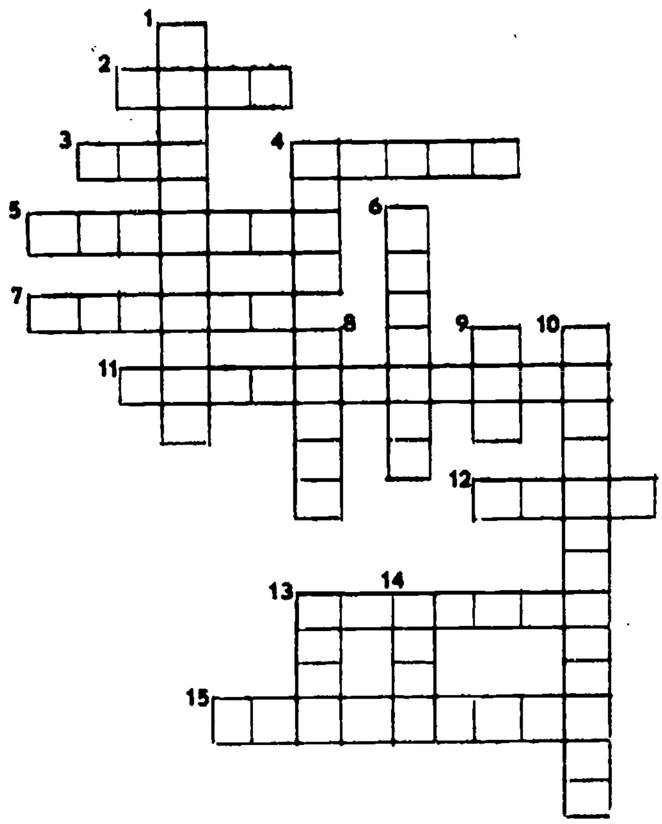
5. Write the name of the fuel or the amount used in the chart.

________	Oil	________	Natural Gas	Coal
13%	___%	13%	___%	___%

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

Lesson 3
Student Handout 6

Network Word Puzzle



Words to choose from:

coal
electricity
fossil fuels
gas
generator
uranium
hydroelectric
nuclear
oil
turn
steam
turbine
roar
atom
ground
wire
water

Across

2. A black, solid fossil fuel.
3. Air-like fuel.
4. Source of energy in hydroelectric plants.
5. Another name for atomic.
7. Fossil fuels may be found in the ________.
11. Used by people to produce heat and light.
12. An ________ is split in a nuclear reactor.
13. A wheel that turns a generator through use of water or steam.
15. A ____________ produces electricity by moving wires through a magnetic field.

Down

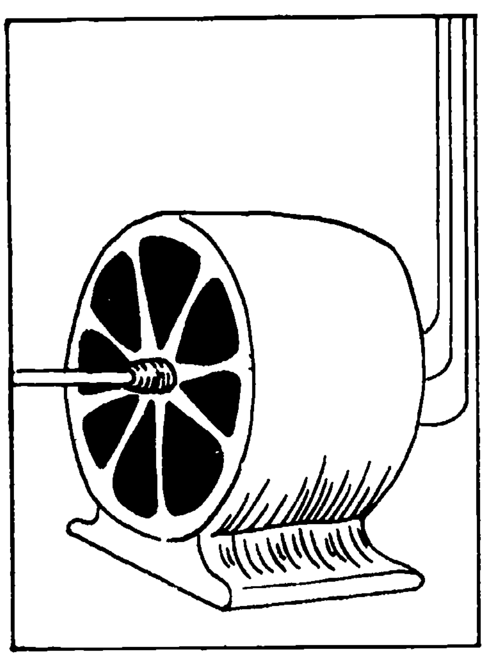
1. Coal, oil and natural gas are ________ ________.
4. Electricity flows through ________s to get to your home.
6. The material used in nuclear reactors is ________.
8. Boiling water makes ________.
9. A black, liquid fossil fuel.
10. The production of electricity by running water.
13. A turbine ________s the generator.
14. Sound of the water falling near the hydroelectric plant.

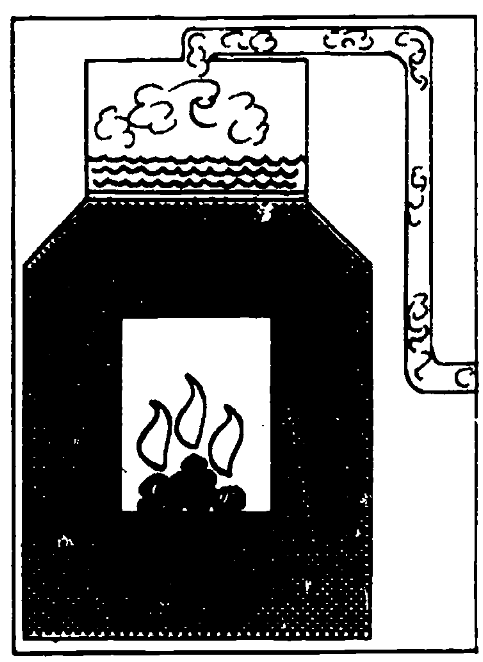
Lesson 4
Student Handout 1

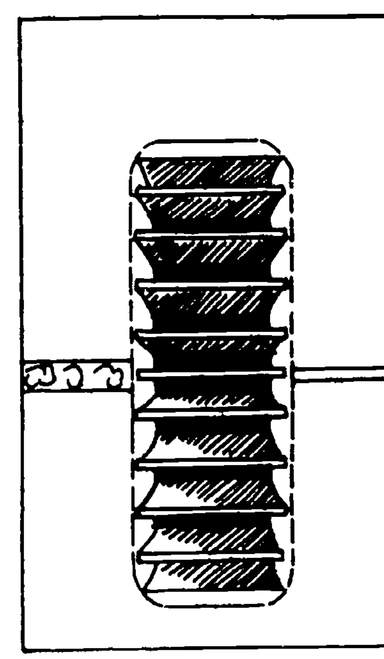
Flow of Energy from Coal to Electricity

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.







Lesson 4
Student Handout 2

Primitive Electric Generator

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. Move the magnet back and forth through the coil of wire. Observe the compass needle. You have made a model of a generator.

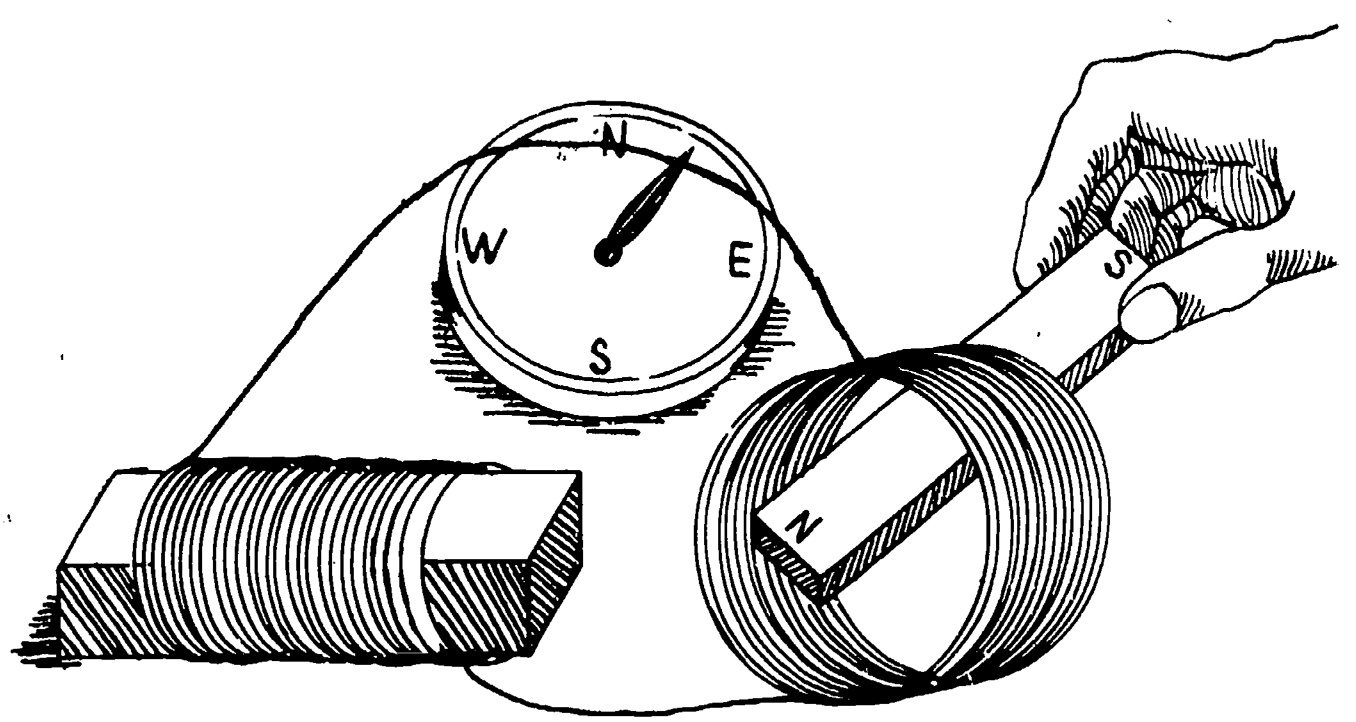
Questions:

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?

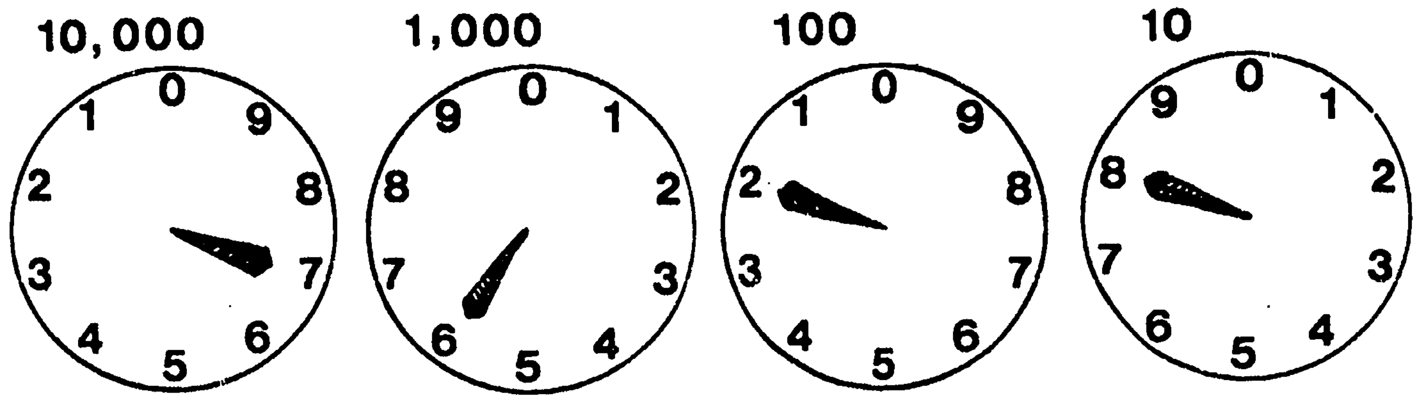
3. Point to these parts in the picture:

magnet   wire   compass   compass needl



Lesson 5
Student Handout 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: 8262
   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.

Lesson 5
Student Handout 2

<u>Checklist for an Inventory of Home Electrical Appliances</u>

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
HEALTH AND BEAUTY	
Hair Dryer	14
Heat Lamp (infrared)	13
Shaver	1.8
Sun Lamp	16
Tooth Brush	0.5
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, 1979.

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.
   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. In the winter, 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 Jose Lopez, Esq.

Witnesses — We have several coughing witnesses with coal smudges on their faces. They wear hard hats 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. It is suggested that 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.

Witnesses

(Coal miners, make up their own speech on black lung problem.)

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 may change 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 programs, then, members of the jury, something must be done! Ladies and gentlemen, (looking meaningful 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 T.V. Without coal you couldn't watch T.V. at all. Without coal many people would not have electricity for light. The U.S. has a lot of coal. The U.S. does not have a lot of oil. If we do not use coal, we may have to import more oil from other countries. That can be very expensive. If we do not use coal, we may have to build more nuclear power plants. Many people are afraid of nuclear power. Coal has its problems, but in our opinion, it is still the best bet. 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.
Witnesses	(Coal miners, make up own speech on good safety records.)
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

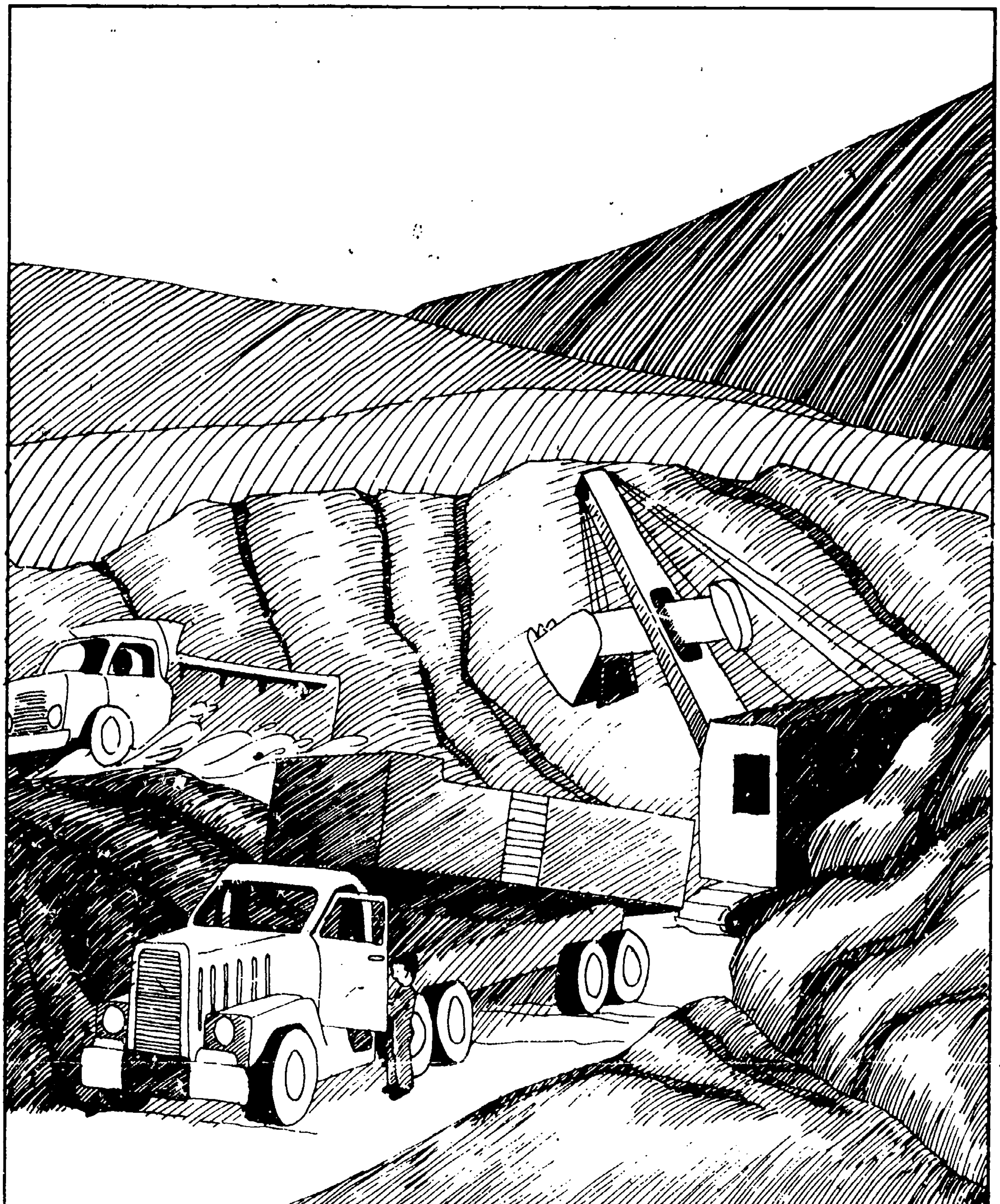
quality. The Clean Air Act gives guidelines for air pollution. Utility companies are building air cleaner plants to clean the air before it is put back into the atmosphere. Protecting the environment costs a lot of money, but we do it.

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.

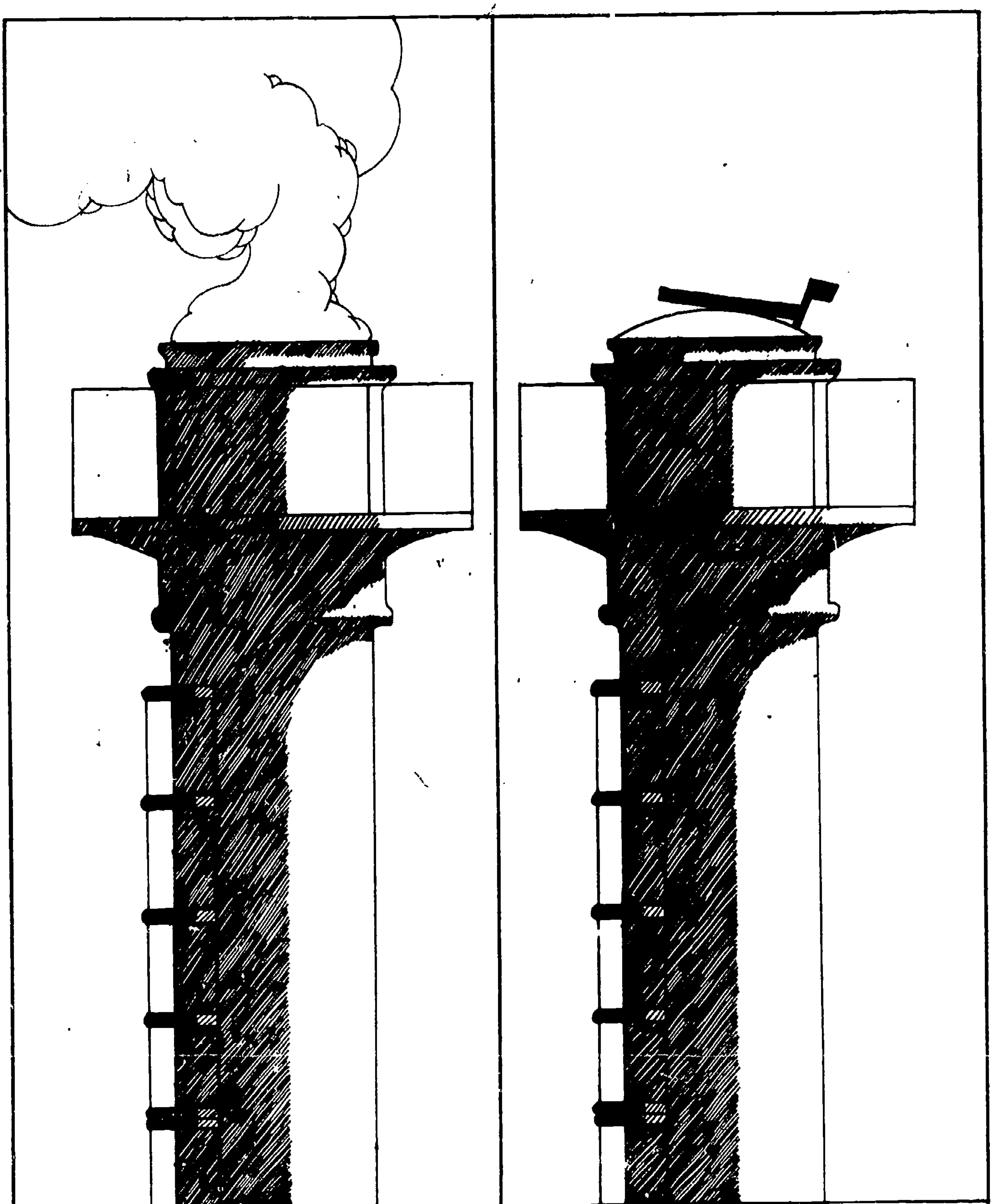
Judge	Do the members of the jury have any questions for these lawyers? (Answer questions.) Could we have a summary of the case for the coal and power companies?
Court Reporter	(Read notes of the coal company and power company presentations.)
Judge	You, members of the jury, must decide if the U.S. should continue to use coal for electricity. Remember, the use of coal creates problems for the land and for the people, but so does the use of oil or nuclear power. If you decide against coal, the U.S. may not have enough electricity for its needs. If you decide in favor of coal, mining will have to continue. 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 jurty 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.

Exhibit A



Digging for coal is noisy. It spoils the land.

Exhibit B



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

Exhibit C

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

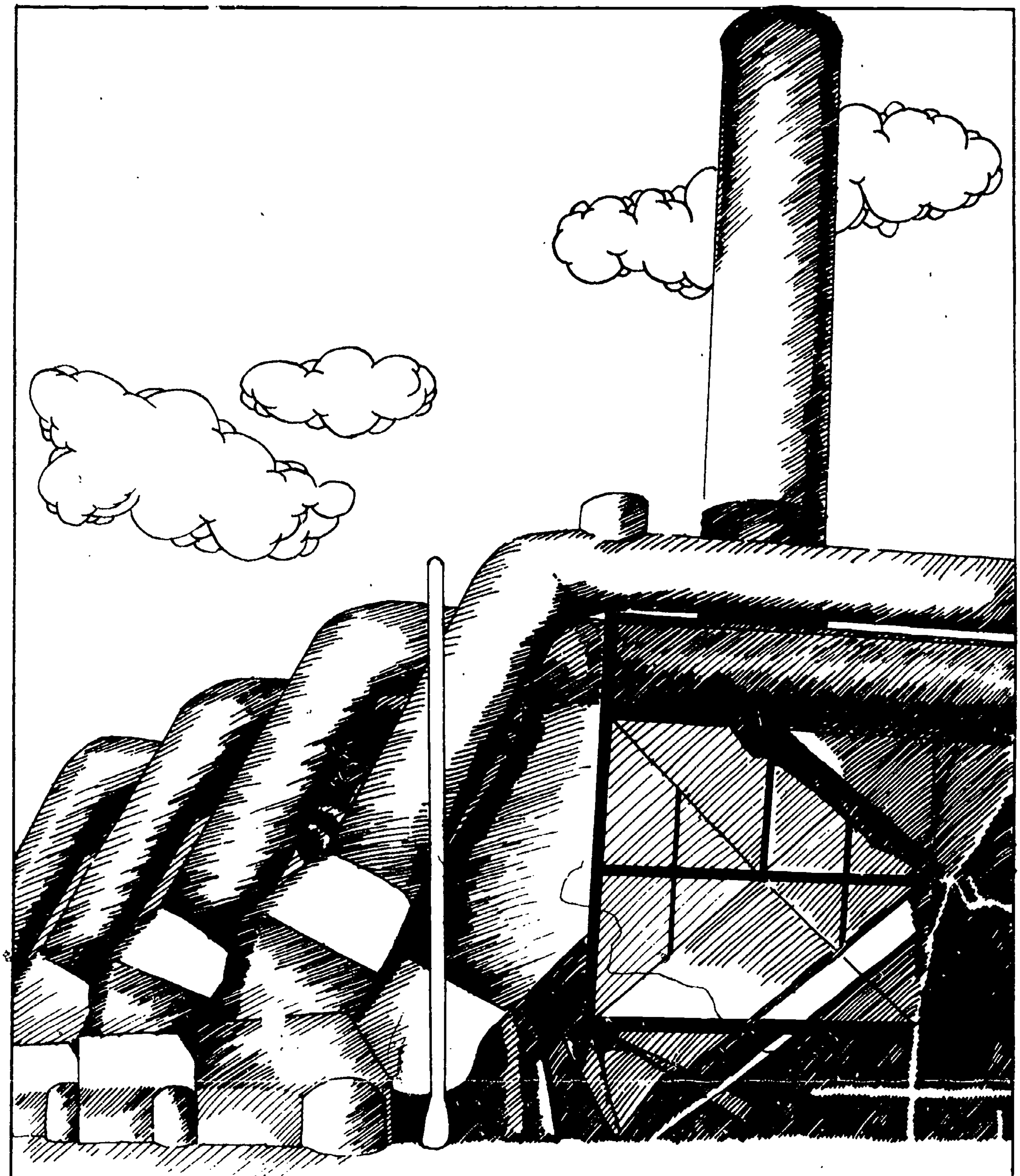
Lesson 6
Student Handout 2

Exhibit D

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

Lesson 6
Student Handout 2

Exhibit E



Keeping the air clean can cost millions of dollars.

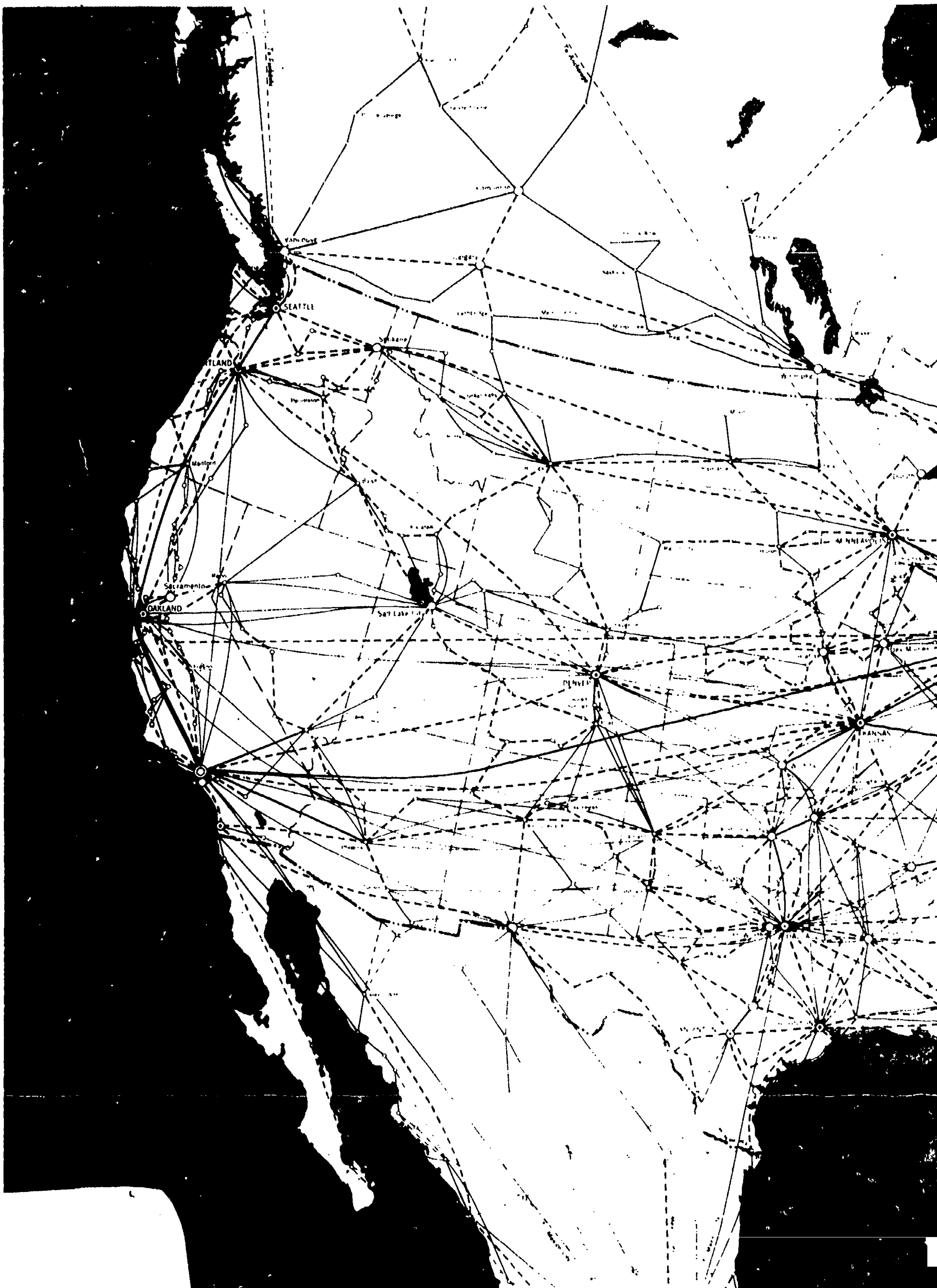
Lesson 6
Student Handout 3

Sources of Electrical Power

	PROBLEMS	BENEFITS
Coal	1.	1.
	2.	2.
	3.	3.
	4.	4.
Nuclear Power	1.	1.
	2.	2.
	3.	3.
Water	1.	1.
	2.	2.
	3.	3.
Natural Gas	1.	1.
	2.	2.

Solar/Wind	1.	1.
	2.	2.
	3.	3.
Oil	1.	1.
	2.	2.
	3.	3.
	4.	4.

Lesson 7
Student Handout 1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Sacramento
OAKLAND
DENVER