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ABSTRACT

Energy Smarts Team members are energy conscious students who want to save energy at school and at home. Students in a classroom and their teacher form an Energy Smarts Team. Selected students monitor their building each day at recess, lunch, or after school for lights or other electrical equipment that has been left on. The team members keep a log and leave friendly reminder "tickets." The program is designed to save money for school districts, encourage the wise use of natural resources, and to provide fun activities for students that give them an opportunity to contribute to their school. This training manual provides a take-home meter reading activity, an energy poster contest activity, six additional energy activities, and procedures and materials that provide a starting point for teams to start monitoring their schools. Procedural materials include member agreements, team log sheets, example reminder tickets, participation certificates, and the "Top Ten Tips to Try to Tame Terrible Temperature Thieves." Background information is provided for various energy sources including coal, oil, natural gas, nuclear energy, renewable energy sources, electricity, and food. (LZ)

ENERGY SMARTS TEAM

Training Manual

A teacher's guide to energy conservation activities for grades 3-8

Adapted by Oregon State University Extension Energy Program from materials by John Bezelj, Eugene, Ore., 4J School District Resource Conservation Teacher on Special Assignment

Bonneville
POWER ADMINISTRATION

OREGON
DEPARTMENT OF ENERGY

OREGON STATE UNIVERSITY
EXTENSION SERVICE

Acknowledgments

This manual was written for the Oregon State University (OSU) Extension Service by John Bezelj, resource conservation teacher on special assignment in Eugene, Ore. It describes training Bezelj gives to 4th and 5th grade classes to help them monitor and reduce their school's energy use. Additional activities in the manual are appropriate for grades 3-8.

The manual was adapted for wider use by Kasia Grisso, energy/environment education coordinator for the OSU Extension Energy Program, with contributions from David Philbrick, OSU Extension Energy Program leader.

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Introduction

The *Energy Smarts Team*

Energy Smarts Team members are energy conscious students who want to save energy at school and at home. Students in a classroom and their teacher form an *Energy Smarts Team*. Selected students monitor their building each day, at recess, lunch, or after school.

Energy Smarts Team members hope to find everything dark and quiet. They dislike energy waste and make sure that lights and equipment not used are turned off. *No, they don't unplug refrigerators or incubators.*

However, they do turn off lights, overhead projectors, radios, or other unused electrical gismos they come across during their search.

They leave gentle reminders with offenders and positive notes with those who watch their watts. They keep careful records to document progress. They regularly recognize rooms with perfect records.

School District 4J in Eugene, Ore. began its aggressive energy conservation program in 1987. The school district has achieved significant savings by installing energy efficiency measures, including behavioral conservation activities. The *Energy Smarts Team* program, called *Watt Watchers* in Eugene, has brought an awareness of resource conservation to students and staff and has encouraged students to make a significant difference in reducing energy consumption at their school.

From this program and other conservation efforts, the Eugene School District saved more than $271,000 in avoided energy costs during the 1991-92 school year.

The *Energy Smarts Team* program has been instrumental in empowering students and staff to start thinking about using resources wisely. It provides activities for students to observe firsthand their school's energy consumption. The program not only draws attention to a school's energy use, but also illustrates the cost of that valuable resource.

Who Are *Energy Smarts Team* Members?

Energy Smarts Team members are *responsible* students who work *independently* as well as part of a *team*. Teachers choose team members.

What do they do?

Energy Smarts Teams monitor their school to help conserve energy. Each *Energy Smarts Team* has an assigned area in the school.

Energy Smarts Teams patrol the school checking for unnecessary lights and other wasted energy. They sometimes keep track of how much energy their school uses and how much that energy costs.

How do they work?

Energy Smarts Teams keep a log where they record when lights and other electrical equipment have been left on or turned off in empty rooms. If people in a classroom, work area, or office have forgotten to turn off the lights, the *Energy Smarts Team* member leaves a friendly reminder "ticket" to help them remember the next time. A "Thank You" note is left when people in the area have remembered to turn off lights and other equipment.

***Energy Smarts Teams* are important because:**

- The money your district is spending for lights and equipment left on in empty rooms could be put to better use for educational purposes.
- Using resources wisely is part of being responsible and taking care of where you live.
- *Energy Smarts Teams* are fun and give students an opportunity to contribute to their school and learn about using resources wisely.

Energy Smarts Team Purpose and Procedures

The purpose of *Energy Smarts* Team training is to provide students with tools and information they need to effectively monitor energy use within their school building.

Energy Smarts Team activities build teamwork among participants. They also increase awareness of energy resource issues.

Team members typically monitor the school once a day—during lunch, recess, or after school. They work in pairs—never alone! An adult or experienced team member should accompany each team the first few times it is on duty.

The teacher or designated sponsor provides log sheets (see p. 31) on clipboards and badges (some type of I.D. tags) for team members to wear while on duty.

The school is divided into routes, each including a small number of rooms to monitor.

Each day, four or five teams pick up a clipboard corresponding to their route. The same team might do the same route at the same time for a week. Scheduling is up to the teacher. Log sheets can be altered to meet a teacher's specific needs.

Team pairs pick up their equipment in a specified place, such as the office, and drop it off immediately upon finishing their rounds. It is good to have them check in with an adult when starting and finishing their rounds so someone knows where they are at all times.

Activity Overview

On the following pages is the outline of a program used in Eugene, Ore. to train *Energy Smarts Team* members. The training, as done in Eugene, takes about 2-1/2 to 3 hours.

This manual includes a detailed outline of activities used during the training, plus additional activities.

Depending on your interests and needs these additional activities could be substituted for part of the basic training. Or they can be used during follow-up meetings with your team. You can modify any activity to meet your needs.

Here is a brief overview of each activity in the manual along with a summary of its goal.

Energy Smarts Team Pretest/Post-test
Take a few minutes and find out how much your students already know and help them focus on important concepts. Test again at the end of the training to determine how successful the training has been.

White Water Rafting
An exercise to familiarize students with the idea of simulations. It also serves to loosen up the group.

H.T. Rae Simulation
Builds problem so'ving and teamwork skills. Begins a discussion and appreciation of finite resources and how they can be managed for the greatest benefit.

Cookie Mining Simulation
A fun exercise that ends with the students being able to eat the cookie. It reinforces the meaning of finite resources and builds an appreciation of different perspectives and the implications they have on management strategies. This exercise provides information that strengthens graphing and math skills.

School Energy Consumption
Starts to build an awareness for how energy is used in a school. It begins to relate energy use to specific activities at the school. The material reinforces lessons relating to graphing and developing different hypotheses.

Electrical Pathways
In this exercise a poster, not contained in this manual, is used to motivate a discussion of how electricity is produced and used. A source for the poster is indicated in the training agenda. Other resources can be substituted for the poster to help motivate a similar discussion.

What's a Watt?
A watt-rate meter is used to measure and compare energy used by typical classroom appliances such as lights, an overhead projector, radio, etc. A watt-rate meter can be made from an old electric meter by retrofitting it with a standard electrical outlet. Local electric utilities often will donate these. This is an excellent tool for demonstrating the effect of different measures such as replacing an incandescent bulb with a fluorescent one. The watt-rate meter also helps students develop a feeling for how much energy a watt-hour represents and the effect their actions as part of the *Energy Smarts Team* can have.

What's a Therm?
Many of the in-school activities focus on lighting, computers, and other equipment that use electricity. As students apply their knowledge at home and as they become more sophisticated at school they will increasingly become involved with space and water heating and with other appliances that may be fueled by natural gas. "What's a Therm?" presents background information and exercises to increase

awareness of gas as an energy resource, how it is measured, and the relationship between it and other resources.

Meter Reading
This is a follow-up activity that helps motivate students to apply their *Energy Smarts Team* training outside of school. After instruction at school, the students are able to read and record their electric and gas meters at home. Following a week or other specified time period, students can compare data. This presents a good vehicle for use of math and graphing skills and for discussions about energy use in their homes. It can be the start of the student becoming *Energy Smart* at home too.

Top Ten Tips to Try to Tame Terrible Temperature Thieves
This activity grew out of an energy-related student poster contest. The poster depicts ten typical actions available to *Energy Smarts Team* members. The graphics have been reproduced in the *Energy Smarts Team* Training Manual along with a short description of the activities. As you and your team discuss them, you may think of other actions that should be added.

***Energy Smarts Team* Procedures and Materials**
These materials provide a starting point for you to work with your team on the steps you want them to take in your building. You are free to use the procedures and materials used in Eugene that are included. You may use them *as is* or customize and improve them based on your experience and setting.

Energy Smarts Team Training Agenda

(If teachers want their students to take the Energy Smarts Team pretest [pp. 11-12], this might be a good time to do it.)

Note: This is the agenda that Eugene 4J School District used for its *Energy Smarts Team* training. The manual includes activities in addition to those described below.

1. Name that energy

Name tag energy introductions. Participants create colorful energy name tags (3 by 5 index cards). Include first name and two energy illustrations. Participants introduce themselves and briefly explain their energy illustrations.

2. Simulations

- **Ask participants to define simulation.**
- **White water rafting simulation.**
  To illustrate a simulation, have participants pretend they are white water rafting. Explain that we are going white water rafting and ask them to put on their life jackets, making sure to tie both strings. Demonstrate each part of this simulation in front of the class. Get your oars out and start paddling. Half of the class might paddle on one side and half on another. Don't forget to stop for lunch on a big rock! Paddle around dangerous rocks, and perhaps paddle backwards furiously when you get too near a waterfall.
- **H.T. Rae simulation.**
  Divide participants into problem-solving groups and read aloud the H.T. Rae story (p. 14) or show it on an overhead transparency. Encourage groups to suggest possible solutions to the problem presented in the story. Have groups share one or two of their solutions with the rest of the class. Read the ending of the story.
- **Cookie mining simulation.**
  See pp. 15-16.

(Possible break. You may want to use this time to tour the boiler room and observe the heating system of the building.)

3. School energy consumption

Show participants how to interpret data on the pie chart (p. 17) and line graph (p. 18). Ask participants to guess what energy uses different slices in the pie chart represent. Also ask them to deduce why electricity use is less during summer months.

4. Electricity pathways

To stimulate discussion about electricity producers, use the *Electricity Serves Our Community* poster available for $3 each plus shipping and handling from the National Energy Foundation, 5160 Wiley Post Way, Suite 200, Salt Lake City, Utah 84116, telephone 801-539-1406. Emphasize similarities in generation of electricity from many different producers—solar, fossil fuels, wind, hydroelectric, geothermal, and nuclear.

Have participants brainstorm a list of devices at school that use electricity. List them on the chalkboard and categorize them according to use, e.g., electricity used to heat, electricity used to light, electricity used to perform work.

5. What's a watt?

Have participants do activities suggested on pp. 19-20. Use the watt-rate meter to show participants actual electrical consumption of electrical devices such as a 100 watt bulb, compact fluorescent bulb, hair dryer, electric drill, overhead projector, radio, etc. Point out the relationship between electrical consumption and generation of heat. Discuss watt, kilowatt, and kilowatt hours. Calculate the cost of using lights for one year.

6. *Energy Smarts Team* procedures and agreements

Read and discuss *Energy Smarts Team* procedures and agreements (pp. 29-30). Train participants in how to use the *Energy Smarts Team* log. Make up humorous scenarios to present to participants. Have them mark their *Energy Smarts Team* log appropriately.

7. Tickets and certificates

Make your own "Positive tickets," "Gentle Reminders," and "Perfect Energy User Certificates." (See pp. 32-33 for ideas.)

8. Evaluation.

To close the workshop, use either "What did you learn" questions or the post-test on pp. 27-28.

Name ______________________________

Class ______________________________

School ______________________________

Date ______________________________

Energy Smarts Team Pretest

1. It pays to turn off the lights in a room as soon as it is empty for more than

   a) 1 second.

   b) 1 minute.

   c) 5 minutes.

   d) 15 minutes.

2. On a cool sunny day, the best idea is to

   a) open the shades and turn on the lights.

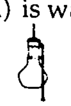
   b) close the shades and turn on the lights.

   c) open the shades and turn off the lights.

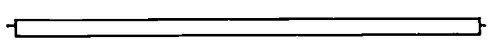
   d) close the shades and turn off the lights.

3. An incandescent light bulb is the most common type used in homes. When it is on it

   a) is warm to the touch and looks like this:

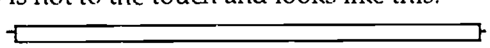


   b) is warm to the touch and looks like this:



   c) is hot to the touch and looks like this:

   d) is hot to the touch and looks like this:



4. Which light bulb uses the most electricity?

   a) a 70 watt incandescent.

   b) a 70 watt fluorescent.

   c) They both use the same.

5. Which light bulb produces the most light?

   a) a 70 watt incandescent.

   b) a 70 watt fluorescent.

   c) They give off the same amount.

6. A school can lose energy right down the drain! All drips being equal, the most expensive leaky faucet

   a) is a cold water faucet.

   b) is a hot water faucet.

   c) is a warm water faucet.

7. If someone asked you which was longer, a 40 centimeter snake or a 2 foot long snake, you would have to convert them both to the same units. It works this same way with energy: Electricity that lights a bulb, oil that burns in a furnace, and heat your body gives off can all be converted to Btu. A Btu is about the amount of heat energy in

   a) one wooden kitchen match.

   b) one firecracker.

   c) one average fireplace log.

   d) one gallon of gasoline.

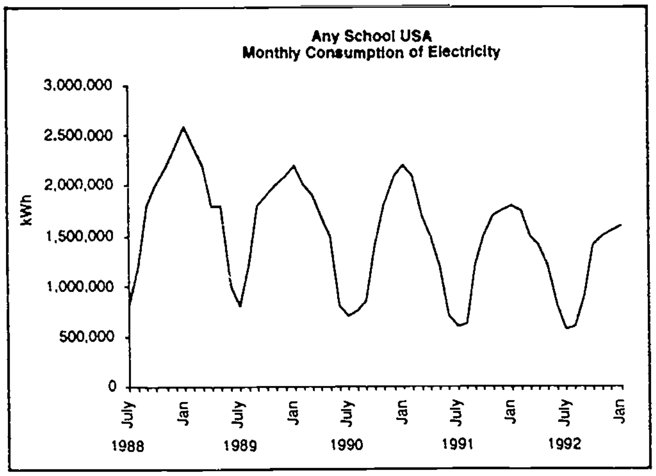
8. Electricity is measured in

   a) therms.

   b) watts.

   c) gallons.

   d) pounds.



9. This graph shows how much electricity was used at Any School USA during a 5 year period. In which month did Any School USA use the most electricity?

a) January 1989.

b) July 1991.

c) March 1990.

d) January 1992.

10. Many tools and appliances besides overhead lights use electricity in schools. Name three common items found at school besides lights that use electricity.

a)

b)

c)

H.T. Rae Simulation

Grades 4-6
Subjects: science and social studies

Activity:

Divide participants into problem-solving groups. Read aloud the H.T. Rae story (p. 14) or show it on an overhead transparency. Encourage groups to brainstorm solutions to the problem. Participants may either write down or draw their solutions.

Ask each group to share one or two solutions that represent the general feeling of the entire group. The instructor records suggestions on the board or on a large sheet of butcher paper.

The ending to the story is read or shown on the overhead projector. The instructor asks the class which solutions suggested by the class might really work.

Once participants realize that the astronaut group, the Uoy, really represents the majority of us, participants often change their minds about what sh uld be done to solve the problem.

Solutions suggested by other students

"Lock them up in a space jail and throw away the key."

"Confine them to their own space and only give them enough food to barely exist."

"Tell them what they are doing wrong and warn them that if they don't change they'll be punished."

"Train them about recycling and other things that will make them understand how to improve."

"Force them out of the spaceship into space and let them deal with what it's like out there."

"Torture them by only giving them a few crumbs to eat until they learn their lesson."

"Do the same to them.... Take their food, mess up their air and water.... Maybe they won't be so mean if they saw how it felt."

H.T. Rae questions for discussion

1. Shall we lock up all people who pollute air and water?

2. Many people drive automobiles. What should be done about people who pollute air with their automobiles?

3. What shall we do with people who generate garbage? After all, most garbage is disposed of in a way that pollutes. Using landfills to bury garbage and incineration to burn garbage each presents a different pollution problem.

4. What about people who waste electricity? Leaving electrical appliances and devices on when they're not being used wastes energy. More energy must be produced when we waste it. Producing energy is expensive and uses earth's valuable resources.

5. Ask other questions that draw attention to the fact that each of us pollutes and wastes resources to some extent.

The H.T. Rae story

The H.T. Rae is a large spaceship that contains everything required for a long mission to explore the universe. Garden plots with fertile soil provide enough food for the astronauts during their voyage. The ship also has the ability to continually purify air and water—recycling these elements for the astronauts' use. The ship, however, has only a limited amount of natural resources on board.

Acquiring additional resources would not be a possibility for the astronauts. Wise use of natural resources on board is important if the ship is expected to have enough for its entire voyage.

The H.T. Rae is fully equipped to support everyone on board, but each of its systems must be carefully maintained, as there is no extra water, air, soil, food, or other resources. Successful maintenance of the entire ship and its systems depends on careful balance of each element and on cooperative behavior of all astronauts.

On board the H.T. Rae are many groups of astronauts. Most groups work well together and help one another for the good of the ship. One of these groups, the Uoy, is well-known for wanting more food than their own areas can produce. They buy, and sometimes take, some of the other astronauts' resources. They don't use resources wisely. In fact, they have been known to throw away their food and waste. This pollution has created a problem with the ship's clean water supply.

The Uoy have often been known to burn their excess waste, polluting the ship's air supply. This group of astronauts has really had quite an effect on the rest of the ship.

What should be done?

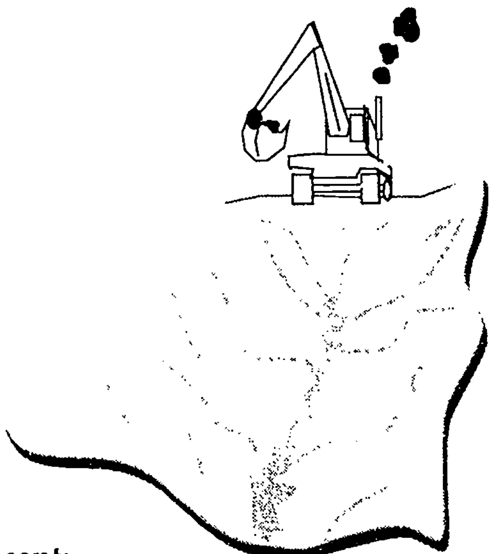
(Read the following after the group finishes the H.T. Rae simulation.)

H.T. Rae is *Earth* spelled backwards. The spaceship represents Planet Earth. Uoy is *you* spelled backwards—this is to point out that we, as human beings, are often guilty of using more natural resources than we need. We are often guilty of throwing away and burying or burning our waste, which pollutes our water and air.

All of the air, water, soil, and natural resources we will ever have are on Earth now. We breathe the same air the dinosaurs breathed and drink the same water they drank. We are rapidly using up natural resources that have taken millions of years to make. We are the astronauts on Spaceship Earth, and it is our responsibility to keep the ecosystem in balance for future generations of inhabitants and to use our natural resources wisely.

Cookie Mining Simulation

Grades 4-6
Subjects: science, math, and social studies



Concept:

- Coal deposits, like many natural resources, are unevenly distributed throughout the world.
- Mining, like other methods used to extract natural resources, affects the environment to varying degrees.
- Many factors need to be considered when making decisions regarding the wise use of natural resources.

Background:

At present, coal provides nearly 20 percent of total United States domestic energy needs. This translates to nearly 3 tons per person each year. At present rate of use, world coal supplies will last slightly more than 70 years.

Fifty years ago when most coal mining was done manually, *underground* mines accounted for 96 percent of coal produced each year, while *surface* mining accounted for only 4 percent. Today, surface mining has increased to nearly 60 percent.

Before a company can surface mine, it must gather information about the site regarding growing conditions, climate, soil composition, vegetation, wildlife, etc. With this information, the company must post a bond for each acre of land it mines to ensure that it will be properly reclaimed.

What you'll need:

- Large, soft chocolate chip cookies, napkins, and paper clips—one of each for every student.
- Butcher paper or large graph paper.
- Optional: juice or milk.

What to do:

1. Give each student a cookie, a napkin, and a paper clip. *They are not to eat the cookies until the exercise is over.*

2. Ask students to suggest what the napkin, cookie, chocolate chips, and paper clip represent in the simulation. (Answers: napkin represents space, the universe; cookie, the earth; chocolate chips, coal; paper clip, mining machinery.)

3. Suggest that students pick a role to play in the simulation. Tell them not to divulge their role at this time. Possible role choices include:

   The president of a coal company—emphasis on mining a maximum amount of coal as a primary responsibility.

   An extremely environmentally conscious person—emphasis on taking care of the earth and its resources as a primary responsibility.

   A middle-of-the-roader—person who tries to strike an even balance between profits and environment.

Number of chips found before mining

Student name	# of chocolate chips
Rosie	16
Larry	19
Joe	13
Cindy	20
Malcolm	18
Carmen	16
Louie	16
Shawn	19
Susan	18
Billy	19
Cecile	18
Juan	21
Abby	17
JoAnne	17
Charlie	20
Total # chips	267
Avr. # chips per student	**18**

4. Instruct students to count how many visible chunks of coal are in their earth. Students may turn the cookie over to include any surface coal visible on the bottom. Record the average number of visible chips on butcher paper or graph.

5. Instruct students to begin "mining" their coal deposits. Students will mine their coal deposits from the perspective of the role they chose earlier.

6. Have students place their coal deposits in one pile and the earth's crust in another. Have students continue "mining" until most appear finished. When students finish, have them record the total number of pieces of coal mined on the butcher paper or graph.

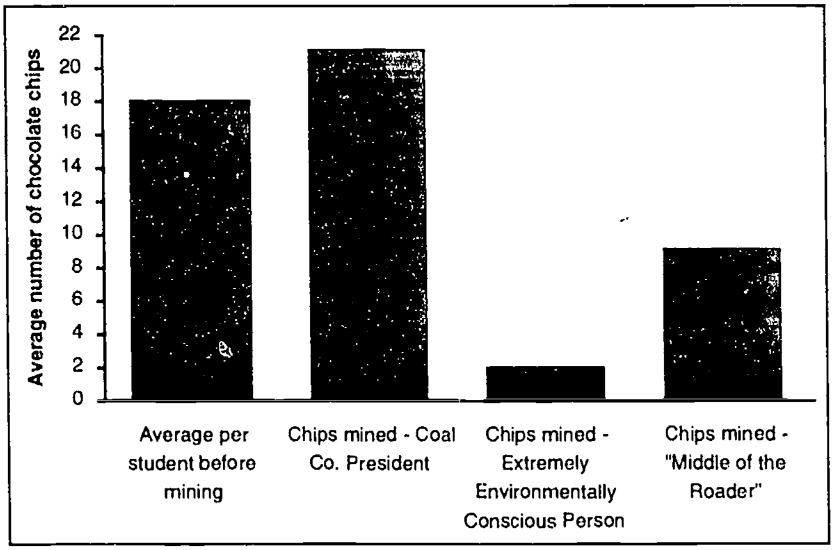
7. Quickly walk around the room asking students to guess the role of a particular student. (A cookie mined by a president of a coal company may appear to have most of the coal mined, with the earth appearing disturbed significantly. Another cookie may appear nearly untouched, with only one or two chocolate chips "mined." This causes minimal impact on the earth. This cookie may be mined by a student taking the role of an environmentalist.) Ask students to explain why they chose their particular role.

8. Before students are allowed to eat their cookie, instruct them to put their "earth" back together. Encourage them to try, even if their cookie looks like a pile of crumbs.

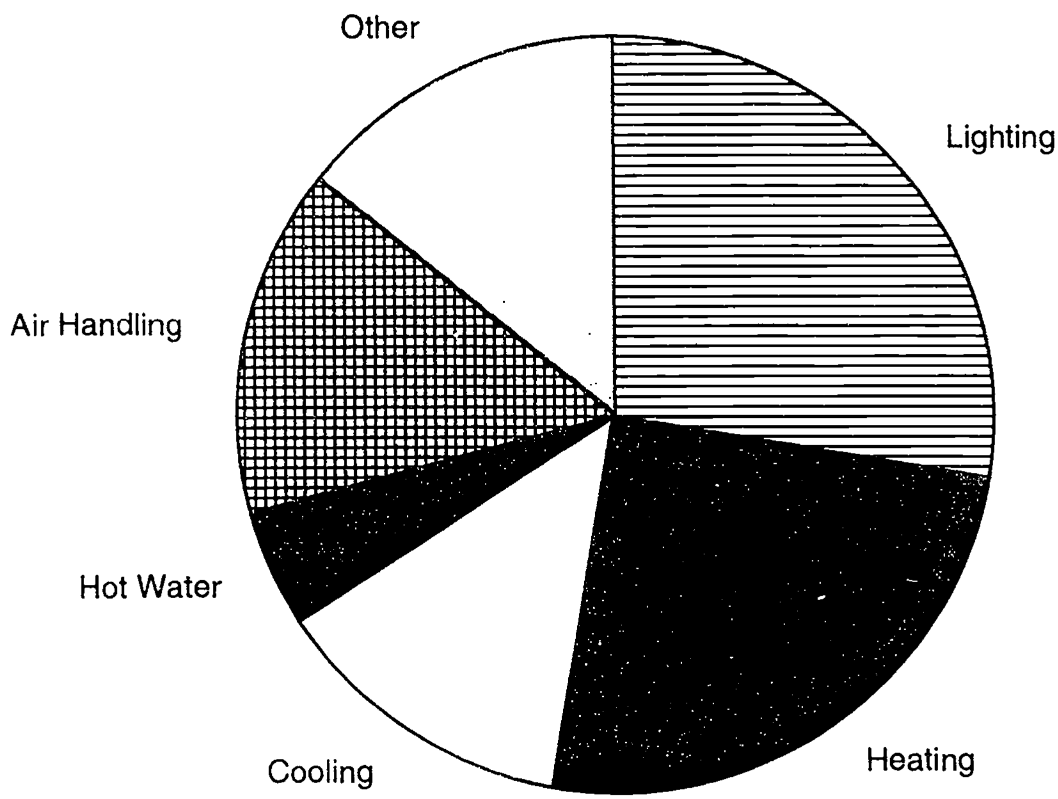
9. Discuss the following points with the class:

- There are more coal deposits than could be seen on the surface.
- "Mining" the deeper coal took more time and was more trouble than mining coal near the surface. (It takes energy to get energy.)
- Coal deposits were unevenly distributed. Some students had more coal deposits than others. Why?
- Once the earth is disturbed by mining, it is difficult to restore to its original state.
- What can be said about the employment of people versus the effect on the earth of obtaining those resources?

10. Allow students to eat their cookie. Provide juice or milk if desired.

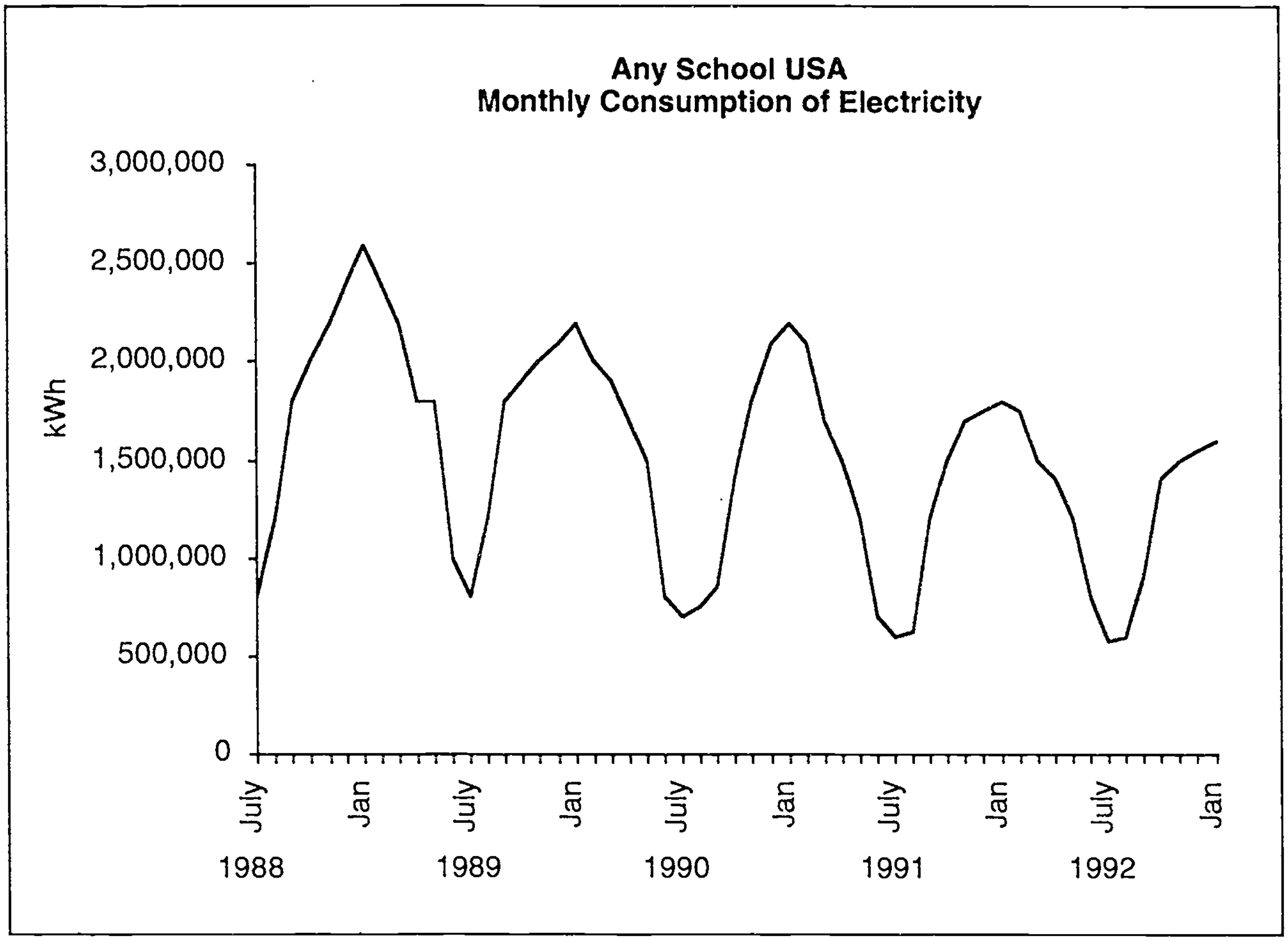


School Energy Consumption



Lighting	28%
Heating	25%
Cooling	13%
Hot Water	5%
Air Handling	15%
Other	14%

Make a transparency of this pie chart. Before you project it, cover up words identifying energy uses. Ask students to guess what energy uses different slices in the pie chart represent. After students guess a school's energy use, uncover words illustrating actual consumption. Point out that lighting is a significant portion of a school's energy use.



Ask students to interpret data on the line graph. Ask them to deduce why electricity use is less during summer months.

What's a Watt?

Grades 3-8
Subjects: science and math

Concept:

- Conservation reduces our energy demands.
- The cost of electricity to run different electrical devices varies.

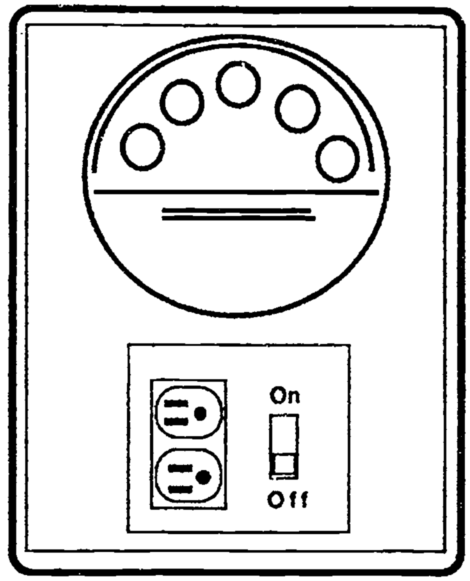
Objectives:

- Students will be able to determine how many watts an electrical appliance uses by timing the dial of a watt-rate meter and by reading electrical consumption information printed on the appliance.
- Students will be able to identify which appliances in their daily lives use more power and which appliances use less.
- Students will be able to state ways they can save energy in their daily lives.

Background:

Electricity is brought to a house through a three-wire cable. An electric meter connected to the household circuit breaker or fuse box shows how much electricity is used. Two *live wires* bring electricity from the fuse box to power outlets (plug-ins), utility boxes (lighting), and wall switches. Each live wire is at a voltage of 120 volts relative to ground and 240 volts relative to each other. The third wire, or *neutral*, is brought to a grounding bar in the circuit breaker box, or attached to a cold water pipe as well as to all power outlets, utility boxes, and wall switches. Every appliance plugged into an outlet also has a ground connection. The appliance ground is connected to the metal or plastic case of the appliance.

At each power and lighting outlet no current flows until a lamp or appliance is plugged in and switched on. However, there is always a voltage at that point whether current flows or not. It is like a water tap; the pressure is always there although there is no flow until it is turned on.



You will find the watt-rate meter a useful addition to your classroom energy equipment. Your local utility company may help you obtain a meter.

Activity:

This exercise uses a watt-rate meter to show students how energy is measured in our homes, and how different appliances use different amounts of energy. A *watt-rate meter* is a device that measures electrical consumption.

What you'll need:

Watt-rate meter, clock with second hand, various common appliances or devices with a wide range of levels of energy consumption. Examples include a 100 watt incandescent bulb, compact fluorescent bulb, hair dryer, electric drill, overhead projector, radio, fan, hot plate, and portable electric heater.

What to do:

1. Time one revolution of the watt-rate meter dial using a 100W bulb. This data should equal 120 seconds for all watt-rate (electrical) meters. It can be used as a standard for students studying appliances.

2. Help students understand that the faster the dial goes, the more power (watts) is being used. Therefore, *half* the time needed for 100 watts would equal 200 watts and *twice* the time would equal 50 watts.

3. Using the watt-rate meter, show students electrical consumption of many common electrical appliances and equipment in the classroom. Switch appliances several times (e.g., from hair dryer to overhead projector) so students can see how speed of the dial changes.

4. Have students determine how many watts per hour different electrical appliances and equipment use. They can do this by timing revolutions of the dial and then calculating watts for that period of time. The 100-watt time is the starting point for calculations. Explain that all watt-rate meters, including the ones in their homes, measure watts at the same speed.

5. Have students record their findings in a chart with three columns. In the first column, write the name of the appliance. In the second column, record the number of seconds it takes for the dial to turn *one* time. Since they know that 100 watts takes 2 minutes (120 seconds) for one revolution, they then can fill in the third column with the number of watts the appliance uses. Have them compare their findings with the chart below:

One turn of the dial in seconds	Watts
7.5	1600
11.25	1200
13	1000
15	800
30	400
45	300
60	200
75	175
90	150
105	125
120	100
240	50

6. Point out the relationship between increased electrical consumption and the generation of heat. (A hair dryer is a good example.)

7. Discuss watt, kilowatt, and kilowatt-hours.

8. Show students that each appliance has electrical consumption information imprinted somewhere on the appliance.

9. Calculate the cost of using the lights in a classroom for one year.

Example:

42 lamps per room X 34 watts each =

42 X 34 = 1428 watts or 1.428 kilowatts (1 kilowatt = 100 watts)

1.428 kilowatts per hour X 6 hours =

8.568 kWh (kilowatt-hours) X $0.03 per kilowatt hour =

$0.26 per day per classroom

$0.26 X 175 days of school per year = $45 per year per classroom just for lights.

(Note: The 3 cents per kWh rate is the rate customers pay for electricity in Eugene, Ore. in 1993. This rate needs to be modified for specific areas. In Rhode Island, for example, customers pay 26 cents per kWh. All conditions being the same, it would cost a typical classroom in Rhode Island $389.84 per year just for lights.)

10. Discuss the two results conservation measures offer—using valuable resources wisely and saving money.

11. Discuss ways students can conserve energy in their daily lives. Some facts about conservation that may be useful to use in discussion include:

- Heat is measured in Btu (British thermal unit)—a common measuring unit of energy. One Btu is the amount of heat needed to raise 1 pound of water 1 degree Fahrenheit. One Btu is approximately equal to the amount of heat generated from one wooden kitchen match.
- The ballasts that charge the gas inside fluorescent lights are much more energy efficient then they were 25 years ago. In fact, energy used by a ballast manufactured 25 years ago would use about 15 minutes worth of electricity. In other words, many years ago it would be beneficial to leave the lights on in a room if you would return within 15 minutes. Many people still believe that leaving the lights *on* saves energy. Today's ballasts are so energy efficient, they require less than a second's worth of energy to ignite the gas inside a fluorescent tube. It does save energy to turn *off* the lights even if you're going to be gone for only a few seconds.

12. A lot of energy is used to heat a school. Discuss some ways to help save energy on heating both at home and in school.

What's a Therm?

Grades 5-8
Subjects: science, math, and social studies

Concept:

- Ability to visualize the amount of energy represented by a therm: what it does, how much it typically costs, how it compares to other energy units.
- What we know about long-term availability of natural gas and possible environmental consequences from its use.
- Options for conserving natural gas.

Background:

Natural gas is a combustible gas found in nature in underground reservoirs of porous rocks, either alone or in association with crude oil. Most commercial natural gas in the United States is *nonassociated gas*—gas that is independent of crude oil deposits.

Natural gas is measured in cubic feet. The largest constituent of natural gas (70 to 90 percent of the volume) is methane. Other components include ethane, propane, butanes, and some larger molecules.

On average, the heating value of commercial natural gas is 1,000 Btu/cubic foot. Heating value for a specific sample varies depending on the amount of gases having a higher heating value (such as ethane) and the amount of inert gases, which lower the heating value. Pipeline quality gas is required to have a minimum heating value of 900 Btu/cu ft.

In the United States before the 1870's, natural gas was considered largely a curiosity. In 1872, the first iron pipeline in the United States was built to carry natural gas 5-1/2 miles for use in Titusville, Pennsylvania. By the 1920's, natural gas production reached 80 billion cubic feet a year. In the 1930's, pipelines carried natural gas from Texas to the Midwest, and the fuel became important for heating and cooking.

By the 1960's, more than 500,000 different chemical compounds were being made from natural gas and oil. These chemicals are used in detergents, drugs, fertilizers, paints, plastics, synthetic rubber, nylon and rayon.

In 1991, 21.58 trillion cubic feet of natural gas was used in the United States. Of this, 4 percent was used in transportation, 14 percent in commercial buildings, 14 percent by electric utilities, 24 percent in homes, and 44 percent in industry.

Natural gas reserves in the United States and Canada were estimated in 1991 to be 338.7 trillion cubic feet.

Improving efficiency:

You can save energy if you get more benefit from each unit of fuel you use. For natural gas, you can improve efficiencies by reducing the amount of energy needed for a given benefit, by improving combustion efficiency, by increasing transfer of heat produced to the desired application, and by improving control so energy is used only when needed.

Natural gas and global climate change:

Methane and the carbon dioxide generated when natural gas is burned contribute to "greenhouse gases." Burning a therm of natural gas releases about 11.8 pounds of carbon dioxide into the atmosphere.

Use of natural gas as an energy source in Oregon was estimated to contribute 4.8 million tons of carbon dioxide in 1988 (about 8.5 percent of all greenhouse gas emissions in Oregon in 1988). Without actions to reduce increases, this is expected to grow to 6.2 million tons by 2005 (about 12.8 percent of the total in 2005). The actual increase is likely to be larger as these figures do not include the use of natural gas to produce electricity. Some Oregon utilities are turning to significant numbers of combustion turbines (which use natural gas to produce electricity) to meet electricity needs in the near term.

Natural gas measurement:

One cubic foot of commercial natural gas (on average)	1,000 Btu*
One kilowatt-hour (kWh) of electricity	3,412 Btu
One therm of natural gas	100,000 Btu

*British thermal unit

Questions:

1. Natural gas bills typically are based on the number of therms used. Electricity use is based on the number of kilowatt-hours (kWh). How many cubic feet of natural gas are in a therm? How many kWh represent the same amount of energy as a therm of natural gas?

2. How many cubic feet of natural gas would be burned to deliver the same amount of energy as in 1 kWh of electricity?

3. How much does your household pay for a kWh of electricity? If natural gas is available in your community, how much do people pay for a therm of natural gas? In terms of energy available, which is the better buy?

4. If consumption of natural gas in the United States were to remain at 1991 levels, and assuming no imports or exports, how many years would it take before known North American gas supplies would be exhausted?

5. A 100 watt light bulb left on for 24 hours uses energy equivalent to how many therms?

---

6. Savings opportunity:

Draw a line between each action and the appropriatr explanation as to why it saves energy.

A. Home insulation	1. Allows proper airflow through the heat exchanger and back into the home. Without proper airflow, more heat goes up the chimney.
B. Replace a pilot light with an electric ignition	2. Less heat is required if the heat that is produced at the furnace is delivered where it is needed in the home. In traditional forced-air furnaces typically 25 to 30 percent of heat is lost in ducts between the furnace and the room where heat is wanted.
C. Clean furnace filters	3. Reduces the requirements for space heating and cooling.
D. Sealed and insulated ducts	4. Uses less energy by using energy only when it is actually needed.
E. Anticipatory controls	5. As rooms get close to the desired temperature the flame stops and final heating is provided by the residual heat in the furnace. This helps minimize the amount of heat lost up the chimney.

Answers:

1. 100 cubic feet/therm, 29.3 kWh/therm
2. 3.4 cubic feet. Because of net energy loss associated with generation of electricity, it takes 3 times this amount or 10 cubic feet to generate 1 kWh of electricity.
3. Price of electricity/kWh X 29.3 kWh/therm. If greater than cost of gas/therm, then gas would be the better buy.
4. 338.7 trillion cubic feet divided by 21.58 trillion cubic feet/year = 15.7 years.
5. 100 watts X 24 hours = 2,400 watt-hours = 2.4 kWh
   2.4 kWh X .034 therms/kWh = .0816 therms
6. A3, B4, C1, D2, E5

Meter Reading

Grades 5-8
Subjects: science and math

Determine how much energy (electricity and/or natural gas) each family uses in one week by reading their power meters. You do this by reading the electric and/or gas meter every day at the same time each day.

Prepare by going over instructions in "How to Read Your Electric and Gas Meter" (p. 24).

Give each person a copy of the "Meter Reading Worksheet" (p. 25). Go over it together.

(Note: Some electric and gas meters may have five faces instead of four.)

Each participant then reads their electric and/or gas meter every day for one week and records the reading on the "Meter Reading Record" (p. 26). They should be sure to read it at the same time each day.

At the end of one week have each participant calculate how much energy (natural gas and/or electricity) their family used. To determine the amount, subtract the first reading from the last, and convert to common units such as Btu. Have the students share and discuss their results.

Possible discussion topics:

- Why do the amounts differ from household to household?
- How might weather affect energy consumption?
- How might the number of people in the family influence energy consumption?
- How might the size, age, insulation/weatherization, etc. of homes influence energy consumption?
- What were some ways your family used electricity and/or natural gas during the week?

Make a line graph of each household's daily energy use. Possible discussion topics:

- Does the energy use differ from day to day? If so, why?
- Which day did your family use the most energy? Why?

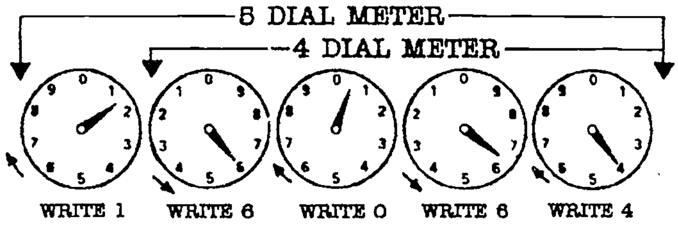
Suggest ways to conserve energy.

HOW TO READ YOUR ELECTRIC AND GAS METER

Name: ______________________________ Date: __________

How To Read Your Electric Meter

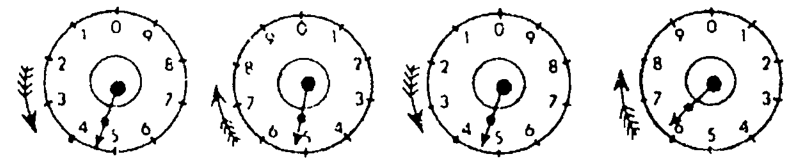
The dials are like watch faces lined in a row (every other dial moves counterclockwise). The reading for a five dial meter would be 16,064. The reading for a four diameter would be 8,064.



Notice that when the pointer is between two numbers, you should record the lower of the two numbers.

When the pointer seems to be directly on a number, look at the dial to the right, if the pointer on the right side dial has passed "0," then write down the number the pointer seems to be on; if the pointer on the right side dial has not passed "0." then write down the previous lower number on the dial you are recording.

How To Read Your Gas Meter



4
Take the number the first pointer has just passed...

5
And the number the second pointer has just passed...

4
And the number the third pointer has just passed...

6
And the number the second pointer has just passed...

Add two zeros 454600
This is the meter reading (in cubic feet of gas).

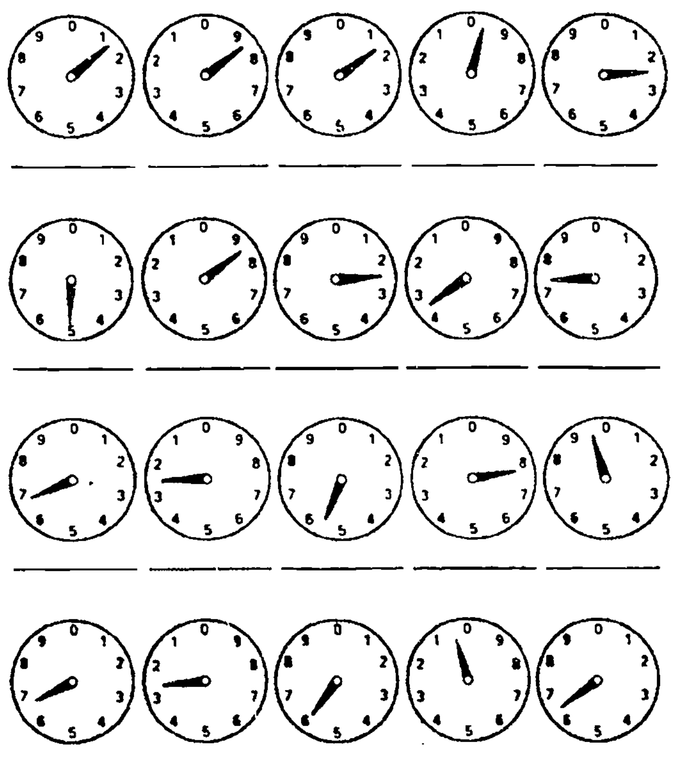
From National Energy Foundation, 1986, Energy 6: Multidisciplinary activities for the classroom developed by the National Energy Foundation especially for teachers. *Used with permission.*

"METER READING WORKSHEET"

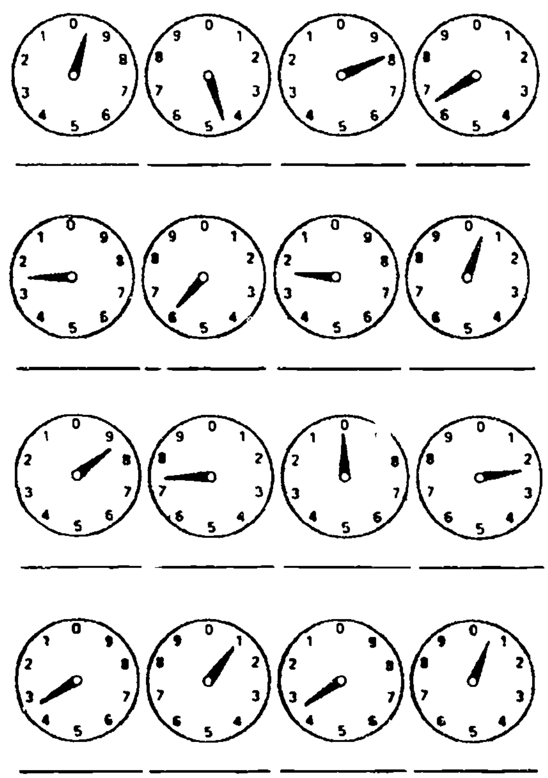
Name: ______________________________ Date: __________

Read the following meters and record your answers in the space below each.

Electric Meters



Gas Meters



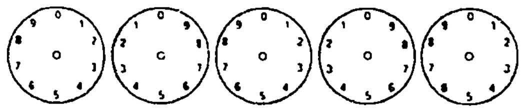
METER READING RECORD

Name: ______________________________ **Date:** __________

ARE YOU SAVING ENERGY? A good way to find out is to keep a record of the electricity or natural gas you use before and after beginning your conservation effort. The chart below will help you record your progress. 1. Draw the positions of the hands of the meter on the dials each day at the same time. 2. Write the number in the space below each dial and on the line at the right. 3. Subtract the readings on day one from day two. Repeat each day for seven days.

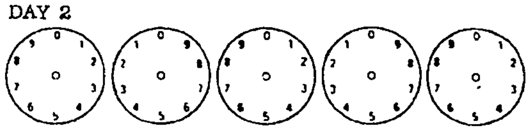
☐ Electric Meter ☐ Natural Gas Meter

DAY 1



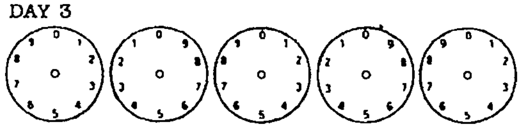
Meter Reading Day 1 ________

DAY 2



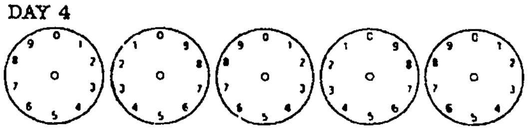
Reading Day 2 ________
Reading Day 1 ________
Energy used ________

DAY 3



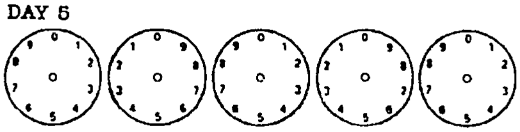
Reading Day 3 ________
Reading Day 2 ________
Energy used ________

DAY 4



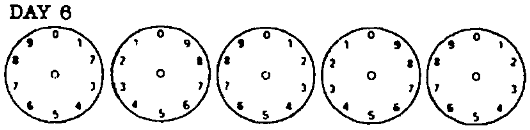
Reading Day 4 ________
Reading Day 3 ________
Energy used ________

DAY 5



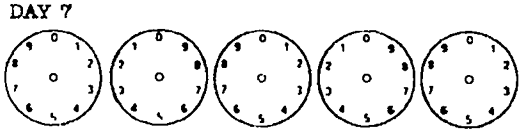
Reading Day 5 ________
Reading Day 4 ________
Energy used ________

DAY 6



Reading Day 6 ________
Reading Day 5 ________
Energy used ________

DAY 7



Reading Day 7 ________
Reading Day 6 ________
Energy used ________

Name ______________________

Class ______________________

School ______________________

Date ______________________

Energy Smarts Team Post-test

1. It pays to turn off the lights in a room as soon as it is empty for more than

   a) 20 minutes.

   b) 15 minutes.

   c) 5 minutes.

   d) 1 second.

2. One way to save energy on lighting is

   a) to use incandescent bulbs whenever possible.

   b) to use sunlight when possible.

   c) to use light bulbs with more watts.

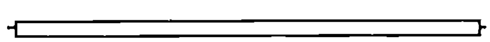
   d) to keep the window shades closed.

3. A fluorescent light bulb is the most common type used in schools. When it is on, it

   a) is warm to the touch and looks like this:

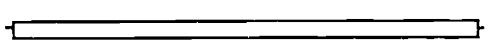
   b) is warm to the touch and looks like this:

   c) is hot to the touch and looks like this:

   d) is hot to the touch and looks like this:

4. Which light bulb uses the most electricity?

   a) a 100 watt incandescent.

   b) a 100 watt fluorescent.

   c) They both use the same.

5. Of all the things that schools do, most energy is used for

   a) heating.

   b) cooling.

   c) lighting.

   d) hot water.

6. Which of the following is an energy waster?

   a) a closed door when the heat is turned on.

   b) a water faucet that doesn't leak.

   c) a dark, empty room.

   d) an empty room with a radio on.

7. If someone asked you which was heavier, a 40 pound monkey or a 2 kilogram tomato, you might have to convert them both to the same units before answering. It works the same way with energy. The electricity that lights a bulb, the oil that burns in a furnace, and even the heat your body gives off can all be converted to Btu. A Btu is about the amount of heat energy in

   a) one wooden kitchen match.

   b) one firecracker.

   c) one average fireplace log.

   d) one gallon of gasoline.

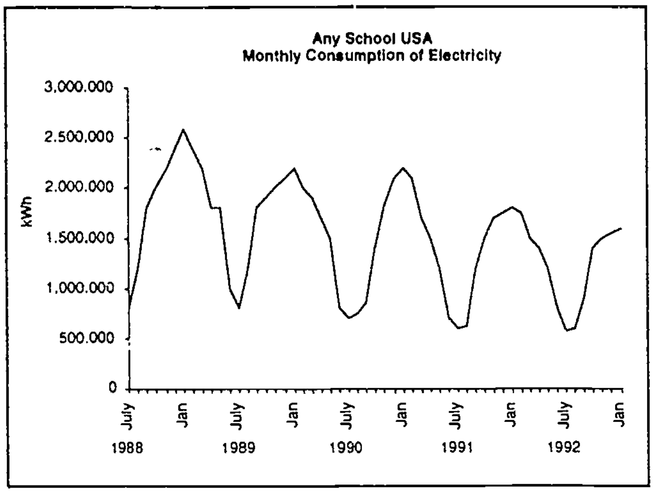
8. Use of electricity is measured in

   a) therms.

   b) kilowatt hours.

   c) gallons.

   d) pounds.



9. This graph shows how much electricity was used at Any School USA during a 5 year period. In which month did Any School USA use the least electricity?

a) January 1989.

b) July 1992.

c) March 1990.

d) January 1992.

10. There are many things that people can do to save energy in schools. Besides turning out lights when leaving the room, give three other energy saving tips.

a)

b)

c)

Energy Smarts Team Procedures for Students

1. Pick up your I.D., clipboard, and log sheet from your teacher or other designated person. *Energy Smarts Team* members should always carry their I.D. while on duty.

2. Do not bring your friends along or allow other students to enter the classrooms. Only qualified *Energy Smarts Teams* may monitor electrical use at your school.

3. Inspect your assigned area and record information neatly and in the appropriate place on the log.

4. Work quietly, quickly, and politely in rooms in which people are working.

5. Return I.D., clipboard, and log sheet to their proper places, and check back in with your teacher or other designated person.

6. At the end of each month, tally results from log sheet and give a progress report to each classroom. *Certificates are great for classes that do an excellent job!*

Energy Smarts Team Member Agreement

I have read the *Energy Smarts Team* procedures, and I understand them. I agree to assume all responsibilities of the *Energy Smarts Team* of my school. I will follow all *Energy Smarts Team* procedures and will do the best job possible.

Name ______________________ Date ____________

Grade level ________ Teacher name ______________________ Room number ____________

Energy Smarts Team Log Sheet

Month ____________________

Location	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Room #																															
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KEY:

Time checked:
- R - Recess
- L - Lunch
- A - After School

Findings:
- / - Area in use
- 0 - Energy in use/no people
- X - No energy in use

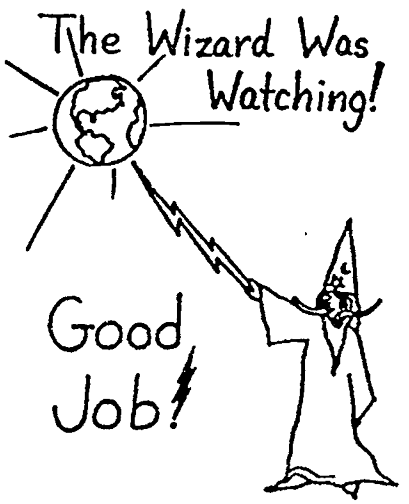
Students responsible:
- Monday ____________________
- Tuesday ____________________
- Wednesday ____________________
- Thursday ____________________
- Friday ____________________

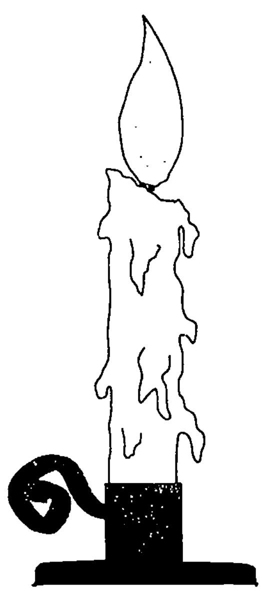
INSTRUCTIONS: Enter for each day the appropriate code for (1) what time of day you check the room and (2) what you find. For example, if you inspect during lunch and the area is not being used but the lights are on, enter "L0."

30

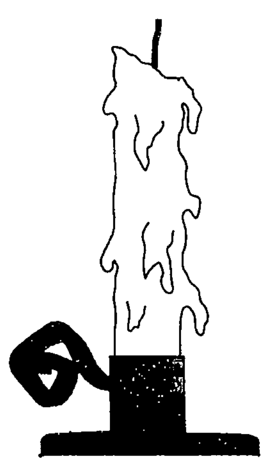
31

Examples of Reminder Tickets and Certificates

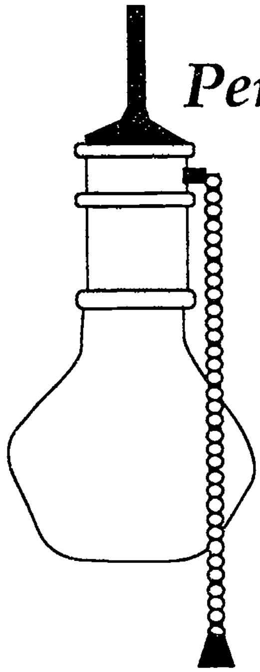




Oops—
Lights On



Thanks—
Lights Off



Perfect Energy User Certificate

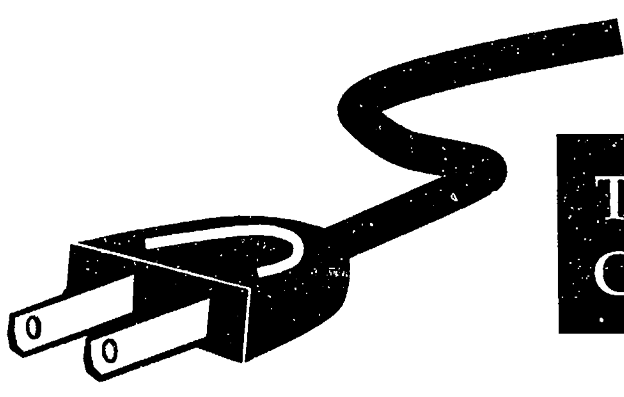
Congratulations

on one week of

perfect Watt Watching!

from the *Energy Smarts Team*

Energy Smarts Team on Duty



Think Energy Conservation!

A Few Last Words to Teachers

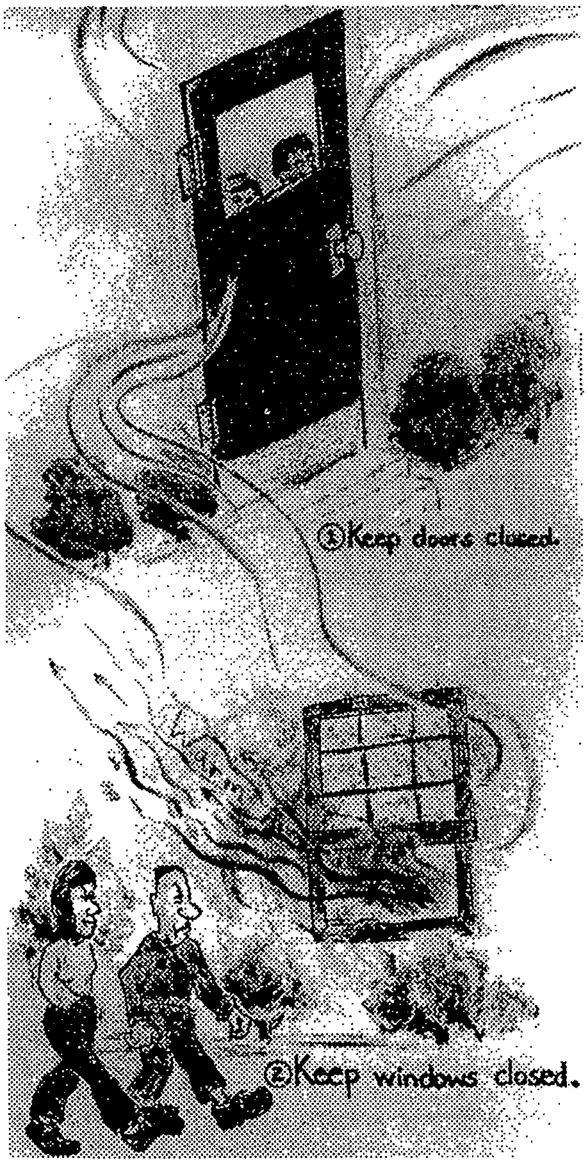
1. Help team members get started. Accompany them on their first few rounds monitoring the school.

2. Check in with team members frequently. Ask them to help each other.

3. Celebrate initial successes. Showing them you care makes it all worthwhile. Throw a party! Or give small tokens in appreciation of a job well done.

4. Have fun!

Top Ten Tips to Try to Tame Terrible Temperature Thieves



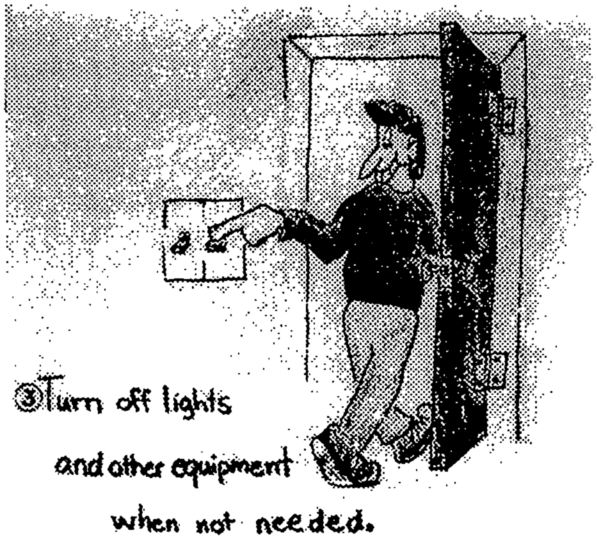
1. Keep doors closed.

Twenty-five percent of electricity used by schools is used by the heating system. Heating and cooling systems are designed to heat and cool the buildings efficiently. The system has to work hard to heat additional air because warm air is leaving through an open door. Doors that open out into a hall allow warm air to heat the halls, creating further demand for heat in the rooms. Doors that open to the outside heat up the outdoors. It would take a heck of a heating system to heat up the entire outdoors.

If you are too warm, tell your custodian or call your building's heating person. Of course the reverse is true during the cooling season. Trying to cool off the room by opening the door doesn't work and wastes energy. If your building is unbearably warm or cool, please let appropriate people know.

2. Keep windows closed.

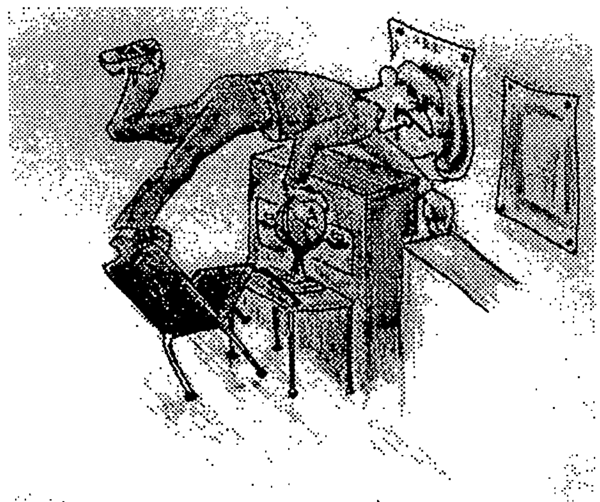
The same explanation applies to windows. Windows are often near univents in buildings. When the heating system is running in the morning, and hot bodies arrive, some rooms get too warm. Opening the windows allows warm air coming out of the univents to leave on the *Airgone Express*. The thermostat will turn on the heat in the room and more warm air will be called for by the system. That warm air will, of course, flow right out the window. Again, let the appropriate person know your needs.



3. Turn off lights and other equipment when not needed.

Twenty-eight percent of electricity used by schools is used by lights. In 1959 when the Dodgers played the White Sox in the World Series, ballasts were relatively inefficient. Ballasts are gismos that ignite gas inside fluorescent lights. Ballasts of that era used a lot of energy to ignite fluorescent lights. In fact, the energy used by a ballast manufactured 25 years ago would use about 15 minutes worth of electricity. In other words, many years ago it would have been good to leave the lights on in a room if you would return within 15 minutes. Many people still believe that leaving lights *on* saves energy.

But today's ballasts are so energy efficient they need less than a second's worth of energy to ignite the gas inside the fluorescent tube. It saves energy to turn *off* the lights even if you're going to be gone for only a few seconds.



④Keep thermostats unobstructed.

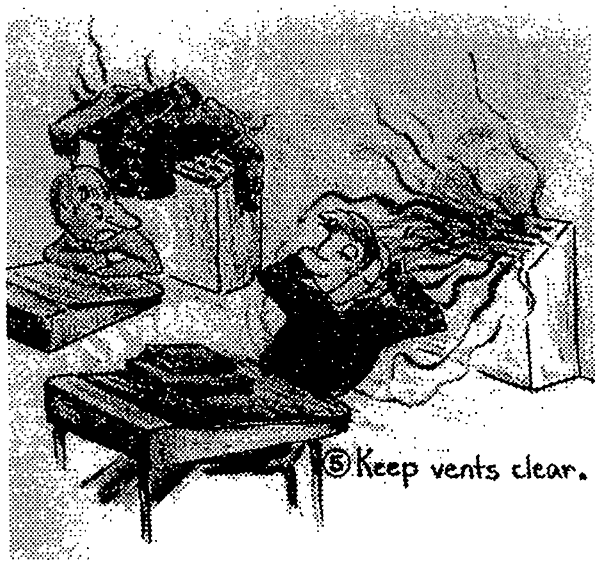
4. Keep thermostats unobstructed.

Thermostats are only as intelligent as we let them be. New technology has yet to produce a thermostat capable of reading minds. One high school coach wanted his locker room very warm. He placed a plastic bag full of ice on top of the thermostat. The thermostat tried to do its job by continually sending more heat to the locker room. The locker room was nice and toasty, but energy use skyrocketed.

If you have a coffee pot or other heating device near the thermostat, it will be fooled into thinking that the room is warm enough and will not send for heat. You can see how the saying "It's not nice to trick Mother Thermostat" originated.

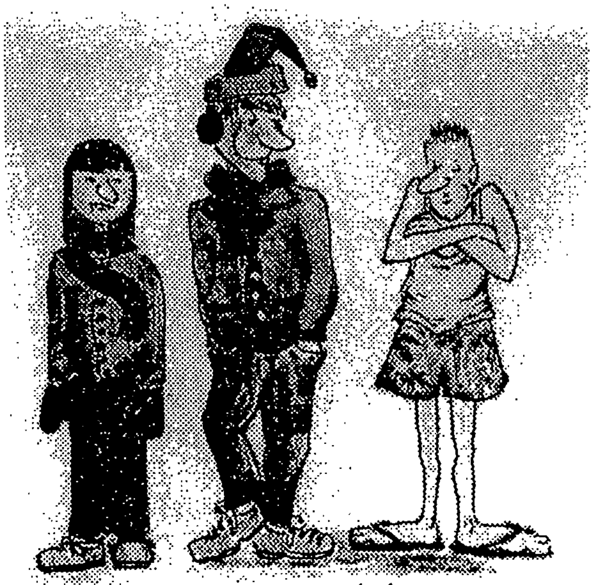
5. Keep vents clear.

Posters, filing cabinets, boxes, coats, and other objects blocking the vents prevent heating and cooling systems from operating efficiently. If the thermostat is calling for heat and the heat can never reach the thermostat because it's obstructed, the heat will continue trying to pour out of the vent and will continue doing so forever without much success.



⑤Keep vents clear.

It's like being in the Twilight Heat Zone—that place in space where a heating system knows it's doing its job of putting out heat but is never able to reach the optimum temperature.



⑥Dress appropriately.

6. Dress appropriately.

Wearing clothing appropriate for the weather will make us all comfortable without the need for extreme heating and cooling. Summer clothing in late fall might cause some to feel cold. Warm clothing will help prevent the chill that creeps in from November through March. So put away those summer clothes until June. Put on a sweater instead.

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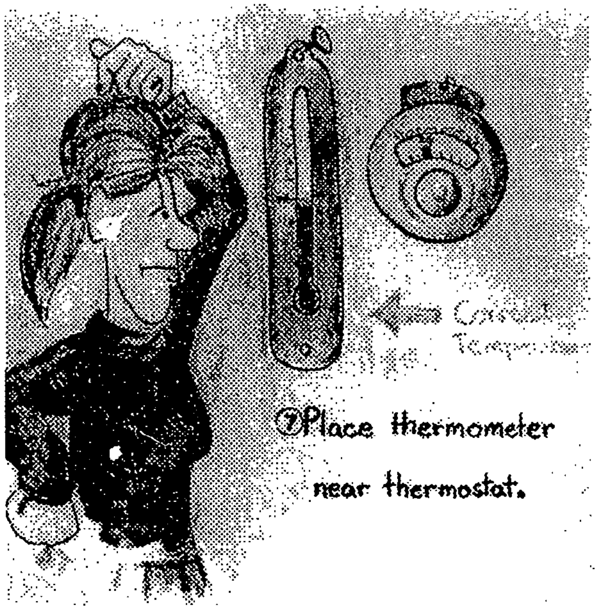
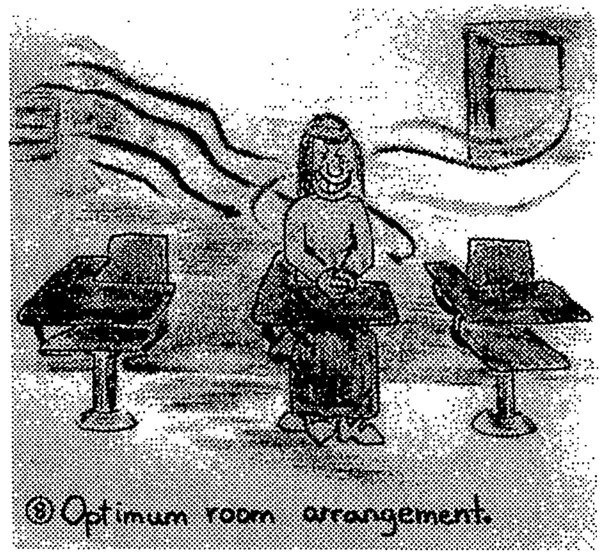


7. Place thermometer near thermostat.

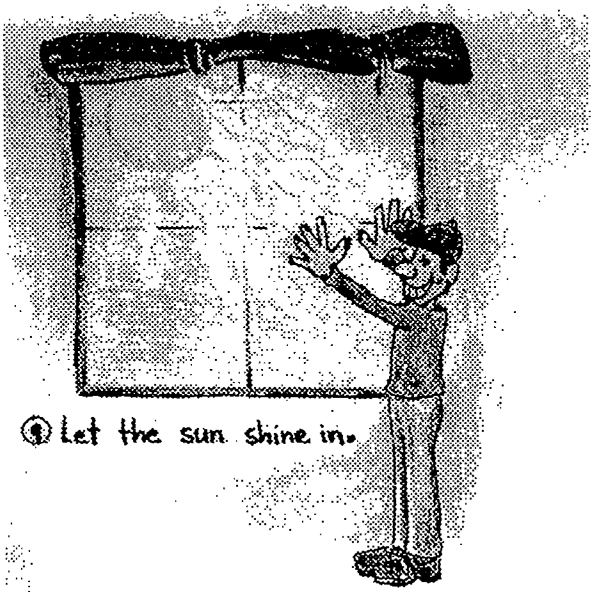
Thermostats are often not accurate. Many thermostats read 3 to 5 degrees off the actual temperature. If you look at the thermostat before you decide whether you are too hot or cold, you might be influenced by what you *think* the temperature is. Get a thermometer for your room and place it near the thermostat. See if your thermostat is accurate. The thermostat should be set to keep the temperature between 68 and 70 degrees. If your thermostat reads 68 and the temperature is really 73 degrees, your room will be too warm.

Conversely, if the thermostat reads 68 and the room temperature is really 63, your room may feel too cold. In other words, don't believe everything a thermostat says—ask for a second opinion. After all, thermostats never go on to receive an advanced degree.



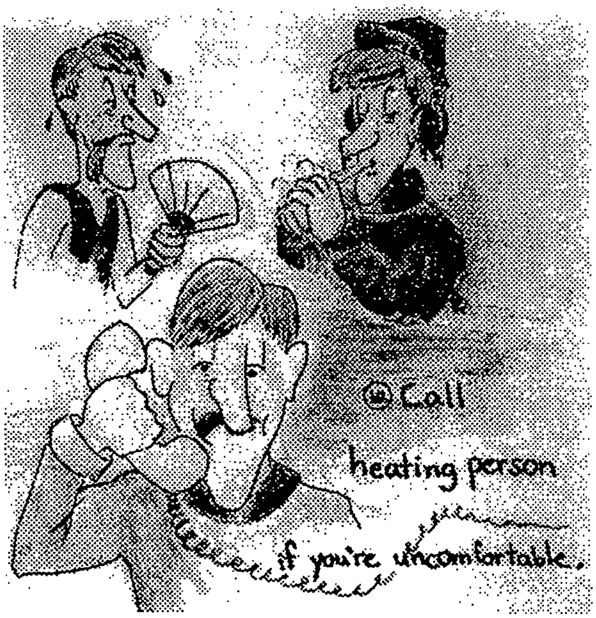
8. Arrange room for optimum comfort.

If you are always too warm and your desk is near the univent, move to a cooler spot in the room. If you're always cold, move away from the windows. Even if windows are not open, on a cold day the temperature near them will be cooler than anywhere else. Unfortunately, air movement is not an exact science yet. The center of a room is the most comfortable. If possible, arrange the room considering these factors.



9. Let the sun shine in.

Use the sun's heat and light whenever possible. You'll save energy by using fewer lights on a bright, sunny day. You'll also allow some heat in if the sun shines directly into your room. If it's terribly cold outside—below freezing—heat gain probably will not compensate for heat loss through the windows.



10. Call your heating person if you're not comfortable.

No one should be uncomfortable at their workplace. Your heating person is willing to do whatever it takes to make you comfortable. The problem may be as simple as adjusting the thermostat to make sure the temperature it registers is accurate. Rather than opening and closing doors and windows to make your area comfortable, let an expert see if something else can be done to make you comfortable. After all, energy is a terrible thing to waste!

The Importance Of Energy

Introduction

Stated simply, energy is the ability to do work or produce change. Like many other normally-occurring facets of our lives, we tend to take energy for granted. But its importance should not be overlooked, because nothing happens without energy.

For example, the act of reading this page requires a complex energy chain. The light which illuminates the words is energy. Energy was necessary to run the machine that printed the page. The ink and paper were produced by energy. It even takes energy to turn these words into meanings in the human mind.

While energy is responsible for making ordinary events such as these possible, its true value is far greater and more basic. In many ways, we depend on energy for our very existence.

Without energy, it would be impossible to produce the food we eat, process and package it, deliver it to stores and, for that matter, consume and digest it.

Similarly, energy is essential to produce warmth, shelter, clothing and other necessities of life. To perform its important work, energy may appear in any of several forms.

What are the forms of energy?

Energy is all around us, all of the time. It may, however, be known by different names, depending on its source. Light, whether it comes from the sun or from a lightbulb, is radiant energy. Gravitational energy is the force which holds objects to the earth. Food and fuel contain stored chemical energy, while objects which are hot contain thermal energy. A machine with moving parts is said to have mechanical energy. Charged objects are filled with electrical energy. And radioactive objects contain nuclear energy.

Another important concept of energy is that it may change forms. Imagine, for instance, that you have a battery-powered robot that sweeps the floor. When you switch it on, it starts to sweep. What happened is that the chemical energy in the battery produced electrical energy in wires, which was converted to mechanical energy in the moving parts of the robot.

What are the sources of energy?

Sunlight, fuel of all types, wind and water are among the list of usable energy sources.

While energy is present in many sources, it may not be working all of the time. Energy in motion is called kinetic energy. Whenever you see something moving or happening, you know that kinetic energy is the force involved. Water flowing over a dam, a person running, a machine in operation are all examples of kinetic energy.

Energy that is not in motion, but could be, is known as potential energy. For example, a piece of firewood contains stored, or potential, energy that is ready to be used.

Without plentiful usable energy sources, life as we know it would grind to a halt.

Is energy important?

Throughout history, the importance of energy has become abundantly clear to developing civilizations. What it comes down to is this: a nation that has many sources of energy is usually highly productive and successful. A nation that can't meet its energy needs has a hard time surviving.

That's why energy conservation and the discovery of new ways to use energy will continue to be major issues of our time. The world is only as safe and secure as its energy supply.

(Adapted from **Energy Readings**, part of the New York Energy Education Project, with permission of the New York Power Pool.)

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From National Energy Foundation, 1992, Teach With Energy!: Fundamental Energy, Electricity and Science Lessons for Grades 4-6. *Used with permission.*

Coal

How is coal formed?

Coal is classified by geologists as a mineral. But most minerals, like salt or iron ore, were formed by inorganic matter. Coal, on the other hand, came from organic matter—plants, that lived about 300 million years ago.

During the Pennsylvanian Period in earth's history, the earth was covered with huge swampy forests of giant ferns, reeds and mosses, which grew taller than our tallest trees today. As these plants died and fell into the swamp water, new plants grew to take their place; and when these plants died, still others grew. In time, there was a thick layer of dead, decaying plants in the water.

The surface of the earth also changed and dirt washed into the water covering the dead plants, preventing them from completely decomposing. More plants grew but they too died and fell into the water, forming a separate layer of dead decaying plants, which over time was also covered by sediments, preventing complete decomposition. After millions of years many layers had formed, one on top of the other.

The weight of the overlying layers compressed the lower layers of plant matter forming peat. Heat and pressure, caused by the overlying sediments, produced chemical changes in the peat, forcing out oxygen and hydrogen leaving behind rich carbon deposits—coal.

Geologists estimate that a layer of plants 20 feet thick may have been required to form a coal seam one foot thick. Coal seams vary in thickness, ranging from only a few inches thick to more than 100 feet in thickness.

Where is coal located in the United States?

Coal represents the United States' most abundant energy source. The U.S. Geological Survey has identified 1.7 trillion tons of coal resources in the United States. If yet undiscovered, but likely deposits are added, potential reserves may be as high as 4 trillion tons. The World Energy Conference estimated that the coal reserve of the United States accounts for two-thirds of the free world's total and nearly 28 percent of the total world recoverable coal. By comparison, Saudi Arabia has about 23 percent of the world's proven petroleum reserves.

The United States has about 490 billion short tons of demonstrated reserves, which by definition are potentially mineable on an economic basis with existing technology. At current domestic consumption levels, this is enough coal to last 300 years.

Measurable quantities of coal are found in 36 states, and in 31 states the coal is considered mineable. At present, coal mining occurs in 26 states, including areas of Appalachia, the Midwest, the Central and Northwestern Plains states, the Rocky Mountains and the Pacific Northwest.

How is coal mined?

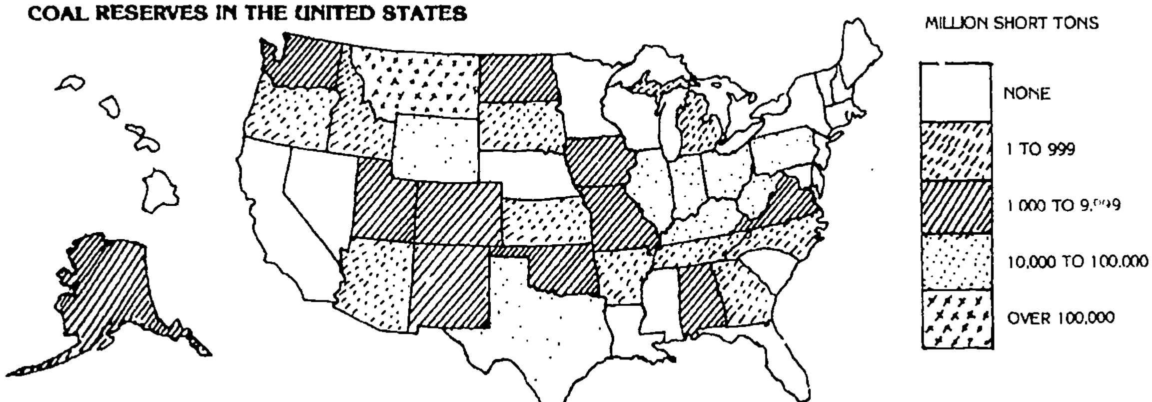
As was the case 50 years ago, most coal is produced from two major types of mines—underground and surface. But the methods for recovering coal from the earth have undergone drastic changes in the past 25 years, as a consequence of technological advances.

Fifty years ago when most coal mining was done manually, underground mines accounted for 96 percent of the coal produced each year. Today, almost 60 percent is produced from surface mines. Most underground mines in the United States are located east of the Mississippi River, although there are some in the West, particularly in Utah and Colorado.

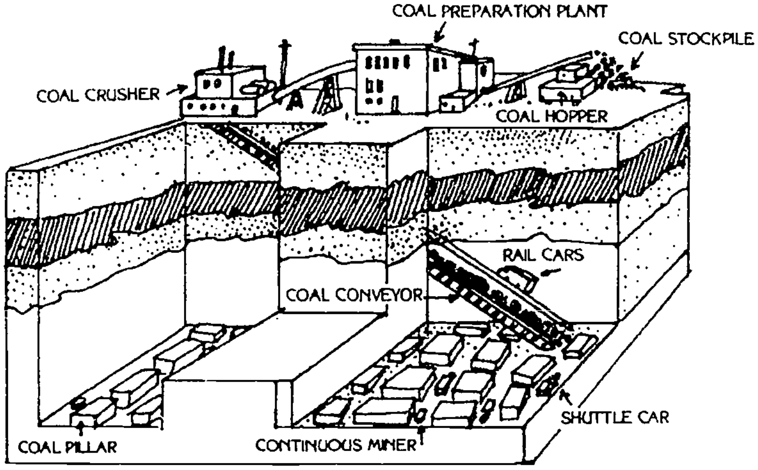
More than two-thirds of the coal produced underground is extracted by continuous mining machines in the room-and-pillar method. The continuous mining machine contains tungsten bits on a revolving cylinder. The continuous miner breaks the coal from the face and then conveys it to a waiting shuttle car which transports it to the conveyor belt to be moved to the surface. No blasting is needed. After advancing a specified distance, the continuous miner is backed out and roof bolts are put in place. The process is repeated until the coal seam is mined.

Another method, called longwall mining, accounts for about 20 percent of production. This method involves pulling a cutting machine across a 400 to 600 foot long face (longwall) of the coal

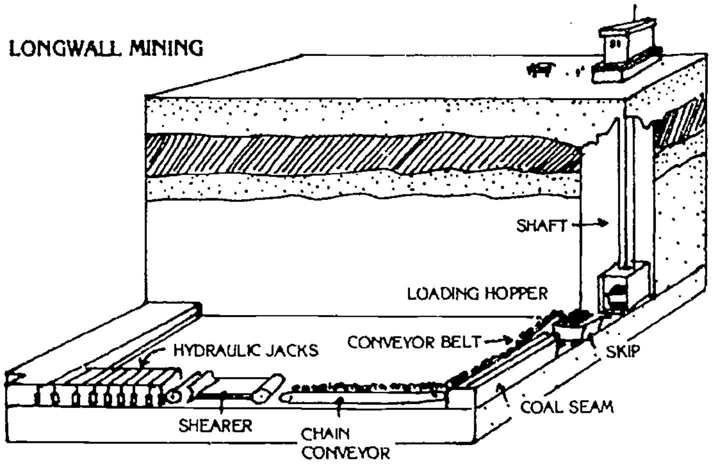
COAL RESERVES IN THE UNITED STATES



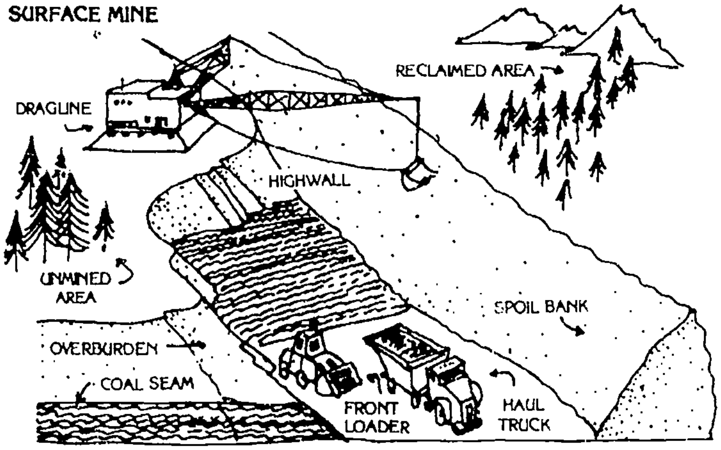
ROOM AND PILLAR METHOD



LONGWALL MINING



SURFACE MINE



seam. This machine has a revolving cylinder with tungsten bits that shear off the coal. The coal falls into a conveyor system which carries it out of the mine. The roof is supported by large steel supports, attached to the longwall machine. As the machine moves forward, the roof supports are advanced. The roof behind the supports is allowed to fall. Nearly 80 percent of the coal can be removed using this method. The remaining 11 percent of underground production is produced by conventional mining which uses explosives to break up the coal for removal.

Half of the mineable surface coal in the United States is located in the West, but significant amounts are also present in Appalachia and midwestern states. Surface mining is used when the coal seam is located relatively close to the surface, making underground mining impractical.

Before a company can surface mine, it must gather information about the site regarding growing conditions, climate, soil composition, vegetation, wildlife, etc. With this information, the company then applies to the federal government for a permit to mine. The company must post a bond for each acre of land it mines to assure that it will be properly reclaimed.

Most surface mines follow the same basic steps to produce coal. First, bulldozers clear and level the mining area. The topsoil is removed and stored for later use in the reclamation process. Many small holes are drilled through the overburden (dirt and rock above the coal seam) to the coal seam. Each is loaded with explosives which are discharged, shattering the rock in the overburden. Giant power shovels or draglines clear away the overburden until the coal is exposed. Smaller shovels then scoop up the coal and load it onto trucks, which carry the coal to the preparation plant.

Once the coal is removed, the land is regraded to the desired contour and the topsoil is replaced. Native vegetation and/or trees are planted. Coal companies operating surface mines must comply with strict requirements and regulations of the Federal Surface Mining Control and Reclamation Act. A crucial part of the surface mining process is restoring a mined site to acceptable ecological conditions, which means it must be made as productive as it was prior to mining. There are farms, parks, wilderness and recreation areas on what were once surface mines.

The major stigma with the coal industry today is the abandoned or "orphan" mines of the early coal mining years.

These orphan mines are systematically being reclaimed under the Surface Mining Act. The Surface Mining Act taxes coal producers at the rate of 35 cents a ton for surface mined coal, 10 cents a ton for lignite mined coal, and 15 cents a ton for underground mined coal. The tax is paid to the government and is used to reclaim the orphaned mines.

How is coal used?

Coal has four major markets: electric utilities, industrial/retail users, the steel industry and exports.

Electric utilities use more than 86 percent of the coal produced in the United States. Upon close examination, it is clear that price has been a major deciding factor in coal's increased use. More than 57 percent of the electricity generated in the United States comes from coal.

In an electric power plant, coal, like oil and natural gas, is burned to produce heat. The heat is used to change water into steam. The steam then turns the blades of a turbine, spinning the generator, producing electricity. Before the coal is burned it is crushed and pulverized to the consistency of face powder.

Coal's second largest market is industrial and retail users. Among the industries using coal, the largest consumers are chemical manufacturers, users of stone, clay and glass, paper mills, primary metal industries and the food industry. Industry uses coal as a chemical feedstock to make dyes, insecticides, fertilizers, explosives, synthetic fibers, food preservatives, ammonia, synthetic rubber, fingernail polish, medicines, etc.

The third largest market is the iron and steel industry, where coal is used to make coke. Coke is derived from bituminous coal through heating in airtight ovens. The lack of air prevents the coal from burning and converts some of the solids to gases, leaving coke.

The fourth segment to market is exports. The top five foreign markets are Canada, Japan, Italy, Netherlands and Brazil. U.S. coal distributed to foreign countries in 1988 totaled 95 million short tons (76 million to overseas destinations and 19 million to Canada). Major reasons for the decline in United States' coal exports from the all-time high of 112.5 million tons in 1981 are stiff competition in the international marketplace and worldwide economic conditions.

How does burning coal affect the environment?

Coal is a chemically complex fuel. Whenever it is burned, gases are given off and particles of ash, called "fly ash," are released. The sulfur in coal combines with oxygen to form sulfur dioxide, which can be a major source of air pollution if emitted in large enough quantities.

Today, many of the effects of coal burning have been reduced significantly or eliminated. Three basic methods are used to reduce the quantity of pollutants resulting from coal combustion.

The first, a pre-combustion method for removing contaminants from coal, is coal cleaning or "coal benefication." In coal cleaning the coal is crushed and screened from impurities. Further processing utilizes the different gravities of coal and impurities to separate them in a liquid medium. Coal cleaning can remove the pyritic sulfur, which can reduce sulfur content by as much as 30 percent.

The second, a post-combustion method, uses flue gas desulfurization systems, commonly called scrubbers. According to the Electric Power Research Institute, scrubbers can remove more than 90 percent of the sulfur dioxide emissions from coal combustion. The flue gas is sprayed with a slurry made up of water and an alkaline agent—usually lime or limestone. The sulfur dioxide reacts chemically, forming calcium sulfate or calcium sulfite. This is removed and disposed of as a wet sludge. There are currently 134 scrubbers operated by the electric utility industry in the United States.

The final method for reducing or eliminating pollution from coal combustion is the use of electrostatic precipitators or baghouses which are used to remove fly ash. In electrostatic precipitators the particulate matter is given an electrical charge. The charge attracts it to a collector plate, where the particles are collected, preventing their discharge into the atmosphere. In a baghouse, the particulate matter is filtered out as it passes through a series of filters, similar to a household vacuum cleaner.

The two major environmental concerns today dealing with the use of coal are: increases in atmospheric carbon dioxide levels and acid rain. Much remains to be learned about the relationship between fossil fuels (coal, oil, natural gas) and the environment. It is believed that combustion has partially contributed to the increase in atmospheric carbon dioxide levels. Increased atmospheric carbon dioxide levels may result in warmer climates due to the "greenhouse effect." The increase in atmospheric carbon dioxide prevents heat from escaping from the earth, thus warming the atmosphere.

The combustion of coal also appears to contribute to acid rain, although precise measures of the scope and seriousness of acid rain are not clear or well understood. What is clear is that further study of the phenomenon is necessary.

There is an interesting riddle to the acid rain phenomenon, and that is that acid rain damage has occurred during periods when sulfur dioxide discharges have declined or remained stable (sulfur dioxide is considered to be the principal cause of acid rain).

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Oil

What is oil?

Oil is naturally occurring and is often referred to as petroleum. Crude oil or crude is unrefined oil or petroleum.

Oil is a mixture of hydrogen and carbon compounds referred to as hydrocarbons. Thousands of different hydrocarbons make up crude oil. The simplest or basic hydrocarbon unit (molecule) is methane or natural gas (CH_4). Hydrocarbons occur as liquids, gases or as solids like gilsonite. The longer hydrocarbon chains are more likely to be liquids.

It is thought that petroleum originated from tiny marine plants and animals (biotic material) that inhabited the earth in prehistoric times. Through time, the tiny marine plants and animals were buried by ocean sand and silt. Over time, the pressure and heat transformed the biotic material into petroleum.

As the biotic material changed from a solid to a gas or a liquid, it began to migrate, being propelled by water or capillary action through the porous marine sediments. In some instances, the petroleum migrated to the earth's surface. Petroleum migrates upward until it is trapped by a non-porous rock structure called a cap. This specific geologic formation is referred to as a "trap." It is these subterranean traps that are sought by the oil industry. Petroleum,then,is associated with porous sedimentary rock layers and fossilized marine life.

How is crude oil refined?

At a refinery, crude oil is distilled or separated into its components or fractions. Distillation involves boiling the petroleum, drawing off the vapors, and then condensing the vapors. The different hydrocarbon compounds that make up petroleum vaporize at different temperatures; thus when they are condensed,they separate out into different fractions. Fractions represent the diverse range of products that can be obtained from petroleum.

How is oil located ?

One of the most accurate exploration methods is seismic technology. In seismic technology, sound waves, created by explosives detonated either on the earth's surface or underground, are sent into the earth and are reflected back by the rock layers. The reflected sound waves are recorded by seismographs. Seismographs are similar to instruments used to measure earthquakes. The reflected sound waves are received by geophones, which transmit the sound waves to a seismograph located in a truck. The particular rate at which the sound waves are reflected create a picture of the underground geology and possible location of oil traps.

Even after the seismic picture is assimilated and analyzed by geophysicists, there is no guarantee of discovering oil. At best, the seismic picture can provide only a guess to what lies beneath us.

Occasionally, oil companies drill for oil in areas where oil or natural gas has not been discovered. Wells drilled in this fashion are known as "wildcat" wells.

What processes are involved in oil drilling?

Before exploration can begin, energy companies need to obtain permits and drilling rights from landowners. Leases might be purchased, or a development agreement reached, with the landowner often receiving royalties if oil is discovered.

Before drilling equipment can be brought on site, preparatory work is required, such as road building, land clearing or housing development for workers.

In 1859, Edwin Drake, a retired railroad engineer, tried to drill for oil. He used a rig that punched or pounded a hole 69½ feet deep. The pounding pulverized the rock and soil, which was removed by flushing the hole with water. Today's primary form of drilling is rotary drilling. Drill bits are used to grind or bore through the rock. As the drill bit is lowered into the earth, pipe stems are added to the top. Drilling usually runs 24 hours per day until the well is completed. The average well today runs a mile deep. On the Overthrust Belt (Utah and Wyoming), it is common to find wells drilled between 8,000 and 15,000 feet deep because of the folded and faulted rock layers.

An important part of the drilling process is the "mud," a mixture of water, clay, and chemical additives which is pumped into the well during drilling. This constantly circulating liquid cools the drill bit and carries debris out of the well. It also prevents the drilled area from collapsing around the drill pipe and serves to control the natural pressures within the well.

Most onshore rigs are portable and include tall derricks that handle the tools and equipment that descend into the well. Offshore drilling may be done from bottom-based platforms, drill ships, or submersible platforms. Each is self-contained with its own set of equipment. Workers and suppliers are ferried by boat or helicopter to the rig.

Gushers — what caused them?

After petroleum is discovered, the underground pressure forces it to the surface. The days of the "gushers," when oil would explode to the surface, are gone. Each well contains blowout preventers which automatically shut off the flow of gas or oil should well pressure change, preventing gushers, protecting the environment, and preserving the precious fuel.

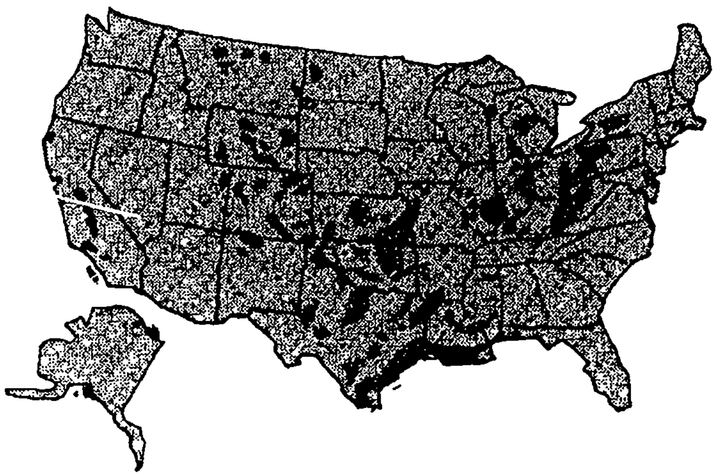
How is oil transported to market?

Three-fourths of the domestic crude oil and a third of the refined products in the U.S. are transported by pipeline. Over 1.2 million miles of pipeline connect production sites with refineries and the petroleum market.

Crude from the Overthrust Belt (Utah and Wyoming) is transported by pipeline to refineries serving the Midwest and

OIL AND GAS FIELDS IN THE UNITED STATES

FROM THE AMERICAN GAS ASSOCIATION



Western markets. Other major pipelines run between Texas and the Northeastern U.S.

Probably the most famous pipeline is the trans Alaska pipeline, which carries crude from the north slope of Alaska, to Valdez in Southern Alaska. The trans Alaska pipeline transports 1.9 million barrels per day, 25 percent of the nation's oil.

Much of the foreign crude used in the United States is brought to American ports by tankers. These "super tankers" are over a thousand feet long and have a capacity to transport more than two million barrels of crude.

On a regional basis, semitank trucks and railroad cars haul petroleum products to consumers or industries that develop and manufacture petroleum-related products.

Where do we obtain oil?

Oil discoveries in the U.S. since the oil embargo in 1973 are numerous. They include the Overthrust Belt of Utah and Wyoming, the Louisiana Trench and its subsequent development into the Gulf of Mexico; and fields off the Texas and California coasts, as well as new fields in Arctic Alaska.

Oil or natural gas is produced in 33 of the 50 states, with Texas still the leader in production. Other top producing states include Alaska, Louisiana, and California.

The largest producers of crude oil and natural gas liquids in 1987 were the U.S.S.R., the United States, and Saudi Arabia.

How is oil used?

Oil has become an integral part of our society. Much of our high standard of living can be traced to the use of petroleum.

At the turn of the century, it was relatively simple to pinpoint the major uses of petroleum. Grease was the major lubricant and kerosene the major illuminant. Coal, eventually to be displaced by petroleum, was the major energy source for heating.

In the 1900s, America became the land of the horseless carriage. The advent of the internal combustion engine to propel the automobile provided a use for what had been a waste product at the refinery—gasoline. Gasoline quickly became an important product of petroleum as automakers adapted engines to utilize this practical fuel.

Today, about 6,000 products are produced, wholly or in part, from petroleum. Among the products derived from petroleum are gasoline, aviation gasoline, jet fuels (highly-refined kerosene), kerosene (now used mostly for cooking, space heaters and farm equipment), diesel fuels (for heavy equipment), fuel oils (for residential and commercial heating, manufacturing processes, and industrial steam and electrical generation), petroleum coke (almost pure carbon which burns with little or no ash), and liquefied petroleum gas (primarily propanes and butanes obtained from refined natural gas). Other products include lubricating oils, greases, waxes, asphalt, nylon stockings, plastics, fertilizers, shoe polish, washing powders, medicines, photographic film, pesticides, insecticides, and waxed paper.

What environmental safeguards exist?

The oil industry is regulated by major federal laws including the Federal Water Pollution Control Act, the Clean Air Act, the National Environmental Policy Act, and the Federal Land Management and Policy Act. These laws govern the amount of emissions that can enter the atmosphere from refineries, the amount of pollutants that can be discharged into waters, roadbuilding, and land restoration after drilling.

Energy companies have been very diligent in making certain they leave a quality environment. But accidents do occur. The 1969 Santa Barbara oil spill, the 1981 Mexico oil spill in the Gulf of Mexico, and the 1989 oil spill near Valdez, Alaska provide examples of the damage that can occur to the environment.

Less obvious environmental damage results from burning petroleum and natural gas.

Automobiles, the primary petroleum consumer in the country, emit carbon monoxide, carbon dioxide, sulfur and nitrogen oxides into the atmosphere from the combustion of petroleum. Industry and homes also emit sulfur when fuel oils are combusted.

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Natural Gas

Introduction

Of the energy sources available, Americans rely on natural gas to supply about 26 percent of their energy needs. This ranks natural gas second in use only to oil which supplies about 43 percent of America's energy needs. Natural gas provides about 42 percent of our industrial needs. Nearly six out of every 10 homes is heated with natural gas and in most cases, is used for cooking, drying clothes, and heating water. Businesses and industries use natural gas in many ways, from cooking in restaurants to fueling high temperature blast furnaces for the manufacturing of steel. In fact, natural gas affects everything we do and use.

What is natural gas?

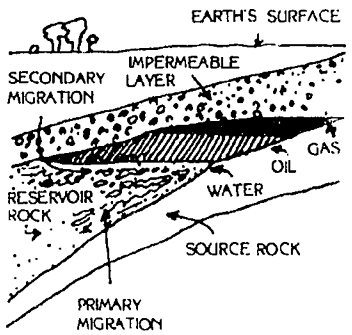
Natural gas has been defined as naturally occurring hydrocarbon and non-hydrocarbon gases found in the porous geological formations beneath the earth's surface. It is made up of about 90 percent methane, with small amounts of ethane, propane, butane, carbon dioxide and nitrogen.

What are the origins of natural gas?

Conventionally, it has been accepted that natural gas is a by-product of the breakdown of marine organisms and/or terrestrial plant debris which accumulated in vast deposits on the bottoms of ancient lakes, rivers and seas. Over time, the deposits were buried by layers of sediment consisting of mud, sand and rock. With each additional layer of sediment the pressure on the organic deposits increased. As pressure and heat from the buildup of sediments increased, chemical changes in the organic deposits took place and a complex, tar-like substance called kerogen was formed. As temperatures continued to increase and the kerogen continued "cooking," more complex compounds of carbon and hydrogen known as oil were formed. Natural gas is generated at the same time as is oil; however, peak generation occurs when oil begins to break down because of high geothermal temperatures, e.g. greater than 205°C (400°F). This range of petroleum (oil and natural gas) generation is called the petroleum window.

As natural gas molecules form, they migrate out of the shaley "source rock" into more porous areas such as sandstone. From there, they eventually make their way to either the earth's surface where they escape into the atmosphere, or they are trapped when their migration path is blocked. In the latter case, impermeable rock layers prevent the molecules from migrating farther and a natural gas accumulation occurs.

NATURAL GAS FORMATION AND ACCUMULATION



In contrast to the biological explanation of the origin of natural gas, the "deep gas theory" speculates that natural gas is derived from non-biological materials that formed the earth billions of years ago. The brainchild behind the deep gas theory is an American named Thomas Gold of Cornell University. In 1979, Gold published the first papers to contend that, "on earth, as on other planets, most hydrocarbons were formed from non-biological sources."

The theory proposes that the earth is made up of primordial materials that combined together in space billions of years ago when the basic structure of the earth evolved. The materials are believed to still be buried far below the earth's crust, where they have been trapped for 4.5 billion years. Cracks and fissures in the earth's crust allow the gases to migrate into reservoirs and to the surface. In this manner, it is believed that the supply of hydrocarbons produced from the primordial material were instrumental in the creation of the earth's atmosphere.

The deep gas theory further proposes that oil molecules are capable of surviving greater temperatures and pressures found tens of miles beneath the earth's surface, and that many of the hydrocarbons that migrate up to the two-to-three-mile depths do in fact break up into methane gas. This would explain the presence of both oil and gas found at two-to-three-mile depths and further theorizes that a much greater supply of oil is present in "deep wells" which range in depth from 50,000 to 60,000 feet and more.

Much of the deep gas theory evolved out of our growing understanding of how the universe and planets are formed, and from information supplied by the space program. For example, when it was learned that many planets contained hydrocarbons in their atmosphere, with little likelihood of ever supporting plant or animal life, the deep gas theory became more credible.

How is natural gas located?

For thousands of years, humans have known of the existence of natural gas and have been able to find it easily in small quantities near the surface of the earth. But as the readily available supplies became scarce, man was forced to search deeper into the earth. By analyzing what was already known about the location and geological formations in which deposits were found, it was determined that natural gas would most likely be found in areas containing source rock, "porous" reservoir rock and favorable trapping mechanisms such as "migration blocks." Based on this knowledge, new methods evolved that would help locate other areas most likely to contain accumulations. At first, fairly simple surface methods including geologic mapping, surveys and aerial photographs where used. But over time more sophisticated methods were developed. Some of the methods used today include: (1) magnetic measurement, a measure of the magnetic field of base rock to determine how much sediment is lying above it; (2) satellite imagery, which helps identify surface structures and patterns that aid in the search for probable underlying hydrocarbon deposits; (3) gravity mapping, which determines thickness of the basin or sedimentary rock layer and helps identify base rock topography; and (4) seismic sound wave reflection, which measures the time to various rock units that reflect acoustic energy. These reflections are plotted in terms of time and amplitude creating a "slice of the earth" view.

Once a trap with economic potential is identified, a drill site is selected. A drill rig is contracted to bore through the layers of rock to the desired level, or "target horizon." The rig uses an engine to turn a table, which turns a pipe that has a drill bit attached on the end. With each rotation of the table, the bit at the end of the pipe digs deeper into the ground. During the process, which generally takes a few weeks, drilling mud (bentonite clay with barite added for weight) is circulated through the drill pipe and well bore. The mud cools and lubricates the bit. It also cleans the hole of cuttings and leaves a thin cake around the well bore to prevent caving of rock fragments and loss of water to the formation. The mud is "weighted" to exceed any expected subsurface pressure. Should a reservoir of natural gas, oil or water that contains higher than expected pressures be encountered, more dense mud is immediately added. If this cannot be done in time, then the well is "shut in" using the surface blowout prevention system. This system is a series of valves that allows the driller several options to close off the well depending upon just how deep the high pressure zone was encountered. The drilling mud is then weighted and circulated through the drill pipe and well bore until the natural gas, oil or water-cut mud is removed and the pressure zone is under control. If the target horizon contains commercial quantities of hydrocarbons (oil and/or natural gas), the well is completed for production. If there is no discovery, the well is plugged and abandoned and the site restored to natural conditions. About one out of eight "wildcats" (wells in unproved areas) result in a significant discovery.

How is natural gas processed and distributed?

Once natural gas has been found, it is necessary to process it and distribute it to users. Hundreds of years ago the Chinese used bamboo to pipe natural gas directly from their wells to their cooking pots. And in the early 1820s William Hart, the first person to develop a practical use for natural gas in America, used hollow logs to bring natural gas from shallow wells to street lamps and small nearby businesses. But as Hart and others continued to pioneer the uses for natural gas, it was found that higher quality natural gas and more functional and durable distribution networks were needed. As a result, hollow logs soon gave way to steel and cast iron pipes. Today, natural gas reprocessing plants are used to turn hundreds of thousands of cubic feet of unrefined wellhead natural gas into commercial, high quality natural gas.

Before natural gas is distributed, it must first be sent to a processing or "stripping" plant where it is cleaned and separated. At the processing plant, the natural gas is first sent through a separator where secondary byproducts including oils, impurities and heavier hydrocarbons such as butane, ethane and propane are removed. Most of these byproducts are reprocessed, packaged and sent to market for a variety of different uses.

As natural gas leaves the processing plant it enters a compressor station where it is pressurized for transmission. As the pressure is increased, the volume of natural gas is reduced and more natural gas can be filled into the same unit space, and the pressure needed to move natural gas through the pipelines is achieved. As natural gas flows through the pipeline, some pressure is lost due to fluid friction caused by the natural gas rubbing against the inside walls of the pipe. This loss of pressure is made up at compressor sub-stations located about every 50-to-100 miles along the transmission pipelines. Along the pipelines are valves used to control pressure and cut off flow in an emergency such as a break in the line or a fire.

During the summer months when peak demands are much lower, natural gas can be stored in empty wells, underground caverns, and in liquified form in storage tanks.

How safe is natural gas?

There are a number of properties of natural gas which make this energy form extremely safe. First, unlike other hydrocarbon fuels, natural gas is lighter than air. This permits it to dissipate into the air if a leak occurs. Other hydrocarbons like propane, ethane and butane are heavier than air and will "puddle" if leaks occur.

Secondly, natural gas has a higher combustion temperature than other fuels. Natural gas ignites at 649°C (1,200°F) compared to as low as 371°C (700°F) for some other fuels.

A third inherent property of natural gas that helps provide a safety barrier is the flammability range previously mentioned. If the exact requirement for mixing natural gas and oxygen are not met, combustion cannot occur.

Although natural gas is safe when properly used, it exhibits certain characteristics that make it potentially dangerous. First, if natural gas and the mixture of oxygen are not properly balanced when lit, incomplete combustion will occur and carbon monoxide will be produced. Second, if a leak occurs and supplants all the available oxygen, asphyxiation may occur.

Because of the potential hazards, it is important that the user know how to safely use natural gas and care for natural gas appliances. One of the first steps to prevent accidents from occurring is to ensure that natural gas appliances and equipment have been properly installed, adjusted, vented and inspected. Other safety precautions that should also be taken include the following:

1. Follow manufacturer's instructions for the installation, operation and maintenance of gas equipment and appliances.
2. Keep flammable materials (paints, solvents, cloth, paper) away from appliances.
3. Provide proper ventilation in areas around furnaces, water heaters, dryers, ranges, etc. Many new appliances use an electronic ignition instead of a pilot light.
4. Perform or have performed routine maintenance on appliances to keep them clean and in proper working order.
5. If the flame goes out, turn the gas off, ventilate the area and notify the natural gas company.

6. Teach children how to use appliances safely and to recognize the smell of natural gas.
7. When lighting a flame, always strike the match first, then turn on the natural gas.
8. Keep fire extinguishers in the vicinity of appliances with open flames.

If a natural gas leak is detected, the following safety precautions should be taken immediately.

1. Open windows and doors to ventilate the area.
2. Get everybody outside then call the natural gas company or other authorized personnel for assistance. (The telephone call should be made from outside the home. A spark from an electric switch or telephone could ignite the natural gas.)
3. Avoid flames and don't turn on or off electrical equipment or appliances. Never look for a natural gas leak with a lighted flame or match.
4. Your natural gas can be turned off at the valve next to the natural gas meter. A quarter turn of the valve in either direction will shut the natural gas off; the raised part of the valve will then be crosswise to the pipe.
5. If there is only a faint odor, it probably means a pilot light is out on an appliance. Check the pilot lights on all appliances. To relight the pilot light, follow the instructions in the owner's manual. If you still can't find the source or are unsure of how to relight the pilot light, call the local natural gas company.

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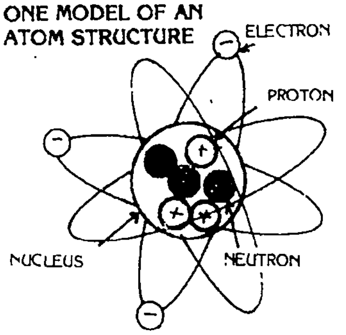
Nuclear Energy

What is nuclear energy?

Nuclear energy is derived from atoms. Atoms are particles that make up matter and are composed of neutrons, protons and electrons. The neutrons and protons are clumped together to form the center or nucleus of the atom, while the electrons orbit the nucleus.

Nuclear energy is the energy inside the nucleus of the atom which binds the nucleus together. A change in the nuclear composition of the atom results in a release of energy.

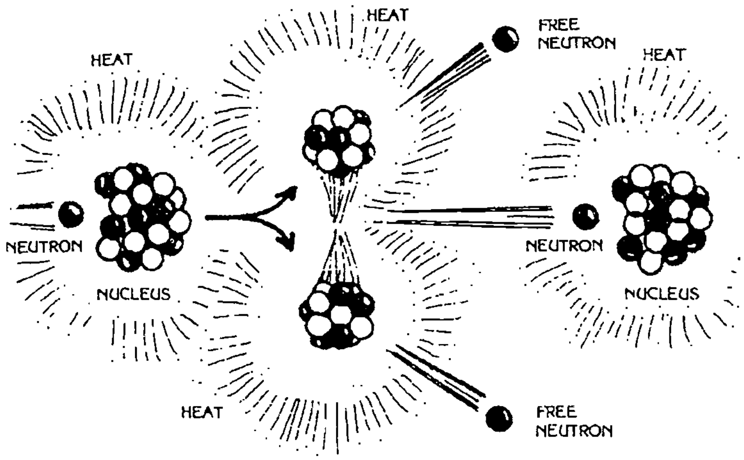
ONE MODEL OF AN ATOM STRUCTURE



How is nuclear energy released from an atom?

Nuclear energy is released from an atom through nuclear **fission** or nuclear **fusion**. In the fission process, commonly used in today's nuclear reactors, a nucleus of a target material such as uranium-235 is bombarded by a neutron which is absorbed. The absorbed neutron causes the atom's nucleus to split apart or "fission" into two atoms of lighter weight, releasing energy, neutrons and radioactivity. Fission, then is the splitting of atoms. Fission reactions produce enormous amounts of heat which turns water into steam for generating electricity. The heat is produced from the collision of fissioned particles with other atoms.

In the second process of releasing energy from the atom, the nuclei of atoms are joined through "fusion," resulting in the creation of a third element, a free neutron, and nucleus. Heat is produced when the free neutron collides with other atoms. The sun and stars get their energy from the fusion of hydrogen to produce helium. Scientists have been attempting to imitate this process for many years, but it requires extremely high temperatures. Although scientists have been unable to develop a container capable of holding such extremely hot material, one of the more promising efforts involves containing the material within a magnetic field, while it is being heated to the required temperature. The United States anticipates the eventual construction of fusion power plants.



What is a chain reaction?

When an atom undergoes fission, heat, neutrons and two lighter atoms are produced. The released neutrons are absorbed by new atoms causing them to fission, releasing more heat and more neutrons. Repeating this process over and over is a chain reaction.

Why do we use uranium?

Uranium, which is naturally radioactive, occurs in nature as either uranium-235 or uranium-238. (The number refers to the element's atomic mass or the number of protons plus neutrons in the nucleus.) Less than 1% of naturally occurring uranium is uranium-235, with more than 99% being uranium-238. It is uranium-235 which fissions, releasing energy. Uranium-238, on the other hand, absorbs bombarding neutrons and is transformed into Plutonium-239, which fissions when struck by neutrons, releasing energy. Thus, the ability of uranium to fission or to be transformed into a fissionable element is why uranium is used in nuclear reactors.

How is fission accomplished in a nuclear reactor?

Nuclear reactors are composed of three principal parts: **reactor vessel, core** and **control rods.** The reactor vessel, a tank-like container weighing more than 500 tons with steel walls, six to nine inches thick, is located at the base of the reactor building. The core, located at the bottom of the reactor vessel, holds the fuel assemblies. Control rods are inserted into the core to regulate the rate of fission. The control rods are able to do this because of their cadmium or boron composition (materials that absorb neutrons). The absorption of neutrons controls the rate of fission. To slow the reaction, the control rods are inserted farther into the core. This decreases the number of neutrons that collide with uranium atoms, thus slow-

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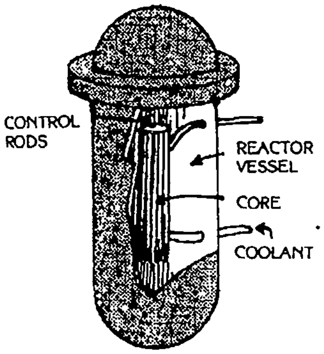
ing the reaction. The actual operation of the core involves the consumption of uranium-235, the subsequent creation of fission by-products and the production of plutonium. Energy released by fission is transferred to water, turning it to steam. From this point on, nuclear power plants operate just like fossil-fueled power plants.

REACTOR VESSEL



What is spent fuel?

When the fuel assemblies can no longer efficiently sustain a fission reaction (approximately three years), they are removed from the core. The "spent fuel" as it is called, contains unused nuclear fuel and radioactive nuclear waste. The spent fuel is stored in pools of water at the nuclear power plant, until it can be reprocessed or disposed of. Water is used to cool the fuel and absorb radiation.

How do you isolate and store radioactive waste from land, water and air?

Several methods are being developed to isolate and safely store radioactive nuclear waste. One method proposed includes reprocessing the spent fuel. The used fuel would be transported to reprocessing plants where the still unused nuclear fuel would be separated from the radioactive material that needs to be safely stored.

The low-level or high-level material can be fused into a glass or ceramic solid, which is impervious to air and water, and buried in deep, stable, underground geologic formations. These storage areas would be constantly monitored.

In the future, radioactive wastes will be stored in federal repositories.

What is radiation?

Radiation is a naturally occurring phenomenon which is the result of an imbalance in the number of neutrons and protons in the nucleus of the atom. The imbalance results in an unstable atom, which emits energy or radiation. Three forms of radiation are: alpha particles, which can be stopped by a single sheet of paper; beta particles, which are stopped by a thin sheet of aluminum; and gamma rays, which are stopped by several inches of lead or about three feet of concrete. The intensity of the radiation depends on the speed at which the particle or ray travels. Thus, gamma rays are more radioactive than alpha particles as they travel at a greater speed.

What safety precautions are taken at nuclear power plants?

The Nuclear Regulatory Commission (NRC) is responsible for the regulation of nuclear power plants in the U.S. The NRC goes to great lengths to prevent nuclear accidents. The NRC requires nuclear plant operators to undergo three or more years of extensive training and examination. The NRC also administers strict construction, maintenance and safety regulations.

Nuclear power plants are monitored for radiation and are designed with safety systems which "take control" in event of an accident. Other safety features of nuclear plants are: cooling systems which pump water into the core to keep it cool; the containment building, a large dome-shaped thick-walled steel and concrete building which can prevent the escape of radiation should a problem develop; and an automatic procedure which inserts the control rods into the core to stop the chain reaction.

Because of the dilute quantities of uranium-235 used in commercial nuclear reactors, nuclear explosions are impossible. It requires at least 90% uranium-235 or plutonium-239 to produce a nuclear explosion similar to that of nuclear weapons.

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Renewable Energy Sources

Introduction

Energy is essential in our society. Energy lights and heats our homes, offices and factories. It powers the machines of industry and transportation. The clothing we wear, the food we eat, the buildings in which we live and work, and even the systems we use to communicate—all depend on energy.

For generations, our society has been enjoying the benefits of plentiful, inexpensive, and easily available energy—fossil fuels. But these fuels, such as coal, oil and natural gas, are finite. As supplies have become scarce and expensive to extract, the search has intensified for alternative energy sources—sources of energy other than fossil fuels.

How is the sun an energy source?

The most obvious and virtually limitless energy source is the natural fusion reactor which the earth revolves around in space—the sun. In terms of humankind's residence on earth, the sun is an object that will last forever, continuously radiating energy that makes life on our planet possible. Although the earth intercepts only a small fraction of the total energy emitted by the sun, the amount received is thousands of times the present energy requirement of the world's human population.

The surface of the sun, which radiates energy in the form of heat and light, is called the photosphere. The sun's interior is composed of dense gases (70% hydrogen and 28% helium) and high temperatures (27 million degrees Fahrenheit/15 million degrees Celsius). The heat and light energy is produced through a thermonuclear reaction (fusion) in which hydrogen atoms are fused together to form helium.

Of the sun's energy that reaches the earth's atmosphere, 30 percent is reflected back into outer space, 47 percent is absorbed by the earth's surface and converted into heat energy, 23 percent drives the hydrological (water) cycle, less than one percent creates winds and ocean currents, and only 0.03 percent is captured by plants and used in photosynthesis. The 0.03 percent of the sun's energy captured by plants provides all the world's food energy and produced the stored fossil-fuel energy (coal, oil, natural gas). Thus, the sun is the primary source of all energy on earth.

The sun's position in the sky has a major effect on the solar energy received by the earth. In order to collect and use solar energy efficiently, one must be knowledgeable of the sun's movements, both daily and seasonally.

What is solar radiation?

Solar radiation is a form of electromagnetic radiation, just as x-rays, light waves, microwaves, television waves and radio waves. However, solar radiation differs from heat flow radiation. This difference is important to solar energy technologies.

First, color is an important factor in solar radiation, but is not in radiation heat flow. Black or dark-colored objects absorb solar radiation and become hotter, while white or light-colored objects reflect solar radiation. Color has no effect on radiation heat flow. Light- and dark-colored objects will absorb the same amount of heat energy from radiation heat flow.

The second most important difference is that solar radiation passes through transparent materials (glass, plastics), whereas radiation heat flow cannot. Thus, transparent materials trap heat energy.

How is the sun's energy harnessed?

Three primary processes exist by which solar energy can be put to practical use: photochemical, photoelectrical, and photothermal. The photochemical process, called photosynthesis, uses solar energy to unite carbon dioxide, water, and nutrients from the soil to create carbohydrates (chemical potential energy) and oxygen. The coal, oil and natural gas we use today probably resulted from photosynthesis that took place eons ago.

In the photothermal process, light energy (shortwave radiation) is transformed into heat energy (longwave radiation). As light energy strikes an object, it is either absorbed, reflected or transformed into heat energy. The heat energy is then either radiated away from the object, carried off by air or water (convection) or conducted to surrounding objects.

Photothermal technologies include: passive and active solar energy systems, power towers and Ocean Thermal Energy Conversion (OTEC) systems.

The photoelectrical process converts light energy into electrical energy. It involves the use of photons (light energy) to excite the outer (valence) electrons of atoms, causing the electrons to move, producing an electrical current. Photoelectric technologies include photovoltaics.

What is wood energy?

Chemical potential energy is produced by plants through photosynthesis and is stored as biomass. The chemical potential energy of biomass is released when the plants decay or are burned.

Wood is one of the most abundant and useful forms of biomass on this planet. Trees are a renewable resource which today cover over 30 percent of the earth's land surface. If 100 million acres of this could be used to produce wood fuel, the United States could reduce its oil consumption by 15 percent, an equivalent of 900 million barrels of oil. Even though trees take 50 to 100 years to reach maturity, we can use this valuable resource forever if we grow and harvest trees with care and planning. In our grandparents' day, wood played a major role as a fuel resource, accounting for 90 percent of the United States' energy supply. In terms of fuel use today, wood accounts for less than five percent of the United States' energy consumption.

The most ambitious plan for the use of wood fuel is the "energy plantation." These are large tracts of land devoted to the production of trees for use in nearby electrical generating plants. It is estimated that a 1,000 megawatt plant would require between 200 and 600 square miles of woodland in order to have a sufficient supply of wood fuel.

However, there are problems with large-scale use of wood. Unless the harvesting of trees is done carefully and properly, the soil can become seriously depleted of nutrients and eroded. Also, there are simply too many of us and we want far more energy than our parents or grandparents did; so wood cannot fully satisfy our energy needs. There are also air pollution problems with burning wood in heavily populated areas.

What are biofuels?

Biofuels are derived from plants, which capture the sun's energy and convert it to biomass (chemical potential energy) through photosynthesis. Biofuels are distinguished from fossil fuels, which are also of biological origin, but are non-renewable. Biomass, in the process of being eaten, burned or decayed, transfers its energy to the rest of the living world. There are many proposals for biomass energy plantations. One idea calls for the growing of sea kelp in offshore waters of California and Peru to produce 1.8 billion tons of dry marine algae per year. This biomass would then be converted to methane, which could meet 17 percent of the current United States' natural gas demands. Some farmers are already growing crops to convert into ethanol, which when combined with gasoline makes gasohol. Gasohol is a mixture of 10 percent ethanol and 90 percent gasoline. Gasohol is one way of stretching fossil fuel supplies.

The advantages of biofuels over other fuel sources are: domestic production would have a favorable economic impact, a favorable impact on the environment (biomass is low in polluting sulfur), and the energy produced is renewable. There are, however, problems with the energy plantation concept; large land areas would be converted to single crop stands which are susceptible to disease and pest outbreaks; by centralizing energy production, the energy plantation requires elaborate electricity transmission grids.

How is refuse an energy source?

One type of biomass that has potential as an energy source is organic waste or refuse (garbage). Although still considered a problem rather than a resource, there is little doubt that refuse will be used more and more as raw materials for conversion and recycling. Refuse can also be converted to other useful forms by composting (decaying organic materials in carefully constructed piles to produce a soil conditioner and fertilizer) or anaerobic digestion (decaying organic material in airtight containers to produce methane, liquid fertilizer, or distilled to produce ethanol). However, we must remember that it takes energy to produce the items that become our refuse. Conservation — using less paper, plastics, fabrics, aluminum, etc. — saves more energy than conversion and recycling.

How is wind an energy source?

Wind is a form of kinetic energy created in part by the sun. About two percent of the sun's energy that reaches the earth is converted to wind energy. The atmosphere is heated during the day by the sun and at night it cools by losing its heat to space. Wind is the reaction of the atmosphere to the heating and cooling cycles, as well as the rotation of the earth. Heat causes low pressure areas, and the cool of the night results in high pressure areas. This process creates wind when air flows from high pressure areas into low pressure areas.

Wind energy has been used for hundreds of years. The windmills of Europe and Asia converted the kinetic energy of the wind into mechanical energy, turning wheels to grind grain. Today wind-driven generators are used to convert the kinetic energy of wind into electrical energy. Wind-driven systems consist of a tower to support the wind generator, devices regulating generator voltage, propeller and hub system, tail vane, a storage system to store electricity for use during windless days, and a converter which converts the stored direct current (DC) into alternating current (AC).

In the year 2000, wind could generate from seven to 10 percent of the total electricity produced in the United States. Farms in rural areas across the nation already find wind generators a viable energy supplement. However, the cost of a wind system that provides energy at our present rate of consumption is expensive for a single family. The most ambitious proposals to harness wind power involve the construction of wind "farms" where hundreds of wind turbines will produce electricity.

The main problem with wind energy is that it is not constant or predictable, it has a load factor of only 25 percent and is only 35 percent efficient. Many areas do not have enough wind to make generation feasible, while some locations are susceptible to gales which would destroy or damage the system. Icing can also be a problem in cooler climates. Wind systems also take up large areas and can be quite noisy. If these problems can be overcome, wind energy could be an optimum energy alternative, due to the fact that it is renewable and environmentally safe.

What is hydropower?

Hydropower is a form of solar energy. The sun's energy drives the hydrologic cycle by evaporating water from lakes and oceans and by heating air. The hot air then rises over the water carrying moisture to the land. The cycle continues when the water falls as precipitation and flows back to lakes and oceans.

The potential energy of water located at elevations above sea level is one of the "purest" forms of energy available. It can provide energy without producing pollution. It is relatively easy to control and can be converted to electricity with an efficiency of 75-85 percent. As a result, large and small rivers around the world with the appropriate topography have been dammed and waterwheels and water turbines installed to capture the kinetic energy of the falling or flowing water.

Hydroelectric installations require the construction of dams to increase the reliability of the energy available from a stream. The dam also regulates the flow of water and creates water pressure at the bottom of the dam. The water pressure is proportional to the depth of the reservoir created by the dam. The greater the water pressure, the greater the power.

Water from the reservoir flows through the dam in pipes called penstocks to the powerhouse. In the powerhouse the water pressure is applied to a turbine which spins a generator to produce electricity. After the water has moved through the turbine, it is released into the river below the dam.

Hydroelectric power is cost-effective and proven. However, there are drawbacks. The damming of a river or stream has a critical and sometimes irreversible impact on the long-term ecological balance of that river or stream. Dams also encourage an accumulation of silt and can be a hazard in earthquake zones. However, dams create a better environment for some animals and plants, provide new recreational areas, and can control natural disasters such as floods and erosion.

How are ocean tides an energy source?

The potential energy of gravity—caused by the relationship between the earth, moon, and sun—and the kinetic energy of the earth's rotation create tides and the kinetic energy associated with their rising and falling. The key to the usefulness of tidal energy is the height difference between high and low tide.

In order to obtain energy from tides a dam must be constructed across a coastal inlet. The dam allows water to flow inwards at high tide, trapping the water. At low tide the water is allowed to flow back through the dam in a penstock. The flowing water turns a turbine and generator, producing electricity.

There are only a few locations in the United States that would be suitable for tidal energy development. In addition to the environmental concerns, there are technical and economic problems that will have to be worked out before tidal energy is feasible.

How are ocean waves an energy source?

The kinetic energy of waves is derived from the interactions of winds and ocean currents. Methods for harnessing the kinetic energy of waves are new and untested. Several different devices have been successful on a small-scale operation. All of them operated by using the natural up-and-down motion of waves. For example, the Madsuda buoy consists of an upturned canister with two holes in the top portion of the container floating in the water. As the waves rise and fall inside it, air is forced in and out by air pressure. The stream of air drives an air turbine, which, in turn, drives a generator producing electricity.

Waves, like wind, are unpredictable. Also, the environmental impact of any proposal would have to be carefully studied. Presently, wave energy is not economically feasible.

What is geothermal energy?

Geothermal energy, heat from within the earth, is the result of radioactive decay, chemical reactions, friction from the movement of crustal plates, and heat present from the earth's formation.

There are three basic forms of geothermal energy: hydrothermal, geopressurized, and hot dry rock. Hydrothermal systems are composed of hot water and steam trapped in porous or fractured rock near the earth's surface. Geopressurized reservoirs contain a mixture of hot water and methane gas trapped in sedimentary rock far beneath the earth's surface. Hot dry rock formations contain abnormally hot rock and little water.

Most of the recoverable United States geothermal reserves are located within the Western states: Alaska, California, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, and Washington.

All geothermal energy sources can be used in industrial processes and space heating, but only hydrothermal resources can be used in electrical generation. Hydrothermal resources use steam directly to turn a turbine and generator to produce electricity. In the process, steam is converted to water in a condenser and returned to the earth.

Direct application of geothermal energy to heat buildings can be found in Reykjavik, Iceland; Klamath Falls, Oregon; and Boise, Idaho. Electricity is produced by geothermal energy in only two locations in the United States: Pacific Gas and Electric Company's field at the Geysers in California, and Utah Power and Light Company's field near Milford, Utah.

Environmental and maintenance problems arise when the hot geothermal water, saturated with soluble minerals, cools and deposits the minerals in pipes and equipment. Geothermal energy, because of its localization, cannot satisfy the United States' overall energy needs.

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Electricity

Introduction

Electricity is a secondary energy source, that is, it is generated from the conversion of a primary energy source—solar, oil, coal, natural gas, or nuclear. Electricity is unique, as it is energy in transit, kinetic energy, obtained when electric charges are set in motion by an electromotive force.

But to most people, electricity is the cause of lightning, or the form of energy that powers their television set and lights their home. They have a limited understanding of the scientific principles and technologies required to generate, transmit, use, and manage electricity.

What is the atomic structure of matter?

Since the time of the ancient Greeks, matter has been thought to be made up of atoms ("atom" is the Greek word for "indivisible"), though the Greek ideas about the nature of these "indivisible" particles were rather vague. Through the work of Niels Bohr, Lord Rutherford and others it was revealed that atoms actually have a complex structure.

According to Bohr's theory, an atom consists of a positively charged nucleus, surrounded by negatively charged particles, called electrons. The nucleus of an atom consists of two fundamental particles: protons and neutrons. The proton carries a positive charge while the neutron has no charge.

The positive charge of a proton is equal to the negative charge of an electron. Since atoms ordinarily are electrically neutral, the number of positive charges equals the number of negative charges — that is, the number of protons in the nucleus is equal to the number of electrons surrounding the nucleus.

What are ions and ionization?

An ion is an atom that has become electrically unbalanced by the loss or gain of one or more electrons. When an atom loses an electron, its remaining electrons no longer balance the positive charge of the nucleus, and the atom acquires a positive charge. This atom is called a cation. Similarly, when an atom gains an electron, it acquires a negative charge and is called an anion. The process of producing ions is called ionization.

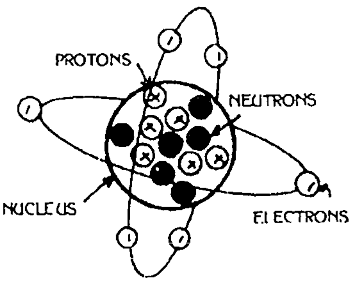
Ionization does not alter the chemical properties of an atom, but it does produce an electrical charge. Ionization can be brought about by the collision of electrons or by exposure to radiation. This is because the electrons in the outermost shell of an atom are held rather loosely and, hence, can be dislodged easily.

What are free electrons, conductors and insulators?

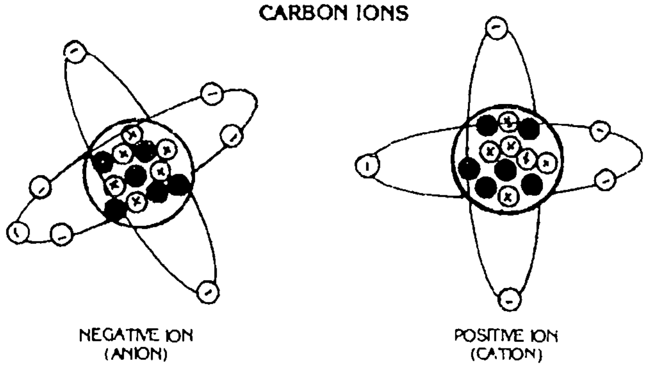
Electrons that have been "knocked" out of the outer shell of an atom are known as "free" electrons. These free electrons can exist by themselves outside of the atom, and it is these electrons which are responsible for most electrical phenomena. The movement of free electrons constitutes an electric current.

All substances normally contain free electrons that are capable of moving from atom to atom. Metallic materials, such as silver, copper, or aluminum, contain numerous free electrons capable of carrying an electric current and are called conductors. Non-metallic materials, which contain few free electrons, are called insulators. Materials that have an intermediate number of free electrons available are classed as semiconductors. The more free electrons a material contains, the better it will conduct electricity.

A CARBON ATOM



CARBON IONS



What is electric current?

The free electrons in a conductor are ordinarily in a state of chaotic motion. However, when an electromotive force (or voltage) is applied. such as that provided by a battery or electric power plant generator, the free electrons in the conductor are guided in an orderly fashion, atom to atom. This orderly motion of free electrons under the influence of an electromotive force is called an electric current. Although electrons drift through the wire at a relatively slow speed. the disturbance or impulse is transmitted almost at the speed of light. The electron current continues to flow through the conductor as long as the electromotive force is applied. The conductor itself remains electrically neutral. since electrons are neither gained nor lost by the atoms within the conductor. What happens is electrons enter the conductor from one end and an equal number of electrons are given up by the other end of the conductor. Thus, the free electrons present within the conductor act simply as current carriers.

Electric current is the transport of electric charge (electrons). Electric current is measured in amperes and is the amount of electrons passing a given point in one second. An ampere is equal to about 6.25×10^{18} electrons per second.

Voltage on the other hand is a measure of potential difference, the electromotive force necessary to move electrons through conductors. The amount of electric current moved through a conductor by the voltage is influenced by the conductor's resistance.

Electric power, the rate at which work is performed by moving electrons (electric current), is measured in watts and is determined by multiplying the current by the voltage:

1 watt = 1 amp x 1 volt

Because of the relationship between electric current and voltage to perform work, the same amount of work can be performed with either a high current and low voltage or a low current and high voltage.

What is resistance?

The opposition to the flow of free electrons in a material is called resistance. The resistance of material dissipates energy in the form of heat, because of friction between the free electrons and atoms of the material. As the material is heated, more collisions occur and the resistance to the flow of electric current increases.

The resistance of electrical conductors depends on their dimension and on their composition. As the cross-sectional area increases, the resistance decreases; but as the length increases, the resistance rises. A long, thin conductor, therefore, has more resistance than a short, thick one with the same volume of material. Silver has less resistance than copper, whereas aluminum and iron have more.

Although the same voltage may be applied to a light bulb and an electric iron, the actual current flow is different in each, because each has a different resistance. So not only does the voltage determine how much current flows through an electrical appliance but also the resistance of the appliance. The relationship between resistance (R), voltage (V), and current (I) then, can be expressed by the mathematical formula: $I = V/R$. The unit of measure for resistance is the Ohm, which is named after George Ohm who was the first person to specify the relationship between resistance, voltage, and current. It is this resistant property of conductors which is used to produce light or heat from electricity.

What is static electricity?

When certain materials are rubbed together, free electrons are transferred by friction from one to the other, and both materials become electrically charged. These charges are not in motion but reside statically on each material, and hence this type of electricity is known as static electricity. We've all had experience with static electricity: lightning during a storm; sparks flying after we shuffle over a rug; hair standing up on end after brushing — all these are typical examples of the effects of static electricity. This type of electricity is produced by friction.

What is thermoelectricity?

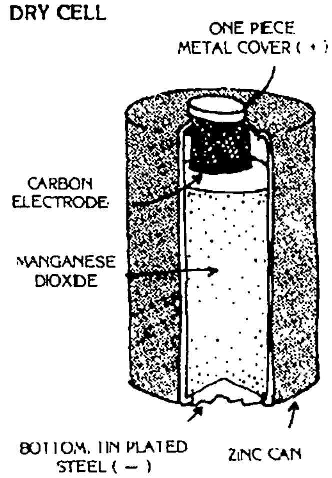
When two dissimilar metals, such as a copper and iron wire, are joined together at both ends, the free electrons will pass haphazardly in both directions across the junction. Because of the different atomic structure of the metals, electrons pass more readily in one direction than in the other. This results in a displacement of charges, making one metal positive and leaving the other negative. By keeping one junction at a higher temperature than the other, a thermal electromotive force is obtained, and an electric current is produced.

A single junction of two different metals that are twisted, brazed or riveted together at one end, is called a thermocouple. Thermocouples are not used to produce electric current, since the effect is small. Their chief use is for measuring temperatures and currents in electrical appliances and furnaces.

What is electrochemistry?

In 1795, the Italian physicist Alessandro Volta made the first electrical cell by placing two dissimilar metal electrodes in a conducting chemical solution, called an electrolyte. An electromotive force is produced in such a cell by the separation of charge, brought about by the chemical reaction between the elec-

DRY CELL

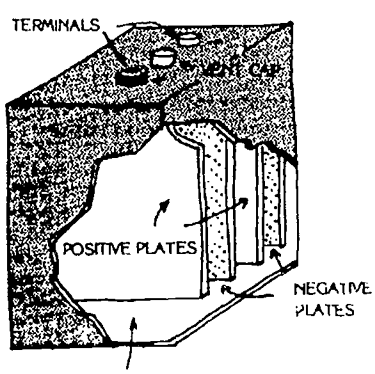


trodes and the electrolyte. This arrangement is known as a voltaic cell after its inventor. The electromotive force generated by a voltaic cell depends on the tendency of the electrodes' atoms to lose electrons and thus form positive ions.

The voltaic cell most widely used as a convenient source of "portable" electricity is the "dry cell," or common flashlight battery. A typical dry cell consists of a zinc metal housing, which acts as the negative electrode, and a carbon rod in the center, acting as the positive electrode. The electrolyte is a chemical paste consisting of ammonium chloride mixed with manganese dioxide. The manganese dioxide absorbs hydrogen produced from the chemical reaction. In operation, the metallic zinc delivers positive zinc ions to the electrolyte, causing a difference in charge between the zinc and carbon electrodes. If the zinc and carbon electrodes are connected in a circuit, electrons will flow from the zinc electrode to the carbon electrode, producing an electric current of about 1.5 volts. Since the electric current produced by a battery flows only in one direction, it is called direct current (DC).

Secondary cells, also called lead storage batteries, deliver current by chemical reaction like voltaic cells. However, the chemical reaction in a secondary cell is reversible, permitting it to be restored to its original condition. To restore or recharge a secondary cell, all you have to do is pass an electric current through it in a direction opposite to that of its normal use or discharge. The lead storage batteries in automobiles are secondary cells.

LEAD STORAGE BATTERY



What are magnetism and electricity?

Magnetism and electricity are not two separate phenomena. In fact, whenever an electric current flows, a magnetic field is created, and whenever a magnet moves, an electric current is produced. The properties of magnetism and electricity are both bound up in the nature of the physical structure and arrangement of atoms and their electrons. Materials that appear to be magnetic, without any outside source of electricity, depend on electron movement within their atomic structure to provide the electric current.

Electromagnetism is the effect by which electrical currents produce magnetic fields. The magnetic field around a straight wire is weak. Stronger magnetic fields are obtained by coiling wire into a spiraling loop, known as a solenoid. The effect of forming a solenoid is to increase the intensity of the magnetic field without having to increase the current. An iron-cored solenoid has a stronger magnetic field than that of an air-cored solenoid. This is because the electrons in the iron align themselves with the magnetic field produced by the current. Iron-cored solenoids are called electromagnets. Electromagnets energize the fields of motors and generators, and are part of telephones, loudspeakers, buzzers, electric bells, telegraphs, relays, electric meters and many other devices.

To produce an electric current from a magnet, the magnet must rotate inside a loop of wire or the wire loop must rotate between two magnets. The magnet creates an electromotive force, which causes the electrons in the wire to move, inducing an electric current. The rotation of the magnet or wire loop alternates between "pushing" and "pulling" the electrons, due to the magnet's polarity. The electric current produced thus alternates its direction of flow, and is therefore called alternating current (AC). Alternating current changes direction 60 times a second in the United States.

How do motors and generators work?

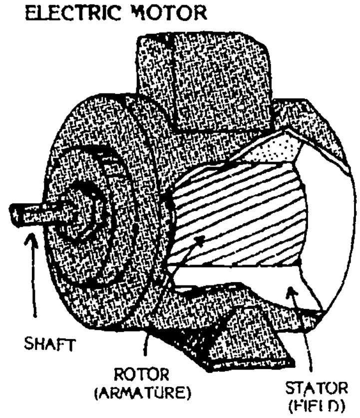
Motors and generators are basically the same in construction, although their functions are opposite. Motors are supplied with electrical energy to provide mechanical energy; generators are supplied with mechanical energy to produce electrical energy.

The two most essential elements of each of these machines are field and the armature. The field is a magnetic field which may be derived from permanent magnets or electromagnets.

The armature is a conductor arranged to pass through the field's magnetic lines of flux at right angles. The armature conductors may be wound onto a cylinder that rotates in the field, or they may be fixed to the inner walls of a cylinder, within which the field windings rotate. The armature is generally wound on a soft iron core to produce maximum flux for a given current. The soft iron is laminated (made up of thin slices) to prevent the electric current from circulating in the iron itself, and thus generating heat. The static part of the machine is called the stator and the revolving part the rotor. Both the field and the armature may be on either the stator or the rotor.

The armature must be supplied with electrical current if it is the rotor of a motor, and there must be a way of taking the electric current from it if it is a generator.

ELECTRIC MOTOR



What is a transformer?

One of the most essential electrical devices is the transformer. It is used in power stations and at substations — in the former to boost voltages for transmission over power lines and in the latter to reduce voltages to levels suitable for industrial or domestic use. Transformers contain two separate wire coils wrapped around an iron core. Electricity flows into the transformer through the first coil. As the electricity flows through the first coil, it produces a magnetic field in the iron core. The magnetic field then induces an electric current in the second coil which flows out of the transformer. Oil is circulated around the coils and iron core to insulate and cool the transformer. If the voltage is to be increased, the second coil contains more turns of the wire than the first coil. If the voltage is to be decreased, the second coil contains fewer turns of the wire than the first coil. Transformers are also used in many electrical appliances — such as radios, televisions and battery chargers — wherever voltage different from the supply is required.

How does the light bulb work?

The incandescent light bulb consists of a thin resistive tungsten filament, attached to a metal screw-type base. The filament is mounted inside a glass bulb, which is filled with an inert gas—either argon or nitrogen. The inert gas prevents the rapid burning of the filament. The resistance causes the filament to be heated to incandescence, producing light.

Fluorescent light bulbs contain filament electrodes at each end of the tube. The tube wall is coated with phosphor (a material that fluoresces under ultra-violet radiation) and is filled with mercury vapors. Electricity flows through the filament, causing the filament to emit electrons. The electrons cause the mercury vapor to break down and discharge ultra-violet radiation, which causes the phosphor to fluoresce, producing light.

Fluorescent lights are more efficient than incandescent lights. A 40-watt fluorescent light bulb will produce the same amount of lumens (light) as a 150-watt incandescent light bulb.

How does a circuit work?

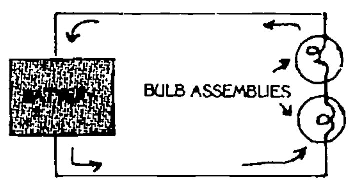
An electric circuit is the system by which an electric current is directed, controlled, switched on, or switched off. Circuits can contain from two or three to many hundred different components, according to the way in which the current is to be controlled.

The primary requirement of a circuit is that it form a complete path; electrons must be able to flow through the whole system so that as many electrons pass back into the source of the current as leave it.

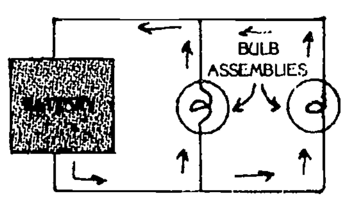
If the electricity is able to flow completely through the circuit, the circuit is said to be a "closed-circuit." If the electricity is unable to flow completely through the circuit, the circuit is said to be an "open-circuit."

There are two basic circuits in which electricity flows — series or parallel circuits. In a series circuit all of the electrical components are connected to each other in a "series," thus, the electric current has only one path to follow and flows through each component. In parallel circuits, the electrical components are connected individually to the main electrical circuit; thus, the electric current has more than one path to follow. Parallel circuits allow for individual control of each electrical component. Buildings, most appliances, motors, etc., are wired in parallel circuits.

SERIES CIRCUIT



PARALLEL CIRCUIT



How is electricity distributed in the home?

Electricity is brought to a house through a three-wire cable and connected via an electric meter, which indicates power consumption to the household circuit breaker or fuse box. The two "live wires" are then brought from the fuse box to power outlets (plug-ins), utility boxes (lighting), and wall switches. Each of the two live wires is at a voltage of 120 volts relative to ground and 240 volts relative to each other. The third wire, or neutral, is brought to a grounding bar in the circuit breaker box, or attached to a metal cold water pipe, as well as to all power outlets, utility boxes, and wall switches. Every appliance that is plugged into an outlet also has a ground connection. The appliance ground is connected to the metal or plastic case of the appliance.

If the two live wires should inadvertently come in contact with each other or the ground, a "short circuit" occurs which can result in a fire. In a properly wired house, such a short circuit causes a fuse to melt or a breaker to open, thus breaking or opening the circuit preventing electricity from flowing to that portion of the house or appliance and causing damage.

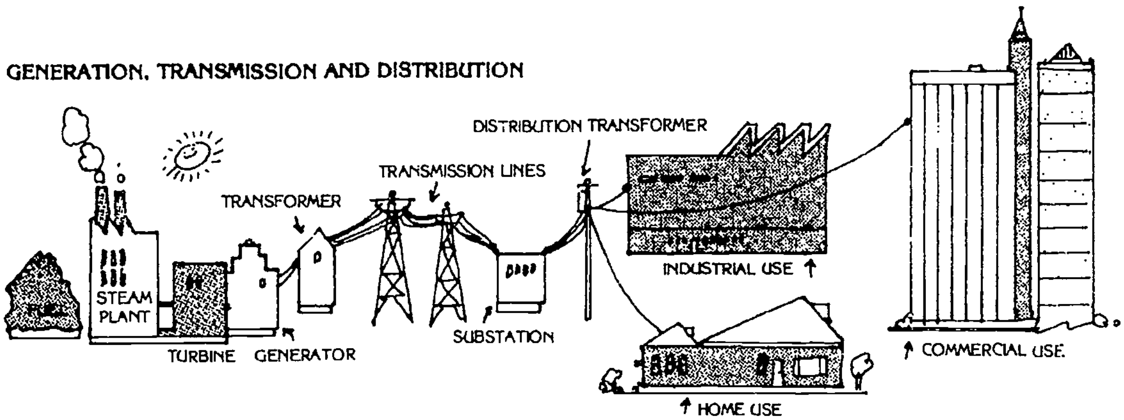
Fuses contain a metal alloy strip that melts when overloaded. Circuit breakers are essentially heat- or current-activated switches that open when overloaded.

At each power and lighting outlet no current flows until a lamp or appliance is plugged in and switched on. However, there is always a voltage at that point whether current flows or not. It is like a water tap; the pressure is always there although there is no flow until it is turned on.

How is electricity generated, transmitted and distributed?

Heat produced by the combustion of fossil fuels (coal, oil or natural gas) or the fission of uranium is used to convert water to steam. The steam is then piped to a turbine where it strikes the turbine blades, causing the turbine shaft to rotate. The rotating turbine shaft is connected to the generator's wire coil. As the turbine shaft rotates, it causes the generator's wire coil to spin. The spinning wire coil is surrounded by

GENERATION, TRANSMISSION AND DISTRIBUTION



magnets, which induce an electric current in the wire coil. The generator produces an electric current of about 22,000 volts. The electric current flows from the generator to the power plant transformer where the voltage is increased or stepped up.

The voltage is increased to reduce transmission loss. Transmission loss is due to the resistance of the transmission line to the flow of the electric current. The resistance produces heat. As the electric current increases, so does resistance and thus transmission loss. Since the same power can be obtained by transmitting electricity either at high current and low voltage or high voltage and low current, it is more efficient to transmit electricity at high voltage and low current, as less electricity is converted to heat through transmission line resistance. However, at high voltages the air surrounding the transmission line becomes partially ionized and some electricity is lost through atmospheric discharge. The distance the electricity needs to be transmitted determines how much the voltage is increased; the voltage can be stepped up as high as 765,000 volts. A 765,000-volt transmission line transports about as much electricity as five 345,000-volt transmission lines, due to transmission loss of the lower voltage system. From the power plant transformer, the electricity is transmitted throughout the electric utilities' service area through high power transmission lines. The utility's transmission lines are also connected with other electric utilities' transmission lines forming a power pool. The transmission lines transport the electricity to the electric utility's local substations. Substation transformers decrease or step down the voltage to between 5,000 and 35,000 volts (12,000 volts is the most common). Wooden power-pole distribution lines carry the electricity from the substation to consumers. However, before the electricity is used by the consumer, its voltage is stepped down by the power-pole transformer. The voltage is stepped down to either 120 or 240 volts.

What is energy conservation?

Electricity, while one of the most convenient forms of energy, is also one of the most inefficient. Steam turbine efficiencies have risen from 5 percent early in this century to about 35 percent today, but this still means that 65 percent of the coal or oil burned in power plants is lost as waste heat and pollution. The generating efficiency of an electrical network, including losses in transmission, is about 25 percent. A further small loss occurs when electricity is converted into heat, light, or mechanical energy of appliances, producing an overall efficiency of about 22 percent. However, electricity can do things that other energy sources cannot. It can drive a whole variety of household machines, power record players and television sets, and provide instant, clean and effective lighting.

Since much of our electricity must be produced through the use of the earth's supply of fossil fuels, conservation is important. Residential appliances consume roughly one-third of the electricity produced in the United States. Refrigerators alone utilize the electrical output of about 25 large power plants, nearly seven percent of the nation's consumption. Improving the energy efficiency of appliances is, therefore, an important step toward conserving fuel resources.

When buying home appliances it is important to check the energy efficiency rating and purchase the right size appliance. Oversized appliances consume more electricity and undersized appliances will have to work harder and thus, consume more electricity. Always compare the wattage of appliances (wattage will inform you how much electricity the appliance will consume). Also be sure to turn off lights and other electrical appliances when you are not using them.

Is electricity safe?

Electricity, when used properly, is a safe and convenient form of energy, but when used improperly, electricity can cause fires, shocks, injuries, and even death. The following safety tips will help you avoid electrical accidents.

- Be careful with electrical cords: don't place cords where people will trip over them or where they will receive excessive wear; keep cords away from heat and water; don't pull on cords to disconnect them, pull on the plug; and don't twist, kink or crush cords.
- Never use an appliance while standing in water or when wet.
- Don't touch metal plumbing or metal objects and appliances at the same time.
- Keep combustible materials away from lamps or heating devices.
- Disconnect appliances before cleaning.
- Keep ladders away from electric power lines.
- Turn off circuits when changing light bulbs.
- In case of an electrical fire, call the fire department; unplug appliance if safe: use fire extinguisher or baking soda, never use water.

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- Never touch broken electric lines. Call police and the electric company immediately.
- In case of electric shock, do not touch victim until electricity is turned off. If victim is in contact with electric power lines, the only safe procedure is to call the power company. If victim is in contact with low voltage cord, use a dry rope or stick to remove victim. Call hospital and, if necessary, give artificial respiration or, for shock, cover victim and raise his/her feet.
- Never attempt to remove a kite from electric power lines, and be aware of the location of electric power lines when flying kites.
- When climbing trees, be sure that electric power lines don't touch the tree; if so don't climb the tree.

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Food: The Fuel That Keeps You Going

Introduction

Everyone knows that the real reason to eat isn't simply for pleasure. Eating is what provides our bodies with the energy to live. The attractive colors, aromas, flavors and textures of favorite foods aren't really important to the solid necessity of eating for survival. They do play a role, however, since they provide variety and make eating a lot more enjoyable.

Where does energy in food come from?

The food chain for humans begins with plants. Under ordinary growing conditions, plants require soil, water, air and sunlight. Of these elements, the energy source is sunlight, or solar energy, which is used by the plant leaves to combine chemicals from air and water.

Carbon dioxide from air and hydrogen from water are combined to form carbohydrates. These carbohydrates, stored in the plant's leaves, stems and roots, are the major energy source for the animals (including humans) who eat them.

Plants get their food from the soil which supplies chemicals for making proteins, vitamins and minerals.

When we, in turn, eat plants, our bodies use these proteins, vitamins and minerals as building materials for bones, muscles and all the rest of our physical parts.

It's the carbohydrates, though, that we use for energy. Our bodies break down the carbohydrates into three fuels. Glucose is the fuel we use for a constant level of energy. Glycogen provides an extra-rich fuel for sudden emergencies. And fat is a long-term storage fuel.

All three fuels are necessary to provide the heat that keeps our bodies operating at a constant temperature of 98.6° F (37° C). These fuels also provide the energy for your heartbeat, breathing, walking, talking and other physiological functions.

When we eat beef, fish, poultry and other meats, we are really eating plants that have been converted to another form. The energy is still there.

How is energy used to make food and deliver it to us?

The days are long gone when most people grew their own food and survived independently. Today, much of what we eat comes from other people and places and is the result of a complex series of events.

A good example of a staple crop is corn.

Corn requires many chemicals from the soil, so farmers must keep fertilizing the soil to replace important chemicals. Usually, fertilizers made from natural gas are used.

Farm machinery, of course, burns gasoline or diesel fuel to do the plowing and planting. If rainfall is poor, farmers may need to irrigate, which requires electricity to run the irrigation pumps. Pesticides made from petroleum keep the corn healthy.

Then, fuel-burning machinery picks the corn which is transported by truck or rail to where it is sold. Since this may be thousands of miles away, the fuel (and energy used) is often substantial.

Once the corn gets to you, other forms of energy may be necessary to husk it, clean it and cook it to your tastes.

Meanwhile, energy is being used to produce and ship many other types of foods which will eventually end up on your table.

And the entire process has only one purpose: to give you energy to survive.

(Adapted from **Energy Readings**, part of the New York Energy Education Project, with permission of the New York Power Pool.)

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