Unit Pre and Post Test

1 **The energy in fossil fuels such as coal is stored as...**

- a chemical energy
- b electrical energy
- c thermal energy
- d nuclear energy

2 **Which energy source provides the nation with the most energy?**

- a coal
- b natural gas
- c petroleum
- d electricity

3 **Which residential task uses the most energy?**

- a lighting
- b heating water
- c heating rooms
- d cooling rooms

4 **Most energy conversions produce...**

- a light
- b heat
- c motion
- d sound

5 **The major use of coal in the U.S. is to...**

- a fuel trains
- b heat homes and buildings
- c make chemicals
- d generate electricity

6 **What percentage of the energy we use comes from renewable energy sources?**

- a 4 percent
- b 8 percent
- c 16 percent
- d 25 percent

7 **Compared to incandescent light bulbs, fluorescent bulbs...**

- a use more energy
- b use less energy
- c use the same amount of energy

8 **Which fuel provides most of the energy to commercial buildings?**

- a electricity
- b natural gas
- c coal
- d petroleum

9 **Which sector of the economy consumes the most energy?**

- a transportation
- b commercial
- c industrial
- d residential

10 **Which greenhouse gas is considered the most significant to global climate change?**

- a sulfur dioxide
- b methane
- c ozone
- d carbon dioxide

11 **Electricity is measured in...**

- a amperes
- b volts
- c kilowatt-hours
- d current

12 **Natural gas is transported mainly by...**

- a barge
- b tanker
- c pipeline
- d truck

13 **The average cost of a kilowatt-hour of electricity in the U.S. is...**

- a 8 cents
- b 25 cents
- c 1 dollar
- d 5 dollars

14 **Natural gas is measured by...**

- a volume
- b weight
- c heat content
- d flammability

All About Energy

What Is Energy?

Energy does things for us. It moves cars along the road and boats on the water. It bakes a cake in the oven and keeps ice frozen in the freezer. It plays our favorite songs and lights our homes at night so we can read a good book.

Energy is defined as the ability to do work—to cause change-- and that work can be divided into five main tasks:

1. **Energy gives us light.**
2. **Energy gives us heat.**
3. **Energy makes things move.**
4. **Energy makes things grow.**
5. **Energy makes technology work.**

Forms of Energy

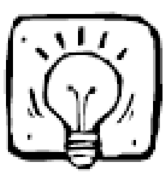
Energy takes many different forms. It can light our homes or heat them. There are six forms of energy.

Mechanical

Mechanical energy puts something in motion. It moves cars and lifts elevators. It pulls, pushes, twists, turns, and throws. A machine uses mechanical energy to do work and so do our bodies! We can throw a ball or move a pencil across a piece of paper. Sound is the energy of moving air molecules!

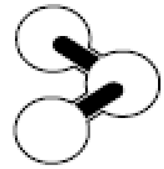
Kinetic energy is a kind of mechanical energy. It is the energy of a moving object. A moving car has kinetic energy. A stalled car does not; however, if it's poised at the top of a hill, it may have potential energy.

Potential energy is the energy an object has because of its position. Potential energy is resting or waiting energy. A spring is a good example of potential energy. Energy can be stored in the spring by stretching or compressing it. The sum of an object's kinetic and potential energy is the object's mechanical energy.



Radiant

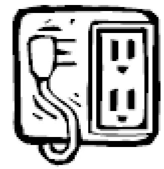
Radiant energy is commonly called light energy. But light energy is only one kind of radiant energy. All waves emit energy. Radio and television waves are other types of radiant energy. So are gamma rays and x-rays. Light waves do work by wiggling the receptors in back of our eyes.



Chemical

Chemical energy is the energy stored in food, wood, coal, petroleum, and other fuels. During photosynthesis, sunlight gives plants the energy they need to build complex chemical compounds. When these compounds are broken, the stored chemical energy is released in the form of heat or light.

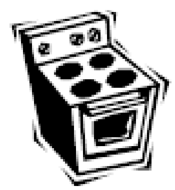
What happens to a wood log in a fireplace? Burning the wood breaks up the compounds, releasing the stored chemical energy in the forms of thermal and radiant energy.



Electrical

Electrical energy is a special kind of kinetic energy—the energy of moving electrons. Everything in the world is made up of tiny particles called atoms. Atoms are made up of even tinier particles called electrons, protons, and neutrons.

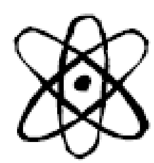
Electricity is produced when something upsets the balancing force between the electrons and protons in atoms and the electrons move from one atom to another. We can use electricity to perform work like lighting a bulb, heating a cooking element on a stove, or moving a motor.



Thermal

Thermal energy, or heat energy, is also a special kind of kinetic energy. It is the energy of moving or vibrating molecules. The faster the molecules move, the hotter an object becomes and the more thermal energy it possesses.

Thermal energy can do work for us or it can be the result of doing work. Do this. Rub your hands together quickly. What do you feel? You feel heat. When two objects slide against each other they produce friction heat.

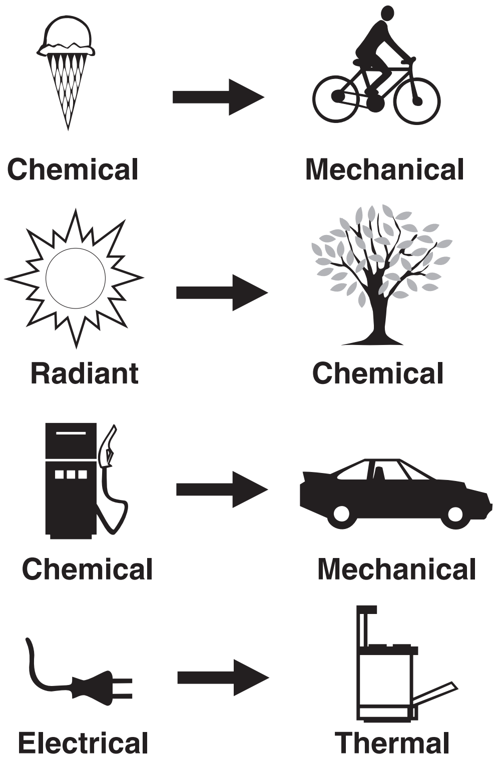


Nuclear

Nuclear energy is energy locked in the nucleus of the atom. It is the force that binds the nucleus of the atom together. The energy can be released when atoms are combined or split apart.

Nuclear power plants split atoms of uranium in a process called **fission**. The sun combines atoms of hydrogen to produce helium in a process called **fusion**. In both fission and fusion, mass is converted into energy, according to Einstein's Theory, $E + mc^2$.

Energy Transformations



Conservation of Energy

Your parents may tell you to conserve energy by turning off the lights. But, to scientists, conservation of energy means something else. The **law of conservation of energy** says energy is neither created nor destroyed.

Energy cannot be created or destroyed, but it can be transformed. That's really what we mean when we say we use energy. We change one form of energy into another. A car engine burns gasoline, converting its chemical energy into heat and mechanical energy that makes the car move. Wind mills change the kinetic energy of the wind into electrical energy. Solar cells change radiant energy into electrical energy.

Energy can change form, but the total quantity of energy in the universe remains the same. The only exception to this law is when mass is converted into energy during nuclear fusion and fission.

Energy Efficiency

Energy efficiency is how much useful energy you can get out of a system. In theory, a 100 percent energy-efficient machine would change all the energy put in it into useful work. Converting one form of energy into another form always involves a loss of usable energy, usually in the form of heat. In fact, most energy transformations are not very efficient.

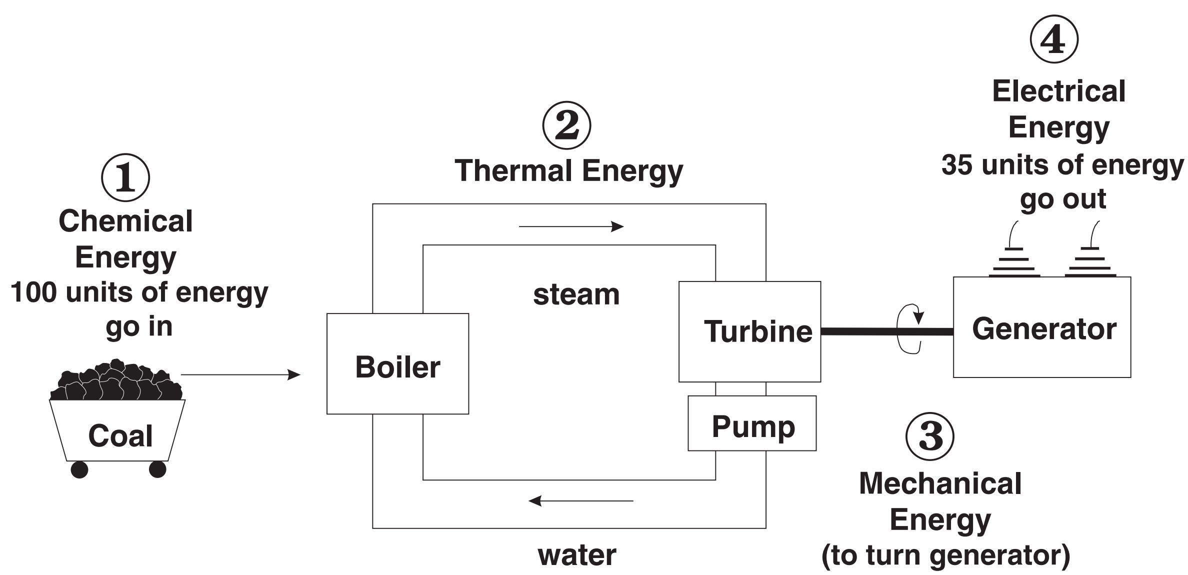
The human body is no exception. Your body is like a machine, and the fuel for your "machine" is food. Food gives us the energy to move, breathe, and think. But your body isn't very efficient at converting food into useful work. Your body is less than five percent efficient most of the time, and rarely better than 15 percent efficient. The rest of the energy is lost as heat. You can really feel the heat when you exercise!

An incandescent light bulb isn't efficient either. A light bulb converts ten percent of the electrical energy into light and the rest (90 percent) is converted into thermal energy (heat). That's why a light bulb is so hot to the touch.

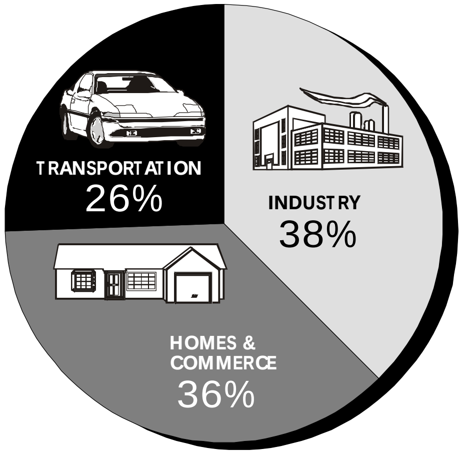
Most electric power plants are about 35 percent efficient. It takes three units of fuel to make one unit of electricity. Most of the other energy is lost as waste heat. The heat dissipates into the environment where we can no longer use it as a practical source of energy.

Energy Efficiency

Most power plants are about 35% efficient. That means for every 100 units of energy that go in a plant, 65 units are "lost" as one form of energy is converted to another form. Thirty-five units are left to do usable work.



Modern Energy Use



SOURCE: ENERGY INFORMATION ADMINISTRATION

Energy Use

Imagine how much energy you use every day. You wake up to an electric alarm clock. You take a shower with water warmed by a hot water heater. You listen to music on the radio as you dress. You catch the bus to school. And that's just some of the energy you use to get you through the first part of your day!

Every day, the average American uses about as much energy as is stored in seven gallons of gasoline. That's every person, every day. Over a course of one year, the sum of this energy is roughly equal to 2,500 gallons of oil. Energy use is sometimes called **energy consumption**.

Who Uses Energy?

The U.S. Department of Energy uses three categories to classify energy users: residential and commercial; industrial; and transportation. These users are sometimes called sectors of the economy.

Residential & Commercial

Residences are people's homes. Commerce includes office buildings, hospitals, stores, restaurants, and schools. Residential and commercial are lumped together because homes and businesses use energy for much the same reasons—heating, air conditioning, water heating, lighting, and operating appliances.

The residential and commercial sector of the economy consumed about 34 quads of energy in 1997 (the residential sector consumed more than two-thirds of this energy.)

Industrial

The industrial sector includes manufacturing, construction, mining, farming, fishing, and forestry. This sector consumed 35 quads of energy in 1997—more energy than the residential and commercial sector.

Transportation

The transportation sector refers to energy use by cars, buses, trucks, trains, ships, and airplanes. In 1997, the United States used large amounts of energy for transportation, more than 24 quads. About 95 percent was supplied by petroleum products like gasoline, diesel fuel and jet fuel.

Energy Use and Prices

In 1973, when Americans faced their first oil price shock, people didn't know how the country would react. How would Americans adjust to skyrocketing energy prices? How would manufacturers and industries respond? We didn't know the answers.

Now we know that Americans tend to use less energy when energy prices are high. We have the statistics to prove it.

When energy prices increased sharply in 1973, energy use dropped, creating a gap between actual energy use and how much the experts had thought Americans would be using.

The same thing happened when energy prices shot up again in 1979 and 1980—people used less energy. In 1985 when prices started to drop, energy use began to increase.

We don't want to simplify energy demand too much. The price of energy is not the only factor in the equation. Other factors that affect how much energy we use include the public's concern for the environment and new technologies that can improve the efficiency and performance of automobiles and appliances.

Most energy savings in recent years have come from improved technologies in industry, vehicles, and appliances. Without these energy conservation and efficiency technologies, we would be using much more energy today.

In 2000 and 2001 deregulation of power utilites and years of population increases without the building of new power plants, caused an energy crisis in California. Energy prices tripled in the state in one year. power companies could not keep up with energy demand. This added to the problem as power providers began to go bankrupt, leading to rolling blackouts and further price increases.

MEASURING*energy*

"You can't compare apples and oranges," the old saying goes. And that holds true for energy sources. Just think. We buy gasoline in gallons, wood in cords, and natural gas in cubic feet. How can we compare them?

With British thermal units, that's how. The heat energy contained in gasoline, wood, or other energy sources can be measured by British thermal units or Btu's.

One Btu is the heat energy needed to raise the temperature of one pound of water one degree Fahrenheit. A single Btu is quite small. A wooden kitchen match, if allowed to burn completely, would give off one Btu of energy. One ounce of gasoline contains almost 1,000 Btu's of energy. Every day the average American uses roughly 889,000 Btu's.

We use the quad to measure very large quantities of energy. A quad is equal to one quadrillion (1,000,000,000,000,000) Btu's. The United States uses about one quad of energy every 3.9 days. In 1997, Americans consumed 94.2 quads of energy, an all-time high.

ENERGY*sources*

Modern Consumption

Source	Consumption	Type	Uses
BIOMASS	2.9%	*renewable energy source*	Used for heating, electricity, transportation
GEOTHERMAL	0.4%	*renewable energy source*	Used for heating, electricity
HYDROPOWER	4.1%	*renewable energy source*	Used for electricity
SOLAR	0.15%	*renewable energy source*	Used for heating, electricity
WIND	0.05%	*renewable energy source*	Used for electricity
COAL	22.7%	*nonrenewable energy source*	Used for electricity, manufacturing
NATURAL GAS	23.1%	*nonrenewable energy source*	Used for heating, industrial production
URANIUM	7.1%	*nonrenewable energy source*	Used for electricity
PETROLEUM	37.7%	*nonrenewable energy source*	Used for transportation, manufacturing
PROPANE	1.7%	*nonrenewable energy source*	Used for heating, transportation

* Consumption of Other Energy Sources 0.1%

Sources of Energy

People have always used energy to do work for them. Thousands of years ago, cave men burned wood to heat their homes. Later people used the wind to sail ships. A hundred years ago, people used falling water to make electricity.

Today people are using more energy than ever before and our lives are undoubtedly better for it. We live longer, healthier lives. We can travel the world, or at least see it on television.

Before the 1970s, Americans didn't think about energy very much. It was just there. Things changed in 1973. The Organization for Petroleum Exporting Countries, better known as OPEC, placed an embargo on the United States and other countries.

The embargo meant they would not sell their oil to those countries. Suddenly, our supply of oil from the Middle East disappeared. The price of oil in the U.S. rose very quickly. Long lines formed at gas stations as people waited to fill their tanks with the amber-colored liquid they hadn't thought much about before.

Petroleum is just one of the many different sources of energy we use to do work for us. It is our major transportation fuel. We use coal and uranium to produce most of our electricity, and natural gas to heat our homes and cook our food.

There are ten major energy sources that we use in the United States today, and we classify those sources into two broad groups—renewable and nonrenewable.

Nonrenewables

Nonrenewable energy sources are the kind we use most in the United States. Coal, petroleum, natural gas, propane, and uranium are the major nonrenewable energy sources. They are used to make electricity, to heat our homes, to move our cars, and to manufacture all sorts of products from aspirin to CDs.

These energy sources are called nonrenewable because they cannot be replaced in a short period of time. Petroleum, for example, was formed millions of years ago from the remains of ancient sea life, so we can't make more petroleum in a short time. The supply of nonrenewable sources will become more limited in the future.

Renewables

Renewable energy sources include biomass, geothermal energy, hydropower, solar energy and wind energy. They are called renewable energy sources because they can be replenished by nature in a relatively short period of time. Day after day, the sun shines, the wind blows, and the rivers flow. We mainly use renewable energy sources to make electricity.

Speaking of electricity, is it a renewable or nonrenewable source of energy? The answer is neither.

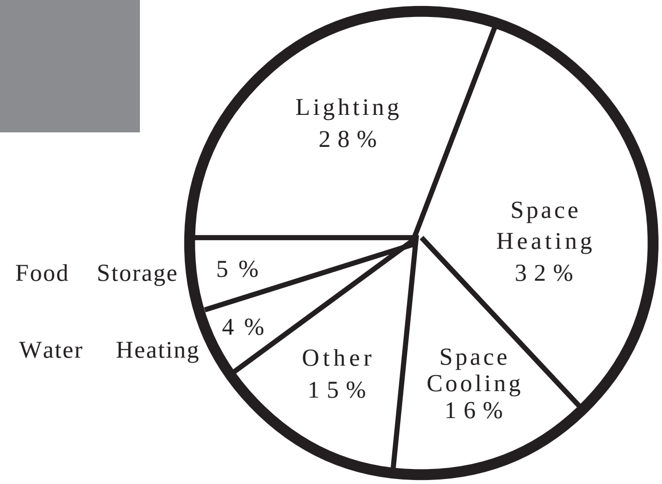
Electricity is different from the other energy sources because it is a **secondary** source of energy. That means we have to use another energy source to make it. In the United States, coal is the number one fuel for generating electricity.

Energy Consumption

Residential/Commercial Sector

The residential and commercial sectors–homes and buildings–consume 36 percent of the energy used in the United States today. We use that energy to heat and cool our homes and buildings, to light them, and to operate appliances and office machines.

In the last 25 years, Americans have significantly reduced the amount of energy we use to perform these tasks, mostly through technological improvements in the systems we use, as well as in the manufacturing processes to make those systems.



COMMERCIAL ENERGY USE

Heating & Cooling

The ability to maintain desired temperatures is one of the most important accomplishments of modern technology. Our ovens, freezers, and homes can be kept at any temperature we choose, a luxury that wasn't possible 100 years ago.

Keeping our living and working spaces at comfortable temperatures provides a healthier environment, and uses a lot of energy. Half of the average home's energy consumption is for heating and cooling rooms.

The three fuels used most often for heating are natural gas, electricity, and heating oil. Today, more than half of the nation's homes are heated by natural gas, a trend that will continue, at least in the near future. Natural gas is the heating fuel of choice for most consumers in the United States. It is a clean-burning, inexpensive fuel.

Most natural gas furnaces in the 1970s and 1980s were about 60 percent efficient - they converted 60 percent of the energy in the natural gas into usable heat. Many of these furnaces are still in use today, since they can last 20 or more years with proper maintenance.

New furnaces manufactrured today can reach efficiency ratings of 98 percent, since they are designed to capture heat that used to be lost up the chimney. These furnaces are more complex and costly, but they save significant amounts of energy.

The payback period for a new high-efficiency furnace is between four and five years, resulting in considerable savings over the life of the furnace.

Electricity is the second leading source of energy for home heating and provides almost all of the energy used for air conditioning. The efficiency of air conditioners and heat pumps has increased more than 50 percent in the last 25 years.

In 1973, air conditioners and heat pumps had an average Seasonal Energy Efficiency Rating, or SEER, of 7.0. Today, the average unit has a SEER of 10.7, and units are available with SEER ratings as high as 18.

These high-rated units are more expensive to buy, but their payback period is only three to five years. **Payback period** is the amount of time a consumer must use a system before beginning to benefit from the energy savings, because of the higher initial investment cost.

Heating oil is the third leading fuel for home heating, and is widely used in northeastern states. In 1973, the average home used 1,294 gallons of oil a year. Today, that figure is 833 gallons, a 35 percent decrease.

This decrease in consumption is a result of improvements in oil furnaces. Not only do today's burners operate more efficiently, they also burn more cleanly. According to the Environmental Protection Agency, new oil furnaces operate as cleanly as natural gas and propane burners.

A new technology under development would use PV cells to convert the bright, white oil burner flame into electricity.

Cost Management

The three most important things a consumer can do to reduce heating and cooling costs are:

Maintenance

Maintaining equipment in good working order is essential to reducing energy costs. Systems should be serviced annually by a certified technician, and filters should be cleaned or replaced frequently by the homeowner.

Programmable Thermostats

Programmable thermostats raise and lower the temperature automatically, adjusting for time of day and season. They also prevent people from adjusting the temperature They can lower energy usage appreciably.

Caulking & Weatherstripping

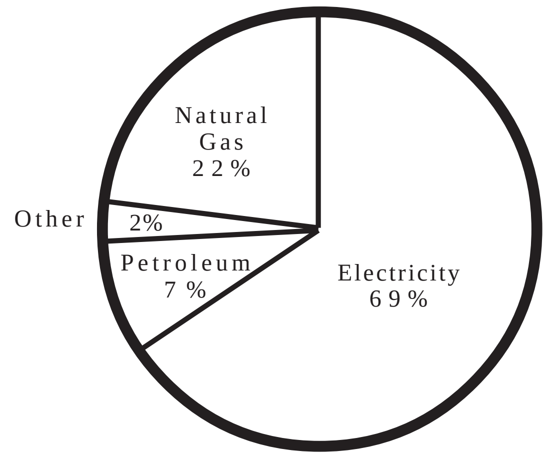
Preventing the exchange of inside air with outside air is very important. Weatherstripping and caulking around doors and windows can significantly reduce air leakage. Keeping windows and doors closed when systems are operating is also a necessity.

Building Design

The placement, design, and construction materials used can affect the energy efficiency of homes and buildings. Making optimum use of the light and heat from the sun is becoming more prevalent, especially in commercial buildings.

Many new buildings are situated with maximum exposure to the sun, incorporating large, south-facing windows to capture the energy in winter, and overhangs to shade the windows from the sun in summer. Windows are also strategically placed around the buildings to make use of natural light, reducing the need for artificial lighting during the day. Using materials that can absorb and store heat can also contribute to the energy efficiency of buildings.

For existing houses and buildings, there are many ways to increase efficiency. Adding insulation and replacing windows and doors with energy-efficient ones can significantly reduce energy costs. Adding insulated blinds, and using them wisely, can also result in savings. Even planting trees to provide shade in summer and allow light in during the winter can make a difference.



FUELS USED BY
COMMERCIAL BUILDINGS

Lighting

Lighting is essential to a modern society. Lights have revolutionized the way we live, work, and play. Today, about five percent of the energy used in the nation is for lighting our homes, buildings, and streets.

Lighting accounts for about 10 percent of the average home's energy bill but, for stores, schools, and businesses, the figure is much higher. On average, the commercial sector uses about 28 percent of its energy consumption for lighting.

Most homes still use the traditional incandescent bulbs invented by Thomas Edison. These bulbs only convert about ten percent of the electricity they use to produce light; the other 90 percent is converted into heat. With new technologies, such as better filament designs and gas mixtures, these bulbs are still more efficient than they used to be. In 1879, the average bulb produced only 1.4 lumens per watt, compared to about 17 lumens per watt today. By adding halogen gases, this efficiency can be increased to 20 lumens per watt.

Most commercial buildings have converted to fluorescent lighting, which costs more to install, but uses much less energy to produce the same amount of light. Buildings can lower their long-term lighting costs by as much as 50 percent with fluorescent systems.

Heating Water

In residential buildings, heating water uses more energy than any other task, except for heating and cooling. In commercial buildings, such as schools, heating water consumes about four percent of total energy consumption. Most water heaters use natural gas or electricity as fuel.

Water heaters today are much more energy efficient than earlier models. Many now have timers that can be set to the times when hot water is needed, so that energy is not used 24 hours a day.

New systems on the market combine high efficiency water heaters and furnaces into one unit to share heating responsibilities. Combination systems can produce a 90 percent efficiency rating.

In the future, expect to see water heaters that utilize heat from inside the building that is usually pumped outside as waste heat. Systems will collect the waste heat and direct it into the water heater, resulting in efficiency ratings three times those of conventional water heaters.

The temperature on most water heaters is set much higher than necessary. Lowering the temperature setting can result in significant energy savings. Limiting the amount of hot water usage with low-flow faucets and conservation behaviors also contributes to lower energy bills.

Energy Efficiency Ratings

We use many appliances every day. Some use less than 10 cents worth of electricity a year, while others use much more. Have you noticed that those appliances that produce or remove heat require the most energy?

In 1990, Congress passed the National Appliance Energy Conservation Act, which requires appliances to meet strict energy efficiency standards. All appliances must display a yellow label which tells how much energy the appliance uses.

When purchasing any appliance, consumers should define their needs and pay attention to the Energy Efficiency Rating (EER) included on the yellow label of every appliance. The EER allows consumers to compare not just purchase price, but operating cost as well, to determine which appliance is the best investment. Usually, more energy efficient appliances cost more to buy, but result in significant energy savings over the life of the appliance. Buying the cheapest appliance is rarely a bargain in the long run.

In the next few years, consumers will have the choice of many *smart* appliances that incorporate computer chip technology to operate more efficiently, accurately, and effectively.

Electricity

The Nature of Electricity

Electricity is a little different from the other sources of energy that we talk about. Unlike coal, petroleum, or solar energy, electricity is a **secondary** source of energy. That means we must use other sources of energy to make electricity. It also means we can't classify electricity as renewable or nonrenewable. The energy source we use to make electricity may be renewable or nonrenewable, but the electricity is neither.

Making Electricity

Almost all electricity made in the United States is generated by large, central power plants. These plants usually use coal, uranium, natural gas, or other energy sources to produce heat energy which superheats water into steam. The very high pressure of the steam turns the blades of a turbine.

The blades are connected to a generator which houses a large magnet surrounded by a coiled copper wire. The blades spin the magnet rapidly, rotating the magnet inside the coil and producing an electric current.

The steam, which is still very hot, goes to a condenser where it is cooled into water by passing it through pipes circulating over a large body of water or cooling tower. The water then returns to the boiler to be used again.

Moving Electricity

We are using more and more electricity every year. It is considered an efficient energy carrier––it can transport energy efficiently from one place to another. Electricity can be produced at a power plant and moved long distances before it is used.

Let's follow the path of electricity from power plant to a light bulb in your school.

First, the electricity is generated at the power plant. Next, it goes by wire to a transformer that "steps up" the voltage. A transformer steps up the voltage of electricity from the 2,300 to 22,000 volts produced by a generator to as much as 765,000 volts (345,000 volts is typical). Power companies step up the voltage because less electricity is lost along the lines when the voltage is high.

The electricity is then sent on a nationwide network of transmission lines made of aluminum. Transmission lines are the huge tower lines you may see when you're on a highway. The lines are interconnected, so should one line fail, another will take over the load.

Step-down transformers located at substations along the lines reduce the voltage to 12,000 volts. Substations are small buildings or fenced-in yards containing switches, transformers, and other electrical equipment.

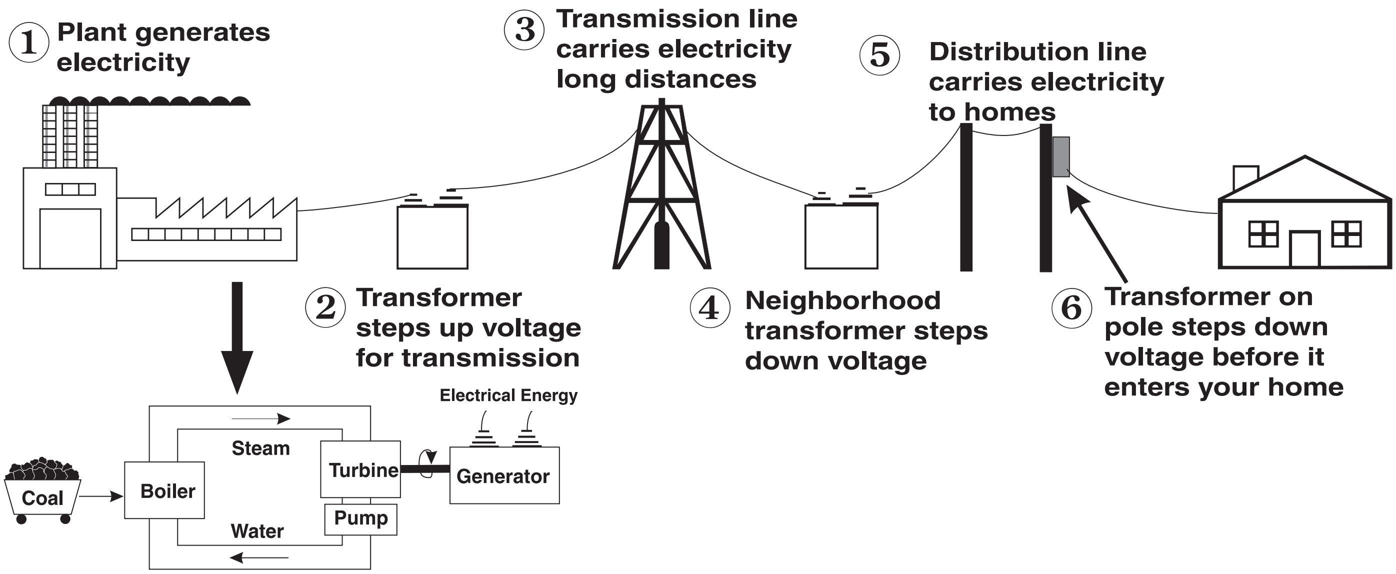
Electricity is then carried over distribution lines which bring electricity to your school. Distribution lines may either be overhead or underground. The overhead distribution lines are the electric lines that you see along streets.

Before electricity enters your school, the voltage is reduced again at another transformer, usually a large gray can mounted on an electric pole. This transformer reduces the electricity to the 120 volts that are needed to run the light bulb in your school.

Electricity enters your house through a three-wire cable. The "live wires" are then brought from the circuit breaker or fuse box to power outlets and wall switches in your home. An electric meter measures how much electricity you use so the utility company can bill you.

The time it takes for electricity to travel through these steps—from power plant to the light bulb in your home—is a tiny fraction of one second.

Transporting Electricity



Power to the People

Everyone knows how important electricity is to our lives. All it takes is a power failure to remind us how much we depend on it. Life would be very different without electricity—no more instant light from flicking a switch; no more television; no more refrigerators; or stereos; or video games; or hundreds of other conveniences we take for granted. We depend on it, business depends on it, and industry depends on it. You could almost say the American economy runs on electricity.

Reliability is the capability of a utility company to provide electricity to its customers 100 percent of the time. A reliable electric service is without blackouts or brownouts.

To ensure uninterrupted electric service, laws require most utility companies to have 15 to 20 percent more capacity than they need to meet peak demands. This means a utility company whose peak load is 12,000 MW, would need to have about 14,000 MW of installed electrical capacity. This helps ensure there will be enough electricity to go around even if equipment were to break down on a hot summer afternoon.

Capacity is the total quantity of electricity a utility company has on-line and ready to deliver when people need it. A large utility company may operate several power plants to generate electricity for its customers. A utility company that has seven 1,000-MW (megawatt) plants, eight 500-MW plants, and 30 100-MW plants has a total capacity of 14,000 MW.

Base-load power is the electricity generated by utility companies around-the-clock, using the most inexpensive energy sources—usually coal, nuclear, and hydropower. Base-load power stations usually run at full or near capacity.

When many people want electricity at the same time, there is a **peak demand**. Power companies must be ready for peak demands so there is enough power for everyone. During the day's peak, between 12:00 noon and 6:00 p.m., additional generating equipment has to be used to meet increased demand. This equipment is more expensive to operate. These peak load generators run on natural gas, diesel or hydro and can be running in seconds. The more this equipment is used, the higher our utility bills. By managing the use of electricity during peak hours, we can help keep costs down.

The use of **power pools** is another way electric companies make their systems more reliable. Power pools link electric utilities together so they can share power as needed.

A power failure in one system can be covered by a neighboring power company until the problem is corrected. There are nine regional power pool networks in North America. The key is to share power rather than lose it.

The reliability of U.S. electric service is excellent, usually better than 99 percent. In some countries, electric power may go out several times a day. Power outages in the United States are usually caused by such random occurrences as lightning, a tree limb falling on electric wires, or a car hitting a utility pole.

Demand-Side Management

Demand-side management is all the things a utility company does to affect how much people use electricity and when. It's one way electric companies manage those peak-load periods.

We can reduce the quantity of electricity we use by using better conservation measures and by using more efficient electrical appliances and equipment.

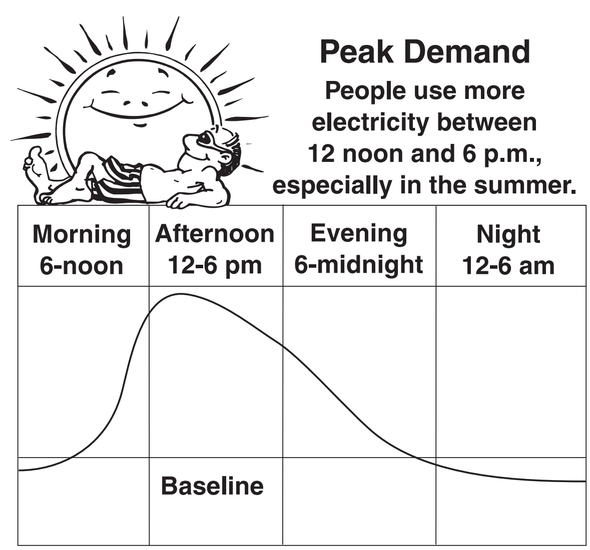
What's the difference between conservation and efficiency? Conserving electricity is like turning off the water in the shower while you shampoo your hair. Using electricity more efficiently is like installing a better shower head to decrease water flow.

Demand-side management can also affect the timing of electrical demand. Some utility companies give rebates to customers who allow the utility company to turn off their hot water heaters (via radio transmitters) during extreme peak demand periods, which occur perhaps 12 times a year. One East Coast power company gives participating customers a $4 per month rebate.

Economics of Electricity

How much does electricity cost? The answer depends on the cost to generate the power (50%), the cost of transmission (20%) and local distribution (30%).The average cost of electricity is 8.5 cents per kWh for residential customers. A major key to cost is the fuel used to generate electricity. For example, electricity produced from natural gas costs more than electricity produced from coal or nuclear power.

Another consideration is how much it costs to build a power plant. A plant may be very expensive to construct, but the cost of the fuel can make it competitive to other plants, or vice versa. For example, nuclear plants are very expensive to build, but their fuel—uranium—is very cheap. Coal-fired plants, on the other hand, are much less expensive to build than nuclear plants, but their fuel—coal—is more expensive.



When figuring costs, a plant's efficiency must be considered. In theory, a 100 percent energy-efficient machine would change all the energy put into the machine into useful work, not wasting a single unit of energy. But converting a primary energy source into electricity involves a loss of usable energy, usually in the form of heat. In general, it takes three units of fuel to produce one unit of electricity.

In 1900, electric power plants were only four percent efficient. That means they wasted 96 percent of the fuel used to generate electricity. Today's power plants are over eight times more efficient with efficiency ratings around 35 percent. Still, this means 65 percent of the initial heat energy used to make electricity is lost. (You can see this waste heat in the great clouds of steam pouring out of giant cooling towers on newer power plants.) A modern coal plant burns about 8,000 tons of coal each day, and about two-thirds of this is lost when the heat energy in coal is converted into electrical energy.

But that's not all. About two percent of the electricity generated at a power plant must be used to run equipment. And then, even after the electricity is sent over electrical lines, another 10 percent of the electrical energy is lost in transmission. Of course, consumers pay for all the electricity generated whether "lost" or not.

The cost of electricity is affected by what time of day it is used. During a hot summer afternoon from noon to 6 p.m., there is a peak of usage when air-conditioners are working harder to keep buildings cool. Electric companies charge their industrial and commercial customers more for electricity during these peak load periods because they must turn to more expensive ways to generate power.

Deregulation

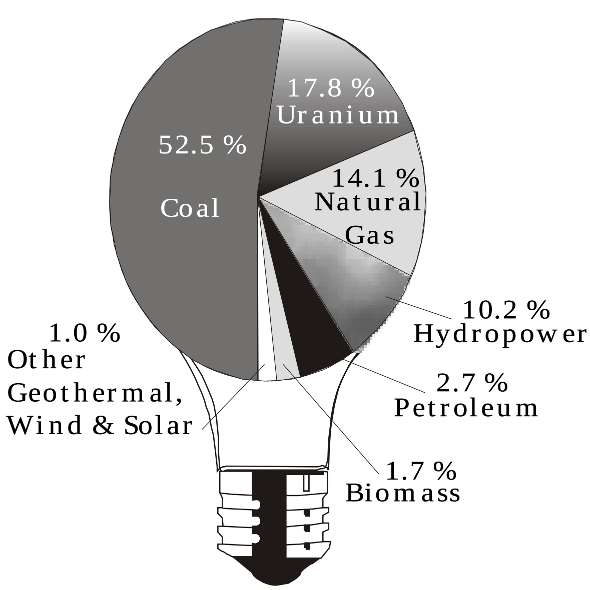
Since the 1930s, most electric utilities in the United States have operated under state and federal regulations in a defined geographical area. Only one utility provides service to any one area. People and businesses can not choose their electricity provider. In return, the utilities have to provide service to every consumer, regardless of the profitability.

Under this model, utilities generate the power, transmit it to the point of use, meter it, bill the customer, and provide information on efficiency and safety. The price is regulated by the state. As a result, the price of a kilowatt-hour of electricity to residential customers varies widely among the states and utilities, from a high of 16 cents to a low of four cents. The price for large industrial users varies, too.

MAKING *electricity*

Three kinds of power plants produce most of the electricity in the United States: fossil fuel; nuclear; and hydropower. There are also wind, geothermal, trash-to-energy, and solar power plants, but they generate less than 3% of the electricity produced in the U.S.

U.S. ELECTRICITY PRODUCTION



SOURCE: ENERGY INFORMATION ADMINISTRATION

Fossil Fuel Power Plants

Fossil fuel plants burn coal, natural gas, or oil. These plants use the energy in fossil fuels to superheat water into steam, which drives a turbine generator. Fossil fuel plants are sometimes called thermal power plants because they use heat energy to make electricity. Coal is the fossil fuel of choice for most electric companies, producing 52.5 percent of the electricity. Natural gas plants produce 14.1 percent. Petroleum produces less than three percent of the electricity in the U.S.

Nuclear Power Plants

Nuclear plants produce electricity much as fossil fuel plants do except that the furnace is called a reactor and the fuel is uranium. In a nuclear plant, a reactor splits uranium atoms into smaller parts, producing heat energy. The heat energy superheats water into steam and the high pressure steam drives a turbine generator. Like fossil fuel plants, nuclear power plants are called thermal power plants because they use heat energy to make electricity. Nuclear energy produces 17.8 percent of the electricity in the U.S.

Hydropower Plants

Hydro (water) power plants use the force of falling water to generate electricity. Hydropower is the cheapest way to produce electricity in this country, but there are few places where new dams can be built. Hydropower is called a renewable energy source because it is renewed continuously by rainfall. Hydropower produces 10.2 percent of the electricity in the United States.

MEASURING *electricity*

Power is the rate (time) of doing work. A watt is a measure of the electric power an appliance uses. Appliances require a certain number of watts to work correctly. All light bulbs are rated by watts, (60, 75, 100 watts) as well as appliances (such as a 1500-watt hairdryer).

A kilowatt is 1,000 watts. A kilowatt-hour (kWh) is the amount of electricity used in one hour at a rate of 1,000 watts. Think of adding water to a pool. In this analogy, a kilowatt is the rate, or how fast water is added to the pool; and a kilowatt-hour is the amount, or how much water is added to the pool.

Just as we buy gasoline in gallons or wood in cords, we buy electricity in kilowatt-hours. Utility companies charge us for the kilowatt-hours we use during a month. If an average family of four uses 750 kilowatt-hours in one month, and a utility company charges 10 cents per kilowatt-hour, the family will receive a bill for $75. (750 x $0.10 = $75)

Power companies use megawatts and gigawatts to measure huge amounts of electrical power. Power plant capacity is measured in megawatts. One megawatt (MW) is equal to one million watts or one thousand kilowatts. Gigawatts are often used to measure the electrical energy produced in an entire state or in all the United States. One gigawatt is equal to one billion watts, one million kilowatts, or one thousand megawatts.

The types of generating plants, the cost of fuel, taxes, and environmental regulations are some of the factors contributing to the price variations.

In the 1970s, the energy business changed dramatically in the aftermath of the Arab Oil Embargo, the advent of nuclear power, and stricter environmental regulations. Independent power producers and co-generators began making a major impact on the industry. Large consumers began demanding more choice in providers.

In 1992, Congress passed the Energy Policy Act to encourage the development of a competitive electric market with open access to transmission facilities. It also reduced the requirements for new non-utility generators and independent power producers. The Federal Energy Regulatory Commission (FERC) began changing their rules to encourage competition at the wholesale level. Utilities and private producers could, for the first time, market electricity across state lines to other utilities.

Some state regulators are encouraging broker systems to provide a clearinghouse for low-cost electricity from under-utilized facilities. This power is sold to other utilities that need it, resulting in lower costs to both the buyer and seller. This wholesale marketing has already brought prices down in some areas.

Many states are now considering whether competition in the electric power industry is a good thing for their consumers. This competition can take many forms, including allowing large consumers to choose their provider and allowing smaller consumers to join together to buy power.

Eventually, individual consumers may have the option of choosing their electric utility, much like people can now choose their long-distance telephone carrier.

Their local utility would distribute the power to the consumer. Some experts say this could lower electric bills, but don't expect to see this happening on a large scale in the next few years.

It will take the industry and the states several years to decide if residential competition is a good thing and figure out how to implement the changes.

Future Demand

Home computers, answering machines, FAX machines, microwave ovens, and video games have invaded our homes and they are demanding electricity! New electronic devices are part of the reason why Americans are using more electricity every year.

The U. S. Department of Energy predicts the nation will need to increase its current generating capacity of 780,000 megawatts by a third in the next 20 years.

Some parts of the nation have experienced power shortages in the last few years. Some utilities resorted to rolling blackouts—planned power outages to one neighborhood at a time—during the 1995 blizzard. New England utility companies warn residents every summer to expect brownouts (decreases in power levels) whenever sweltering weather looms over the region.

Conserving electricity and using it more efficiently help, but experts say we will need more power plants. That's where the challenge begins. Should we use coal, natural gas, or nuclear power to generate electricity?

Can we produce more electricity from renewable energy sources such as wind or solar? And where should we build new power plants? No one wants a power plant in his backyard, but everyone wants the benefits of electricity.

Experts predict we will need 205 thousand more megawatts of generating capacity by the year 2010. Demand for electricity does not seem to be coming to an end.

We must make machines and appliances that use electricity much more energy efficient, or we will have to build the equivalent of 350 coal plants by the year 2010 to meet that demand.

Which energy sources will provide this additional electricity? Most new power generation will come from natural gas. Natural gas is a relatively clean fuel and is abundant in the United States.

New natural gas combined-cycle turbines use the waste heat they generate to turn a second turbine. Using this waste heat increases efficiency to 50 or 60 percent, instead of the 35 percent efficiency of conventional power plants.

The Greenhouse Effect

Earth's Atmosphere

Our earth is surrounded by a blanket of gases called the atmosphere. Without this blanket, our earth would be so cold that almost nothing could live. It would be a frozen planet. Our atmosphere keeps us alive and warm.

The atmosphere is made up of many different gases. Most of the atmosphere (99 percent) is oxygen and nitrogen. The other one percent is a mixture of greenhouse gases. These greenhouse gases are mostly water vapor, mixed with carbon dioxide, methane, CFCs, ozone, and nitrous oxide.

Carbon dioxide is the gas we produce when we breathe and when we burn wood and fossil fuels. Methane is the main gas in natural gas. It is also produced when plants and animlas decay. The other greenhouse gases (ozone, CFCs and nitrous oxide) are produced by burning fuels and in other ways.

Sunlight and the Atmosphere

Rays of sunlight (radiant energy) shine down on the earth every day. Some of these rays bounce off molecules in the atmosphere and are reflected back into space. Some rays are absorbed by molecules in the atmosphere.

About half of the sunlight passes through the atmosphere and reaches the earth. When the sunlight hits the earth, most of it turns into heat (thermal energy). The earth absorbs some of this heat. The rest flows back out toward the atmosphere. This keeps the earth from getting too warm.

When this heat reaches the atmosphere, it stops. It can't pass through the atmosphere like sunlight. Most of the heat energy becomes trapped and flows back to the earth. We usually think it's the sunlight itself that warms the earth, but actually it's the heat energy produced when the sunlight is absorbed by the earth and air that gives us most of our warmth.

The Greenhouse Effect

We call this trapping of heat the greenhouse effect. A greenhouse is a building made of clear glass or plastic. In cold weather, we can grow plants in a greenhouse.

The glass lets the sunlight in. The sunlight turns into heat when it hits objects inside. The heat becomes trapped. The light energy can pass through the glass; the heat energy cannot.

THE GREENHOUSE EFFECT

Radiant energy (white arrows) from the sun travels through space and shines on the earth. Some radiant energy is reflected back into space by the atmosphere. Some radiant energy is absorbed by the atmosphere and turns into heat energy.

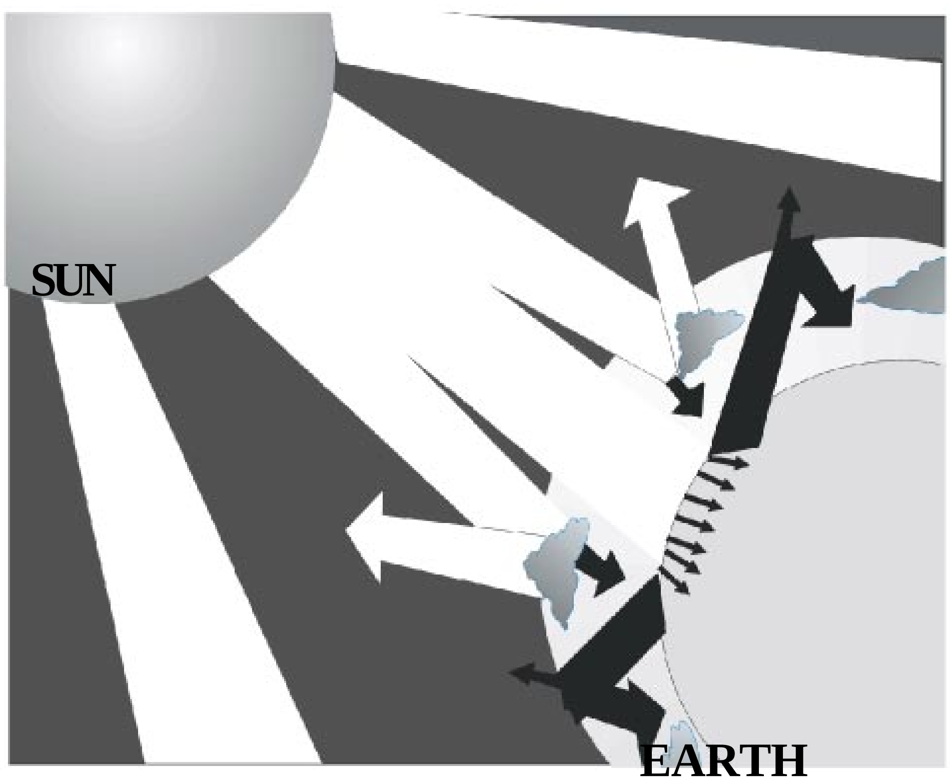
Half of the radiant energy passes through the atmosphere and reaches the earth, where it turns into heat (black arrows).

Some of this heat energy is absorbed by the earth.

Most of the heat energy flows back into the air where it is trapped by the atmosphere.

Very little heat energy passes through the atmosphere and escapes into space.

The trapped heat energy flows back toward the earth.



Greenhouse Gases

What is in the atmosphere that lets light through, but traps heat? It's the greenhouse gases, mostly carbon dioxide and methane. These gases are very good at absorbing heat energy and sending it back to earth.

In the last 50 years, the amount of some greenhouse gases––especially carbon dioxide and methane––has increased dramatically. We produce carbon dioxide when we breathe and when we burn wood and fossil fuels: coal, petroleum, natural gas, and propane.

Some methane escapes from coal mines and oil wells. Some is produced when plants and garbage decay. Some animals also produce methane gas. One cow can give off enough methane in a year to fill a hot air balloon!

Global Climate Change

Scientists around the world believe these greenhouse gases are trapping more heat in the atmosphere as their levels increase. They believe this trapped heat has begun to change the average temperature of the earth. They call this phenomenon **global warming**.

Many long–term studies indicate that the average temperature of the earth has been slowly rising in the last few decades. In fact, the last decade has seen two of the hottest years on record.

Scientists predict that if the temperature of the earth rises just a few degrees Fahrenheit, it will cause major changes in the world's climate. They predict there will be more flooding in some places and periods of drought in others. They think the level of the oceans will rise as the ice at the North and South Poles melts, causing low-lying coastal areas to disappear. They also predict more erratic weather––causing stronger storms and hurricanes.

Some scientists don't believe the world's temperature will rise as much as the predictions indicate. They think it is too soon to tell if there will be long-term changes in the global climate. They think slight warming could prove beneficial, producing longer growing seasons for crops, warmer nights, and milder winters.

Countries all over the world are concerned about the threat of global warming. They believe we need to act now to lower the amount of carbon dioxide we put into the atmosphere. They believe we should decrease the amount of fossil fuels that we burn.

Another continuing dispute is the issue of emissions trading. Europeans want strict limits on trading to force countries to make domestic cuts. Unlimited emissions trading would allow rich countries––like the United States––to have higher domestic emissions in return for investing in clean technologies in developing countries.

Greenhouse gases make up less than one percent of the atmosphere.

Greenhouse gases are more than 97 percent water vapor.