PILOT PROJECT

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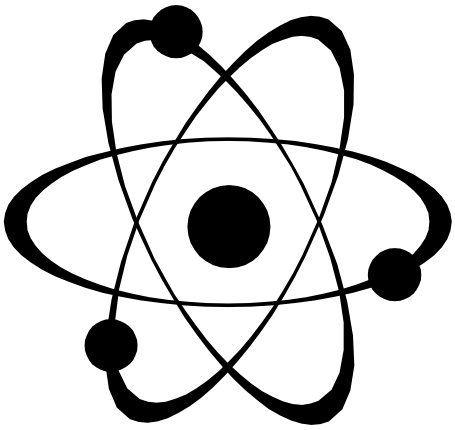

FOUNDATIONS OF ENERGY

Kentucky Department of Education

College and Career Readiness

Frankfort, KY

August 2011

An Overview: Foundations of Energy

This course is an outgrowth of the “The Big Picture” which identified major components of energy education needed by secondary students. The Foundations of Energy course was developed as an introductory course in Career and Technical Education for grades nine or ten. Content material is organized by units/modules and may be structured as a stand-alone course (semester/year) or may be integrated in other career pathways such as engineering/technology, construction, and manufacturing technology. It also could be utilized in conjunction with the science curriculum.

During the school year 2011–12, this course may be offered on a pilot basis under the auspices of Career and Technical Education. Credit would be an elective with the approval of the school’s curriculum committee. Teacher Certification would include those individuals with a valid Kentucky Teaching certificate for grades 9 -12 in one of *the following categories:

Engineering	21-9917	Electricity	46-0399
Technology	21-0112	Electronics	47-0199
Construction	46-0198		

Course Description

Foundations of Energy is a course in career and technical education for secondary students. The course provides an overview of renewable and nonrenewable energy resources reflecting how energy impacts the environment and the economy from regional, state, national and global perspectives. Extensive hands-on laboratory activities are vital components of the curriculum. This course can provide a basis for students working toward various career pathways in energy such as Engineering/Technology, Construction and Manufacturing Technology.

This description provides an overview of the course and basic information regarding the intent and purposes of the course.

Units/Modules

The structure of the units/modules develops the scope and sequence of content materials. Each unit/module uses the following format:

Section I: General Information Overview
Section II: Essential Questions
Section III: Major Focus: Technical Content, Learner Activities, Core Content and Academic Expectations
Section IV: Culminating Project with Scoring Guide
Section V: Assessment and Enabling Skills
Section VI: Supporting Materials

Standards – Content/Process for the course are reflected in the following chart:

NATIONAL STANDARDS (IF NOT AVAILABLE – USE ACADEMIC EXPECTATIONS IN THIS COLUMN)	**Content/Process** **Students will:**
#2.1 – 2.2	identify new and emerging technology
#6.2	develop competencies and skills in the areas of energy
#2.1 – 2.3	engage in meaningful hands-on minds-on conceptual based activities in the areas of energy
#2.3 – 5.5	develop competencies in the safe and efficient use of the tools, machines, materials and processes of energy technology
#2.6	demonstrate employability and social skills relative to careers in energy industry
#1.5 – 6.2	apply concepts of mathematics, science, social studies, and communications in the context of energy
#1.16	use computer-based skills related to concepts of energy in the various technologies
#1.10 – 5.4	demonstrate knowledge and skills in blueprint reading in energy technologies
#5.5	demonstrate and develop fundamental skills and knowledge of tools in the energy industry
#5.1	develop core competencies in the area safety
#5.1	apply basic electricity concepts and knowledge as it applies to energy technologies
#2.3	describe similarities & differences between renewable and nonrenewable sources of energy
#6.2	Identify ways to conserve energy
#5.1	compare advantages and disadvantages in the use of the various energy sources
#2.1	assess the impact of the various energy sources on the economy in Kentucky
#6.2	differentiate between the terms energy and electricity
#6.2	describe the difference in potential and kinetic energy
#2.18	analyze how supply & demand impacts Kentucky's economy in relation to energy
#5.4	investigate the role of technology in the future development of energy usage
#6.2	map the major sources of energy used in Kentucky
#5.1	analyze the impact energy has on the environment
CONNECTIONS	
ACADEMIC EXPECTATIONS	
Occupational Safety and Health Administration (OSHA) Standards	
American Red Cross Safety Training	
Kentucky and U.S. Departments of Labor	
North American Board of Certified Energy Practitioners (NABCEP)	

Standards and technical content, in conjunction with academic expectations and core content are basic foundations of the units/modules and provide the major components for learner activities identified in Section III of each document. . . Other aspects of Sections I, II, IV, V and VI are self-explanatory.

Units/modules developed for this course include Biomass, Building Management, Coal, Emerging and New Technologies, Energy Policies, Geothermal, Hydropower, Natural Gas, Nuclear, Petroleum, Propane, Solar and Wind. The materials are organized on the website in separate folders with some PDF files provided to assist in the instructional process. In addition to the materials in each folder, other reference materials in this overview include *the Big Picture, Introduction to Energy, Background Materials for Teachers (Introduction to Energy, History of Electricity, Non-Renewables, Renewables) and National and Technical Standards.*

Supplemental Materials

Big Picture

Foundations of Energy Outline--"The BIG Picture"

Introduction:

a. History of Energy
b. Forms of Energy
c. Energy Transformations
d. Energy Vocabulary
e. Safety
f. Difference between energy and electricity

Non-Renewable

Fossil Fuels

1. Coal
    a. Types
    b. Distribution
    c. Mining technology
    d. Gasification / Liquefaction
    e. Supply
    f. Conservation

2. Natural Gas
    a. Liquefaction
    b. Supply

3. Propane
    a. Supply
    b. Transport

4. Petroleum
    a. Refinery
    b. Supply

5. Uranium
    a. Nuclear Fission
    b. Fuel Processing
    c. Reactor Process

Renewable:

1. Solar
    a. Passive
    b. Active
    c. Photo-voltaic

2. Wind
    a. Small Wind Scale
    b. Large Wind Scale

3. Hydro Power
    a. Streams and Rivers
    b. Tidal
    c. Ocean Currents

4. Geothermal

5. Bio-Mass
    a. Bio-fuels
    b. Waste to Energy

Environmental/Environmental Impacts

1. Carbon and Greenhouse Effect
    a. Effects
    b. Storage
    c. Sequestration

2. Nuclear Waste
    a. Reprocessing
    b. Storage

3. Water and Land Conservation
    a. Reclamation

Building Management/Conservation

1. Construction and renovation
    a. Windows
    b. Insulation and R Value
    c. Air Exchanges
    d. Heating Systems

2. Usage/Efficiency
    a. Compact Lights
    b. Power Converters
    c. Green IT

3. Detection
    a. Thermography
    b. Blower Door

Emerging and New Technologies

1. Hydrogen
    a. Transportation
    b. Fuel Cells

2. Tidal

3. OTEC

Energy Policy

a. Kentucky
b. National
c. Global

Electrical Generation

Connections with other programs

Background Materials for Teacher*

Introduction to 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 that we can read good books. Energy helps our bodies grow and our minds think. Energy is a changing, doing, moving, working thing.

Energy is defined as the ability to produce change or do work, and that work can be divided into several main tasks we easily recognize:

Energy produces light.
Energy produces heat.
Energy produces motion.
Energy produces sound.
Energy produces growth.
Energy powers technology.

Forms of Energy

There are many forms of energy, but they all fall into two categories–potential or kinetic.

Potential Energy *is stored energy and the energy of position, or gravitational energy.* There are several forms of potential energy, including:

Chemical Energy is energy stored in the bonds of atoms and molecules. It is the energy that holds these particles together. Biomass, petroleum, natural gas, and propane are examples of stored chemical energy.

During photosynthesis, sunlight gives plants the energy they need to build complex chemical compounds. When these compounds are later broken down, the stored chemical energy is released as heat, light, motion and sound.

Stored Mechanical Energy is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of stored mechanical energy.

Nuclear Energy is energy stored in the nucleus of an atom—the energy that holds the nucleus together. The energy can be released when the nuclei are combined or split apart. Nuclear power plants split the nuclei of uranium atoms in a process called **fission**. The sun combines the nuclei of hydrogen atoms into helium atoms in a process called **fusion**. In both fission and fusion, mass is converted into energy, according to Einstein's Theory, $\mathbf{E = mc^2}$.

Gravitational Energy is the energy of position or place. A rock resting at the top of a hill contains gravitational potential energy. Hydropower, such as water in a reservoir behind a dam, is an example of gravitational potential energy.

Kinetic Energy *is motion—the motion of waves, electrons, atoms, molecules, substances, and objects.*

Electrical Energy is the movement of electrons. Everything is made of tiny particles called atoms. Atoms are made of even smaller particles called electrons, protons, and neutrons. Applying a force can make some of the electrons move. Electrons moving through a wire are called electricity. Lightning is another example of electrical energy.

Radiant Energy is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays and radio waves. Light is one type of radiant energy. Solar energy is an example of radiant energy.

Thermal Energy, or **heat**, is the internal energy in substances—the vibration and movement of atoms and molecules within substances. The faster molecules and atoms vibrate and move within substances, the more energy they possess and the hotter they become. Geothermal energy is an example of thermal energy.

Motion Energy is the movement of objects and substances from one place to another. According to **Newton's Laws of Motion,** objects and substances move when a force is applied . Wind is an example of motion energy.

Sound Energy is the movement of energy through substances in longitudinal (compression/rarefaction) waves. Sound is produced when a force causes an object or substance to vibrate; the energy is transferred through the substance in a wave.

Conservation of Energy

Your parents may tell you to conserve energy. "Turn out the lights," they say. But to scientists, conservation of energy means something quite different. The **law of conservation of energy** says energy is neither created nor destroyed.

When we use energy, we do not use it up—we just change its form. That's really what we mean when we say we are using energy. We change one form of energy into another. A car engine burns gasoline, converting the chemical energy in the gasoline into mechanical energy that makes the car move. Old-fashioned windmills changed the kinetic energy of the wind into mechanical energy to grind grain. 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 a small amount of matter 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 of 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.

Sources of Energy

People have always used energy to do work for them. Thousands of years ago, early humans burned wood to provide light, heat their living spaces, and cook their food. Later, people used the wind to move their boats from place to place. A hundred years ago, people began using falling water to make electricity.

Today, people use more energy than ever from a variety of sources for a multitude of tasks and our lives are undoubtedly better for it. Our homes are comfortable and full of useful and entertaining electrical devices. We communicate instantaneously in many ways. We live longer, healthier lives. We travel the world, or at least see it on television and the internet.

Before the 1970s, Americans didn't think about energy very much. It was just there. The energy picture 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 OPEC would not sell its oil to the U.S. or our allies. Suddenly, our supply of oil from the Middle East disappeared. The price of oil in the U.S. rose quickly. Long lines formed at gas stations as people waited to fill their tanks with that liquid that they had taken for granted for so many years.

Petroleum is just one of the many different sources of energy we use to do work for us. The ten major energy sources we use today are classified into two broad groups—renewable and nonrenewable.

Nonrenewable energy sources include coal, petroleum, natural gas, propane, and uranium. They are used to generate electricity, to heat our homes, to move our cars, and to manufacture products from candy bars to MP3 players.

These energy sources are called nonrenewable because they cannot be replenished 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 quickly. We could run out of economically recoverable nonrenewable resources some day.

Renewable energy sources include biomass, geothermal, hydropower, solar and wind. They are called renewable energy sources because their supplies are replenished in a short time. Day after day, the sun shines, the wind blows, and the rivers flow. We use renewable energy sources mainly to make electricity.

Is electricity 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 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 using electricity or natural gas.

You listen to music on your MP3 player 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 equal to about 2,500 gallons of oil per person. This use of energy is 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 categories are called the sectors of the economy.

Residential/Commercial

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

The residential/commercial sector of the economy consumed 40.5 percent of the total energy supply in 2008, more energy than either of the other sectors, with a total of 40.1 quads. The residential sector consumed 21.6 quads and the commercial sector consumed 18.5 quads.

Industrial

The industrial sector includes manufacturing, construction, mining, farming, fishing, and forestry. This sector consumed 31.2 quads of energy in 2008, which accounted for 31.4 percent of total consumption.

Transportation

The transportation sector refers to energy consumption by cars, buses, trucks, trains, ships, and airplanes. In 2008, the U.S. used large amounts of energy for transportation, 27.9 quads. More than 95 percent of this energy was from petroleum products such as gasoline, diesel 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 the early 1970s, 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, 1980 and 2008—people used less energy. 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 reductions in energy consumption in recent years are the result of improved technologies in industry, vehicles, and appliances. Without these energy conservation and efficiency technologies, we would be using much more energy today.

In 2008, the United States used 33 percent more energy than it did in the 1970s. That might sound like a lot, but the population increased by over 40 percent and the nation's **gross domestic product** (the total value of all the goods and services produced by a nation in one year) was more than 75 percent higher!

If every person in the United States consumed energy today at the rate we did in the 1970s, we would be using much more energy than we are today; perhaps as much as double the amount. Energy efficiency technologies have made a huge impact on overall consumption since the energy crisis of 1973.

History of Electricity

Starting with Ben

Many people think Benjamin Franklin discovered electricity with his famous kite-flying experiments in 1752. That isn't the whole story. Electricity was not "discovered" all at once.

Electricity is an action—not really a thing—so different forms of electricity had been known in nature for a long time. Lightning and static electricity were two forms.

In the early years, electricity became associated with light. After all, electricity lights up the sky during a thunderstorm. Likewise, static electricity creates tiny, fiery sparks. People wanted a cheap and safe way to light their homes, and scientists thought electricity could do it.

A Different Kind of Power: The Battery

The road to developing a practical use of electricity was a long one. Until 1800, there was no dependable source of electricity for experiments. It was in this year that an Italian scientist named Alessandro Volta soaked some paper in salt water, placed zinc and copper on alternate sides of the paper, and watched the chemical reaction produce an electric current. Volta had created the first electric cell.

By connecting many of these cells together, Volta was able to "string a current" and create a battery. (It is in honor of Volta that we measure battery power in "volts.") Finally, a safe and dependable source of electricity was available, making it easy for scientists to study electricity. The electric age was just around the corner!

A Current Began

English scientist Michael Faraday was the first to realize that an electric current could be produced by passing a magnet through copper wiring. Both the electric generator and the electric motor are based on this principle. (A generator converts motion energy into electricity. A motor converts electrical energy into motion.)

Mr. Edison & His Light

In 1879, Thomas Edison focused on inventing a practical light bulb, one that would last a long time before burning out. The challenge was finding a strong material to be used as the filament, the small wire inside the bulb that conducts the electricity.

Finally, Edison used ordinary cotton thread that had been soaked in carbon. The filament did not burn—instead, it became incandescent; that is, it glowed. These new lights were battery-powered, though, and expensive.

The next trick was developing an electrical system that could provide people with a practical, inexpensive source of energy. Edison went about looking for ways to make electricity both practical and inexpensive. He engineered the first electric power plant that was able to carry electricity to people's homes.

Edison's Pearl Street Power Station started up its generator on September 4, 1882, in New York City. About 85 customers in lower Manhattan received enough power to light 5,000 lamps. His customers paid a lot for their electricity. In today's dollars, the electricity cost $5 per kilowatt-hour! Today's electricity costs about nine cents per kilowatt-hour.

The Question: AC or DC?

The turning point of the electric age came a few years later with the development of AC (alternating current) power systems. Now power plants could transport electricity much farther than before. In 1895, George Westinghouse and his associates opened a major power plant at Niagara Falls that used AC power.

While Edison's DC (direct current) plant could only transport electricity within one square mile of his Pearl Street Power Station, the Niagara Falls plant was able to transport electricity over 200 miles!

Measuring Electricity

Electricity makes our lives easier, but it can seem like a mysterious force. Measuring electricity is confusing because we cannot see it. We are familiar with terms such as watt, volt, and amp, but we do not have a clear understanding of these terms. We buy a 60-watt light bulb, a tool that requires 120 volts, or an appliance that uses 8.8 amps, but we don't think about what those units mean.

Using the flow of water as an analogy can make electricity easier to understand. The flow of electrons in a circuit is similar to water flowing through a hose. If you could look into a hose at a given point, you would see a certain amount of water passing that point each second. The amount of water depends on how much pressure is being applied—how hard the water is being pushed. It also depends on the diameter of the hose. The harder the pressure and the larger the diameter of the hose, the more water passes each second. The flow of electrons through a wire depends on the electrical pressure pushing the electrons and on the cross-sectional area of the wire.

Voltage

The pressure that pushes electrons in a circuit is called **voltage**. Using the water analogy, if a tank of water were suspended one meter above the ground with a one-centimeter pipe coming out of the bottom, the water pressure would be similar to the force of a shower. If the same water tank were suspended 10 meters above the ground, the force of the water would be much greater, possibly enough to hurt you.

Voltage (V) is a measure of the pressure applied to electrons to make them move. It is a measure of the strength of the current in a circuit and is measured in **volts (V)**. Just as the 10-meter tank applies greater pressure than the 1-meter tank, a 10-volt power supply (such as a battery) would apply greater pressure than a 1-volt power supply. AA batteries are 1.5-volt; they apply a small amount of voltage for lighting small flashlight bulbs. A car usually has a 12-bolt battery—it applies more voltage to push current through circuits to operate the radio or defroster. The standard voltage of wall outlets is 120 volts—a dangerous voltage. An electric clothes dryer is usually wired at 240 volts—a very dangerous voltage.

Current

The flow of electrons can be compared to the flow of water. The water current is the number of molecules of water flowing past a fixed point; electrical current is the number of electrons flowing past a fixed point. **Electrical current (I)** is defined as electrons flowing between two points having a difference in voltage. Current is measured in **amperes** or **amps (A)**. One ampere is 6.25×10^{18} electrons per second passing through a circuit. With water, as the diameter of the pipe increases, so does the amount of water that can flow through it. With electricity, conducting wires take the place of the pipe. As the cross-sectional area of the wire increases, so does the amount of electric current (number of electrons) that can flow through it.

Resistance

Resistance (R) is a property that slows the flow of electrons. Using the water analogy, resistance is anything that slows water flow, such as a smaller pipe or fins on the inside of a pipe. In electrical terms, the resistance of the conducting wire depends on the properties of the metal used to make the wire and the wire's diameter. Copper, aluminum, and silver—metals used in conducting wires—have different resistance. Resistance is measured in units called **ohms (□)**. There are devices called **resistors**, with set resistances, that can be placed in circuits to reduce or control the current flow. Any device placed in a circuit to do work is called a **load**. The light bulb in a flashlight is a load. A television plugged into a wall outlet is also a load. Every load has resistance.

Ohm's Law

George Ohm, a German physicist, discovered that in many materials, especially metals, the current that flows through a material is proportional to the voltage.

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 primary sources of energy, such as coal or wind, to make electricity. It also means we can't classify electricity as a renewable or nonrenewable form of energy. 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 typically use coal, nuclear fission, natural gas, or other energy sources to superheat water into steam in a boiler. The very high pressure of the steam (it's 75 to 100 times normal atmospheric pressure) turns the blades of a turbine. (A **turbine** turns the linear motion of the steam into circular motion.) 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 producing an **electric current**. The steam, which is still very hot but at normal pressure, is piped 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. Power plants can capture some of the heat from the cooling steam. In old plants, the heat was simply wasted.

Moving Electricity

We are using more and more electricity every year. One reason that electricity is used by so many consumers is that it's easy to move 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 a power plant to a light bulb in your home.

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 in fenced-in areas that contain the switches, transformers, and other electrical equipment. Electricity is then carried over distribution lines that bring electricity to your home. 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 house, 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 home. 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.

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.

NON-RENEWABLES:

COAL

What is Coal?

Coal is a fossil fuel created from the remains of plants that lived and died about 100 to 400 million years ago when parts of the earth were covered with huge swampy forests. Coal is classified as a nonrenewable energy source because it takes millions of years to form.

The energy we get from coal today comes from the energy that plants absorbed from the sun millions of years ago. All living plants store solar energy through a process known as photosynthesis. When plants die, this energy is usually released as the plants decay. Under conditions favorable to coal formation, however, the decay process is interrupted, preventing the release of the stored solar energy. The energy is locked into the coal.

Millions of years ago, dead plant matter fell into swampy water and over the years, a thick layer of dead plants lay decaying at the bottom of the swamps. Over time, the surface and climate of the earth changed, and more water and dirt washed in, halting the decay process. The weight of the top layers of water and dirt packed down the lower layers of plant matter. Under heat and pressure, this plant matter underwent chemical and physical changes, pushing out oxygen and leaving rich hydrocarbon deposits. What once had been plants gradually turned into coal.

Seams of coal—ranging in thickness from a fraction of an inch to hundreds of feet—may represent hundreds or thousands of years of plant growth. One seam, the seven-foot thick Pittsburgh seam, may represent 2,000 years of rapid plant growth. One acre of this seam contains about 14,000 tons of coal.

History of Coal

North American Indians used coal long before the first settlers arrived in the New World. Hopi Indians, who lived in what is now Arizona, used coal to bake the pottery they made from clay. European settlers discovered coal in North America during the first half of the 1600s. They used very little at first. Instead, they relied on water wheels and wood to power colonial industries.

Coal became a powerhouse by the 1800s. People used coal to manufacture goods and to power steamships and railroad engines. By the American Civil War, people also used coal to make iron and steel. And by the end of the 1800s, people even used coal to make electricity.

When America entered the 1900s, coal was the energy mainstay for the nation's businesses and industries. Coal stayed America's number one energy source until the demand for petroleum products pushed petroleum to the front. Automobiles needed gasoline. Trains switched from coal power to diesel fuel. Even homes that used to be heated by coal turned to oil or gas furnaces instead.

Coal production reached its low point in the early 1950s. Since 1973, coal production has increased by more than 80 percent, reaching record highs in 1998. Today, coal supplies 32 percent of the nation's total energy needs, mostly for electricity production.

Coal Mining

There are two ways to remove coal from the ground—surface and underground mining. **Surface mining** is used when a coal seam is relatively close to the surface, usually within 200 feet. The first step in surface mining is to remove and store the soil and rock covering the coal, called the **overburden.** Workers use a variety of equipment—draglines, power shovels, bulldozers, and front-end loaders—to expose the coal seam for mining. After surface mining, workers replace the overburden, grade it, cover it with topsoil, and fertilize and seed the area. This land **reclamation** is required by law and helps restore the biological balance of the area and prevent erosion. The land can then be used for croplands, wildlife habitats, recreation, or as sites for commercial development.

Natural Gas

What Is Natural Gas?

Natural gas is generally considered a nonrenewable fossil fuel. *(There are some renewable sources of methane, the main ingredient in natural gas, also discussed in this factsheet.)* Natural gas is considered a fossil fuel because most scientists believe that natural gas was formed from the remains of tiny sea animals and plants that died 200-400 million years ago.

When these tiny sea animals and plants died, they sank to the bottom of the oceans where they were buried by layers of sediment that turned into rock. Over the years, the layers of sedimentary rock became thousands of feet thick, subjecting the energy-rich plant and animal remains to enormous pressure. Most scientists believe that the pressure, combined with the heat of the earth, changed this organic mixture into petroleum and natural gas. Eventually, concentrations of natural gas became trapped in the rock layers like a wet sponge traps water.

Raw natural gas is a mixture of different gases. The main ingredient is methane, a natural compound that is formed whenever plant and animal matter decays. By itself, methane is odorless, colorless, and tasteless. As a safety measure, natural gas companies add a chemical odorant called **mercaptan** (it smells like rotten eggs) so escaping gas can be detected. Natural gas should not be confused with gasoline, which is made from petroleum.

History of Natural Gas

The ancient peoples of Greece, Persia, and India discovered natural gas many centuries ago. The people were mystified by the burning springs created when natural gas seeping from cracks in the ground was ignited by lightning. They sometimes built temples around these eternal flames so they could worship the mysterious fire.

About 2,500 years ago, the Chinese recognized that natural gas could be put to work. The Chinese piped the gas from shallow wells and burned it under large pans to evaporate seawater for the salt.

Natural gas was first used in America in 1816 to illuminate the streets of Baltimore with gas lamps. Lamplighters walked the streets at dusk to light the lamps.

Soon after, in 1821, William Hart dug the first successful American natural gas well in Fredonia, New York. His well was 27 feet deep, quite shallow compared to today's wells. The Fredonia Gas Light Company opened its doors in 1858 as the nation's first natural gas company.

By 1900, natural gas had been discovered in 17 states. In the past 40 years, the use of natural gas has grown. Today, natural gas accounts for 23.5 percent of the energy we use.

Producing Natural Gas

Natural gas can be hard to find since it is usually trapped in porous rocks deep underground. Geologists use many methods to find natural gas deposits. They may look at surface rocks to find clues about underground formations. They may set off small explosions or drop heavy weights on the earth's surface and record the sound waves as they bounce back from the sedimentary rock layers underground. They also may measure the gravitational pull of rock masses deep within the earth.

If test results are promising, the scientists may recommend drilling to find the natural gas deposits. Natural gas wells average 6,100 feet deep and can cost hundreds of dollars per foot to drill, so it's important to choose sites carefully.

Only about 48 percent of the exploratory wells produce gas. The others come up dry. The odds are better for developmental wells—wells drilled on known gas fields. On average, 85 percent of the developmental wells yield gas. Natural gas can be found in pockets by itself or in petroleum deposits.

After natural gas comes out of the ground, it goes to a processing plant where it is cleaned of impurities and separated into its various components. Approximately 90 percent of natural gas is composed of methane, but it also contains other gases such as propane and butane.

Propane

What is Propane?

Propane is a gas derived from natural gas and petroleum. It is found mixed with natural gas and petroleum deposits. Propane is called a **fossil fuel** because it was formed millions of years ago from the remains of tiny sea animals and plants. When the plants and animals died, they sank to the bottom of the oceans and were buried by layers of sediment and sand that turned into rock. Over time, the layers became thousands of feet thick.

The layers were subjected to enormous heat and pressure, changing the energy-rich remains into petroleum and natural gas deposits. Eventually, pockets of these fossil fuels became trapped in rocks, much as a wet sponge holds water.

Propane is one of the many fossil fuels included in the **liquefied petroleum (LP)** gas family. Because propane is the type of LP-gas most commonly used in the United States, propane and LP-gas are often used synonymously. Butane is another LP-gas often used in lighters. The chemical formula for propane is C_3H_8.

Just as water can change its physical state and become a liquid or a gas (steam vapor), so can propane. Under normal atmospheric pressure and temperature, propane is a gas. Under moderate pressure and/or lower temperatures, however, propane changes into a liquid. Propane is easily stored as a liquid in pressurized tanks. Think of the small tanks you see attached to a gas barbecue grill, for example.

Propane takes up much less space in its liquid form. It is 270 times more compact in its liquid state than it is as a gas. A thousand-gallon tank holding gaseous propane would provide a family enough cooking fuel for one week. A thousand-gallon tank holding liquid propane would provide enough cooking fuel for more than five years!

When propane vapor (gas) is drawn from a tank, some of the liquid in the tank instantly vaporizes to replace the vapor that was removed. Propane is nicknamed the portable gas because it is easier to store and transport than natural gas, which requires pipelines.

Like natural gas, propane is colorless and odorless. An odorant called mercaptan is added to propane (as it is to natural gas) to serve as a warning agent for escaping gas. And, like all fossil fuels, propane is a **nonrenewable** energy source. We can't make more propane in a short period of time.

History of Propane

Propane does not have a long history. It wasn't discovered until 1912 when people were trying to find a way to store gasoline. The problem with gasoline was that it evaporated when stored under normal conditions.

Dr. Walter Snelling, directing a series of experiments for the U.S. Bureau of Mines, discovered that several evaporating gases could be changed into liquids and stored at moderate pressure. The most plentiful of those gases was propane. Dr. Snelling developed a way to bottle the liquid gas. One year later, the propane industry began heating American homes. By 1915, propane was being used in torches to cut through metal.

Producing Propane

Propane comes from natural gas and petroleum wells. Forty-five percent of the propane used in the United States is extracted from raw natural gas. Raw natural gas contains about 90 percent methane, five percent propane, and five percent other gases. The propane is separated from the raw natural gas and the other gases at a natural gas processing plant. Forty-five percent of the propane is extracted from crude petroleum. Petroleum is separated into its various products at a processing plant called a refinery. The other ten percent of the propane we use in the U.S. is imported from other countries, mostly from Canada and Mexico.

Petroleum

What Is Petroleum?

Petroleum is a **fossil fuel**. It is called a fossil fuel because it was formed from the remains of tiny sea plants and animals that died millions of years ago. When the plants and animals died, they sank to the bottom of the oceans. They were buried by thousands of feet of sediment and sand that turned into rock.

Over time, this organic mixture was subjected to enormous pressure and heat as the layers increased. The mixture changed chemically, breaking down into compounds made of hydrogen and carbon atoms—hydrocarbons. Finally, an oil-saturated rock—much like a wet household sponge—was formed.

All organic material buried underground does not turn into oil; certain geological conditions must exist within the rock formations. First, there must be a trap of non-porous rock that prevents the material from seeping out, and a seal (such as salt or clay) to keep the material from rising to the surface. Even under these conditions, only about two percent of the organic material is transformed into oil.

A typical petroleum reservoir is mostly sandstone or limestone in which oil is trapped. The oil in it may be as thin as gasoline or as thick as tar. It may be almost clear or black. Petroleum is called a **nonrenewable** energy source because it takes millions of years to form. We cannot make more oil in a short time.

History of Oil

People have used naturally available crude oil for thousands of years; the ancient Chinese and Egyptians, for example, burned oil to produce light.

Before the 1850s, Americans often used whale oil for light. When whale oil became scarce, people began looking for other oil sources. In some places, oil seeped naturally to the surface of ponds and streams. People skimmed this oil and made it into kerosene. Kerosene was commonly used to light America's homes before the arrival of the electric light bulb.

As demand for kerosene grew, a group of businessmen hired Edwin Drake to drill for oil in Titusville, Pennsylvania. After much hard work and slow progress, he discovered oil in 1859. Drake's well was 69.5 feet deep, very shallow compared to today's wells.

Drake refined the oil from his well into kerosene for lighting. Gasoline and other products made during refining were simply thrown away because people had no use for them.

In 1892, the horseless carriage, or automobile, solved this problem since it required gasoline. By 1920, there were nine million motor vehicles in this country and gas stations were opening everywhere.

Producing Oil

Although research has improved the odds since Edwin Drake's days, petroleum exploration today is still a risky business. Geologists study underground rock formations to find areas that might yield oil. Even with advanced methods, only about 44 of every 100 exploratory wells find oil, and only 10 of those are profitable.

When the potential for oil production is found on shore, a petroleum company brings in a 50 to 100-foot drilling rig and raises a **derrick** that houses the drilling tools. Today's oil wells average 6,000 feet deep and may sink below 20,000 feet. The average well produces about 11 barrels of oil a day.

To safeguard the environment, oil drilling and oil production are regulated by state and federal governments. Oil companies must get permission to explore for oil on new lands. Many experts believe that 85 percent of our remaining oil reserves are on land owned by the federal government. Oil companies lease the land from the federal government, which, in return, receives rental payments for the mineral rights as well as percentage payments from each barrel of oil.

Texas produces more oil than any other state. The other top producing states are Alaska, California, Louisiana, New Mexico, and Oklahoma. In all, 31 states produce petroleum.

Uranium

What is Uranium?

Uranium is the heaviest of the 92 naturally occurring elements and is classified as a metal. It is the fuel used by nuclear power plants for fissioning.

It is also one of the few elements that is easily fissioned. Uranium was formed when the earth was created and is found in rocks all over the world. Rocks that contain a lot of uranium are called uranium ore, or pitch-blende. Uranium, although abundant, is a **nonrenewable** energy source.

Two forms (isotopes) of uranium are found in nature, uranium-235 and uranium-238. These numbers refer to the number of neutrons and protons in each atom. Uranium-235 is the form commonly used for energy production because, unlike uranium-238, the nucleus splits easily when bombarded by a neutron. During fission, the uranium-235 atom absorbs a bombarding neutron, causing its nucleus to split apart into two atoms of lighter weight.

At the same time, the fission reaction releases energy as heat and radiation, as well as releasing more neutrons. The newly released neutrons go on to bombard other uranium atoms, and the process repeats itself over and over. This is called a chain reaction.

What is Nuclear Energy?

Nuclear energy is energy that comes from the nucleus (core) of an atom. Atoms are the particles that make up all objects in the universe. Atoms consist of neutrons, protons, and electrons.

Nuclear energy is released from an atom through one of two processes: **nuclear fusion** or **nuclear fission**. In nuclear fusion, energy is released when the nuclei of atoms are combined or fused together. This is how the sun produces energy. In nuclear fission, energy is released when the nuclei of atoms are split apart. Nuclear fission is the only method currently used by nuclear plants to generate electricity.

History of Nuclear Energy

Compared to other energy sources, nuclear energy is a very new way to produce energy. It wasn't until the early 1930s that scientists discovered that the nucleus of an atom is made up of protons and neutrons. Then in 1938, two German scientists split the nucleus of the atom apart by bombarding it with a neutron—a process called fission. Soon after, a Hungarian scientist discovered the chain reaction and its ability to produce enormous amounts of energy.

Under the dark cloud of World War II, nuclear fission was first used to make a bomb. After the war, nuclear fission was developed for generating electricity.

The first nuclear power plant came online in Shippingport, Pennsylvania in 1957. Since then, the industry has experienced dramatic shifts in fortune. Through the mid 1960s, government and industry experimented with demonstration and small commercial plants. A period of rapid expansion followed between 1965 and 1975. No new plants, however, were ordered after the 1970s until recently, as a result of public opposition, as well as building costs, problems with siting a waste repository, and lower demand for power. Today, there is renewed interest in nuclear power to meet future demand for electricity and plans for new plants are underway.

The Nuclear Fuel Cycle

The steps—from mining the uranium ore, through its use in a nuclear reactor, to its disposal—are called the nuclear fuel cycle.

RENEWABLES:

Solar

What is Solar Energy?

Solar energy is radiant energy that is produced by the sun. Every day the sun radiates, or sends out, an enormous amount of energy. The sun radiates more energy in one second than people have used since the beginning of time!

Where does the energy come from that constantly radiates from the sun? It comes from within the sun itself. Like other stars, the sun is a big ball of gases—mostly hydrogen and helium atoms. The hydrogen atoms in the sun's core combine to form helium and generate energy in a process called **nuclear fusion**.

During nuclear fusion, the sun's extremely high pressure and temperature cause hydrogen atoms to come part and their nuclei (the central cores of the atoms) to fuse or combine. Four hydrogen nuclei fuse to become one helium atom. But the helium atom contains less mass than the four hydrogen atoms that fused. Some matter is lost during nuclear fusion. The lost matter is emitted into space as radiant energy.

It takes millions of years for the energy in the sun's core to make its way to the solar surface, and then just a little over eight minutes to travel the 93 million miles to earth. The solar energy travels to the earth at a speed of 186,000 miles per second—the speed of light.

Only a small portion of the energy radiated by the sun into space strikes the earth, one part in two billion. Yet this amount of energy is enormous. Every day enough energy strikes the United States to supply the nation's energy needs for one and a half years!

Where does all this energy go? About 15 percent of the sun's energy that hits the earth is reflected back into space. Another 30 percent is used to evaporate water, which, lifted into the atmosphere, produces rainfall. Solar energy also is absorbed by plants, the land, and the oceans. The rest could be used to supply our energy needs.

History of Solar Energy

People have harnessed solar energy for centuries. As early as the 7th century B.C., people used simple magnifying glasses to concentrate the light of the sun into beams so hot they would cause wood to catch fire. More than 100 years ago in France, a scientist used heat from a solar collector to make steam to drive a steam engine. In the beginning of this century, scientists and engineers began researching ways to use solar energy in earnest. One important development was a remarkably efficient solar boiler invented by Charles Greeley Abbott, an American astrophysicist, in 1936.

The solar water heater gained popularity at this time in Florida, California, and the Southwest. The industry started in the early 1920s and was in full swing just before World War II. This growth lasted until the mid-1950s when low-cost natural gas became the primary fuel for heating American homes.

The public and world governments remained largely indifferent to the possibilities of solar energy until the oil shortages of the 1970s. Today, people use solar energy to heat buildings and water and to generate electricity.

Solar Collectors

Heating with solar energy is not as easy as you might think. Capturing sunlight and putting it to work is difficult because the solar energy that reaches the earth is spread out over such a large area. The sun does not deliver that much energy to any one place at any one time. How much solar energy a place receives depends on several conditions. These include the time of day, the season of the year, the latitude of the area, and the clearness or cloudiness of the sky. A solar collector is one way to collect heat from the sun. A closed car on a sunny day is like a solar collector. As sunlight passes through the car's glass windows, it is absorbed by the seat covers, walls, and floor of the car.

Wind

What Is Wind?

Wind is simply air in motion. It is produced by the uneven heating of the earth's surface by energy from the sun. Since the earth's surface is made of very different types of land and water, it absorbs the sun's radiant energy at different rates. Much of this energy is converted into heat as it is absorbed by land areas, bodies of water, and the air over these formations.

On the coast, for example, the land heats up more quickly than the water. The warm air over the land expands and rises, and the heavier, cooler air over the water rushes in to take its place, creating winds. In the same way, the large atmospheric winds that circle the earth are produced because the earth's surface near the equator receives more of the sun's energy than the surface near the North and South Poles.

Similarly, the large atmospheric winds that circle the earth are created because the surface air near the equator is warmed more by the sun than the air over the North and South Poles.

Wind is called a **renewable** energy source because wind will continually be produced as long as the sun shines on the earth. Today, wind energy is mainly used to generate electricity.

The History of Wind

Throughout history, people have harnessed the wind in many ways. Over 5,000 years ago, the ancient Egyptians used wind power to sail their ships on the Nile River. Later, people built windmills to grind their grain. The earliest known windmills were in Persia (Iran). These early windmills looked like large paddle wheels.

Centuries later, the people of Holland improved the basic design of the windmill. They gave it propeller-type blades made of fabric sails and invented ways for it to change direction so that it could continually face the wind. Windmills helped Holland become one of the world's most industrialized countries by the 17th century.

American colonists used windmills to grind wheat and corn, pump water, and cut wood. As late as the 1920s, Americans used small windmills to generate electricity in rural areas without electric service. When power lines began to transport electricity to rural areas in the 1930s, local windmills were used less and less, though they can still be seen on some Western ranches.

The oil shortages of the 1970s changed the energy picture for the country and the world. It created an environment more open to alternative energy sources, paving the way for the re-entry of the windmill into the American landscape to generate electricity.

Monitoring Wind Direction

A weather vane, or wind vane, is a device used to monitor the direction of the wind. It is usually a rotating, arrow-shaped instrument mounted on a shaft high in the air. It is designed to point in the direction of the source of the wind.

Wind direction is reported as the direction ***from which the wind blows***, not the direction toward which the wind moves. A north wind blows from the north, toward the south.

Wind Velocity

It is important to know how fast the wind is blowing. Wind speed is important because the amount of electricity that wind turbines can generate is determined in large part by wind speed, or *velocity*. A doubling of wind velocity from the low range to optimal range of a turbine can result in eight times the amount of power produced. This is a huge difference and helps wind companies decide where to site wind turbines.

Wind speed can be measured with wind gauges and **anemometers**.

One type of anemometer is a device with three arms that spin on top of a shaft. Each arm has a cup on its end. The cups catch the wind and spin the shaft. The harder the wind blows, the faster the shaft spins.

Hydropower

What is Hydropower?

Hydropower (from “hydro” meaning water) is energy that comes from the force of moving water. The fall and movement of water is part of a continuous natural cycle called the water cycle.

Energy from the sun evaporates water in the earth’s oceans and rivers and draws it upward as water vapor. When the water vapor reaches the cooler air in the atmosphere, it condenses and forms clouds. The moisture eventually falls to the earth as rain or snow, replenishing the water in the oceans and rivers. Gravity drives the water, moving it from high ground to low ground. The force of moving water can be extremely powerful.

Hydropower is called a **renewable** energy source because the water on the earth is continuously replenished by precipitation. As long as the water cycle continues, we won’t run out of this energy source.

History of Hydropower

Hydropower has been used for centuries. The Greeks used water wheels to grind wheat into flour more than 2,000 years ago. In the early 1800s, American and European factories used the water wheel to power machines. The water wheel is a simple machine. The water wheel is located below a source of flowing water. It captures the water in buckets attached to the wheel and the weight of the water causes the wheel to turn. Water wheels convert the potential energy (gravitational energy) of the water into motion. That energy can then be used to grind grain, drive sawmills, or pump water.

In the late 19th century, the force of falling water was used to generate electricity. The first hydroelectric power plant was built at Niagara Falls in 1879. In the following decades, many more hydroelectric plants were built. At its height in the early 1940s, hydropower provided 33 percent of this country’s electricity.

By the late 1940s, the best sites for big dams had been developed. Inexpensive fossil fuel plants also entered the picture. At that time, plants burning coal or oil could make electricity more cheaply than hydro plants. Soon they began to underprice the smaller hydroelectric plants. It wasn’t until the oil shocks of the 1970s that people showed a renewed interest in hydropower.

Hydro Dams

It’s easier to build a hydro plant where there is a natural waterfall. That’s why the first hydro plant was built at Niagara Falls. Dams, which are artificial waterfalls, are the next best way.

Dams are built on rivers where the terrain will produce an artificial lake or **reservoir** above the dam. Today there are about 80,000 dams in the United States, but only three percent (2,000) have power-generating hydro plants. Most dams are built for flood control and irrigation, not electric power generation.

A dam serves two purposes at a hydro plant. First, a dam increases the **head** or height of the water. Second, it controls the flow of water. Dams release water when it is needed for electricity production. Special gates called **spillway gates** release excess water from the reservoir during heavy rainfalls.

Hydropower Plants

As people discovered centuries ago, the flow of water represents a huge supply of kinetic energy that can be put to work. Water wheels are useful for generating mechanical energy to grind grain or saw wood, but they are not practical for generating electricity. Water wheels are too bulky and slow.

Hydroelectric plants are different. They use modern turbine generators to produce electricity, just as thermal (coal, oil, nuclear) power plants do, except that they do not produce heat to spin the turbines.

Geothermal

What is Geothermal Energy?

Geothermal energy comes from the heat within the earth. The word geothermal comes from the Greek words *geo*, meaning *earth*, and *therme*, meaning *heat*. People around the world use geothermal energy to produce electricity, to heat homes and buildings, and provide hot water for a variety of uses.

The earth's core lies almost 4,000 miles beneath the earth's surface. The double-layered core is made up of very hot molten iron surrounding a solid iron center. Estimates of the temperature of the core range from 5,000 to 11,000 degrees Fahrenheit.

Surrounding the earth's core is the mantle, thought to be partly rock and partly magma. The mantle is about 1,800 miles thick. The outermost layer of the earth, the insulating crust, is not one continuous sheet of rock, like the shell of an egg, but is broken into pieces called plates. These slabs of continents and ocean floor drift apart and push against each other at the rate of about one inch per year in a process called **plate tectonics**. This process can cause the crust to become faulted (cracked), fractured or thinned, allowing plumes of magma to rise up into the crust.

This magma can reach the surface and form volcanoes, but most remains underground where it can underlie regions as large as huge mountain ranges. The magma can take from 1,000 to 1,000,000 years to cool as its heat is transferred to surrounding rocks. In areas where there is underground water, the magma can fill rock fractures and porous rocks. The water becomes heated and can circulate back to the surface to create hot springs, mud pots and fumaroles, or it can become trapped underground, forming deep geothermal reservoirs.

Geothermal energy is called a **renewable** energy source because the water is replenished by rainfall, and the heat is continuously produced within the earth by the slow decay of radioactive particles that occurs naturally in all rocks.

History and Uses of Geothermal Energy

Many ancient peoples, including the Romans, Chinese, and Native Americans, used hot mineral springs for bathing, cooking, and heating. Water from hot springs is now used worldwide in spas, for heating buildings, and for agricultural and industrial uses. Many people believe hot mineral springs have natural healing powers.

Today, we drill wells into geothermal reservoirs deep underground and use the steam and heat to drive turbines in electric power plants. The hot water is also used directly to heat buildings, to increase the growth rate of fish in hatcheries and crops in greenhouses, to pasteurize milk, to dry foods products and lumber, and for mineral baths.

Where is Geothermal Energy Found?

Geologists use many methods to find geothermal reservoirs. They study aerial photographs and geological maps. They analyze the chemistry of local water sources and the concentration of metals in the soil. They may measure variations in gravity and magnetic fields. Yet the only way they can be sure there is a geothermal reservoir is by drilling an exploratory well.

The hottest geothermal regions are found along major plate boundaries where earthquakes and volcanoes are concentrated. Most of the world's geothermal activity occurs in an area known as the **Ring of Fire**, which rims the Pacific Ocean and is bounded by Indonesia, the Philippines, Japan, the Aleutian Islands, North America, Central America, and South America.

High Temperature: Producing Electricity

When geothermal reservoirs are located near the surface, we can reach them by drilling wells. Some wells are more than two miles deep. Exploratory wells are drilled to search for reservoirs. Once a reservoir has been found, production wells are drilled.

Biomass

What is Biomass?

Biomass is any organic matter—wood, crops, seaweed, animal wastes—that can be used as an energy source. Biomass is probably our oldest source of energy after the sun. For thousands of years, people have burned wood to heat their homes and cook their food.

Biomass gets its energy from the sun. All organic matter contains stored energy from the sun. During a process called photosynthesis, sunlight gives plants the energy they need to convert water and carbon dioxide into oxygen and sugars. These sugars, called **carbohydrates**, supply plants and the animals that eat plants with energy. Foods rich in carbohydrates are a good source of energy for the human body!

Biomass is a **renewable** energy source because its supplies are not limited. We can always grow trees and crops, and waste will always exist.

Types of Biomass

We use four types of biomass today—wood and agricultural products, solid waste, landfill gas and biogas, and alcohol fuels.

Wood and Agricultural Biomass

Most biomass used today is homegrown energy. Wood—logs, chips, bark, and sawdust—accounts for about 53 percent of biomass energy. But any organic matter can produce biomass energy. Other biomass sources include agricultural waste products like fruit pits and corncobs.

Wood and wood waste, along with agricultural waste, are used to generate electricity. Much of the electricity issued by the industries making the waste; it is not distributed by utilities, it is **co-generated.** Paper mills and saw mills use much of their waste products to generate steam and electricity for their use. However, since they use so much energy, they need to buy additional electricity from utilities.

Increasingly, timber companies and companies involved with wood products are seeing the benefits of using their lumber scrap and sawdust for power generation. This saves disposal costs and in some areas, may reduce the companies' utility bills. In fact, the pulp and paper industries rely on biomass to meet half of their energy needs. Other industries that use biomass include lumber producers, furniture manufacturers, agricultural businesses like nut and rice growers, and liquor producers.

Solid Waste

Burning trash turns waste into a usable form of energy. One ton (2,000 pounds) of garbage contains about as much heat energy as 500 pounds of coal. Garbage is not all biomass; perhaps half of its energy content comes from plastics, which are made from petroleum and natural gas.

Power plants that burn garbage for energy are called **waste-to-energy plants**. These plants generate electricity much as coal-fired plants do, except that combustible garbage—not coal—is the fuel used to fire their boilers. Making electricity from garbage costs more than making it from coal and other energy sources. The main advantage of burning solid waste is that it reduces the amount of garbage dumped in landfills by 60 to 90 percent, which in turn reduces the cost of landfill disposal. It also makes use of the energy in the garbage, rather than burying it in a landfill, where it remains unused.

Landfill Gas

Bacteria and fungi are not picky eaters. They eat dead plants and animals, causing them to rot or decay. A fungus on a rotting log is converting **cellulose** to sugars to feed itself. Although this process is slowed in a landfill, a substance called **methane gas** is still produced as the waste decays.

New regulations require landfills to collect methane gas for safety and environmental reasons. Methane gas is colorless and odorless, but it is not harmless. The gas can cause fires or explosions if it seeps into nearby homes and is ignited. Landfills can collect the methane gas, purify it, and use it as fuel.

Methane, the main ingredient in natural gas, is a good energy source. Most gas furnaces and stoves use methane supplied by utility companies. East Kentucky Power Cooperative began this in 2003.

Efficiency & Conservation

Introduction

The United States uses a lot of energy—a million dollars worth of energy each minute, 24 hours a day, every day of the year. With less than five percent of the world's population, we consume almost one quarter (24 percent) of the world's energy resources. We are not alone among industrialized nations; 16 percent of the world's population consumes 80 percent of its natural resources.

The average American consumes six times the world average per capita consumption of energy. Every time we fill up our vehicles or open our utility bills, we are reminded of the economic impacts of energy.

Energy Efficiency & Conservation

Energy is more than numbers on a utility bill; it is the foundation of everything we do. All of us use energy every day—for transportation, cooking, heating and cooling rooms, manufacturing, lighting, water-use, and entertainment. We rely on energy to make our lives comfortable, productive, and enjoyable. Sustaining this quality of life requires that we use our energy resources wisely. The careful management of resources includes reducing total energy use and using energy more efficiently.

The choices we make about how we use energy—turning machines off when not in use or choosing to buy energy efficient appliances—will have increasing impacts on the quality of our environment and lives. There are many things we can do to use less energy and use it more wisely. These things involve energy conservation and energy efficiency. Many people use these terms interchangeably; however, they have different meanings.

Energy conservation includes any behavior that results in the use of less energy. **Energy efficiency** involves the use of technology that requires less energy to perform the same function. A compact fluorescent light bulb that uses less energy to produce the same amount of light as an incandescent light bulb is an example of energy efficiency. The decision to replace an incandescent light bulb with a compact fluorescent is an example of energy conservation.

The U.S. Department of Energy divides the way we use energy into three categories—residential and commercial, industrial, and transportation. As individuals, our energy choices and actions can result in a significant reduction in the amount of energy used in all three sectors of the economy.

Residential/Commercial

Households use about one-fifth of the total energy consumed in the United States each year. The typical U.S. family spends over $1,900 a year on utility bills. About 65 percent is in the form of electricity; the remainder is mostly natural gas and oil.

Much of this energy is not put to use. Heat, for example, pours out of homes through doors and windows and under-insulated attics, walls, floors, and basements. Some idle appliances use energy 24 hours a day. The amount of energy lost through poorly insulated windows and doors equals the amount of energy flowing through the Alaskan oil pipeline each year.

Energy-efficient improvements cannot only make a home more comfortable, they can yield long-term financial rewards. Many utility companies and energy efficiency organizations provide energy audits to identify areas where homes are poorly insulated or energy inefficient. This service may be free or at low cost.

Household operations account for 35 percent of the greenhouse gas emissions that contribute to global climate change and 32 percent of the common air polluting emissions. The average home contributes up to two times as much carbon dioxide as the average automobile. Using a few inexpensive energy-efficient measures can reduce the average energy bill by 10 to 50 percent and, at the same time, reduce air pollution.

Energy Consumption

Residential/Commercial

The residential and commercial sector—homes and buildings—consumes 40.5 percent of the energy used in the United States today. We use 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.

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 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 manufactured 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. **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.

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 11.1, and high-efficiency 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.

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.

Saving Energy on Heating and Cooling

The four 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. A certified technician should service systems annually, and filters should be cleaned or replaced on a regular schedule by the homeowner.

Global Climate Change

Earth's Atmosphere

Our earth is surrounded by layers of gases called the atmosphere. Without these gases in the atmosphere, the 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 comprised of oxygen and nitrogen gases. Less than one percent is a mixture of **heat-trapping gases**. These heat-trapping gases are mostly water vapor, mixed with carbon dioxide, methane, CFCs, ozone, and nitrous oxide.

Carbon dioxide is the gas that is produced when we breathe, and when we burn biomass and fossil fuels. Methane is the main gas in natural gas—a fossil fuel. Methane is also found in oil and coal deposits, in magma, and in offshore methane hydrate formations. Methane is released into the atmosphere through natural processes such as volcanic eruptions, as well as during oil drilling and coal mining. Methane is also produced when plants and animals decay.

The other heat-trapping gases (ozone, CFCs and nitrous oxide) are produced when fuels are burned, as by-products of manufacturing processes, 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 and are turned into thermal energy (heat).

About half of the radiant energy passes through the atmosphere and reaches the earth. When the sunlight hits the earth, most of it is converted into heat. The earth absorbs some of this heat; the rest flows back out toward the atmosphere. This outward flow of heat keeps the earth from getting too warm.

When this out-flowing heat reaches the atmosphere, most of it is absorbed. It can't pass through the atmosphere as readily as sunlight. Most of the heat becomes trapped and flows back again toward the earth. Most people think it's sunlight that heats the earth, but actually it's this contained heat that provides most of the warmth.

The Greenhouse Effect

We call this trapping of heat by the atmosphere the **greenhouse effect**. A greenhouse is a building made of clear glass or plastic in which we can grow plants in cold weather. The glass allows the sunlight to pass through, where it turns into heat when it hits objects inside. The heat becomes trapped. The radiant energy can pass through the glass; the thermal energy cannot.

What is in the atmosphere that allows radiant energy to pass through but traps thermal energy? It is the presence of greenhouse gases—mostly carbon dioxide and methane. These gases are very good at absorbing heat in the atmosphere, where it can flow back toward earth.

According to studies conducted by NASA and many other researchers around the world, the concentration of carbon dioxide has increased by about 25 percent since the Industrial Revolution in the early 19th century. Climate change experts have concluded that this increase is due in large part to the expanding use of fossil fuels.

In addition to the increase in the level of carbon dioxide, there has also been a substantial rise in the amount of methane in the atmosphere. While there is much less methane in the atmosphere than carbon dioxide, it is many times more efficient than carbon dioxide at trapping heat. However, it does not remain intact as long in the atmosphere.

Global Climate Change

Increased levels of greenhouse gases are trapping more heat in the atmosphere. This phenomenon is called **global climate change** or **global warming**. According to NASA, the National Air and Space

Agency, the average temperature of the earth has risen by 1.4°F since the Industrial Revolution. This increase in average temperature has been the major cause of a 4–8 inch rise in sea level over that time period, as well as an increase in extreme precipitation events. Sea levels are rising because land-based ice is melting in the Arctic and Antarctic and in glaciers. Regions such as the Gulf Coast of the United States and several Pacific islands have already experienced losses to their coastlines. Recent research has also linked the increased severity of hurricanes and typhoons to global warming.

Climate scientists use sophisticated computer models to make predictions about the future effects of climate change. Because of the increased level of carbon dioxide and other greenhouse gases already in the atmosphere, NASA has determined that the earth will experience at least another 2°F temperature increase by the end of the century. The climate models predict more floods in some places and droughts in others, along with more extreme weather, such as powerful storms and hurricanes. They predict an additional rise in sea level of up to one foot, which would lead to the loss of low–lying coastal areas.

These predictions have lead many scientists to call for all countries to act now to lower the amount of carbon dioxide they emit into the atmosphere. Countries around the world are working to determine ways to lower the levels of carbon dioxide in the atmosphere while minimizing negative impacts on the global economy.

Kyoto Protocol

In December 1997 in Kyoto, Japan, representatives from countries around the world agreed upon a landmark treaty to reduce greenhouse gas emissions. In November 1998, the global community met again, in Buenos Aires, Argentina to discuss implementation of the Kyoto Treaty. Representatives of more than 160 countries agreed upon deadlines and an action plan for implementing the treaty.

The Kyoto Treaty was signed by the United States on November 12, 1998, but still must be ratified by the U.S. Senate and signed by the president before it becomes law. President Bush did not approve the treaty because it does not include limits on emissions for developing countries such as China, which will soon surpass the United States as the world's leading emitter of greenhouse gases.

In 2005, seven Northeastern and Mid-Atlantic states— Connecticut, Delaware, Maine, New Hampshire, New Jersey, New York, and Vermont—announced an agreement to implement the Regional Greenhouse Gas Initiative. These states are developing a set of regulations and incentives designed to decrease greenhouse gas emissions. Meanwhile, California adopted the most stringent greenhouse gas regulations in the country. Recently, Massachusetts, Oregon, and Washington passed regulations based on the California model. In 2009, the United States Congress began debate on a National Climate bill.

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