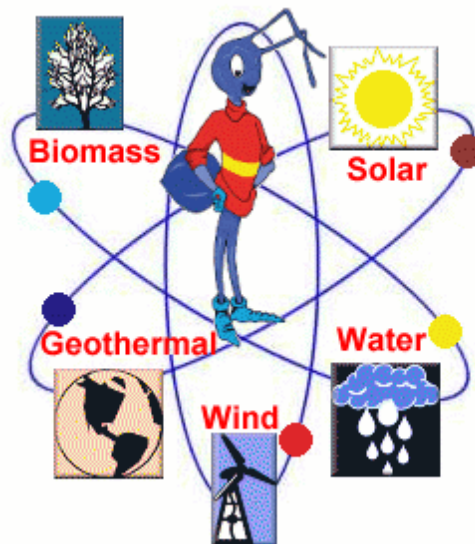


## Objective 5 Sources of Energy

Investigate and compare the economic and environmental impact of using various energy sources such as rechargeable or disposable batteries and energy cells

**Renewable energy sources** can be replenished in a short period of time. The five renewable sources used most often include hydropower (water), solar, wind, geothermal, and biomass.



Renewable energy's impact on the world's energy picture is significant. Many milestones have occurred during the history of using renewable sources to generate electricity - but the overall use of these fuels has declined by almost 24 percent from their 1996 peak to less than 6 quads (5.668 quads) in 2001.

The use of renewable energy is not new. Five generations (125 years) ago, wood supplied up to 90 percent of our energy needs. Due to the convenience and low prices of fossil fuels, wood use has fallen. Now, the biomass which would normally present a disposal problem is converted into electricity (e.g., manufacturing wastes, rice hulls, and black liquor from paper production).



### **Hydropower -- Energy from Moving Water**

Of the renewable energy sources that generate electricity, hydropower is the most often used. It accounted for 6 percent of U.S. generation and 42 percent of renewable generation in 2001. It is one of the oldest sources of energy and was used thousands of years ago to turn a paddle wheel for purposes such as grinding grain. Mechanical energy is derived by directing, harnessing, or channeling moving water. The amount of available energy in moving water is determined by its *flow* or *fall*. Swiftly flowing water in a big river, like the Columbia River along the border between Oregon and Washington, carries a great deal of energy in its flow. So, too, with water descending rapidly from a very high point, like Niagara Falls in New York. In either instance, the water flows through a pipe, or *penstock*, then pushes against and turns blades in a turbine to spin a generator to produce electricity. In a *run-of-the-river system*, the force of the current applies the needed pressure, while in a *storage system*, water is accumulated in reservoirs created by dams, then released when the demand for electricity is high.



## Wind Energy -- Energy from Moving Air

What is wind?

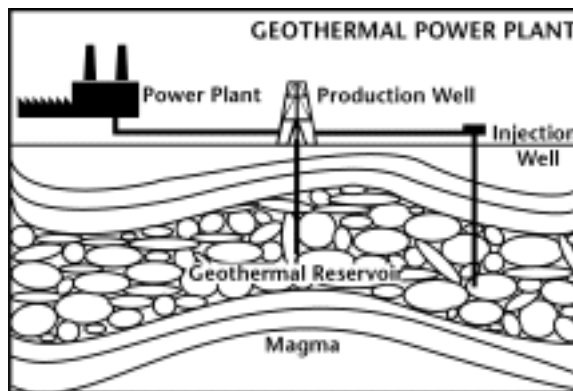
Wind is air in motion. It is produced by the uneven heating of the earth's surface by the sun. Since the earth's surface is made of various land and water formations, it absorbs the sun's radiation unevenly. When the sun is shining during the day, the air over landmasses heats more quickly than the air over water. The warm air over the land expands and rises, and the heavier, cooler air over water moves in to take its place, creating local winds. At night, the winds are reversed because the air cools more rapidly over land than over water.



## Geothermal Energy -- Energy from the Earth's Core

On May 18, 1980, Mt. St. Helens, an active volcano in Washington, erupted, providing a vivid display of the energy contained within the Earth. Most volcanic activity occurs around the Pacific Ocean's rim, the Ring of Fire.

Volcanic energy cannot be harnessed (controlled and collected), but in a few places heat from the earth, called geothermal energy, can be collected. Usually, engineers try to collect this heat in the rare places where the Earth's crust has trapped steam and hot water. Here, they drill into the crust and allow the heat to escape, either as steam, or as very hot water. Pipes carry the hot water to a plant, where some of the steam is allowed to "flash," or separate from the water. That steam then turns a turbine - generator to make electricity.

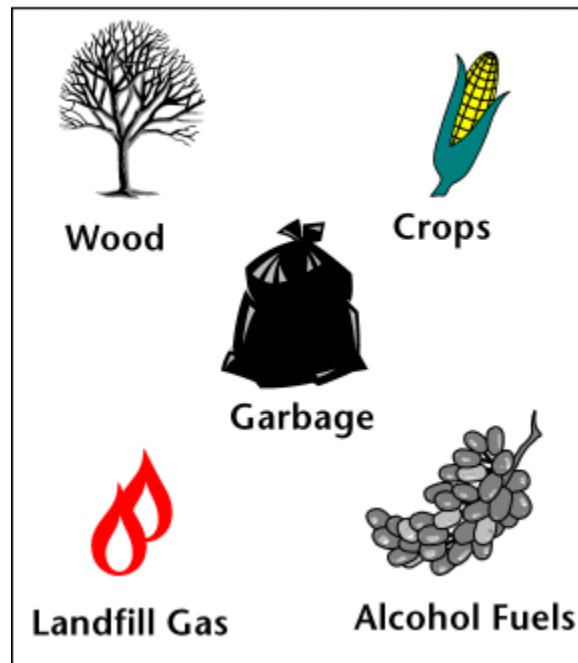
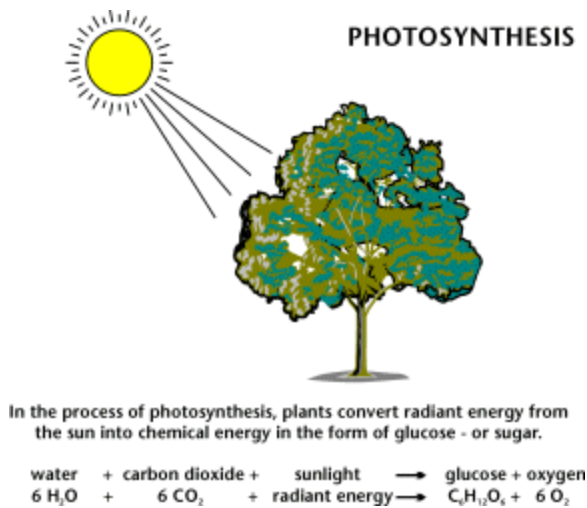


## BIOMASS -- Energy from Wood, Garbage, and Agricultural Waste

Biomass is organic material which has stored sunlight in the form of chemical energy. Biomass fuels include wood, wood waste, straw, manure, sugar cane, and many other byproducts from a variety of agricultural processes.

When burned, the chemical energy is released as heat. If you have a fireplace, the wood you burn in it is a biomass fuel. What we now call biomass was the chief source of heating homes and other buildings for thousands of years. In fact, biomass continues to be a major source of energy in much of the developing world.

## Types of Biomass



### Solar Energy -- Energy from the Sun

The sun has produced energy for billions of years. Solar energy is the solar radiation that reaches the earth.

Solar energy can be converted directly or indirectly into other forms of energy, such as heat and electricity. The major drawbacks (problems, or issues to overcome) of solar energy are: (1) the intermittent and variable manner in which it arrives at the earth's surface and, (2) the large area required to collect it at a useful rate.

Solar energy is used for heating water for domestic use, space heating of buildings, drying agricultural products, and generating electrical energy.

In the 1830s, the British astronomer John Herschel used a solar collector box to cook food during an expedition to Africa. Now, people are trying to use the sun's energy for lots of things.

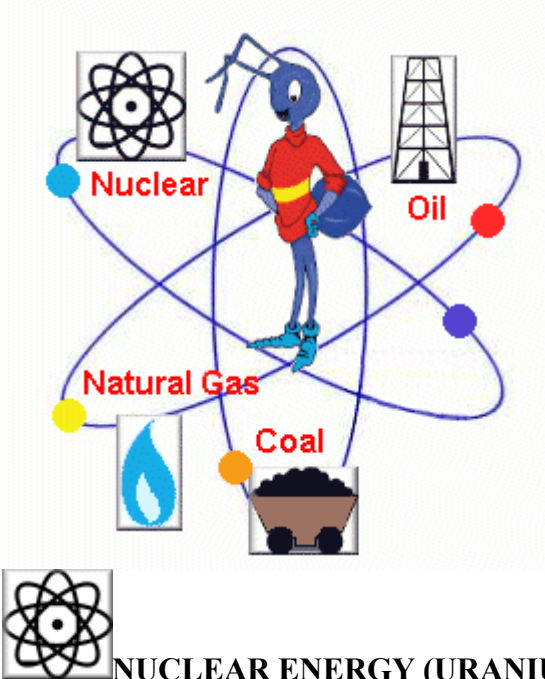
Electric utilities are trying photovoltaic, a process by which solar energy is converted directly to electricity. Electricity can be produced directly from solar energy using photovoltaic devices or indirectly from steam generators using solar thermal collectors to heat a working fluid.

There were 15 solar electric generating units operating in the US at the end of 2002, with more on the way. Most of these are in California, though Nevada, Arizona, Texas, and Virginia have them, too.

**Nonrenewable energy sources** come out of the ground as liquids, gases and solids. Right now, crude oil (petroleum) is the only naturally liquid commercial fossil fuel. Natural gas and propane are normally gases, and coal is a solid. Coal, petroleum, natural

gas, and propane are all considered fossil fuels because they formed from the buried remains of plants and animals that lived millions of years ago. Uranium ore, a solid, is mined and converted to a fuel. Uranium is not a fossil fuel. These energy sources are nonrenewable because they can not be replenished (made again) in a short period of time. Renewable energy sources can be replenished naturally in a short period of time.

**Non-Renewable Energy**



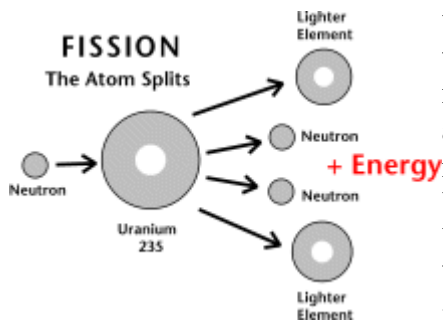
## NUCLEAR ENERGY (URANIUM) ENERGY FROM ATOMS

Nuclear power accounts for about 20 percent of the total electricity generated in the United States, an amount comparable to all the electricity used in California, Texas and New York, our three most populous (having the most people) states. In 2001, there were 66 nuclear power plants (composed of 104 licensed nuclear reactors) throughout the United States, located mostly on the East Coast and in the Midwest.

A nuclear power plant operates basically the same way as a fossil fuel plant, with one difference: the source of heat. The process that produces the heat in a nuclear plant is fission or splitting of uranium atoms. That heat boils water to make the steam that turns the turbine-generator, just as in a fossil fuel plant. The part of the plant where the heat is produced is called the reactor core.

### NUCLEAR FUEL

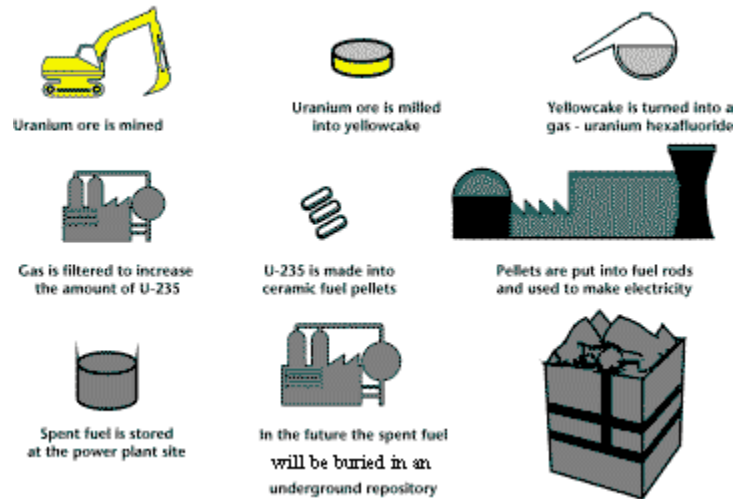
Atoms are made up of three major particles: protons, neutrons and electrons. The most common fissionable atom is an isotope (the specific member of the atom's family) of uranium known as uranium-235 (U-235 or  $U^{235}$ ),



relatively rare. Most U.S. uranium is mined, in the Western United States. Once uranium is mined the U-235 must be extracted and processed before it can be used as a fuel. In its final usable state, the nuclear fuel will be in the form of a pellet roughly one-inch-

long, which can generate approximately the same amount of electricity as one ton of coal.

## URANIUM FUEL CYCLE



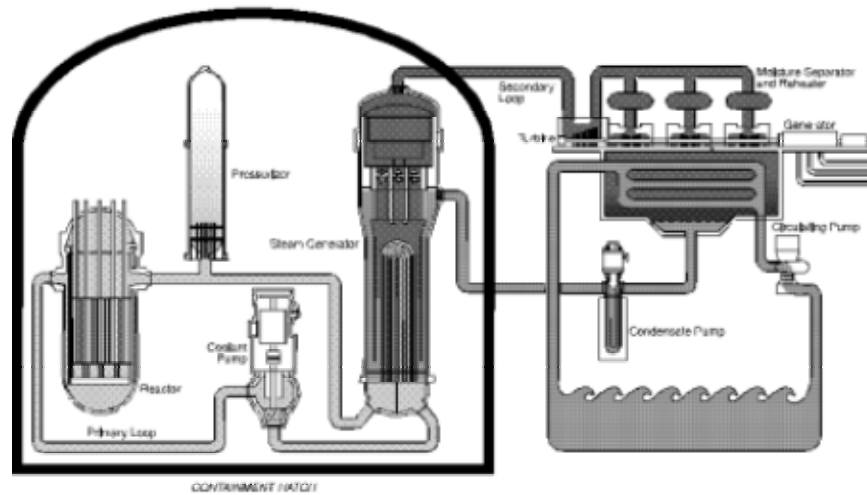
### TYPE OF REACTORS

Just as there are different approaches to designing and building airplanes and automobiles, engineers have developed different types of nuclear power plants. Two types are used in the United States: boiling-water reactors (BWRs), and pressurized-water reactors (PWRs).

In the BWR, the water heated by the reactor core turns directly into steam in the reactor vessel and is then used to power the turbine-generator. In a PWR, the water passing through the reactor core is kept under pressure so that it does not turn to steam at all -- it remains liquid. Steam to drive the turbine is generated in a separate piece of equipment called a steam generator. A steam generator is a giant cylinder with thousands of tubes in it through which the hot radioactive water can flow. Outside the tubes in the steam generator, nonradioactive water (or clean water) boils and eventually turns to steam. The clean water may come from one of several sources: oceans, lakes or rivers. The radioactive water flows back to the reactor core, where it is reheated, only to flow back to the steam generator. Roughly seventy percent of the reactors operating in the U.S. are PWR.

Nuclear reactors are basically machines that contain and control chain reactions, while releasing heat at a controlled rate. In electric power plants, the reactors supply the heat to turn water into steam, which drives the turbine-generators. The electricity is shipped or distributed through transmission lines to homes, schools, hospitals, factories, office buildings, rail systems and other customers.

Figure FE1. Nuclear Steam Supply System  
(U-tube Design Steam Generator)



The reactor core is composed of four main elements:

*THE FUEL.* Nuclear fuel consists of pellets of enriched uranium dioxide encased in 12-foot long pencil-thick metal tubes, called fuel rods. These fuel rods are bundled to form fuel assemblies. A nuclear plant can operate continuously for up to 2 years. To run this long, a reactor must have as many as 100 to 300 fuel assemblies.

*THE CONTROL RODS.* The control rods contain material that regulates the rate of the chain reaction. If they are pulled out of the core, the reaction speeds up. If they are inserted, the reaction slows down.

*THE COOLANT.* A coolant, usually water, is pumped through the reactor to carry away the heat produced by fission of the fuel. This is comparable to the water in the cooling system of a car, which carries away the heat built up in the engine. In a reactor, as much as 330,000 gallons of water flow through the reactor core every minute to carry away the heat.

*THE MODERATOR.* A moderator, water, slows down the speed at which atoms travel. This reduction in speed actually increases the opportunity to split, thereby releasing energy.

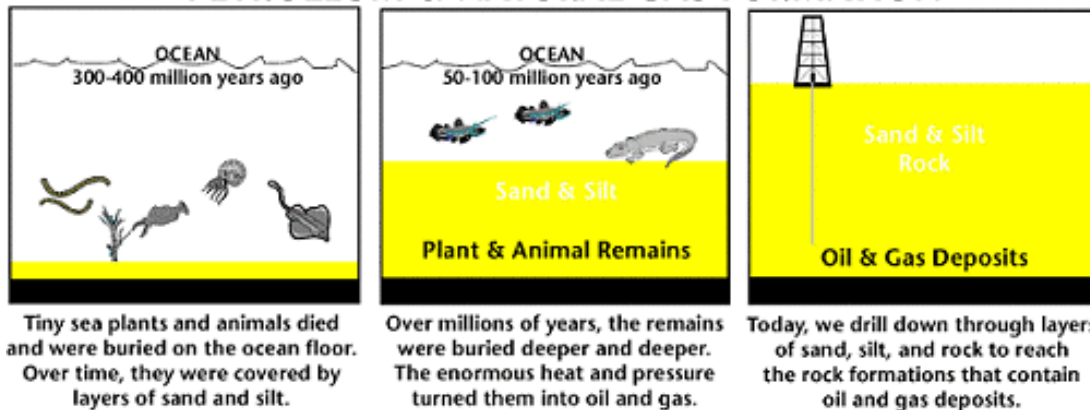
Although engineering designs are quite complex, these four elements -- the fuel, the control rods, the coolant and the moderator -- are the basic components of a nuclear reactor.



### **Petroleum (Oil) -- A Fossil Fuel**

Oil was formed from the remains of animals and plants that lived millions of years ago in a marine (water) environment before the dinosaurs. Over the years, the remains were covered by layers of mud. Heat and pressure from these layers helped the remains turn into what we today call crude oil. The word "petroleum" means "rock oil" or "oil from the earth."

## PETROLEUM & NATURAL GAS FORMATION



### WHERE DOES OIL COME FROM?

Crude oil is a smelly, yellow-to-black liquid and is usually found in underground areas called reservoirs. Scientists and engineers explore a chosen area by studying rock samples from the earth. Measurements are taken, and, if the site seems promising, drilling begins. Above the hole, a structure called a 'derrick' is built to house the tools and pipes going into the well. When finished, the drilled well will bring a steady flow of oil to the surface.

The world's top five crude oil-producing countries are:

- Saudi Arabia
- Russia
- United States
- Iran
- China

and in the United States the top five crude oil-producing states are:

- Texas
- Alaska
- California
- Louisiana
- Oklahoma

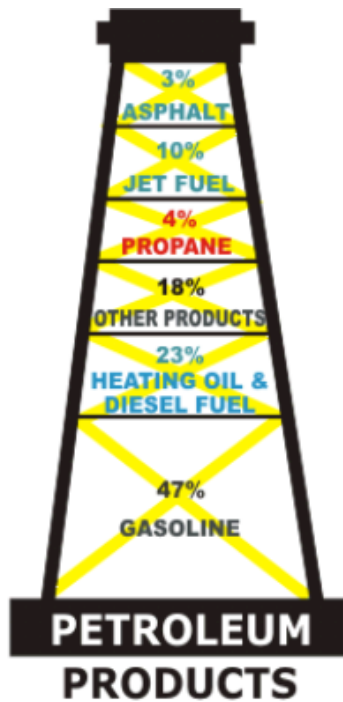
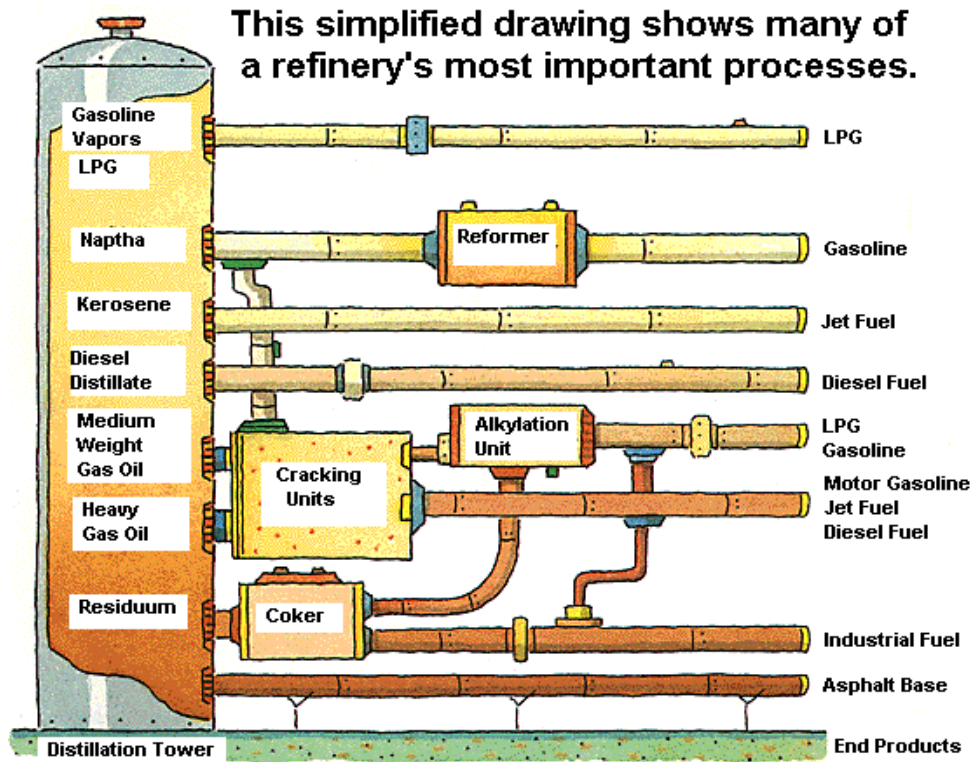
The amount of crude oil produced (domestically) in the United States has been getting smaller each year. However, the use of products made from crude oil has been growing, making it necessary to bring more oil from other countries. Over 60 percent of the crude oil and petroleum products used in the United States comes from other countries.

### HOW IS IT USED?

After crude oil is removed from the ground, it is sent to a refinery by pipeline, ship or barge. At a refinery, different parts of the crude oil are separated into useable petroleum products. Crude oil is measured in barrels. A 42-U.S. gallon barrel of crude oil provides slightly more than 44 gallons of petroleum products. This gain from processing the crude oil is similar to what happens to popcorn, it gets bigger after it is popped.

One barrel of crude oil, when refined, produces 19.9 gallons of finished motor gasoline, as well as other petroleum products. Most of the petroleum products are used to produce energy. For instance, many people across the United States use propane to heat their homes and fuel their cars. Other products made from petroleum include: ink, crayons,

bubble gum, dishwashing liquids, deodorants, eyeglasses, records, tires, ammonia, and heart valves.

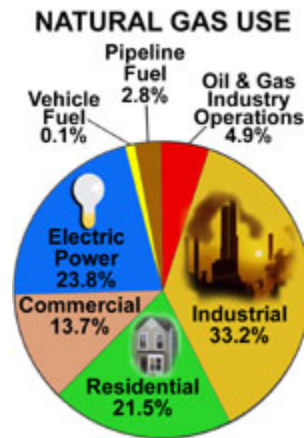


The gain from processing is about 5%.



## Natural Gas -- A Fossil Fuel

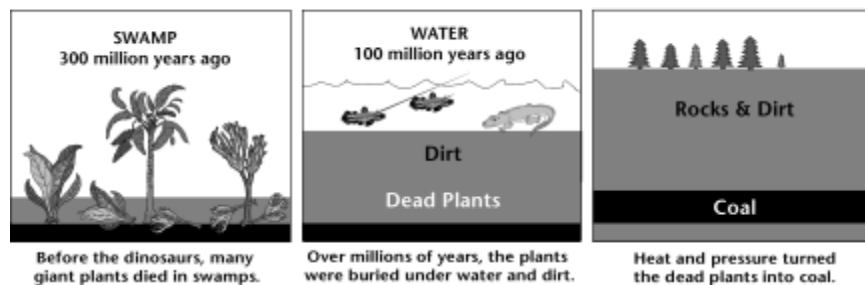
Millions of years ago, the remains of plants and animals decayed and built up in thick layers. This decayed matter from plants and animals is called organic material -- it was once alive. Over time, the mud and soil changed to rock, covered the organic material and trapped it beneath the rock. Pressure and heat changed some of this organic material into coal, some into oil (petroleum), and some into natural gas -- tiny bubbles of odorless gas. The main ingredient in natural gas is methane, a gas (or compound) composed of one carbon atom and four hydrogen atoms.



## COAL -- A Fossil Fuel

The United States produces over 1/5 of the world's coal and has nearly 275 billion short tons of coal we can mine.

### HOW COAL WAS FORMED



### IT'S USEFUL

Coal is used to generate more than half of all electricity produced in the United States. It's also used as a basic energy source in many industries, including, steel, cement and paper.

### THERE'S PLENTY OF IT and IT'S AVAILABLE

Many U.S. coal beds are very near the ground's surface. Modern mining methods allow us to easily reach most of our coal reserves.

## ITS EFFECT ON THE ENVIRONMENT

Environmental issues, such as clean water and clean air, will determine the future of coal.

## COAL PRODUCTION

Coal production provides thousands of jobs in all aspects of the coal industry - exploration, reclamation, mining, equipment supply, and transportation.

## HOW DOES COAL GET FROM WHERE IT IS MINED TO WHERE IT IS USED?

The route from the coal mine to the places where it is used can take many paths. Most coal is transported by train and barge.

## A VISIT TO A REAL COAL MINE

### **4 MAJOR USES**

#### FOR ELECTRIC POWER

Power plants burn coal to make steam. The steam turns turbines which generate electricity. Electric utility companies use over 80% of the coal mined in the United States.

#### FOR INDUSTRY

A variety of industries use coal's heat and by-products. Separated ingredients of coal (such as methanol and ethylene) are used in making plastics, tar, synthetic fibers, fertilizers, and medicines. The concrete and paper industries also burn large amounts of coal. Industrial consumers use over six percent of the coal mined in the United States.

#### FOR MAKING STEEL

Coal is baked in hot furnaces to make coke, which is used to smelt iron ore into iron needed for making steel. It is the very high temperatures created from the use of coke that gives steel the strength and versatility for products such as bridges, buildings, and automobiles.

#### FOR EXPORT

The United States is the world's 4th largest coal exporter, after China. Approximately 60 million short tons are exported every year to about 40 different countries worldwide. Most trade is with Western Europe, Canada and Brazil.