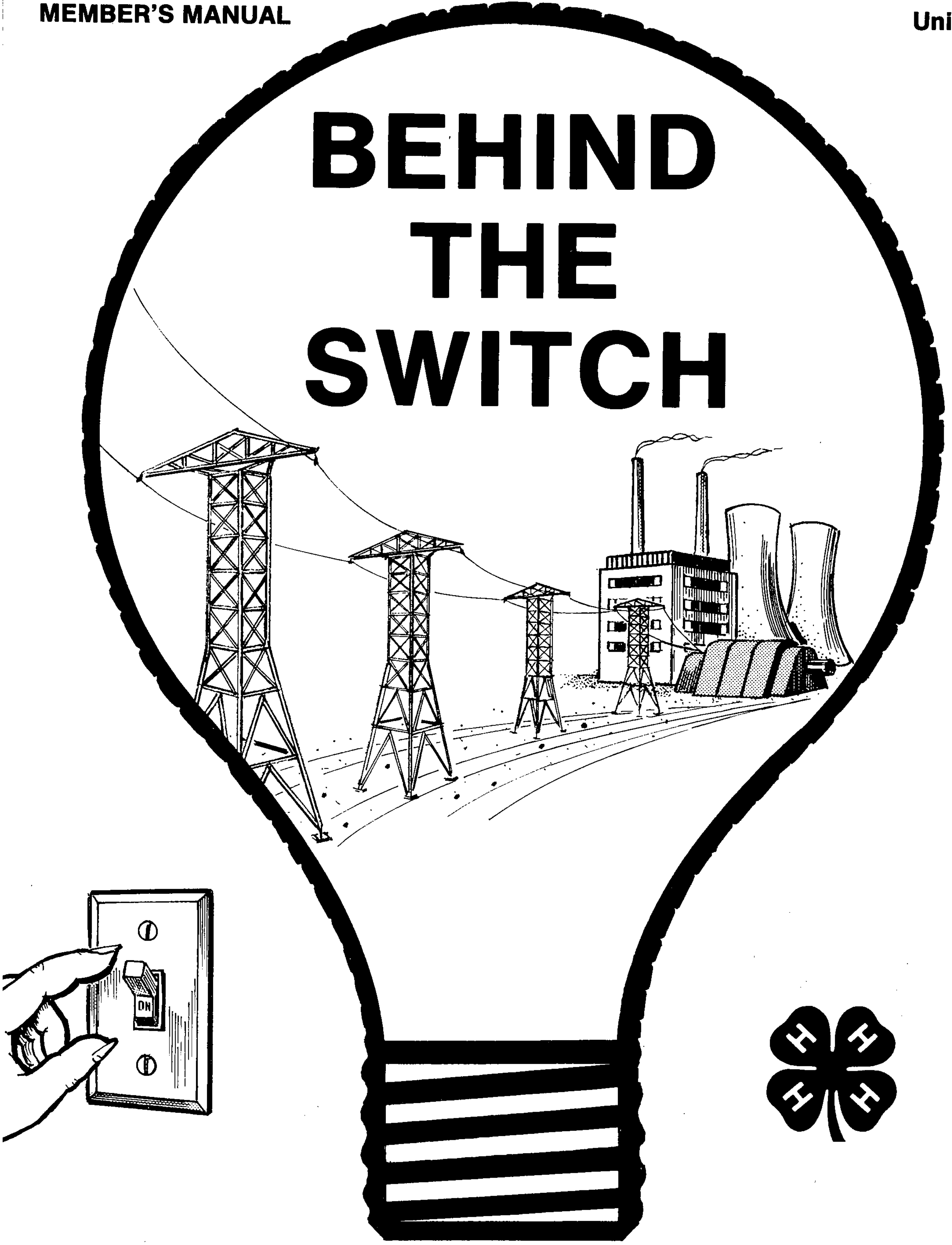
MEMBER'S MANUAL

Unit 5

BEHIND THE SWITCH



GENERATION, TRANSMISSION, AND DISTRIBUTION

CO 009

BEHIND THE SWITCH

Generation, Transmission and Distribution

CONTENTS PAGE

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I. Introduction

As a part of your continuing interest in electricity, you should know what is "behind the switch" — the generation, transmission and distribution of electricity.

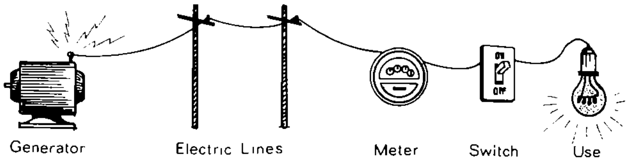
You have already learned that electricity exists "free" in nature as static electricity or lightning. However, generating electricity, moving it from place to place, and finally distributing it takes a lot of expensive equipment and hard-gained knowledge.

This portion of the Electric Energy Program takes you behind the switch to learn for yourself how electricity is produced and delivered to your home.

II. Electricity — The Instant Product

It is obvious that electricity is a valuable product. Electricity must be ordered, manufactured, delivered, sold and used — just like any other product. The difference is that with electricity, all of these steps occur in the same instant!

When you "order" electricity by flipping the switch, your power supplier "manufactures" it by putting out just a bit more electricity from its generators. The utility delivers it at virtually the speed of light over power lines to your home and sells it to you by measuring through a meter the amount you have ordered. Finally, you start to use it in the light or appliance you have turned on — all in just a fraction of a second.



(Stylized Power Flow Diagram)

Generator To Light Bulb

When we buy another product, we know exactly how much we have purchased. Gasoline comes in gallons (or liters), butter is sold by the pound (or kilogram), fabric by the yard (or meter). Since we can't weigh or carry electricity in a bucket or box, how do we know how much we are using?

Watts, Kilowatts and Kilowatt-hours

We are now familiar with the term "watts". We know that it is a measure of electric power and that it represents the combination of "amps" (electric current) and "volts" (electrical pressure) working together. Neither amps nor volts, by themselves, give you electric power.

For example, you can have 230 volts available, but if there are no free electrons to flow (and thus no current), there can be no power. Or you can have enough free electrons to provide a flow of 70 amps, but with no voltage to make them flow, there is still no power. However, if you combine 230 volts and 70 amps, you have enough power to heat a home or run a large electric motor.

We know that to arrive at the number of watts of electric power, you multiply the volts times amps. **VOLTS x AMPS = WATTS.** Pressure times current flow equals power. Our example above would give us 230 volts times 70 amps or 16,100 watts of power.

When referring to a large number of watts, we use the term "kilowatts." This takes advantage of the Greek word "kilo" which means 1000. Thus, a kilowatt is 1,000 watts. So, 16,100 watts becomes 16.1 kilowatts; 100,000 watts becomes 100 kilowatts. Now we have the terms watts and kilowatts as measures of electrical power. But what do they *really* mean to us?

The terms are measures of the *rate* of doing work. They can also be considered as a measure of power, or *ability* to do work.

When we buy an appliance with a wattage rating, we are buying a capacity or *ability* to do work. The higher the wattage, the more work the appliance can do in a given period of time.

Ability to do work is important, but it isn't the whole story. When you hire a person to work for you, you would first consider his or her "power" or ability to do work. You would be willing to pay a higher salary, if he has high ability — but a lower salary if his ability is limited.

You also might pay more for a higher wattage hair dryer because you know that higher wattage means a greater ability to work.

But the most important measure of electrical energy is not its *ability* to do work but the *amount* of work it does.

We must have some measure of the amount of work *done* — the amount of energy consumed. Watts do not give a measure of the total amount of energy that a piece of electrical equipment uses. You still need another unit of measure that takes into account the *time* the equipment is in use. This is not difficult. We simply multiply the ability of electricity to do work — or the rate at which it does work — as measured in watts, times the number of hours it worked.

The result is a "watt-hour". It is a measure of electrical work (not power), or energy delivered. A watt-hour is one watt of electrical power used for one hour. If you use an electric mixer with a 100-watt motor at full speed for one hour, you have used 100-watt hours of electrical work or energy.

A watt-hour is a rather small amount of work. So, we use, the Greek word kilo again to express electrical work done in kilowatt-hours — often abbreviated "kwh".

You will use one kilowatt-hour of electrical energy if you use:

* A 100 watt light bulb for 10 hours. (100 watts x 10 hours = 1,000 watt hours = 1 kwh.)

* A 1,500 watt electric dryer for 40 minutes. (1,500-watts x 2/3 hours = 1,000 watt-hours = 1 kwh.)

* A 20,000 watt central heating unit for three minutes. (20,000-watts x 1/20 hour = 1000 watt-hours = 1 kwh.)

Watts are thus a rate of doing work, while kilowatt-hours are the amount of work done. Kilowatt-hours are the product that electric companies manufacture, deliver and sell to make your life easier, safer and more comfortable.

Things To Do.

1. Discuss with club members ways in which electricity, as a product, is similar to other manufactured products. For example, how is electricity marketed?
2. Describe to club members the difference between power and energy.
3. Estimate the amount of energy consumed by some common appliances at home. Look at the appliance nameplates for the number of watts required. Multiply this by the number of hours the appliance is used each month. Divide that by 1,000. This will give you the number of kilowatt-hours used each month by that appliance.
4. Conserving energy is important so that there will be enough to go around. Discuss with club members some of the ways this can be done. Ask your local power supplier for some tips on energy conservation.

III. Generating Electricity

Magnets and Conductors in Motion

In the world of electricity, "generation" means the same thing as manufacturing. We know that electric energy can be produced from chemical energy in batteries. We also know that magnetism can be used to produce electricity by moving a conductor through a magnetic field. It doesn't matter whether the conductor or the magnet moves, so long as one moves with respect to the other. <u>Motion</u> is the key.

To produce the electricity used in your home, a coil of wire and a magnet must be continually in motion.

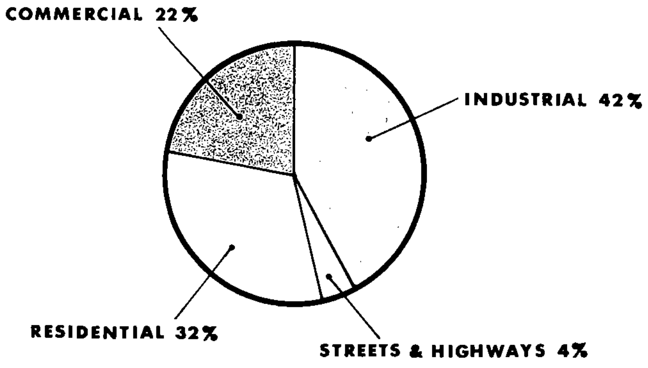
Of course the simplest way to produce this motion is by hand, as you learned when you constructed a small generator in Unit 2. This is obviously not enough to produce even a fraction of the electricity used in your home every day.

Much more electricity is needed to power the lights and appliances used in millions of homes, factories and businesses across the country. Producing electricity on such a scale is called "commercial generation".

It is difficult to grasp the actual amount of electricity used. Depending upon the size of the home and the number of appliances, each family may use from 300 to over 3,000 kilowatt-hours of electric energy per month. Considering the total number of households in the nation, you can begin to see the magnitude of the demand for electric energy.

But, that's only part of the story. Residential use of electric energy is only about a *third* of the total amount used.

The following chart shows that businesses — stores, shopping centers, offices, etc. — are lumped into a category called "commercial" use and account for almost a *quarter* of electricity used. Large factories such as steel mills, automobile assembly plants, paper and textile mills and many others use just over 40 percent of the electricity produced. The lighting of streets and highways requires an additional four percent of total production.

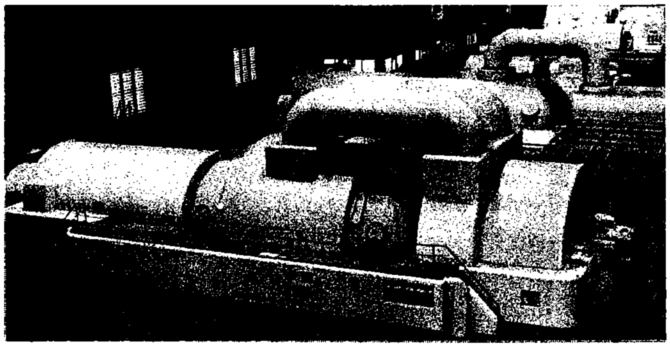


To measure such a huge amount of energy, the terms kilowatt and kilowatt-hours are no longer convenient. Instead, we use the prefix "mega", meaning million. Thus, a megawatt is a million watts and is abbreviated as "MW". The ability of a commercial-sized electric generation plant to produce energy is defined in terms of its "megawatt" capacity. As a rule of thumb, it requires a generating capacity of about 1,000 megawatts to supply electric energy to a city of half-a-million people.

What kind of equipment must an electric power supplier use to generate that much power? Obviously, a utility must have something larger and more complicated than batteries or hand-cranked generators.

The giant generators used by power suppliers work on the same principle as the small hand-cranked generator. The only difference is, in commercial generators, the magnets move and the coils of wire are stationary. Powerful electromagnets are attached to the rotor, which spins at 1,800 revolutions or more per minute. The effect is the same as that produced by the hand-operated generator. The coils of wire ringing the generator "see" a moving magnetic field and produce electricity, at levels as high as 25,000 volts.

These commercial generators are huge. A typical one may be 50 feet or more long, weigh several hundred tons and use miles of wire in its coils.



Most electric generators are connected to large turbines that supply the power to spin the rotor.

Turbines work like large, many-bladed pinwheels. Turbines usually share a common shaft or axle with the generator. Turbines that are used to spin the huge generators usually must be even larger than the generators. While it takes only a small trickle of water, a breath of air or a puff of steam to turn a pinwheel, to turn one of these turbines requires tremendous force.

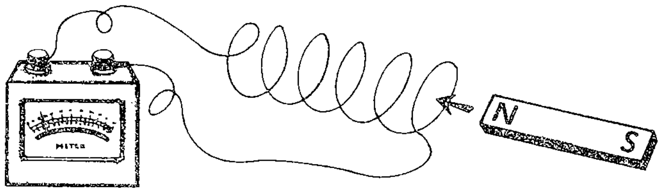
Electric companies use various types of equipment and fuels to provide this spinning force. Which ones are the best is a central issue of the energy crisis. The next section of this manual takes into account the different ways electric utilities provide the mechanical energy needed to keep their turbines spinning.

Things To Do.

1. Demonstrate how electricity is induced in a conductor by magnetism.

Materials Needed

Electric current meter, borrowed from your local power supplier
Three feet of thin wire
Paper towel tube
Two small bar magnets



Wrap the wire into a large coil, using the paper towel tube as a guide, and connect the ends of the wire to the meter. Move the bar magnet back and forth inside the coil. What happens if you move the magnet faster? Add more coils of wire. Use two magnets held together with like poles at the same end. What happens?

2. Ask your local power supplier what percentage of the energy that it delivers goes to residential, commercial, industrial and civic uses. How does this compare to the percentages shown on the pie chart? How many households does your local supplier serve? What is the total capacity of your local supplier for generating and delivering electric energy?

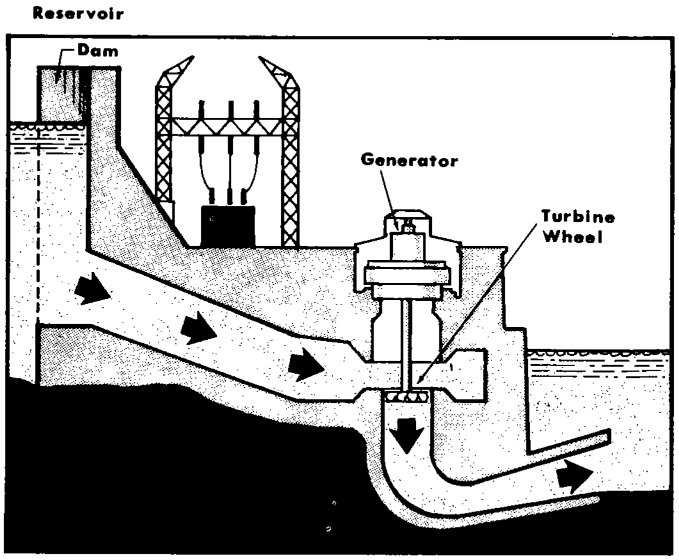
IV. Hydro Power-Water At Work

One of the least expensive sources of power to spin a turbine is the force of falling water.

Mankind has known about this force for hundreds of years. Waterwheels have been used for centuries to produce the power to grind grain into flour, operate machinery or run saw mills. It was only natural that this force be harnessed to produce electricity.

Harnessing flowing water is accomplished by utilizing the speed and gravity energy released when water drops from a higher elevation to a lower one.

Plants which produce large amounts of electricity from the flow of water are called hydroelectric plants and are usually located on large



rivers. These hydroelectric plants are built in conjunction with dams. Most of these are located in the western states.

As you can see from the diagram, rushing water is channeled to the blades of a large waterwheel, or hydraulic turbine, causing it to spin at a high speed. This, in turn, spins the generator, producing electricity.

Since the first plant was built in 1880, hydroelectric power developed steadily in the United States. Today, about 15 percent of our electricity is produced by these plants. As other types of generating plants are built, it is expected that the share of total electricity produced by hydroelectric plants will drop.

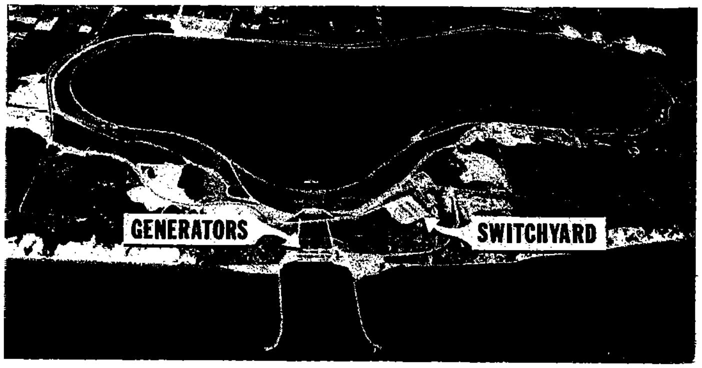
This is because locations for hydro plants are limited. Most choice river locations are already in use. Dams are constructed to control water flow and create more locations, but they can cause river water to back up and spread out, covering as much as 100,000 acres of land. Too many new dams means that land could be lost for farming, forestry and recreational purposes.

Some electric utilities have built what amounts to artificial hydroelectric plants, called pumped storage plants. These use pumps to force water uphill into a holding pond or reservoir. The pumping is usually done at night when the demand for electricity is at its lowest point. During the day, when the need for power is high, the water is allowed to run back down to turn the turbines.

Pumped storage plants may not seem practical at first glance, since it takes as much energy to pump the water uphill as it produces when it runs down. However, *timing* is the key. As we shall see later, electric utilities usually have a large spare generating capacity at night. They can easily afford the power to operate the pumps.

Hydroelectric plants are expensive to build, but, since gravity and a constant supply of water make a "free" fuel, the plants provide inexpensive electric power. They also have the added advantage of being almost pollution-free.

By the year 2000, we probably can expect that hydro power — as desirable as it is — will be producing only about five percent of the electricity we need.



Things To Do

1. Do you have any hydroelectric power plants in your area? What percentage of the electricity used in your community is produced by this method? Your local power supplier can help with this information.

2. Is your power supplier planning new hydroelectric plants? Discuss what effect new plants could have on environment, farm lands, streams and local business.

3. Let's see how much water you would need to produce all of the electric energy used in your community. Find out what your local power supplier's generating capacity is in kilowatts (remember, one megawatt = 1,000 kilowatts). It takes 7,500 gallons of water falling through 42½ feet to generate one kilowatt of electric energy in a hydroelectric plant. Now, assuming you have a waterfall 42½ feet high, what kind of flow would you need from the river? Simply multiply the kilowatt capacity of your utility by 7,500 gallons and divide by 60 minutes. This gives you the gallons-per-minute flow you would need from the river. How does this compare with Niagara Falls, with 95 million gallons-per-minute? How about the Mississippi River, with a 224 million gallons-per-minute average at Memphis, Tennessee?

V. The Steam Cycle

Most areas of the country do not have enough water power resources for hydro plants. Therefore, they use steam to spin their turbines. In fact, about 85 percent of all electricity used in the United States is produced from steam.

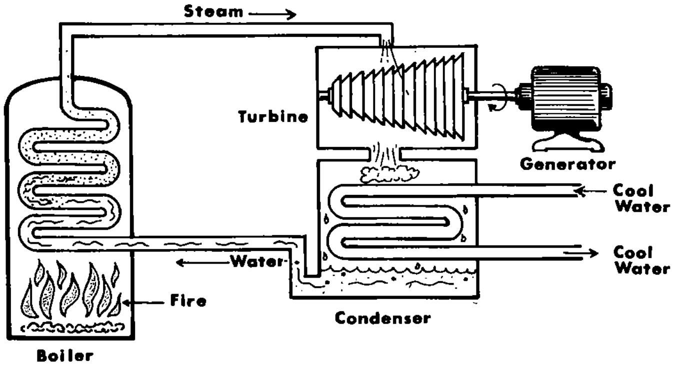
Burning various types of fuel produces heat, which converts large quantities of water into steam.

Steam creates a great force. Steam engines were used to power locomotives and factory machinery even before electricity became available.

In the manufacture of electricity, when steam is forced against the blades of a turbine, the turbine spins with great speed. These turbines weigh upwards of 1500 tons but are quite precise. They usually have several rows of blades, with a large number of blades in each row. The blades can be relatively short or up to a yard in length.

The turbine must spin so fast — in order to produce up to 1800 RPM — that sometimes the tips of the blades are moving at the speed of sound. This means they must be built of extra strong metal to exact measurements, and be well-maintained so that they literally won't fly apart.

This process is called steam generation. It begins by converting chemical energy (or nuclear energy) from fuel into steam heat energy in large boilers. Heat energy is then converted into mechanical energy by the turbine. Finally, this is converted into electrical energy by the generator.



STEAM CYCLE

What happens once the steam is "used" in the turbine? It is collected from the turbine and directed toward many small tubes in a "condenser". The tubes are filled with cool water from a source outside the plant. The cool water absorbs heat from the steam and the steam condenses back into water. This water is then returned to the boiler where it is again turned to steam. The continual flow of water to steam and back to water is called the steam cycle.

Whenever any form of energy is converted to another form, some energy is lost. The amount left, expressed as a percent of the amount started with, is called the "efficiency" of the conversion process. For example, if you started with ten mechanical energy units and converted them to eight electrical energy units through some process, the efficiency of the process would be 8/10 or 80 percent.

Few energy converting processes are considered efficient. Automobiles are only 5 to 10 percent efficient in converting the heat energy of burning gasoline into the mechanical energy of motion. This isn't poor design or manufacturing, it's simply a matter of a natural law of science.

Since energy is lost in each step of the steam cycle — chemical to heat, heat to mechanical and mechanical to electrical — the efficiency of the steam cycle is about one-third, or 33 percent, regardless of the fuel used.

This means that great quantities of fuel are needed to produce the ever-expanding need for electrical energy. This is one of the concerns of the energy crisis. Where will this fuel come from?

Many individuals are working to find additional fuel or substitutes for fuels now in use. The problem is made more complex by the fact that each alternate fuel produces its own problems — scientific, environmental and economical.

Each electric utility must decide what fuels it will use to generate electricity, while weighing the cost, reliability and the environmental effect.

In the next few lessons, we'll be looking at some of the fuel sources and some ways the fuels are being used.

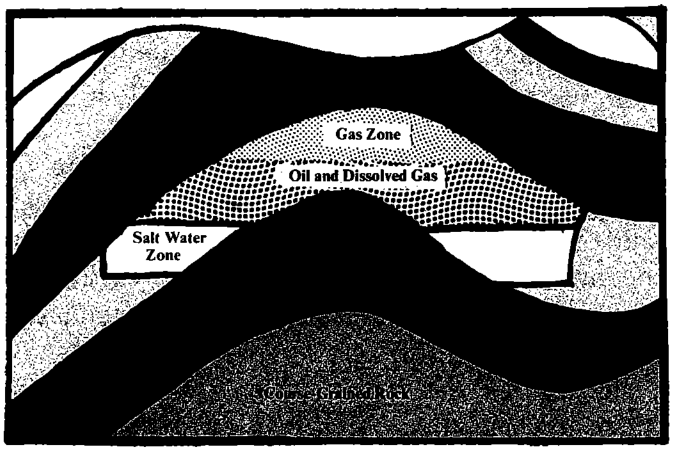
Things To Do

1. Ask your power supplier what percent of electricity used in your community is generated by the steam cycle.
2. Where does the water used to generate your power supply come from? List the sources of water used by the utility plant nearest you.

VI. Fossil Fuels - A Gift From The Past

Millions of years ago, the earth was covered with strange plants, most of which are now extinct. These plants soaked up energy from the sun and grew into a variety of sizes and shapes. Equally strange animals, such as dinosaurs, ate the plants for food.

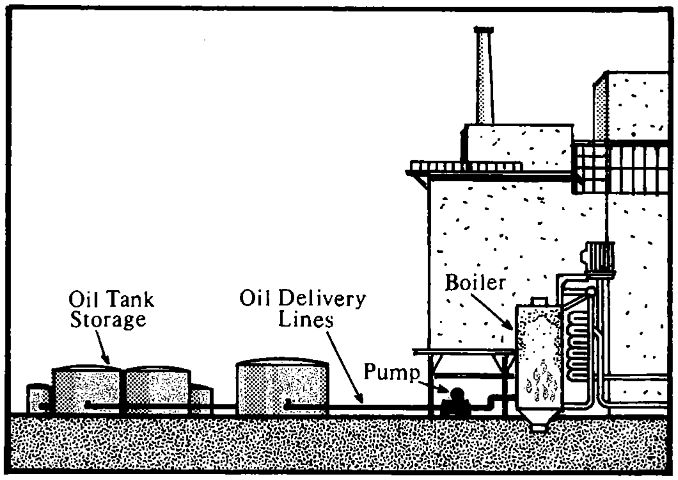
As all living things do, the plants and animals eventually died. Generation after generation of dead plants and animals were covered over with mud and soil as they decayed. Over more millions of years, the layers of mud and soil increased in thickness and finally turned to rock, leaving the compressed remains of animals and plants many feet below the surface.



Rock Formations & Petroleum Deposits

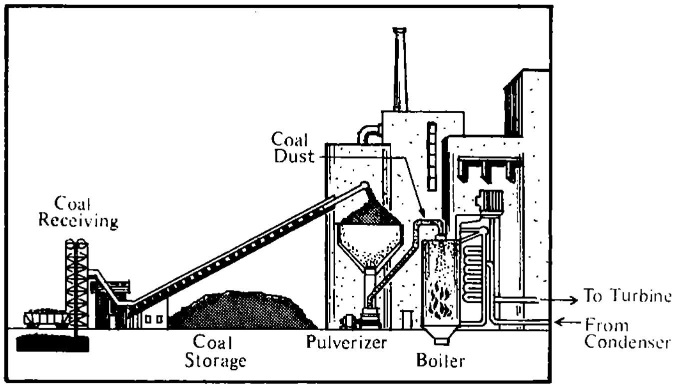
Great chemical changes took place in the decayed material. Today, we know these ancient remains as coal, oil and natural gas and they are the substances we call fossil fuels.

With the exception of natural gas, which is usually piped directly from the supplier to the power plant, electric utilities keep a large supply of fossil fuels in storage — usually a 90 day supply. Oil is stored in large tanks and coal is placed in sheds or dumped in the open. The oil or gas is pumped into the plant's boiler where it is mixed with air and ignited to produce a higher amount of heat.



Coal is more difficult to handle. Conveyers carry the coal from the supply area into the plant where pulverizers grind it into a dust as fine as talcum powder. Fans blow air mixed with coal dust into a boiler under high pressure where it ignites almost instantly.

A ton of coal will produce about 3,000 kilowatt-hours of electricity in a steam generating unit. The boilers can be as tall as a 24-story



building. The walls are lined with as much as 200 *miles* of piping which is filled with water to be turned into steam.

Fire in the boiler unit can get as hot as 28,000 F and water in the pipes turns quickly into steam under pressure of over 2,600 pounds per square inch. It reaches a temperature of more than 10,000 F. At this temperature and pressure level, steam has great force behind it and can easily turn giant turbines at high speed.

The boilers require constant monitoring and maintenance to keep them operating properly. Monitoring is carried out in a control room which is the nerve center of the power plant.

Here, charts and dials record the operation of every piece of equipment used in the power manufacturing process. There is a dial, for example, which tells how much electricity is being manufactured. Another dial records pressure inside the boiler while still another tells how much water is passing through the boiler and the level of steam pressure at all points within the system.

The control room of a power plant is staffed on a 24-hour basis. Operators now use computers to help mechanize the manufacturing process.

How does the electric utility decide which type of fossil fuel it will use? One important consideration is availability.

Natural gas has been a popular fuel for electric utilities. It produces little air pollution, is clean-burning and leaves no ash to be discarded. It requires the least amount of handling since it is piped directly from the source. It takes about nine cubic feet of natural gas to produce one kilowatt-hour of electricity.

Supplies of natural gas are becoming limited. Much of it is being used for purposes other than generation of electricity — heating homes, as a raw material for plastics, synthetic fibers and even drugs.

Many producers use gas on an "interruptable" basis. This allows the gas company to limit or stop delivery during times when supplies are low or gas is needed elsewhere. Some electric power suppliers use gas to fuel small, quick-starting generators used only during periods when power usage is at a peak.

Oil used for generating electricity is usually the thick, heavy type remaining after gasoline, kerosene and lighter oils have been processed out. One cup of oil will produce one kilowatt-hour of electric energy.

Like natural gas, oil has been a popular fuel for many years. It is relatively pollution-free, ashless and easy to handle. Reliable sources of oil are becoming more and more scarce. Electricity generated from oil costs more than that generated from more plentiful, less expensive fuels.

A number of electric utilities are converting their power plants so that they can burn the most abundant of the three types of fossil fuels — coal.

Coal is still the most commonly used fuel for making steam in electric generating stations. From the turn of the century, coal has been used in power production. Its popularity grew until the 1930's when the clean burning fuels came into their own. Its use declined through the 1960's until the first signs of the energy crisis hit. Oil imports from foreign nations were squeezed and prices soared. Then the scramble to convert to coal began. New plants were ordered and plans to build oil consuming plants were changed.

One reason for this change is that our supply of coal is still very great. Scientists estimate that there is enough coal to last for at least 500 years.

Although we are drawn to using this fuel because there is a lot of it, coal creates its own problems in electric power production. Burning coal produces large quantities of potentially harmful gasses (usually sulfur gas), soot and literally thousands of railroad cars full of ashes.

To control these by-products, equipment must be added at coal-burning plants. This equipment removes most of the soot, collects ash for disposal and scrubs some of the sulfur gas from the fumes. Some coal is known for its low sulfur content and is in high demand.

Coal mining under the surface is difficult and dangerous. Strip or surface mining is potentially harmful to the environment and is being controlled by an increasing number of strict laws.

While plenty of coal exists, how much of it we can use to meet our future needs will depend upon how well we solve the problems connected with its mining and burning.

Turning Coal Into Oil And Gas

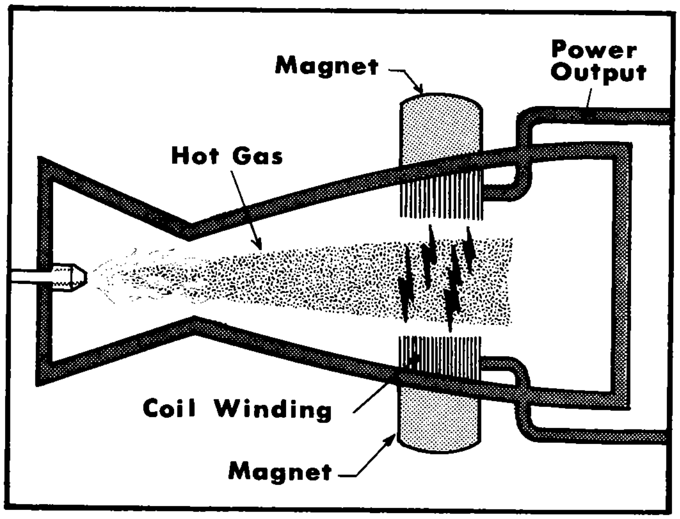
Scientists are busy finding ways to use our remaining fossil fuels in more efficient and less polluting ways.

One way to eliminate air pollution problems from burning coal, and to utilize the cheaper grades with their high sulfur content, is to turn the coal into clean burning liquid or gas. This is known as liquification or gasification. A complicated and expensive process, it amounts to "cooking" the coal under pressure until it gives off a burnable liquid or gas.

Magnetohydrodynamics

Try to pronounce that word! Even scientists refer to this method of producing electricity simply as "MHD".

Still in the experimental stage, the MHD method has promise since it can double the amount of electricity derived from a given amount of fuel. MHD skips one of the conversion steps in the steam cycle. Heat energy is converted directly into electrical energy.



MHD generators burn fossil fuels using preheated or oxygen-enriched air. The hot gas, heated to about 5,000 degrees F, becomes "ionized". This means that the individual molecules of gas break down into parts that are positively and negatively charged with electricity.

The ionized gas is blown through a cooled chamber called the MHD channel. The channel is surrounded by a strong magnet. As the gas flows through the magnetic field, it acts much like the rotor in a conventional generator. It produces electricity which is drawn off by electrodes in the channel. The basic problem with MHD generators is that they produce direct current. We can convert DC to AC, utilizing the proper equipment, but it is costly.

Other problems with the MHD process are extremely high temperatures and high-speed gases which tend to erode the metal walls of the channel and the electrodes. Exhaust gases from this process pose a potentially dangerous pollution problem. Yet exhaust gas can be run through a boiler to make steam to run turbines for better power efficiency.

Things To Do

1. Talk to a geologist or take a trip to a natural history museum to learn about how coal, oil and gas deposits were laid down.
2. Where possible, arrange to visit: a coal mine, an oil refinery, a natural gas well or pumping station, a fossil fueled electric power plant.
3. Talk to your power supplier about their problems with fossil fuels. Which do they now use? What are their thoughts about future fuel use?

VII. Nuclear Power-Controlling The Atom

Nuclear, or atomic, power is one of the most powerful discoveries of the human race. First used in war as a tool of destruction, atomic power holds great promise for our society — when used in a safe and controlled manner.

How Atoms Release Energy

The atom is the smallest particle of matter which can exist alone. An atom is so small that if an orange were blown up to the size of the earth, each atom of this giant orange would be the size of a cherry. As small as they are, atoms are composed of even smaller particles called protons, neutrons and electrons.

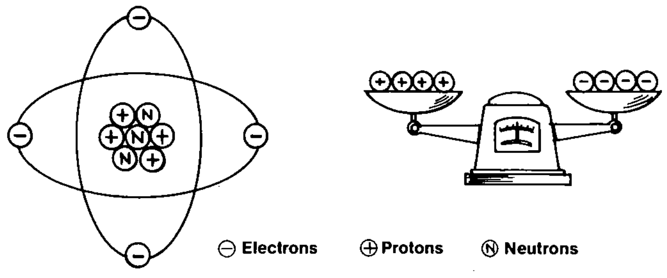
Protons carry a positive electric charge and are held together in a bundle with neutrons, which have no charge. This bundle is called the nucleus. In our picture of cherry-sized atoms, the nucleus would be so small it would still be invisible to the naked eye. Electrons have a negative charge and circulate around the nucleus. Normally, an atom contains the same number of protons and electrons. They balance each other so the result is the same as if the atom has no charge at all.

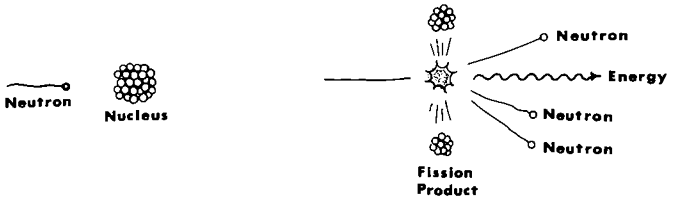
Elements are determined by the number of *protons* in the nucleus of the atom. For example, an atom of carbon has six protons. Add another proton and the element becomes nitrogen. Oxygen has eight protons, iron 26, gold 79, lead 82, etc. There are 104 known elements.

It is important to remember that the nuclei of the same element sometimes vary in the number of neutrons they contain. Atoms which vary in this way are called *"isotopes"*. Most hydrogen atoms have a neutron as well as a proton in the nucleus. This type of hydrogen is called "deuterium" or "heavy hydrogen".

In some elements, atoms change themselves by shooting out rays and particles. This is called decaying, or "radioactivity". The rays and particles cause a Geiger counter to tick when they strike the sensing probe of the counter. The radioactive element you are most familiar with is radium. Often used in paint on the hands and numbers of watches, its radiation causes a glow which can be seen in the dark.

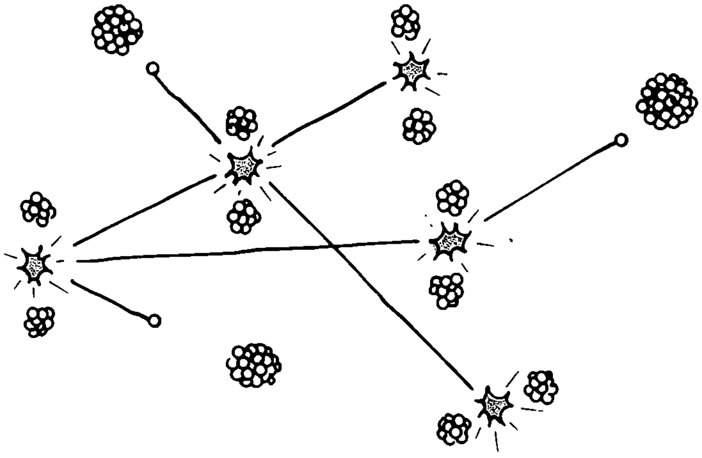
Scientists have found ways to change atoms to obtain energy. One is called "fission". Fission is the splitting of atoms and can occur naturally as a result of radioactivity.





THE FISSION PROCESS

Fission occurs when a neutron escaping from one atom strikes the nucleus of another atom with such force that it splits the nucleus in half. These halves, along with their electrons, form new, lighter-weight elements called "fission products" The process also releases energy and one, two or more neutrons which continue the splitting process. This is called a "chain reaction". When the chain is controlled, it is the source of tremendous amounts of usable energy. Nuclear energy is a more accurate term than atomic energy since it is the nucleus that yields the most energy.



CHAIN REACTION

Nuclear Reactors

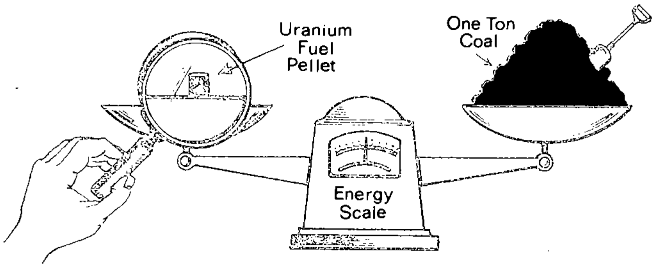
A nuclear reactor is a kind of giant steel teakettle which contains the heat energy released by the fissioning fuel. This heat energy is used to create steam to spin a turbine, just as with a fossil fuel boiler.

Remember that isotopes are atoms that vary in the number of neutrons they contain. The U-235 isotope of uranium has 143 neutrons and 92 protons in its nucleus. Most of the uranium found in nature is U-238 with 92 protons *but* with 146 neutrons. U-235 is important because it provides the fuel which is used in nuclear reactors.

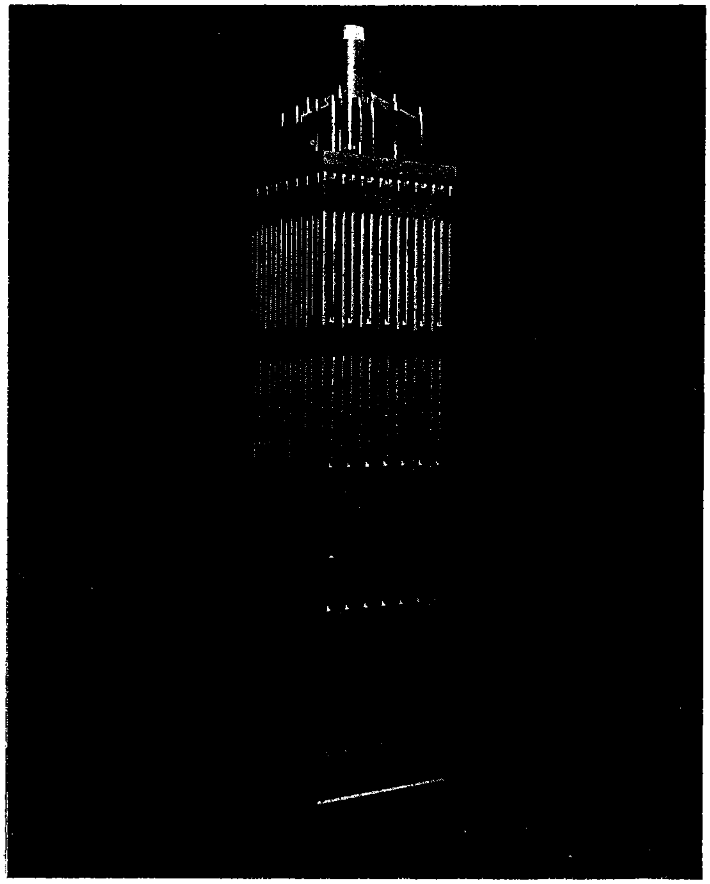
Obviously, uranium fuel used in a reactor isn't burned in the same sense as fossil fuels. The nuclear reactor must be fueled with great care and technical accuracy.

Fueling A Reactor

Uranium fuel for a reactor is made in the form of small cylindrical pellets, each about one-half inch in diameter and 3/4 inches in length. Each pellet releases the same amount of energy as *one ton* of coal!



The powerful little pellets are loaded end-to-end into metal tubes that range from 8 to 12 feet in length depending upon the type of reactor. The tubes are then assembled into square-shaped bundles containing from five to over 140 tubes. These are called "Fuel Assemblies".



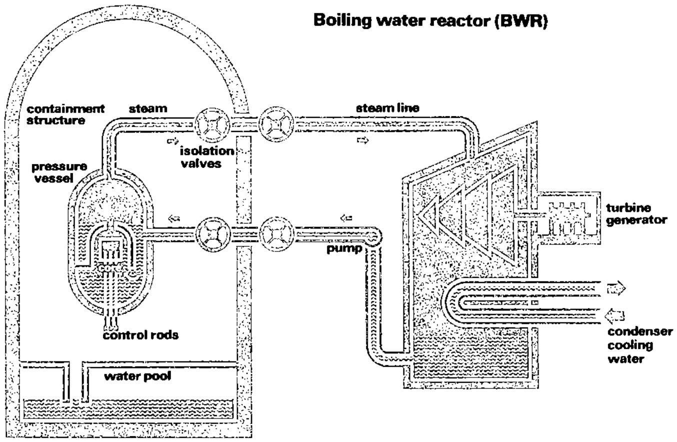
At the reactor, fuel bundles are carefully loaded into specially constructed slots or racks. The complete fuel load, or "core", is composed of several hundred bundles which, when viewed from above, look like a crossword puzzle.

The core is located in the center of a large steel container, with walls several inches thick. This is the reactor "vessel". It is filled with water at all times to keep the core completely submerged. The fuel core and vessel make up the nuclear reactor.

How Reactors Work

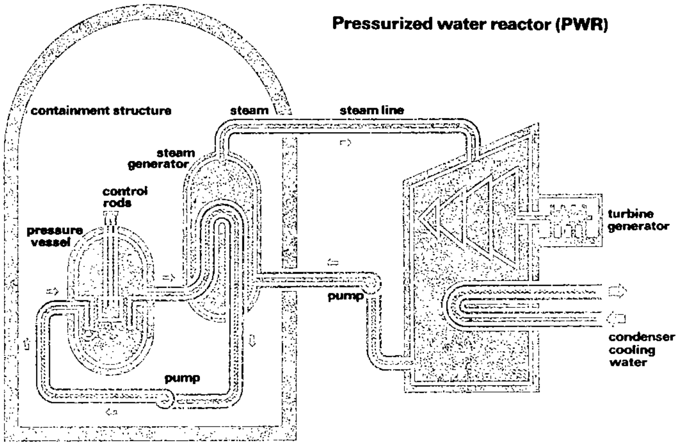
Once loaded with fuel and water, the reactor is ready for the chain reaction to begin. As the fuel heats up, so does the water surrounding it. The heated water is used to produce steam in two different ways, depending upon the type of reactor system used.

Boiling Water Reactors turn water in the reactor into steam in the reactor vessel. From the vessel, steam goes directly to the turbine, is condensed back into water and returned to the reactor. This cycle or "loop" of water continues with none of the water leaving the plant.



Pressurized Water Reactors are a bit different. Like pressure cookers used at home, they utilize the fact that water will not turn into steam — even when its temperature is raised above 212° Farenheit — if it is held under high pressure.

In this system, water subjected to 2250 pounds per square inch of pressure can reach a temperature of 600 degrees Farenheit without boiling. This super-heated water goes to a "heat-exchanger" or steam generator where it flows through hundreds of small pipes. The pipes are bathed in water from another source. This water absorbs heat and turns into steam to power the turbines. Thus, there are two complete water cycles in this system.



Measures of Control

In a fossil fuel plant, the heat in the boiler is easy to control, simply by reducing the fuel being delivered. But in a nuclear reactor the same amount of fuel is always present. So how do we control the amount of heat produced? The answer is that one-hundred or more "control rods" are used to limit the reactor's heat output. These metal rods absorb neutrons and thus control how many neutrons remain flying around in the core. This slows down the chain reaction.