Name: ________________________ Period: _____

Energy Source: Biomass

Biomass is matter usually thought of as garbage. Some of it is just stuff lying around -- dead trees, tree branches, yard clippings, left-over crops, wood chips (like in the picture to the right), and bark and sawdust from lumber mills. It can even include used tires and livestock manure.

Photo credit:
U.S. Department of Energy,
Energy Efficiency & Renewable
Energy Network (EREN)

Your trash, paper products that can't be recycled into other paper products, and other household waste are normally sent to the dump. Your trash contains some types of biomass that can be reused. Recycling biomass for fuel and other uses cuts down on the need for "landfills" to hold garbage.

This stuff nobody seems to want can be used to produce electricity, heat, compost material or fuels. Composting material is decayed plant or food products mixed together in a compost pile and spread to help plants grow.

California produces more than 60 million bone dry tons of biomass each year. Of this total, five million bone dry tons is now burned to make electricity. This is biomass from lumber mill wastes, urban wood waste, forest and agricultural residues and other feed stocks.

If all of it was used, the 60 million tons of biomass in California **could** make close to 2,000 megawatts of electricity for California's growing population and economy. That's enough energy to make electricity for about two million homes!

How biomass works is very simple. The waste wood, tree branches and other scraps are gathered together in big trucks. The trucks bring the waste from factories and from farms to a biomass power plant. Here the biomass is dumped into huge hoppers. This is then fed into a furnace where it is burned. The heat is used to boil water in the boiler, and the energy in the steam is used to turn turbines and generators.

Biomass Power Plant - Photo credit:
U.S. Department of Energy,
Energy Efficiency & Renewable
Energy Network (EREN)

Biomass can also be tapped right at the landfill with burning waster products. When garbage decomposes, it gives off methane gas. Natural gas is made up of methane. Pipelines are put into the landfills and the methane gas can be collected. It is then used in power plants to make electricity. This type of biomass is called landfill gas.

A similar thing can be done at animal feed lots. In places where lots of animals are raised, the animals - like cattle, cows and even chickens - produce manure. When manure decomposes, it also gives off methane gas similar to garbage. This gas can be burned right at the farm to make energy to run the farm.

Using biomass can help reduce global warming compared to a fossil fuel-powered plant. Plants use and store carbon dioxide (CO_2) when they grow. CO_2 stored in the plant is released when the plant material is burned or decays. By replanting the crops, the new plants can use the CO_2 produced by the burned plants. So using biomass and replanting helps close the carbon dioxide cycle. However, if the crops are not replanted, then biomass can emit carbon dioxide that will contribute toward global warming.

So, the use of biomass can be environmentally friendly because the biomass is reduced, recycled and then reused. It is also a renewable resource because plants to make biomass can be grown over and over.

Today, new ways of using biomass are still being discovered. One way is to produce ethanol, a liquid alcohol fuel. Ethanol can be used in special types of cars that are made for using alcohol fuel instead of gasoline. The alcohol can also be combined with gasoline. This reduces our dependence on oil - a non-renewable fossil fuel.

Source: http://www.energyquest.ca.gov/story/chapter10.html

Name: _________________________ Period: _____

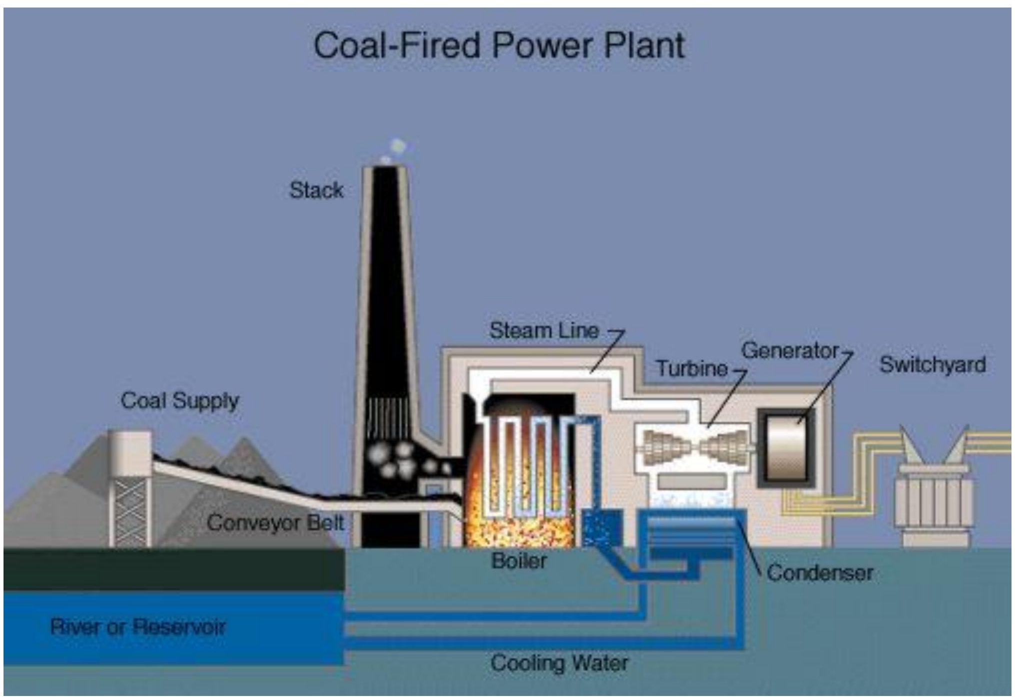
Energy Source: Coal (Fossil Fuel)

Most of the electricity that Tennessee Valley Authority (TVA) makes is generated at the 11 coal-fired power plants that TVA runs across the Tennessee Valley. These plants burn coal to make electricity. They are also called "fossil" plants because the coal they burn was formed from the remains of prehistoric plants.

TVA's Cumberland Fossil

TVA built the first of its 11 large fossil plants in the 1940s, and today these plants produce 100.1 billion kilowatt-hours of electricity—64 percent of the electricity TVA makes.

How does a fossil plant work?
Electricity is made at a fossil plant by burning coal, which heats water in a boiler to produce steam. The steam, under a lot of pressure, flows into a turbine, and the turbine spins a generator to make electricity. (See a diagram of a coal-fired power plant.)



TVA's Kingston Plant near Knoxville, Tennessee, is a good example of a fossil plant. It generates about 10 billion kilowatt-hours a year, or enough electricity to supply 700,000 homes. To meet this demand, Kingston burns about 14,000 tons of coal a day, an amount that would fill 140 railroad cars.

Coal use and the environment
The burning of coal to produce power can help cause air pollution. Scientists have also linked fossil plants to climate change, the gradual, possibly harmful, warming of the world's climate. The Tennessee Valley Authority is among the world leaders in finding ways to help control environmental damage from fossil plants.

What is coal?
Coal is a rocklike mineral found in beneath Earth's surface that can be burned to release energy.

Millions of years ago large quantities of dead plants collected and slowly began to decay. This happened most often in wet, swampy areas, where the decaying plants turned into a spongy brown material called peat.

Over millions of years this peat came to be buried deep under Earth's surface, where it was pushed together and heated up by the weight of Earth's surface above it. The compressed peat finally turned into coal.

People have been mining and burning coal to produce heat (and later, power) for many centuries. Today, about half the world's six billion people cook their food and heat their homes with coal.

Coal is easy to find and inexpensive. In the United States, we use coal to create about 50 percent of the electricity we use. TVA is the largest single utility buyer of coal in the U.S. It bought almost 45 million tons in 2001.

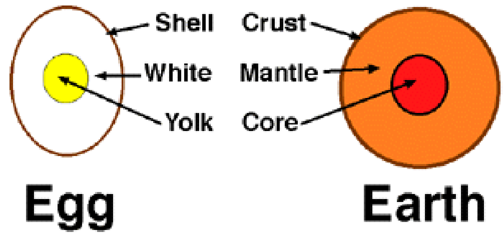
Source: http://www.tvakids.com/electricity/fossil.htm
(Permission Granted by: http://www.tvakids.com/teachers/resources.htm .: "These materials can be used to enrich any science curriculum and are graded for students at all levels".)

Name: ________________________ Period: _____

Energy Source: Geothermal

Geothermal Energy has been around for as long as the Earth has existed. "Geo" means earth, and "thermal" means heat. So, geothermal means earth-heat.

Have you ever cut a boiled egg in half? The egg is similar to how Earth looks like inside. The yellow yolk of the egg is like the core of Earth. The white part is the mantle of Earth. And the thin shell of the egg, that would have surrounded the boiled egg if you didn't peel it off, is like Earth's crust.



Below the crust of Earth, the top layer of the mantle is a hot liquid rock called magma. The crust of Earth floats on this liquid magma mantle. When magma breaks through the surface of Earth in a volcano, it is called lava.

For every 100 meters you go below ground, the temperature of the rock increases about 3 degrees Celsius. Or for every 328 feet below ground, the temperature increases 5.4 degrees Fahrenheit. So, if you went about 10,000 feet below ground, the temperature of the rock would be hot enough to boil water.

Deep under the surface, water sometimes makes its way close to the hot rock and turns into boiling hot water or into steam. The hot water can reach temperatures of more than 300 degrees Fahrenheit (148 degrees Celsius). This is hotter than boiling water (212 degrees F / 100 degrees C). It doesn't turn into steam because it is not in contact with the air.

When this hot water comes up through a crack in Earth's surface, we call it a hot spring, like Emerald Pool at Yellowstone National Park or, it sometimes explodes into the air as a geyser, like Old Faithful Geyser pictured on the right.

Photo Credit: National Park Service

About 10,000 years ago, Paleo-Indians used hot springs in North American for cooking. Areas around hot springs were neutral zones. Warriors of fighting tribes would bathe together in peace. Every major hot spring in the United States can be associated with Native American tribes. California hot springs, like at the Geysers in the Napa area, were important and sacred areas to tribes from that area.

In other places around the world, people used hot springs for rest and relaxation. The ancient Romans built elaborate buildings to enjoy hot baths, and the Japanese have enjoyed natural hot springs for centuries.

Photo Credit: California Energy Commission

Geothermal Today

Today, people use the geothermally heated hot water in swimming pools and in health spas. Or, the hot water from below the ground can warm buildings for growing plants, like in the green house on the right.

In San Bernardino, California, hot water from below ground is used to heat buildings during the winter. The hot water runs through miles of insulated pipes to dozens of public buildings. The City Hall, animal shelters, retirement homes, state agencies, a hotel and convention center are some of the buildings which are heated this way. In the country of Iceland, many of the buildings and even swimming pools in the capital of Reykjavik (RECK-yah-vick) and elsewhere are heated with geothermal hot water. The country has at least 25 active volcanoes and many hot springs and geysers.

Geothermal Electricity

Hot water or steam from below ground can also be used to make electricity in a geothermal power plant. In California, there are 14 areas where we use geothermal energy to make electricity. The red areas on the map show where there are known geothermal areas. Some are not used yet because the resource is too small, too isolated or the water temperatures are not hot enough to make electricity.

Some of the areas have so much steam and hot water that it can be used to generate electricity. Holes are drilled into the ground and pipes lowered into the hot water, like a drinking straw in a soda. The hot steam or water comes up through these pipes from below ground.

Photo credit: California Energy Commission

A geothermal power plant is like in a regular power plant except that no fuel is burned to heat water into steam. The steam or hot water in a geothermal power plant is heated by Earth’s underground heat. It goes into a special turbine. The turbine blades spin and the shaft from the turbine is connected to a generator to make electricity. The steam then gets cooled off in a cooling tower. The white "smoke" rising from the plants in the photograph above is not smoke. It is steam given off in the cooling process. The cooled water can then be pumped back below ground to be reheated by Earth’s underground heat. The hot water flows into turbine and out of the turbine. California's geothermal power plants produce about one-half of the world's geothermally generated electricity. The geothermal power plants produce enough electricity for about two million homes.

Geothermal / Ground Source Heat Pumps

Though it gets much hotter as we go deep below ground, the upper layer of Earth close to the surface is not very hot. Almost everywhere across the entire planet, the upper 10 feet below ground level stays the same temperature, between 50 and 60 degrees Fahrenheit (10 and 16 degrees C). If you've ever been in a basement of a building or in a cavern below ground, the temperature of the area is almost always cool.

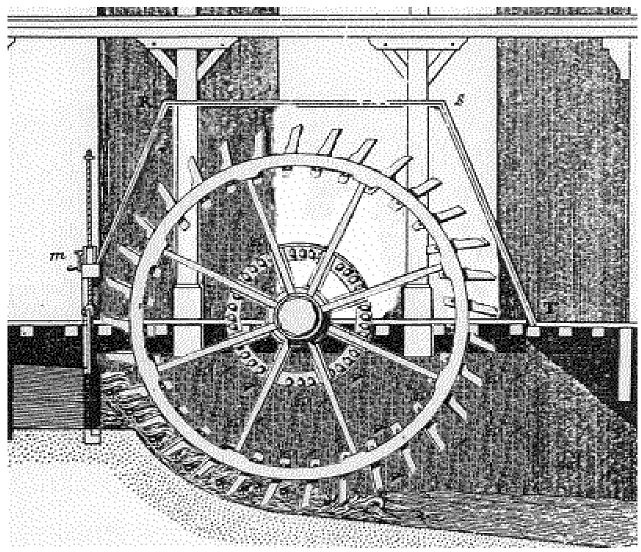
A geothermal or ground source heat pump system can use that constant temperature to heat or cool a building. Pipes are buried in the ground near the building. Inside these pipes a fluid, like the antifreeze in a car radiator, is circulated. In winter, heat from the warmer ground goes through the heat exchanger of a heat pump, which sends warm air into the home or business. During hot weather, the process is reversed. Hot air from inside the building goes through the heat exchanger and the heat is passed into the relatively cooler ground. Heat removed during the summer can also be used to heat water.

Source: http://www.energyquest.ca.gov/story/chapter11.html

Name: ________________________ Period: _____

Energy Source: Hydro (Water)

When it rains in hills and mountains, the water becomes streams and rivers that run down to the ocean. The moving or falling water can be used to do work. Energy, you'll remember is the ability to do work. So moving water, which has kinetic energy, can be used to make electricity.



For hundreds of years, moving water was used to turn wooden wheels that were attached to grinding wheels to grind (or mill) flour or corn. These were called grist mills or water mills.

In the year 1086, the **Domesday Book** was written. The multi-volume books are very large. Hand-written on the pages of the books are lists of all properties, homes, stores and other things in England. The Domesday Book listed 5,624 waterwheel-driven mills in England south of the Trent River. That was about one mill for each 400 people.

Photo credit: Pond Lily Mill Restorations

Water can either go over the top of the wheel like in the photograph on the left, or the wheel can be placed in the moving river. The flow of the river then turns the wheel at the bottom like in the graphic above.

Today, moving water can also be used to make electricity.

Hydro means *water*. Hydro-electric means *making electricity from water power.*

Hydroelectric power uses the kinetic energy of moving water to make electricity. Dams can be built to stop the flow of a river. Water behind a dam often forms a reservoir Like the picture of Shasta Dam in Northern California pictured on the right. Dams are also built across larger rivers but no reservoir is made. The river is simply sent through a hydroelectric power plant or powerhouse. You can see this in the picture (see back of page) of The Dalles Dam on the Columbia River along the border of Oregon and Washington State.

Photo credit: U.S. Bureau of Reclamation

Hydro is one of the largest producers of electricity in the United States. Water power supplies about

10 percent of the entire electricity that we use. In states with high mountains and lots of rivers, even more electricity if made by hydro power. In California, for example, about 15 percent of all the electricity comes from hydroelectric.

The state of Washington leads the nation in hydroelectricity. The Grand Coulee, Chief Joseph and John Day dams are three of six major dams on the Columbia River. About 87 percent of the electricity made in Washington state is produced by hydroelectric facilities. Some of that electricity is exported from the state and used in other states.

How a Hydro Dam Works

Photo credit: U.S. Bureau of Reclamation

The water behind the dam flows through the intake and into a pipe called a penstock. The water pushes against blades in a turbine, causing them to turn. The turbine is similar to the kind used in a power plant. But instead of using steam to turn the turbine, water is used.

The turbine spins a generator to produce electricity. The electricity can then travel over long distance electric lines to your home, to your school, to factories and businesses.

Hydro power today can be found in the mountainous areas of states where there are lakes and reservoirs and along rivers

Source: http://www.energyquest.ca.gov/story/chapter12.html

Name: ________________________ Period: _____

Energy Source: Natural Gas (Fossil Fuel)

Sometime between 6,000 to 2,000 years BCE (Before the Common Era), the first discoveries of natural gas seeps were made in Iran. Many early writers described the natural petroleum seeps in the Middle East, especially in the Baku region of what is now Azerbaijan. The gas seeps, probably first ignited by lightning, provided the fuel for the "eternal fires" of the fire-worshiping religion of the ancient Persians.

Natural gas is lighter than air. Natural gas is mostly made up of a gas called methane. Methane is a simple chemical compound that is made up of carbon and hydrogen atoms. Its chemical formula is CH_4 - one atom of carbon along with four atoms hydrogen. This gas is highly flammable.

Photo courtesy: corbisimages.com

Natural gas is usually found near petroleum underground. It is pumped from below ground and travels in pipelines to storage areas.

Natural gas usually has no odor and you can't see it. Before it is sent to the pipelines and storage tanks, it is mixed with a chemical that gives a strong odor. The odor smells almost like rotten eggs. The odor makes it easy to smell if there is a leak.

Natural gas is a fossil fuel. It is a gaseous molecule that's made up of two atoms - one carbon atom combined with four hydrogen atom. Its chemical formula is CH_4.

Don't confuse natural gas with "gasoline," which we call "gas" for short. Like oil, natural gas is found under ground and under the ocean floor. Wells are drilled to tap into natural gas reservoirs just like drilling for oil. Once a drill has hit an area that contains natural gas, it can be brought to the surface through pipes. The natural gas has to get from the wells to us. To do that, there is a huge network of pipelines that brings natural gas from the gas fields to us. Some of these pipes are two feet wide.

Natural gas is sent in larger pipelines to power plants to make electricity or to factories because they use lots of gas. Bakeries use natural gas to heat ovens to bake bread, pies, pastries and cookies. Other businesses use natural gas for heating their buildings or heating water.

From larger pipelines, the gas goes through smaller and smaller pipes to your neighborhood. In businesses and in your home, the natural gas must first pass through a meter, which measures the amount of fuel going into the building. A gas company worker reads the meter and the company will charge you for the amount of natural gas you used. In some homes, natural gas is used for cooking, heating water and heating the house in a furnace.

In rural areas, where there are no natural gas pipelines, propane (another form of gas that's often made when oil is refined) or bottled gas is used instead of natural gas. Propane is also called LPG, or liquefied petroleum gas, is made up of methane and a mixture with other gases like butane.

Propane turns to a liquid when it is placed under slight pressure. For regular natural gas to turn into a liquid, it has to be made very, very cold.

Cars and trucks can also use natural gas as a transportation fuel, but they must carry special cylinder-like tanks to hold the fuel.


Photo credit: Southern California Gas Company

When natural gas is burned to make heat or burned in a car's engine, it burns very cleanly. When you combine natural gas with oxygen (the process of combustion), you produce carbon dioxide and water vapor; plus the energy that's released in heat and light.

Some impurities are contained in all natural gas. These include sulphur and butane and other chemicals. When burned, those impurities can create air pollution. The amount of pollution from natural gas is less than burning a more "complex" fuel like gasoline. Natural gas-powered cars are more than 90 percent cleaner than a gasoline-powered car. That's why many people feel natural gas would be a good fuel for cars because it burns cleanly.

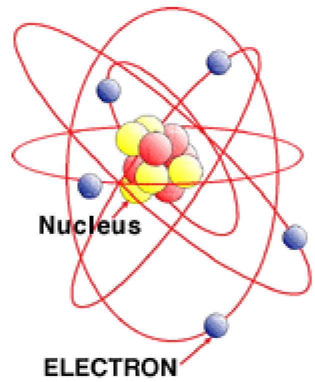
Source: http://www.energyquest.ca.gov/story/chapter09.html

Name: ________________________ Period: _____

Energy Source: Nuclear - Fission and Fusion

Another major form of energy is nuclear energy, the energy that is trapped inside each atom. One of the laws of the universe is that matter and energy can't be created nor destroyed. But they can be changed in form and matter can be changed into energy. The world's most famous scientist, Albert Einstein, created the mathematical formula that explains this. It is: $\mathbf{E = m\,c^2}$

This equation says: **E** [energy] equals **m** [mass] times $\mathbf{c^2}$ [**c** stands for the velocity or the speed of light. $\mathbf{c^2}$ means c times c, or the speed of light raised to the second power -- or c-squared.] (You can listen to Einstein's voice explaining this at: www.aip.org/history/einstein/voice1.htm)



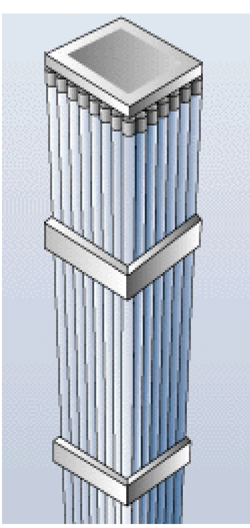
Scientists used Einstein's famous equation as the key to unlock atomic energy and also create atomic bombs. The ancient Greeks said the smallest part of nature is an atom. But they did not know 2,000 years ago about nature's even smaller parts. Atoms are made up of smaller particles -- a nucleus of protons and neutrons, surrounded by electrons which swirl around the nucleus much like Earth revolves around the Sun.

Nuclear Fission

An atom's nucleus can be split apart. When this is done, a tremendous amount of energy is released. The energy is both heat and light energy. Einstein said that a very small amount of matter contains a very LARGE amount of energy. This energy, when let out slowly, can be harnessed to generate electricity. When it is let out all at once, it can make a tremendous explosion in an atomic bomb.

Photo credit: Pacific Gas & Electric Company

A nuclear power plant (like Diablo Canyon Nuclear Plant shown on the right) uses uranium as a "fuel." Uranium is an element that is dug out of the ground many places around the world. It is processed into tiny pellets that are loaded into very long rods that are put into the power plant's reactor.



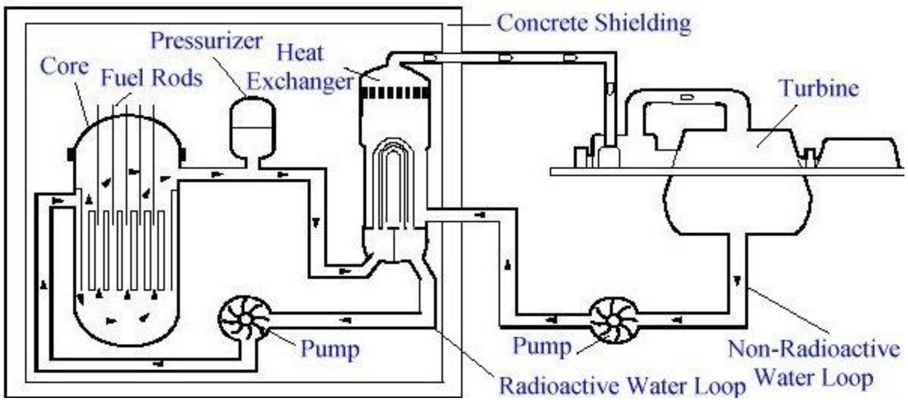
The word fission means to split apart. Inside the reactor of an atomic power plant, uranium atoms are split apart in a controlled chain reaction.

In a chain reaction, particles released by the splitting of the atom go off and strike other uranium atoms splitting those. Those particles given off split still other atoms in a chain reaction. In nuclear power plants, control rods are used to keep the splitting regulated so it doesn't go too fast.

If the reaction is not controlled, you could have an atomic bomb. But in atomic bombs, almost pure pieces of the element Uranium-235 or Plutonium, of a precise mass and shape, must be brought together and held together, with great force. These conditions are not present in a nuclear reactor.

The reaction also creates radioactive material. This material could hurt people if released, so it is kept in a solid form. The very strong concrete dome in the picture is designed to keep this material inside if an accident happens. This chain reaction gives off heat energy. This heat energy is used to boil water in the core of the reactor. So, instead of burning a fuel, nuclear power plants use the chain reaction of atoms splitting to change the energy of atoms into heat energy.

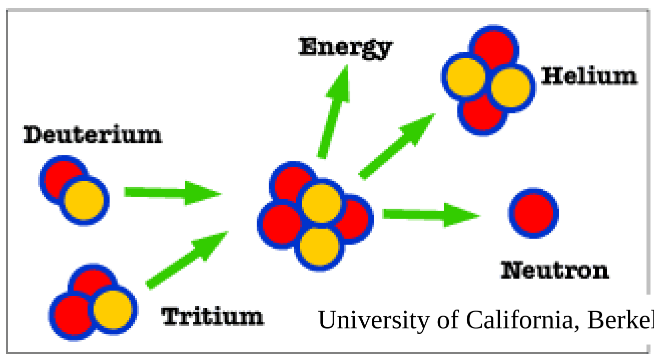
This water from around the nuclear core is sent to another section of the power plant. Here, in the heat exchanger, it heats another set of pipes filled with water to make steam. The steam in this second set of pipes turns a turbine to generate electricity. Below is a cross section of the inside of a typical nuclear power plant.



Power plant drawing courtesy Nuclear Institute

Nuclear Fusion

Another form of nuclear energy is called fusion. Fusion means joining smaller nuclei (the plural of nucleus) to make a larger nucleus. The Sun uses nuclear fusion of hydrogen atoms into helium atoms. This gives off heat and light and other radiation.



University of California, Berkeley

In the picture to the right, two types of hydrogen atoms, deuterium and tritium, combine to make a helium atom and an extra particle called a neutron. Also given off in this fusion reaction is energy.

Scientists have been working on controlling nuclear fusion for a long time, trying to make a fusion reactor to produce electricity. But they have been having trouble learning how to control the reaction in a contained space.

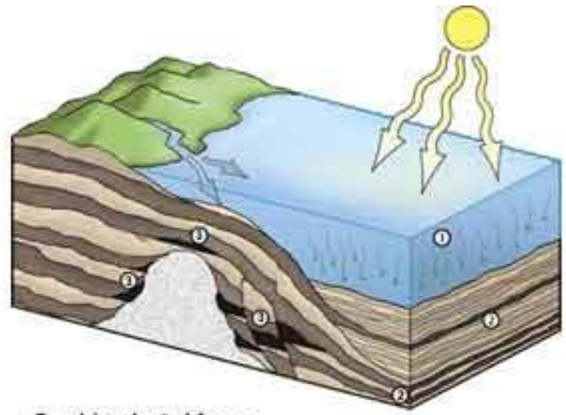
What's better about nuclear fusion is that it creates less radioactive material than fission, and its supply of fuel can last longer than the Sun.

Source: http://www.energyquest.ca.gov/story/chapter13.html

Name: ________________________ Period: _____

Energy Source: Oil or Petroleum (Fossil Fuel)

Oil is another fossil fuel. It was also formed more than 300 million years ago. Some scientists say that tiny diatoms are the source of oil. *Diatoms* are sea creatures the size of a pin head. They do one thing just like plants; they can convert sunlight directly into stored energy.



Graphic adapted from: Paleontological Research Institution

In the graphic on the right, as the diatoms died they fell to the sea floor (1). Here they were buried under sediment and other rock (2). The rock squeezed the diatoms and the energy in their bodies could not escape. The carbon eventually turned into oil under great pressure and heat. As Earth changed and moved and folded, pockets where oil and natural gas can be found were formed (3).

Oil has been used for more than 5,000-6,000 years. The ancient Sumerians, Assyrians and Babylonians used crude oil and asphalt ("pitch") collected from large seeps at Tuttul (modern-day Hit) on the Euphrates River. A seep is a place on the ground where the oil leaks up from below ground. The ancient Egyptians, used liquid oil as a medicine for wounds, and oil has been used in lamps to provide light.

The Dead Sea, near the modern Country of Israel, used to be called Lake Asphaltites. The word asphalt was derived is from that term because of the lumps of gooey petroleum that were washed up on the lake shores from underwater seeps.

In North America, Native Americans used blankets to skim oil off the surface of streams and lakes. They used oil as medicine and to make canoes water-proof. During the Revolutionary War, Native Americans taught George Washington's troops how to treat frostbite with oil.

As our country grew, the demand for oil continued to increase as a fuel for lamps. Petroleum oil began to replace whale oil in lamps because the price for whale oil was very high. During this time, most petroleum oil came from distilling coal into a liquid or by skimming it off of lakes - just as the Native Americans did.

Photo credit: Drake Well Museum, Titusville, PA

Then on August 27, 1859, Edwin L. Drake (the man standing on the right in the black and white picture to the right), struck liquid oil at his well near Titusville, Pennsylvania. He found oil under ground and a way that could pump it to the surface. The well pumped the oil into barrels made out of wood. This method of drilling for oil is still being used today all over the world in areas where oil can be found below the surface.

Oil and natural gas are found under ground between folds of rock and in areas of rock that are porous and contain the oils within the rock itself. The folds of rock were formed as Earth's surface shifts and moves. It's similar to how a small, throw carpet will bunch up in places on the floor.

To find oil and natural gas, companies drill into Earth's surface to the deposits deep below the surface. The oil and natural gas are then pumped from below the ground by oil rigs (like in the picture). They then usually travel through pipelines or by ship.

Photo credit: California Energy Commission

Oil is found in 18 of the 58 counties in California. Kern County, the County where Bakersfield is found, is one of the largest oil production places in the country. But we only get one-half of our oil from California wells. The rest comes from Alaska, and an increasing amount comes from other countries. In the entire U.S., more than 50 percent of all the oil we use comes from outside the country...most of it from the Middle East.

Oil is brought to California by large tanker ships. The petroleum or crude oil must be changed or refined into other products before it can be used.

Photo credit: California History Room, California State Library, Sacramento

Refineries
Oil is stored in large tanks until it is sent to various places to be used. At oil refineries, crude oil is split into various types of products by heating the thick black oil.

Oil is made into many different products - fertilizers for farms, the clothes you wear, the toothbrush you use, the plastic bottle that holds your milk, the plastic pen that you write with. They all came from oil. There are thousands of other products that come from oil. Almost all plastic comes originally from oil. Products include gasoline, diesel fuel, aviation or jet fuel, home heating oil, oil for ships and oil to burn in power plants to make electricity.

Photo credit: California Energy Commission

Source: http://www.energyquest.ca.gov/story/chapter08.html

Name: ________________________ Period: _____

Energy Source: Solar (Sun)

The Sun is our nearest star. Without it, life would not exist on our planet. We use the Sun's energy every day in many different ways. When we hang laundry outside to dry in the Sun, we are using the Sun's heat to do work -- drying our clothes. Plants use the Sun's light to make food. Animals eat plants for food. Decaying plants hundreds of millions of years ago produced the coal, oil and natural gas that we use today. So, fossil fuels is actually sunlight stored millions and millions of years ago.

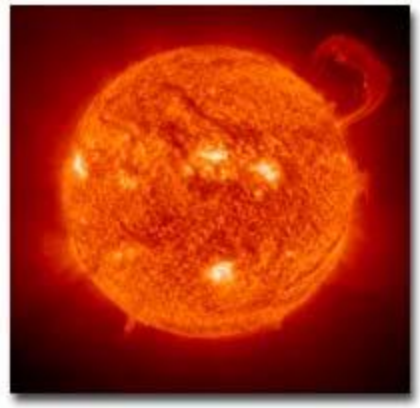


Photo credit: NASA - SOHO Project
Extreme Ultraviolet Imaging Telescope

Indirectly, the Sun or other stars are responsible for ALL our energy. Even nuclear energy comes from a star because the uranium atoms used in nuclear energy were created in the fury of a nova - a star exploding. Let's look at ways in which we can use the Sun's energy.

Solar Hot Water

In the 1890s solar water heaters were being used all over the United States. They proved to be a big improvement over wood and coal-burning stoves. Artificial gas made from coal was available too to heat water, but it cost 10 times the price we pay for natural gas today. And electricity was even more expensive if you even had any in your town!


Photo credit: Ken Butti and John Perlin, *Coevolution Quarterly*, Fall 1977

Many homes used solar water heaters. In 1897, 30 percent of the homes in Pasadena, just east of Los Angeles, were equipped with solar water heaters. As mechanical improvements were made, solar systems were used in Arizona, Florida and many other sunny parts of the United States. The picture shown here is a solar water heater installed on the front roof of a house in Pomona Valley, California, in 1911 (the panels are circled above the four windows).

By 1920, ten of thousands of solar water heaters had been sold. By then, however, large deposits of oil and natural gas were discovered in the western United States. As these low cost fuels became available, solar water systems began to be replaced with heaters burning fossil fuels.

Today, solar water heaters are making a comeback. There are more than half a million of them in California alone! They heat water for use inside homes and businesses. They also heat swimming pools like in the picture. Panels on the roof of a building, like this one on the right, contain water pipes. When the Sun hits the panels and the pipes, the sunlight warms them. That warmed water can then be used in a swimming pool.


Photo credit:
California Energy Commission


Photo credit: California Energy Commission

Solar Thermal Electricity

Solar energy can also be used to make electricity. Some solar power plants, like the one in the picture to the left in California's Mojave Desert, use a highly curved mirror called a parabolic trough to focus the sunlight on a pipe running down a central point above the curve of the mirror. The mirror focuses the sunlight to strike the pipe, and it gets so hot that it can boil water into steam. That steam can then be used to turn a turbine to make electricity.

Photo credit:
U.S. Department of Energy

In California's Mojave desert, there are huge rows of solar mirrors arranged in what's called "solar thermal power plants" that use this idea to make electricity for more than 350,000 homes. The problem with solar energy is that it works only when the Sun is shining. So, on cloudy days and at night, the power plants can't create energy. Some solar plants, are a "hybrid" technology. During the daytime they use the Sun. At night and on cloudy days they burn natural gas to boil the water so they can continue to make electricity.

Another form of solar power plants to make electricity is called a Central Tower Power Plant, like the one to the right - the Solar Two Project. Sunlight is reflected off 1,800 mirrors circling the tall tower. The mirrors are called heliostats and move and turn to face the Sun all day long. The light is reflected back to the top of the tower in the center of the circle where a fluid is turned very hot by the Sun's rays. That fluid can be used to boil water to make steam to turn a turbine and a generator.

This experimental power plant is called Solar II. It was re-built in California's desert using newer technologies than when it was first built in the early 1980s. Solar II will use the sunlight to change heat into mechanical energy in the turbine. The power plant will make enough electricity to power about 10,000 homes. Scientists say larger central tower power plants can make electricity for 100,000 to 200,000 homes.

Solar Cells or Photovoltaic Energy
We can also change the sunlight directly to electricity using solar cells.

Solar cells are also called photovoltaic cells - or PV cells for short - and can be found on many small appliances, like calculators, and even on spacecraft. They were first developed in the 1950s for use on U.S. space satellites. They are made of silicon, a special type of melted sand.

When sunlight strikes the solar cell, electrons (red circles) are knocked loose. They move toward the treated front surface (dark blue color). An electron imbalance is created between the front and back. When the two surfaces are joined by a connector, like a wire, a current of electricity occurs between the negative and positive sides.

These individual solar cells are arranged together in a PV module and the modules are grouped together in an array. Some of the arrays are set on special tracking devices to follow sunlight all day long.

The electrical energy from solar cells can then be used directly. It can be used in a home for lights and appliances. It can be used in a business. Solar energy can be stored in batteries to light a roadside billboard at night. Or the energy can be stored in a battery for an emergency roadside cellular telephone when no telephone wires are around.

Some experimental cars also use PV cells. They convert sunlight directly into energy to power electric motors on the car.

But when most of us think of solar energy, we think of satellites in outer space. Here's a picture of solar panels extending out from a satellite.

Source: http://www.energyquest.ca.gov/story/chapter15.html

Name: ________________________ Period: _____

Energy Source : Wind

Photo credit:
California Energy Commission

Wind can be used to do work. The kinetic energy of the wind can be changed into other forms of energy, either mechanical energy or electrical energy.

When a boat lifts a sail, it is using wind energy to push it through the water. This is one form of work. Farmers have been using wind energy for many years to pump water from wells using windmills like the one on the right. In Holland, windmills have been used for centuries to pump water from low-lying areas. Wind is also used to turn large grinding stones to grind wheat or corn, just like a water wheel is turned by water power.

Today, the wind is also used to make electricity.

Blowing wind spins the blades on a wind turbine -- just like a large toy pinwheel. This device is called a wind turbine and not a windmill. A windmill grinds or mills grain, or is used to pump water.

The blades of the turbine are attached to a hub that is mounted on a turning shaft. The shaft goes through a gear transmission box where the turning speed is increased. The transmission is attached to a high speed shaft which turns a generator that makes electricity.

If the wind gets too high, the turbine has a brake that will keep the blades from turning too fast and being damaged.

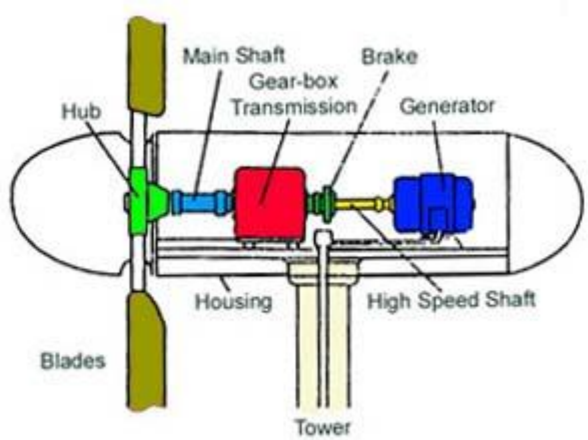


Photo credit: American Wind Energy Association - AWEA

You can use a single smaller wind turbine to power a home or a school. The small turbine on the right makes enough energy for a house. In the picture on the left, the children at this Iowa school are playing beneath a wind turbine that makes enough electricity to power their entire school.

We have many windy areas in California. And wind is blowing in many places all over Earth’s surface. The only problem with wind is that it is not windy all the time. In California, it is usually windier during the summer months when wind rushes inland from cooler areas, like the ocean to replace hot rising air in California's warm central valleys and deserts.

In order for a wind turbine to work efficiently, wind speeds usually must be above 12 to 14 miles per hour. Wind has to be this speed to turn the turbines fast enough to generate electricity. The turbines usually produce about 50 to 300 kilowatts of electricity each. A kilowatt is 1,000 watts (kilo means 1,000). You can light ten 100 watt light bulbs with 1,000 watts. So, a 300 kilowatt (300,000 watts) wind turbine could light up 3,000 light bulbs that use 100 watts!

As of 1999, there were 11,368 wind turbines in California. These turbines are grouped together in what are called wind "farms," like those in Palm Springs in the picture on the right. These wind farms are located mostly in the three windiest areas of the state:

- Altamont Pass, east of San Francisco
- San Gorgonio Pass, near Palm Springs
- Tehachapi, south of Bakersfield

Photo credit: Warren Gretz, Natl. Renewable Energy Lab

Together these three places in California make enough electricity to supply an entire city the size of San Francisco! About 11 percent of the entire world's wind-generated electricity is found in California. Other countries that use a lot of wind energy are Denmark and Germany.

Once electricity is made by the turbine, the electricity from the entire wind farm is collected together and sent through a transformer. There the voltage is increase to send it long distances over high power lines.

Source: http://www.energyquest.ca.gov/story/chapter16.html

Name: ________________________ Period: _____

Energy Source: Fossil Fuels (Coal, Oil, Natural Gas)

Where Fossil Fuels Come From

There are three major forms of fossil fuels: coal, oil and natural gas. All three were formed many hundreds of millions of years ago before the time of the dinosaurs - hence the name fossil fuels. The age they were formed is called the Carboniferous Period. It was part of the Paleozoic Era. "Carboniferous" gets its name from carbon, the basic element in coal and other fossil fuels. At the time, the land was covered with swamps filled with huge trees, ferns and other large leafy plants, similar to the picture above. The water and seas were filled with algae - the green stuff that forms on a stagnant pool of water. Algae is actually millions of very small plants.

As the trees and plants died, they sank to the bottom of the swamps of oceans. They formed layers of a spongy material called peat. Over many hundreds of years, the peat was covered by sand and clay and other minerals, which turned into a type of rock called sedimentary.

More and more rock piled on top of more rock, and it weighed more and more. It began to press down on the peat. The peat was squeezed and squeezed until the water came out of it and it eventually, over millions of years, it turned into coal, oil or petroleum, and natural gas.

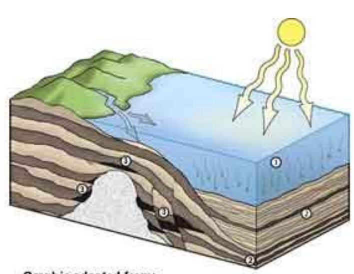
Coal

Coal is a hard, black colored rock-like substance. It is made up of carbon, hydrogen, oxygen, nitrogen and varying amounts of sulphur. Today, the precursor to coal - peat - is still found in many countries and is also used as an energy source. The earliest known use of coal was in China. Coal from the Fu-shun mine in northeastern China may have been used to smelt copper as early as 3,000 years ago. The Chinese thought coal was a stone that could burn.

Photo credit:
American Coal Foundation

Coal is found in many of the lower 48 states of U.S. and throughout the rest of the world. Coal is mined out of the ground using various methods. Some coal mines are dug by sinking vertical or horizontal shafts deep under ground, and coal miners travel by elevators or trains deep under ground to dig the coal. Other coal is mined in strip mines where huge steam shovels strip away the top layers above the coal. The layers are then restored after the coal is taken away.

The coal is then shipped by train and boats and even in pipelines. In pipelines, the coal is ground up and mixed with water to make what's called slurry. This is then pumped many miles through pipelines. At the other end, the coal is used to fuel power plants and other factories.



Graphic adapted from:
Paleontological Research Institution

Oil or Petroleum

Oil is another fossil fuel. It was also formed more than 300 million years ago. Some scientists say that tiny diatoms are the source of oil. Diatoms are sea creatures the size of a pin head. They do one thing just like plants; they can convert sunlight directly into stored energy.

In the graphic on the left, as the diatoms died they fell to the sea floor (1). Here they were buried under sediment and other rock (2). The rock squeezed the diatoms and the energy in their bodies could not escape. The carbon eventually turned into oil under great pressure and heat. As Earth’s surface changed and moved and folded, pockets where oil and natural gas can be found were formed (3).

Oil has been used for more than 5,000-6,000 years. The ancient Egyptians, used liquid oil as a medicine for wounds, and oil has been used in lamps to provide light. The Dead Sea, near the modern Country of Israel, used to be called Lake Asphaltites. The word asphalt was derived is from that term because of the lumps of gooey petroleum that were washed up on the lake shores from underwater seeps.

As our country grew, the demand for oil continued to increase as a fuel for lamps. Petroleum oil began to replace whale oil in lamps because the price for whale oil was very high. During this time, most petroleum oil came from distilling coal into a liquid or by skimming it off of lakes - just as the Native Americans did.

Then on August 27, 1859, Edwin L. Drake struck liquid oil at his well near Titusville, Pennsylvania. He found oil under ground and a way that could pump it to the surface. The well pumped the oil into barrels made out of wood. This method of drilling for oil is still being used today all over the world in areas where oil can be found below the surface.


Photo credit: California Energy Commission

Oil and natural gas are found under ground between folds of rock and in areas of rock that are porous and contain the oils within the rock itself. The folds of rock were formed as Earth's surface shifts and moves. It's similar to how a small, throw carpet will bunch up in places on the floor.

To find oil and natural gas, companies drill into Earth's surface to the deposits deep below the surface. The oil and natural gas are then pumped from below the ground by oil rigs (like in the picture). They then usually travel through pipelines or by ship.

Oil is found in 18 of the 58 counties in California. Kern County, the County where Bakersfield is found, is one of the largest oil production places in the country. But we only get one-half of our oil from California wells. The rest comes from Alaska, and an increasing amount comes from other countries. In the entire U.S., more than 50 percent of all the oil we use comes from outside the country...most of it from the Middle East.

Oil is brought to California by large tanker ships. The petroleum or crude oil must be changed or refined into other products before it can be used.

Natural Gas

Sometime between 6,000 to 2,000 years BCE (Before the Common Era), the first discoveries of natural gas seeps were made in Iran. Many early writers described the natural petroleum seeps in the Middle East, especially in the Baku region of what is now Azerbaijan. The gas seeps, probably first ignited by lightning, provided the fuel for the "eternal fires" of the fire-worshiping religion of the ancient Persians.

Natural gas is lighter than air. Natural gas is mostly made up of a gas called methane. Methane is a simple chemical compound that is made up of carbon and hydrogen atoms. Its chemical formula is CH_4 - one atom of carbon along with four atoms hydrogen. This gas is highly flammable.

Natural gas is usually found near petroleum underground. It is pumped from below ground and travels in pipelines to storage areas. Natural gas usually has no odor and you can't see it. Before it is sent to the pipelines and storage tanks, it is mixed with a chemical that gives a strong odor. The odor smells almost like rotten eggs. The odor makes it easy to smell if there is a leak.

Source: http://www.energyquest.ca.gov/story/chapter08.html