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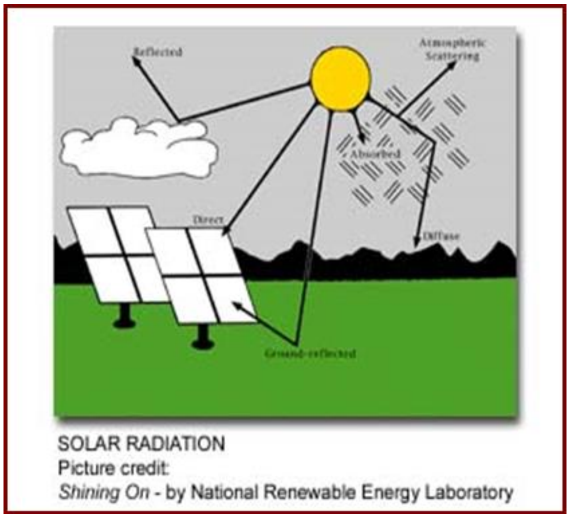
RENEWABLE ENERGY SOURCES - HOW THEY ARE USED

Unit Overview

Renewable sources of energy will be defined and investigated in this unit. Their use in our society to provide our basic needs for electricity, transportation, and heating will be discussed. The process of energy transformations from the source to its use will be noted as well as the efficiency of those transformations. Other energy transformations in common household objects will also be noted.

In the last unit we studied the nonrenewable energy sources, those which exist in limited amounts and cannot easily be replaced. Now we will study the renewable sources – wind, biomass, solar, geothermal, hydro and ocean power. Renewable resources are able to be replenished as long as the sun continues to shine. Although these sources of energy are used to supply only 7.6% of our energy at present, they may one day be the answer to making us less dependent upon foreign energy sources and conserving our limited supply of the nonrenewables. Usually, the renewables are less polluting as well. Scientific research has been ongoing to find a way to make these sources more efficient and less costly to use. The goal is to have **sustainable energy resources**; that is, resources that can continually be replenished and not run out. Within your lifetime, it is nearly certain you will see a great increase in the use of these renewable sources.

Solar Energy



Solar energy is reflected from clouds and the ground.
Some is scattered or absorbed. Only a small amount directly hits solar panels.

The first renewable source is one we are all familiar with, the sun. As we stated earlier, the sun is a huge nuclear reaction sending out radiant energy throughout the solar system. Radiant energy travels in waves that move very fast at 186,000 miles per second. It only takes about 8 minutes for the light from the sun to reach Earth over a distance of 93 million miles. Only a small fraction of the sun's energy strikes Earth because it spreads out from the sun in all directions. But, the amount of solar energy that strikes the United States daily is enough to supply our energy needs for one-and-one-half years.

What happens to all that energy? About 15% hits the earth and is reflected back into space. You have seen light reflect off of water. It can create a glare as it bounces back into your eyes. Another 30% is used to evaporate water from oceans, lakes, and other natural water sources. This water eventually returns to Earth as precipitation. Some energy is absorbed by plants for photosynthesis and by the land and oceans causing them to warm. The remaining energy could be used to supply our energy needs.

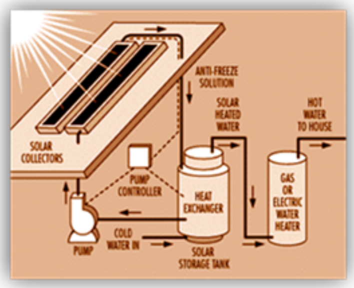
(above) This is an example of a passive solar home. Notice all the south-facing windows and the overhang above them

One of the problems in harnessing solar energy is that it is spread out over the entire surface of Earth, but it needs to be concentrated to produce more heat. If the heat is to be used to heat a home or a building, there are two ways which it can be accomplished. One method is **passive solar heating.** This system uses no special devices, but relies upon the building being designed so it can take advantage of as much sunshine as possible. Of course, the region on Earth in which you live affects the amount of heat that can be generated. If you live in an area where the sun shines often and the weather does not get severely cold, it will be easier to heat your house. With passive solar heating, large windows exist on the south side of the house since, during the winter, the sun travels through the southern section of the sky in the northern hemisphere. Just like a car in the sun, the infrared rays from the sun will enter the windows, be absorbed by material within the house, and radiate heat. Since the heat inside does not readily pass through glass, it is trapped in the house. Often heavy draperies are closed over the windows at night to help keep the heat in. Another way to hold the heat in is to provide a large mass of material within the house to absorb the infrared radiation. Stone or brick can be used in flooring and walls. Often these are quite thick. In addition, some designs allow for pools of water under the floor to absorb this energy. Then, when the sun is not shining, these heated objects radiate heat into the living space. Sometimes deciduous trees or a large overhang exists by these large windows to keep some sun out during hot summer months. The sun is higher in the sky during summer, so the overhang provides some shade, as do the trees. Usually, no windows are placed on the cooler, northern side of the building. Placing the house partially underground also helps it remain warm in the winter.

It is protected from winds, and below the frost line, the Earth stays about 52 degrees Fahrenheit all year round.

Passive solar homes are very quiet because there are no moving parts or machines involved. Energy transformation is from radiant to thermal energy. The sun may provide from 50 to 80% of the heat. A backup system of a furnace or wood-burning stove is usually needed, especially in our part of the country, to add additional heat. Sometimes fans are added to help circulate the heat; the system is then called a hybrid system.

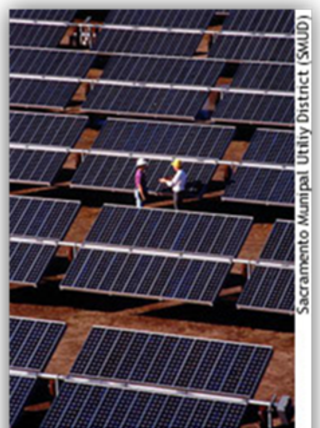
Active solar heating involves the use of mechanical equipment like solar collectors. These are basically boxes with glass covers to trap the heat just like in a car. The bottom of the box is usually a dark color since darker colors absorb more infrared radiation. Pipes inside the collector contain a fluid that absorbs the heat. The fluid is pumped to another location where the heat is transferred to a large tank of fluid or to rock bins beneath the dwelling. The cooled fluid from the collector is then returned to the box to be reheated. Even in active solar heating, back-up heating systems are usually needed in the colder parts of the country. Energy transformation is from radiant to heat although additional electrical energy is needed to operate pumps.



This is a design for an active solar hot water system. The pump circulates the antifreeze. In the heat exchanger the antifreeze cools as it heats the water to be used in the house. The gas or electric water heater adds additional heat if needed.

Active solar homes have solar panels on the south-facing roof.

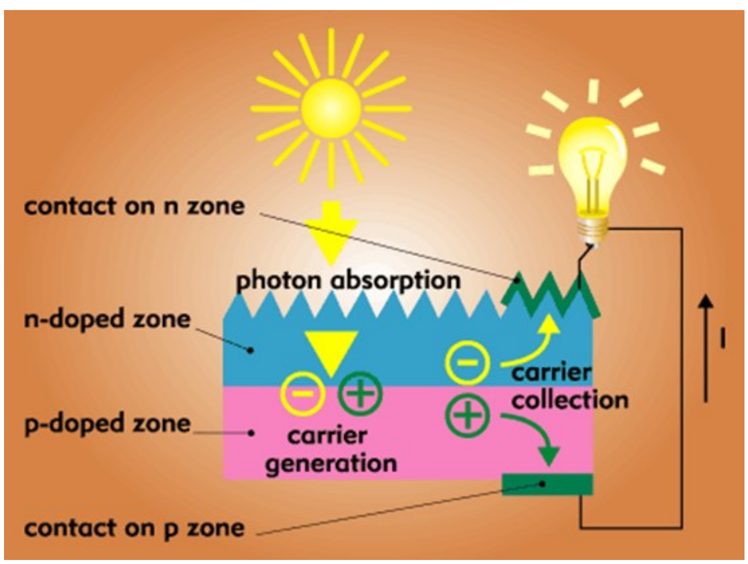
Over one-and-a-half million homes in the U.S. use solar water heaters to heat their water supply or swimming pools. These work much the same as the active solar heating for a house. The collector, located on the roof, heats fluid that is pumped to a storage tank to heat the water there. It is then used for bathing, washing clothes or dishes, or for other purposes. A solar water heater can pay for itself in five years and will last much longer than a conventional water heater. Often, it will last for 15 to 20 years. Heating water is the second most expensive home energy expense. Energy transformation here is a rather simple process, as radiant energy changes to thermal energy.



Photovoltaic technologies, like these flat-plate crystalline silicon arrays, can produce electricity even on cloudy days.

Another use for solar energy is in the production of electricity. You may have a solar calculator or a toy that operates with a solar cell. Call boxes along highways have solar cells to power them. Another name for a solar cell is a photovoltaic cell. If we look at the parts of this word, it will lead us to its meaning. “Photo” is a synonym for light, and “volt” is a way to measure electricity. So, photovoltaic simply means the production of electricity using light. Sometimes the term “photovoltaic cell” is shortened to PV cell. These cells use a thin sliver of silicon in which a small amount of phosphorus is added to half of the silicon slices and boron is added to the other half. The phosphorus layers have some easily moved electrons and are known as the n-layers. The boron layers have the ability to attract electrons and are known as the p-layers. These two types of layers are sandwiched together in a PV cell, and some electrons move from the n-layer to the p-layer. This makes the n-layer positive because it lost negative electrons. The p-layer is negative because it gained electrons. When radiant energy strikes this cell, it causes electrons in the region between the two layers to move toward the positive n-layer.

If a wire is attached to these layers, it provides a path on which the electrons can flow and an electric current is created. This is not a very efficient process, with only about 10 to 14% of the energy being used to create electricity. For small portable applications, like calculators, or supplying electricity in regions where it is hard to string lines, the PV cell can be useful. Scientists are still working to make these cells more efficient so they can be used in more places. Energy transformation would be radiant energy transformed to electricity.



Operation of a photovoltaic cell

	
Solar parabolic troughs heat fluid in the tube in the center which is then used to heat water to produce steam to make electricity.	**A solar power tower receives concentrated sunlight from the mirrors surrounding it. The heat warms the fluid inside the tower that is used to boil water to make electricity.**

Another way to create electricity using solar energy is with devices that concentrate the sun's rays. There are three ways this is being done: parabolic troughs, power towers, and dish/engine systems. These work best in dry, hot areas where sunlight is plentiful, as in desert areas. The Mohave Desert in California has the world's largest **parabolic trough**. The trough is a curved mirror that focuses the sun on a pipe in the center of the curve. Fluid inside the pipe is heated and sent to a heat exchanger where water is turned into steam and drives a turbine attached to an electric generator. **Power towers** use large rotating mirrors that follow the sun's path. The sunlight is focused on a fluid-filled panel. The fluid is then sent to heat water in the same manner as the parabolic trough. **Dish/engine systems** have mirrors shaped like satellite dishes that focus sunlight on a heat engine that produces electricity. These units are often mobile and can be moved into remote areas. Energy transformations here would be radiant to heat to mechanical, and, finally, to electrical.

Solar energy is useful because it is available everywhere, although it is more constant in some climates than in others, and it creates no pollution. However, the manufacturing of PV cells can create some pollution. Also, large solar farms in desert areas must be well-managed so they do not affect the desert ecosystem.

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

Biomass

Biomass is any matter that comes from a living source, whether plant or animal. It is probably the oldest source of energy. For thousands of years, people have been heating and cooking with wood. It is also the most used source of the renewables, supplying about 3.6% of our current energy needs. The energy in biomass is stored chemical energy placed there, originally, by the process of photosynthesis. If the biomass is an animal byproduct, it came from what the animal ate, which can be eventually traced back to plants. Examples of biomass are wood and wood wastes like chips and sawdust, agricultural waste like corn cobs and fruit pits, solid waste or garbage, landfill gas, biogas, and alcohol fuels.

Most biomass (over 75%) comes from the lumber industry, including paper mills and saw mills. Often the companies that create this waste use it to produce heat to generate electricity. This may supply up to one-half of their energy needs. It also saves on disposal costs because they are using up wastes. Garbage which contains biomass and waste plastic and rubber has about 25% of the energy content of coal. Waste-to-energy plants are power plants that burn garbage to generate electricity or to generate heat. This is a more expensive way to generate electricity, but it reduces the amount of material we add to landfills.

Landfills themselves generate methane gas through the action of bacteria and fungi. This gas must be trapped because it can cause explosions and fires, and it also contributes to global warming. The gas is either burned off into the air, which releases carbon dioxide or it is used as natural gas once it is purified. A plant in Florence, Alabama, does just that and pumps it into the city's gas lines. Although burning this gas creates carbon dioxide, methane is a greater threat to global warming than carbon dioxide. Also, since this gas came from a recently living plant that used carbon dioxide for photosynthesis, it is simply completing a cycle, and the carbon dioxide will soon be used again in green plants.

Another way to produce methane from biomass is with **biogas digesters**. These are airtight containers or pits lined with steel or bricks. Wastes are put into them and fermentation occurs in the absence of oxygen. The result is methane gas that is safe for cooking, heating, and lighting. These digesters hold great promise for third world countries as an energy source. Using digesters may help slow deforestation and reduce air pollution, and the material left can be used to fertilize fields for agriculture.

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

Harvesting corn to make ethanol

Ethanol can be made by using biomass. Ethanol is a clean-burning alcohol that can be used as a gasoline additive producing a cleaner burning gasoline. There are two processes that can be used. One is **fermentation,** using yeast to convert sugars and starch in a plant, generally corn, to alcohol. This is the same process used to produce wine, beer, and liquor. The other process, which is still in the development stage, is using **enzymes** to break down cellulose in woody fibers that can then be converted to alcohol. An enzyme is a chemical found in organisms that makes a reaction occur more quickly. This process would also use more of the plant. Biologists are developing fast-growing trees which could be used as a source of cellulose, and would be ready to harvest in ten years. Another source is perennial grasses that could be harvested twice a year and used for ethanol production. Perennial plants are those that live for many years. These plants could also prevent soil erosion, since they would be mowed and not totally destroyed when harvested. These plants require less fertilizer and attention than corn. Today there are over 50 factories that make ethanol in the U.S., and more are being planned.

Another source of fuel using biomass is biodiesel. In this case, ethanol is mixed with vegetable oil, animal fat, or recycled cooking oil. It can be used directly in diesel engines or added to gasoline to reduce emissions. Just think of all the cooking oil that is disposed of by fast-food restaurants that could be used to fuel vehicles instead of being thrown away. Energy conversion, in all of these fuels, is from chemical to thermal.

Hydropower and Ocean Power

The second most-used renewable energy source in the U.S. is hydropower. Hydropower is harnessing the mechanical energy of falling water and converting it to electricity using turbines and generators. Years ago hydropower was used to grind grain, drive sawmills, and pump water using water wheels. You may have seen water wheels at an old grist mill. There are some still in operation at historic sites. The wheel has pockets in it which catch flowing water, often from a mill pond that is somewhat higher than the wheel. As gravity lowers the wheel, the mechanical motion is used for the purposes stated above. Today there are other ways of doing these jobs, but we still use the power of falling water, either from natural waterfalls or dams, to produce about 8% of our electricity. It is the largest renewable source used to produce electricity. In Oregon and Washington states it supplies 85% of the electricity!

Dams provide potential energy differences

Niagara Falls was the site for the first hydroelectric power plant in the U.S. Built in 1879, this plant took advantage of a natural waterfall. Using natural falls severely limits the location of hydroelectric plants. However, dams can be built to provide an artificial reservoir to store water at a higher level than the dam and has the same effect. In either case, a large tube, called a penstock, carries the falling water to the turbine. This mechanical energy is then transferred to generators to create electrical energy. Two factors, the height the water drops and how fast the water is flowing, determine the amount of electricity that can be produced.

Huge amounts of potential energy are released as water flows over Niagara Falls.

The biggest advantage to hydroelectric power is energy can be stored in the water behind the dam. This is gravitational potential energy because the water has the ability to fall to a lower level. This water can be stored indefinitely and released only when electricity is needed. Electricity, once generated, cannot be stored but must be sent over wires to homes, businesses, and factories. Hydropower is also much more efficient than using fossil fuels to produce electricity. Hydropower plants run more often than thermal plants and it is the cheapest way to generate electricity. No fuel needs to be purchased since rain and snow continually replenish the water in the river or reservoir.

There are some disadvantages, however. The creation of a reservoir disrupts the ecosystem, and some animals may die or have to relocate. Silt at the bottom of the river may be stirred up releasing toxins placed there earlier. Water temperatures will be changed since the reservoir is deeper than the original water source. Unless fish ladders are constructed beside the dam, fish, such as salmon, that must go upriver to lay their eggs are prevented from doing so. But, with care, hydroelectric power plants can produce reliable, cheap, and non-polluting energy.

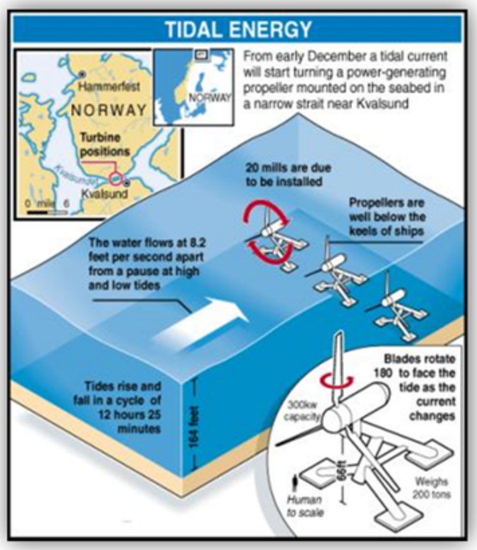
The future for development of more hydropower is limited because the best sites are already in use. These could be expanded, and dams that are now used for flood control or recreational purposes may be able to be converted to hydroelectric power plants.

The oceans cover 70% of the earth; they are abundant and nonpolluting and can be a source of electricity. One way is to harness the mechanical energy of wave action. The best spots for this type of device are in western Scotland, northern Canada, South Africa, Australia, and the northeastern and northwestern United States. Waves result from winds that blow across the surface of the ocean. Devices that harness wave power can be either onshore or offshore. Those that are on the shore are of several types. One uses the waves to push and pull air through a pipe. The moving air moves the blades of a turbine. Another device uses a tapered channel to feed a reservoir behind a dam, but is not in operation at this time. A third uses a rectangular box with a flapping opening that powers a generator. Offshore devices include a pump that operates by the up and down action of waves which creates water pressure to turn a turbine. Another type uses special plastic streamers that create electricity when they are moved about. These are used to power buoys, to recharge robot subs, and possibly can be used to power communications and desalination plants.

More success has been achieved using the energy of tides. Tides are the changing levels of ocean water on shore due to the pull of the moon and sun on the oceans and are repeated four times a day. In order to work properly, the difference in tides must be about 10 to 16 feet. There are a limited number of places on earth where this occurs, namely Brittany in France, Nova Scotia in Canada, and possibly the northeastern and northwestern U.S. The oldest installation is in France and has been in operation since 1968. A low dam called a **barrage** is built. When the tide comes in, one-way gates, called sluices, let the water flow behind the dam. As the tide goes out, water is released through turbines as it flows back out to sea.

Photo credit: *Popular Mechanics*, December 1997.
Top picture shows water flowing from left to right.
Bottom left shows project while under construction.
Right picture shows turbine assembly and baldes.

Tidal energy to electricity at La Rance plant in Brittany in France.



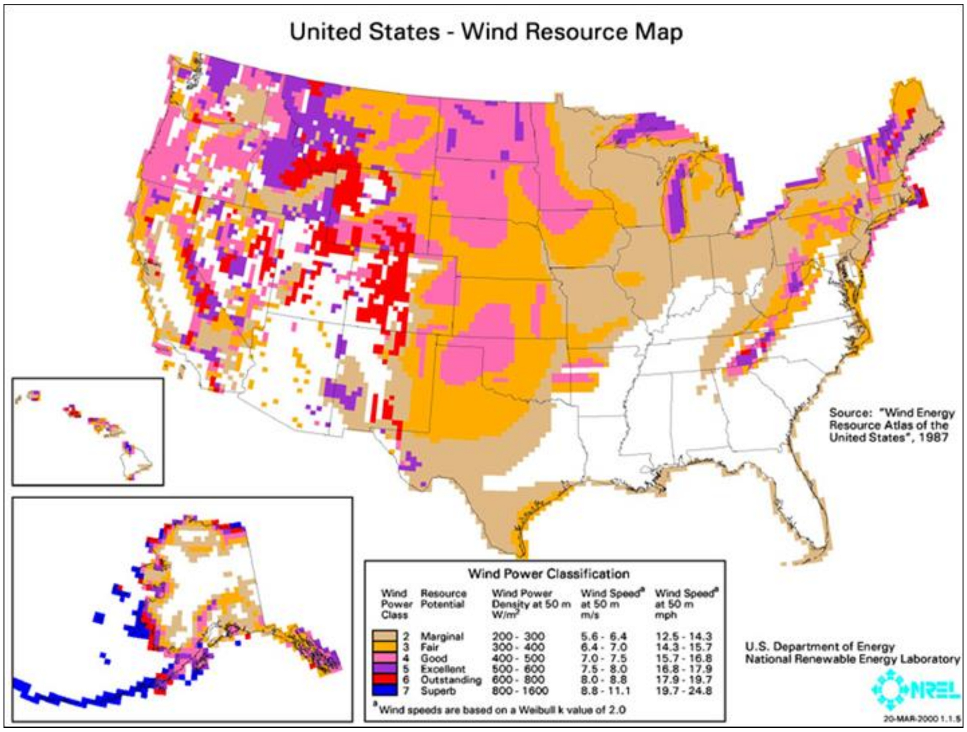
This is a typical use of a barrage to gather water at high tide. As the tide falls the propellers are turned as the water recedes, creating electricity.

Several experimental devices are being tested as possible additional ways to get electricity from the ocean. A tidal turbine would operate underwater at speeds of 4 to 5.5 miles per hour. Also a technology called Ocean Thermal Energy Conversion (OTEC) uses the thermal energy stored in ocean water near the equator. The water temperature difference between the surface water and water deep in the ocean must be at least 38 degrees Fahrenheit. The warm water is used to create steam directly under low pressure or to heat another fluid that vaporizes easily. The vapor or steam is used to turn the turbine. Colder water from deep in the ocean is pumped up to cool the vapor back into a liquid and the cycle begins again. The process is only 2.5% efficient partly because it is difficult to pump the cold water upward. This is also an offshore operation, so the electricity must be transported to land. At present, Hawaii has a test plant in operation experimenting with this process.

Certainly the future will see some of these uses expanded, and we will be using the vast energy of ocean water, both its mechanical and thermal energies, to help supply our energy needs.

Wind

Wind is caused by the uneven heating of Earth's surface by the sun, so as long as the sun shines, we will have wind. However, wind is not constant, and the amount and speed of wind varies in different locations around the world. The following map shows the United States and the regions which have the best winds. As you can see, the coastal areas in the northeast and northwest, Alaska, and parts of the Midwest near the Rocky Mountains appear to be the best areas. Ohio has only marginal or poor wind quality except for a small band along Lake Erie. Areas near water have more wind because the land heats quicker during the day than the water. This warms the air above the land. As the warm air rises, it is replaced by the cooler air over the water. This cool breeze inland can be a welcome relief from heat for those living in coastal areas. At night the situation is reversed because the land cools more quickly than the water. The air above the water is warmer and rises and air from the land moves out to replace it. Both of these situations create wind.



The productive use of the wind has been documented over a long period of the world's history. Egyptians used the wind to sail ships on the Nile River over 5000 years ago. The early Persians, in what is now Iran, used windmills, but we probably associate windmills with Holland, where they helped that country become an industrialized nation in the 1700's. Early American pioneers used windmills to grind grain, pump water, and saw wood, but it wasn't until the oil embargo in the 1970's, when oil became expensive and in short supply, that alternative energy sources began to be seriously investigated.

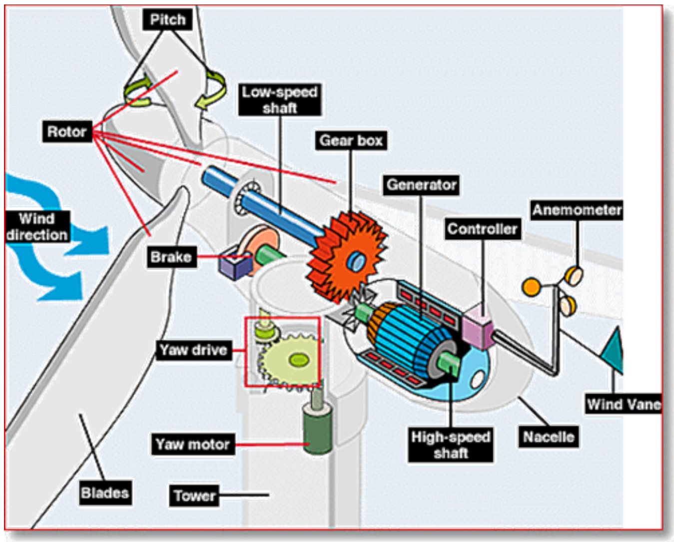
Today, wind machines are used almost exclusively to generate electricity. The blades are made of fiberglass or other high-strength material. As the blades turn when the wind strikes them, they turn a generator to produce electricity. There is only one conversion of energy – from mechanical to electrical. Several designs have been tried. However, the vertical Darrieus machine is not in use at this time. Named after its French designer, it needs no tower or yaw mechanism to keep it facing the wind, and the generator can be located on the ground where it is easier to maintain. But the air speed is close to the ground, it needs guy wires to hold it up, its efficiency is low, and to replace the main bearing, it must be totally disassembled. This machine is only about 100 feet tall and 50 feet wide.

Wind Machine Designs

Horizontal axis into the wind machine	**Darrieus horizontal wind machine**	**Horizontal axis facing away from the wind**

Two types of wind machines in use are both horizontal; one has the propellers facing into the wind and the other away from the direction the wind is coming. They are very tall, about as high as a 20-story building and have blades about 200 feet across. The most commonly used one has the blades facing into the wind. This is done with a tail on a small machine or a yaw mechanism to achieve this on a large machine. See the diagram below for the description of the parts of a wind machine.



Main parts of a horizontal wind machine that operates into the wind.

Rotor: **blades and hub**

Brake: **stops rotor in an emergency**

Generator: **produces electricity**

Controller: **starts the generator when wind speeds are 8-16 mph and shuts it off when speeds are above 65mph to
avoid overheating**

Anemometer: **reads the wind speed**

Wind Vane: **tells wind direction**

Yaw drive and motor: **keep rotor into the wind**

Pitch: **the twist of the blades that determines speed of wind that will begin to turn the blades**

These machines occupy a large amount of land, about 2 acres each, but farmers can graze cattle or grow crops under them. They are about as efficient as coal-fired plants, but, of course, have none of the associated water or air pollution problems. The biggest problem is they can injure wild birds that try to fly near them. Today only about .1% of our electricity comes from wind power, about the same amount as from solar power. California, however, produces 1% of its electricity from the wind, partly because their state government supports the development of renewable energy sources.

In the future, there may be more wind machines. It is estimated that half of the country could use wind machines that would serve over half of the homes in those areas. If new technologies bring the price down or people are willing to pay a little bit more for their electricity if it is from a renewable source, wind power may just take off. One of the experimental technologies is called the WARP system. It has no blades and looks like a stack of wheel rims. Each surface of the rim has a generator mounted on it. The shape of the rims causes the air to flow past the generators. It is going to be used to power offshore oil platforms and wireless telecommunication systems. In the future, this design might be built right into buildings to supply electricity for that site.

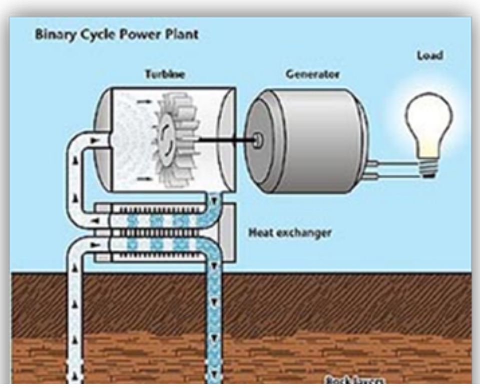
Geothermal Energy

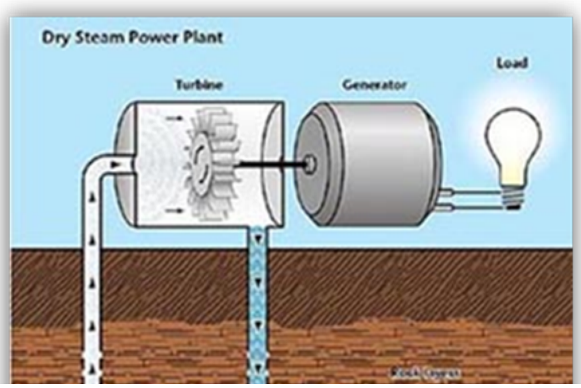
Magma heats underground water that is vented as steam in this volcano.

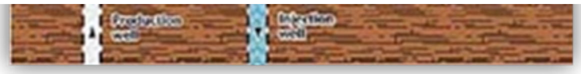
Geothermal energy, as the name implies, comes from heat within the earth. Deep inside the earth is a layer of hot molten iron. Above this is a layer thought to consist of magma or molten rock and solid rock. Then there is the crust, which is the surface. The crust is broken into areas called plates, and between these plates are cracks where the molten magma can escape as volcanic eruptions, or water heated by the magma can escape as hot springs, mud pots, or geysers. Sometimes, the hot water is simply trapped underground. This is renewable energy because, as long as the earth has molten magma and iron and rain supplies ground water, this energy source will not end.

Finding geothermal sources is not easy unless the warm water or magma comes from the ground. Otherwise, geologists must study aerial photographs, geological maps, and the chemistry of the water and soil for trace minerals before drilling a test well. The hottest geothermal regions are along the major plate boundaries where earthquakes and volcanoes are concentrated. One such region is the Ring of Fire which circles the Pacific Ocean.

For centuries hot water springs have been used for bathing, cooking, and heating and are still being used for these purposes today. Heating can involve heating buildings or using the heat in greenhouses or in fisheries to increase the growth rate of fish and amphibians. Other uses are for pasteurizing milk or drying foods or lumber. Today, we use geothermal energy for electricity production as well. Most geothermal plants use **flashed steam** to run a turbine. When released from underground, the superheated water explosively boils into steam. After running through the turbine, the steam is condensed into water and sent back into the earth to be reheated. Some factories use **dry steam** as it shoots from the earth. In this factory, a rock catcher catches rocks that are blown out to protect the turbine. The first factory using geothermal energy to produce electricity was in Lorderello, Italy, in 1904. It is still in use today. In California a similar plant has been producing electricity since 1960. **Binary power plants** transfer the heat from the hot water to another liquid that boils at a lower temperature. This vapor then runs the turbine. The hot water is in a closed system and is returned to the earth to be reheated. The advantage of this system is it can use geothermal water that is not boiling. Some factories use more than one method. These are called hybrid power plants. One such power plant supplies the big island of Hawaii with 25% of its electricity. Although geothermal energy only produces .4% of the electricity in the U.S., California gets 6% of its electricity from geothermal energy.



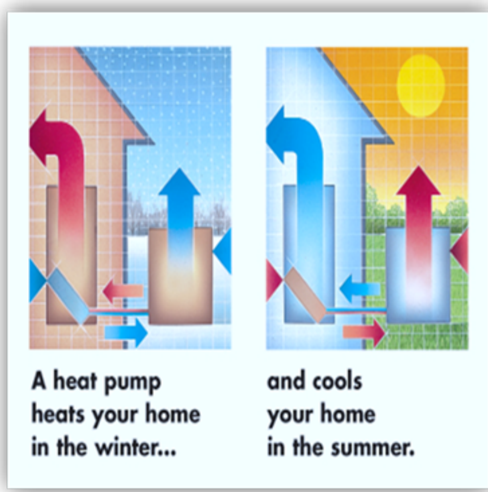
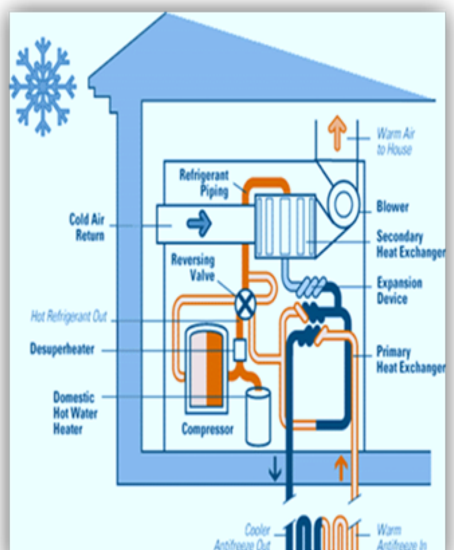


	
A binary power plant transfers thermal energy from one liquid to another in the heat exchanger then to mechanical and electrical energy.	**A dry steam power plant transfer thermal to mechanical to electrical energy.**

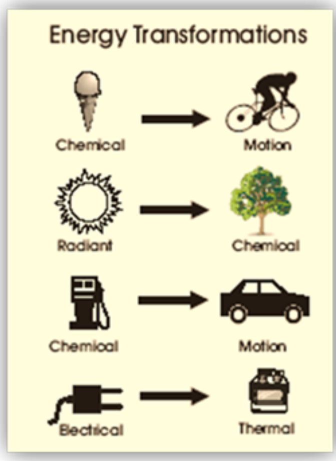
Heating with geothermal energy can involve using the hot water to heat other water through a heat exchanger and sending it to homes throughout an area. Such a factory has been in use in Boise, Idaho, since 1893. In France 500,000 people use geothermal energy to heat their homes and in Reykjavik, Iceland, 95% of the buildings use this renewable energy.

Another use for the heat within the earth is the use of a **heat pump.** Heat pumps are heat exchange devices. Below a certain depth, approximately 4 to 6 feet, the earth has a constant temperature of about 52 degrees. Heat pumps transfer this heat inside the house. Pipes run through the ground with water and antifreeze in them. Heat is transferred to the liquid from the ground in winter and is pumped into the house with an electric pump. Additional heating of the 52 degree water happens with an alternative energy source, and it is pumped to the rest of the house or used to heat air that is blown into the rooms. In the summer, the heat pump removes heat from the house and transfers it to the earth, making the heat pump an air conditioner. Although the initial cost of installing a heat pump is high, the unit lasts for years and costs very little to operate. Although some electricity is required to operate the pump, no emissions result from using a heat pump except for those to produce the electricity at the power plant. Today over 300,000 buildings in the U.S. use heat pumps.

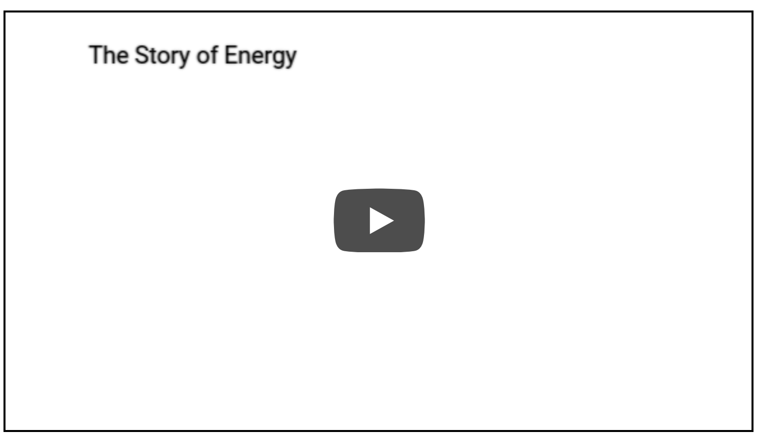
In the future, more geothermal power plants may be used. It is estimated that 4% of our reserve energy can come from geothermal sources. This is the third highest reserve behind coal and biomass. Power plants emit few emissions, and if scrubbers are used to wash out the gases dissolved in the hot water, the emissions are very low. Binary plants have no emissions so many areas in our country can be used at sites for these plants, such as deserts, cropland, and mountain forests. As nonrenewable sources increase in cost and become more scarce, geothermal will certainly be a good alternative.

	
In winter the heat pump moves heated liquid from the ground into the house.	

Other Energy Conversions



We have concentrated on energy sources and their conversions to heat and/or electricity in most of this lesson. What about transformations of energy that occur within our homes with appliances and tools? The following diagram shows some common energy transformations within our everyday lives. The ice cream cone is food, so it has stored chemical energy which is often transformed within our bodies to mechanical energy. As we have already discussed, all photosynthesis changes radiant energy into stored chemical energy as starches, sugars, and other materials within plants. Gasoline, being a fuel, has stored chemical energy which is transformed to mechanical energy within the engine of the car after it is first transformed into heat or thermal energy. Finally, electrical energy is changed into mechanical energy in a microwave oven (if the microwave has a carousel in it) and radiant energy (the microwaves) and then into thermal energy. What about a flashlight? Can you name the conversions that occur in it? If you include the energy to turn it on, you must start with mechanical energy that comes from the chemical energy in our bodies from the food we eat. Now a circuit is completed which causes electricity to flow, but wait! What makes the electrons flow? Batteries contain chemicals that produce a reaction that causes electron flow. Therefore, we have chemical energy transferring to electrical energy and then to radiant energy, the light from the light bulb.



Unit Conclusions

Within this unit we have investigated six different renewable energy sources. Most of these have a form of energy transformed into at least another energy form before it is used, just as the nonrenewables do. The difference is these sources can be replenished and most are much kinder to the environment because they cause less pollution. However, they may not be as efficient or as available as most of our current sources, most of which are nonrenewable sources. As the nonrenewable sources become more scarce and more expensive and as new technologies and research make renewable sources more efficient, we will see more and more of our energy needs being met by the renewables. Much of the increased efficiency will come from making the energy transformations fewer and easier to attain.