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Renewable Resources

Reading Material to Accompany Activity

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FOSSIL FUELS

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how fossil fuels formed

Contrary to what many people believe, fossil fuels are not the remains of dead dinosaurs. In fact, most of the fossil fuels we find today were formed millions of years before the first dinosaurs.

Fossil fuels, however, were once alive!

They were formed from prehistoric plants and animals that lived hundreds of millions of years ago.

Think about what the Earth must have looked like 300 million years or so ago. The land masses we live on today were just forming. There were swamps and bogs everywhere. The climate was warmer. Ancient trees and plants grew everywhere. Strange looking animals walked on the land, and just as weird looking fish swam in the rivers and seas. Tiny one-celled organisms called protoplankton floated in the ocean.

When these ancient living things died, they decomposed and became buried under layers and layers of mud, rock, and sand. Eventually, hundreds and sometimes thousands of feet of earth covered them. In some areas, the decomposing materials were covered by ancient seas, then the seas dried up and receded.

During the millions of years that passed, the dead plants and animals slowly decomposed into organic materials and formed fossil fuels. Different types of fossil fuels were formed depending on what combination of animal and plant debris was present, how long the material was buried, and what conditions of temperature and pressure existed when they were decomposing.

For example, oil and natural gas were created from organisms that lived in the water and were buried under ocean or river sediments. Long after the great prehistoric seas and rivers vanished, heat, pressure and bacteria combined to compress and "cook" the organic material under layers of silt. In most areas, a thick liquid called oil formed first, but in deeper, hot regions underground, the cooking process continued until natural gas was formed. Over time, some of this oil and natural gas began working its way upward through the earth's crust until they ran into rock formations called "caprocks" that are dense enough to prevent them from seeping to the surface. It is from under these caprocks that most oil and natural gas is produced today.

The same types of forces also created coal, but there are a few differences. Coal formed from the dead remains of trees, ferns and other plants that lived 300 to 400 million years ago. In some areas, such as portions of what-is-now the eastern United States, coal was formed from swamps covered by seawater. The seawater contained a large amount of sulfur, and as the seas dried up, the sulfur was left behind in the coal. Today, scientists are working on ways to take the sulfur out of coal because when coal burns, the sulfur can become an air pollutant. (To find out about these methods, see the section "Cleaning Up Coal.")

Some coal deposits, however, were formed from freshwater swamps, which had very little sulfur in them. These coal deposits, located largely in the western part of the United States, have much less sulfur in them.

COAL our most abundant fuel

America has more coal than any other fossil fuel resource. The United States also has more coal reserves than any other single country in the world. In fact, 1/4 of of all the known coal in the world is in the United States.

The United States has more coal that can be mined than the rest of the world has oil that can be pumped from the ground.

Large coal deposits can be found in 38 of the 50 states.

Coal is used primarily in the United States to generate electricity. In fact, it is burned in power plants to produce more than half of the electricity we use. If your family uses an electric stove, you use about half a ton of coal a year. If your water heater is electric, you are using about two tons of coal a year. If you have an electric refrigerator, that's another half-ton a year. Even though you may never see coal, you use several tons of it every year!

The material that formed fossil fuels varied greatly over time as each layer was buried. [Read more about how coal was formed.] As a result of these variations and the length of time the coal was forming, several types of coal were created. Depending upon its composition, each type of coal burns differently and releases different types of emissions [You'll learn more about this in the later section Cleaning Up Coal].

The four types (or "ranks") of coal mined today are: anthracite, bituminous, subbituminous, and lignite.

- **Lignite**: The largest portion of the world's coal reserves is made up of lignite, a soft, brownish-black coal that forms the lowest level of the coal family. You can even see the texture of the original wood in some pieces of lignite that is found west of the Mississippi River in the United States.
- **Subbituminous**: Next up the scale is subbituminous coal, a dull black coal. It gives off a little more energy (heat) than lignite when it burns. It is mined mostly in Montana, Wyoming and a few other western states.
- **Bituminous**: Still more energy is packed into bituminous coal, sometimes called "soft coal." In the United States, it is found primarily east of the Mississippi River in midwestern states like Ohio and Illinois and in the Appalachian mountain range from Kentucky to Pennsylvania.
- **Anthracite**: Anthracite is the hardest coal and gives off a great amount of heat when it burns. Unfortunately, in the United States, as elsewhere in the world, there is little anthracite coal to be mined. The U.S. reserves of anthracite are located primarily in Pennsylvania.

OIL our untapped energy wealth

Oil keeps our country moving. Almost our entire transportation fleet – our cars, trucks, trains and airplanes – depends on fuels made from oil. Lubricants made from oil keep the machinery in our factories running. The fertilizer we use to grow our food is made from oil. We make plastics from oil. It is quite likely that the toothbrush you used this morning, the plastic bottle that holds your milk, and the plastic ink pen that you write or draw with are all made from oil.

In fact, we use more oil in the United States than any other form of energy. Oil supplies 40 percent of all the energy this country consumes.

Imagine a lake 10 miles long, 9 miles wide and 60 feet deep. Fill that lake with oil. That would be about as much oil as the entire world uses in one year. The United States would use about 1/4 of it.

The problem that the United States cannot produce enough oil to satisfy our needs. In fact, today, only about half the oil consumed in the United States is actually produced in the United States. The rest is pumped from oil fields in other countries and sold to the United States. We spend billions of dollars a year to buy oil from other countries.

The second problem is that the oil fields in the United States are among some of the oldest fields still producing in the world. Some have been pumping for 50 years or more. Most of the easiest oil has already been pumped out.

You will read later in this section that there is still a lot of oil left in the ground. In fact, for every one barrel of oil we produce, we leave two barrels behind. In the history of oil fields in this country – a history stretching back almost 150 years – we have produced almost 175 billion barrels of oil. But there are more than 350 billion barrels of oil remaining in the ground that we know exist. Perhaps there are billions more in fields yet to be discovered. But this oil is hard to find and even harder to produce.

Ever wonder what oil looks like underground, down deep, hundreds or thousands of feet below the surface, buried under millions of tons of rock and dirt?

If you could look down an oil well and see oil where Nature created it, you might be surprised. You wouldn't see a big underground lake, as a lot of people think. Oil doesn't exist in deep, black pools. In fact, an underground oil formation - called an "oil reservoir" - looks very much like any other rock formation. It looks a lot like...well, rock.

Oil exists underground as tiny droplets trapped inside the open spaces, called "pores," inside rocks. The "pores" and the oil droplets can be seen only through a microscope. The droplets cling to the rock, like drops of water cling to a window pane.

Squeezing Oil out of Rocks

Imagine trying to force oil through a rock. Can't be done, you say? Actually, it can.

In fact, oil droplets can squeeze through the tiny pores of underground rock on their own, pushed by the tremendous pressures that exist deep beneath the surface. How does this happen?

Imagine a balloon, blown up to its fullest. The air in the balloon is under pressure. It wants to get out. Stick a pin in the balloon and the air escapes with a bang!

Oil in a reservoir acts something like the air in a balloon. The pressure comes from millions of tons of rock lying on the oil and from the earth's natural heat that builds up in an oil reservoir and expands any gases that may be in the rock. The result is that when an oil well strikes an underground oil reservoir, the natural pressure is released - like the air escaping from a balloon. The pressure forces the oil through the rock and up the well to the surface.

If there are fractures in the reservoir -- fractures are tiny cracks in the rock -- the oil squeezes into them. If the fractures run in the right direction toward the oil well, they can act as tiny underground "pipelines" through which oil flows to a well.

Oil producers need to know a lot about an oil reservoir before they start drilling a lot of expensive wells. They need to know about the size and number of pores in a reservoir rock. They need to know how fast oil droplets will move through these pores. They need to know where the natural fractures are in a reservoir so that they know where to drill their wells.

Today, scientists have invented many new ways to learn about the characteristics of an oil reservoir. They have developed ways to send sound waves through reservoir rock. Sound waves travel at different speeds through different types of rocks. By listening to soundwaves using devices called "geophones," scientists can measure the speed at which the sound moves through the rock and determine where there might be rocks with oil in them.

Scientists also measure how electric current moves through rock. Rocks with a lot of water in the tiny pores will conduct electricity better than rocks with oil in the pores. Sending electric current through the rock can often reveal oil-bearing rocks.

Finally, oil companies will look at the rocks themselves. An exploratory well will be drilled, rock samples, called "cores," will be brought to the surface. Scientists will look at the core samples under a microscope. Often they can see tiny oil droplets trapped inside the rock.

When companies are convinced that they have found the right kind of underground rock formation that is likely to contain oil, they begin drilling production wells. When the wells first hit the reservoir, some of the oil begins coming to the surface immediately.

Many years ago, when oil field equipment wasn't very good, it was sometimes difficult to prevent the oil from spurting hundreds of feet out the ground. This was called a "gusher." Today, however, oil companies install special equipment on their wells called "blowout preventors," that prevent "gushers", like putting a cork in a bottle.

When a new oil field first begins producing oil, Nature does most of the work. The natural pressures in the reservoir force the oil through the rock pores, into fractures, and up production wells. This natural flow of oil is called "primary production." It can go on for days or years. But after a while, an oil reservoir begins to lose pressure, like the air leaving a balloon. The natural oil flow begins dropped off, and oil companies use pumps (like the drawing at the very top of the page) to bring the oil to the surface.

In some fields, natural gas is produced along with the oil. In some cases, oil companies separate the gas from the oil and inject it back into the reservoir. Like putting air back into a balloon, injecting natural gas into the underground reservoir keeps enough pressure in the reservoir to keep oil flowing.

Eventually, however, the pressure drops to a point where the oil flow, even with pumps and gas injection, drops off to a trickle. Yet, there is actually a lot of oil left in the reservoir. How much? In many reservoirs, as many as 3 barrels can be left in the ground for every 1 barrel that is produced. In other words, if oil production stopped after "primary production," almost 3/4ths of the oil would be left behind!

That's why oil producers often turn to "secondary recovery" processes to squeeze some of this remaing oil out of the ground.

Natural Gas: It is colorless, shapeless, and in its pure form, odorless.

For many years, it was discarded as worthless. Even today, some countries (although not the United States) still get rid of it by burning it in giant flares, so large they can be seen from the Space Shuttle. Yet, it is one of the most valuable fuels we have.

Natural gas is made up mainly of a chemical called methane, a simple, compound that has a carbon atom surrounded by four hydrogen atoms. Methane is highly flammable and burns almost completely. There is no ash and very little air pollution.

Natural gas provides one-fifth of all the energy used in the United States. It is especially important in homes, where it supplies nearly half of all the energy used for cooking, heating, and for fueling other types of home appliances.

Because natural gas has no odor, gas companies add a chemical to it that smells a little like rotten eggs. The odor makes it easy to smell if there is a gas leak in your house.

The United States has a lot of natural gas, enough to last for at least another 60 years and probably a lot longer. Our neighbor to the north, Canada, also has a lot of gas, and some gas pipelines that begin in Canada run into the United States.

The United States is looking for more ways to use gas, largely because it is easy to pipe from one location to another and because it burns very cleanly. More and more, we are using gas in power plants to generate electricity. Factories are using more gas, both as a fuel and as an ingredient for a variety of chemicals.

While natural gas is plentiful, there is still some uncertainty about how much it will cost to get it out of the ground in the future. Like oil, there is "easy" gas that can be produced from underground formations, and there is gas that is not so easy. If we can find better and cheaper ways to find more of the "easy" gas and produce some of the more difficult gas, we can rely increasingly on natural gas in the future.

How Natural Gas is Produced

Natural gas is, in many ways, the ideal fossil fuel. It is clean, easy to transport, and convenient to use. Industrial users use almost half of the gas produced in the U.S. A large portion is also used in homes for heating, lighting, and cooking. However, there are limits on how much natural gas we can find and get out of the ground with today's technologies.

Researchers are continuing to study about how natural gas was formed and where it has collected within the earth's crust. They have found that gas is not only found in pockets by itself but in many cases, with oil. Often, both oil and gas flow to the surface from the same underground formation.

Like oil production, some natural gas flows freely to wells because the natural pressure of the underground reservoir forces the gas through the reservoir rocks. These types of gas wells require only a ""Christmas tree", or a series of pipes and valves on the surface, to control the flow of gas.

Only a small number of these free-flowing gas formations still exist in many U.S. gas fields, however. Almost always, some type of pumping system will be required to extract the gas present in the underground formation.

One of the most common is the "horse head" pump which rocks up and down to lift a rod in and out of a well bore, bringing gas and oil to the surface.

Often, the flow of gas through a reservoir can be improved by creating tiny cracks in the rock, called "fractures," that serve as open pathways for the gas to flow. In a technique called "hydraulic fracturing," drillers force high pressure fluids (like water) into a formation to crack the rock. A "propping agent", like sand or tiny glass beads, is added to the fluid to prop open the fractures when the pressure is decreased.

Natural gas can be found in a variety of different underground formations, including:

1. shale formations,
2. sandstone beds,
3. coal seams, and
4. deep, salt water aquifers (underground ponds of water).

Some of these formations are more difficult and more expensive to produce than others, but they hold the potential for vastly increasing the nation's available gas supply.

The Department of Energy is funding research into how to obtain and use gas from these sources. Some of the work has been in Devonian shales, which are rock formations of organic rich clay where gas has been trapped. Dating back nearly 350 million years (to the Devonian Period), these black or brownish shales were formed from sediments deposited in the basins of inland seas during the erosion that formed the Appalachian Mountains.

Other sources of unconventional gas include "tight sand lenses". These deposits are called "tight" because the holes that hold the gas in the sandstone are very small. It is hard for the gas to flow through these tiny spaces. To get the gas out, drillers must first crack the dense rock structure to create ribbon-thin passageways through which the gas can flow.

Coal bed methane gas that is found in all coal deposits was once regarded as only a safety hazard to miners but now, due to research, is viewed as a valuable potential source of gas.

Once natural gas is produced from underground rock formations, it is sent by pipelines to storage facilities, then by smaller pipes to homes and factories.

So the next time, you see the blue flame on top of the kitchen stove, remember that the natural gas that is being burned likely came from an underground rock formation hundreds if not thousands of miles away.

RENEWABLE RESOURCES

Info from: http://www.energy.gov/sources/index.html

Bioenergy Basics

Biomass (organic matter) can be used to provide heat, make fuels, and generate electricity. This is called bioenergy. Wood, the largest source of bioenergy, has been used to provide heat for thousands of years. But there are many other types of biomass—such as wood, plants, residue from agriculture or forestry, and the organic component of municipal and industrial wastes—that can now be used as an energy source. Today, many bioenergy resources are replenished through the cultivation of energy crops, such as fast-growing trees and grasses, called *bioenergy feedstocks*.

Unlike other renewable energy sources, biomass can be converted directly into liquid fuels for our transportation needs. The two most common biofuels are ethanol and biodiesel. Ethanol, an alcohol, is made by fermenting any biomass high in carbohydrates, like corn, through a process similar to brewing beer. It is mostly used as a fuel additive to cut down a vehicle's carbon monoxide and other smog-causing emissions. Biodiesel, an ester, is made using vegetable oils, animal fats, algae, or even recycled cooking greases. It can be used as a diesel additive to reduce vehicle emissions or in its pure form to fuel a vehicle.

Heat can be used to chemically convert biomass into a fuel oil, which can be burned like petroleum to generate electricity. Biomass can also be burned directly to produce steam for electricity production or manufacturing processes. In a power plant, a turbine usually captures the steam, and a generator then converts it into electricity. In the lumber and paper industries, wood scraps are sometimes directly fed into boilers to produce steam for their manufacturing processes or to heat their buildings. Some coal-fired power plants use biomass as a supplementary energy source in high-efficiency boilers to significantly reduce emissions.

Even gas can be produced from biomass for generating electricity. Gasification systems use high temperatures to convert biomass into a gas (a mixture of hydrogen, carbon monoxide, and methane). The gas fuels a turbine, which is very much like a jet engine, only it turns an electric generator instead of propelling a jet. The decay of biomass in landfills also produces a gas—methane—that can be burned in a boiler to produce steam for electricity generation or for industrial processes.

New technology could lead to using biobased chemicals and materials to make products such as anti-freeze, plastics, and personal care items that are now made from petroleum. In some cases these products may be completely biodegradable. While technology to bring biobased chemicals and materials to market is still under development, the potential benefit of these products is great.

Geothermal Energy Basics

Geo (Earth) *thermal* (heat) energy is an enormous, underused heat and power resource that is **clean** (emits little or no greenhouse gases), **reliable** (average system availability of 95%), and **homegrown** (making us less dependent on foreign oil).

Geothermal resources range from shallow ground to hot water and rock several miles below Earth's surface, and even farther down to the extremely high temperatures of molten rock called magma.

Earth's energy can be converted into heat and electricity. The three technology categories are geothermal heat pumps, direct-use applications, and power plants.

Geothermal Heat Pumps Use Shallow Ground Energy to Heat and Cool Buildings

Almost everywhere, the upper 10 feet of Earth's surface maintains a nearly constant temperature between 50 and 60 degrees F (10 and 16 degrees C). A geothermal heat pump system consists of pipes buried in the shallow ground near the building, a heat exchanger, and ductwork into the building. In winter, heat from the relatively warmer ground goes through the heat exchanger into the house. In summer, hot air from the house is pulled through the heat exchanger into the relatively cooler ground. Heat removed during the summer can be used as no-cost energy to heat water.

Direct-Use Piped Hot Water Warms Greenhouses and Melts Sidewalk Snow

In the U.S., most geothermal reservoirs are located in the western states, Alaska, and Hawaii. Hot water near Earth's surface can be piped directly into facilities and used to heat buildings, grow plants in greenhouses, dehydrate onions and garlic, heat water for fish farming, and pasteurize milk. Some cities pipe the hot water under roads and sidewalks to melt snow. District heating applications use networks of piped hot water to heat buildings in whole communities.

Power Plants Generate Electricity from Geothermal Reservoirs

Mile-or-more-deep wells can be drilled into underground reservoirs to tap steam and very hot water that drive turbines that drive electricity generators. Three types of power plants are operating today:

Dry steam plants, which directly use geothermal steam to turn turbines;

Flash steam plants, which pull deep, high-pressure hot water into lower-pressure tanks and use the resulting flashed steam to drive turbines; and

Binary-cycle plants, which pass moderately hot geothermal water by a secondary fluid with a much lower boiling point than water. This causes the secondary fluid to flash to steam, which then drives the turbines.

The Future of Geothermal Energy

The three technologies discussed above use only a tiny fraction of the total geothermal resource. Several miles everywhere beneath Earth's surface is hot, dry rock being heated by the molten magma directly below it. Technology is being developed to drill into this rock, inject cold water down one well, circulate it through the hot, fractured rock, and draw off the heated water from another well. One day, we might also be able to recover heat directly from the magma. We're standing on a resource that could easily supply the energy needs of the entire world for centuries.

Hydropower Basics

Flowing water creates energy that can be captured and turned into electricity. This is called *hydropower*. Hydropower is currently the largest source of renewable power, generating nearly 10% of the electricity used in the United States.

The most common type of hydropower plant uses a dam on a river to store water in a reservoir. Water released from the reservoir flows through a turbine, spinning it, which, in turn, activates a generator to produce electricity. But hydropower doesn't necessarily require a large dam. Some hydropower plants just use a small canal to channel the river water through a turbine.

Another type of hydropower plant—called a *pumped storage plant*—can even store power. The power is sent from a power grid into the electric generators. The generators then spin the turbines backward, which causes the turbines to pump water from a river or lower reservoir to an upper reservoir, where the power is stored. To use the power, the water is released from the upper reservoir back down into the river or lower reservoir. This spins the turbines forward, activating the generators to produce electricity.

Environmental Issues and Mitigation

Current hydropower technology, while essentially emission-free, can have undesirable environmental effects, such as fish injury and mortality from passage through turbines, as well as detrimental effects on the quality of downstream water. A variety of mitigation techniques are now being used to address these environmental issues, and environmentally friendly turbines are under development.

Fish Passage
Fish populations can be impacted if fish cannot migrate upstream past impoundment dams to spawning grounds or if they cannot migrate downstream to the ocean. Upstream fish passage can be aided using fish ladders or elevators, or by trapping and hauling the fish upstream by truck. Downstream fish passage is aided by diverting fish from turbine intakes using screens or racks or even underwater lights and sounds, and by maintaining a minimum spill flow past the turbine.

Water Quality and Flow
Hydropower plants can cause low dissolved oxygen levels in the water, a problem that is harmful to riparian habitats and is addressed using various aeration techniques. Maintaining minimum flows of water downstream of a hydropower installation is also critical for the survival of riparian habitats.

Solar Energy Basics

Sunlight—solar energy—can be used to generate electricity, provide hot water, and to heat, cool, and light buildings.

Photovoltaic (solar cell) systems convert sunlight directly into electricity. A solar or PV cell consists of semiconducting material that absorbs the sunlight. The solar energy knocks electrons loose from their atoms, allowing the electrons to flow through the material to produce electricity. PV cells are typically combined into modules that hold about 40 cells. About 10 of these modules are mounted in PV *arrays*. PV arrays can be used to generate electricity for a single building or, in large numbers, for a power plant. A power plant can also use a *concentrating solar power system*, which uses the sun's heat to generate electricity. The sunlight is collected and focused with mirrors to create a high-intensity heat source. This heat source produces steam or mechanical power to run a generator that creates electricity.

Solar water heating systems for buildings have two main parts: a solar collector and a storage tank. Typically, a *flat-plate collector*—a thin, flat, rectangular box with a transparent cover—is mounted on the roof, facing the sun. The sun heats an *absorber plate* in the collector, which, in turn, heats the fluid running through tubes within the collector. To move the heated fluid between the collector and the storage tank, a system either uses a pump or gravity, as water has a tendency to naturally circulate as it is heated. Systems that use fluids other than water in the collector's tubes usually heat the water by passing it through a coil of tubing in the tank.

Many large commercial buildings can use solar collectors to provide more than just hot water. Solar process heating systems can be used to heat these buildings. A solar ventilation system can be used in cold climates to preheat air as it enters a building. And the heat from a solar collector can even be used to provide energy for cooling a building.

A solar collector is not always needed when using sunlight to heat a building. Some buildings can be designed for *passive solar* heating. These buildings usually have large, south-facing windows. Materials that absorb and store the sun's heat can be built into the sunlit floors and walls. The floors and walls will then heat up during the day and slowly release heat at night—a process called *direct gain*. Many of the passive solar heating design features also provide *daylighting*. Daylighting is simply the use of natural sunlight to brighten up a building's interior.

Solar Technologies

Photovoltaics (PV)
Photovoltaic solar cells, which directly convert sunlight into electricity, are made of semiconducting materials. The simplest cells power watches and calculators and the like, while more complex systems can light houses and provide power to the electric grid.

Passive Solar Heating, Cooling and Daylighting
Buildings designed for passive solar and daylighting incorporate design features such as large south-facing windows and building materials that absorb and slowly release the sun's heat. No mechanical means are employed in passive solar heating. Incorporating passive solar designs can reduce heating bills as much as 50 percent. Passive solar designs can also include natural ventilation for cooling.

Concentrating Solar Power
Concentrating solar power technologies use reflective materials such as mirrors to concentrate the sun's energy. This concentrated heat energy is then converted into electricity.

Solar Hot Water and Space Heating and Cooling
Solar hot water heaters use the sun to heat either water or a heat-transfer fluid in collectors. A typical system will reduce the need for conventional water heating by about two-thirds. High-temperature solar water heaters can provide energy-efficient hot water and hot water heat for large commercial and industrial facilities.

Quick Facts about Wind Energy

What is wind energy? The terms "wind energy" or "wind power" describe the process by which the wind is used to generate mechanical power or electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity to power homes, businesses, schools, and the like.

What causes the wind to blow? Wind is a form of solar energy. Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. Wind flow patterns are modified by the earth's terrain, bodies of water, and vegetative cover. This wind flow, or motion energy, when "harvested" by modern wind turbines can be used to generate electricity.

When was wind energy first used? Since earliest recorded history, wind power has been used to move ships, grind grain and pump water. There is evidence that wind energy was used to propel boats along the Nile River as early as 5000 B.C. Within several centuries before Christ, simple windmills were used in China to pump water.

In the United States, millions of windmills were erected as the American West was developed during the late 19th century. Most of them were used to pump water for farms and ranches. By 1900, small electric wind systems were developed to generate direct current, but most of these units fell into disuse as inexpensive grid power was extended to rural areas during the 1930s. By 1910, wind turbine generators were producing electricity in many European countries.

How is the energy in the wind captured? Wind turbines, like aircraft propeller blades, turn in the moving air and power an electric generator which supplies an electric current. Modern wind turbines fall into two basic groups; the horizontal-axis variety, like the traditional farm windmills used for pumping water; and the vertical-axis design, like the eggbeater-style Darrieus model, named after its French inventor. Modern wind technology takes advantage of advances in materials, engineering, electronics, and aerodynamics. Wind turbines are often grouped together into a single wind power plant, also known as a wind farm, and generate bulk electrical power. Electricity from these turbines is fed into the local utility grid and distribute to customers just as it is with conventional power plants.

How big are wind turbines? Wind turbines are available in a variety of sizes, and therefore power ratings. The largest machine, such as the one built in Hawaii, has propellers that span the more than the length of a football field and stands 20 building stories high, and produces enough electricity to power 1400 homes. A small home-sized wind machine has rotors between 8 and 25 feet in diameter and stands upwards of 30 feet and can supply the power needs of an all-electric home or small business.

What are wind turbines made of? All electric-generating wind turbines, no matter what size, are comprised of a few basic components: the rotor (the part that actually rotates in the wind), the electrical generator, a speed control system, and a tower. Some wind machines have fail-safe shutdown systems so that if part of the machine fails, the shutdown systems turn the blades out of the wind or puts on brakes.

Are there good wind resources in the United States? Wind energy is very abundant many parts of the United States. Wind resources are characterized by wind-power density classes, ranging from class 1 (the lowest) to class 7 (the highest). Good wind resources (class 3 and above) which have an average annual wind speed of at least 13 miles per hour, are found along the east coast, the Appalachian Mountain chain, the Great Plains, the Pacific Northwest, and some other locations. North Dakota, alone, has enough energy from class 4 and higher winds to supply 36% of the electricity of the lower 48 states. Of course, it would be impractical to move electricity everywhere from North Dakota. Wind speed is a critical feature of wind resources, because the energy in wind is proportional to the cube of the wind speed. In other words, a stronger wind means a lot more power.

What are the advantages of wind-generated electricity? Numerous public opinion surveys have consistently shown that the public prefers wind and other renewable energy forms over conventional sources of generation. Wind energy is a free, renewable resource, so no matter how much is used today, there will still be the same supply in the future. Wind energy is also a source of clean, non-polluting, electricity. Unlike conventional power plants, wind plants emit no air pollutants or greenhouse gases. In 1990, California's wind power plants offset the emission of more than 2.5 billion pounds of carbon dioxide, and 15 million pounds of other pollutants that would have otherwise been produced. It would take a forest of 90 million to 175 million trees to provide the same air quality.

What are the economic obstacles to greater wind power usage? Even though the cost of wind power has decreased dramatically in the past 10 years, the technology requires a higher initial investment than fossil-fueled generators. Roughly 80% of the cost is the machinery, with the balance being the site preparation and installation. If wind generating systems are compared with fossil-fueled systems on a "life-cycle" cost basis (counting fuel and operating expenses for the life of the generator), however, wind costs are much more competitive with other generating technologies because there is no fuel to purchase and minimal operating expenses.

Are there environmental problems facing wind power? Although wind power plants have relatively little impact on the environment compared to other conventional power plants, there is some concern over the noise produced by the rotor blades, aesthetic (visual) impacts, and sometimes birds have been killed by flying into the rotors. Most of these problems have been resolved or greatly reduced through technological development or by properly siting wind plants. Avian mortality remains an issue to be better understood and resolved.

Are there other drawbacks to the use of wind energy? The major challenge to using wind as a source of power is that it is intermittent and it does not always blow when electricity is needed. Wind cannot be stored (unless batteries are used); and not all winds can be harnessed to meet the timing of electricity demands. Further, good wind sites are often located in remote locations far from areas of electric power demand (such as cities). Finally, wind resource development may compete with other uses for the land and those alternative uses may be more highly valued than electricity generation. However, wind turbines can be located on land that is also used for grazing or even farming.

Is wind energy good for the economy? Wind energy avoids the external or societal costs associated with conventional resources, namely, the trade deficit from importing foreign oil and other fuels, the health and environmental costs of pollution, and the cost of depleted resources. Wind energy is a domestic, reliable resource that provides more jobs per dollar invested than any other energy technology--more than five times that from coal or nuclear power. In 1994, wind turbine and component manufacturers contributed directly to the economies of 44 states, creating thousands of jobs for Americans.

Is the cost of wind power competitive with conventional power plants? New, utility-scale, wind projects are being built all around the United States today with energy costs ranging from 3.9 cents per kilowatt-hour (at very windy sites in Texas) to 5 cents or more (in the Pacific Northwest). These costs are competitive with the direct operating costs of many conventional forms of electricity generation now--and prices are expected to drop even further over the next 10 years. Since wind is an intermittent electricity generator and does not provide power on an "as needed" basis, it has to compare favorably with the costs saved on fuel from fossil generators.

Can homeowners sell excess electricity to the utility? Under the Public Utilities Regulatory Policy Act of 1978 (PURPA), any qualifying individual can install a wind generator and the local electric utility must pay for any excess power produced. PURPA was specifically intended to create a market for clean, renewable, electric-generating technologies by guaranteeing a buyer for the excess power. Prior to PURPA, selling power to the utility was an option but was the discretion of the utility. With PURPA, small power producers meeting specific criteria are guaranteed purchase and interconnection. Many states now permit "net metering," in which the utility must buy wind power generated by homeowners at the same retail rate the utility charges. This essentially allows the customer's meter to turn backward while wind energy is supplied to the grid by the cusomer's turbine.

Wind industry...today The wind energy industry has grown steadily over the last 10 years and American companies are now competing aggressively in energy markets across the nation and around the world. The industry, in partnership with the U.S. Department of Energy, continues to expand and develop a full range of highly reliable, efficient wind turbines. These new-generation turbines, when installed, perform at 98 percent reliability in the field, representing remarkable progress since the technology was first introduced in the early 1980s.

Wind power...tomorrow Wind power has an expansive future according to experts. Wind energy has been the fastest growing source of electricy generation in the world in the 1990s. However, the majority of this growth has been in Europe, where goverment policies and high conventional energy costs favor the use of wind energy. The U.S. Department of Energy recently announced the Wind Powering America initiative with goals to power at least 5% of the nation's electricity with wind by 2020, increase the number of states with more than 20 megawatts of wind to 16 by 2005 and 24 by 2010, and increase federal use of wind energy to 5% by 2010.

Drawbacks…

But there are also drawbacks to renewable energy development.

For example, solar thermal energy involving the collection of solar rays through collectors (often times huge mirrors) need large tracts of land as a collection site. This impacts the natural habitat, meaning the plants and animals that live there. The environment is also impacted when the buildings, roads, transmission lines and transformers are built. The fluid most often used with solar thermal electric generation is very toxic and spills can happen.

Solar or PV cells use the same technologies as the production of silicon chips for computers. The manufacturing process uses toxic chemicals. Toxic chemicals are also used in making batteries to store solar electricity through the night and on cloudy days.. Manufacturing this equipment has environmental impacts.

Also, even if we wanted to switch to solar energy right away, we still have a big problem. All the solar production facilities in the entire world only make enough solar cells to produce about 350 megawatts, about enough for a city of 300,000 people. that's a drop in the bucket compared to our needs. California alone needs about 55,000 megawatts of electricity on a sunny, hot summer day. And the cost of producing that much electricity would be about four times more expensive than a regular natural gas-fired power plant.

So, even though the renewable power plant doesn't release air pollution or use precious fossil fuels, it still has an impact on the environment.

Wind power development too, has its downside, mostly involving land use. The average wind farm requires 17 acres of land to produce one megawatt of electricity, about enough electricity for 750 to 1,000 homes. However, farms and cattle grazing can use the same land under the wind turbines.

Wind farms could cause erosion in desert areas. Most often, winds farms affect the natural view because they tend to be located on or just below ridgelines. Bird deaths also occur due to collisions with wind turbines and associated wires. This issue is the subject of on-going research.

Producing geothermal electricity from the earth's crust tends to be localized. That means facilities have to be built where geothermal energy is abundant. There are several geothermal resource locations in California. The Geysers area north of San Francisco is an example. In the course of geothermal production, steam coming from the ground becomes very caustic at times, causing pipes to corrode and fall apart. Geothermal power plants sometimes cost a little bit more than a gas-fired power plant because they have to include the cost to drill.

Environmental concerns are associated with dams to produce hydroelectric power. People are displaced and prime farmland and forests are lost in the flooded areas above dams. Downstream, dams change the chemical, physical and biological characteristics of the river and land.