Renewable Energy Primer

Back in colonial times, a student's first book was called a primer. It was used to introduce students to reading and spelling. This book is written to introduce you to renewable energy. Each reading is designed to go with an activity that you will do in class.

An Introduction to Energy

What is **energy**? It's a hard word to define, but you probably have a sense of what it means. Someone might have even described you as being "full of energy", and you knew that meant you were very active. Physicists define energy as "the ability to do work" and physicists say work happens when a force is applied to an object and it moves. So energy and movement are connected. The term **kinetic energy** means the energy of motion. You eat food which supplies you with the energy to move. Food is stored energy. Stored energy is known as **potential energy.** A battery, like the one you put in a flashlight is also stored energy. In a battery, energy is stored in the chemicals that make up the battery. When you turn the flashlight on, the stored energy in the battery becomes electrical energy which is then converted to light energy, and heat energy in the bulb of the flashlight. If you turned on a blender instead of a flashlight, electrical energy would then be transformed into mechanical energy as the blades of the blender whirled around. It would also be transformed into sound energy and heat energy. Nearly everything you do involves one form of energy being converted into another form.

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Batteries where chemical energy is converted to electrical energy

Bulb where electrical energy is converted to light and heat energy

There is a law in science called the law of conservation of energy. This law says that energy cannot be created or destroyed. Energy can only be transformed. Most of the time energy is not completely converted to the form you want. For example with the flashlight, not all of the electrical energy from the batteries is converted to light. Some of the electrical energy is instead converted to heat energy. This is also true with the blender.

You can't weigh energy or calculate a volume but you can still measure it. A **joule** is a unit used to measure energy. A joule is defined as the amount of energy needed to apply a force of one newton over a distance of one meter. That definition may not mean much to you so think of a joule as the amount of energy needed to lift an apple from the floor to a table.

In this unit you will think about the energy sources you use for the things you do every day. You will think about energy in terms of fuel for cars, trucks and other vehicles. You will think about energy in terms of heating a home. And you will think about energy in terms of providing electricity.

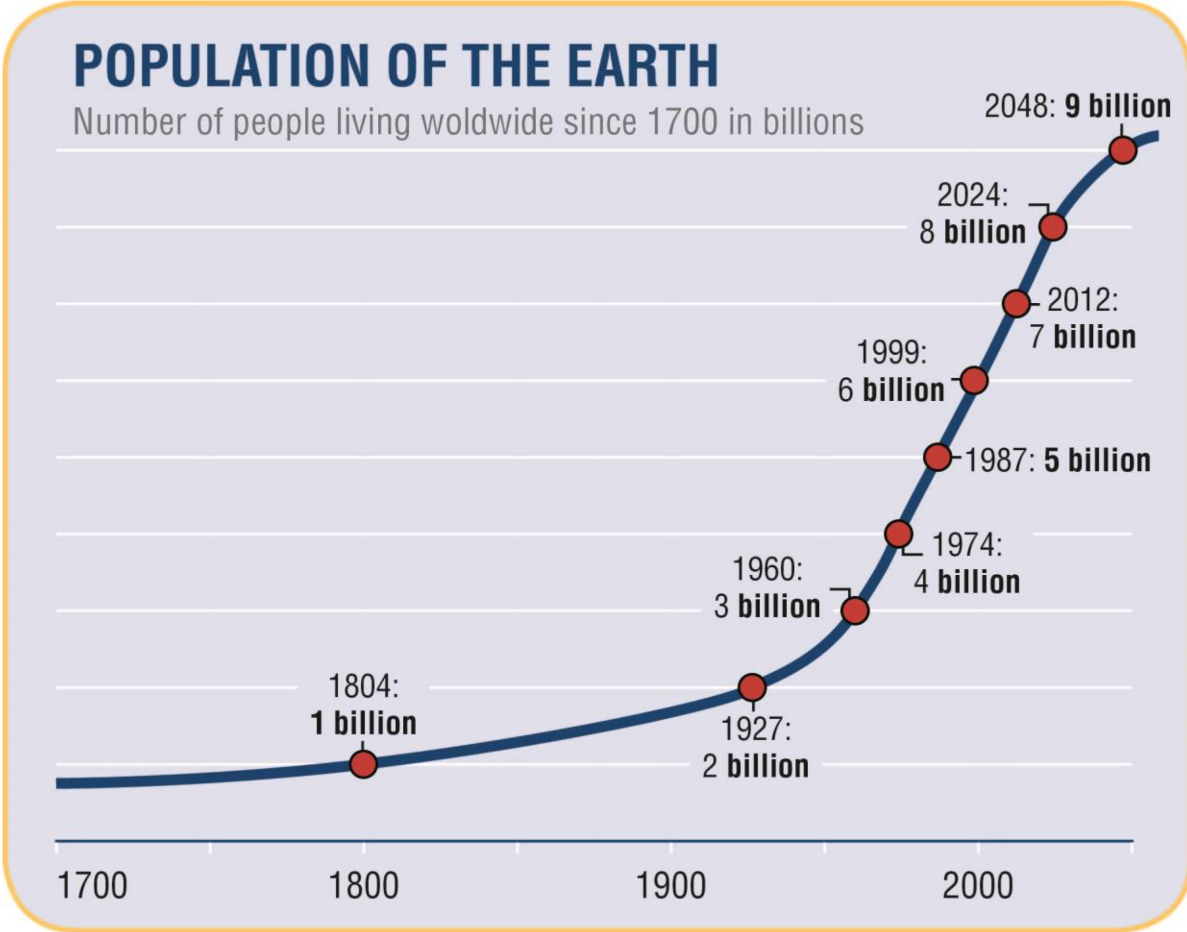
Renewable vs. Nonrenewable

What does the word **renewable** mean? It means the supply can be replaced within a lifetime. Let's define a lifetime as 78 years. The average American is expected to live 78 years. Renewable energy is energy that comes from the sun, wind, water or crops. The sun's energy is replenished every day. As long as sun heats the earth unevenly, wind will continue to blow. Corn, grasses, even trees are harvested for fuel. These crops can be re-planted and a new crop harvested again within a lifetime. Let's contrast renewable energy with **nonrenewable** energy. Coal, oil and natural gas are the three main nonrenewable energy sources. The quantity of coal, oil and natural gas that you use in your lifetime cannot be replaced within your lifetime. Coal, oil and natural gas are called **fossil fuels**. They form in much the same way as sedimentary rocks. It takes thousands upon thousands of years for coal, oil and natural gas to form.

If coal, oil and natural gas are nonrenewable sources of energy, why do we use them? We use them because we have built a way of life around them. For example, most of our cars are designed to run on gasoline. (Gasoline comes from crude oil.) We have a network of gas stations across this country ready to re-supply cars that run on gasoline. If we suddenly stopped using gasoline and replaced gasoline with another type of fuel, what would happen to all these gas stations? We have built an **infrastructure**, a way of life that is based on the use of these nonrenewable sources of energy.

How soon will our supply of nonrenewable energy run out? That's a hard question to answer. There are predictions that we will run out of oil before the end of this century, and we will run out of coal by the middle of the next century. But these predictions do not always take into account that people are discovering new sources of oil and natural gas.

There is another factor that will affect how soon our supply of nonrenewable energy will run out. That factor is demand. Right now the United States, Japan, South Korea and the nations of Europe use much more nonrenewable energy than the nations of South America, Africa and Asia. United States, Japan, South Korea and the nations of Europe are called developed nations. Most families in developed nations have a lot of **consumer goods** such as a car, a television, a computer, and appliances like a toaster, vacuum cleaner, washing machine and so forth. Most of these goods require electrical energy to work. The nations of South America, Africa and Asia are called emerging nations. Most families in these nations do not have many consumer goods, but these families would like to have them. The demand for energy worldwide is increasing as living conditions improve. Not only is the demand for energy increasing but populations are increasing. Right now the population of the world is 6.8 billion people. By 2025 the population is predicted to be 8 billion people. Nearly all that increase of population will occur in emerging nations.



There are other concerns with coal, oil and natural gas, besides the fact that they are nonrenewable. To get energy from these substances we burn them. The chemical reaction for burning is called combustion**.** In combustion, the chemical energy in coal, oil and natural gas is released usually in the form of heat. Another by-product of this reaction is carbon dioxide. Developed nations have burned so much coal, oil and natural gas over the past 150 years that they have significantly raised the level of carbon dioxide in the atmosphere. Scientists, who have studied earth's history, have noticed that **climate change** is associated with significant changes in the level of carbon dioxide in the atmosphere. Another concern with burning coal and oil is that they give off air pollutants. Smog and acid rain are two problems that come from burning coal and oil. Yet another concern is that when people mine coal or drill for oil, they often damage the environment where they have found these resources. Interest in renewable resources is not just about supply. Many renewable resources do not pollute or give off carbon dioxide.

Ethanol and Other Biofuels

Ethanol is a biofuel. The prefix "bio" means life, and a **biofuel** is a fuel that comes from something that is alive or was recently alive. Wood for a wood burning stove or a fireplace is a type of biofuel. In countries with few trees, people will burn dried animal wastes for fuel. Burning wood and animal wastes for heating and for cooking has been done for centuries. Now people are using biofuels to power motor vehicles.

Gasoline comes from **crude oil**. Crude oil is a fossil fuel, and it is formed over thousands of years in much the same way as sedimentary rock forms. A number of plants such as corn, soybean and sunflowers are grown, harvested and pressed to make vegetable oil. In some places the vegetable oil is being used to power cars and trucks. Often this vegetable oil was first used to fry food in a restaurant. Then, instead of throwing out the oil when the restaurants are done with it, the oil is recycled as a motor fuel. Cars and trucks that use this vegetable oil are usually vehicles that run on diesel fuel. Vehicles that use cooking oil will be specially fitted with a dual fuel system. One system allows the vehicle to run on diesel. The other fuel system lets it run on cooking oil.

Ethanol is another type of biofuel that has become popular for use in cars. Ethanol comes from plant materials. In the United States most of our ethanol comes from corn; in Brazil it comes from sugar cane. In New York when we put gas in our car, 10% of that gas is actually ethanol. The other 90% is gasoline. This means each time we "gas" up the car, we use 10% less of the nonrenewable resource gasoline. **Flex fuel** vehicles use a mixture of 85% ethanol and 15% gasoline. The nation of Brazil has truly embraced ethanol as an alternative to gasoline. In Brazil most cars run on Flex-fuel.

Ethanol is called a **carbon neutral** renewable resource. Many renewable energy resources do not give off carbon dioxide when they are used. Ethanol does give off carbon dioxide. However, plants take in carbon dioxide as they do photosynthesis. Corn plants will take in carbon dioxide as they grow which balances the carbon dioxide given off when the corn in the form of ethanol is burned. Another advantage to using ethanol is that it burns cleaner than gasoline. This means it gives off fewer pollutants.

A disadvantage of ethanol is that it is not as energy efficient as gasoline. Cars that run on flex fuel have lower miles per gallon ratings. For example, a car that gets 31 miles per gallon with gasoline may only get 23 miles per gallon with flex fuel. People have criticized the premise of growing corn for fuel. They argue that since there are people going hungry, good farm land should be used for growing food and not for fuel. To deal with this criticism, scientists are looking at crops, other than corn, which grow on land that isn't suitable for growing food crops. One such crop is switch grass which Cornell University in Ithaca New York has been studying. Also scientists are looking at a new technology to make ethanol from plant by-products. This means that in the future, instead of growing corn only for ethanol, corn will be grown for food. The left-over corn stalks will be ground up to become the starting material for ethanol. Another criticism of ethanol is that the farm equipment needed to plant and harvest corn runs on gasoline. Gasoline is a nonrenewable resource.

A Visit to an Ethanol Plant

Western New York Energy LLC is a company in upstate New York that makes ethanol. These are the steps that they take to produce this fuel.

Farmers bring pick-up trucks filled with corn. The corn is dumped into bins in the floor covered with a grid as seen in this picture on the right. Conveyors in the bottom of the bin take the corn to silos where the corn will be stored.

These are silos in which the corn is stored.

This is a large vat where one of the enzymes is added to the mash.

Each day some corn is removed from the silos and ground into flour. This flour is mixed with water and **enzymes** to form a mash. The mash is cooked, cooled and more enzymes are added. Enzymes are chemicals which speed up the rate of a chemical reaction. In this situation, the enzymes speed up the rate at which starch in the corn is converted into sugar. The mash has to have high sugar content for fermentation to happen.

Fermentation is the process where ethanol is produced. To bring about fermentation, yeast is added to the mash. Yeast are tiny one celled organisms. When yeast is added to the corn mash, they become active because they are being provided with food. Like animals, yeast will use the sugar in corn as an energy source. The yeast will break down the sugar into energy, carbon dioxide and ethanol. Most animals break down the sugar into energy, carbon dioxide and water through a process known as cellular respiration. Since yeast breaks down sugar without oxygen, it produces ethanol instead of water. The process of breaking down sugar into carbon dioxide and ethanol is known as **fermentation**. It happens when conditions are low in oxygen.

This is the tank where fermentation happens

After distillation, these tanks hold the ethanol. Trucks will carry the ethanol from here to another location where it will be blended with gasoline.

The fermentation process takes about 48 to 64 hours. After fermentation, distillation occurs. Ethanol boils at a lower temperature than water. Ethanol is boiled into a gas. The water remains as a liquid. The ethanol gas is then removed, cooled and condensed back into a liquid ethanol. This process is known as **distillation.** The ethanol is now ready to be blended with gasoline.

Besides ethanol, there are two other main by-products of fermentation: carbon dioxide and the corn mash. At Western New York Energy LLC, the carbon dioxide is piped away to a nearby business that uses it for carbonated beverages like soda pop. The left over mash is dried and used as a high protein animal feed.

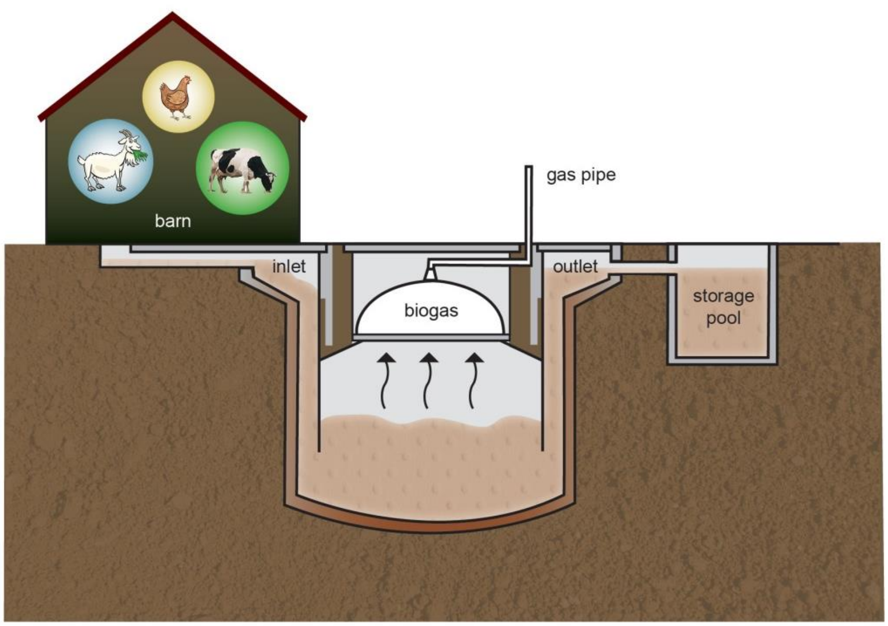
These pipes take carbon dioxide from the fermentation area to the building where it is bottled for use in soda pop.

This high quality animal feed made from dried corn mash.

Renewable Methane Gas

Methane, ethane, propane and butane are all **natural gases**. Propane is often used to heat homes. It is also commonly used to heat up an outdoor grill. However, of these three natural gases, methane is the most abundant and 90% of all natural gas is methane. Like propane, methane is used primarily for heating homes.

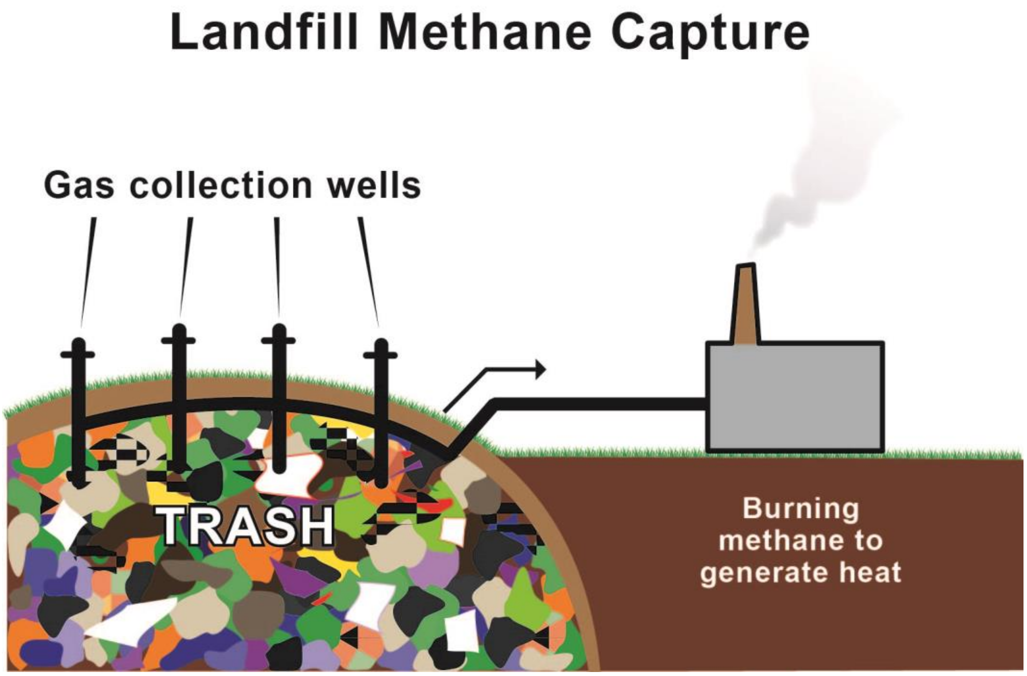
Although most natural gas is non-renewable, there are renewable sources of methane. The two key renewable sources of methane are animal wastes and landfills. In New York State, there are a lot of dairy farms. The cows on these farms produce a lot of manure. Many times this manure is spread over fields to fertilize the fields. However, if the manure is put into a **biogas digester**, this manure can produce methane. The methane gas then can be piped into the farmer's home where it can be used for cooking and heating. What is interesting about this process is there is material left over that can be spread on fields as fertilizer. Methane produced from animal wastes is a type of biofuel.



A **landfill** is a large area set aside within a community for handling wastes. Everything that you throw out, that does not go in a recycling bin, will end up in a landfill. In the old days, the landfill was a hole in the ground where trash was dumped and later buried. This way of handling trash often led to problems with water supplies getting contaminated. Now landfills are large holes dug in the ground, but the hole is lined with several layers of plastic. This way there is no danger of rain water moving through the landfill and leaching dangerous materials out of the landfill and into the water supply. If you drive by a landfill you can often see short pipes sticking up from the covered surface of the landfill. These pipes are venting methane gas into the air. In some communities instead of venting the methane gas into the air the gas is piped away to heat homes that are near the landfill. In Akron, New York, the methane gas is piped to heat greenhouses that are growing tomatoes through the winter.

What do biogas digesters and landfills have in common? In both, waste materials are decomposed (broken down) by bacteria. Bacteria are microscopic one-celled organisms. There are many different types of bacteria. There are the "bad ones" that give you strep throat as well as the "good ones" that line your large intestine and help with digestion. The bacteria found in biogas digesters and landfills are bacteria that specialize in breaking down materials in conditions where there is very little oxygen. **Anaerobic** is a word that describes conditions where there is little to no oxygen. Some anaerobic bacteria give off methane as they decompose or breakdown manure and trash. Others give off carbon dioxide. The result is that landfill gas is almost 50% methane, 50% carbon dioxide. This landfill gas has to be processed to produce pure methane gas that can then be piped into homes or greenhouses to be used as fuel for heating.

There is a downside to using methane from a landfill. When methane is burned, it gives off carbon dioxide. However, methane itself is a greenhouse gas. In fact, methane holds in more heat in the atmosphere than carbon dioxide. Perhaps, it is better to burn methane and get carbon dioxide and to just let methane gas from the landfill seep into the atmosphere.


Landfill Methane Capture
Gas collection wells
TRASH
Burning
methane to
generate heat

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Generating Electricity

Electricity is a secondary source of energy. That means that we must use another energy source to make electricity. The energy source we chose can be renewable or nonrenewable.

There are two ways we can make or generate electricity. One way is by chemical reactions in a **battery**. The other way is through electromagnetism in a **generator**.

Battery

Electricity is the flow of **electrons**. Electrons are tiny particles inside an atom. They carry a negative charge. Some materials like to give up electrons; other materials like to receive electrons. Each end of a battery is called a terminal. One end of the battery is the **negative terminal**. This end is made of the material that likes to give up electrons. The other end of the battery is the **positive terminal**. This end is made of a material that likes to receive electrons. The positive and negative terminals are grounded in the **electrolyte**. The electrolyte helps promote the chemical reactions at each terminal that gets the electrons moving once the terminals are connected. When you connect the terminals with a **conductor** such as metal wire, electricity will flow from the negative terminal to the positive terminal.

When a wire is connected to the terminals of a battery, a complete path or **circuit** is formed and an electric **current** flows. Current is measured in units called **amps**. Amps measure the number of electrons flowing through the wire at given point. **Volts** measure the force applied to make the electrons move. Volts are a measure of the strength of the current in a circuit.

You want electricity to do something for you so you add a **load** to your circuit. If you want light, you may add a load in the form of a light bulb to the circuit. If you want sound, you may add a load in the form of a radio to the circuit. The lamp and the radio both need a certain amount of power to work. Electrical power is measured in **watts**. You can calculate how much power, in watts, there is in a circuit by multiplying the amps times the volts.

Generator

At a power plant there are generators. Generators create electricity through a very different process than a battery. A generator is based on a discovery by Michael Faraday in 1831. He found that when a conductor, like a copper wire, was moved through a magnetic field, electrical current flowed through the wire. The same thing happens when a magnet was moved through a coil of wire. In both situations, there was movement that brought about changing magnetic fields.

In a power plant a **turbine** turns coils of wire within the magnetic field of the generator. A turbine looks something like a gigantic fan. High pressure steam is directed at the turbine causing the blades to spin. The spinning turbine has mechanical energy. As the turbine spins, it spins a long **shaft**. The shaft turns the coils of wire inside the magnetic field of the generator. This gets electrical current flowing within the wires. As electricity leaves the generator, it goes to step-up **transformers**. Step-up transformers increase the voltage. Electricity travels more efficiently, with less loss of energy, at high voltages. At some power plants the voltage is increased to 230,000 volts. Electricity travels by high voltage transmission lines to towns and cities. Near towns, there are substations which have step down transformers. Step down transformers reduce the voltage in the power lines. Electricity that leaves the substation then goes to businesses and homes. Before the current enters your home, it is stepped down one more time. That often happens at a small transformer on a utility pole near your house.

Steam under high pressure is what gets the turbine turning. Where does that steam come from? In two-thirds of the power plants in the United States, that steam comes from burning coal to boil water in the boiler room. Methane gas from a landfill can also be used to boil the water in small power plants near the landfill. As you will learn, there are other renewable sources of energy that can be used to boil water and some forms of renewable energy can be used to directly spin the turbine.

Model turbine – on display

Wind Power

Wind is the fastest growing source of renewable energy in New York State. Currently, 5% of New York State's electricity comes from wind. In Texas, California, and Nebraska this percentage is higher.

Windmills have been around for a long time. They are symbols of the Netherlands. They can be found on ranches and farms here in the United States. These windmills were designed to pump water, and they are the inspiration for today's wind turbine. Traditionally when wind sets the **blades** on a windmill spinning, they set in motion a mechanism for pumping water. When the wind hits the blades of the wind turbine and sets the blades spinning, they turn a shaft that turns a coil wire within the magnetic field of a generator. This sets off the flow of electricity.

On and Off the Grid

A business owner, a home owner or a school can attach a windmill to their roof or have one standing in their yard. These wind turbines supply electricity to the school, business or home. Shown here is picture of a wind turbine on the roof of a community college. Because the wind does not blow all the time, business owners, home owners, and schools cannot rely only on their wind turbines to meet all their energy needs. They still need electricty from a power station. People who have electricity coming in from a power station are said to be **"on the grid"** and they pay for that electricity. When the wind does blow, people who have a wind turbine have a free supply of electricity. Sometimes they have enough that they are able to go **"off the grid"**. This means that they don't need the electricity from the power plant and don't pay for it. However, installing a wind turbine can be expensive.

Beside individual home owners and businesses putting up wind turbines, there are wind energy companies that build wind turbines. They usually build turbines in groups of 20 to 100. These are called **wind farms**. The farm part of the name comes from the fact that these wind turbines are usually built out in the country and often on land leased from farmers. The electriciy from a wind farm may be used to provide electricity to a nearby town or city. Most of the time, however, the electricity produced by wind farms is sold to a power company who adds it to the grid.

Wind energy companies carefully select where they build their wind farms. They choose areas where the wind blows almost continually at 12 miles or more per hour. These sites tend to be on hill tops, open plains, or mountain passes. Coastal areas are also good sites for a wind farm because there is almost always wind moving either on shore or off shore. There are even plans to build wind farms in the water near a coastal area. In the water off shore, the winds tend to be even stronger than along the shore. Also, there are no obstacles off shore to block the wind's flow.

Utility Scale Wind Turbines

Utility-scale wind turbines are the very large turbines used on wind farms. One model has vertical blades and looks something like an eggbeater. But the most popular model and the one that is common in New York has two to three horizontal blades. These blades look like long slender propeller blades. These blades can be up to 50 meters long. Engineers have found that doubling the length of the blade can quadruple the amount of electricity that the turbine generates. The turbines are on very tall supports called towers. These towers are up to 25 stories tall. They are this tall by design. Winds high above the ground are stronger than those near the ground. Raising a wind turbine from 10 feet above the ground to 50 feet above the ground doubles the wind speed. The faster the wind blows the more energy produced. Doubling wind speed increases the power of the wind by a factor of eight. So for example, increasing the wind from 10 miles per hour to 20 miles per hour can increase the power output from 1,000 watts to 8,000 watts. However, there is a limit to wind speed. Wind speeds greater than 45 miles per hour can damage the turbine. Most utility-scale turbines are programmed to stop working at high wind speeds.

Pros and Cons of Wind Power

The very size of utility-scale wind turbines and the amount of land that they take up has brought controversy to wind power. There are those who are very much for wind power and those who oppose it. Let's look at the arguments for both sides. Those who oppose wind power point out that wind turbines only work when the wind is blowing between 10 and 45 miles per hour. Opponents claim that the wind turbines are noisy. They also say wind turbines annoy people who live near the wind farms with light flickering off the blades as they spin in the sunlight. Opponents point out that wind turbines can kill birds that migrate through areas where the

wind farms are located. Opponents also point out that the very size of the wind turbines makes them a danger if extreme weather should cause a blade to spin off or a tower to fall over.

Those in favor of wind power point out that wind is a free, renewable source of energy. Wind does not cause pollination nor does it give off carbon dioxide. Though wind farms may be expensive to build, once built, they do not cost much to maintain. Those in favor of wind farms see them as a way to help farmers. Farmers, who lease their land for use as a wind farm, get extra money from leasing, and yet, in many cases, are still able to graze cattle or plant crops on the land near the wind turbines. Those in favor of wind power, claim that the turbines are not noisy. One of the early wind farms was built by accident in an area through which many birds flew when migrating. Today an **environmental impact study** is usually done before a wind farm is built. An environmental impact study looks at how animals and plants within an area will be affected by the construction of a wind farm or other businesses. By doing an impact study, people would learn whether or not migrating birds moved through the area. If they did, then the wind farm wouldn't be built in that location.

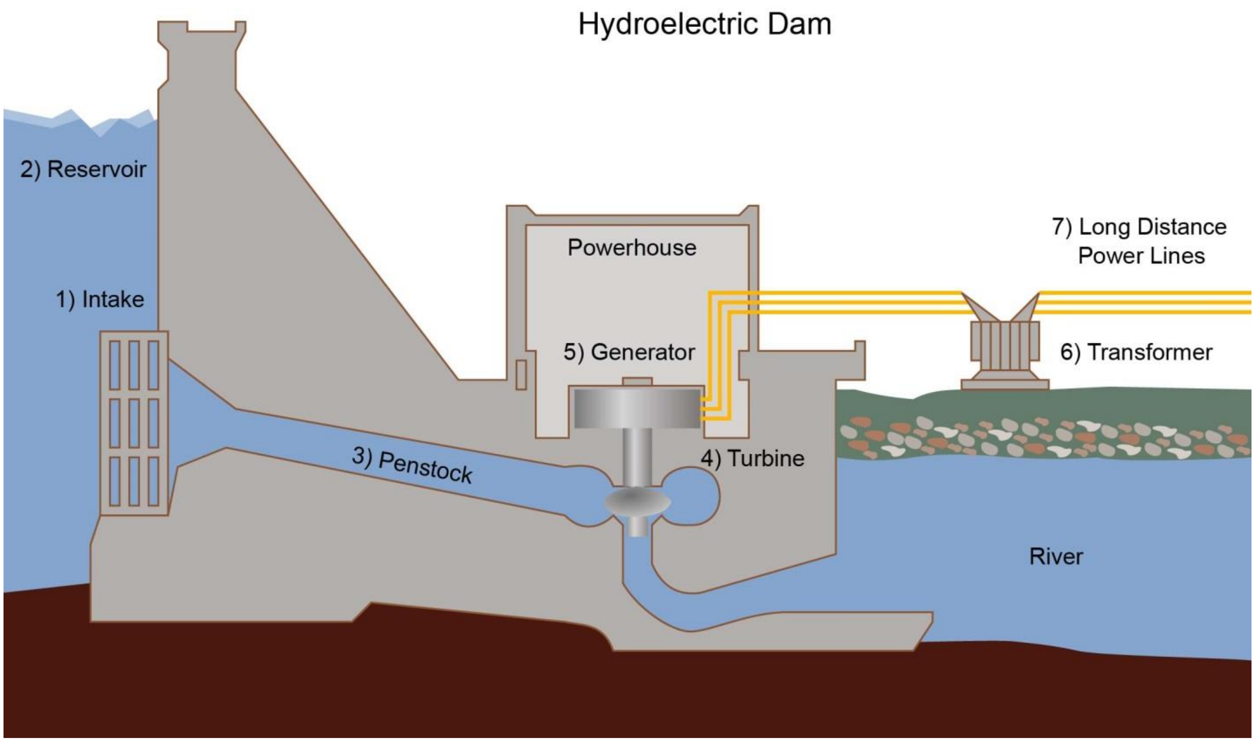
Water Power

Hydro is Greek for water. **Hydroelectricity** is electricity generated by water. In a hydroelectric power plant, flowing water turns the blades of the turbine. Hydroelectric power plants were the first power plants to generate electricity. Water power remains the most popular form of renewable energy worldwide. In New York State, 24% of our electricity is generated by water.

Waterwheels and Hydroelectricity

Just like windmills preceded wind turbines, waterwheels preceded a water driven turbine. The waterwheel is a machine that has buckets attached to the edge of a large wheel. The waterwheel is situated below flowing water. As falling water fills the buckets, the weight of the water causes the wheel to turn. Waterwheels were used in the early industrial history of the United States to grind grain and drive saw mills. A water driven turbine is basically a waterwheel turned on its side. Instead of buckets, the turbine has blades. When the water hits the blades, they turn a shaft that turns coils of wire inside the magnets of the generator. This sets off the flow of electricity. The water that hits the blades of the turbine flows down a large tube called a **penstock**. The penstock is directed at the turbine. The force with which the water hits the blades is due to the force of falling water - the greater the height from which the water falls, the greater the force of the water. Another factor that affects the force with which the water hits the blades is volume. The more water flowing down the penstock, the greater the force will be. In hydroelectricity, the height from which the water flows is called the **head**. The amount or volume of water is called the **flow.**

The earliest hydroelectric power plants were located near natural waterfalls but an artificial waterfall will form when a river is dammed. When a river is dammed, the flow of the river is blocked above the dam. This causes the river to slow down and overflow its banks forming an artificial lake called a **reservoir**. **Dams** are usually built only where the area above the dam will make a good reservoir. The reservoir is important because it represents stored energy also known as potential energy**.** It holds the water that will be sent through the penstocks to a turbine. Once water starts flowing into the penstocks, the potential energy of the water in the reservoir is converted into the kinetic energy of falling water. Dams and reservoirs are used not only for hydroelectricity. They are also used for flood control and irrigation.



To generate electricity an operator opens the intake gate (1). This starts water from the reservoir (2) flowing through a large tube called a penstock (3). At the bottom of the penstock, the fast moving water spins the blades of a turbine (4). The turbine is connected to a generator (5). Electricity from the powerhouse is taken to step-up transformers (6) to increase voltage then sent via transmission lines (7) to towns and cities.

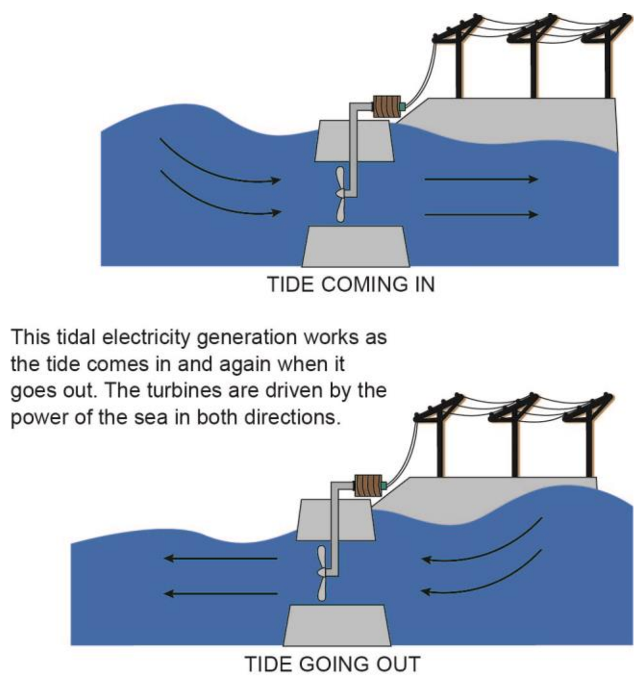
To build a dam and a hydroelectric plant is very expensive. Once built, these structures last a long time. There are costs involved with taking care of the dam but the fuel for the dam costs nothing. The water is free. Water does not give off noxious fumes or pollutants or carbon dioxide. Another advantage of water power over wind and solar is that water can flow all the time so electricity can be generated 24 hours a day. The reservoir represents stored energy. Operators control the amount of electricity being produced. Most dams have 5 to 15 penstocks. At the Robert Moses Power Plant in Lewiston, New York there are 13 penstocks. When the demand for electricity is low, operators open only a few intake gates. When the demand for electricity is high, operators open intake gates to more penstocks. Another advantage of water power is **efficiency**. Hydroelectric plants are very efficient in converting the kinetic energy of flowing water into electricity. They are much more efficient than wind or coal.

There are problems associated with hydroelectricity. Most of these problems are related to building the dam. As mentioned, when a dam is built, the river above the dam overflows its banks and creates a reservoir. Overflowing water destroys the habitats of many organisms that live on the shores of the river. Internationally, dam-building has even involved re-locating people because their homes and villages were about to be destroyed. Damming a river also alters the natural flow of the river downstream. On the West Coast of the United States, extensive dams have been built in Washington and Oregon states on the Columbia and Snake Rivers. These dams prevent the salmon and trout that naturally live in these rivers from migrating upstream to spawn (lay eggs). Fish ladders have been built by a number of dams with the hope that the salmon could swim up the gentler slope of the ladders and move up stream this way. The ladders have helped a little but the number of salmon and trout have been greatly reduced in the last 50 years. Environmental groups like "Save our Wild Salmon" actually want dams taken down so the salmon populations can be restored.

There is not much room for future growth with hydroelectricity. The rivers, that are most suitable for hydroelectricity, already have power plants on them. Furthermore, any future dam construction will probably involve lengthy and expensive environmental impact studies before any construction even begins.

Tidal Power

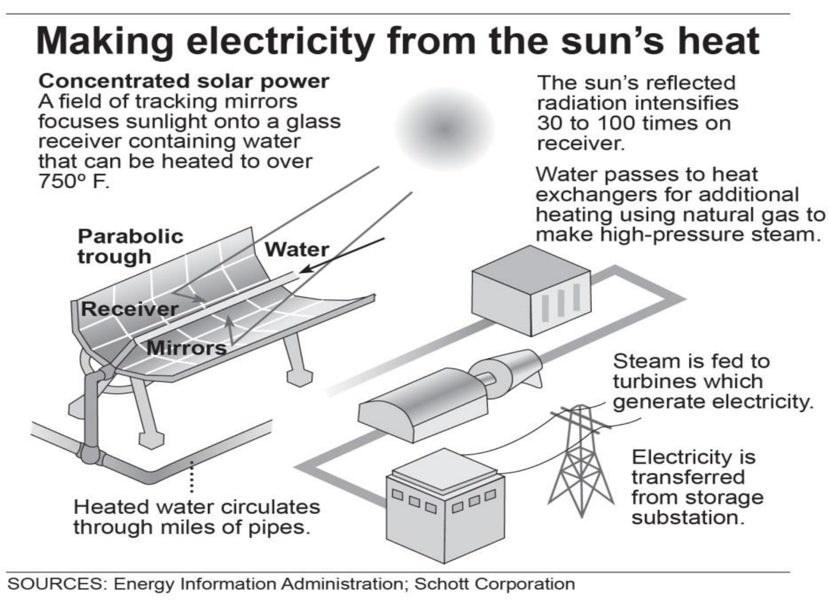
An interesting twist on hydropower is tidal power. Tides are the movement of water up and down the beaches surrounding large bodies of water. They are most evident by oceans. The cycle of high and low tides is set in play by the gravitational pull of the moon on earth's waters. This constant movement of water can be used to push the blades on a turbine in a fashion similar to what happens at a hydroelectric plant. Tidal turbines are built into low dams that are constructed across inlets. There are gates in the dam that open to let tidal water push through the dam. As the tidal waters push through, they turn the blades of the turbines. There are no tidal hydroelectric plants currently in the United States, but there are a few located in France.



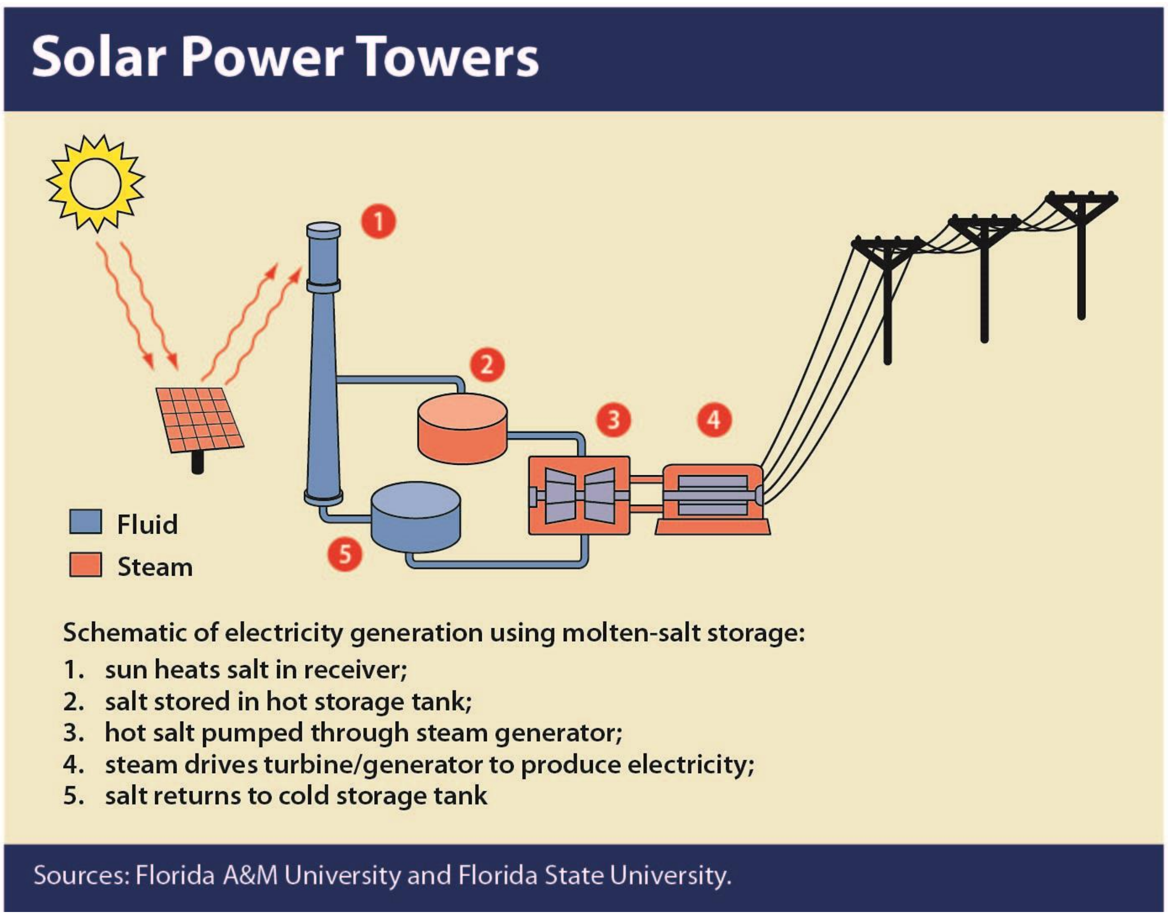
Solar Thermal Power Plants

The Latin word for sun is sol. **Solar** energy is energy from the sun, and it is the greatest source of renewable energy. Solar thermal power plants tap into this energy source. With wind and water, the kinetic energy of blowing wind or flowing water is used to turn the blades of a turbine. With a solar thermal power plant, the energy of the sun powers the boiler room and is used to boil water to steam. The steam is then directed at the blades of the turbine. Thermal comes from the Greek word for heat. Although there are several different types of solar power plants all of them use sunlight to heat a **fluid**. Solar collectors capture the sunlight that heats this fluid. There are three main types of solar collectors: the **parabolic trough**, the **heliostat** and the **dish**.

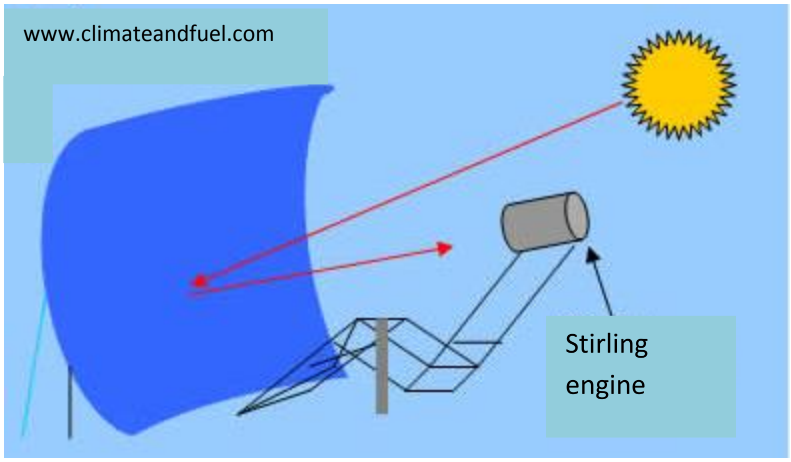
In the Mojave Desert south of Los Angeles is the Kramer Junction Solar Electric Generating station. Kramer Junction has acres of parabolic troughs. Parabolic troughs are long curved rectangular mirrors. These mirrors are up to 40 feet in length and 10 feet in height. The mirrors are on a base that turns the mirrors so they can track the sun as it moves across the sky from east to west. The importance of the parabolic shape is that when sunlight hits the mirrored inside of the trough, the curved surface focuses reflected sunlight onto a tube that runs the length of the mirror. The tube contains a liquid that is heated by the sun to very high temperatures. The hot liquid is pumped to the power station. At the power station, hot liquid is pumped though **heat exchangers** where the heat from the liquid boils water to steam. The steam powers the turbine that turns the coils of wire in the generator. Near the boiler room the hot liquid can also be stored in thermos-like containers for use later after the sun goes down.



The Ivanpah solar thermal power plant is being built in southern California. This will be a power tower power plant. Like Kramer Junction, this will involve acres of mirrors. The mirrors will encircle a very tall tower. The mirrors are called heliostats. Helios is the Greek word for sun. Heliostats capture the sun. They are not parabolic in shape but are flat and angled upward. Like the parabolic trough the base of each heliostat turns so that the heliostat can track the movement of the sun. Heliostats receive sunlight and reflect it to a receiver at the top of the tower. The receiver absorbs the reflected sunlight and transfers the heat to a fluid. This fluid can be stored for future use or used directly to provide steam to drive the turbines.



The final model is called a dish **stirling engine**. The mirrors used with this system are called dish heliostats. They are similar in shape and appearance to a large satellite dish. The curved shape of this dish concentrates reflected sunlight onto a fluid which is heated to 550° Celsius (1022° F). The thermal energy from this fluid sets in motion a set of mechanisms within the stirling engine which end with the engine moving a magnet back and forth inside a coil of wire. Moving a magnet within coils of wire generates electricity in the same way as moving coils of wire inside a magnet.

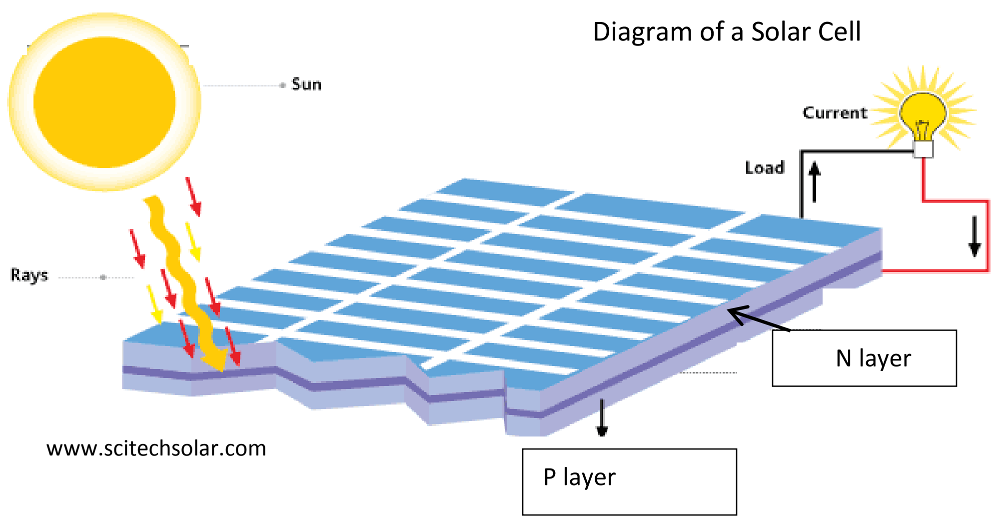


One advantage of solar energy is that, like wind and water, sunlight is free. And like wind and water, solar energy is clean energy. It does not pollute the atmosphere the way coal-burning electric power plants do. Also, solar power plants do not give off carbon dioxide. The drawbacks to solar are similar to those of wind. The wind doesn't always blow, and the sun doesn't always shine. But solar thermal power plants have developed ways to store the sunlight. The sunlight heats up a liquid which is then stored in tanks that are insulated so they don't lose the heat. Both wind farms and solar power plants take up a lot of land. In the United States the solar power plants are located in or are being planned for desert areas in the southwest. In the desert, the sun shines nearly every day. There are not many days when the weather is overcast and cloudy. Desert lands are not usually close to cities so a network of transmission lines has to be built to carry the electricity from the power plant to the people. Using deserts to make energy may seem like a good use of "wasted" land. Environmental groups, however, point out that deserts have their own unique ecosystems. They worry about the impact of hundreds and hundreds of mirrors on the creatures of the desert.

Photovoltaic Cells

The Greek word for light is photo. A **photovoltaic cell** is a device that takes the sun's energy and uses it to create electricity. A photovoltaic cell is also known as a solar cell. And it works in much the same way a battery works. In a battery, a chemical reaction gets the electrons moving; in a solar cell, sunlight gets the electrons moving. The flow of electrons is electricity. A solar cell is very thin. There are two main layers to a solar or photovoltaic cell: the **p-layer** or positive layer and the **n-layer** or negative layer. As in a battery, electrons flow from the negative layer to the positive layer.

Diagram of a Solar Cell



More Details on How a Solar Cell Works

In a solar cell, the p-layer is on the bottom. The n-layer is on top. When sunlight hits the p-layer, electrons from that layer absorb the sun's energy and get excited. These excited electrons move up to the n-layer. They push out electrons from the n-layer. The electrons that have been pushed out start moving. If you look down on a solar cell, you will see a metallic grid. These extra electrons in the n-layer travel down the thin wires of the metallic grid to the black coated wire. Electrons travel through this wire to the load. In the diagram, the load is a light. Then the electrons travel back from the load through the red coated wire to the p-layer to complete the electrical circuit. These electrons that travel back to the p-layer replace the electrons that were pushed up to the n-layer.

The p and n layers of a solar cell are made primarily of silicon. Silicon is a semi-conductor. This means silicon conducts electricity but not as well as metals such as copper or silver. The silicon in the p-layer has a little bit of the element boron in it while the silicon in the n-layer has a little of the element phosphorus in it. The phosphorus makes the n-layer want to give up electrons while the boron makes the p-layer want to receive electrons.

Uses of the Solar Cell

Most of the time solar cells are connected with other solar cells to generate more power. Connected solar cells create a solar panel. Small solar panels can be found in calculators and larger ones in outdoor lighting. A collection of solar panels is called a solar array. Some homeowners and businesses choose to **supplement** the electricity they get from the grid with electricity from large panels installed on their roofs. Schools are also doing this. Through a program called “School Power Naturally”, 50 schools in New York State received money so that they could install solar panels.

On sunny days, people with solar panels may actually generate more electricity than they need so they sell the extra electricity back to the power company. Many people think solar panels only work in sunny places like California and Florida, but solar panels do work in northern areas like New York. High temperatures of southern areas during the summer can actually damage the solar panels.

The advantages of solar cells and solar panels are similar to the advantages of solar power plants. The fuel, sunlight, is free. Sunlight, like wind and water, does not give off pollutants when used nor does sunlight give off carbon dioxide. The supply of sunlight is nearly endless. We receive more energy from the sun in one day than is available in all the known oil reserves here on earth. While solar thermal power plants require acres of mirrors, solar panels can be installed on roofs and everyone who has a home has a roof. Sometimes if a house is not orientated to receive a maximum amount of light during the day the panels may have to be installed as free-standing structures in a homeowner’s yard.

There is work being done to improve the efficiency of solar panels. Right now, most solar panels are from 10% to 20% efficient. That means only 10% to 20% of the sunlight is converted to electricity. The light around us is called “white light”, and it is made of ultra-violet, blue, green, yellow, orange and red light. These colors make up the visible light spectrum and by using a prism, you can break white light down into these colors. Many of the solar panels that were developed early on only absorbed light from the red end of the spectrum. Newer designs of panels use light more efficiently from the whole visible light spectrum. Another area of interest for solar technology is the development of solar films to take the place of solar panels.

One type of film is being developed as a covering for roof tops. Another type of film is transparent and being developed as a covering for windows. Both of these films will generate electricity. The sun is an endless source of energy. Research scientists and engineers will continue to experiment and create more efficient and practical ways of using this renewable energy source.

Solar Panels on the Roof of a Building at Alfred State

Reverse Engineering

Reverse engineering is the process of taking something apart to see how it works. It can be a good way to learn how something works as long as there is no danger in taking the item apart. Sometimes reverse engineering is used to correct a problem. Software engineers will do this to correct glitches in computer programs. A program is the set of instructions that a computer uses to complete certain tasks. You are probably familiar with Word or Power Point. These are software programs were created by a company named Microsoft. The most common reason for reverse engineering is to take something apart so a person can see how it works and then make their own copy of it.

Reverse engineering started during wartime. When one side captured superior weapons from the other side, they would take these weapons apart to see how they worked and then copy them. Americans and the English did this in World War II with captured German equipment. During the Cold War, Soviets captured three American B-29 fighter planes. The Soviets took them apart, copied the parts and developed their own military plane, the Tu-4. The Tu-4 was nearly identical to the B-29.

More recently reverse engineering has become part of industrial espionage. Espionage means spying. If a company makes a product that earns lots of money, another company will purchase the product, take it apart to see how it's made then make their own version of this product. Knock-off copies of everything from perfume to cell phones to vacuum cleaners have come about through reverse engineering. Now this may seem like stealing, and in many cases, it is. There are laws in place to protect inventors.

Copyrights and Patents

Copyright laws protect authors of original works. An author may be someone who writes a song, creates a painting or develops a computer program. If something has a © symbol with a date by it, then it has a copyright. A copyright lasts a long time. It lasts as long as the person who created the work lives plus 70 more years. You can apply to the United States Copyright Office to officially receive a copyright for something you have created. However, copyright protection is in place from the moment a person finishes creating the work. So if you wrote a song and someone steals it, you can take them to court even if you did not publish the song and get a formal copyright on it. However, without publication, you might have a hard time proving that it was your song.

A **patent** protects inventions. A patent can be given for a new and useful process, a new machine or a new substance or new design. An inventor applies for a patent by submitting paperwork to the United States Patent Office. In the paperwork, the inventor gives a detailed description of how to make the invention, and how the invention works and how it should be used. If a patent is granted, then no one else may make, use or offer for sale the invention without permission from the inventor. Patents last about 20 years.

As the owner of a copyright or patent, you can give another person the right to use your creation. Usually the person who uses your creation pays you a **royalty**. A royalty is payment for the privilege of using your work.

Copyrights and patents reward people for being clever and inventive. They can go a long way to prevent people from stealing ideas, recipes and machinery through reverse engineering. Copyrights and patents help to limit reverse engineering to those who want to understand better how something works. Then maybe these people will use that knowledge to create their own inventions.

Hydrogen - the Fuel of the Future

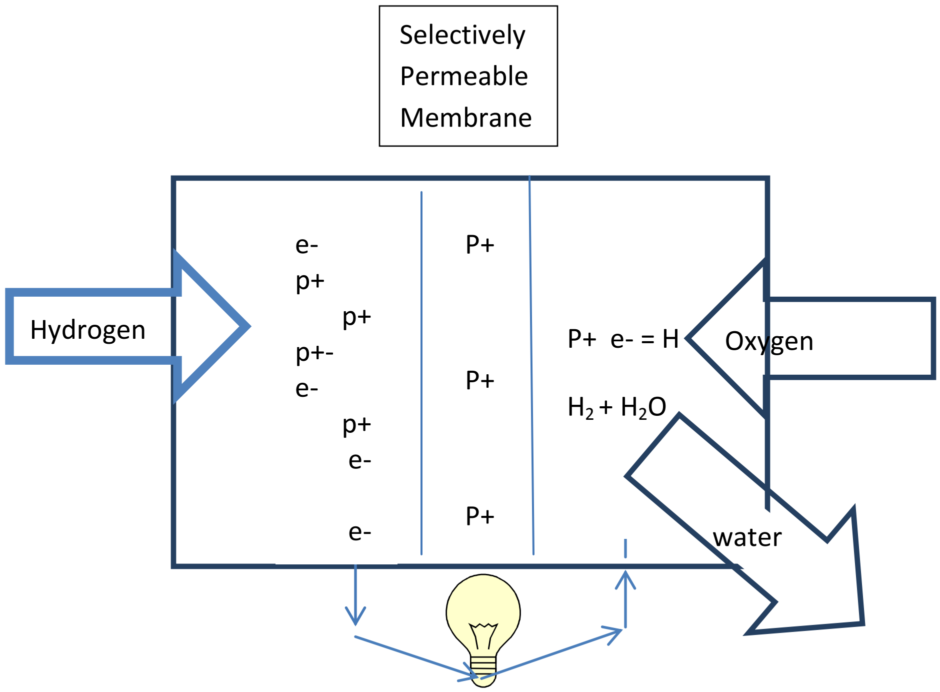
The space agency NASA has been using hydrogen for years. Liquid hydrogen is the fuel that launches rockets into space. Hydrogen fuel cells powered the computers and the electrical system on the space shuttle.

Hydrogen is the most abundant element in the universe. Stars are made of it. Hydrogen is the first element on the Periodic Table of Elements. Of all the elements, hydrogen has the simplest atomic structure. A hydrogen atom has only one **electron** and one **proton**. There are no neutrons.

Hydrogen is a gas like methane. Like methane, it can be burned to release energy in the form of heat. And like methane, hydrogen can be used to heat homes. Hydrogen can also be used in the boiler room of a power plant to heat water to steam. Hydrogen can take the place of gasoline and be used to run a car. Even adding 5% hydrogen to gasoline can reduce the amount of pollution a car gives off by 30 to 40%. However, when most people talk about hydrogen being the fuel of the future, they are talking about **fuel cells**. Car companies and universities are working to develop a car that runs on a hydrogen fuel cell. A fuel cell is like a battery.

Details of a PEM Hydrogen Fuel Cell

The most common hydrogen fuel cell is called a PEM fuel cell. PEM stands for polymer exchange membrane. This membrane is **selectively permeable** which means some materials are able to go through it while other materials are not. The membrane surrounding the cells of our body is selectively permeable. In a hydrogen fuel cell, the membrane is between two chambers. Each chamber is like the terminal of a battery. One chamber is negative terminal. The other is the positive terminal. Hydrogen gas enters the chamber that is the negative terminal. In that chamber there is a catalyst. A **catalyst** is a chemical that speeds up the rate of a chemical reaction. The catalyst in the negative chamber of the fuel cell speeds up the rate at which the protons of the hydrogen atoms are separated from their electrons. The hydrogen protons can move through the membrane and enter the second chamber. The membrane does not let the electrons through. Instead, these electrons are directed to flow through a circuit. A flow of electrons is electricity. To complete the circuit the wire comes back to the positive terminal which is the second chamber. In the second chamber, the electrons join up with the hydrogen protons to form hydrogen atoms again. Air enters the chamber. 20 % of the air is oxygen. The oxygen combines with the hydrogen to form liquid water. On the space shuttle the water given off by the hydrogen fuel cells was used for drinking water.



Too Good to Be True

Hydrogen is the most abundant element in the universe so you would think it would be a great source of renewable energy. But for hydrogen fuel cells to work, they need a steady supply of pure hydrogen. Very rarely does hydrogen exist in a pure form. Hydrogen is very reactive. By its chemical nature, it wants to react with other elements to form compounds.

Electrolysis is one way to get pure hydrogen. In electrolysis, an electric current is used to split water into hydrogen and oxygen. This process is expensive. Right now, hydrogen is too expensive to be a good source of renewable energy. However, scientists are continuing to look for ways of producing an inexpensive supply of pure hydrogen gas. Researchers are looking at certain types of algae and bacteria that give off hydrogen. Researchers are also looking at synthetic or manmade leaves. In the first step of photosynthesis, leaves use sunlight to split water into hydrogen and oxygen. Scientists are trying to make synthetic leaves that will do the same thing. Scientists will then collect the hydrogen. Even if we could produce a good supply of hydrogen, some people are scared to use it. Hydrogen is very explosive. Also, as a gas, it is hard to ship from one place to another.

Will hydrogen be the fuel of the future? Research is still being done to answer that question.

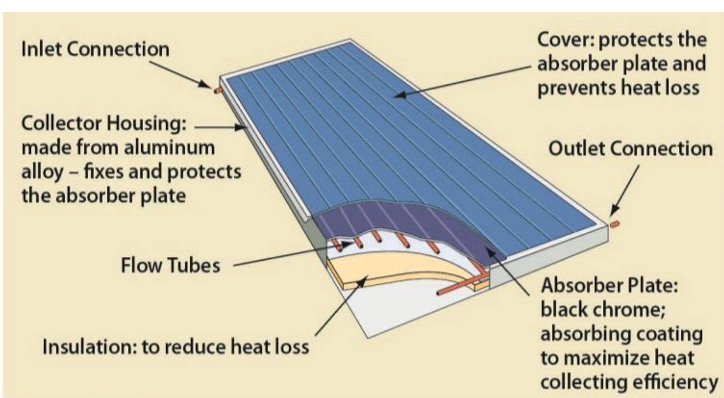
Solar Hot Water Heaters

We use energy to heat the water that we use in our showers, washing machines and to do our dishes. Often the energy for heating our water is from nonrenewable sources. Propane gas is often used. It is a type of natural gas. Sometimes electricity is used for heating the hot water tank. But we can also use the sun directly to heat our water and even to heat our homes. When we talk about heating our homes with the sun, we talk about active and passive solar heating. We can understand the difference between these two approaches by looking at how the sun can be used just to heat our water.

In all solar hot water systems there are two main parts: a **solar collector** and a storage tank. The collector is where the water is heated by the sun and the storage tank is where the warm water is held until it is used. In an **active** system, the water is pumped through the house and the pump is powered by electricity. In a **passive** system, the water moves by gravity down from the tank to where the warm water will be used. Usually the solar collector is placed on the roof. Sometimes it is placed on the south facing wall of a home.

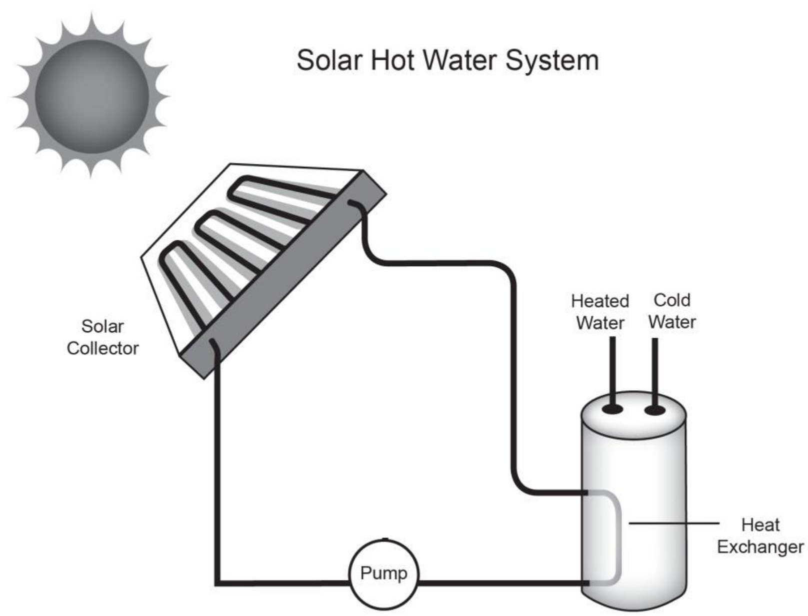
Active systems are much more common than a passive one. Homeowners don't have to pay for the sunlight heating the water but they usually have to pay for the electricity that pumps water from the storage tank to the collector and to the rest of the house. Of course, it is possible that the electricity could come from a solar panel on the roof.

The solar collector used for a hot water system looks different from the solar collectors used at a solar power plant. The collectors at a solar power plant have surfaces made of mirrors to reflect the sunlight. A hot water solar collector has a dark surface called the **absorber plate**. This dark surface absorbs the sun's radiation. Over the dark surface of the absorber plate are tubes. The front of the collector is a clear cover to hold in the heat. The tubes that cover the absorber plate have water in them. As the absorber plate is heated by the sun, the water in these tubes gets heated. The water then goes from the solar collector into a main pipe and that main pipe then goes to the hot water heater.



Source: Green Spec.

During winter in New York State, and many other areas, the temperature often drops below the freezing point of water. In these areas, water cannot be used in the solar collectors. There is too much risk of the water freezing at night and possibly bursting the pipes. Instead another fluid such as anti-freeze is used. If another fluid is used instead of water, then another step is added to this system. This fluid does not go directly into the hot water tank. It does not mix with the water that will be pumped to the shower or the dish washer. Instead, the fluid goes into a heat-exchanger. A heat exchanger is a coil of piping which is put inside the hot water heater. The water picks up the heat from the fluid going through the heat-exchanger.



In New York, most people who have a solar hot water heater do not count on it for all their hot water. They have a regular hot water heater as a back-up. There are many cloudy days during the winter when there is not enough sunlight to warm up all the hot water that a family might need. Solar hot water heaters are now becoming popular among people who own pools. They are using the heaters to warm the water for swimming.

The Passive Solar Home

A passive solar home is a home that is heated by the sun but does not use any other energy source to help store or move heat throughout the home. Such a home requires good planning. When designing a solar home, a person has to balance a number of different factors.

Orientation: Orientation means to be aligned or arranged in a certain direction. A passive solar home should be designed so that one of the long sides of the house faces south. On this side of the house should be large windows. During the winter, these windows should not be shaded from 9 am to 3 pm. The sunlight coming through the south facing windows is the main source of heat for the home.

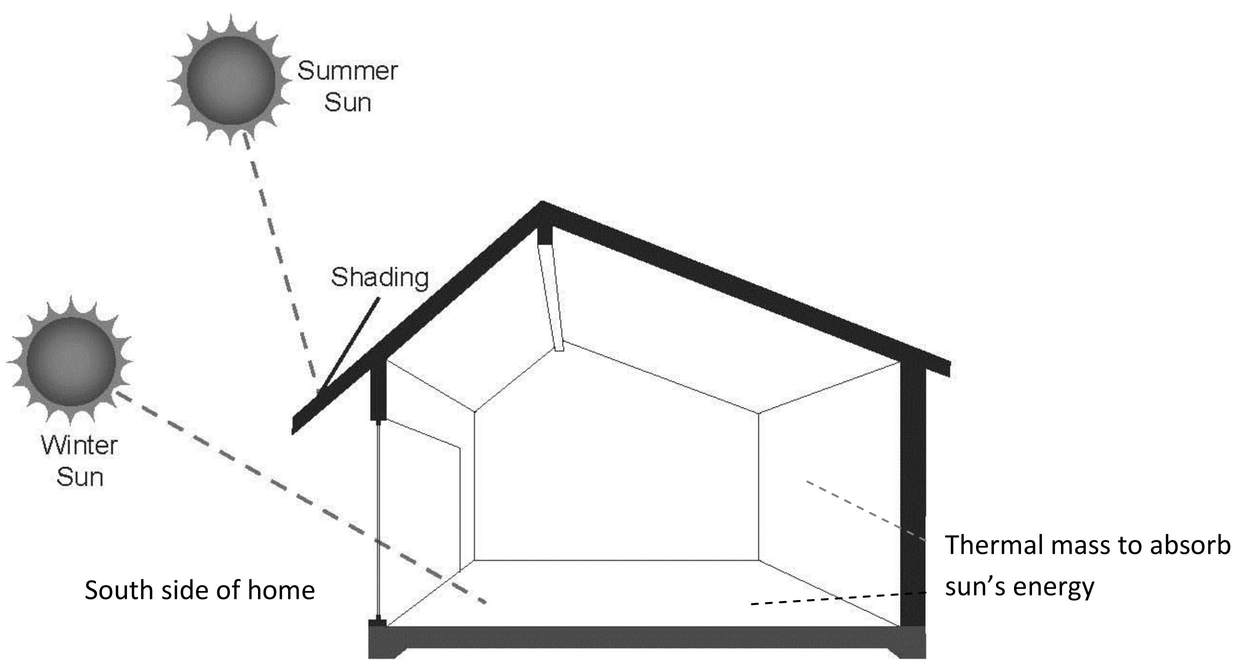
Heat storage: Sunlight is the source of heat but this heat has to be stored. In a passive solar home, the heat is usually stored in stone, concrete, brick or tile. These materials are said to be high in thermal mass. Stone, concrete and brick are dense materials. They absorb the heat as the sun is shining on them and then release the heat to warm rooms slowly after the sun has gone down. Stone, concrete, brick and tile are used for the floor and for the wall opposite the windows. In a passive solar home, this is how heat is stored. The floors and walls in a passive solar home are usually dark in color because dark colors are better at absorbing heat. The size of the south facing window needs to be in proportion to the size of the walls and floor which will be storing the sun's heat. If not, the house may end up being too cold or too warm.

Insulation: Insulation is critical to holding heat within a home. This is true whether a home is a passive solar home, an active solar home or just an ordinary home heated by propane gas. Insulation is a material that is put between the inside walls and outside walls of a home. It is also very important to put insulation in the ceiling and attic. Many different products can be used for insulation such as foam, fiberglass, and cotton batting - even old newspapers. All these materials are poor conductors of heat. Air is a very poor conductor of heat. Often a good insulating material holds pockets of air. Think of a cotton ball. It holds air. That's what makes it fluffy. It makes a good insulator. Insulation is rated by the **R-value**. The greater the R value, the more effective the material is at slowing down the transfer of heat.

In addition to insulation, a person who owns a passive solar home has to make sure that heat is not escaping from the areas around windows and doorways. Sealing these areas with caulk or weather stripping can prevent this. Heat can also escape windows. Storm windows and double paned windows help to cut down on the loss of heat through glass. Certain types of glass do a better job of blocking heat loss. At night, insulated curtains can cover the windows. This too will help to help keep the heat in.

Staying cool in summer: In addition to keeping the house warm in the winter, a passive solar home must be kept cool in the summer. Solar homes are designed to take advantage of the changing position of the sun. This is done by allowing the sun to shine into the house in the winter, and by blocking the sun from shining into the house in the summer. The sun in winter is low in the sky, and the sun in summer is high in the sky. By knowing the position of the summer sun, a homeowner will know where to build roof overhangs and how large to make them. The overhang stops the summer sun from shining into the house.

There are other ways to cool the house during summer. One way would be to cover the windows facing south. This could be done inside the house by using curtains or shades. It could be done on the outside of the house by using shutters. Although the south facing windows will let in the most sun, covering the east and west windows also helps to keep the inside of a home cool. Another way to cool a house during the summer is by planting **deciduous** trees along the south side of the house. In the spring and summer, these trees grow leaves and shade the house. In the fall, the trees drop their leaves so in the winter they don't block the sun. When there is breeze, opening windows can also help to cool a home. In many places in New York, the breezes blow from west to east so opening windows on the east and west side of the house can help to move warm air out of the house.



A passive solar home involves balancing many different factors to make sure that the home is warm in the winter and comfortable in the summer. In places which experience cold winters with many cloudy days, a totally passive solar home usually doesn't work.   But a homeowner can bring down the costs of heat and even cooling his home when he uses the features of passive solar home.

An Active Solar Home

This article describes a gentleman named David Slayton who built a solar home in the 1970's. Until the 1970's, crude oil was cheap. Gasoline and heating oil both come from crude oil, so they were also cheap. For political reasons in the 1970's, the price of crude oil went up. As a result, the price of gas and heating oil were much higher than they had ever been before. This made people seriously think about renewable sources of energy. Many people became interested in solar energy.

David Slayton was one of those people. He became interested in building an active solar home. Mr. Slayton decided that rather than build a solar home from scratch, he would convert his own home into a solar house. His first step was to build a hot air solar collector on his roof. This collector was ten feet wide and forty-five feet long. It ran the entire length of the roof that faced south. The collector was held in a wood frame. The frame held the collector at a 58° degree angle to take advantage of the winter sun.

The base and sides of the collector were made out of sheet metal and painted black with a heat absorbent coating. The front of the collector was clear fiberglass to let in sunlight. A series of fiberglass sheets were suspended in the middle of the collector. These sheets ran the length of the collector and were also painted black with a heat absorbent coating. These sheets helped to trap air heated by the sun. The hot air in the solar collector was then pumped down to a storage area in the basement of the greenhouse.

The greenhouse was built on the south side of the house beneath the collectors. When the sun would shine through the greenhouse windows, the heat from the sun would warm the inside of the greenhouse. For **thermal mass**, the greenhouse had a heavy tile floor and a solid brick back wall. The floor and wall absorbed and held heat energy. During the day as the brick wall absorbed the sun's heat, this heat would slowly move through the wall and gradually warm the room on the other side. At night, the windows of the greenhouse were covered with heavy curtains. These curtains prevented heat from being lost through the windows.

Solar collector

Greenhouse with wooden slats to prevent the greenhouse from getting too warm in the summer

The greenhouse had a deep basement. This basement was heavily insulated. In this basement were two heat storage units. The heat storage units held small cans which were the size of soda pop cans. These cans were filled with water. The cans were stacked on their sides in two storage areas. Each storage area contained sixteen thousand cans. This averaged to about fifteen hundred gallons of water in each storage area. Hot air from the solar collector was directed to the storage areas where it heated the water in the cans. One storage area would be programmed to take very hot air at 110° F (43° C) or higher. The other area would take slightly cooler air between 80° F to 109° F (27° C to 43°C).

The heat from the solar collector was stored in the water held in these small cans. Water holds heat longer than almost any other material. At night, the heat from the water in the cans warmed the air of the storage unit. From there the warmed air was piped up into the rest of the house. Small cans were used instead of a large barrel of water because small amounts of water heat up faster than a large amount.

Cans filled with water

Just before the hot air from the solar collector entered the storage units in the greenhouse basement, the air moved through a heat exchanger in a water tank. The heat exchanger transferred some of the heat from the air to the water in the tank. Once this water was preheated by the hot air from the collectors, it went on to the normal hot water heater. Since the water going into the hot water heater was already warm, the hot water heater did not have to use as much energy to make the water hot enough for doing laundry and dishes.

Mr. Slayton also improved the insulation of his home. All the outside walls of the house were increased in size so they doubled the insulation value of Mr. Slayton's home. The attic had three times more insulation than a normal house. An air lock was also built around the back door. The air lock was a small entrance room built on the outside of the house. Entering the house through this room cut down on the cold air coming into the house.

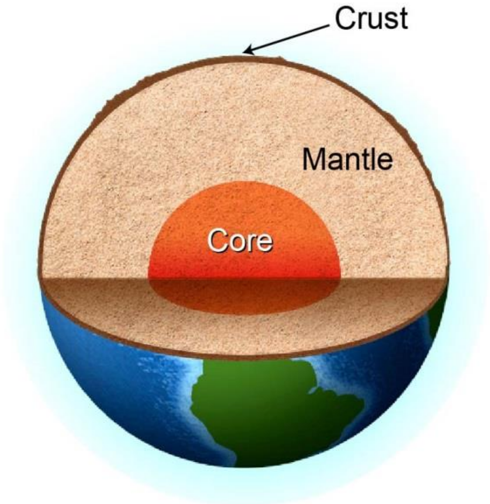
With all these features to keep the house warm in the winter, Mr. Slayton had to think about how he would keep the house cool in the summer. To cool down the greenhouse, Mr. Slayton put wooden slats into the outer frames of the greenhouse windows. On the roof of Mr. Slayton's house were vents that warm air could escape through. Also on the roof was a whole house fan which removed warm air from inside of the house. Remember if a home is well-insulated, once cooled down, it will hold in the coolness as effectively as it held in the heat.

Even though Mr. Slayton re-fitted his home to be heated by the sun, he did have back-up systems. He had a regular hot water heater. He had a small furnace and a wood burning stove. Mr. Slayton lives in Rochester, New York which is known for its harsh winters.

Mr. Slayton spent a year and a-half making over his home into an active solar house. Mr. Slayton even got his children to help. They dug up the brick patio so that area could be used for the greenhouse. And they helped collect and wash pop cans to be used in the storage area. (Later, the Slaytons decided not to use the pop cans and instead purchased cans of similar size.) Mr. Slayton and his family lived in their active solar home for 10 years. After that, they moved to a passive solar home, but it was one which also used a traditional heating system for cloudy cold winter days.

Geothermal and Geoexchange

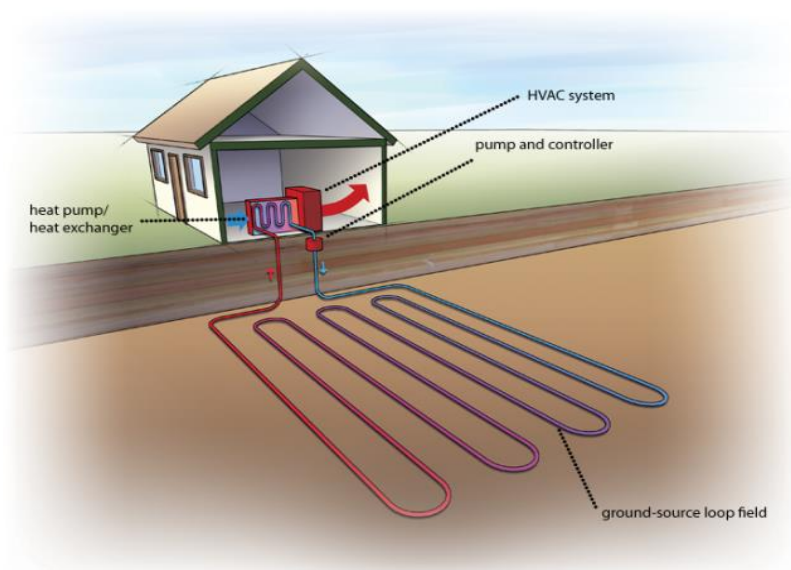
Geothermal comes from two Greek words: geo which means earth and therme which means heat. When some people talk about geothermal energy, they are talking about heat



from the earth's core. Geologists describe the earth as having three layers. At the center of the earth is the core; going out from the core is a thick layer called the mantle then comes the thin outermost layer called the crust. The crust is the surface of the earth. It is the layer we walk on. The crust is not solid but broken into sections called plates. The core of the earth is very hot. The temperature of the outer part of the core is about 2204° C (4,000° F). This heat works its way through the mantle and in the uppermost part of the mantle the temperature is about 870° C (1,600° F). The heat from the mantle makes its way into the crust in certain areas particularly near plate boundaries. The heat from inside the earth heats ground water and in some places this creates hot springs and geysers. People can drill into the heated water underground and pipe either steam or hot water to a power plant where it can be used in the boiler room.

New York State is not near a plate boundary. In New York State, when people talk about geothermal energy, it has a different meaning. Perhaps, a better term for what New Yorkers mean is **geoexchange.**

This is the idea behind a geoexchange system. Beneath the **frost line**, usually around 10 feet below the surface, the ground stays the same temperature year-round. In New York, it stays about 54°F. Pipes are run through this layer of the ground and connected to the inside of a building. A fluid circulates through these pipes. In the winter, this fluid is warmed to the temperature of the surrounding soil. Pipes bring the fluid into the house. The warmed fluid enters a **heat exchanger** which extracts the heat from the fluid**.** Then a heat pump compresses and concentrates this heat. This heat is then spread throughout the home through pipe-like connections called ducts. Pipes now



carry the fluid away from the heat exchanger and heat pump and back into the ground. The fluid is now cool and the whole process of being warmed by soil is ready to start again.

In the summer a reverse process happens. The ground and the fluid inside the pipes are cooler than the inside of the house. The fluid draws in the excess heat from the home. This excess heat is then absorbed by the earth. Think of the house as one system and the area underground as another system. The fluid brings these two systems in contact with each other. When that happens, heat will always move from the warmer system to the cooler system. This process is known as **conduction**.

At the present time, a geoexchange system is expensive to install. Few homeowners can afford this approach to heating and cooling their home. However, several large public buildings such as Sullivan Community College and the Museum of the Earth have put in such systems. Here the savings on heating and cooling bills balance the cost of installing this system.

Conserving Energy

People are interested in renewable energy because the demand for energy is increasing. Populations are growing in many countries around the world. Around the world more and more people are driving cars, owning televisions, computers and other appliances. For the last 150 years we have relied heavily on coal, oil, and natural gas to meet our energy needs. These are nonrenewable resources. Now we worry that our supply of these nonrenewable resources will run out. We also worry about the pollution and the carbon dioxide that is given off when we burn coal, oil and natural gas. These worries have led leaders in government, research and industry to look at renewable energy sources. But whether we use renewable or nonrenewable resources, we cannot talk about meeting the increasing need for energy without talking about **conserving** energy.

Conserving energy is the idea of using energy wisely. Conserving energy requires that we look at how we use energy in our everyday lives and ask these questions. Are there times when we waste energy? Are there ways we can use energy more effectively? In answering these questions, we should look at how we can conserve energy directly and indirectly.

Directly conserving energy

Directly conserving energy means realizing when you waste energy. One of the most obvious ways that many of us waste energy is leaving lights, television sets and computers on when we are not using them. When you leave a room, look around for a second. What can you turn off? Just developing this habit goes a long way to making you more conscious of conserving electricity.

There are other ways we can reduce our use of energy. You can save gas by walking or biking places rather than having someone drive you there. If you do your own laundry or do the dishes, run the washing machine and the dishwasher with full loads. This is more energy efficient than running these machines when they are only partly filled.

Do you enjoy long hot showers? Can you cut back that 5 minute shower to 4 minutes? A minute a day may not sound like much, but by the end of the year, you will have saved 4 hours of energy used to heat and pump that hot water. If water in the hot water tank can hold its heat longer, then less energy is spent re-heating it. That is why insulating hot water pipes and also the hot water tank can also save energy. Another way your family can cut down on energy is to turn down the thermostat to 68°F, especially at night when everyone is sleeping. If every family in North America turned down the heat six degrees, we'd save over 550,000 barrels of oil a day.

If your family has to buy a new appliance, like a new refrigerator, they can look for Energy Star products. A product with the energy star label is one that meets certain requirements that make it energy efficient. These requirements are set by the Environmental Protection Agency. For example, an energy star refrigerator requires 40% less energy than the usual models.

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Indirectly Conserving Energy

To conserve energy indirectly involves thinking about all of the things you use. Everything you use took energy to make and in most cases, took energy to be shipped to the stores where you bought these things. For example, just think about some of the foods you eat and the containers these foods come in. Pop cans, water bottles, yogurt containers, candy wrappers, the plastic or film bags that potato chips and cookies come in - just to name a few. What happens to these containers when you are done? Some of these containers you can reuse or recycle, but others you just throw away. It took energy to make these containers. Plastic containers are made from either oil or natural gas. Both of which are nonrenewable resources. Containers made of cardboard or paper come from trees. Trees are a renewable resource.

Think about other choices that you might make. If you use a compact fluorescent light bulb you will use 75% less energy than if you used a regular light bulb (an incandescent light bulb). Think about using rechargeable batteries instead of regular batteries. Rechargeable batteries can be used many times and when they can no longer be recharged, they can be recycled. Regular batteries are thrown out once they are used up. There is no recycling program for them. What a waste!

Conserving energy doesn't involve taking one big action. It involves taking many small ones. Sometimes, these actions don't look like they amount to much, but over time these actions add up, especially if lots of other people join you in doing them. Conserving energy involves reflecting about the things you do every day and taking action where you can to stop wasting energy.

Glossary

Absorber plate – the black back of a solar collector used in a hot water system.

Active solar – uses solar energy to heat a building but also uses electricity to move the heat from room to room.

Amp/amperage – measure of electric current.

Anaerobic – does not need oxygen.

Battery – a device that produces an electric current.

Biogas digester – equipment that turns animal waste into methane gas.

Biofuel – a fuel that is based on something that is alive or was recently alive.

Blade – surface that rotates and pushes against air or water.

Carbon neutral – usually refers to biofuels based on plants. The carbon dioxide given off when the fuel is burned is offset by the carbon dioxide taken in while the plant is growing.

Catalyst – a chemical compound that speeds up the rate of reaction for other compounds but is not involved in the reaction itself.

Circuit – the path that an electric current follows.

Climate change – change in rainfall, wind patterns and temperature around the world as a result of the increased amount of carbon dioxide in the atmosphere.

Conductor – a material that carries electric current and heat.

Conduction – movement of heat from a hot object to a cold that happens when the two objects are in direct contact with each other.

Consumer goods – things that people use to make life easier or more enjoyable; things like televisions, computers, vacuum cleaners, blenders.

Copyright – legal ownership given to an author.

Current – flow of electricity through a conductor measured in amps.

Conserve – to prevent waste or loss of something.

Crude oil – the type of oil that is directly pumped from the earth. Crude oil is refined into gasoline, diesel, motor oil, kerosene and other fuels.

Dam – a structure that blocks the flow of a river.

Distillation – the process of purifying a liquid by boiling it off then condensing the gas.

Glossary (cont.)

Efficiency – when a large amount of the input energy being converted into the desired form of output energy.

Electricity – the flow of electrons.

Electrolyte – a material within a battery that promotes the generation of electricity once the terminals have been connected with a conductor.

Electrolysis – running an electric current through water to split water into hydrogen and oxygen.

Electron – tiny particle in the atom that orbits the nucleus and has a negative charge.

Energy – source of the ability to move.

Enzyme – a catalyst found in living things.

Environmental impact study – study done to see how much damage building in an area will do to the plants and animals living there.

Ethanol – a fuel produced from fermenting plants.

Extract – to remove from.

Fermentation – process of breaking down sugar into ethanol, energy and carbon dioxide that happens when there is little or no oxygen present.

Flex fuel – a fuel used in cars that is made mostly of ethanol.

Fossil fuel – coal, oil and natural gas; fuels that come from ancient plants and organisms formed in much the same way as sedimentary rocks.

Flow – amount or volume of water flowing toward the turbine in a hydroelectric plant.

Fluid – liquid.

Frost line – depth to which the ground freezes.

Fuel cell – a battery-type device that makes electricity by combining hydrogen with oxygen.

Generator – a device where coils of wire are turned rapidly within a magnetic field or where a magnet is moved rapidly through a coil of wire.

Geoexchange – system of heating which uses heat from the earth.

Geothermal – using the heat from inside the earth to produce electricity and heat.

Head – the height from which water falls in a hydroelectric plant.

Glossary (cont.)

Heat exchanger – a device for moving heat from one substance to another.

Heliostat – a type of solar collector.

Hydroelectricity – using water to generate electricity.

Infrastructure – the basic structure and organization needed to make a community work.

Insulation – a material that blocks heat or cold from leaving an area.

Joule – unit used when measuring energy.

Kinetic Energy – energy of motion.

Landfill – area where a community dumps its trash.

Load – the part of a circuit that converts electricity into another form of energy like light.

Methane – a type of natural gas.

N layer – the layer within a solar cell which acts like the negative terminal.

Natural gas – a gas that is often used as a fuel for cooking, heating and powering vehicles.

Negative terminal – the side of a battery or battery-type device from which electrons flow.

Nonrenewable – a resource that once removed from the area where it was formed will not be replaced.

Off the grid – when a home or business generates their own electricity.

On the grid – when a home or business pays for their electricity from a power plant.

P layer – the layer within a solar cell that acts like the positive terminal.

Parabolic trough –a solar collector that is long and curved.

Passive solar – using only the energy of the sun to heat water or to heat a building.

Patent – permission given to an inventor that he/she can be the only one to sell his/her invention.

Penstock – a tube or pipe through which water flows from the top of the dam to the turbine.

Photovoltaic cell – a solar cell; a battery-type device that converts the sun's energy to electricity.

Positive terminal – the side of a battery or battery-like device to which electrons flow.

Potential Energy – stored energy.

Glossary (cont.)

Proton – a particle with a positive charge that is found in the nucleus of an atom.

R-value – rating system for insulation; a higher number means better insulation.

Renewable – resource that is replaced within a lifetime.

Reservoir – lake that forms when a dam is built that blocks or slows the flow of a river.

Royalty – fee paid to an inventor or an author for use of their work.

Selectively permeable – allows some material through while blocking other materials.

Shaft – rod or pole.

Solar collector – a device with a broad flat surface that is angled to receive the sun's energy.

Stirling engine – engine in which heat from outside the engine sets off a series of mechanisms.

Supplement – something that is added that completes a thing.

Thermal mass – dense, dull materials that absorb heat and then releases the heat later.

Transformer – equipment that increases or decreases voltage in electrical power lines.

Turbine – machine with blades that provides mechanical energy to a generator.

Utility scale – very large wind turbine.

Volt – measure of the force of an electric current.

Watt – a unit used to measure electrical power: volts X amps = watts.

Wind farm – an area where there is a group of wind turbines.