Sustainable Energy

http://www.wmky.org/post/electric-co-ops-dedicate-60-acre-solar-farm

Lake Shelbyville Eco-Meet 2018

Varsity

U.S. ARMY CORPS OF ENGINEERS – ST. LOUIS DISTRICT

LAKE SHELBYVILLE

1989 State Highway 16

SHELBYVILLE, IL 62565

(217) 774-3951

US Army Corps of Engineers®

TABLE OF CONTENTS

INTRODUCTION

As time goes on, the population living on Earth continues to increase while the amount of fossil fuels decreases. Fossil fuels, such as coal and oil, are burned to create energy in this fast-paced, technology-driven world. Once these resources are used, they cannot be reused or easily replaced. This has led to a new age of looking for sustainable energy sources. Sustainable energy is energy that does not have significant effects on the environment and can be easily replaced. One key characteristic of a sustainable energy source is its renewability. Scientists have come up with ways of creating this renewable energy without harming the environment. There are at least six different types of sustainable energy: solar power, wind power, hydroelectric energy, marine energy, geothermal energy, and biomass. These forms of sustainable energy are becoming more popular as the demand for energy increases. It is imperative we begin looking at sustainable energy sources to replace fossil fuels.

FOSSIL FUELS

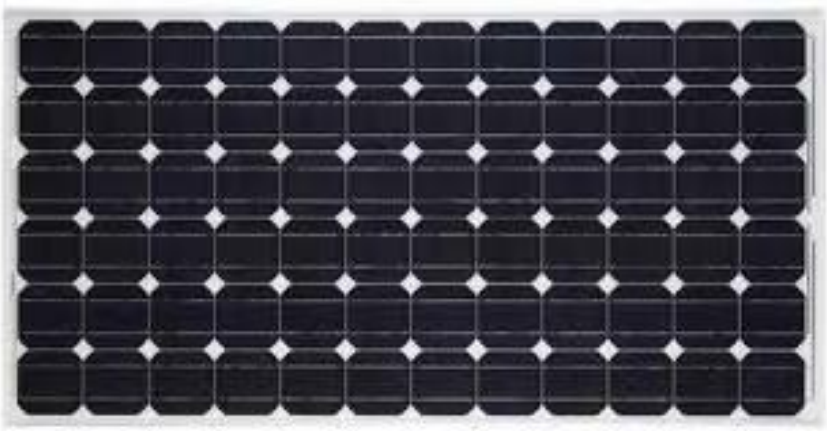
Fossil fuels were used as early as 1100 B.C., but they became most popular during the Industrial Revolution in the 1800s. Coal use was especially prevalent in factories, where it was burned as an energy source. Today, fossil fuels provide 66.6% of the energy generated in the United States. Fossil fuels form as a result of geologic processes acting on the remains of plants and animals that lived millions of years ago. This type of fuel is not considered reusable, because it would take millions of years to create more of it. Furthermore, it is used in such large quantities that it could not easily be replaced. The five main types of fossil fuels are coal, natural gas, oil, petroleum, and liquefied petroleum gas. Fossil fuels are still heavily used today to produce energy. However, this study guide will focus on the sustainable energy sources that are beginning to replace fossil fuels.

SOLAR POWER

Solar power is one of the most popular forms of sustainable energy. It can easily be used in a household where only small quantities of energy are needed. Even though it is gaining in popularity, solar energy only accounts for about 0.6% of the energy generated in the United States. The largest photovoltaic power station in the world is located in India. The Kamuthi Solar Power Project covers over 10 square miles with solar panels. Solar panels harvest the sun’s energy. The solar panels allow photons, or particles of light, to knock electrons free from atoms, thus creating energy. Solar panels are made of photovoltaic cells that contain different elements, which give the layers inside each cell positive or negative charges, resulting in a magnetic field. A magnetic

field is required to direct the flow of the electrons that are knocked free by the photons. The electrons are transferred to wires where they are able to be used like any other form of electricity. There are three different types of solar panels including monocrystalline, polycrystalline, and thin-film.

Monocrystalline solar panels are silicon-based. The silicon is manufactured using a special process resulting in maximum efficiency. Silicon of a high purity is cut it into thin slices that are then placed into a grid. The slices are cut with rounded corners to give them a distinct look. This type of solar panel has an efficiency rating of 21.5%. Monocrystalline panels perform better than other solar panels in low light conditions.



http://homeof12volt.com.au/product/flat-200-watt-monocrystalline-solar-panel/

Polycrystalline solar panels are also made of silicon. The silicon is melted and then cut into squares. This method produces less waste during the manufacturing process. Polycrystalline solar panels often have a blue tint. They appear to be blue because of an anti-reflective coating that is put on the silicon. This helps the panel absorb more rays, which increases efficiency and production. These solar panels have an efficiency of 13%-16%.

http://www.joshnka.com/product_info.php/products_id/54

Thin-Film solar panels are not silicon-based. They are made of cadmium telluride, amorphous silicon, and copper indium gallium selenide. These elements are melted and spread in a thin layer over a substrate. Thin-Film solar panels are also known as organic photovoltaic cells. These panels have an efficiency of 15%-16% and are easier to manufacture than the other types of solar panels. Waldpolenz Solar Park in Germany is the largest thin-film photovoltaic power station in the world.

https://www.gogreensolar.com/products/sharp-na-v121h1-121-watt-thin-film-solar-panel

These are the most common solar panel models used, but other photovoltaic cell models are being developed. Models currently in the development process include: Multijunction Photovoltaic Cells, Dye-Sensitive Photovoltaic Cells, and 3D Photovoltaic Cells. Multijunction Photovoltaic Cells are cells designed to maximize efficiency by using multiple layers of photovoltaic junctions. Dye-Sensitive Cells are considered the third generation of photovoltaic cells. Instead of using solid silicone and other materials, they will use a gel electrolyte to produce a photo-electrochemical photovoltaic cell. These cells are manufactured using microscopic molecules of photosensitive dye on a crystalline or polymer film.

WIND POWER

People have used wind power for centuries, starting with the windmill. The windmill had large arms that were pushed by the wind and milled the wheat on the inside. Today wind turbines turn the rotation of the blades into an electric current. Wind power provides 4.7% of the energy generated in the United States.

However, wind power cannot be utilized everywhere. The turbines require winds at a certain speed in order for their blades to be able to turn. Many places in the United States do not fit this condition. Where the wind is of suitable speed, turbines are often built on large wind farms. Nonetheless, a location only needs two wind turbines to be considered a wind farm. The largest wind farm in the United States is Alta Wind Energy Center in California. This wind farm is home to 586 large turbines, making it the third

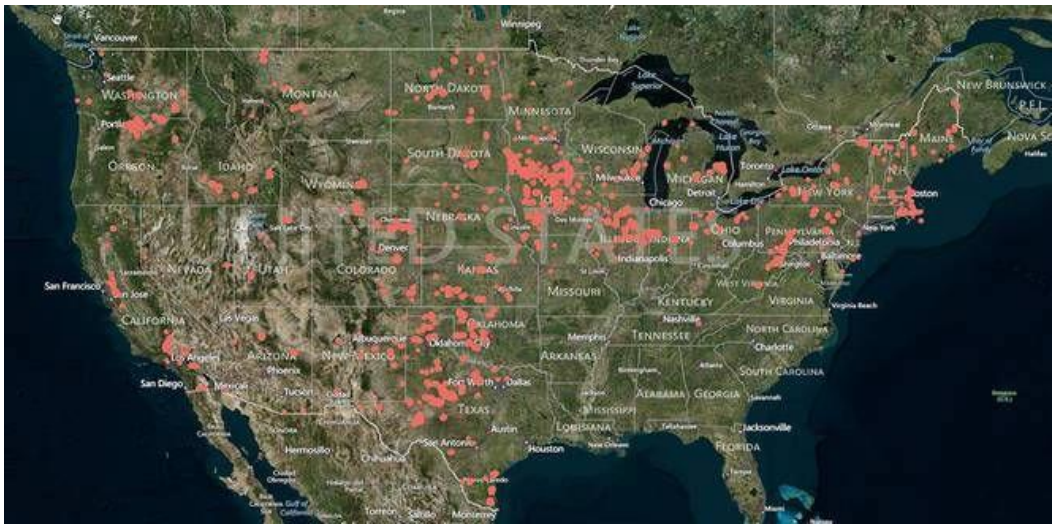
largest wind farm in the world. Gansu Wind Farm Project in China is the largest, with over 7,000 turbines.

Even though wind turbines do not release any emissions, they can cause some harm to the environment. The Institute for Energy Research claims that an estimated 573,000 birds and 888,000 bats are killed by wind turbines each year. Solar panels are also guilty of killing birds, but their impact on the environment is much smaller., as an estimated 3,500 birds per year are killed by solar panels. Wind farms also require considerable amounts of land. Furthermore, residents near wind farms may complain of the lack of aesthetic appeal as well as noise pollution.

Nonetheless, wind power is growing rapidly. The Institute for Energy Research attributes this growth, in part, to government intervention.

> "The Federal Government has extended the production tax credit (PTC) for wind several times since it was first introduced as part of the Energy Policy Act of 1992. The American Taxpayer Relief Act passed on January 1, 2013 extended the production tax credit through 2013, but with definitional differences that make the tax credit more expensive for taxpayers than its original incarnation. While the original PTC stipulated that the wind unit must begin operation in the year of the credit, the extension that was passed indicates only that the project must begin construction in 2013 with no specific date for beginning operation. It is therefore a significant expansion of the current law. Further, the Internal Revenue Service upped the credit from 2.2 cents per kilowatt hour to 2.3 cents per kilowatt hour. It is paid on electricity generated for the first 10 years of operation of the wind unit. More recently, Public Law No. 113-295 extended the PTC through 2014, and in December 2015, Congress extended it for 5 years in the Omnibus Bill. The new legislation retroactively extended the PTC for 2015, leaving the incentive at its 2.3 cents per kilowatt hour level through 2016 and phasing it down at 80 percent of its present value in 2017, 60 percent in 2018 and 40 percent in 2019. The rules allow wind projects to qualify as long as they start construction before the end of the period.
>
> [...]Besides the subsidies that wind power receives, more than half the states have renewable portfolio standards requiring a certain percentage of their electricity to be generated from qualified renewable energy technologies. These standards have helped to develop onshore wind energy as it is the least expensive qualifying renewable technology. No offshore wind farms have been built to date, though there are proposals for offshore wind farms along the Atlantic coast and in the Great Lakes. Offshore wind is more than 2.5 times more expensive than onshore wind, according to the Energy Information Administration."

The map below shows the locations of wind turbines in the United States.



http://www.climatecentral.org/news/interactive-map-unveils-mystery-of-wind-turbines-19737

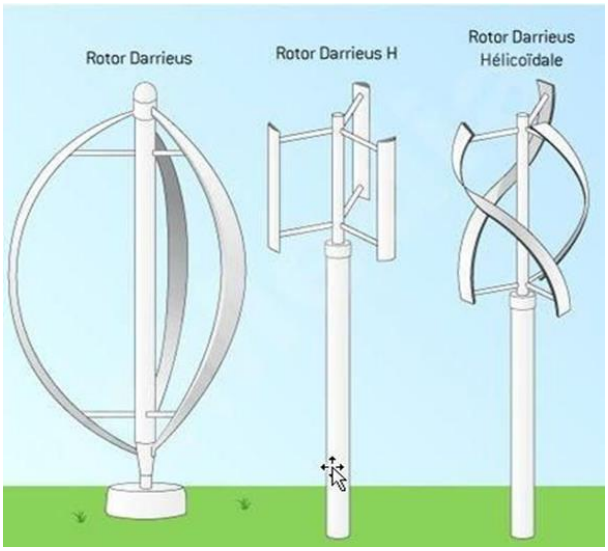
There are 2 different types of wind turbines: horizontal-axis turbines and vertical-axis turbines. Horizontal-axis wind turbines make up the majority of turbines used to create wind power in the United States because they are more efficient than the vertical-axis turbines. They use 3 long blades that are centered on an axis that is parallel to the ground. The largest versions of this turbine are as tall as a 20 story building and have blades 100 feet long. These turbines produce noise pollution in the form of a swooshing sound.

https://www.poweredbymothernature.com/what-is-wind-energy/

Vertical-axis wind turbines were invented by Georges Darrieus, a French engineer, in 1931. This type of wind turbine is very different than the horizontal-axis wind turbine. Two long curved blades attach on each end to an axis that runs perpendicular to the ground. It resembles a two-bladed egg beater. The largest forms of this design are up to 100 feet tall and 50 feet wide. While this turbine is less efficient, one of its greatest advantages is the ability to catch the wind from any direction. This type of turbine is better suited for areas with unpredictable wind patterns.

http://www.mechanicalbooster.com/2017/01/types-of-wind-turbines.html

New versions of the Darrieus model vertical-axis turbine have been developed including the Rotor Darrieus H and the Rotor Darrieus Helicoidal.



http://www.mech4study.com/2016/01/what-is-wind-turbine-what-are-main-types-of-wind-turbines.html

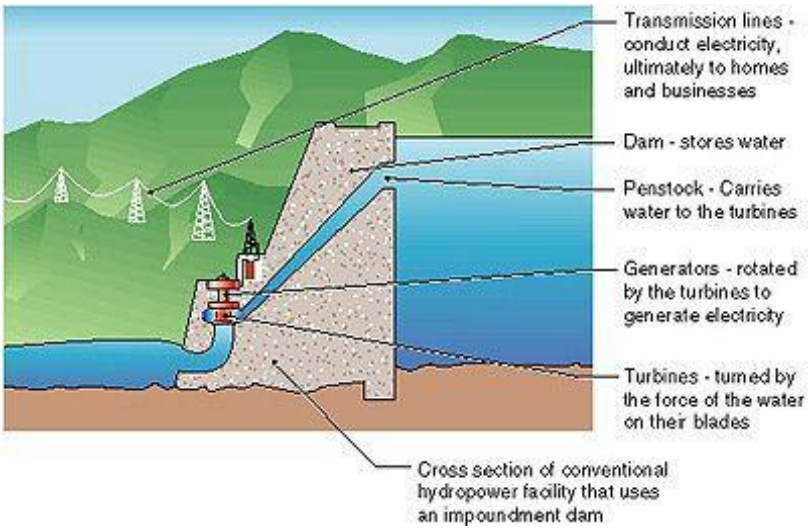
Another design for the vertical-axis wind turbine is the Savonius model. Sigurd Johannes Savonius created this model in 1922. This model rotates slower and has higher torque than other models. This model is larger and less efficient than the Darrieus model. It uses 2 or more scoop shaped blades to catch the wind. Many new models have been made combining the Savonius and Darrieus models. The link to Savonius model shows the turbine in use.

https://www.youtube.com/watch?v=5zFyw6QiPUA

HYDROELECTRIC POWER

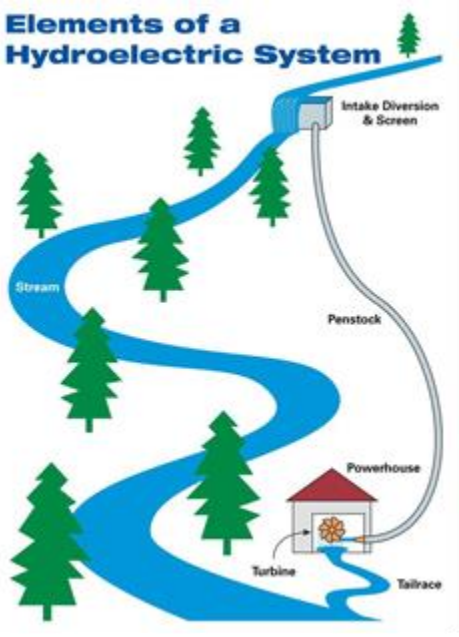
Hydroelectric power is another sustainable energy source. It already creates 6.1% of the energy produced in the United States. This method of creating energy utilizes the earth's water cycle and releases no emissions. Unfortunately, it still has a big impact on the environment. Most methods of harvesting hydroelectric power involve creating a dam and reservoir. This can have serious impacts on the environment down river from the plant. Also, building these large permanent structures is very costly. These structures cannot be easily removed once they are built, like a wind turbine or solar panel can. Many dams have an additional purpose such as flood control for the surrounding area. The largest hydroelectric dam in the world is the Three Gorges Dam in China. The largest in the United States is the Grand Coulee Dam. The Hoover Dam creates about 4 billion kilowatts per year, and the Grand Coulee Dam produces about 21 billion kilowatts. There are three different types of hydropower plants: impoundment, diversion, and pumped storage.

Impoundment plants are the most common type of hydroelectric power plants. This method requires a dam to hold water in a reservoir. Water is released so that it turns a turbine that powers a generator, making electricity.



https://energy.gov/eere/water/types-hydropower-plants

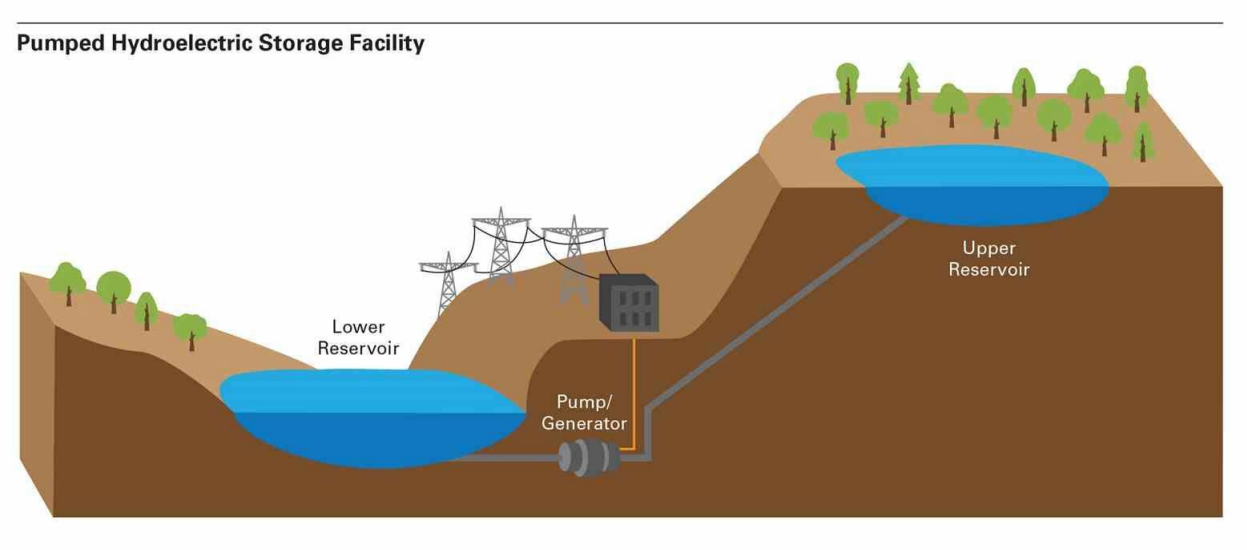
Diversion does not require a dam but some do operate with one. This method diverts a portion of a river through a canal to power a turbine. The Grand Coulee Dam uses this method to create hydroelectric power.



https://www.homepower.com/articles/microhydro-power/equipment-products/intro-hydropower-part-1

Pumped storage involves a combination of the other hydroelectric methods and other methods of creating sustainable energy. Water is pumped from a reservoir of a low elevation to a reservoir of a high elevation using solar, wind or another form of sustainable power. When energy is in high demand the water is released back into the lower elevation reservoir using one of the hydroelectric power methods. This method is

the power storage, or battery, of sustainable energy. The energy can be saved until it is needed.



http://www.timesnews.net/Business/2017/06/20/Dominion

In the process of creating hydroelectricity, the turbines are turned by the water which powers a generator. The United States Bureau of Reclamation, which manages the Hoover Dam, describes the process as follows:

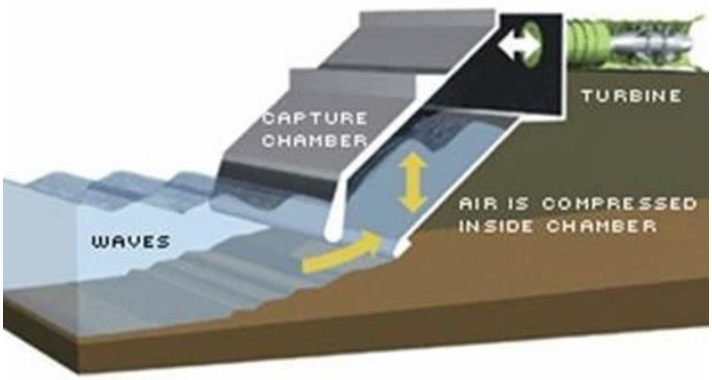
> "Water flows through large pipes inside a dam and turns a large wheel called a turbine. The turbine turns a shaft which rotates a series of magnets past copper coils and a generator to produce electricity. This converts the energy of falling water into mechanical energy to drive the generator. "

This concept was discovered in 1831 by the English scientist Michael Faraday. This is the same concept that is used for many other methods of creating sustainable energy using a turbine.

MARINE ENERGY

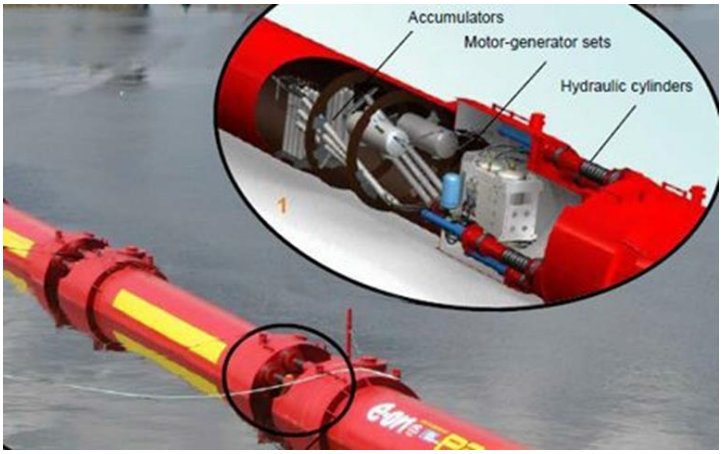
Marine energy, much like hydropower, gets its energy from moving water. Unlike hydropower it gains energy from the surface waves, tidal power, and pressure in the ocean. Marine energy is also known as ocean energy or ocean wave energy. It is most economical to only utilize marine energy in the places with the biggest waves and tides. In the United States, only a few states have working marine energy equipment. New equipment is constantly being developed. Marine energy equipment does not release any emissions or noise pollution, but often receives criticism for visual or aesthetic pollution. Point absorbers, attenuators, overtopping devices, and terminators are all used to harness the power of waves. The Bureau of Ocean Energy Management gives the following descriptions:

“Terminator devices extend perpendicular to the direction of the wave and capture or reflect the power of the wave. These devices are typically on shore or nearshore; however, floating versions have been designed for offshore applications. The oscillating water column is a form of terminator in which water enters through a subsurface opening into a chamber, trapping air above. The wave action causes the captured air column to move up and down like a piston, forcing the air through an opening connected to a turbine to generate power.”



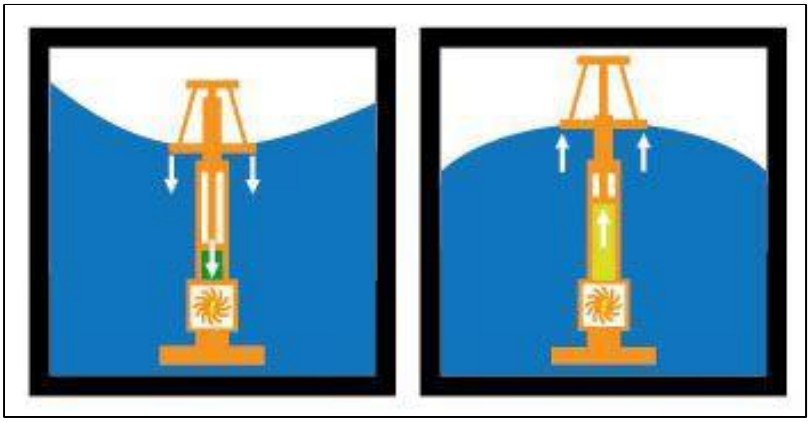
http://www.esru.strath.ac.uk/EandE/Web_sites/01-02/RE_info/wavecase.htm

“Attenuators are long multisegment floating structures oriented parallel to the direction of the waves. They ride the waves like a ship, extracting energy by using restraints at the bow of the device and along its length. The differing heights of waves along the length of the device causes flexing where the segments connect. The segments are connected to hydraulic pumps or other converters to generate power as the waves move across. A transformer in the nose of the unit steps up the power-to-line voltage for transmission to shore. Power is fed down an umbilical cable to a junction box in the seabed, connecting it and other machines via a common subsea cable to shore.”



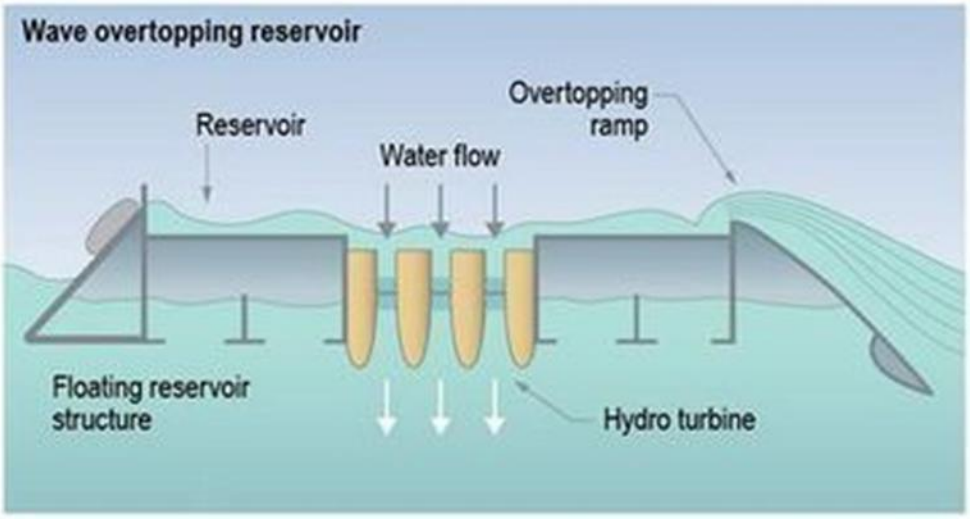
http://www.solarninovinky.cz/indNR.php?zpravy/2015052701/prilivove-elektrarny-se-mohou-stat-klicovym-zdrojem-elektriny-pro-evropu#.Wjr AN9KnGUk

“A point absorber is a floating structure with components that move relative to each other due to wave action (e.g., a floating buoy inside a fixed cylinder). Point absorbers often look like floating oceanographic buoys. They utilize the rise and fall of the wave height at a single point for energy conversion. The relative up and down bobbing motion caused by passing waves is used to drive electromechanical or hydraulic energy converters to generate power.”



http://nnmrec.oregonstate.edu/nnmrec/education/wave-energy-101/how-do-waves-work

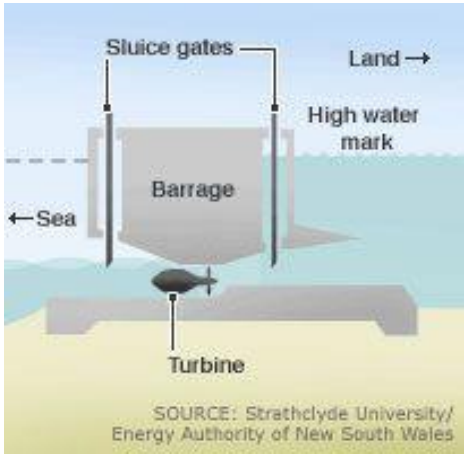
“Overtopping devices have reservoirs that are filled by incoming waves, causing a slight buildup of water pressure like a dam. The water is then released, and gravity causes it to flow back into the ocean. The energy of the falling water is used to turn hydro turbines to generate power. Specially built floating platforms can also create electricity by funneling waves through internal turbines and then back into the sea.”



https://wave-energies.weebly.com/types-of-wec.html

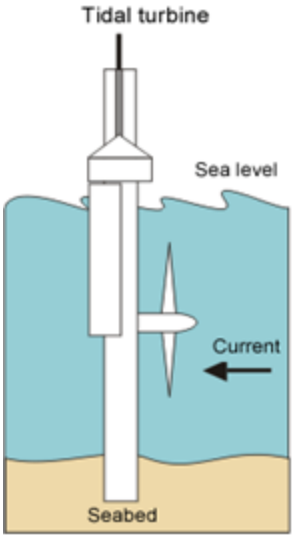
Three different methods are used around the world to harness the power of tides: tidal barrages, tidal fences, and tidal turbines. The only one of these methods used in the United States at this time is the tidal turbine which is located in New York.

The oldest operating tidal power plant is in La Rance, France.The barrage is installed at the opening of a bay or lagoon. Gates on the barrage control the water level and flow rates to allow the basin to fill at high tide and then to empty through a turbine system at low tide. Two-way tidal power systems generate electricity when water enters and leaves the basin. This form of marine energy can harm the ecosystem in the basin due to the change in water level and an increased amount of matter suspended in water because of the continuous movement.



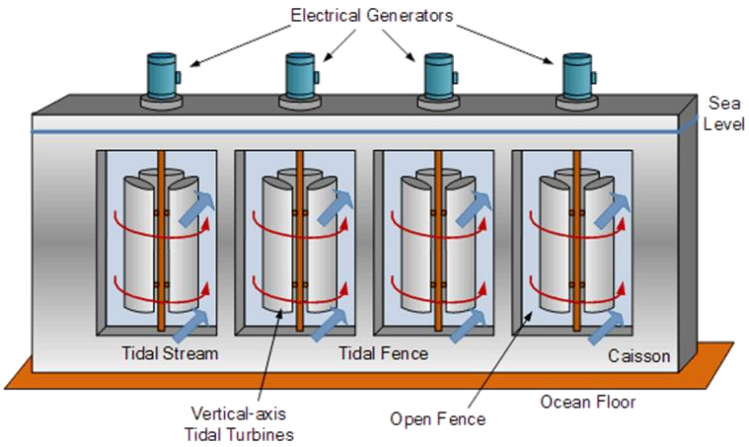
http://energyeducation.ca/encyclopedia/Tidal_barrage

Tidal turbines are much like underwater wind turbines. They are placed near the bottom of the ocean where the tidal flow is the strongest. Water is much denser than air so the turbine parts must be stronger and heavier. These are more expensive to produce and operate than wind turbines, but they are also more efficient.



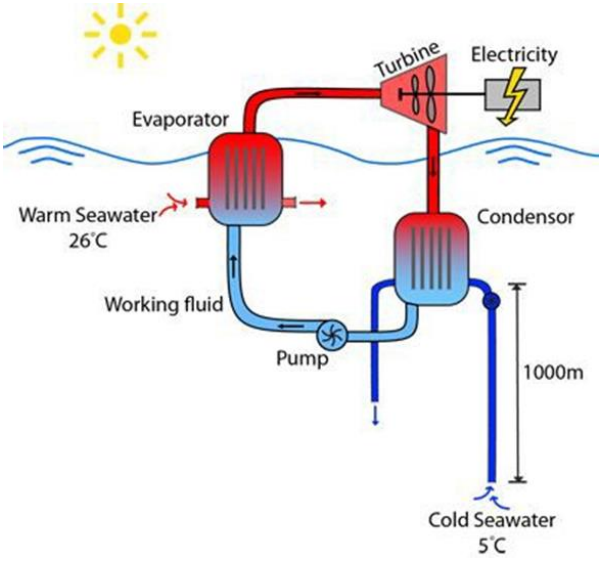
https://www.eia.gov/energyexplained/index.cfm?page=hydropower_tidal

Tidal fences are a tidal power system that uses vertical axis turbines mounted in a row on the seafloor. Water flowing through the turbines makes electricity. As of the end of 2016, no tidal fence projects are currently operating. This model of marine energy is the most economical and efficient version. It requires less material and space than other models do.



http://www.alternative-energy-tutorials.com/tidal-energy/tidal-fence.html

Another way to harness energy from the ocean is through ocean thermal energy conversion. This method uses the difference in temperature between surface water and deep water to produce energy. This method if often used in tropical areas where the surface water gets very hot. The water must have a difference of at least 77 degrees Fahrenheit. Hot surface water is pumped to an evaporator. The vapor pressure drives the turbine connected to a generator. The vapor is cooled by deep ocean water turning it back into a liquid. This process results in desalinated water giving this form of sustainable energy a second purpose. There is an operational ocean thermal energy conversion site in Hawaii.

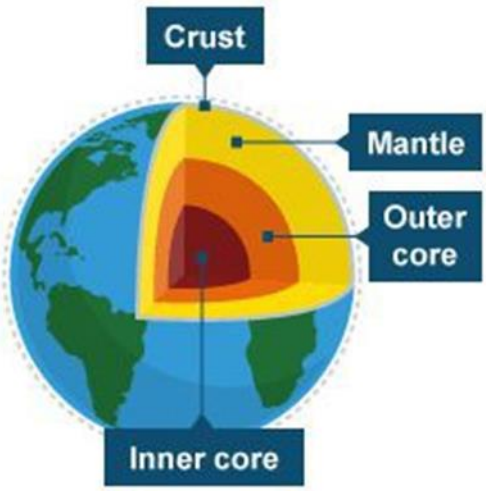


http://www.greenentrepreneurship.com/power-island-ocean-thermal-energy/

GEOTHERMAL ENERGY

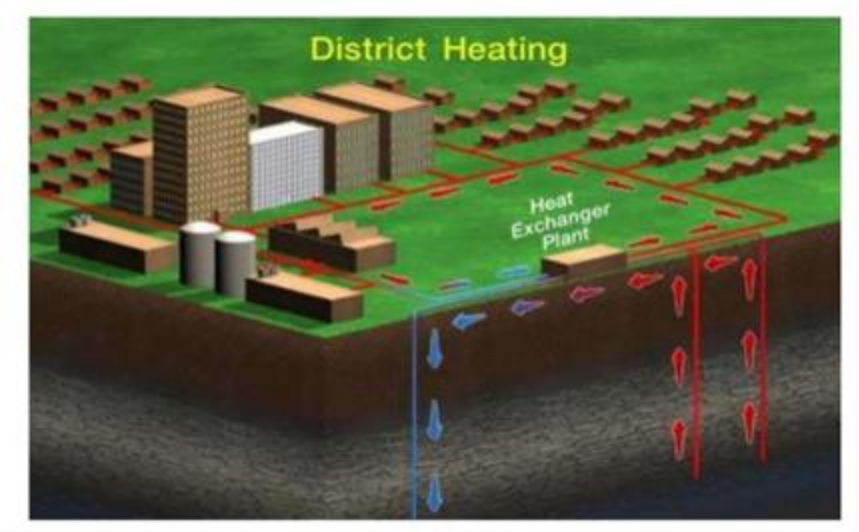
Geothermal energy is harnessing the earth's natural heat. This can be done by either using the very hot steam deep in the earth or by tapping into a shallow heat sink. Today, geothermal energy creates about .4% of the energy produced in the United States. Like many other forms of sustainable energy, geothermal energy is growing in popularity. Geothermal energy is not completely without emissions like many other forms of sustainable energy. Federal law was passed in 2005 to encourage the development of geothermal energy use on government property. It releases less 1% of the carbon dioxide that fossil fuels release and 3% of the emissions that acid rain releases.

The earth is composed of many layers. The inner core is solid iron. This is surrounded by an outer core of molten rock, also known as magma. The mantle, that is 1,802 miles thick, surrounds the core. It is comprised of magma and rock. The crust is the outer layer, and it forms the continents and ocean floors. The crust can be as thin as 3 to 5 miles thick under the oceans and 15 to 35 miles thick underneath continents.



http://www.bbc.co.uk/bitesize/ks3/geography/physical_processes/plate_tectonics/revision/2/

Geothermal energy is used either as a heat source or to produce electricity. Using it as a heat source is also known as direct use and district heating systems. Roman, Chinese, and Native American people have been using this form of geothermal energy for many years by bathing in naturally hot pools of water, heated by the earth's heat. This method is also heavily utilized in Iceland. A district heating system heats most of the buildings in Reykjavik, Iceland. This form of geothermal energy uses shallow heat sinks to heat buildings, not to produce electricity. Heat sinks are reservoirs of hot water and air under the earth's surface. Hot steam and water from the reservoir is piped through homes to heat and cool it.



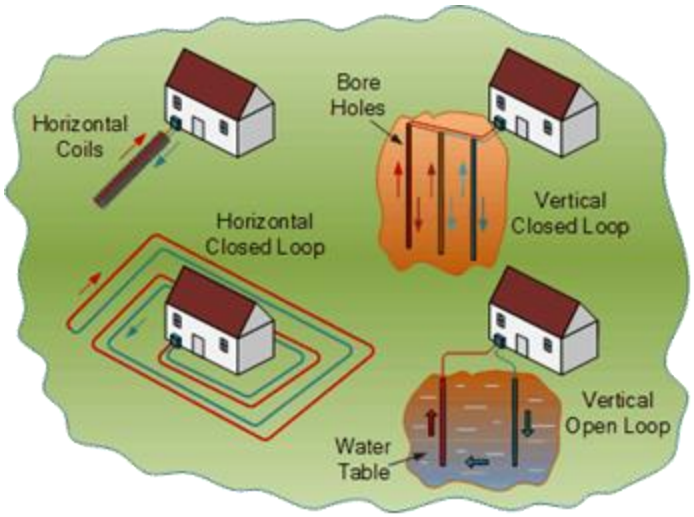
https://www.slideshare.net/PiyushIkhar1/geothermal-energy-and-indias-scenario

Direct use heating is only used to heat one home. This does not require as much heat as district heating does. Instead of using heat sinks, single homes are able to use the ground temperature and bodies of water to heat and cool their homes. Direct use requires a geothermal heat pump system. About 30 feet below the surface, the ground remains at a constant 55 degrees Fahrenheit all year round. In the summer, the ground temperature can be channeled to cool a home, and in the winter, is can be used to heat a home. The geothermal heat pump system allows people to heat and cool their homes using geothermal energy. This can also be done in water, such as a pond or lake. According to the U.S. Environmental Protection Agency, geothermal heat pumps are the most energy-efficient, environmentally clean, and cost-effective way to heating and cooling buildings.

Many different designs are used to place the pipes needed for geothermal heating underground. Horizontal trench earth loops are comprised of one or more shallow trenches being dug with the pipes laid out flat horizontally inside the trench. There are various designs of horizontal earth loops, using either one, two, three or more parallel branches within a single trench. This design relies heavily on an open area to place the pipes.

Horizontal coils are another horizontal design option. These coils require less room than the horizontal trench loops. The pipes are coiled next to each other to take up less space. Most designs can be either open or close looped. Closed looped systems loop back around geothermal heat pumps.

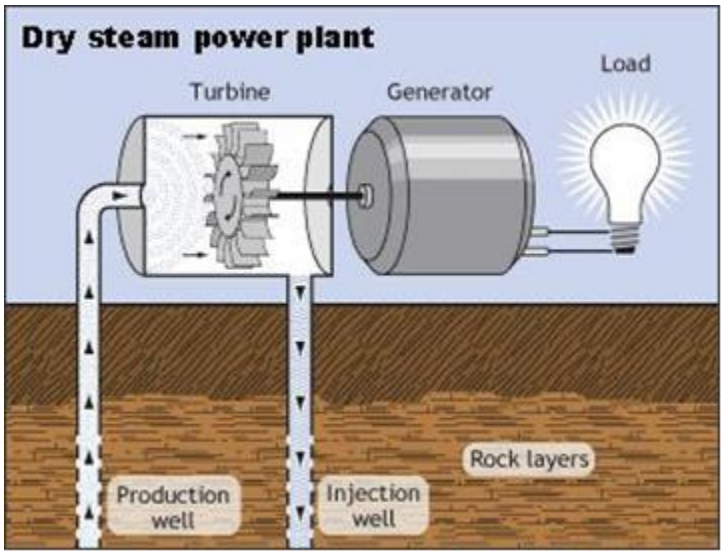
Vertical earth loops can be used where space is limited or where the conditions are not suitable for horizontal loops, such as rocky terrain. Vertical earth loops require the use of a drilling rig to bore holes at least 100 feet deep. This can be either open or close looped. The depth of the pipes does not change the amount of heat that is conducted but rather the amount of pipe underground.



http://www.alternative-energy-tutorials.com/geothermal-energy/geothermal-energy.html

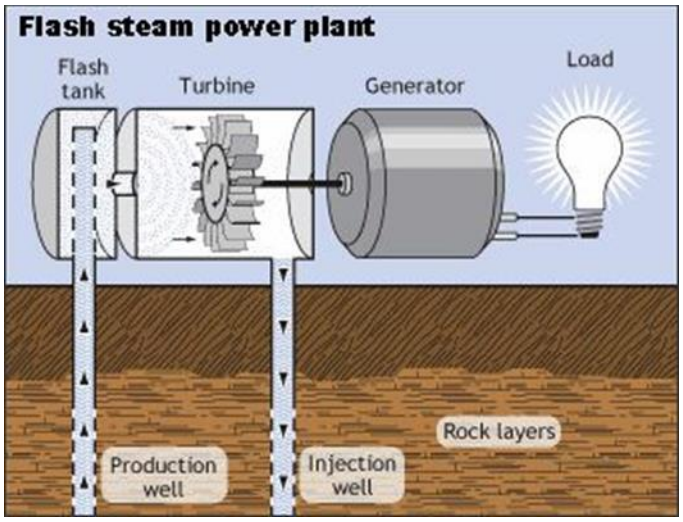
Geothermal energy can also be used to create electricity. This method most often uses very deep wells that reach the hottest reservoirs underground. These well can be up to 2 miles long. The hot steam comes up the pipe and powers a turbine connected to a generator. There are three different types of power plants: Dry Steam Plants, Flash Steam Plants, and Binary Cycle Power Plants.

Dry steam plants use steam directly from the reservoir to power the turbine.



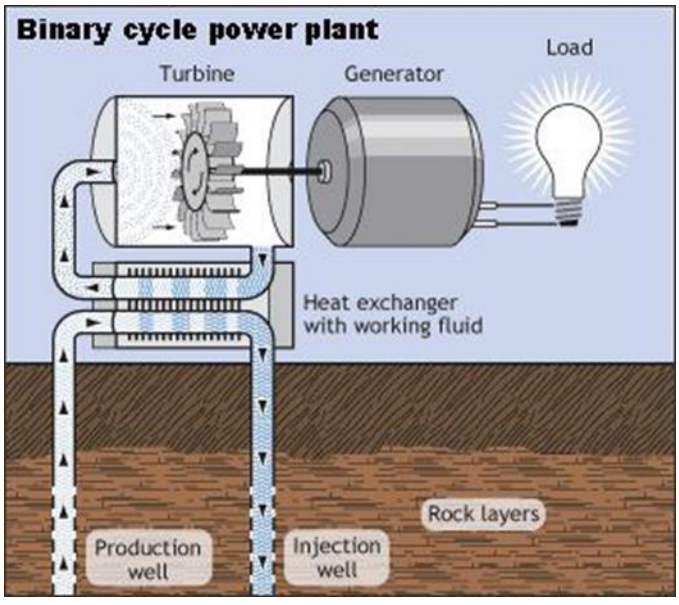
https://www.eia.gov/energyexplained/index.cfm?page=geothermal_power_plants

Flash steam plants take hot water from the earth and convert it to steam, after it powers the turbine it is cooled back to a liquid and injected back into the ground. This is the most common type of geothermal energy plant.



https://www.eia.gov/energyexplained/index.cfm?page=geothermal_power_plants

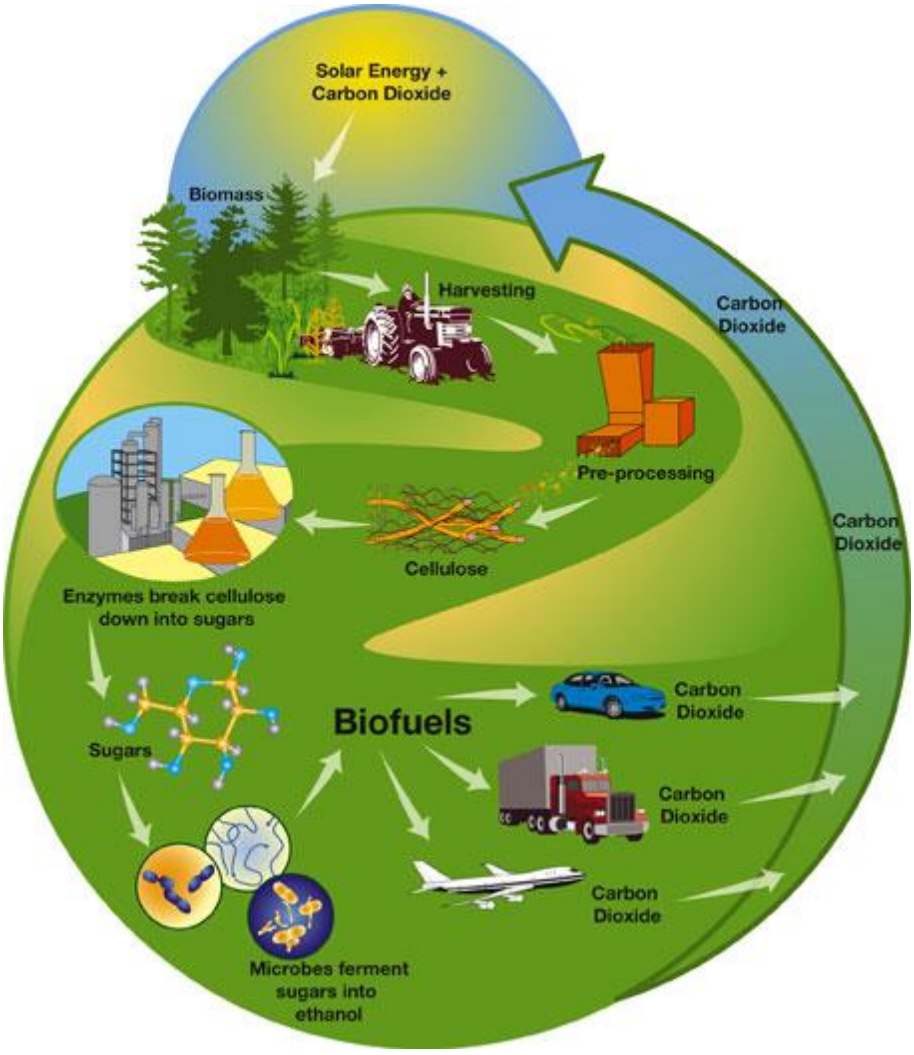
Binary cycle power plants use the geothermal hot water to turn another liquid to steam that powers the turbines. The first geothermal power plant was built in Tuscany, Italy, in 1904.



https://www.eia.gov/energyexplained/index.cfm?page=geothermal_power_plants

BIOMASS

Biomass energy comes from living or recently dead biological matter. Biomass technologies are being created that will enable living plant matter, such as agricultural crops, seeds, grasses, wild plants, and trees, as well as organic waste, in the form of biodegradable materials, garbage, compost, animal manure and other waste products, to be converted into usable energy. Biomass takes on many forms, but a good example of “biomass energy” is the open burning of dead wood on a campfire. However, this type of biomass incineration is not very efficient, as most of the heat energy it produces is lost. Through photosynthesis, living plants capture and use the sun's energy, along with carbon from the earth’s atmosphere, and nutrients absorbed from the soil. By burning the biomass, the energy procured from the sun can be released again. Biomass is organic matter just like fossil fuels, except biomass does not need to rest for millions of years. It is much easier to replace and make more because of this. Energy created from biomass is weaker than fossil fuel energy. Biomass does pollute the air when it is burned, and in the case of traditional residential wood burning, can be very obnoxious. In fact, some communities have banned the burning of firewood because it contributes a substantial amount of air pollution. Fortunately, new technologies, including pollution control and combustion engineering, have made advancements so that the emissions from biomass in industrial facilities are less than fossil fuels. Many of the carbon dioxide emissions are used by crops during photosynthesis.



http://refuelingthefuture.yolasite.com/biofuels-and-bioenergy.php

Biomass is available in all three basic forms of matter: solid, liquid, and gas. These groups can be divided further into primary and secondary products. Primary products are produced by direct use of solar energy through photosynthesis, and secondary products are generated by the decomposition or conversion of organic substances. Solid biomass is also known as feedstock. Liquid biomass is also referred to as biofuel, and gas biomass is also called biogas. Biofuel is receiving more attention due to its growing use, stemming from government mandates requiring it and subsidies encouraging its use. All forms of biomass are used in the United States. Here is a list of a few examples for each:

FEEDSTOCK	BIOFUEL	BIOGAS
Wood	Vegetable Oil	Methane
Grass	Biodiesel	Natural Gas
Solid Waste	Ethanol Based Fuel	Waste Gas

Biomass is used to create energy in four main ways: thermal combustion of biomass, electrical generation using biomass, gasification of biomass, and liquid conversion of biomass.

Thermal combustion of biomass means that solid biomass is burned, and the energy is released. Bioenergy that is released from this process gets used mostly for heating houses and water. This is not a very efficient way to cook or to burn in a fireplace, because most of the heat is lost. Fireplace systems have been developed especially for biomass energy combustion.

Electrical generation using biomass is also known as biopower. Energy is released by burning feedstock, and the heat and steam released from this power a turbine that generates electricity. Some energy plants use a method called cofiring. This is when they mix biomass and coal to be burned together. Cofiring is one of the most efficient and cost effective ways of producing energy.

The gasification of biomass utilizes biogas. Animal manure, garbage, and algae all release biogas. Biogas is burned and heat energy is released. Burning biogas has many advantages over burning natural gas. Biogas energy plants can be built quickly and are less expensive. Also biogas is produced very quickly compared to natural gas. Another gas that is released as organic matter decays is methane. Methane is a major contributor to global warming. By burning the gas that comes from the organic matter, the methane is also being destroyed. Whenever biogas is burnt, it leaves behind residue. This residue is called “activated sludge” and can be used as fertilizer.

Liquid conversion of biomass is another way of saying that the biomass is turned into biofuel. Biofuel is usually made from plant matter, however many types exist. Biodiesel is an ester-based oxygenated biofuel that results from processing vegetable oils and animal fats. The biggest advantages of biofuels is that they are renewable. Biofuel is an exciting prospect because farmers will be able to turn excess crops into fuel. Biofuel also reduces dependence on imported oil, as much of the fuel can be produced within the country. Biomass is not as efficient as other forms of sustainable energy, because fossil fuels must be burned with the biomass. Also, large amounts of land are needed to grow the biomass crops. This could lead to problems, such as increased food prices and shortage of certain crops. Ethanol has been a growing biomass product due to the government encouraging the use of biofuel. The Institute for Energy Research states the following:

> “Ethanol is a renewable fuel that is a clear, colorless, slightly toxic alcohol made from sugars found in grains such as corn, sugar beets, and sugarcane. Its widespread use as a fuel is of recent origin, and it is currently the most common of the “alternative fuels” used in transportation.
>
> Ethanol first began significant use in the 1970’s as a popular domestic alternative to foreign oil imports in the wake of the “Arab Oil Embargo” that highlighted the growing U.S. dependence on foreign oil. It continued as a small contributor to energy supplies during the low oil prices of the late 1980’s and throughout the 1990’s, growing in use as a gasoline additive because of its value as an oxygenate under federal clean air laws.

Congress initially mandated ethanol's use to supplement gasoline in 2005, and increased the requirement in the Energy Independence and Security Act of 2007, which requires an increasing amount of ethanol to be mixed into fuel through 2022, at which point the Environmental Protection Agency is authorized to determine its future levels.

Ethanol is blended in the United States with gasoline to produce such fuels such as E85 (85 percent ethanol, 15 percent gasoline) and E10 (ten percent ethanol and 90 percent gasoline – "gasohol"). All automobiles are capable of using E10, and increasingly, automakers are offering E85 vehicles that can use this fuel interchangeably with other gasoline, albeit with reduced mileage per gallon of fuel. The U.S. Environmental Protection Agency wants to up the percentage blended with gasoline from 10 percent to 15 percent for use in automobiles of 2001 vintage and later models. Automobile manufacturers and small engine producers are against the increase citing damage to engines.

The United States has joined Brazil as the world's leading producers of ethanol. In 2015, 214 ethanol plants in 29 states [ii] in the United States produced 14.8 billion gallons of ethanol – over 9 times more than the amount produced in 2000.[iii] Total capacity on line is 15.6 billion gallons. Under construction or expanding are 3 plants with 0.16 billion gallons of additional capacity. The Department of Agriculture estimates that the U.S. ethanol industry consumed 5.18 billion bushels of corn, which is 44 percent of the corn harvest of 11.86 billion bushels in 2015.

Brazil produces its ethanol from sugarcane while U.S. production of ethanol comes almost exclusively from corn. This distinction is an important one, as it comes at considerable costs and with several unintended consequences.

Corn yields far less per acre than sugarcane, and its refining uses substantial amounts of energy. As a result, to get the industry started, domestic ethanol producers had depended on a 45 cent per gallon subsidy – as well as a 54 cent per gallon tariff on imported ethanol. Because the subsidy and tariff expired at the end of 2011, the further expansion of the ethanol industry is based on economics and the Renewable Fuels Standard that requires 36 billion gallons of biofuels by 2022, of which 15 billion gallons can be corn-based. Also, the growing use of corn-based ethanol in the US has created challenges in the agricultural sector. The price of food, for example, has increased considerably as land once used for food production competes to produce an energy feedstock for transportation fuel.

In addition to the displacement of food crops, the increase in corn-for-ethanol farming may place strains on the Midwest's water supply. According to a 2007 report by the National Academy of Sciences, "increased biofuels production will likely increase pressure on the water management challenges the nation already faces as biofuels drive changing agricultural practices, increased corn production, and growth in the number of biorefineries." It also increases demand

for natural gas, as corn growth is relatively fertilizer-intensive and natural gas is a key component of fertilizer.

Nonetheless, the growth of U.S. corn ethanol as a transportation fuel to supplement petroleum will continue as government programs mandate its use. At present, over 200 ethanol plants are operating, most in the corn-rich Midwest, and several additional plants are under construction or expanding.

Because of such impediments to corn-based ethanol, much research has been undertaken to develop processes for the conversion of cellulosic biomass into a source of ethanol. Some believe that simple grasses and woody products of little other value would be attractive sources for a “next generation” ethanol fuel source. On September 3, 2014, a joint venture company called POET-DSM Advanced Biofuels held the grand opening of its Project Liberty cellulosic ethanol plant in Emmetsburg, Iowa. The plant is the first of three commercial-scale cellulosic ethanol facilities under development in the Midwest that convert corn stover (corn cobs, leaves, husk, and stalk) into ethanol. [v]

Biodiesel is a renewable fuel made from vegetable oils, animal fats, or grease. Most biodiesel today is made from soybean oil. Biodiesel is most often blended with petroleum diesel in ratios of 2 percent (B2), 5 percent (B5) and 20 percent (B20). Fueling engines with biodiesel is, relative to other fuels, in its infancy. From an environmental standpoint, it is biodegradable, non-toxic, and, unlike conventional diesel fuel, produces no sulfur emissions.”

NUCLEAR ENERGY

All of the forms of sustainable energy that have been discussed thus far are renewable. However, many people debate whether or not nuclear energy is renewable. Nuclear energy is produced by nuclear fission, or the splitting of atoms. This reaction creates heat, which is used to boil water, and the steam is used to rotate a turbine. Those arguing that nuclear energy is renewable point to the fact that this reaction releases few carbon emissions. Uranium is also needed for this process. Professor Cohen from the University of Pittsburgh believes that there is enough uranium on Earth to power this reaction indefinitely. Those who classify nuclear power as a nonrenewable energy source would argue that uranium is not an indefinite resource, like the wind and sun. They would also cite that even though nuclear energy releases few carbon emissions, nuclear plants create nuclear waste that is a radioactive pollutant. Thus, you may see nuclear energy classified as renewable or nonrenewable, depending on the viewpoint of the particular author.

http://www.energyres.com.au/company/nuclear-energy-industry/

BIBIOGRAPHY

The information contained in this study guide was adapted from the following sources:

https://energy.gov

https://www.eia.gov

https://www.usbr.gov

https://www.boem.gov

http://instituteforenergyresearch.org

http://www.alternative-energy-tutorials.com