

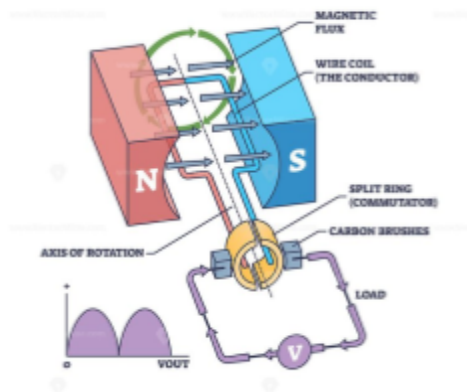
Name: _____

Can I Get a Watt, Watt?

("Watt" are our Energy Choices?)

What does a 4th grader's typical school-day morning look like? The day begins with their **alarm clock** blaring, waking them up in their cozy bedroom, kept warm by the **heater**. They flick on the **lights**, and walk to the bathroom to take a steamy shower with water that was warmed by the **water heater**. Next, they head to the kitchen, where some family members are watching **TV** while they get ready to prepare breakfast. They take eggs out of the chilled **refrigerator** to cook on the **gas stove**. While waiting for the eggs to cook, they **microwave** some bacon. After breakfast, they brush their teeth with an **electric toothbrush**. On the way out the door, they press the **garage door opener**, hop in the **car**, and zoom off to school. At school the room is **warm**, the classroom **lights** are on and they are using their **computers** to complete an activity.

Figure 1: Electricity Generator



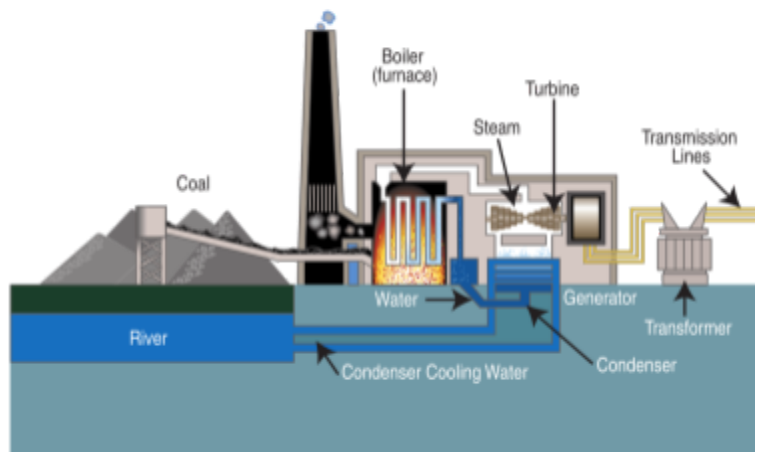
What do all of the **bolded** words above have in common? They take energy! By the end of the day, the average person has used 30 kilowatt hours (KWh) of energy without ever thinking about where that energy comes from and the environmental consequences of using that energy. The energy that we consume comes from many different sources, such as coal, natural gas, petroleum, uranium, water, sun, wind, and biomass. Most of the energy in the United States is used for electrical power (34%) and

transportation (30%).

You might wonder how these sources can be turned into electrical power. In order to do this you need a generator, Figure 1. A generator consists of a magnet and wire coil. When the wire coil is rotated near a magnet it produces electricity.

Some energy sources, such as water or wind, can turn the wire coil directly. Other energy sources such as coal, natural gas, and petroleum have to heat water to make high pressure steam which turns the

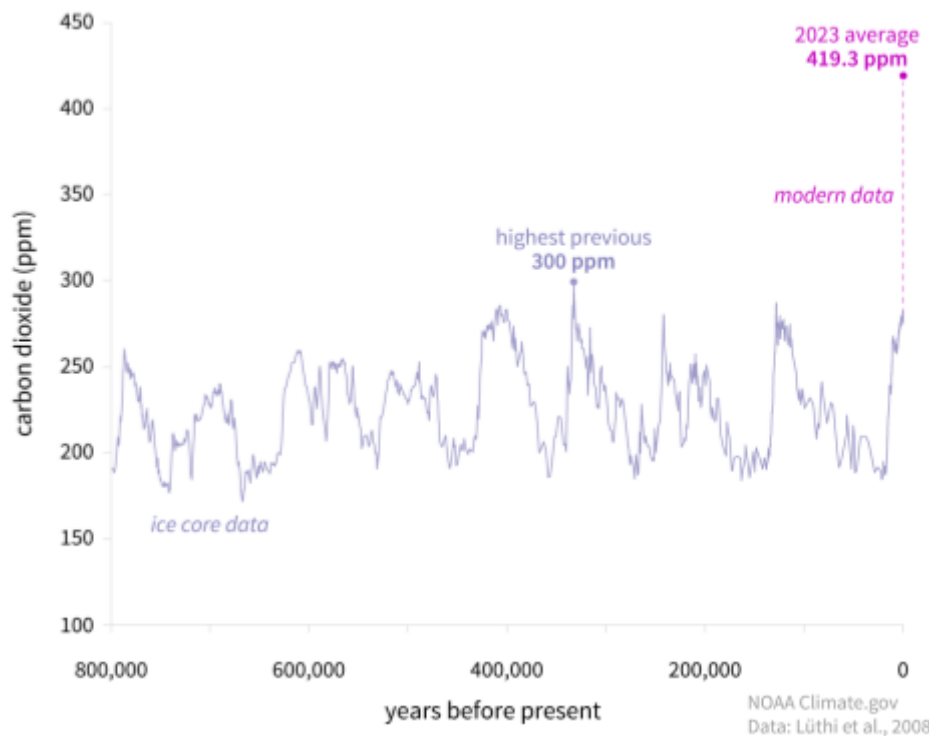
Figure 2: Coal-Powered Power Plant



wire coil. A diagram of a coal power plant is shown in Figure 2. Currently, there is no way for utility companies to store electricity.

In order to get the energy from many energy sources, it is necessary to burn them. Materials that came from living things, such as plants or animals, are considered organic materials, which means they contain carbon. Burning these materials produces carbon dioxide (CO₂), a greenhouse gas. Greenhouse gasses have been increasing in the atmosphere since the industrial revolution in 1750, Figure 3. Increased greenhouse gas levels in the atmosphere lead to global warming, which has many negative impacts on humans, including rising sea levels,

Figure 3: Carbon Dioxide Levels over 800,000 years



more severe storms, droughts, wildfires, and loss of species. Therefore, when evaluating energy sources it is important to consider the amount of CO₂ that they release.

All energy sources have pros and cons. This text will detail the most common energy sources used in the United States.

Coal

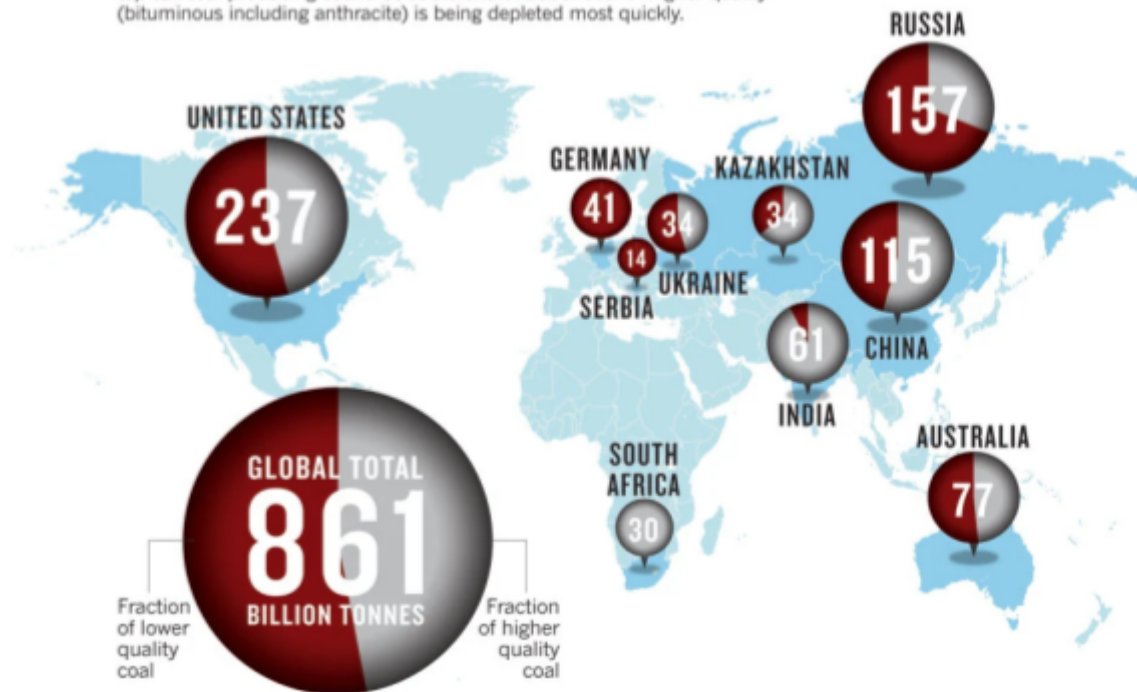
Coal is an energy source that is mostly used to generate electricity. For every 1 g of coal that is burned, 18 kilojoules (kJ) of energy is released (enough energy to power your TV for 18 s). The first coal-burning power plant in the United States was built in 1882 in New York under the supervision of Thomas Edison. Today, there are 200 operating coal power plants in the United States that provide energy at a cost of roughly \$0.09 per kWh. The average cost of building a coal power plant in the United States is \$3,500 per kW.

Coal is formed when mainly land-based plant matter is subjected to heat and pressure over millions of years. Coal is located all over the world (Figure 4), but the United States has the largest coal reserves in the world. Coal must be mined from the ground. Coal mining is a dangerous job, and while the number of fatalities has been going down, between 1983-2020, 2,885 miners died. Mining also causes land to become unstable, soil to erode, and air to become polluted with coal dust. These can lead to habitat destruction as well as diseases in humans, like black lung (inflammation and scarring in the lungs, making it difficult to breathe).

Approximately 42,600 people in the United States work in the coal mining industry, with the largest employers located in Wyoming, West Virginia, Pennsylvania, and Illinois. The average salary of a person working in the coal mining industry is \$44,000 (for comparison, the average salary of a fast food worker is \$27,000).

Figure 4: Location of Global Coal Reserves

Proven recoverable coal reserves reported to the World Energy Council by the top-ten coal-producing countries at the end of 2008. Coal of higher quality (bituminous including anthracite) is being depleted most quickly.



Coal can easily be stored and transported. Therefore, it can be burned at any time, making it usable 100% of the time. When coal is burned, it turns the chemical energy into usable electrical energy (electricity). This process produces CO₂. Additional CO₂ was produced when the coal was extracted from the ground and brought to the power plant. Taking into account all of the CO₂ produced, from first extraction to electric generation, for every kWh of electricity generated, 2.3 pounds (lb) of CO₂ are produced.

In addition to CO₂, coal produces other gasses when burning because it contains impurities. One impurity is sulfur, which produces sulfuric acid when burned. This makes the water in the air acidic, a phenomenon known as acid rain. In 1978, the United States started requiring that coal power plants have a device called a scrubber installed on them. These devices help catch the sulfuric acid, reducing the level of acid rain. Addition of scrubbers has decreased the amount of sulfuric acid in the air, lowering it by more than 70% since the late 1980s.

Petroleum

Petroleum is an energy source that is mostly used in transportation (82%) by providing fuel for everything from cars to planes. Other minor uses include heating, electricity generation, and manufacturing. For every 1 g of petroleum that is burned, 45 kJ of energy is released (enough energy to power your TV for 45 s).

The first gas station in the United States was built in St. Louis Missouri in 1905. Today there are more than 145,000 gas stations in the United States. People pay \$0.13 per KWh for energy that is derived from petroleum. The average cost of building a petroleum power plant in the United States is \$2,080 per kW.

The formation of petroleum is similar to that of coal. The biggest difference is instead of being formed from land-based plants, petroleum is formed from the remains of marine organisms. Petroleum is located all over the world, Figure 5, with Saudi Arabia having the largest petroleum reserves, at 22%. The US has about 2% of the petroleum reserves making it 11th on the list.

Figure 5: Countries Shown by Size of Petroleum Reserves

Who has the oil?



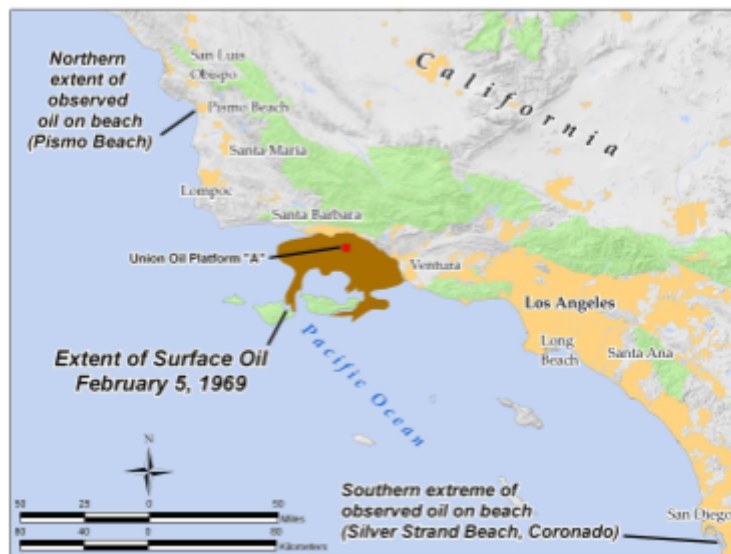
Petroleum is pumped from the ground. On land, the pumps are called oil rigs and at sea they are called oil platforms. Petroleum can be transferred to refining facilities via pipelines, ships, and trains. These facilities purify the petroleum, converting it into products that can be used

such as gasoline, diesel, and jet fuel. It can then be trucked to the place of sale fairly easily (ex: gas stations) for individuals or companies to purchase.

The oil and gas extraction industry in the United States employs about 116,000 people, with the largest employers located in Texas, Oklahoma, and Colorado. The average salary of a person working in oil and gas extraction is \$133,000. In addition, another 2 million people have jobs that rely on the oil and gas extraction industry such as gas station owners, truckers, pipeline builders, and refinery workers.

Similar to coal, petroleum can easily be stored and transported to any place that it is needed, making it usable 100% of the time. However, since petroleum is a liquid instead of a solid, when spills occur it is harder to clean up. For example in 1969 there was a blowout (uncontrolled release of petroleum when pressure controls failed) in one of the oil rigs off of the Santa Barbara coast. 4.2 million gallons of petroleum were released into the ocean, Figure 6. This resulted in the largest oil spill in the United States at the time. This oil spill caused the deaths of at least 3,686 birds (and countless more that were not recorded) as well as other marine life such as sea lions and elephant seals. The protest from the oil spill led to the creation of the first Earth Day (April 22, 1970) which is still celebrated in Santa Barbara and all across the United States today. Since the Santa Barbara oil spill, there have been two larger spills in the United States. Deep Horizon (2010) happened in the Gulf of Mexico releasing 134 million gallons of petroleum and killing 11 people. Exxon Valdez (1989) happened in Alaska, releasing 100 million gallons of petroleum. Both of these spills had devastating environmental impacts.

Figure 6: Area Affected by 1969 Oil Spill



Oil spills can also happen on land, but are usually easier to stop and clean up. For example in 2015, a pipeline that brought oil from the platforms off the Santa Barbara coastline to the shore near Refugio beach ruptured, causing 100,000 gallons of petroleum to be released. While some of this petroleum was on land, making it easier to clean up, much of it ran into a storm drain and a ravine under the freeway, and entered the ocean.

Cars engines take the chemical energy in petroleum and change it into motion energy, allowing us to drive from place to place. In this process, cars burn liquid gasoline which is transformed into a gaseous substance that takes up more space. This expansion forces a piston to turn, which makes the wheels of a car move. Like coal, when petroleum is burned, it produces CO₂. For every kWh of energy generated from petroleum, approximately 2.5 lb of CO₂ is produced.

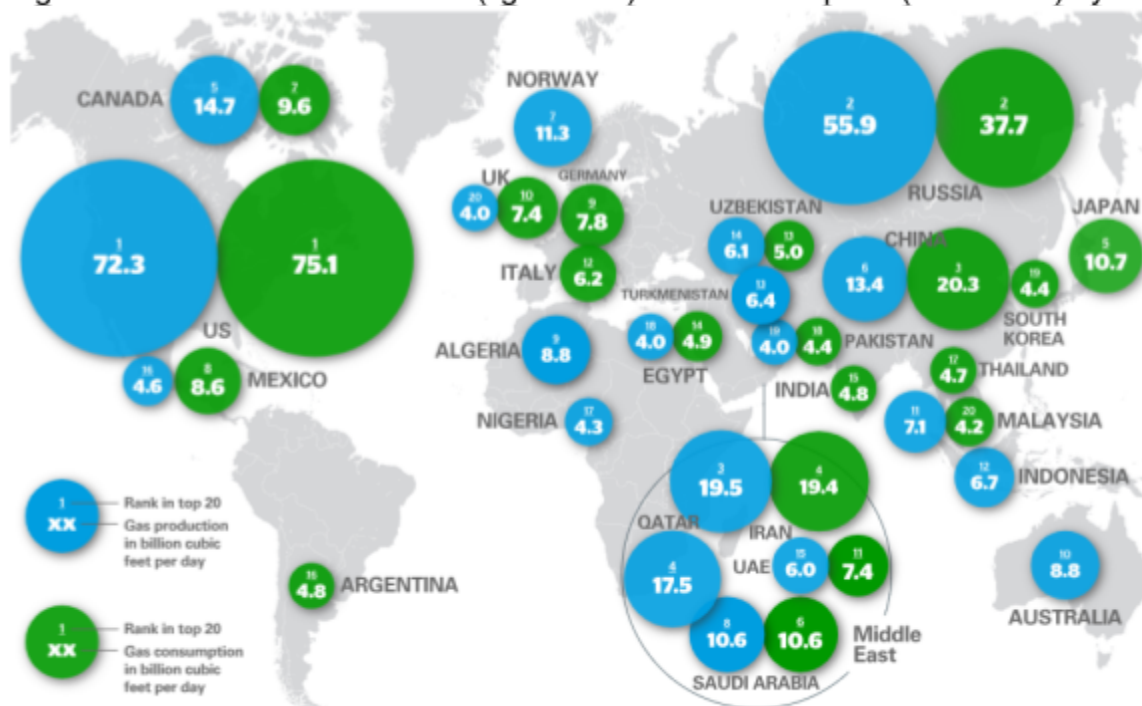
Natural Gas

Natural Gas is an energy source that is primarily used to generate electricity (40%) as well as to heating air and water (37%) for homes and businesses. For every 1 g of natural gas burned, 56 kJ of energy is released (enough energy to power your TV for 56 s).

The first natural gas power plant was built in the United States in 1949 in Oklahoma City, Oklahoma. Today we have approximately 2,000 operating natural gas plants. The closest natural gas burning power plant to Santa Barbara is the Ellwood Generation Station, which is located next to the freeway, 1.8 miles from Costco. The Ellwood Station produces 54 MW of power, enough to support 45,000 houses. Natural gas can provide energy at a cost of roughly \$0.07 per kWh. The average cost of building a natural gas power plant in the United States is \$722 per kW.

Natural gas formation is similar to both coal and petroleum formation. However, it can be formed from both prehistoric land-based plants as well as the remains of marine organisms. Natural gas is located all over the world, Figure 7, with the United States having the largest reserves with 5%. The United States is also the largest user of natural gas.

Figure 7: Natural Gas Production (light circle) and Consumption (dark circle) by Country

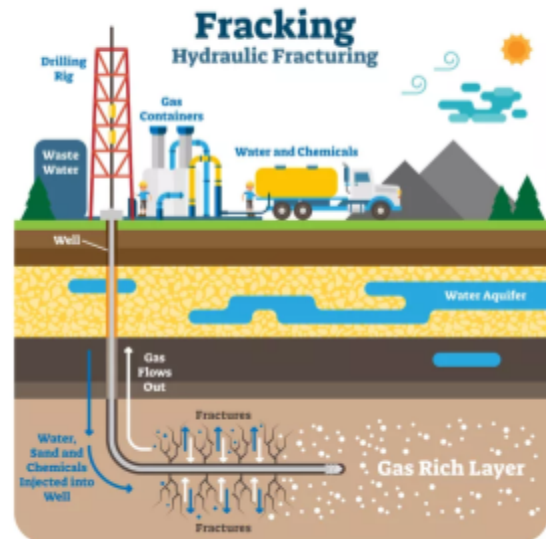


Natural gas is extracted from the ground by drilling wells into underground rock formations where the gas is trapped. Depending on the sedimentary rock (usually shales and sandstones) the natural gas will either flow up the well with no additional processing (33%) or need to be released from the rock by a process called hydraulic fracturing (fracking; 67%), Figure 8. In the fracking process, high pressure liquid is forced into the ground and breaks apart the rocks,

which releases the stored natural gas so that it can flow to the well's surface. One advantage of fracking is it allows for much quicker gas extraction than traditional wells. It also allows the extraction from areas where traditional wells are unable to extract natural gas. An advantage of fracking is that it keeps supply high, which keeps the price of natural gas down, and allows the United States to be more energy independent (not depending on other countries for our energy needs).

There are gas fields located near Santa Barbara. These are known as the La Goleta Gas fields and are about 1 mile from Goleta beach. This facility consists of 19 active wells that use traditional drilling techniques (not fracking). This facility is also used as a storage facility by pumping natural gas into the reservoirs when it is not needed.

Figure 8: Fracking infrastructure



Once extracted, natural gas can be easily transported or stored. But before the gas can be used, it must go to a purification plant for processing. After purification, the natural gas enters pipes connecting the processing plants to most businesses and houses in the United States. Similar to coal and petroleum, natural gas is available for use 100% of the time. The fracking industry in the United States employs about 64,000 people, with the largest employers located in Texas, Pennsylvania, and Louisiana. The average salary of a person working in the fracking industry is \$42,000.

There are environmental concerns with the fracking process. The process is very water intensive, using approximately 100 billion gallons of water per year (by comparison, the city of Santa Barbara uses 2 billion gallons of water per year). In addition, the water is mixed with other chemicals before it is forced underground. Waste fluid can get into the groundwater supply, contaminating it and causing health risk for humans. The process of fracking can also cause "induced" earthquakes; most of these are magnitude 1 or smaller and do not concern scientists. Larger earthquakes can be caused when wastewater is injected into deep wells under high pressures, which can cause earthquakes large enough to be damaging.

Since natural gas is used for electricity, heating, and cooking, there are several devices such as stoves and water heaters that turn the chemical energy into heat energy that can heat our houses or make electricity. All of these devices burn natural gas, which produces CO₂. For every kWh of electricity produced, 1.0 lb of CO₂ is generated.

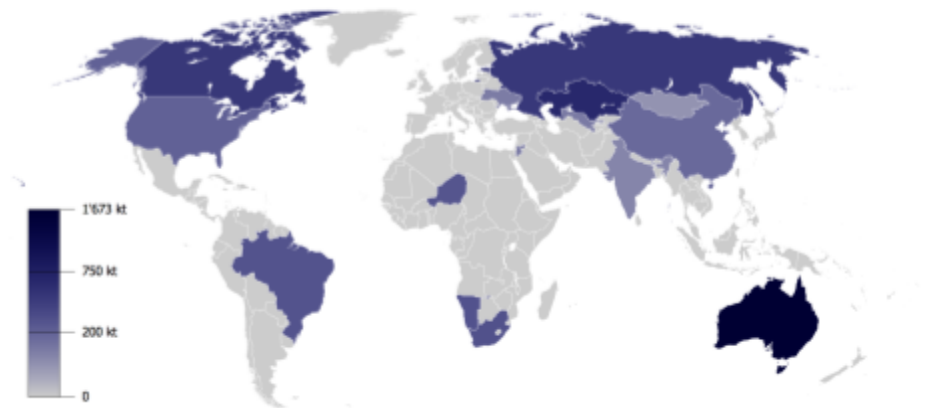
Uranium

Most nuclear energy (energy from uranium) is used to generate electricity. For every 1 g of uranium used, 82,200,000 kJ of energy is produced. (That's enough energy to power your TA for 2.6 years!). The first commercial nuclear energy plant in the United States was built in Virginia in 1958. There are 94 active nuclear reactors in the United States that provide energy at a cost of \$0.08 per KWh. Most of these are located on the east coast. California has one operating nuclear reactor called Diablo Canyon, which is located near San Luis Obispo and can produce 2,200 MW of electricity, enough power for 1.8 million houses. The average cost of building a nuclear power plant in the United States is \$6,800 per kW.

Similar to fossil fuels (coal, petroleum, and natural gas), uranium is used to heat water, which turns a generator to produce electricity. But unlike fossil fuels, the fuel is not burned. The heat is produced from the uranium itself as it undergoes nuclear reactions. During this process, the unstable uranium breaks apart into other lighter elements, releasing large amounts of heat, which is the heat source for the water that turns the generators. This process turns chemical energy into electrical energy.

Australia has the largest uranium supply, with 25% of the world's reserves, Figure 9. The US only has 1.3% of the world's reserves making it 17th on the list. The states with the largest uranium reserves are Wyoming, New Mexico, and Colorado. The US only has five operating uranium mines employing approximately 340

Figure 9: Uranium reserves. The darker the country the larger the reserve.



workers, who make on average \$55,800 a year. Due to the low uranium reserves in the US, they must import most of their uranium from other countries. The three countries which we import the most uranium from are Canada (27%), Kazakhstan (25%), and Russia (12%).

To extract uranium from the ground, it must be mined or dissolved in a process called in situ leaching. When there is a large amount of uranium in the ground, it is mined. If the uranium is close to the surface, it can be mined via open pit mining. This technique strips away all of the top soil and rock to get down to the uranium which is then removed. This process destroys the habitat around the mine, leaving behind a giant hole, Figure 10. If the uranium is located deep underground, then miners must dig tunnels to reach the uranium ore. Similar to open pit mining, this type of mining involves large-scale movements of soil and loss of habitat. When there is a

small amount of uranium in the ground, then in situ leaching must be used. In this technique, chemicals pumped into the groundwater dissolve the uranium, allowing it to be pumped to the surface. This is the most common uranium extraction method in the United States. In situ leaching can contaminate groundwater and lead to habitat destruction.

Figure 10: Uranium Pit Mining



Before the uranium can be used to make electricity it must be extracted from rocks and then purified. Less than 1% of a natural uranium sample is useful for generating electricity. This process leaves behind radioactive waste, which is hazardous and must be stored indefinitely. Another major drawback of uranium is that if it is further purified, it can be used in nuclear weapons.

Some pros of uranium are that it is very energy dense, making it easy to transport and store. In addition, it is available 100% of the time and it does not produce greenhouse gasses in the generation of electricity. However, the building of the reactor does produce CO_2 . When this is taken into account, for every kWh of electricity produced, 0.01 lb of CO_2 is generated.

There are also cons with nuclear energy. For example, if the nuclear reactions in the power plants are not carefully controlled, the nuclear fuel can explode, hurting people and causing human health issues (such as radiation sickness and cancers), along with habitat destruction for miles around the plant. The largest recent nuclear disaster occurred in 2011 at the Fukushima Daiichi Nuclear Power plant in Japan. An earthquake damaged the Fukushima plant, causing an explosion and contaminating the surrounding area. While no one died due to the explosion, there was an increase in human health issues in the surrounding areas.

The largest United States nuclear disaster was in 1979 in Pennsylvania, at a plant called Three Mile Island.

Water

Energy generated from water is called hydroelectric energy. This energy source is used to generate electricity. The United States built their first hydroelectric power station in Appleton Wisconsin in 1882. Hydroelectric power is generated when a river is dammed, causing water to build up behind it. This water is forced to travel through the dam, turning generators which produce electricity. As long as there is water behind the dam, it can produce electricity 100% of the time.

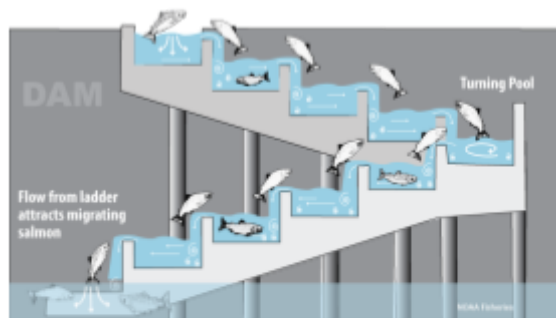
The United States has thousands of hydropower plants which provide electricity at a cost of \$0.03 per kWh. 1,600 of these hydroelectric plants are located in California. The closest hydroelectric plant to Santa Barbara is the Gibraltar Reservoir, which is located upstream of the Cachuma reservoir. However due to droughts, many times the plant is not operable. When operating at full capacity, it can produce 820 kW of power, enough to power 670 homes. The average cost of building a hydroelectric facility in the United States is \$4,525 per kW.

One challenge with generating hydroelectric power is the facilities have to be placed on reliable water sources, and most of the best river spots already have hydroelectric plants on them. Once the plants are built, the main cost is paying for the workers. Currently about 75,000 people work at hydroelectric plants and earn an average salary of \$92,700.

Hydroelectric plants have a considerable impact on the surrounding area. After construction, the area behind the dam is flooded, destroying the habitat in the area. Anyone living in this area would also be forced to move. People and animals downstream are also affected by the hydroelectric plant. The dam restricts the water downstream, decreasing the water that can be used by humans and animals. There are also safety risks for people downstream. If the dam ever fails, large amounts of water can be released quickly causing deadly floods.

Another impact of dams is that they make it impossible for fish to move freely up and down the river. For migrating fish such as salmon this is a problem. One solution is a fish ladder, Figure 11. This is a water-filled structure with pools that fish can jump between to go from the bottom of the dam to the top of the dam. However, this only works for short dams (40 ft or less). For taller dams, where the water level fluctuates, or changes, more, the technique of “trap and haul” can be used. The fish are caught at the bottom of the dam and hauled above the dam to be released. But neither of

Figure 11: Fish Ladders



these techniques are as effective as a free-flowing river that hasn't been dammed.

Another environmental impact caused by hydroelectric electricity generation is deoxygenation of the water. This happens because as the water turns the generators, it heats up. The hotter the water, the less oxygen the water can store. Fish and other aquatic life get the oxygen they need from the water. If the oxygen level becomes too low, aquatic life cannot survive.

Since hydroelectric plants are not burning fuels, they do not produce CO₂ in the electricity generating process. However, the building process does release a significant amount of CO₂. When this is taken into account for every kWh of electricity produced, 0.03 lb of CO₂ is generated.

Sun

Energy generated from the sun is called solar energy. This energy source is predominantly used to generate electricity. There are two types of solar power, concentrated solar power (CSP) and photovoltaics.

Concentrated solar power uses the power of the sun to heat water which can then make electricity, similar to fossil fuel plants, Figure 12. Photovoltaics are made with a material that can directly turn the power of the Sun into electricity. The United States installed their first utility-grade CSP plant in 1984 in Daggett, California (70 miles northwest of San Bernardino), named Solar Energy Generating System (SEGS) 1. Today the new solar installations are photovoltaics. The United States put in their first

Figure 12: Power Tower (CSP)



photovoltaic power plant in 1982 in Hesperia, California (35 miles north of San Bernardino). Currently the United States has 11 CSP plants and over 2,500 utility-scale photovoltaic power plants. Since most of the solar power in the United States is from photovoltaics, we will focus on this. The cost of electricity generated from solar panels is \$0.03 per kWh. The cost of building photovoltaic power plants is roughly \$1,588 per kW.

The idea of a clean (not producing CO₂) renewable (doesn't get used up or run out) energy source is attractive to utility companies, businesses, schools, and individual homeowners. This is why the solar industry is rapidly growing. Currently the solar industry employs approximately 279,477 people who make an average salary of \$48,000. Additional benefits of photovoltaics are that they are quiet, easy to maintain, and unlike the other energy sources discussed, a personal homeowner can install them on their own house.

But, as with the other energy sources, there are also cons. One is that they can only operate when the sun is out. This means that they are only useful during the day (approximately 50% time), and during the summer months they generate significantly more electricity than in the winter. If we want electricity at all times, they must be paired with other energy sources that can produce electricity when the panels are not able to.

While individual homeowners can place panels on their roofs, a considerable amount of space is needed for solar farms (large numbers of solar panels used to generate electricity for many

homes). A 500 MW natural gas plant takes up approximately 6 acres. For a solar farm to produce this amount of electricity, it would use around 4,000 thousand acres.

To understand the full environmental consequences of solar power we also have to look at how these panels are constructed. The solar panels are made from silicon, which is found in sand and other substances like quartzite, mica, and talc that can be mined. In addition, other elements such as arsenic, antimony, and gallium must be used. All of these have to be mined from the Earth, which causes devastating environmental impacts.

Once the raw materials are gathered, they have to be heated to extreme temperatures to make the silicon wafers needed for the panels. Currently, China produces 70% of this material. These factories are usually powered by coal-powered power plants. Therefore, just like all of the other power sources, photovoltaics not only cause habitat destruction, but also release CO₂ into the atmosphere. When the lifetime of the solar panels is taken into account, it is estimated that they produce about 0.09 lb of CO₂ for every kWh of electricity produced.

Another big downside of solar panels is that they only last for approximately 30 years. At that point their efficiency has dropped, making them useless. Many times they end up in landfills. This can also cause negative environmental impacts because they contain toxic substances which can contaminate the area. As more and more people put solar panels on their houses, this will become a bigger problem.

Wind

Wind energy is used to generate electricity. Generating electricity from the wind is similar to all the sources that generate electricity from steam. However, instead of using steam to turn the generator, wind is used. The United States installed their first wind farm (20 wind turbines) in New Hampshire in 1980. There are now thousands of wind farms across the United States. In addition, in 2024 the first offshore wind farm was installed off the coast of Long Island, New York. The closest wind farm to Santa Barbara is located 3.5 miles from Lompoc and is called the Strauss Wind Farm. It has 27 wind turbines and delivers 98 MW of energy, enough energy for 82,000 houses.

The cost of electricity generated from wind turbines is \$0.03 per kWh. The cost of building a wind farm is about \$1,500 per kW. More than 131,000 Americans work in the wind industry, making an average of \$61,770 per year. The states that employ the top number of workers are Texas and California.

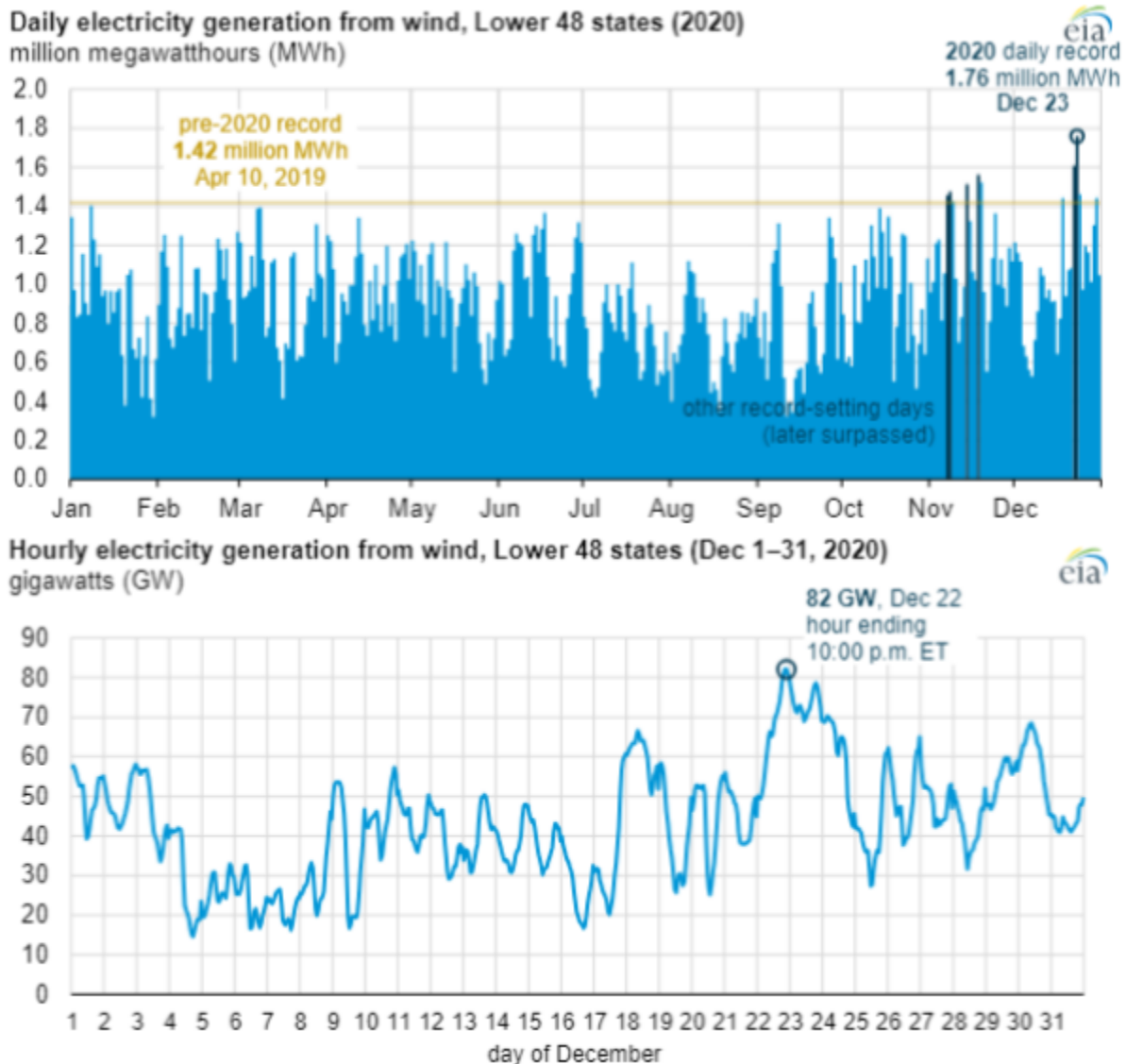
Wind is caused by the uneven heating of the Earth's surface by the Sun. This process happens naturally with or without wind farms. Therefore, the original source of energy (wind) does not have any additional negative environmental impacts that would not be there if the wind farm was not there. The wind turbine transformation of the motion energy in the wind into usable electrical energy.

One large challenge with wind energy, similar to water energy, is there are only certain locations that wind farms can be located. Companies need locations where the average wind speed is at least 9 mph. Good locations are often flat plains, tops of rounded hills, or mountain gaps that funnel and intensify the wind. This results in most wind farms generating electricity 80% of the time. In addition, electricity generation is both day and night as well as season dependent, Figure 13. In general more electricity is generated in the late night/early morning and during the months of November through April.

Wind farms take up a lot of space. A 500 MW wind farm needs about 26,000 acres, which is much larger than the same size solar farm. However, only 4% of the land is developed when wind farms are installed, whereas for solar it is 22%. This means that it is easier to use the land for other things such as growing crops. This allows farmers (or others with land) to lease their land to wind companies and still use it for their own needs.

Wind turbines also kill wildlife like birds and bats. Scientists have estimated they kill between 140,000 and 679,000 birds per year, which gives an average of 0.08 birds per turbine per day. This number is increasing as more wind turbines are installed. To put these numbers into perspective, house cats kill between 1,300,000,000 (1.3 billion) and 4,000,000,000 (4 billion) birds a year. However, while cats typically kill smaller song birds, wind turbines can kill larger birds such as eagles, hawks, herons, and gulls.

Figure 13: Electricity Generation from Wind Turbines



Even though wind turbines are typically around 750 ft tall (size of a 55 story building), they still produce noise. The closest a building can be to a wind turbine is 300 m/984 ft (length of 3 football fields). At this distance wind turbines produce 40 decibels of noise, the same amount of noise as a refrigerator. Another downside is that some people do not like how they look.

A benefit of wind energy is that since it is not burning anything, the electricity production does not produce greenhouse gases. However, the building of the wind farms does produce CO₂. When this is taken into account, for every kWh of electricity produced, 0.002 lb of CO₂ is generated.

Biomass

Biomass is energy generated from organic material (plants and animals). For every 1 g of biomass that is burned, 12 kJ of energy is released (enough energy to power your TV for 12 s). Unlike coal, petroleum, and natural gas, which are made from organic matter that is millions of years old, the organic matter in biomass has been produced recently. Some forms of biomass are wood, animal manure, trash/garbage, as well as crop and agriculture residues. Biomass is our oldest fuel source. It was first used by humans for keeping warm and cooking foods. Now the main uses of biomass are heating (63%), transportation (28%), and electricity (9%). The cost of electricity generated from biomass is \$0.13 per kWh. The cost of building a biomass electricity generation plant is roughly \$3,500 per kW.

Biomass is used for heating when wood, wood pellets, or agricultural waste is burned in a stove, converting chemical energy into heat. In other words if you have a wood burning fireplace at your house, you are using biomass.

Biomass can also be used for transportation. Crops such as corn are fermented to make a chemical known as ethanol, which allows chemical energy to be converted to motion energy. The ethanol is then mixed into gasoline. In California, approximately 10% of the gasoline that we use in our cars is made from ethanol. Henry Ford's first vehicle, the quadricycle, could run off of ethanol. But the large-scale commercial use of ethanol did not start until around 1973.

When biomass is used for electricity, organic materials can be directly burned or heated in a low oxygen environment to produce biogas, which is made up of hydrogen and methane, as well as other gasses. The organic material or biogas can be burned to heat water that turns into steam, which can then turn a generator, converting the chemical energy into electrical energy. Similar to fossil fuels, biomass is available 100% of the time for use.

Biomass has been used in the United States since the early 19th century to produce electricity. The closest biomass (utility-grade) electrical plant to Santa Barbara is Mt. Poso Cogeneration Company. This plant can produce 45 MW of electricity (enough energy for 37,000 homes) by burning urban wood waste, logs from forest thinning, trees, orchard trimmings, and agricultural waste.

The first biomass gasification plant in the United States was opened in 1998 near Burlington, Vermont. The closest biomass gasification plant to Santa Barbara is located at the ReSource center at Tajiguas landfill. This plant takes organic waste that has been thrown away and converts it into electricity. It generates enough electricity to power the landfill along with 2,000 homes. There are about 630 biomass power plants currently in the United States.

7,890 people work directly with biomass electricity generation in the United States. These people make an average salary of \$65,870 per year. In addition, there are another 400,000 jobs

that are related to biomass, such as farmers that grow corn for ethanol and truckers that move the biomass to where it will be used.

One of the largest benefits of biomass is that it reduces waste. However, if more biomass is needed than the waste provides, it can lead to deforestation. Other downsides of biomass include the conversion of farmland (that would typically be used for food) into corn or other crops used for biomass. Growing plants solely for biomass uses a lot of water, fertilizer, and energy which could be used to produce food.

To get the energy out of the biomass, it must be burned. Like burning fossil fuels, burning biomass releases CO₂ into the environment. However, unlike fossil fuels, the area where the biomass came from is usually used to grow plants again. When plants grow, they absorb CO₂ from the environment. This removes the CO₂ that was put into the environment from burning the biomass. Therefore, the process can be carbon neutral, which is not the case for fossil fuels.

Even though the burning process is carbon neutral, the energy needed for growing and hauling the biomass does create a carbon footprint. When this is taken into account, for every kWh of electricity produced, 0.50 lb of CO₂ is generated. In addition, when the biomass is burned, it also releases gasses such as carbon monoxide and nitrogen oxides into the air, which causes air pollution.