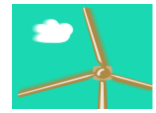
2024 LEBANON COUNTY ENVIROTHON
MIDDLE SCHOOL



CURRENT ISSUE – ALTERNATIVE ENERGY

Study concepts:

1. Vocabulary
2. What is energy?
3. Energy sources
4. Renewable energy
5. Non-renewable energy
6. The greenhouse effect
7. Energy innovations
8. Saving energy
9. History of the electric car

Students should be able to:

- Understand differences between renewable and non-renewable resources
- Identify energy sources and the benefits and challenges of each source
- Explain the greenhouse effect and link global warming to climate change
- Raise awareness of what individuals can do at home to conserve energy

Vocabulary:

1. **Atom**: The smallest unit of matter, consists of protons, neutrons, and electrons.
2. **Biomass**: A renewable energy source that comes from recently living plants and animals, like wood, crops, manure, and garbage.
3. **British Thermal Unit (BTU)**: Unit of energy used globally in the power, steam generation, and heating and air conditioning industries.
4. **Carbon dioxide**: A colorless, odorless greenhouse gas formed by burning animal or plant matter and by breathing. Plants absorb it during photosynthesis.
5. **Chemical energy**: Stored within bonds between molecules.
6. **Climate change**: A change in long-term weather patterns.
7. **Coal**: A black, organic rock formed from plant remains over hundreds of millions of years.
8. **Electricity**: The flow of electrical charge.
9. **Electrical energy**: Comes from tiny charged particles called electrons.
10. **Electric vehicle (EV)**: A vehicle that runs at least partially on electricity.
11. **Energy**: The ability to do work.
12. **Energy conservation:** A behavior that results in the use of less energy.
13. **Energy efficiency:** The use of technology that requires less energy to perform the same function.
14. **Fossil fuels**: Fuels such as coal, oil, and natural gas that formed from the remains of ancient plants and animals buried underground.
15. **Geothermal energy**: Heat, hot water, or steam from under the earth's surface that is used to create electricity and for heating and cooling.
16. **Global warming**: An average increase in the earth's temperature.
17. **Greenhouse gases**: Gases that trap the heat of the sun in the earth's atmosphere.
18. **Greenhouse effect**: The process of greenhouse gases making the earth warmer by trapping heat in the atmosphere.
19. **Hydropower**: Energy from flowing water.
20. **Infrastructure**: The network of people, buildings, and equipment required to supply energy for use throughout the world.
21. **Light-emitting diodes (LEDs)**: A technology that uses the movement of electrons through a semiconductor to produce visible light.
22. **Renewable energy**: Energy from natural sources or processes that are constantly replenished. For example, solar, wind, water, geothermal, and biomass.
23. **Non-renewable energy**: Energy from sources that do not replenish quickly. For example, natural gas, coal, oil, and nuclear (uranium).
24. **Nuclear energy**: Energy released when atoms join together (fusion) or split (fission).
25. **Solar energy**: Energy from the sun. Solar power uses the sun's energy to produce electricity or heat.
26. **Thermal energy**: Energy created from moving molecules.
27. **Wind energy**: Energy from moving air.

What is Energy?

Energy is the ability to do work. Energy comes in several forms, including thermal (heat), light, kinetic (motion), electrical, chemical, nuclear, and gravitational. When we heat our homes, flip a light switch, or plug in our television, we are using energy. *Electricity* is generated from energy sources, such as natural gas, nuclear, and solar. Wood burning in a fireplace is using biomass energy to heat our homes. The gasoline we use to fuel our cars comes from petroleum (oil). This is another energy source.

How do we measure energy?

Different types of energy or fuels are measured in different ways.

Energy or Fuel Type	***Unit***
Liquid petroleum fuels (gasoline, diesel & jet fuel)	Gallons or barrels
Biofuels (ethanol & biodiesel)	Gallons or barrels
Natural gas	Cubic feet
Coal	Tons
Electricity	Kilowatt-hours

To compare these fuels, measurements are often converted into *Btu*, or British thermal units. Btu is a measure of heat energy.

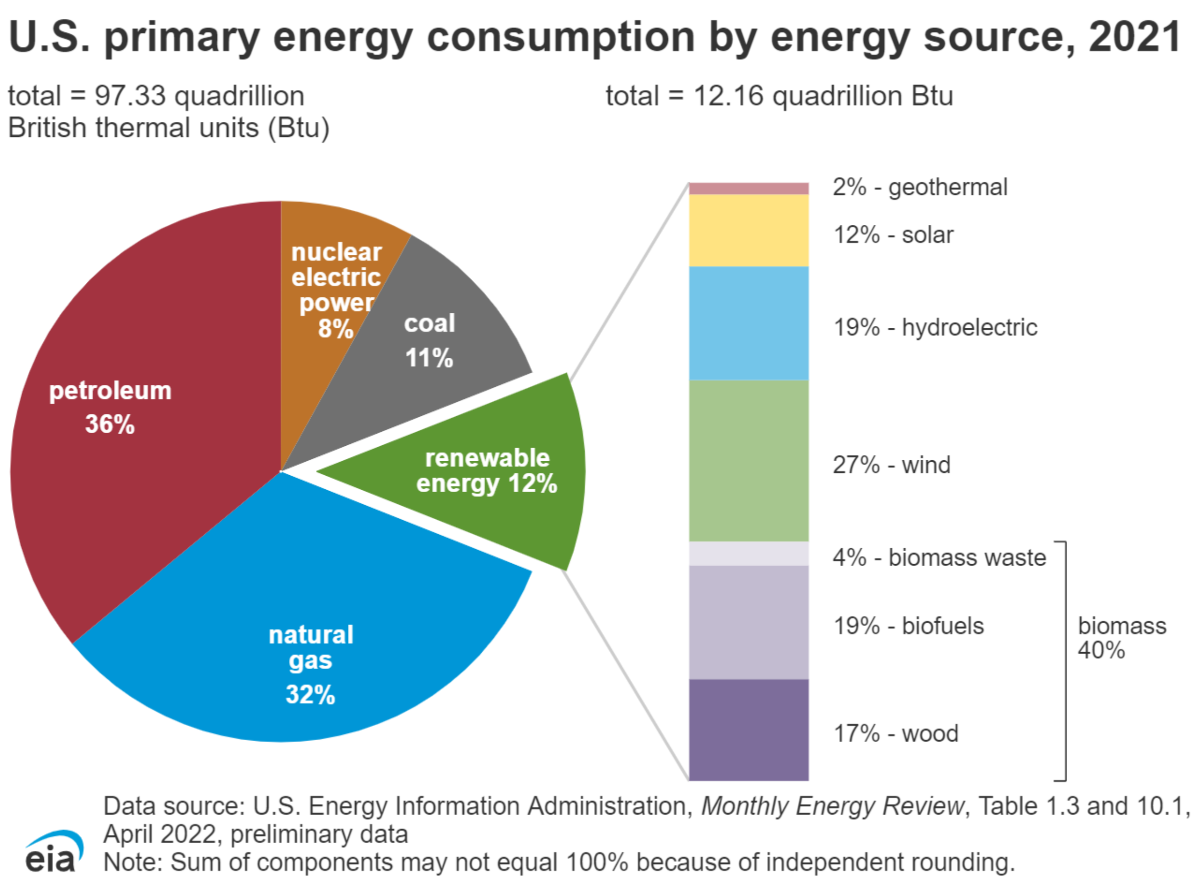
Energy or Fuel Type	***Original Measurement***	***Btu Equivalent***
Crude oil	1 barrel (42 gallons)	5,691,000 Btu
Natural gas	1 cubic foot	1,039 Btu
Coal	1 ton (2,000 pounds)	18,934,000 Btu
Electricity	1 kilowatt-hour	3,412 Btu

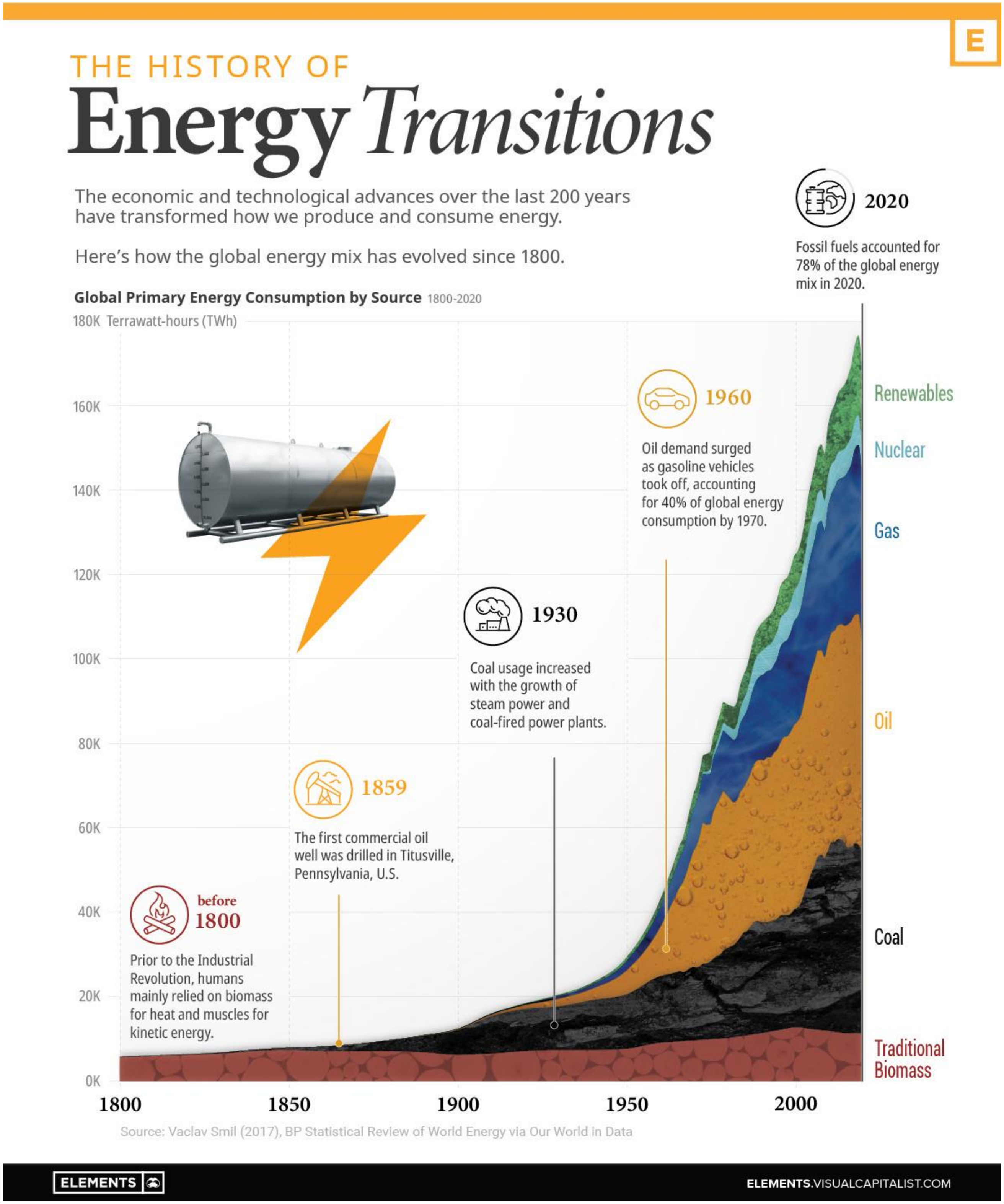
Energy Sources

Energy sources can be *renewable* or *non-renewable*. Renewable energy sources can be easily replenished. Nonrenewable energy sources cannot be easily replenished. These renewable and non-renewable energy sources are known as primary energy sources and can be used to produce electricity or heat.

Renewable sources	*Non-renewable sources*
Wind	Oil
Solar	Natural Gas
Hydropower	Coal
Biomass	Nuclear
Geothermal	

In the U.S., most of the energy we use comes from nonrenewable sources. Petroleum (oil) and natural gas are the largest sources, followed by coal and nuclear. In 2021, all renewable sources combined produced about 12% of the energy we consumed.




THE HISTORY OF
Energy Transitions
The economic and technological advances over the last 200 years have transformed how we produce and consume energy.
Here's how the global energy mix has evolved since 1800.
Global Primary Energy Consumption by Source 1800-2020
180K Terrawatt-hours (TWh)
160K
140K
120K
100K
80K
60K
40K
20K
0K
1800
1850
1900
1950
2000
2020
Fossil fuels accounted for 78% of the global energy mix in 2020.
1960
Oil demand surged as gasoline vehicles took off, accounting for 40% of global energy consumption by 1970.
1930
Coal usage increased with the growth of steam power and coal-fired power plants.
1859
The first commercial oil well was drilled in Titusville, Pennsylvania, U.S.
before 1800
Prior to the Industrial Revolution, humans mainly relied on biomass for heat and muscles for kinetic energy.
Renewables
Nuclear
Gas
Oil
Coal
Traditional Biomass
Source: Vaclav Smil (2017), BP Statistical Review of World Energy via Our World in Data
ELEMENTS
ELEMENTS.VISUALCAPITALIST.COM

Renewable Energy

In 2021, renewable energy sources produced about 12% of the total energy consumed in the U.S. Most renewable energy use in the U.S. is for electricity. Renewable energy sources are cleaner energy sources than coal, oil, and natural gas, but do come with environmental impacts. The construction of any type of power plant or equipment may use fossil fuels, alter the landscape, and require mining for metals and other construction materials.

Biomass
Hydropower
Geothermal
Wind
Solar

Biomass:

Biomass means "natural material." Biomass energy uses natural materials like paper waste, cardboard, crops, and other plant matter to make electricity. Biomass was the largest energy source until about 1900. Burning biomass releases carbon dioxide, but since the plants or plant products that are burned took up that carbon dioxide while growing, biomass is considered a carbon-neutral energy source.

Environmental costs: Burning biomass can produce harmful air pollution and ash. Some plants are grown specifically to be used for biofuel, which is controversial because the land could be used for other purposes (like natural ecosystems or food crops) instead.

Hydropower:

Hydropower energy comes from water and has been used for over 2,000 years. Civilizations as early as ancient Egypt used water wheels for tasks like grinding grain. Hydroelectric power is a way to use the water's power to create electricity. To do this, people build dams on large rivers. The river's flowing water spins the turbines of a generator, producing electricity. The largest hydroelectric dam in the U.S. is in Washington state and measures 5,233 feet long and 550 feet high, and makes enough electricity for over 2 million homes. In addition to damming streams and rivers, hydropower is also generated by waves and ocean thermal energy.

Environmental costs: Hydroelectric dams can block fish migration in streams and rivers and change the characteristics of the water body.

Geothermal:

Geothermal energy is heat within the earth. Geothermal energy uses the heat beneath the earth's surface to generate useable heat and electricity. Hot springs and reservoirs are also used as a direct heating system and for heating buildings. Its use is limited to where geothermal resources are near the earth's surface. In the U.S., geothermal plants are in Hawaii and the western states. The world's largest geothermal power plant is in California and produces enough electricity for over 22,000 homes.

Environmental costs: No major environmental concerns.

Solar:

Solar energy is energy from the sun and can be used as a heat source and as electricity. The sun is the original source of all other energy sources. Solar photovoltaic (PV) devices convert sunlight into electricity. PV cells can be used for small devices or to power homes. The solar panels you may see on rooftops are made up of many PV cells. Use of solar energy is increasing in the U.S. but has limitations because the amount of sunlight that reaches the earth's surface depends on location, time of day, season, and weather.

Environmental costs: Some plants may require large amounts of water for cleaning and cooling. Some hazardous materials are used to make photovoltaic (PV) cells. Laws regulate these materials.

Wind:

Wind energy is the energy from moving air, or wind. It is commonly captured in windmills. These windmills can be small, like one found on a farm, or large, like the massive wind turbines found on mountainsides. On a windy day, the wind turns the blades of the turbine, spinning a shaft. The shaft is connected to a generator, which then produces electricity.

Environmental costs: Some types of windmills may harm birds and bats.

Non-renewable Sources

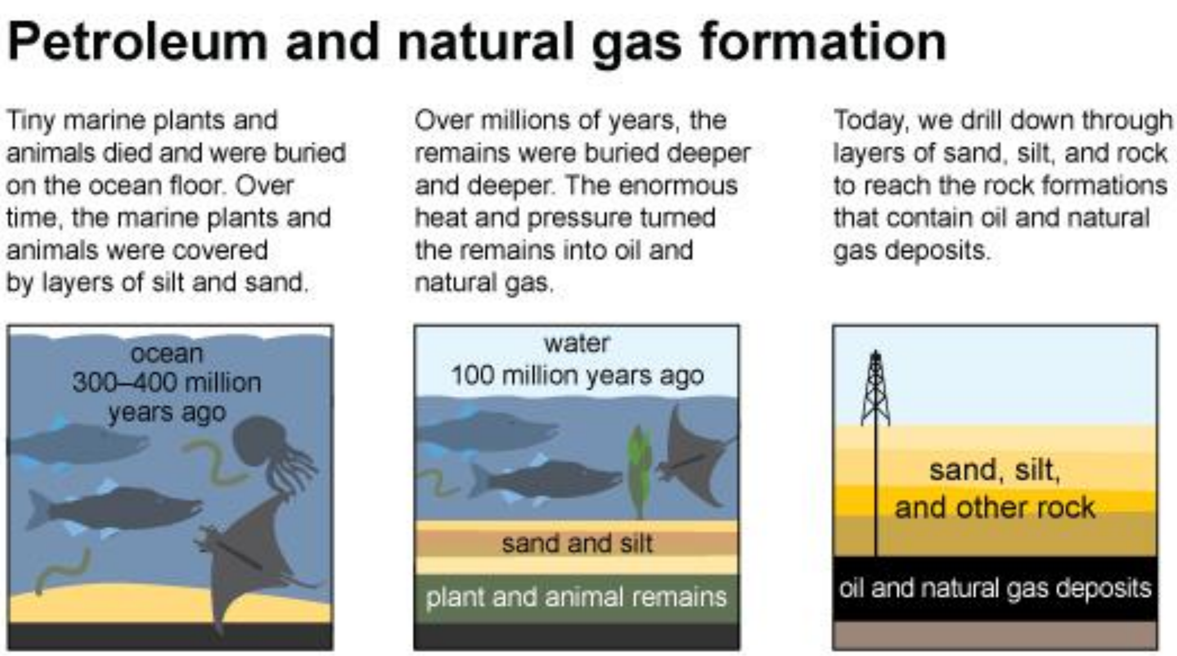
The three most common non-renewable energy sources are oil, natural gas, and coal. These are also known as *fossil fuels* because they formed when prehistoric plants and animals died and were buried by soil and rock. The other major non-renewable energy source is nuclear (uranium) energy. Let's explore these sources in more detail.

Oil
Natural Gas
Coal
Nuclear

Oil:

Today's crude oil reserves were formed from plants and animals that lived millions of years ago. The remains of these creatures were buried by sediment. Over millions of years, the pressure turned the covered organic matter into crude oil, or petroleum. The U.S. is one of the largest producers of crude oil in the world, with Texas being the highest-producing state. Once crude oil is removed from underground, it can be refined. The refining process converts crude oil into useful petroleum products including gasoline, diesel fuel, heating oil, and tar.

Using oil as an energy source has negative environmental impacts. Burning oil releases greenhouse gases. Hydraulic fracturing, or fracking, produces oil from underground rock layers but uses a lot of water and potentially harmful chemicals that can contaminate the environment. Oil spills can occur at oil wells or when oil is being transported. Accidents like the Exxon Valdez oil spill in Alaska in 1989 and the Deep Horizon explosion and spill in the Gulf of Mexico in 2010 can devastate marine ecosystems. These incidents prompted new regulations and reviews of existing procedures for the oil drilling and transportation processes.



Source: Adapted from National Energy Education Development Project (public domain)

Natural Gas:

Like oil, natural gas was formed when prehistoric plant and animal remains were under tremendous heat and pressure. Deposits are found in the spaces between rocks. Almost all of the natural gas the U.S. uses is produced in the U.S. By state, Pennsylvania trails only Texas in natural gas production.

Natural gas also has environmental impacts. While it is considered cleaner to burn than oil and coal, natural gas is mainly made of methane, a strong greenhouse gas. Natural gas is colorless and odorless, so gas companies add a harmless chemical called mercaptan that makes the gas smell like rotten eggs. This helps detect gas leaks – in 2019, 29% of U.S. methane emissions were from abandoned oil and natural gas wells. Land is cleared or disturbed to dig wells and lay pipelines to transport natural gas. Most natural gas in the U.S. is extracted by fracking, which forces water, chemicals, and sand down a well. Fracking makes natural gas more accessible but uses a lot of water, can cause small earthquakes, and can release hazardous chemicals and wastewater.

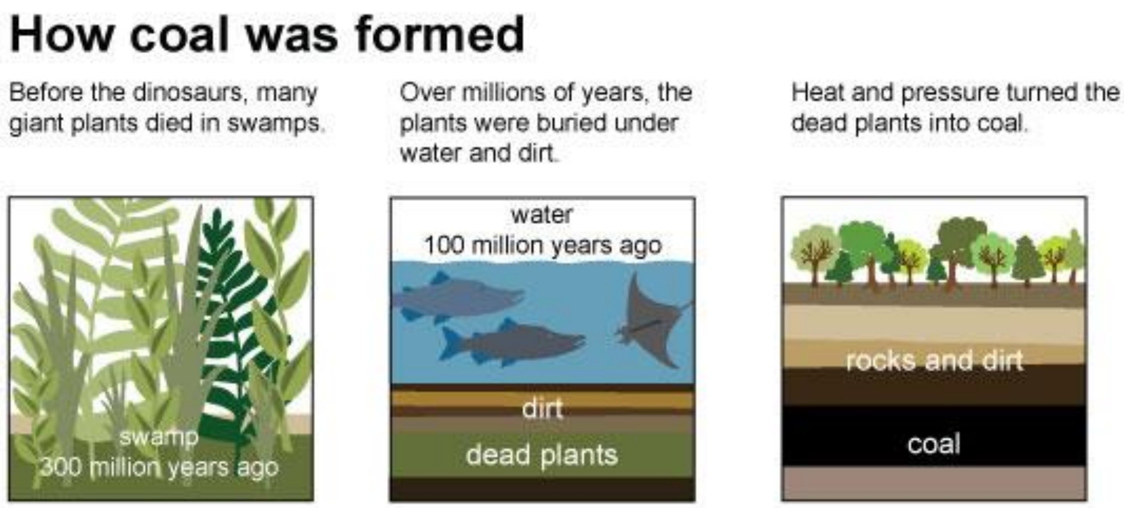
Hydraulic fracturing well.

Coal:

Coal was formed similarly to oil and natural gas, when plant matter was buried millions of years ago and transformed by pressure and heat. When coal is less than 200 feet underground, it is extracted by surface mining, also called strip mining. During surface mining, large machines move the land on top of the coal deposits. The other extraction method is underground mining, which is used when coal is far below the surface. In the U.S., underground mining is more expensive and less common than surface mining. Pennsylvania is the third-highest coal producing state in the U.S.

Like oil and natural gas, using coal as an energy source has several environmental impacts. Surface mining changes landscapes, destroys habitats, and pollutes waterways. Acid mine drainage from abandoned mines harms nearby streams and creeks. Burning coal releases greenhouse gases as well as other compounds and particulates that contribute to smog, acid rain, and respiratory illness.

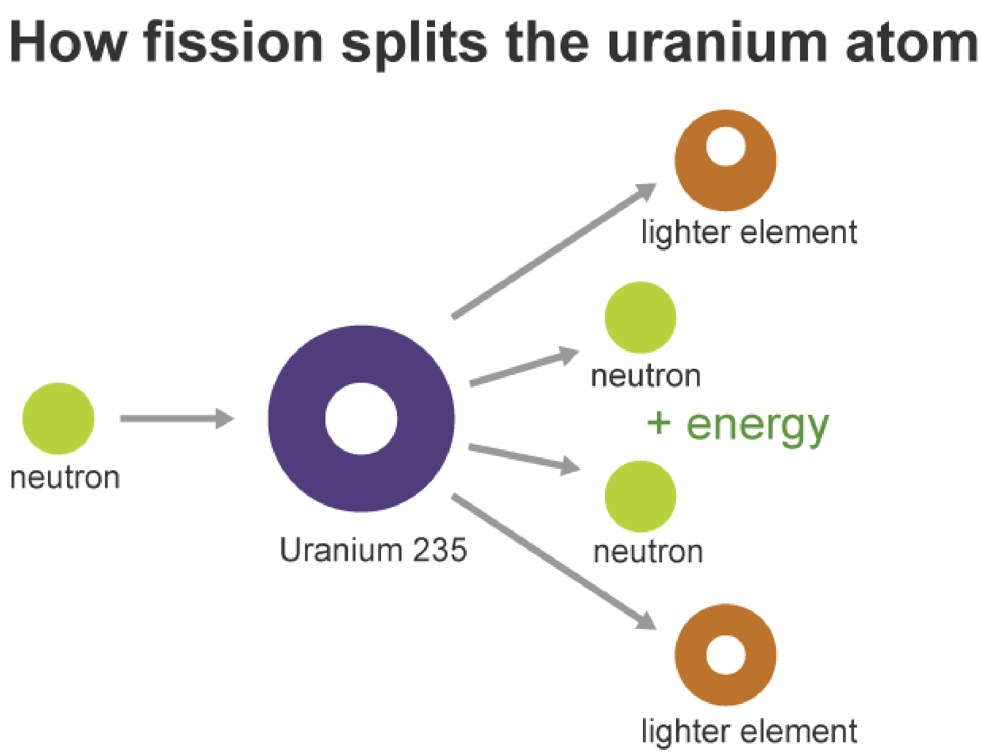
Acid mine drainage in a stream.



Source: Adapted from National Energy Education Development Project (public domain)

Nuclear:

Nuclear energy is not a fossil fuel source. Nuclear power plants use the element uranium to produce the energy we use. In a nuclear reaction, uranium *atoms* are split apart, releasing energy. The specific kind of uranium used by nuclear power plants is U-235, which is relatively rare. Rock containing uranium is mined in the western U.S. Uranium is then extracted from the rock and processed. In the U.S., nuclear power generates about 20% of our electricity.



Source: Adapted from National Energy Education Development Project (public domain)

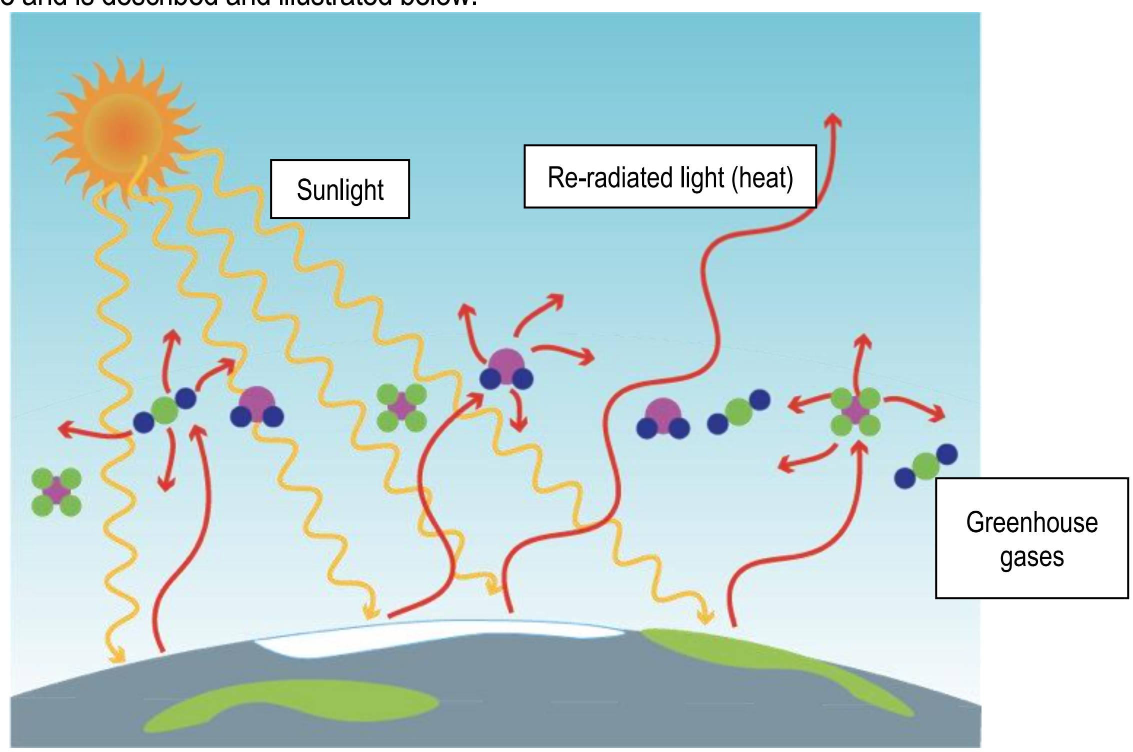
Nuclear reactions do not produce greenhouse gases like fossil fuels do; however, they do produce hazardous, radioactive waste. This nuclear waste must be stored in specially designed facilities for thousands of years. Critics of nuclear energy argue its risks outweigh its benefits. Nuclear accidents such as the 1986 Chernobyl disaster in Ukraine and the Three Mile Island partial meltdown in 1979 can release radioactive materials into the environment. In Chernobyl, forests and livestock died, waters were contaminated, and people suffered radiation poisoning and related diseases. These accidents are rare because nuclear power plants have complex technology and safety features to prevent harmful chemicals from escaping into the environment.

The Three Mile Island nuclear plant, shown above, is located on the Susquehanna River in Dauphin County. It shut down permanently in 2019.

The Greenhouse Effect

Fossil fuels are very useful energy sources but release *greenhouse gases* and other harmful particles into the atmosphere when burned. Fossil fuels are the largest source of *carbon dioxide* emissions in the U.S. and emissions are expected to increase as Earth's population grows and industry expands. In the U.S., pollutant emissions from power plants are regulated by the Clean Air Act.

So, why are these emissions a problem? Greenhouse gases like carbon dioxide (CO_2) and methane (CH_4) trap heat in the atmosphere, contributing to *global warming*. Between 1880 and 2012, the earth's climate warmed 1.53 °F, an increase due mainly to anthropogenic (human-caused) greenhouse gas emissions. The *greenhouse effect* is the process by which greenhouse gases trap heat in the atmosphere and is described and illustrated below.



Consider the picture above. First, energy from the sun passes through the atmosphere and reaches the Earth. Some of this sunlight is reflected off Earth's surface back into space. However, some of the sunlight is absorbed by Earth's surface and re-radiated into the atmosphere. When sunlight is absorbed by Earth and re-reradiated, it becomes heat. Unlike reflected light, heat can be absorbed and re-radiated by greenhouse gases in the atmosphere. Put simply, greenhouse gases trap heat in the atmosphere. This causes the atmosphere and the Earth to warm.

Without the greenhouse effect, Earth's average temperature would be around 0 °F (it is currently about 58 °F). While we need some greenhouse gases, increasing emissions due to human activity are resulting in unprecedented global warming. Global warming is one part of *climate change*, or shifts in long-term weather patterns. The effects of climate change are difficult to predict. It is likely that as Earth warms, sea levels will rise when glacier and ice caps melt, and precipitation and droughts will become more extreme.

Energy Innovations

LED (light-emitting diodes) light bulbs use electron movement to produce visible light. They are a better alternative to lighting than incandescent bulbs and can be used to save energy. Compared to incandescent bulbs, LEDs:

- Reveal colors more brightly
- Cost 80% less to operate
- Are cool to the touch
- Last 50 times longer

Electric vehicles (EVs) run on electricity, or a mix of electricity and gas. Battery electric vehicles use a rechargeable battery to store electric energy. This energy powers the motor. These vehicles can travel over 200 miles before recharging. Plug-in hybrid electric vehicles use a combination of an electric motor with a rechargeable battery, and an internal combustion engine. These vehicles can travel over 50 miles on electric power and up to 400 total miles before refueling.

Both types of EVs produce fewer emissions than gas-powered vehicles because EVs run on a rechargeable battery instead of burning fuel. In addition to the environmental benefits, there are other incentives to owning an EV. On average, EVs cost half as much to charge than to fill a gas-powered vehicle. Electric vehicle technology is advancing, and charging stations are getting faster and more common. Production and sales of EVs in the U.S. have increased over the past several years and are projected to continue increasing in the future.

Saving Energy

There are two components to reducing energy use: Energy Conservation and Energy Efficiency. *Energy conservation* is a behavior that results in the use of less energy. *Energy efficiency* is the use of technology that requires less energy to perform the same function.

Energy conservation tips:

- Turn off the lights when you leave a room
- Unplug electronics and machines when you are done using them
- Keep showers under 10 minutes
- Use cold water to do laundry
- Turn off the faucet when brushing your teeth
- Only do laundry and dishes when you have a full load

Energy efficiency tips:

- Purchase fuel-efficient vehicles
- Use energy-efficient appliances – the ENERGY STAR® label on appliances means the product is certified by the Environmental Protection Agency (EPA) as energy-efficient
- Use LED light bulbs
- Upgrade your HVAC system (this is your home's cooling and heating system)

**The below article is from the Department of Energy and can be found here: https://www.energy.gov/articles/history-electric-car.*

***Note: Students are responsible for understanding the history of electric vehicles. Students will not be tested on information about current numbers in the article as they are outdated.*

The History of the Electric Car

September 15, 2014
By: Rebecca Matulka

Introduced more than 100 years ago, electric cars are seeing a rise in popularity today for many of the same reasons they were first popular.

Whether it's a hybrid, plug-in hybrid or all-electric, the demand for electric drive vehicles will continue to climb as prices drop and consumers look for ways to save money at the pump. Currently more than 3 percent of new vehicle sales, electric vehicles sales could to grow to nearly 7 percent -- or 6.6 million per year -- worldwide by 2020, according to a report by Navigant Research.

With this growing interest in electric vehicles, we are taking a look at where this technology has been and where it's going. Travel back in time with us as we explore the history of the electric car.

The birth of the electric vehicle

It's hard to pinpoint the invention of the electric car to one inventor or country. Instead it was a series of breakthroughs -- from the battery to the electric motor -- in the 1800s that led to the first electric vehicle on the road.

In the early part of the century, innovators in Hungary, the Netherlands and the United States -- including a blacksmith from Vermont -- began toying with the concept of a battery-powered vehicle and created some of the first small-scale electric cars. And while Robert Anderson, a British inventor, developed the first crude electric carriage around this same time, it wasn't until the second half of the 19th century that French and English inventors built some of the first practical electric cars.

Here in the U.S., the first successful electric car made its debut around 1890 thanks to William Morrison, a chemist who lived in Des Moines, Iowa. His six-passenger vehicle capable of a top speed of 14 miles per hour was little more than an electrified wagon, but it helped spark interest in electric vehicles.

Over the next few years, electric vehicles from different automakers began popping up across the U.S. New York City even had a fleet of more than 60 electric taxis. By 1900, electric cars were at their heyday, accounting for around a third of all vehicles on the road. During the next 10 years, they continued to show strong sales.

The early rise and fall of the electric car
To understand the popularity of electric vehicles circa 1900, it is also important to understand the development of the personal vehicle and the other options available. At the turn of the 20th century, the horse was still the primary mode of transportation. But as Americans became more prosperous, they turned to the newly invented motor vehicle -- available in steam, gasoline or electric versions -- to get around.

Steam was a tried and true energy source, having proved reliable for powering factories and trains. Some of the first self-propelled vehicles in the late 1700s relied on steam; yet it took until the 1870s for the technology to take hold in cars. Part of this is because steam wasn't very practical for personal vehicles. Steam vehicles required long startup times -- sometimes up to 45 minutes in the cold -- and would need to be refilled with water, limiting their range.

As electric vehicles came onto the market, so did a new type of vehicle -- the gasoline-powered car -- thanks to improvements to the internal combustion engine in the 1800s. While gasoline cars had promise, they weren't without their faults. They required a lot of manual effort to drive -- changing gears was no easy task and they needed to be started with a hand crank, making them difficult for some to operate. They were also noisy, and their exhaust was unpleasant.

Electric cars didn't have any of the issues associated with steam or gasoline. They were quiet, easy to drive and didn't emit a smelly pollutant like the other cars of the time. Electric cars quickly became popular with urban residents -- especially women. They were perfect for short trips around the city, and poor road conditions outside cities meant few cars of any type could venture farther. As more people gained access to electricity in the 1910s, it became easier to charge electric cars, adding to their popularity with all walks of life (including some of the "best known and prominent makers of gasoline cars" as a 1911 *New York Times* article pointed out).

Many innovators at the time took note of the electric vehicle's high demand, exploring ways to improve the technology. For example, Ferdinand Porsche, founder of the sports car company by the same name, developed an electric car called the P1 in 1898. Around the same time, he created the world's first hybrid electric car -- a vehicle that is powered by electricity and a gas engine. Thomas Edison, one of the world's most prolific inventors, thought electric vehicles were the superior technology and worked to build a better electric vehicle battery. Even Henry Ford, who was friends with Edison, partnered with Edison to explore options for a low-cost electric car in 1914, according to *Wired*.

Yet, it was Henry Ford's mass-produced Model T that dealt a blow to the electric car. Introduced in 1908, the Model T made gasoline-powered cars widely available and affordable. By 1912, the gasoline car cost only $650, while an electric roadster sold for $1,750. That same year, Charles Kettering introduced the electric starter, eliminating the need for the hand crank and giving rise to more gasoline-powered vehicle sales.

Other developments also contributed to the decline of the electric vehicle. By the 1920s, the U.S. had a better system of roads connecting cities, and Americans wanted to get out and explore. With the discovery of Texas crude oil, gas became cheap and readily available for rural Americans, and filling stations began popping up across the country. In comparison, very few Americans outside of cities had electricity at that time. In the end, electric vehicles all but disappeared by 1935.

Gas shortages spark interest in electric vehicles

Over the next 30 years or so, electric vehicles entered a sort of dark ages with little advancement in the technology. Cheap, abundant gasoline and continued improvement in the internal combustion engine hampered demand for alternative fuel vehicles.

Fast forward to the late 1960s and early 1970s. Soaring oil prices and gasoline shortages -- peaking with the 1973 Arab Oil Embargo -- created a growing interest in lowering the U.S.'s dependence on foreign oil and finding homegrown sources of fuel. Congress took note and passed the Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976, authorizing the Energy Department to support research and development in electric and hybrid vehicles.

Around this same time, many big and small automakers began exploring options for alternative fuel vehicles, including electric cars. For example, General Motors developed a prototype for an urban electric car that it displayed at the Environmental Protection Agency's First Symposium on Low Pollution Power Systems Development in 1973, and the American Motor Company produced electric delivery jeeps that the United States Postal Service used in a 1975 test program. Even NASA helped raise the profile of the electric vehicle when its electric Lunar rover became the first manned vehicle to drive on the moon in 1971.

Yet, the vehicles developed and produced in the 1970s still suffered from drawbacks compared to gasoline-powered cars. Electric vehicles during this time had limited performance -- usually topping at speeds of 45 miles per hour -- and their typical range was limited to 40 miles before needing to be recharged.

Environmental concern drives electric vehicles forward

Fast forward again -- this time to the 1990s. In the 20 years since the long gas lines of the 1970s, interest in electric vehicles had mostly died down. But new federal and state regulations begin to change things. The passage of the 1990 Clean Air Act Amendment and the 1992 Energy Policy Act -- plus new transportation emissions regulations issued by the California Air Resources Board -- helped create a renewed interest in electric vehicles in the U.S.

During this time, automakers began modifying some of their popular vehicle models into electric vehicles. This meant that electric vehicles now achieved speeds and performance much closer to gasoline-powered vehicles, and many of them had a range of 60 miles.

One of the most well-known electric cars during this time was GM's EV1, a car that was heavily featured in the 2006 documentary *Who Killed the Electric Car?* Instead of modifying an existing vehicle, GM designed and developed the EV1 from the ground up. With a range of 80 miles and the ability to accelerate from 0 to 50 miles per hour in just seven seconds, the EV1 quickly gained a cult following. But because of high production costs, the EV1 was never commercially viable, and GM discontinued it in 2001.

With a booming economy, a growing middle class and low gas prices in the late 1990s, many consumers didn't worry about fuel-efficient vehicles. Even though there wasn't much public attention to electric vehicles at this time, behind the scenes, scientists and engineers -- supported by the Energy Department -- were working to improve electric vehicle technology, including batteries.

A new beginning for electric cars

While all the starts and stops of the electric vehicle industry in the second half of the 20th century helped show the world the promise of the technology, the true revival of the electric vehicle didn't happen until around the start of the 21st century. Depending on whom you ask, it was one of two events that sparked the interest we see today in electric vehicles.

The first turning point many have suggested was the introduction of the Toyota Prius. Released in Japan in 1997, the Prius became the world's first mass-produced hybrid electric vehicle. In 2000, the Prius was released worldwide, and it became an instant success with celebrities, helping to raise the profile of the car. To make the Prius a reality, Toyota used a nickel metal hydride battery -- a technology that was supported by the Energy Department's research. Since then, rising gasoline prices and growing concern about carbon pollution have helped make the Prius the best-selling hybrid worldwide during the past decade.

(Historical footnote: Before the Prius could be introduced in the U.S., Honda released the Insight hybrid in 1999, making it the first hybrid sold in the U.S. since the early 1900s.)

The other event that helped reshape electric vehicles was the announcement in 2006 that a small Silicon Valley startup, Tesla Motors, would start producing a luxury electric sports car that could go more than 200 miles on a single charge. In 2010, Tesla received at $465 million loan from the Department of Energy's Loan Programs Office -- a loan that Tesla repaid a full nine years early -- to establish a manufacturing facility in California. In the short time since then, Tesla has won wide acclaim for its cars and has become the largest auto industry employer in California.

Tesla's announcement and subsequent success spurred many big automakers to accelerate work on their own electric vehicles. In late 2010, the Chevy Volt and the Nissan LEAF were released in the U.S. market. The first commercially available plug-in hybrid, the Volt has a gasoline engine that supplements its electric drive once the battery is depleted, allowing consumers to drive on electric for most trips and gasoline to extend the vehicle's range. In comparison, the LEAF is an all-electric vehicle (often called a battery-electric vehicle, an electric vehicle or just an EV for short), meaning it is only powered by an electric motor.

Over the next few years, other automakers began rolling out electric vehicles in the U.S.; yet, consumers were still faced with one of the early problems of the electric vehicle -- where to charge their vehicles on the go. Through the Recovery Act, the Energy Department invested more than $115 million to help build a nation-wide charging infrastructure, installing more than 18,000 residential, commercial and public chargers across the country. Automakers and other private businesses also installed their own chargers at key locations in the U.S., bringing today's total of public electric vehicle chargers to more than 8,000 different locations with more than 20,000 charging outlets.

At the same time, new battery technology -- supported by the Energy Department's Vehicle Technologies Office -- began hitting the market, helping to improve a plug-in electric vehicle's range. In addition to the battery technology in nearly all of the first generation hybrids, the Department's research also helped develop the lithium-ion battery technology used in the Volt. More recently, the Department's investment in battery research and development has helped cut electric vehicle battery costs by 50 percent in the last four years, while simultaneously improving the vehicle batteries' performance (meaning their power, energy and durability). This in turn has helped lower the costs of electric vehicles, making them more affordable for consumers.

Consumers now have more choices than ever when it comes to buying an electric vehicle. Today, there are 23 plug-in electric and 36 hybrid models available in a variety of sizes -- from the two-passenger Smart ED to the midsized Ford C-Max Energi to the BMW i3 luxury SUV. As gasoline prices continue to rise and the prices on electric vehicles continue to drop, electric vehicles are gaining in popularity -- with more than 234,000 plug-in electric vehicles and 3.3 million hybrids on the road in the U.S. today.

The future of electric cars

It's hard to tell where the future will take electric vehicles, but it's clear they hold a lot of potential for creating a more sustainable future. If we transitioned all the light-duty vehicles in the U.S. to hybrids or plug-in electric vehicles using our current technology mix, we could reduce our dependence on foreign oil by 30-60 percent, while lowering the carbon pollution from the transportation sector by as much as 20 percent.

To help reach these emissions savings, in 2012 President Obama launched the EV Everywhere Grand Challenge -- an Energy Department initiative that brings together America's best and brightest scientists, engineers and businesses to make plug-in electric vehicles more as affordable as today's gasoline-powered vehicles by 2022. On the battery front, the Department's Joint Center for Energy Storage Research at Argonne National Laboratory is working to overcome the biggest scientific and technical barriers that prevent large-scale improvements of batteries.

And the Department's Advanced Research Projects Agency-Energy (ARPA-E) is advancing game-changing technologies that could alter how we think of electric vehicles. From investing in new types of batteries that could go further on a single charge to cost-effective alternatives to materials critical to electric motors, ARPA-E's projects could transform electric vehicles.

In the end, only time will tell what road electric vehicles will take in the future.

What's the Difference?

- A hybrid electric vehicle (or HEV for short) is a vehicle without the capacity to plug in but has an electric drive system and battery. It's driving energy comes only from liquid fuel.
- A plug-in hybrid electric vehicle (also called a PHEV) is a vehicle with plug-in capability, and it can use energy for driving from either its battery or liquid fuel.
- An all-electric vehicle (often called a battery-electric vehicle, an electric vehicle, or an EV or AEV for short) is a vehicle that gets its energy for driving entirely from its battery and it must be plugged in to be recharged.
- A plug-in electric vehicle (or PEV) is any vehicle that can be plugged in (either a plug-in hybrid or an all-electric vehicle).

Additional Learning

The following sources contain the information above and may be helpful learning resources. Students are only responsible for content in this packet and will not be tested on external material.

1. https://www.publicpower.org/public-power/electricity-basics
2. https://www.epa.gov/energy
3. https://grist.org/climate-energy/how-do-we-use-electricity/
4. https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php
5. https://www.alliantenergykids.com/
6. https://www.eia.gov/kids/index.php
7. https://www.weforum.org/agenda/2022/04/visualizing-the-history-of-energy-transitions/
8. https://education.nationalgeographic.org/resource/nuclear-energy/
9. https://climatekids.nasa.gov/greenhouse-effect/
10. https://education.nationalgeographic.org/resource/greenhouse-effect/