Current Issues
5th-8th Grade Study Packet

Alternative Energy

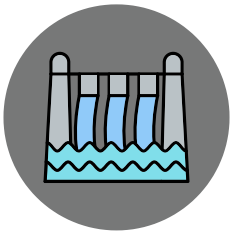
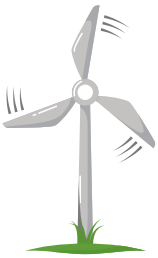
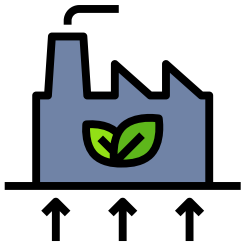
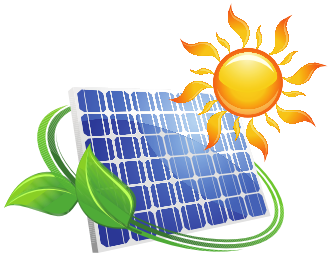
Envirothon 2023

- What is Energy?
- Energy Sources
- Non-Renewable Energy
- Renewable Energy
- Using and Saving Energy
- Electric Vehicles
- Vocabulary

For more info, check out these websites:

www.eia.gov/kids

www.alliantenergykids.com


York County ENVIROTHON

What is Energy?

Energy is the ability to do work

When people use electricity in their homes, the electrical power is probably generated by burning coal or natural gas, by a nuclear reaction, or by a hydroelectric plant on a river, to name just a few sources. When people fill up a car's gasoline tank, the energy source is petroleum (gasoline) refined from crude oil and may include fuel ethanol made by growing and processing corn. Coal, natural gas, nuclear, hydropower, petroleum, and ethanol are called energy sources.

Physical units are measures of distances, areas, volumes, heights, weights, mass, force, and energy. We use different physical units to measure different types of energy or fuels:

- Barrels or gallons for liquid petroleum fuels (such as gasoline, diesel fuel, and jet fuel) and biofuels (ethanol and biodiesel)
- Cubic feet for natural gas
- Tons for coal (a short ton equals 2,000 pounds; a metric ton equals about 2,205 pounds)
- Kilowatt hours for electricity

How do we compare different types of fuels? One practical way is to convert the physical units of fuels, such as weight or volume, into British thermal units or "Btu." A Btu is a precise measure of the heat content of fuels which is the most common unit for comparing energy sources or fuels.

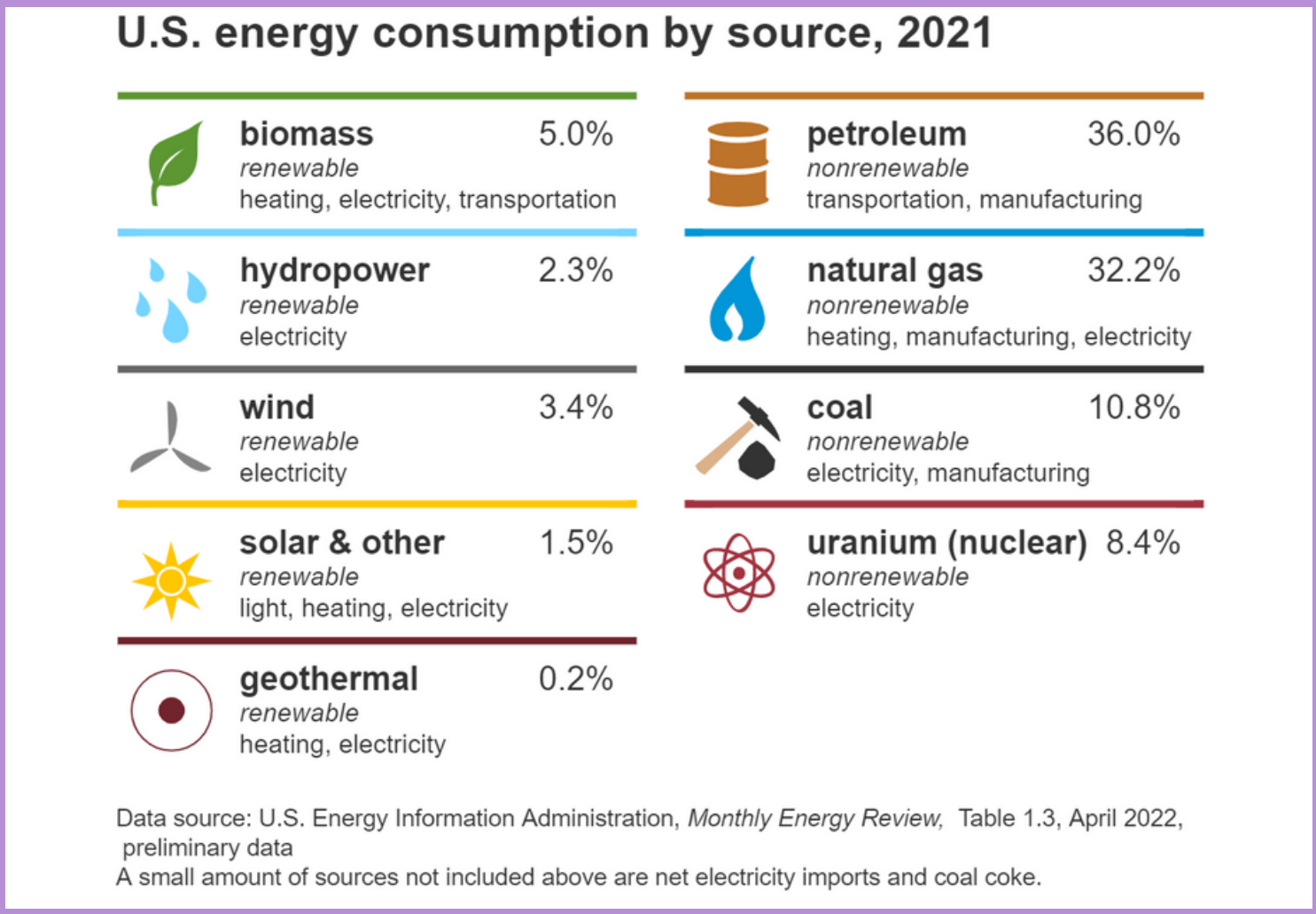
Btu content of common energy units (preliminary estimates for 2021):

- 1 barrel (42 gallons) of crude oil produced in the United States = 5,691,000 Btu
- 1 gallon of finished motor gasoline (containing about 10% fuel ethanol by volume) = 120,238 Btu
- 1 gallon of diesel fuel or heating oil (with sulfur content less than 15 parts per million) = 137,381 Btu
- 1 gallon of heating oil (with sulfur content at 15 to 500 parts per million) = 138,500 Btu
- 1 barrel of residual fuel oil = 6,287,000 Btu
- 1 cubic foot of natural gas = 1,039 Btu
- 1 gallon of propane = 91,452 Btu
- 1 short ton (2,000 pounds) of coal (consumed by the electric power sector) = 18,934,000 Btu
- 1 kilowatthour of electricity = 3,412 Btu

Energy Sources

Energy sources are divided into two groups: Renewable (an energy source that can be easily replenished) and Nonrenewable (an energy source that cannot be easily replenished). Renewable and nonrenewable energy sources can be used as primary energy sources to produce useful energy such as heat or used to produce secondary energy sources such as electricity.

Renewable	Non-Renewable
Biomass	**Oil (petroleum)**
Hydropower	**Natural Gas**
Wind	**Coal**
Solar	**Uranium (nuclear)**
Geothermal	



Non-Renewable Energy Sources

Nonrenewable energy sources come out of the ground as liquids, gases, and solids. There are 4 major non-renewable energy sources:

1. **Oil (petroleum),**
2. **Natural Gas,**
3. **Coal, and**
4. **Uranium (nuclear)**

Oil

The United States is one of the largest crude oil producing countries. Of the 100 countries producing crude oil, the United States was the top crude oil producing country in 2018, 2019, and 2020.

U.S. crude oil is produced in 32 U.S. states and in U.S. coastal waters. In 2021, about 71% of total U.S. crude oil production came from five states: Texas, New Mexico, North Dakota, Alaska, and Colorado.

Oil & the environment: Hydraulic fracturing, or fracking, is a way to produce oil from shale and other tight underground rock layers. Fracking has helped the United States to increase oil production and reduce oil imports a lot in recent years. However, this method has effects on the environment. Fracturing rock uses large amounts of water and may use chemicals that could be harmful to humans and animals. Faulty well construction and improper handling may result in leaks and spills of fracking liquids. In some areas of the country, large amounts of water used for oil production may affect the availability of water for other uses, including for the plants and animals that live in and close to nearby rivers and streams.

Hydraulic fracturing may also produce large amounts of wastewater from fracked wells that contains harmful compounds. Because treating the wastewater can be difficult and expensive, in some places it is pumped (injected) deep underground. Unfortunately, this disposal method may cause earthquakes that are large enough to damage buildings.

Natural Gas

In 2021, U.S. natural gas exports reached a record high, and the United States was a net exporter of natural gas for the fifth year in a row. Five of the 34 natural gas producing states accounted for about 69% of total U.S. dry natural gas production in 2020.

The top five natural gas-producing states and their percentage shares of total U.S. natural gas production in 2020 were: Texas 23.9%, Pennsylvania 21.1%, Louisiana 9.5%, Oklahoma 7.6%, West Virginia 7.1%.

Natural Gas & the environment: The U.S. Environmental Protection Agency estimates that in 2019, methane emissions from natural gas and petroleum systems and from abandoned oil and natural gas wells were the source of about 29% of total U.S. methane emissions and about 3% of total U.S. greenhouse gas emissions (based on carbon-dioxide equivalent). Because a natural gas leak could cause an explosion, there are strict government regulations and industry standards to ensure the safe transportation, storage, distribution, and use of natural gas. Because processed natural gas has no odor, natural gas companies add a strong, rotten egg-like smelling substance called mercaptan to natural gas so that people can smell leaks. Also, hydraulic fracturing is being used to recover natural gas. See above for the effects "fracking" has on the environment.

Non-Renewable Energy Sources

Coal

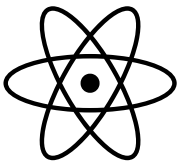
Coal is classified into four main types, or ranks: anthracite, bituminous, subbituminous, and lignite. The ranking depends on the types and amounts of carbon the coal contains and on the amount of heat energy the coal can produce.

1. **anthracite: contains 86-97% carbon, highest heating value, accounts for less than 1% of coal mined in US and it is ALL mined in northeastern PA.**
2. **bituminous: most abundant rank found in US**
3. **subbituminous: mostly produced in Wyoming**
4. **lignite: lowest energy content and mostly used to generate electricity.**

Five states accounted for about 71% of total US coal production in 2020: Wyoming, West Virginia, Pennsylvania, Illinois, and North Dakota.

Coal & the environment: Surface mining (also called strip mining) and mountain top removal changes the landscape and sometimes cover streams with rock and dirt. The water draining from these may contain pollutants that can harm aquatic wildlife. Underground mines affect the landscape less that surface mines but the ground above the mine can collapse and acidic water can drain from abandoned underground mines. Methane gas is also an issue. In 2020, methane emissions from coal mining and abandoned cool mines accounted for about 7% of the total US methane emissions and about 1% of total US greenhouse gas emissions.

Uranium/Nuclear



Nuclear power plants use a certain kind of uranium, referred to as U-235, for fuel because its atoms are easily split apart. Although uranium is about 100 times more common than silver, U-235 is relatively rare.

Country	Nuclear electricity generation capacity (million kilowatts)	Nuclear electricity generation (billion kilowatthours)	Nuclear share of country's total electricity generation
United States	98.12	809.41	19%
France	63.13	382.40	70%
China	45.52	330.12	5%
Russia	28.37	195.54	18%
South Korea	23.09	138.81	25%

Source: U.S. Energy Information Administration, International Energy Statistics, as of March 24, 2021

Top five nuclear electricity generation countries in 2019

In the US, as of December 31, 2020, 94 nuclear reactors were operating at 56 nuclear power plants in 28 states. 35 of the plants have two or more reactors. Nuclear power has supplied about one-fifth of total annual U.S. electricity since 1990.

Nuclear Power & the environment: An uncontrolled nuclear reaction in a nuclear reactor could result in widespread contamination of air and water. The risk of this happening at nuclear power plants in the United States is small. Unlike fossil fuel-fired power plants, nuclear reactors do not produce air pollution or carbon dioxide while operating. However, the processes for mining and refining uranium ore and making reactor fuel all require large amounts of energy. A major environmental concern for nuclear power is the creation of radioactive wastes which can remain dangerous to human health for thousands of years.

Renewable Energy Sources

Renewable energy sources include biomass (which includes biofuels), hydropower, geothermal, wind, and solar. In 2021, about 12% of U.S energy consumption was from renewable energy. Most renewable energy use is for producing electricity.

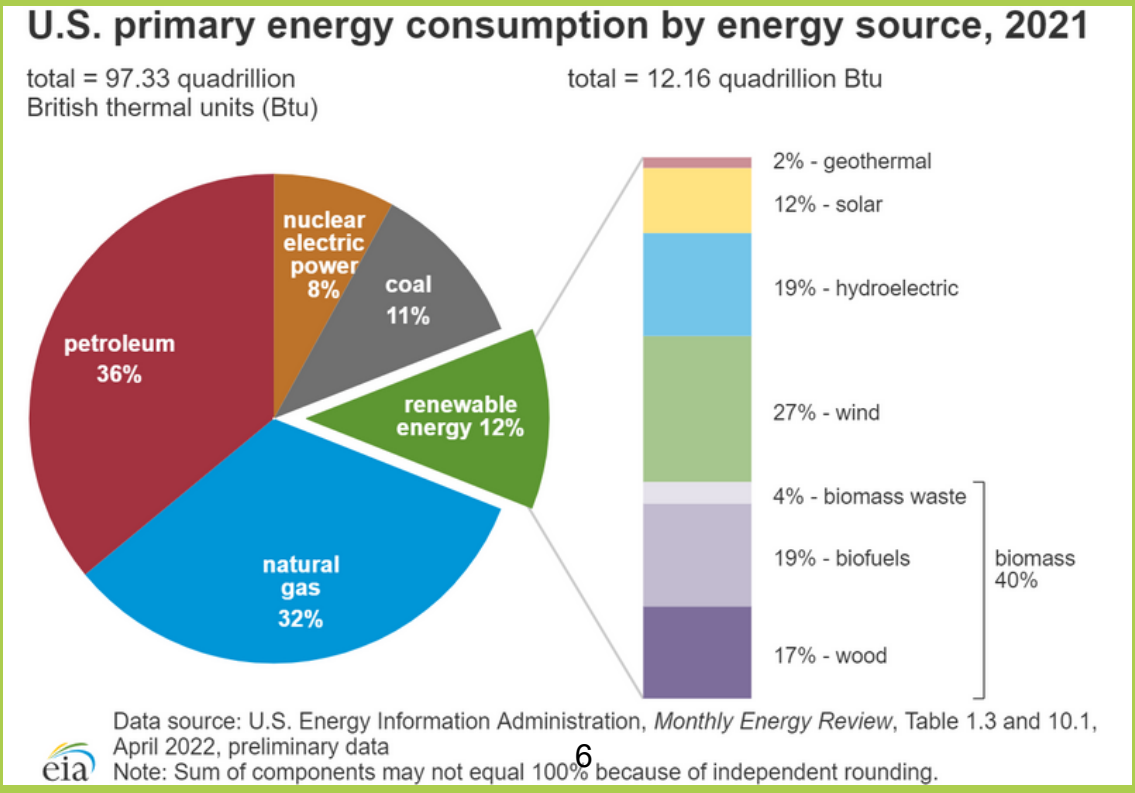
What is renewable energy? Renewable energy is energy from sources that are naturally replenishing but flow-limited; renewable resources are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. The major types of renewable energy sources are:

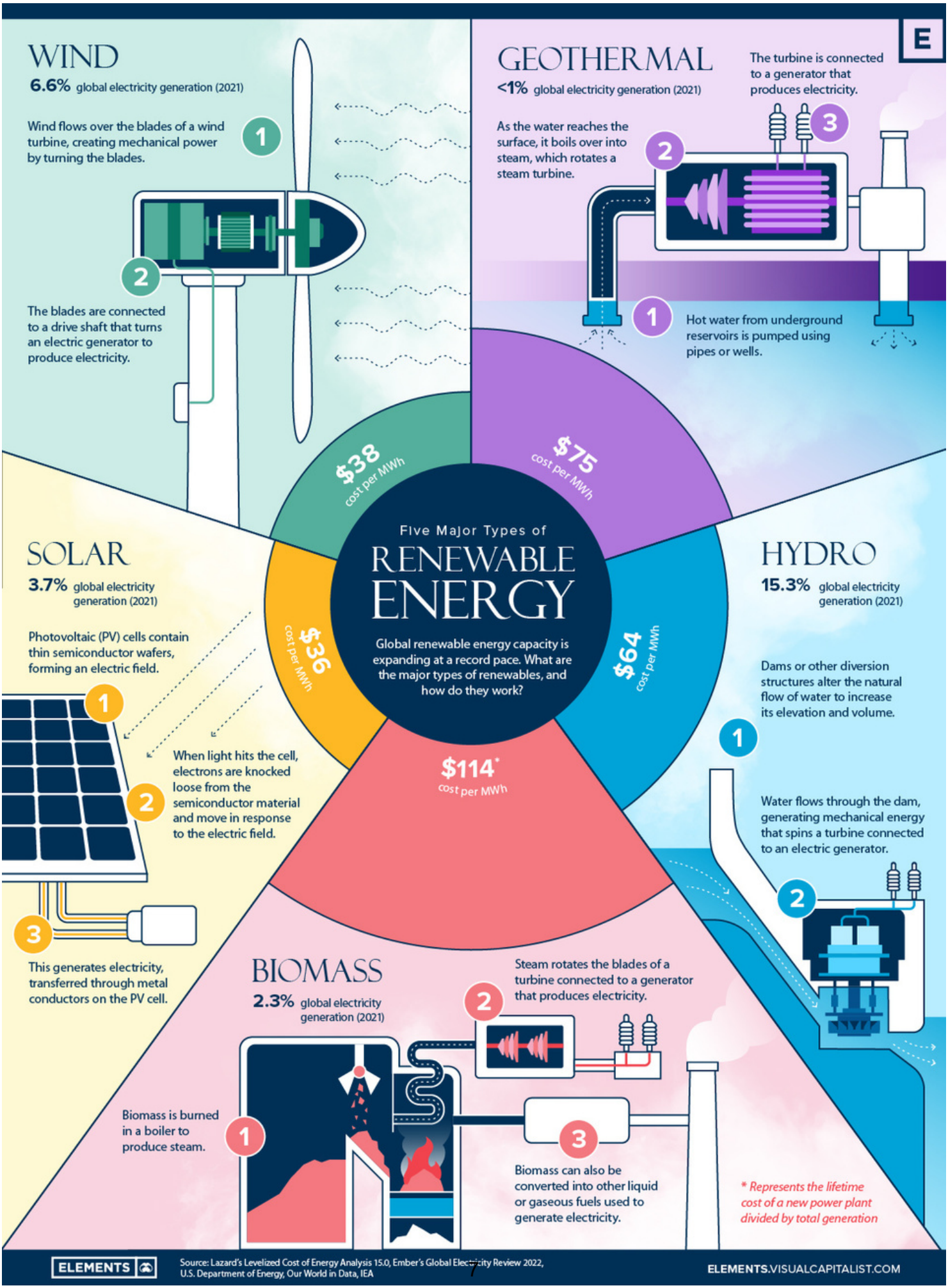
Biofuels
Hydropower
Geothermal
Wind
Solar

What role does renewable energy play in the United States?
Until the mid-1800s, wood was the source of nearly all of the nation's energy needs for heating, cooking, and lighting. From the late 1800's until today, fossil fuels—coal, petroleum, and natural gas—have been the major sources of energy. Hydropower and solid biomass were the most used renewable energy resources until the 1990s. Since then, the amounts and the percentage shares of total U.S. energy consumption from biofuels, geothermal energy, solar energy, and wind energy increased. Total U.S. renewable energy production and consumption reached record highs in 2021.

In 2021, renewable energy provided about 12.16 quadrillion British thermal units (Btu)—1 quadrillion is the number 1 followed by 15 zeros—equal to 12% of total U.S. energy consumption. The electric power sector accounted for about 59% of total U.S. renewable energy consumption in 2021, and about 20% of total U.S. electricity generation was from renewable energy sources.

Renewable energy can play an important role in reducing greenhouse gas emissions. Using renewable energy can reduce the use of fossil fuels, which are the largest sources of U.S. carbon dioxide emissions. In the Annual Energy Outlook 2022 Reference case, the U.S. Energy Information Administration (EIA) projects that U.S. renewable energy consumption will continue to increase through 2050.

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Five Major Types of
RENEWABLE ENERGY
Global renewable energy capacity is expanding at a record pace. What are the major types of renewables, and how do they work?
WIND
6.6% global electricity generation (2021)
1 Wind flows over the blades of a wind turbine, creating mechanical power by turning the blades.
2 The blades are connected to a drive shaft that turns an electric generator to produce electricity.
$38 cost per MWh
GEOTHERMAL
<1% global electricity generation (2021)
1 Hot water from underground reservoirs is pumped using pipes or wells.
2 As the water reaches the surface, it boils over into steam, which rotates a steam turbine.
3 The turbine is connected to a generator that produces electricity.
$75 cost per MWh
HYDRO
15.3% global electricity generation (2021)
1 Dams or other diversion structures alter the natural flow of water to increase its elevation and volume.
2 Water flows through the dam, generating mechanical energy that spins a turbine connected to an electric generator.
$64 cost per MWh
BIOMASS
2.3% global electricity generation (2021)
1 Biomass is burned in a boiler to produce steam.
2 Steam rotates the blades of a turbine connected to a generator that produces electricity.
3 Biomass can also be converted into other liquid or gaseous fuels used to generate electricity.
$114* cost per MWh
SOLAR
3.7% global electricity generation (2021)
1 Photovoltaic (PV) cells contain thin semiconductor wafers, forming an electric field.
2 When light hits the cell, electrons are knocked loose from the semiconductor material and move in response to the electric field.
3 This generates electricity, transferred through metal conductors on the PV cell.
$36 cost per MWh
* Represents the lifetime cost of a new power plant divided by total generation
ELEMENTS
Source: Lazard's Levelized Cost of Energy Analysis 15.0, Ember's Global Electricity Review 2022, U.S. Department of Energy, Our World in Data, IEA
ELEMENTS.VISUALCAPITALIST.COM

Renewable Energy Sources

Biofuels

The term biofuels usually applies to liquid fuels and blending components produced from biomass materials called feedstocks. Using biofuels can reduce the need to import crude oil from other countries to make fuels for cars, trucks, trains, and planes. Biofuels are also cleaner-burning fuels and are considered to have lower carbon-dioxide emissions than fuels made from fossil fuels. For these reasons, the U.S. federal government and state governments have encouraged the production and use of biofuels for many years with various laws and financial incentives such as the federal Renewable Fuel Standard Program. There are 4 major categories of biofuels that qualify for use in the federal Renewable Fuel Standard Program. They are Ethanol, Biodiesel, renewable diesel, and "other" biofuels.

Ethanol: Ethanol is a clear, colorless alcohol that can be made from a variety of biomass materials called feedstocks (the raw materials used to make a product). Ethanol feedstocks include grains and crops with high starch and sugar content such as corn, sorghum, barley, sugar cane, and sugar beets. Ethanol can also be made from feedstocks with a high cellulose content including grasses such as switchgrass, trees, and agricultural and forestry residues. Most motor gasoline now sold in the US is about 10% fuel ethanol by volume.

Biodiesel: Biodiesel and renewable diesel are mostly produced for use in diesel engines, but they can also be used as heating fuels. Vegetable oils (mainly soybean oil) are the main feedstocks for U.S. biodiesel production. Other major U.S. biodiesel feedstocks include animal fats from meat processing plants and used/recycled cooking oil and yellow grease from restaurants.

Renewable diesel: Renewable diesel is a biomass-based diesel fuel similar to biodiesel, but with important differences. Renewable diesel is a hydrocarbon that is chemically equivalent to petroleum diesel and can be transported in petroleum pipelines and sold at retail stations with or without blending with petroleum diesel. It can be produced from cellulosic biomass materials such as crop residues, wood and sawdust, and switchgrass.

Biofuels and the environment: Production and use of biofuels is considered by the U.S. government to have fewer or lower negative effects on the environment compared to fossil-fuel derived fuels. There are also potential national economic and security benefits when biofuel use reduces the need to import petroleum fuels. Pure ethanol and biodiesel are nontoxic and biodegradable, and if spilled, they break down into harmless substances. However, fuel ethanol contains denaturants to make fuel ethanol undrinkable. Similar to petroleum fuels, biofuels are flammable (especially ethanol) and must be transported carefully.

Geothermal

Geothermal energy is heat within the earth. The word geothermal comes from the Greek words geo (earth) and therme (heat). Geothermal energy is a renewable energy source because heat is continuously produced inside the earth. People use geothermal heat for bathing, to heat buildings, and to generate electricity.

Most of the geothermal power plants in the United States are in western states and Hawaii, where geothermal energy resources are close to the earth's surface. California generates the most electricity from geothermal energy. The Geysers dry steam reservoir in Northern California is the largest known dry steam field in the world and has been producing electricity since 1960.

Geothermal, cont.

There are three main types of geothermal energy systems:

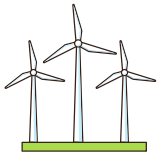
- Direct use and district heating systems
- Electricity generation power plants
- Geothermal heat pumps

Direct Use and District Heating systems
Direct use and district heating systems use hot water from springs or reservoirs located near the surface of the earth. Uses include: It is used to heat buildings through district heating systems. Hot water near the earth's surface is piped directly into buildings for heat. A district heating system provides heat for most of the buildings in Reykjavik, Iceland.

Electricity generation
Geothermal electricity generation requires water or steam at high temperatures (300° to 700°F). The United States leads the world in the amount of electricity generated with geothermal energy (16 billion kilowatt hours (kWh), but only 0.4% of total U.S. utility-scale electricity generation) but Kenya had the largest percentage share of its total annual electricity generation from geothermal energy at about 46% (5 billion kWh).

Heat pumps
Geothermal heat pumps use the constant temperatures near the surface of the earth to heat and cool buildings. Geothermal heat pumps transfer heat from the ground (or water) into buildings during the winter and reverse the process in the summer. According to the U.S. Environmental Protection Agency (EPA), geothermal heat pumps are the most energy-efficient, environmentally clean, and cost-effective systems for heating and cooling buildings. All types of buildings, including homes, office buildings, schools, and hospitals, can use geothermal heat pumps.

Geothermal energy and the environment
The environmental effects of geothermal energy depend on how geothermal energy is used or how it is converted to useful energy. Direct use applications and geothermal heat pumps have a very small effect on the environment. In fact, they may reduce the use of energy sources that may have larger effects on the environment.



Wind

Wind turbines use blades to collect the wind's kinetic energy. Wind flows over the blades creating lift (similar to the effect on airplane wings), which causes the blades to turn. The blades are connected to a drive shaft that turns an electric generator, which produces the electricity.

In 2021, 42 states had utility-scale wind power projects. The five states with the most electricity generation from wind in 2021 were

- Texas
- Iowa
- Oklahoma
- Kansas
- Illinois.

These states combined produced about 56% of total US wind electricity generation in 2021.
There are two basic types of wind turbines:

Horizontal-axis turbines have blades like airplane propellers, and they commonly have three blades. The largest horizontal-axis turbines are as tall as 20-story buildings and have blades more than 100 feet long. Taller turbines with longer blades generate more electricity. Nearly all of the wind turbines currently in use are horizontal-axis turbines.

Vertical-axis turbines look like egg beaters and have blades that are attached to the top and the bottom of a vertical rotor. Some versions of the vertical-axis turbine are 100 feet tall and 50 feet wide. Very few vertical-axis wind turbines are in use today because they do not perform as well as horizontal-axis turbines.

Renewable Energy Sources

Wind and the environment

Wind is a renewable energy source. Overall, using wind to produce energy has fewer effects on the environment than many other energy sources. Wind turbines do not release emissions that can pollute the air or water (with rare exceptions), and they do not require water for cooling. Wind turbines may also reduce the amount of electricity generation from fossil fuels, which results in lower total air pollution and carbon dioxide emissions. The main environmental concerns are visual, sound, and bat/bird deaths.

Hydropower

Did you know? The Safe Harbor Dam on the Susquehanna River in Pennsylvania has elevators that lift migrating shad from the base of the dam to the top of the reservoir.

Hydropower was one of the first sources of energy used for electricity generation and is usually the largest single renewable energy source of annual electricity generation in the United States. In 2021, hydroelectricity accounted for about 6.3% of total U.S. utility-scale electricity generation and 31.5% of total utility-scale renewable electricity generation. There are hydropower facilities in nearly every state. Most hydroelectricity is produced at large dams built by the federal government, and many of the largest hydropower dams are in the western United States.

Hydropower and the environment

Hydropower generators do not directly emit air pollutants. However, dams, reservoirs, and the operation of hydroelectric generators can affect the environment A dam that creates a reservoir may obstruct fish migration. A dam and reservoir can also change natural water temperatures, water chemistry, river flow characteristics, and silt loads.

Solar

We use solar thermal energy systems to heat:

- Water for use in homes, buildings, or swimming pools
- The inside of homes, greenhouses, and other buildings
- Fluids to high temperatures in solar thermal power plants

Solar Photovoltaic (PV) systems convert sunlight into electricity. Depending on the number of PV cells, they can power small electronic devices, produce enough electricity for an entire house, or enough electricity for thousands of homes.

There are Utility-scale PV power plants and small-scale PV systems, sometimes called rooftop PV systems. Utility-scale power plants have at least 1,000 kilowatts (or one megawatt) of electricity generating capacity. Small-scale PV systems are systems that have less than one megawatt of electricity generation capacity.

Solar power and the environment

Solar energy systems/power plants do not produce air pollution, water pollution, or greenhouse gases. Using solar energy can have a positive, indirect effect on the environment when solar energy replaces or reduces the use of other energy sources that have larger effects on the environment. Some toxic materials and chemicals are used to make the photovoltaic (PV) cells that convert sunlight into electricity. As with any type of power plant, large solar power plants can affect the environment near their locations. Clearing land for construction and the placement of the power plant may have long-term effects on the habitats of native plants and animals.

Using & Saving Energy

Efficiency and Conservation are different but related. The terms energy efficiency and energy conservation have distinct meanings:

Energy efficiency is using technology that requires less energy to perform the same function. Energy conservation is any behavior that results in the use of less energy. Below are some ways to be efficient and conserve.

Energy Conservation Tips for at home:

1. Turn off the lights
2. Limit showers to 10 min
3. Avoid wasting water by turning off the faucet
4. **Unplug electronic devices and chargers to avoid "Phantom Energy"**
5. Close the blinds/curtains during hot summer days to block the sun. During the winter, keep them open
6. Don't leave the fridge door open
7. Dress appropriately for the weather inside and outside
8. Wash clothes in cold water

Energy Efficiency Tips for at home:

1. Use Halogen incandescent bulbs, compact fluorescent lights (CFLs), and light-emitting diode (LED) light bulbs
2. Use a programmable thermostat
3. Use energy efficient appliances
4. Install energy efficient windows
5. Upgrade your HVAC system

Try this!

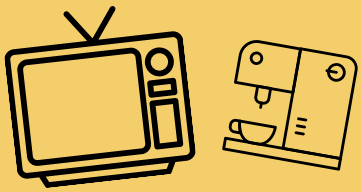
Find out how efficient the shower heads and faucets are in your home. Take a 5-gallon bucket and hold it under a shower head. Time how long it takes to fill up. Once you get the time, divide it by five, and this will tell you the gallon per minute (GPM) rating of the showerhead or faucet. If it's above 2.5 GPM, you could easily save water, energy and money by switching out to a more efficient model.

The ENERGY STAR® label on appliances and electronic equipment identifies energy-efficient products.

Phantom Energy

Phantom energy is the energy that is being used when devices are plugged in, but not in use or even on.

Your TV's phantom power usage can make up to 10% of it's total power usage! So unplug that cell phone and laptop charger when not using them. Maybe even the coffee pot too!



Electric Vehicles (EVs)

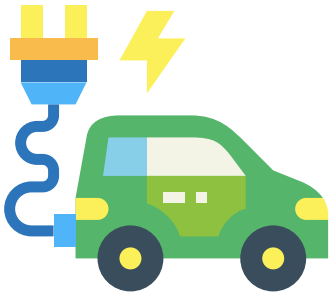
Cars can be powered by gasoline, electricity, or both!

There are two types of electric vehicles (EVs)

1. **Battery-Electric Vehicle (BEV):**
   - Uses a battery to store electric energy that powers the motor
   - Charges battery by plugging into an electric power source
   - Can travel more than 200 miles on one charge
2. **Plug-in hybrid electric vehicle**
   - Powered by an internal combustion engine and electric motor that uses energy from an on-board battery
   - Plugs into electric power source to charge on-board battery
   - Can travel over 50 miles in all-electric mode and up to 400 total miles before refueling

What's next for EVs?

- Longer distances
- Quicker charge times
- More places to charge
- More options and lower prices



EVs convert much more of their output into forward motion. On average, at 80-plus percent mechanical efficiency, they are all more than twice as efficient as even the most efficient gasoline car.

Still, there are differences. Electric vehicles vary widely in terms of their size, weight, aerodynamics, battery technology, motor configurations, and control systems. And just because an electric vehicle has a lot of range doesn't necessarily mean it's more efficient. When looking for the most efficient electric vehicles on sale today, we looked at overall efficiency: how much energy each vehicle uses for every mile it drives. As our benchmark, we used the EPA's MPGe (miles per gallon equivalent) measure. How is a vehicle's MPGe determined? The EPA uses a formula to calculate the precise amount of electric energy that's equal to the energy in one gallon of gasoline. Once that amount of energy is determined, the vehicle's consumption of energy per distance can be used to calculate its MPGe. According to the EPA, here are the five most efficient electric cars you can buy:

1. Tesla Model 3- 132 MPGe
2. Lucid Air- 131 MPGe
3. Tesla Model Y- 122 MPGe
4. Hyundai Kona Electric- 120 MPGe
5. Tesla Model S- 120 MPGe

Fun facts about EVs

<u>EVs are better for the environment</u>
Since electric vehicles can run on a rechargeable battery, they produce fewer emissions.

<u>EVs are high performance and low maintenance</u>
Vehicles powered by electricity are quiet and fast. They don't need to rev up an engine to get speed – they respond as soon as the driver hits the pedal. And EVs come with the latest in gadgets and digital perks, like an app to control the charging status.

<u>EVs can charge at home</u>
Driving an EV means you can charge your car at home. (No more freezing at the gas pump during the winter.) And, on average, it costs half as much to charge an electric vehicle than it does to fuel up a gas-powered vehicle.

Vocabulary

Biomass	Renewable energy from wood, manure, garbage and agricultural waste
British Thermal Unit (BTU)	A precise measure of the heat content of fuels
Electric Vehicle (EV)	A vehicle that uses one or more electric motors for propulsion
Energy	The ability to do work
Fossil Fuel	Remains of plant and animal life that are used to provide energy in the form of coal, oil, and natural gas
Geothermal Energy	A renewable source of steam and hot water produced inside the earth to heat buildings or to generate electricity
Greenhouse Gas	Gases that trap the heat of the sun in the earth's atmosphere
Hydropower	Energy produced from flowing water
Non-renewable Fuel	A fuel that is not capable of being naturally restored or replenished
Nuclear Energy	Energy that is produced from the splitting of atoms (fission)
Phantom Energy	The energy that is being used when devices are plugged in, but not in use or on
Solar Power	The use of the sun's energy to produce electricity or heat
Wind Power	Taking the breezes and winds and converting it into energy