- These slides contain animations, when the PowerPoint file is played
- The content gradually appears with clicks
- Questions appear before their answers

Chemistry and Living in the Desert

Sun

- What we do and don't want from it
- Energy from the sun (fossil fuels vs renewables)
- Light/matter interactions
- Infrared, heat, greenhouse effect
- Ultraviolet, sunburn, sunscreen, oxygen, ozone layer

Energy from the Sun

- Many things that we do require energy!

We use electricity to power many machines and processes

Like what?

Lighting, TV, devices, heating, cooling, power tools, cooking, cleaning (vacuum, dishwasher, clothes washer)

What is the other (not electricity) major method that we use to power things? Give examples.

Burning fuels! Cooking, heating. Big one – transportation.

Energy from the Sun

Burning fuels vs using electricity

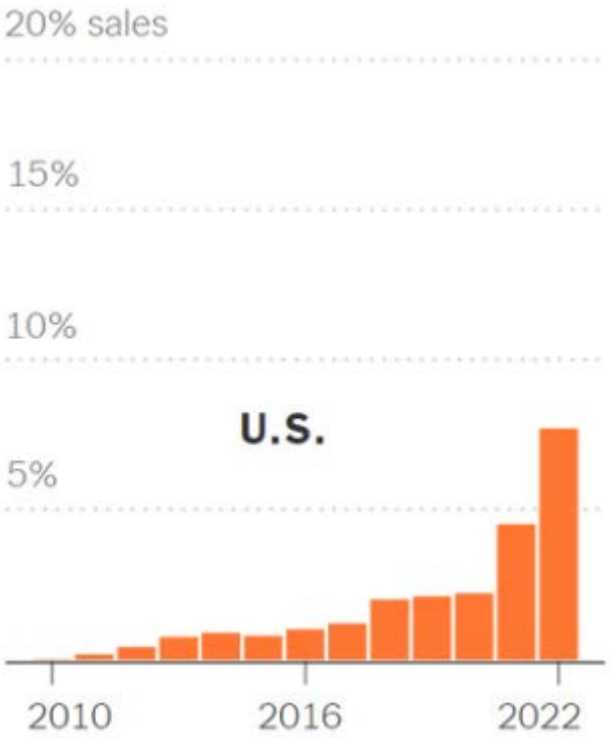
- For some types of transportation, fuel burning engines are apparently the only way to go

Examples?

- Cars? – Not anymore! The last 10 years or so has seen the widespread adoption and use of electric cars
- Aircraft – We are yet to see practical human-carrying electric aircraft

Energy from the Sun

Electric Cars - electric models as percentage of total passenger vehicle sales



New York Times 10-19-2023

Energy from the Sun

Electric Airplanes? - they are certainly being investigated

DHL to add Eviation's electric cargo planes to its fleet

Joann Muller, author of Axios What's Next

DHL Express's electric cargo plane. Image: Courtesy of DHL Express

Energy from the Sun

Transport

Why do we need to use fuel burning engines rather than electricity for making an airplane fly?

- It is all about the energy that can be stored for a given mass
- We can have quite powerful electric devices in the home, which is fine when you can have effectively unlimited energy by plugging it into a wall socket
- But there is presently no competition between the amount of energy that can be carried by a given mass of gasoline or aviation fuel vs batteries (much, much less)! This extra energy is absolutely necessary in some cases, like for airplanes.

Energy Content

In mega joules (M/J) per kilogram

- Hydrogen 142
- Methane 55
- Gasoline 46
- Diesel 48
- Ethanol 26
- Wood 16

Lead acid battery? 0.17

Lithium ion battery? 0.4-0.9

Importantly, a large fraction of the mass of the chemical reactants (O_2 from the air) doesn't have to be carried by fuel-burning vehicles

- Uranium 80,620,000
- Antimatter-matter annihilation 89,876,000,000

https://en.wikipedia.org/wiki/Energy_density

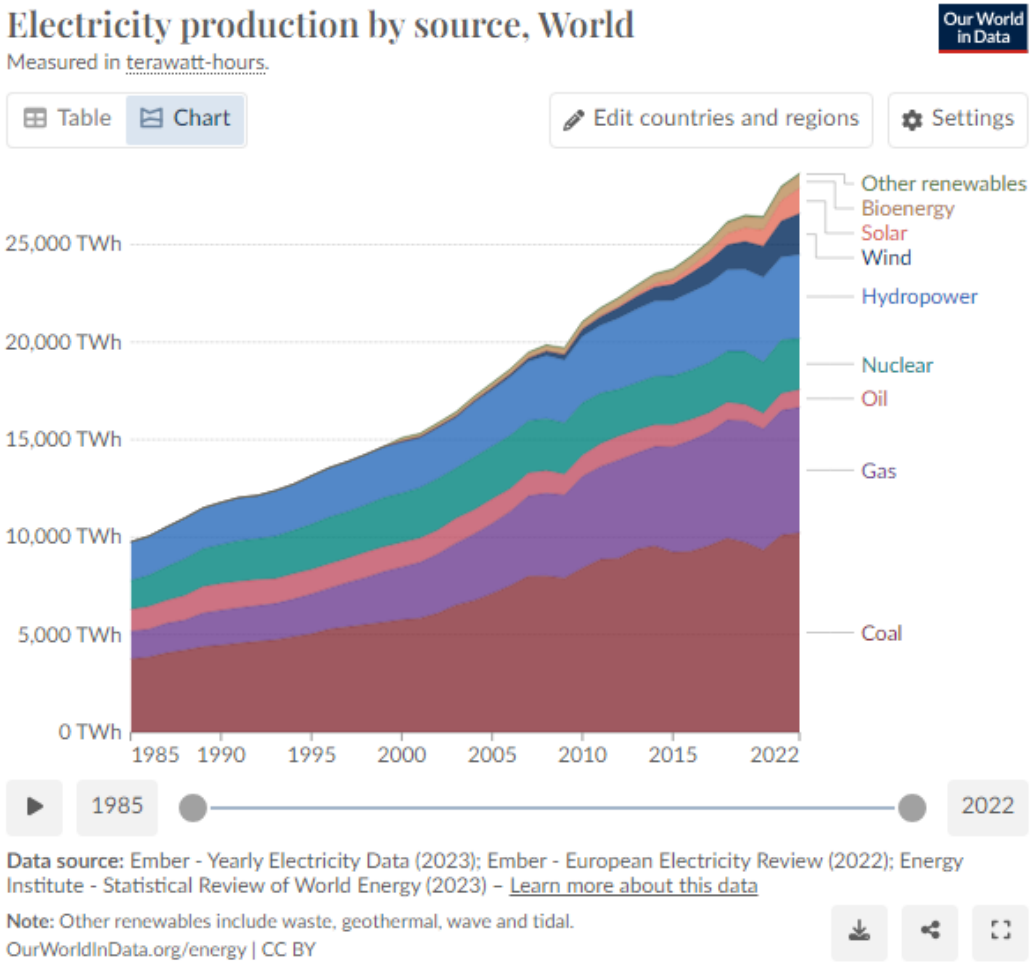
Energy from the Sun

- So, our energy needs are met by using electricity or burning fuels

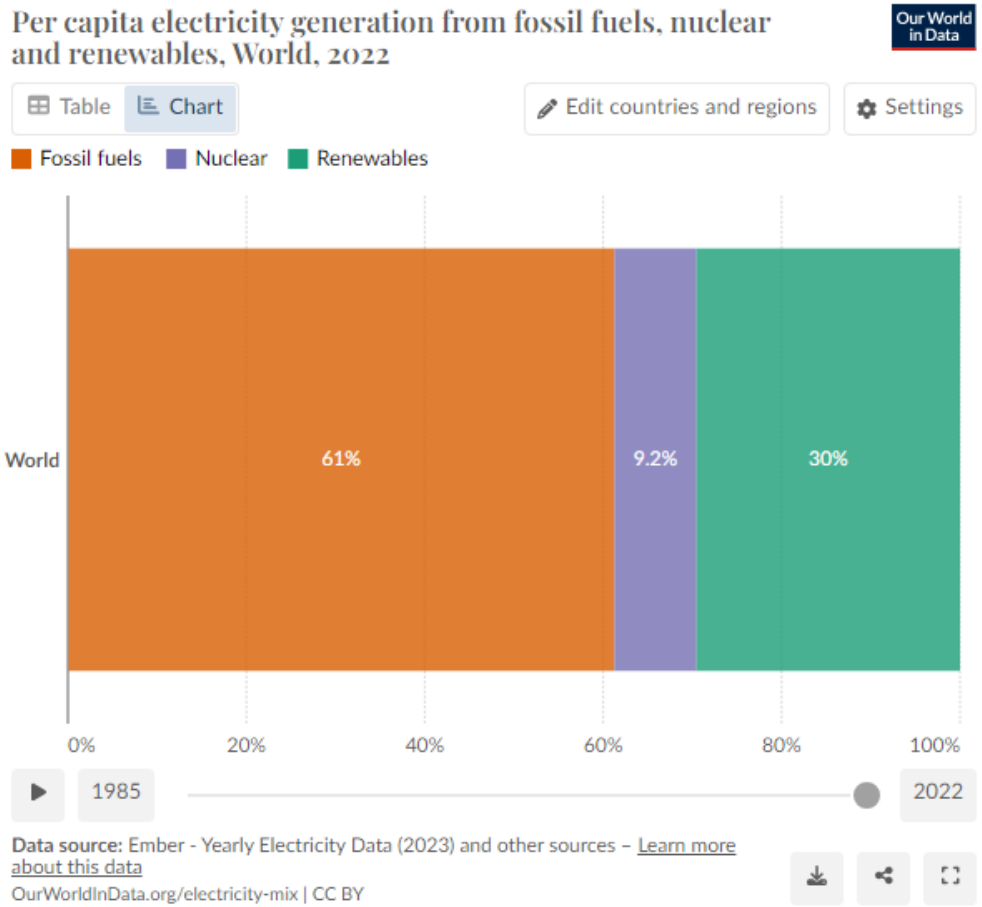
Hang on – Where does the electricity come from?

Mostly from burning fuels!:

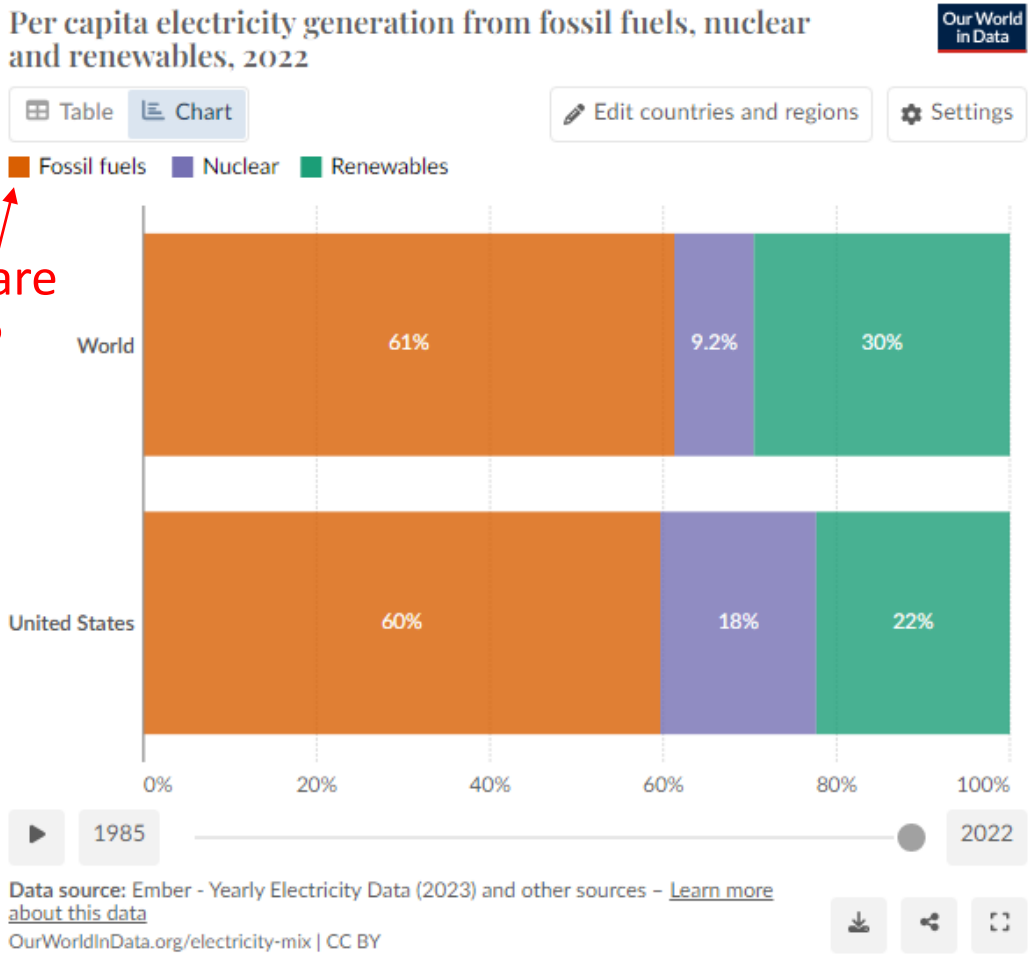
Energy from the Sun



Energy from the Sun



Energy from the Sun



What are those?

Energy from the Sun

Fossil Fuels

What are those?

Oil
Natural Gas
Coal

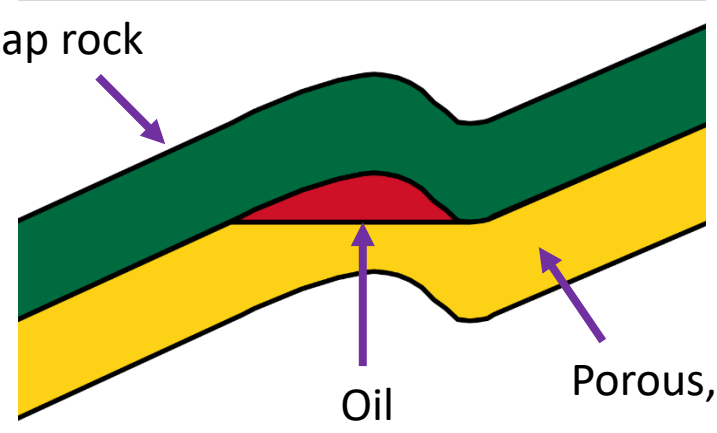
Why are they called fossil fuels? Where did they come from?

- "Fossil" because they were formed hundreds of millions of years ago

Oil

aka Petroleum

- Primarily hydrocarbons
- Formed from zooplankton and algae
  - The material collected underwater in a low oxygen environment, protected from aerobic biodegradation and oxidation
  - Buried, compressed and heated over time to form oil



Natural Gas

- Primarily methane
- Small amounts of other low molecular weight hydrocarbons
- Sometimes small percentages of
  carbon dioxide, nitrogen, hydrogen sulfide, and helium
- Clean burning (compared to coal)

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

Natural Gas

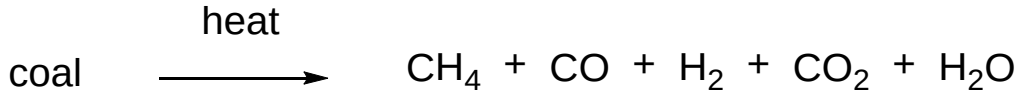
Fossil Fuels -

- Solid – Coal
- Liquid – Petroleum
- Gas - Natural gas Why is it called “natural” gas?

- Before the industrial scale production of natural gas, people used “town gas” = “coal gas” = “man-made gas”(?)

Coal Gas

- This is produced by heating coal with water in a closed environment and collecting the gases that are produced.



- This had various problems including the highly toxic nature of CO (carbon monoxide).

- The residue from the process has uses such as asphalt.

Natural Gas

A cleaner burning fuel than coal

A less complex mixture than coal Why?

Because it is a gas its composition is limited to components that are gases at room temperature and pressure

Methane (CH_4), Ethane (C_2H_6), Propane (C_3H_8)

Major component

Smaller amounts of:

- Carbon dioxide (CO_2)
- Nitrogen (N_2)
- Hydrogen sulfide (H_2S)
- Helium (He)

“Door to Hell” Turkmenistan – Burning (natural gas) since 1971

https://en.wikipedia.org/wiki/Darvaza_gas_crater

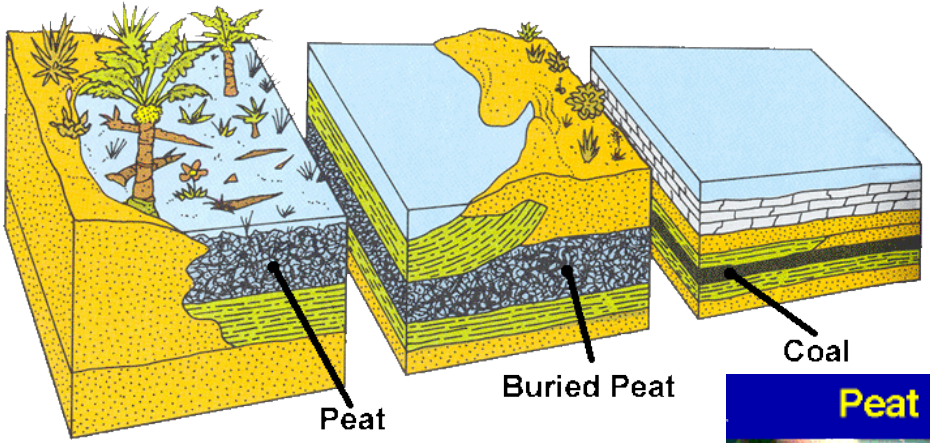
Coal

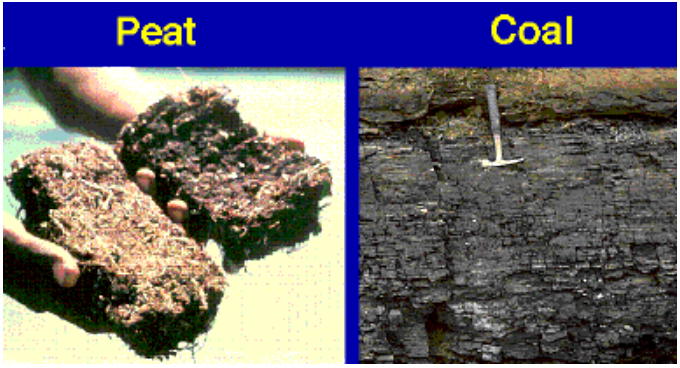
Coal

- Primarily carbon
- Variable amounts of hydrogen, sulfur, oxygen, and nitrogen (mostly present as compounds rather than pure elements)

- Formed from trees
  - The forest material was buried underneath soil and protected from biodegradation and oxidation
  - Compressed and heated over time

Coal





- Most coal is hundreds of millions of years old

Energy from the Sun

Fossil Fuels

Oil
Natural Gas
Coal

- They all come from plant or animal material that lived hundreds of millions of years ago.
- The energy to make them came from the sun! (photosynthesis to make the plants)

Energy from the Sun

Bio related energy sources

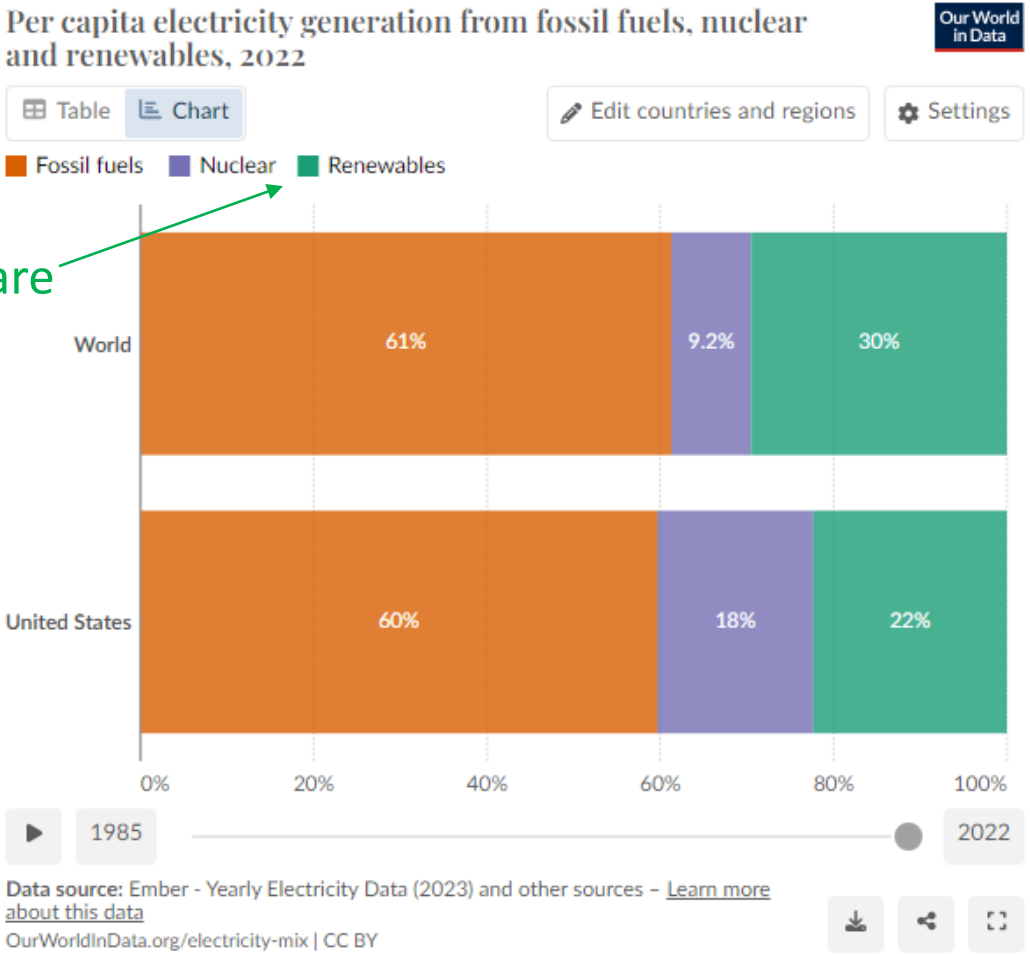
Photosynthesis

- All the energy stored in plant and animal material came from sunlight!
- Animals eat plants – plants get the energy to grow from photosynthesis:

$$6\,CO_2 + 6\,H_2O \xrightarrow{\text{Light energy}} C_6H_{12}O_6 + 6\,O_2$$

glucose

Energy from the Sun



What are those?

Energy from the Sun

Renewable Electricity Sources

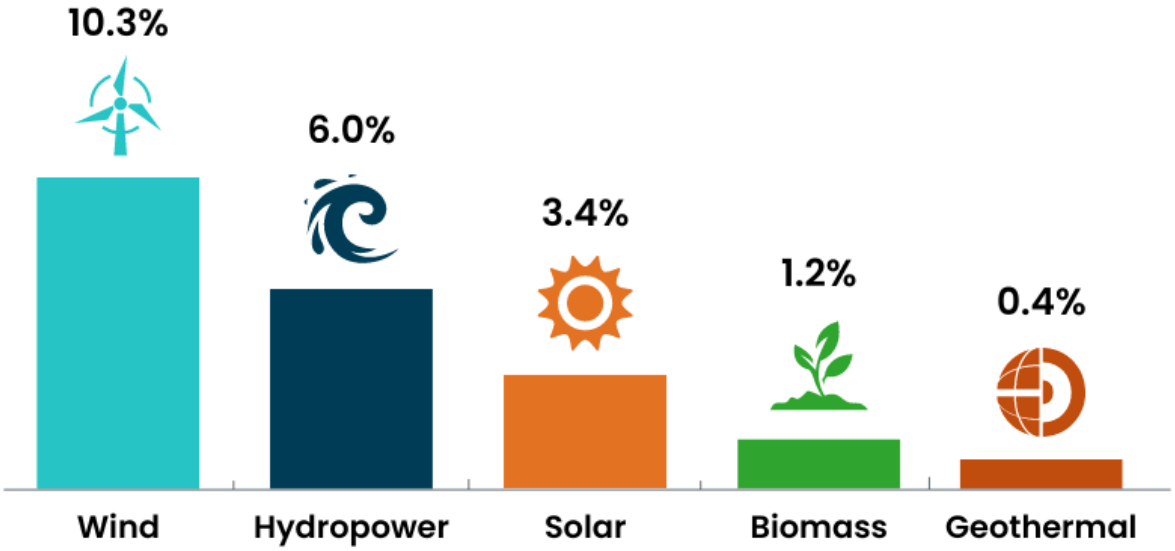
What does that mean?

Renewable	Non-Renewable
Solar	"Fossil Fuels"
Wind	Coal
Hydroelectric	Natural Gas
Biofuels	Oil
ethanol	
biodiesel	

Energy from the Sun

Renewable Energy in the United States

Renewable energy generates **over 20% of all U.S. electricity**, and that percentage continues to grow. The following graphic breaks down the shares of total electricity production in 2022 among the types of renewable power:



https://www.energy.gov/eere/renewable-energy

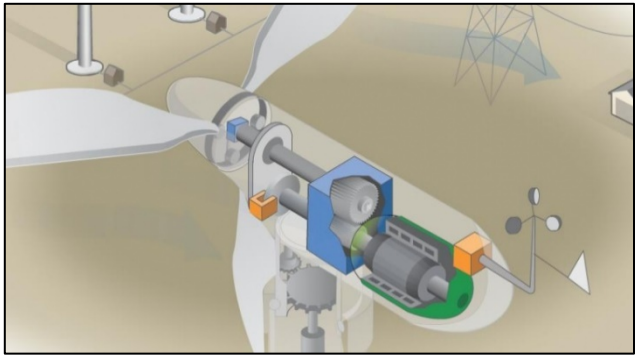
Solar Energy Generation

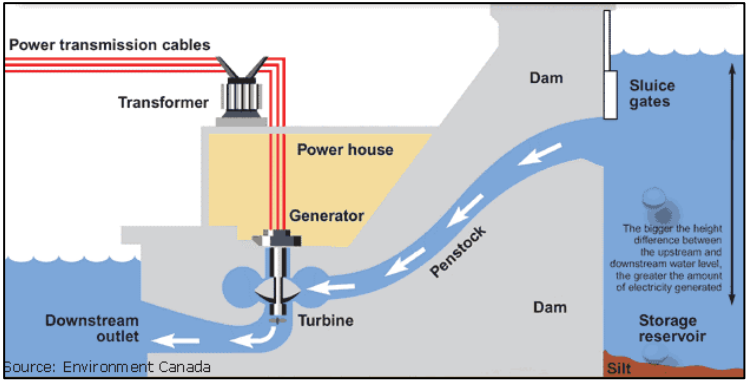
Direct use of energy from the sun

What is going on in this one?

Electrical Energy Generation

- Steam (from burning fuels), wind (air), or water all are used to rotate a turbine-type apparatus to spin a generator.





- Wind – Comes from the sun heating the earth's surface unevenly, leading to air movement
- Water power – Water is raised to a higher gravitational potential energy by evaporating and precipitating - powered by the sun

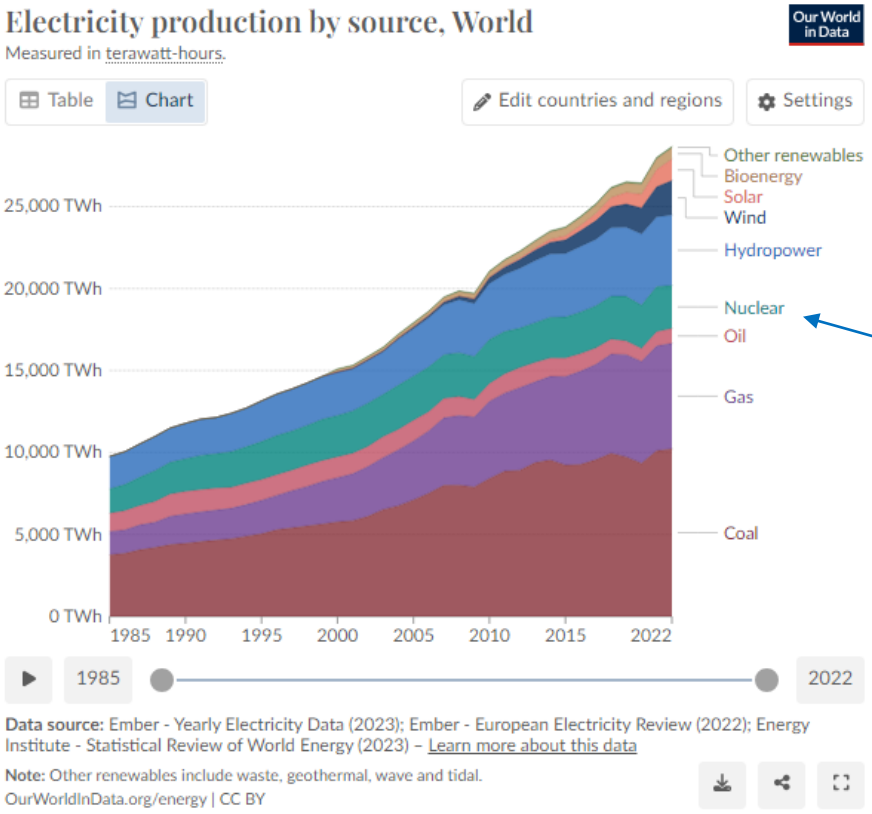
Energy from the Sun

Electricity Sources

Renewable	Non-Renewable
Solar	"Fossil Fuels"
Wind	Coal
Hydroelectric	Natural Gas
Biofuels	Oil
ethanol	
biodiesel	

All of the energy here ultimately came from the sun!

Energy from the Sun



Nuclear

Only nuclear power did not come from the sun!