

ENERGY



ENERGY UNITS

- **Energy: The ability to do work (make something happen)**

- Joule (J)
- Calorie (cal)
 - The calories on food packages are really kcal
- Electron Volt (eV)
- British Thermal Unit (btu)
- Kilowatt hours (kW·h)

1 cal	4.184 J
1 eV	1.620×10^{-19} J
1 btu	1055 J
1 kW·h	3.600×10^6 J

- Your body gets 8,000 J (1,900 cal = 1.9 kcal) of energy from eating a peanut.
- 60 J of energy are need per second to keep a 60 W appliance running.
- 1 gallon of gas produces 1.32×10^8 J of energy or enough energy to keep a 60 W appliance running for 25 days.

WORK

- Work (J)
- Work is always a change in energy. How much energy it took to do _____.



POWER

- Power ($\text{watt}(\frac{J}{s})$ energy per time)

- Mechanical Power

- $P = F \times v$

- F = Force (weight $F = mg$ $g = 9.8 \frac{m}{s^2}$)

- v = velocity

- Electrical Power

- $P = I \times V$

- I = current

- V = voltage

Appliance	Power
T.V.	120 W
Computer and Monitor	270 W
Washing Machine	425 W
Refrigerator	725 W
Dishwasher	1,800 W
Dryer	3,400 W

- The hoover dam on average produces 4.5×10^4 W per hour.

TYPES OF ENERGY

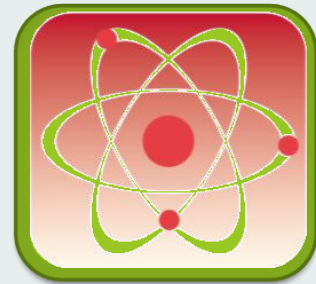
Potential

- Gravitational
- Stored Mechanical
- Chemical
- Nuclear
- Electrical
- Sound



Kinetic

- Motion
- Electrical
- Radiant
- Thermal
- Sound



GRAVITATIONAL POTENTIAL ENERGY

- Energy from position.
- $E = mgh$
 - $g = 9.8 \frac{m}{s^2}$
 - h=height
 - m=mass
- Examples of gravitational energy:



MOTION

KINETIC ENERGY

- Energy from motion.
- $E = \frac{1}{2}mv^2$
 - m=mass
 - V=velocity
- Examples of motion energy:



ENERGY TRANSFER

- Law of conservation of energy
 - Energy cannot be created or destroyed

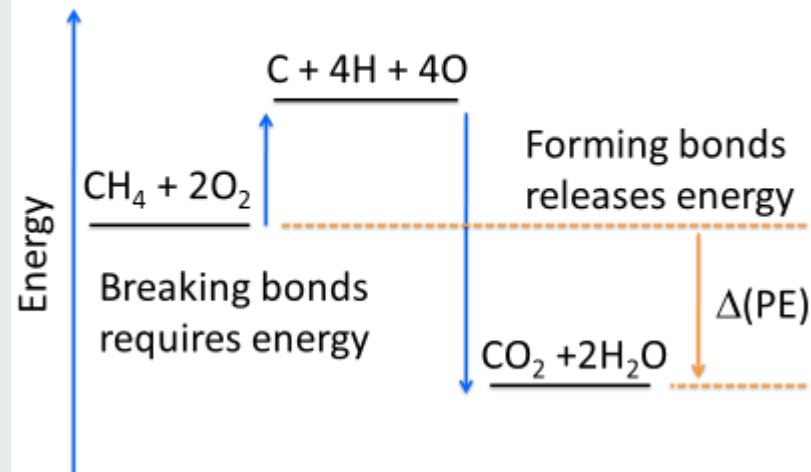


CHEMICAL POTENTIAL ENERGY

- Energy that can be released if a chemical reaction occurs.
- Combustion
 - $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$ $\Delta H = -10,941 \frac{kJ}{mol}$
- Examples of chemical energy:



Combustion of methane



STORED MECHANICAL POTENTIAL ENERGY

- Energy stored in object by tension.

- Spring

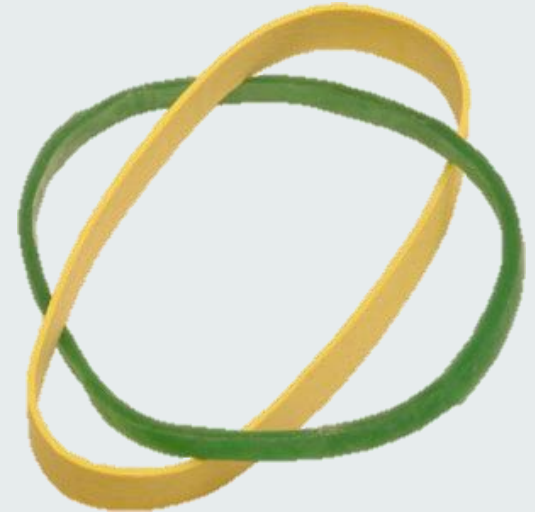
- $E = \frac{1}{2}kx^2$

- K = spring constant

- x = distance from at rest position

- Stretched rubber band

- Examples of stored mechanical energy:



NUCLEAR POTENTIAL ENERGY

- The energy stored inside the nucleus of an atom.

- $pm_p + nm_n \neq m_{nucl}$
- $E = mc^2$
 - m = mass
 - c = speed of light $3.00 \times 10^8 \frac{m}{s}$

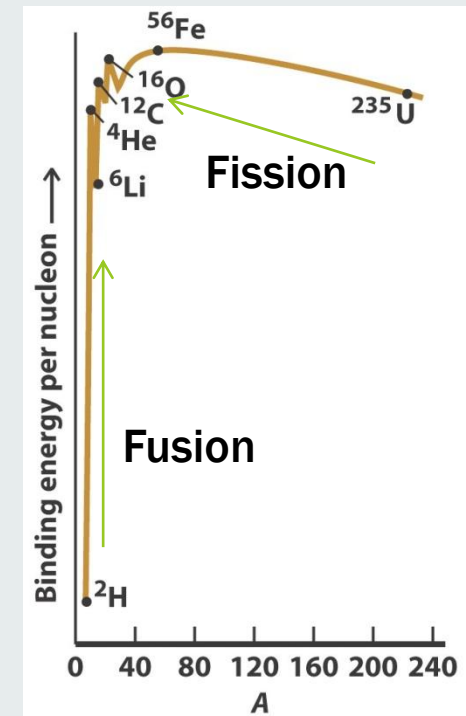
- Examples of nuclear energy

- Fission (Breaking atoms apart)

- ${}_{92}^{235}\text{U} + {}_0^1n \rightarrow {}_{56}^{141}\text{Ba} + {}_{36}^{92}\text{Kr} + 3{}_0^1n$
 - releases 3.5×10^{-11} J per reaction (2.1×10^{13} J per mole)
 - Fission is what happens in nuclear reactors. Although pollutant are produced, radio active waste is left over.

- Fusion (Joining atoms together)

- $6\text{D} \rightarrow 2{}^4\text{He} + 2\text{p} + 2\text{n}$
 - releases 3×10^8 kJ per each gram D
 - These are the type of reactions that go on in the sun.
 - In order to get fusion to happen on earth we need to be at high temperatures (10^8 K)



ELECTRICAL

POTENTIAL OR KINETIC ENERGY

■ Potential

- The energy associated with the attractive force between 2 oppositely charged particles

- $E = \frac{1}{4\pi\epsilon^{\circ}} \frac{q_1 q_2}{r_{12}}$

- ϵ° = vacuum permittivity $8.85 \times 10^{-12} \frac{C^2}{J \cdot m}$
- q = charge
- r = separation

■ Kinetic

- The energy generated from the flow of electrical charge (electrons)

- $E = VIt$

- V = voltage
- I = current
- t = time

■ Examples of electrical energy:



RADIANT KINETIC ENERGY

■ The energy in electromagnetic waves.

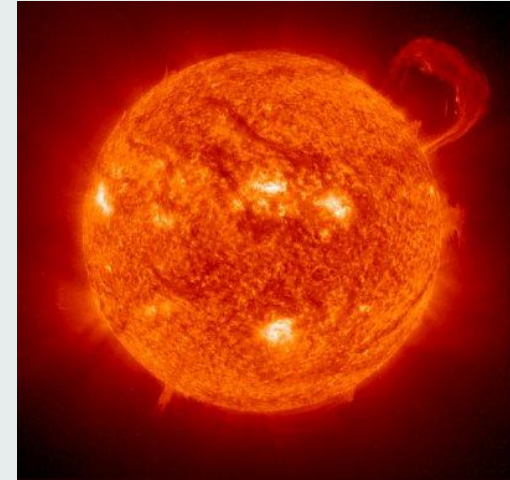
■ $E = h\nu$

■ h plank's constant 6.626×10^{-34} J·s

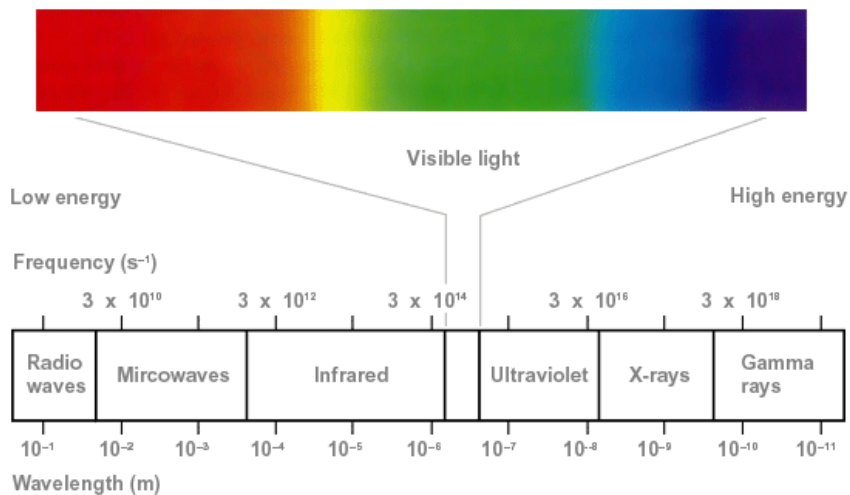
■ Frequency $\nu = \frac{c}{\lambda}$

■ c speed of light $3.00 \times 10^8 \frac{m}{s}$

■ λ wavelength



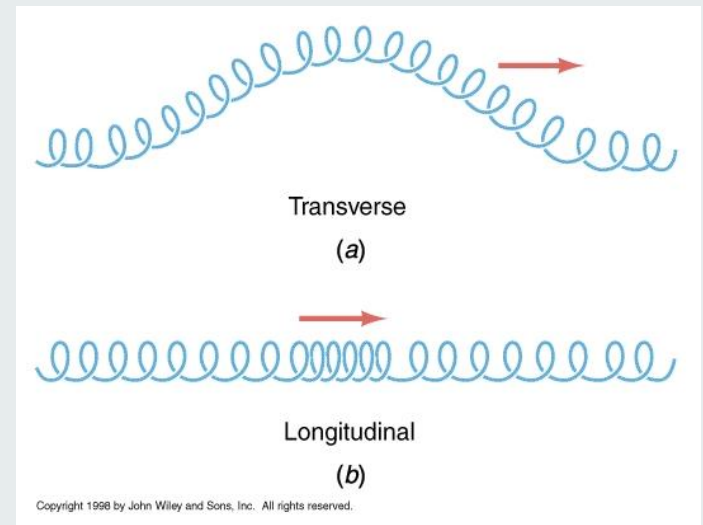
■ Examples of radiant energy:



SOUND

KINETIC AND POTENTIAL ENERGY

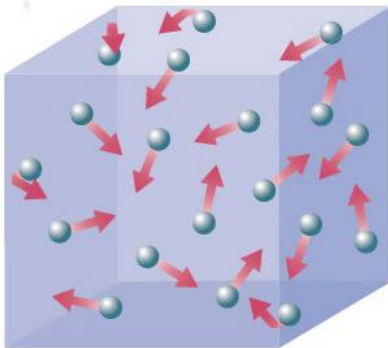
- The energy that is moved through substances with longitudinal waves.
 - $E = \frac{a^2 \rho}{2\pi f}$ (E in this expression is energy density or energy per area)
 - a = particle acceleration
 - ρ = air density
 - f = frequency of sound
- Examples of sound energy:



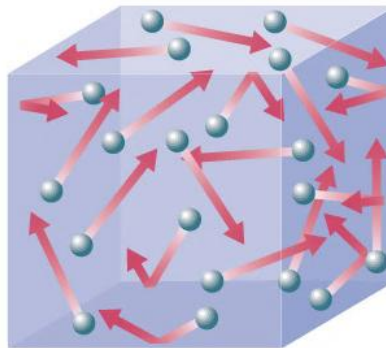
THERMAL KINETIC ENERGY

- Energy that is caused by heat.
 - When thermal energy is applied atoms/molecules move faster.
 - $E = f \frac{1}{2} k T$
 - f = degrees of freedom
 - k = Boltzmann's constant $1.381 \times 10^{-23} \frac{J}{K}$
 - T = temperature

T=Cold



T=Hot



Longer arrows mean higher average speed.

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- Examples of thermal energy:

TYPES OF ENERGY

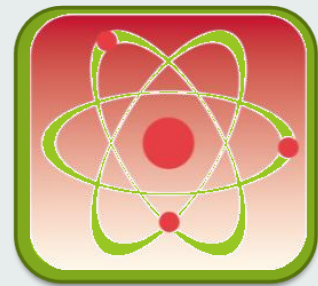
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Kinetic

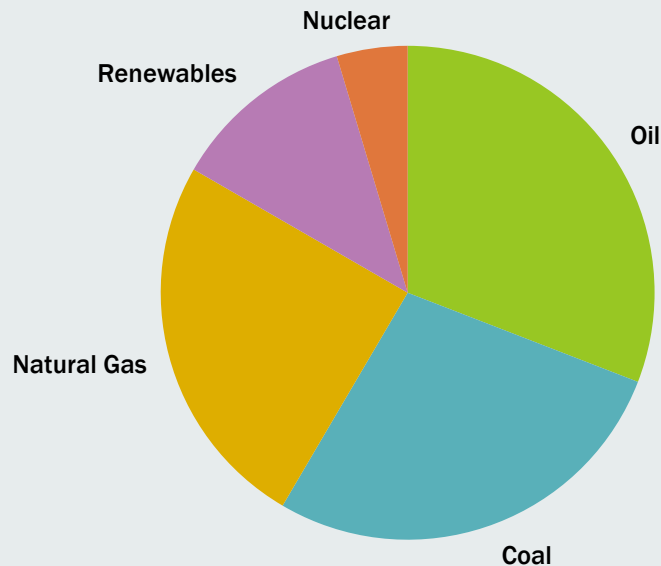
- Motion
- Electrical
- Radiant
- Thermal
- Sound



WORLD ENERGY

2021

WORLD ENERGY CONSUMPTION - 2021

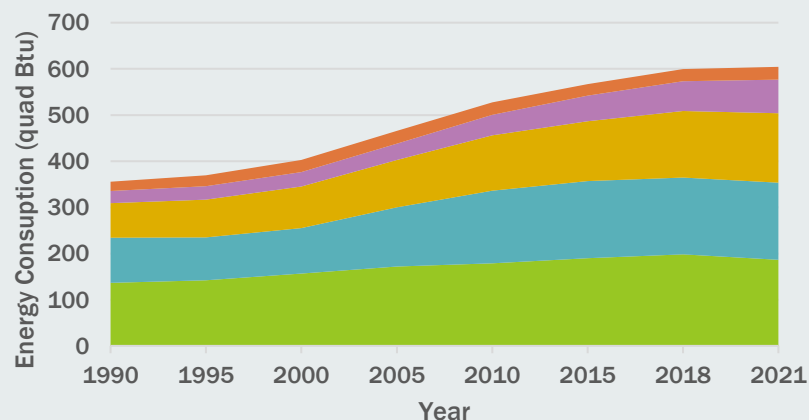


Source of Energy	Percent
Oil	31%
Coal	28%
Natural Gas	25%
Renewables	12%
Nuclear	5%

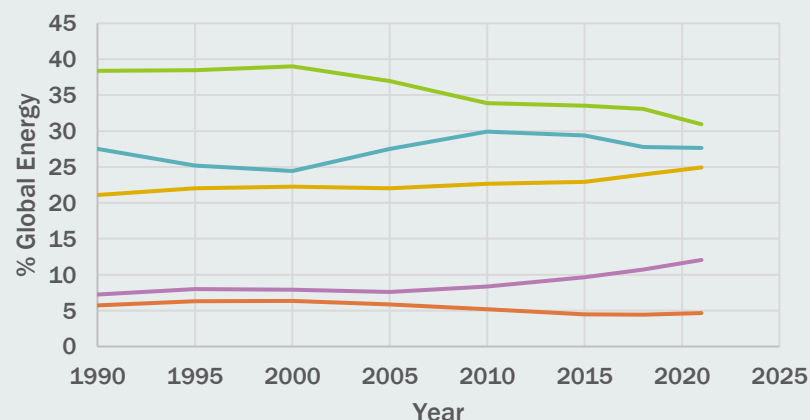
WORLD ENERGY

2021

World Consumption



Share of Global Energy



Source of Energy	Percent Change Since 2018	Percent Change Since 1990
Oil	-6.9%	-24.0%
Coal	-0.5%	0.48%
Natural Gas	3.7%	15.2%
Renewables	11.0%	39.8%
Nuclear	4.9%	-23.1%

WORLD ENERGY

2022

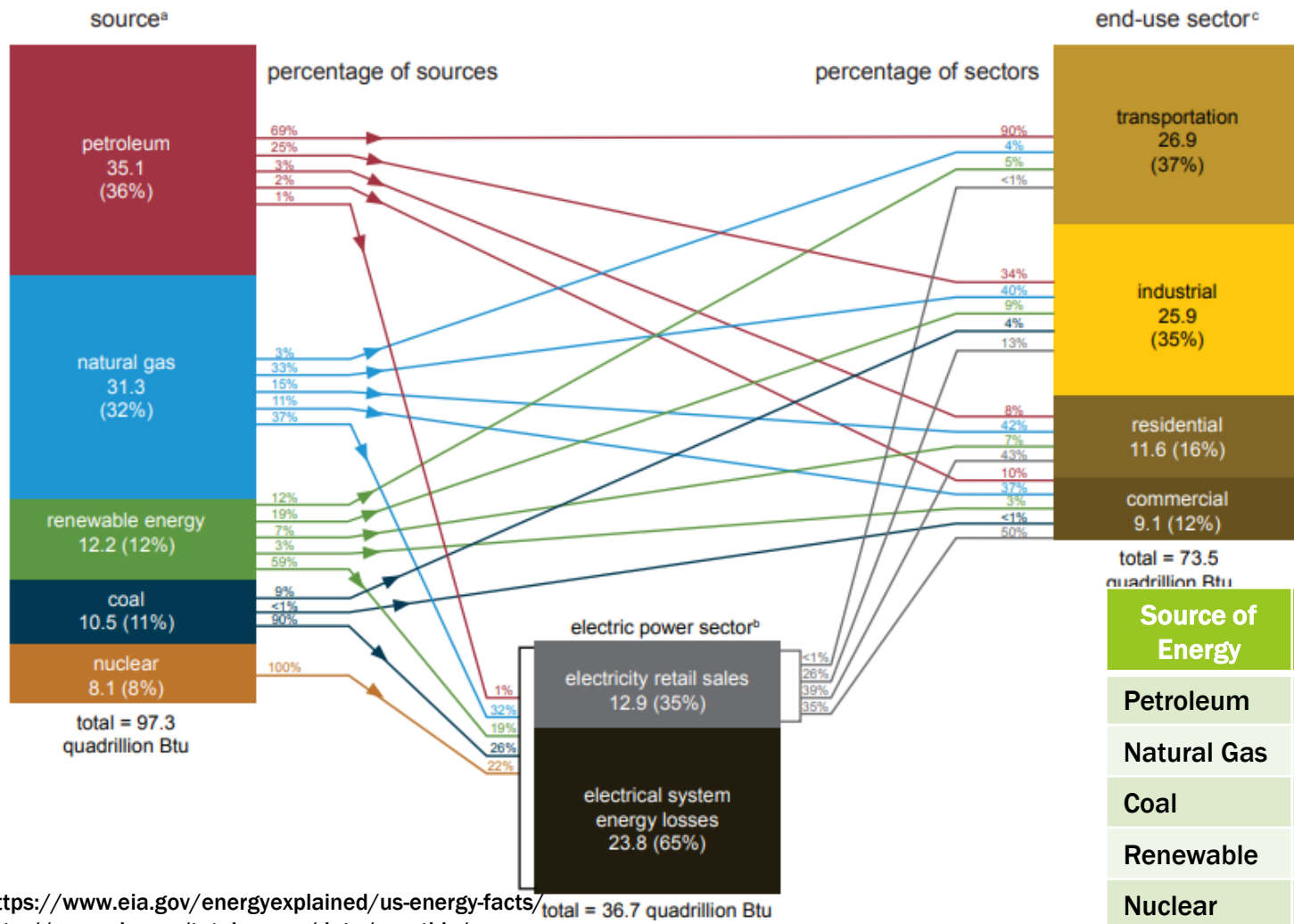
Country	Energy Consumption (Quadrillion Btu)
China	174.0
United States	94.7
India	35.3
Russia	32.5
Japan	16.9
Iran	13.5
Canada	12.3
Korea, South	12.2
Saudi Arabia	11.4
Germany	11.1

Country	Energy Consumption/person (MBtu)
Qatar	810
Singapore	627
Bahrain	539
United Arab Emirates	493
Brunei	461
Trinidad and Tobago	424
Kuwait	399
Saudi Arabia	309
Canada	307
Oman	304
United States (#12)	283

US ENERGY

U.S. energy consumption by source and sector, 2021

quadrillion British thermal units (Btu)



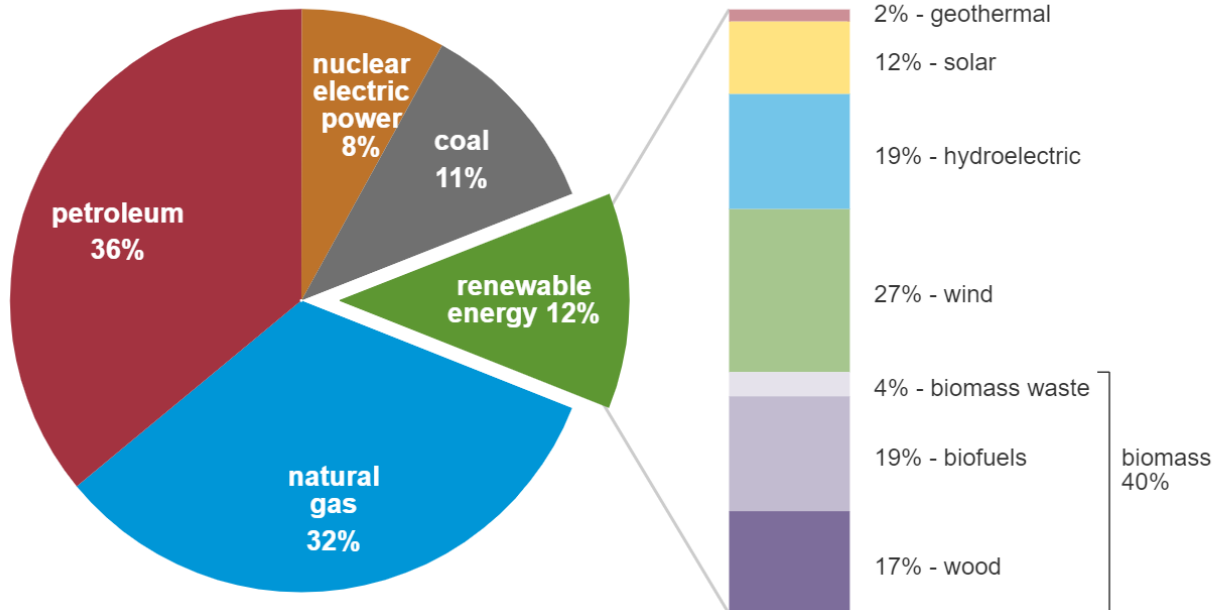
Source of Energy	% World 2021	% US 2021	% US 2009
Petroleum	31%	36%	37%
Natural Gas	28%	32%	25%
Coal	25%	12%	21%
Renewable	12%	11%	8%
Nuclear	5%	8%	9%

US ENERGY

U.S. primary energy consumption by energy source, 2021

total = 97.33 quadrillion
British thermal units (Btu)

total = 12.16 quadrillion Btu



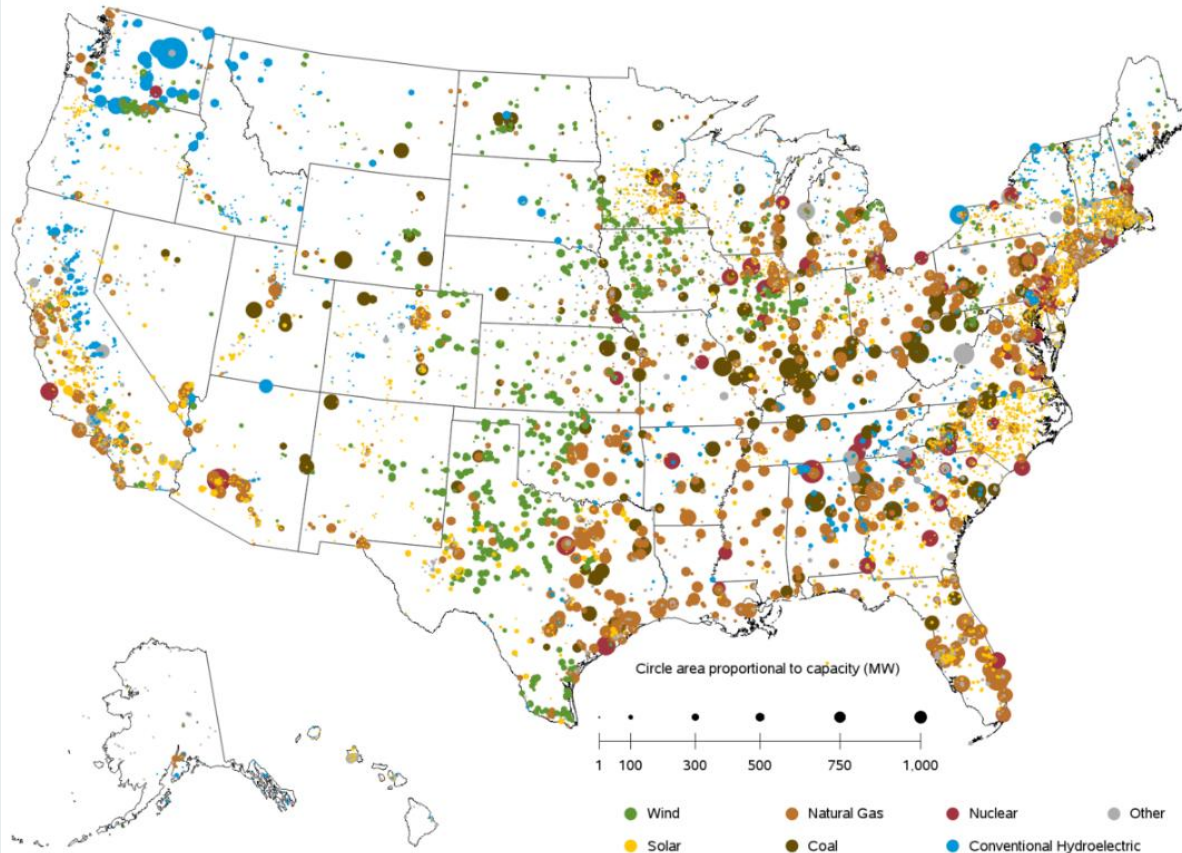
Data source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.3 and 10.1, April 2022, preliminary data



Note: Sum of components may not equal 100% because of independent rounding.

US ENERGY

Operable utility-scale generating units as of December 2022



Sources: U.S. Energy Information Administration, Form EIA-860, 'Annual Electric Generator Report' and Form EIA-860M, 'Monthly Update to the Annual Electric Generator Report.'

CENTRAL COAST COMMUNITY ENERGY

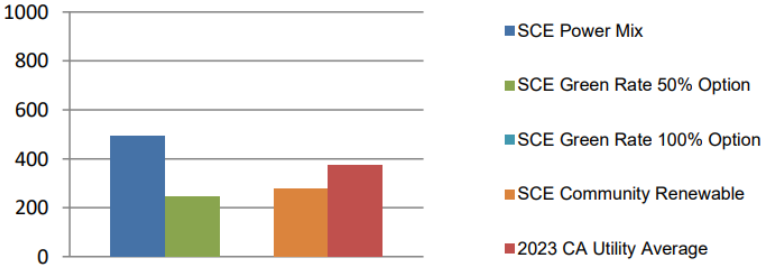
2023 POWER CONTENT LABEL						
(Central Coast Community Energy)						
(https://3cenergy.org)						
Greenhouse Gas Emissions Intensity (lbs CO ₂ e/MWh)			Energy Resources	3Cchoice	3Cprime	2023 CA Power Mix
3Cchoice	3Cprime	2023 CA Utility Average	Eligible Renewable ¹	30.3%	100.0%	36.9%
			Biomass & Biowaste	0.7%	0.0%	2.1%
			Geothermal	12.9%	0.0%	4.8%
			Eligible Hydroelectric	0.4%	0.0%	1.8%
			Solar	14.0%	50.0%	17.0%
			Wind	2.3%	50.0%	11.2%
			Coal	0.0%	0.0%	1.8%
			Large Hydroelectric	0.4%	0.0%	11.7%
			Natural Gas	0.0%	0.0%	36.6%
			Nuclear	0.0%	0.0%	9.3%
			Other	0.0%	0.0%	0.1%
			Unspecified Power ²	69.3%	0.0%	3.7%
			TOTAL	100.0%	100.0%	100.0%
Percentage of Retail Sales Covered by Retired Unbundled RECs ³ :				0%	0%	
¹ The eligible renewable percentage above does not reflect RPS compliance, which is determined using a different methodology. ² Unspecified power is electricity that has been purchased through open market transactions and is not traceable to a specific generation source. ³ Renewable energy credits (RECs) are tracking instruments issued for renewable generation. Unbundled renewable energy credits (RECs) represent renewable generation that was not delivered to serve retail sales. Unbundled RECs are not reflected in the power mix or GHG emissions intensities above.						
For specific information about this electricity portfolio, contact:			(Central Coast Community Energy) (831) 641-7222			
For general information about the Power Content Label, visit:			https://www.energy.ca.gov/programs-and-topics/programs/power-source-disclosure-program			

SOUTHERN CA EDISON

2023 POWER CONTENT LABEL

Southern California Edison Company

www.sce.com

Greenhouse Gas Emissions Intensity (lbs CO ₂ e/MWh)					Energy Resources	SCE Power Mix	SCE Green Rate 50% Option	SCE Green Rate 100% Option	SCE Community Renewable	2023 CA Power Mix
SCE Power Mix	SCE Green Rate 50% Option	SCE Green Rate 100% Option	SCE Community Renewable	2023 CA Utility Average	Eligible Renewable ¹	37.6%	68.7%	100.0%	64.6%	36.9%
	491	246	0	279	Biomass & Biowaste	0.1%	0.1%	0.0%	0.1%	2.1%
					Geothermal	5.2%	2.6%	0.0%	3.0%	4.8%
					Eligible Hydroelectric	0.7%	0.4%	0.0%	0.4%	1.8%
					Solar	19.8%	59.8%	100.0%	54.5%	17.0%
					Wind	11.7%	5.9%	0.0%	6.6%	11.2%
					Coal	0.0%	0.0%	0.0%	0.0%	1.8%
					Large Hydroelectric	4.5%	2.2%	0.0%	2.5%	11.7%
					Natural Gas	20.0%	10.0%	0.0%	11.3%	36.6%
					Nuclear	9.1%	4.5%	0.0%	5.1%	9.3%
					Other	0.1%	0.0%	0.0%	0.0%	0.1%
					Unspecified Power ²	28.8%	14.5%	0.0%	16.4%	3.7%
					TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%
Percentage of Retail Sales Covered by Retired Unbundled RECs ³ :						0%	0%	0%	0%	

¹The eligible renewable percentage above does not reflect RPS compliance, which is determined using a different methodology.

²Unspecified power is electricity that has been purchased through open market transactions and is not traceable to a specific generation source.

³Renewable energy credits (RECs) are tracking instruments issued for renewable generation. Unbundled renewable energy credits (RECs) represent renewable generation that was not delivered to serve retail sales. Unbundled RECs are not reflected in the power mix or GHG emissions intensities above.

For specific information about this electricity portfolio, contact:

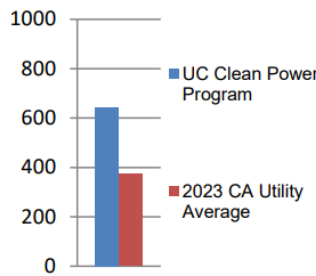
Southern California Edison Company

1-800-655-4555

For general information about the Power Content Label, visit:

<https://www.energy.ca.gov/programs-and-topics/programs/power-source-disclosure-program>

UC REGENTS

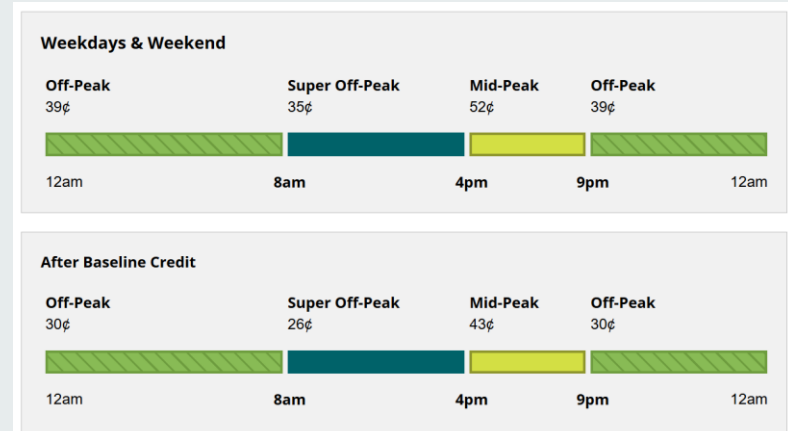
2023 POWER CONTENT LABEL				
The Regents of the University of California				
Greenhouse Gas Emissions Intensity (lbs CO ₂ e/MWh)		Energy Resources	UC Clean Power Program	2023 CA Power Mix
UC Clean Power Program	2023 CA Utility Average	Eligible Renewable¹ Biomass & Biowaste Geothermal Eligible Hydroelectric Solar Wind Coal Large Hydroelectric Natural Gas Nuclear Other Unspecified Power² TOTAL	19.6%	36.9%
645	373		0.0%	2.1%
			0.0%	4.8%
			0.0%	1.8%
			19.6%	17.0%
			0.0%	11.2%
			0.0%	1.8%
			4.0%	11.7%
			0.0%	36.6%
			8.1%	9.3%
			0.0%	0.1%
			68.3%	3.7%
100.0%	100.0%			
Percentage of Retail Sales Covered by Retired Unbundled RECs³:			0%	
¹ The eligible renewable percentage above does not reflect RPS compliance, which is determined using a different methodology.				
² Unspecified power is electricity that has been purchased through open market transactions and is not traceable to a specific generation source.				
³ Renewable energy credits (RECs) are tracking instruments issued for renewable generation. Unbundled renewable energy credits (RECs) represent renewable generation that was not delivered to serve retail sales. Unbundled RECs are not reflected in the power mix or GHG emissions intensities above.				
The unbundled RECs retired in association with UC Clean Power Program's portfolio were procured from eligible renewable sources such as solar, wind, hydroelectric, biowaste, biomass, or geothermal energy. For additional information on unbundled RECs retired in association with the UC Clean Power Program please reach out via email at UC_ESP@ucop.edu.				
For specific information about this electricity portfolio, contact:		The Regents of the University of California 510-287-3360		
For general information about the Power Content Label, visit:		https://www.energy.ca.gov/programs-and-topics/programs/power-source-disclosure-program		

TOU

Summer (June – Sept.)

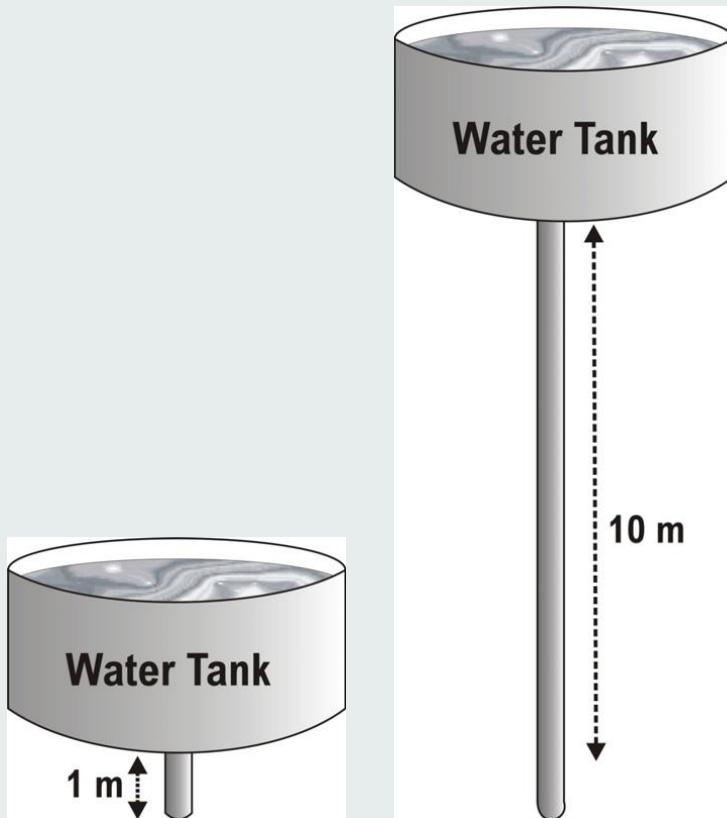


Winter (Oct.- May)



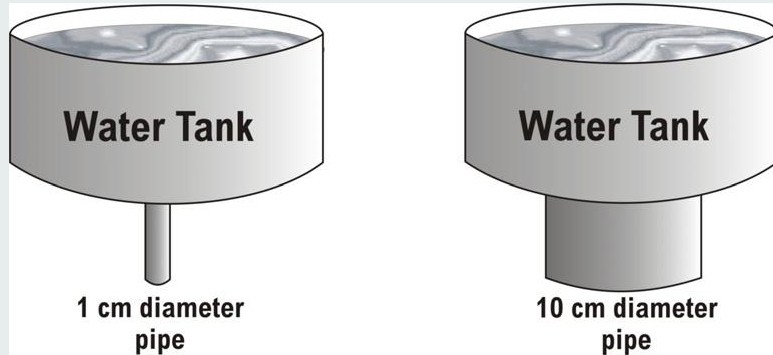
- **Summer Cheapest Power**
 - 9 pm to 4 pm (\$0.27)
 - Weekend are cheaper than weekdays
- **Winter Cheapest Power**
 - 9 pm to 8 am (\$0.30)
 - Weekdays and weekends are same price.

ELECTRICITY



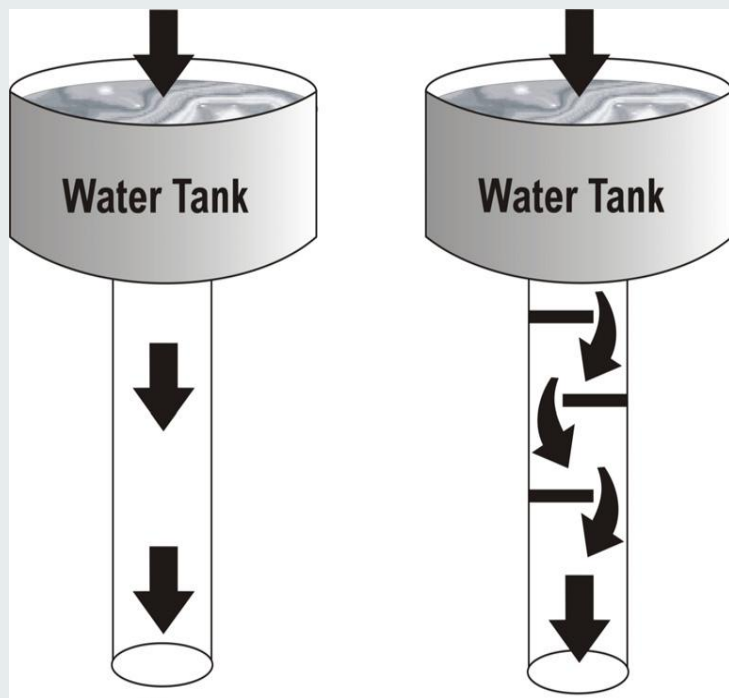
- Voltage (volt V): A measure of its electrical potential .
- Which water tower will have water that comes out at a greater pressure?
- What represents voltage?

ELECTRICITY



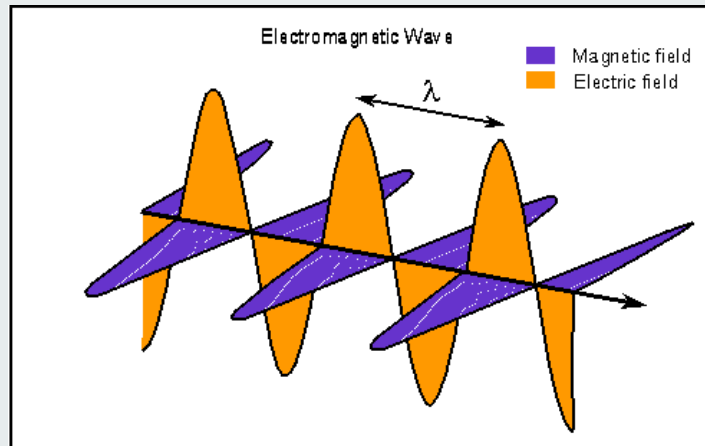
- Current (amps A): The rate of charge flow per time .
- Which water tower will have water come out at a faster rate?
- What represents current?
- Types of Current:

ELECTRICITY



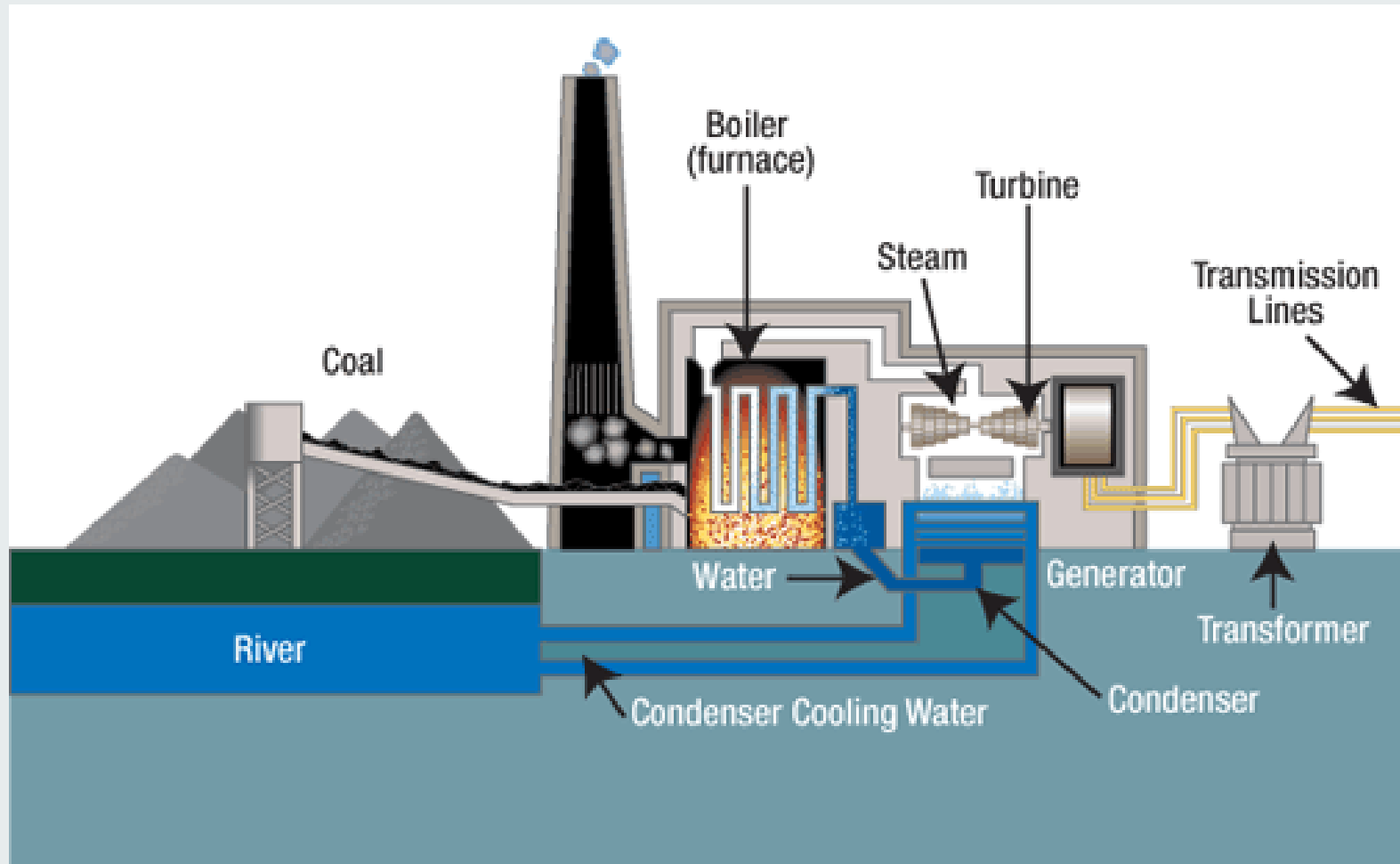
- Resistance (ohms Ω): The amount of resistance a current will encounter.
- Which water tower will have the water encounter more resistance?
- What represents resistance?

ELECTROMAGNETS

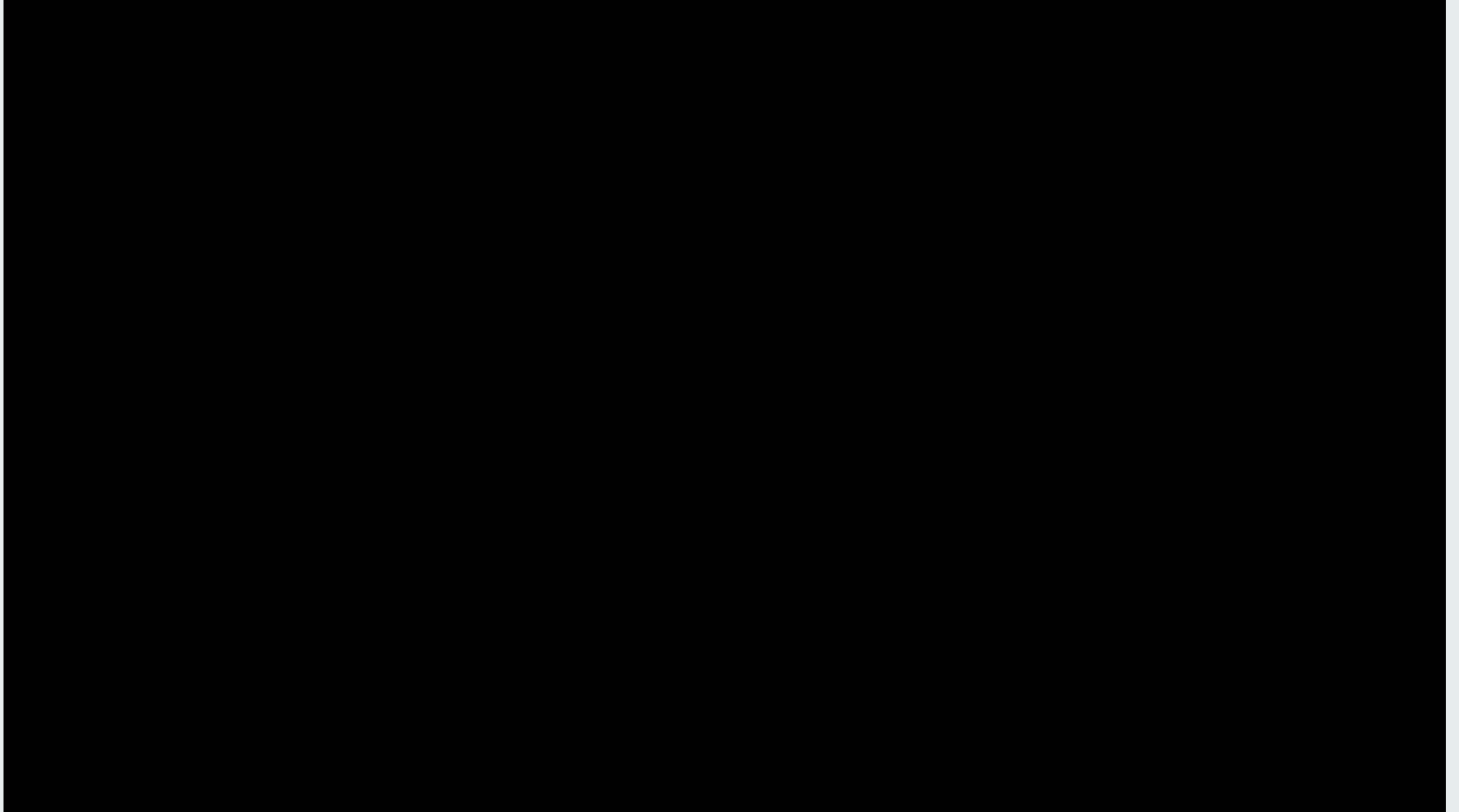


- A changing magnetic field induces a electric field.
- A changing electric field induces a magnetic field.
- Electromagnet: A temporary magnet whose effect is caused by an electric current.

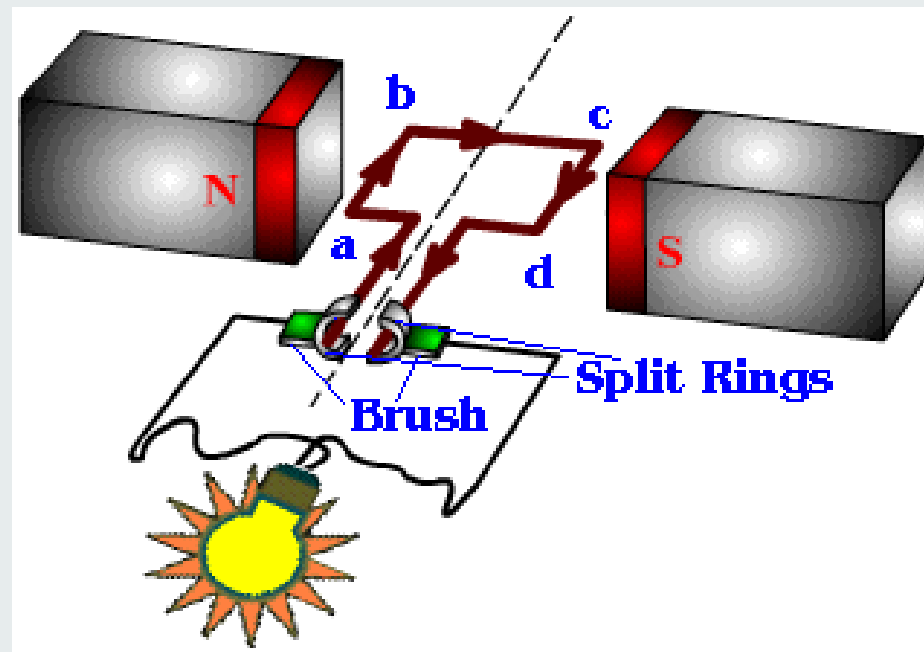
ELECTRICAL PLANTS



ELECTROMAGNETS

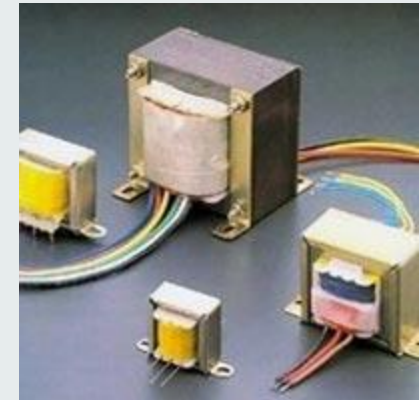
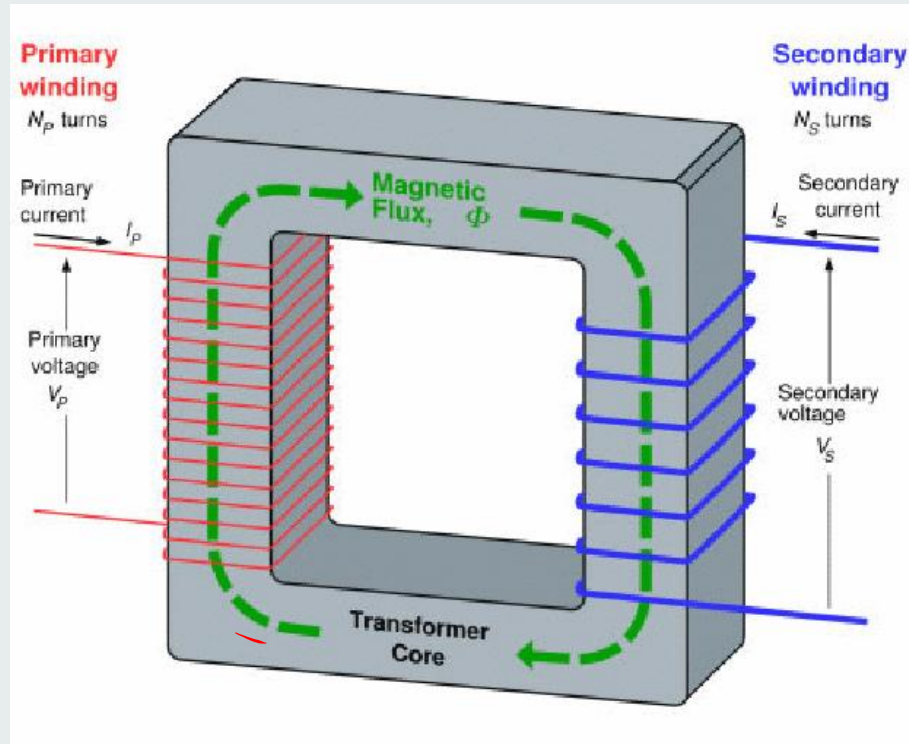


ELECTRICAL PLANTS



- The University of Colorado has computer simulations for different science concepts. Try this one on generators.
<http://phet.colorado.edu/en/simulation/generator>

ELECTRICAL PLANTS



- Transformer: An electrical device by which alternating current of one voltage is changed to another voltage.
 - The greater the number of coils the greater the voltage.