6.1 ENERGY BASICS AND GLOBAL ENERGY CONSUMPTION

College Board Topics 6.1 and 6.2

Related Reading Chapter 19

Learning Objectives and Essential Knowledge

ENDURING UNDERSTANDING

ENG-3

Humans use energy from a variety of sources, resulting in positive and negative consequences.

LEARNING OBJECTIVE

ENG-3.A

Identify differences between nonrenewable and renewable energy sources.

SUGGESTED SKILL

Concept Explanation

1.A

Describe environmental concepts and processes.

ESSENTIAL KNOWLEDGE

ENG-3.A.1

Nonrenewable energy sources are those that exist in a fixed amount and involve energy transformation that cannot be easily replaced.

ENG-3.A.2

Renewable energy sources are those that can be replenished naturally, at or near the rate of consumption, and reused.

LEARNING OBJECTIVE

ENG-3.B

Describe trends in energy consumption.

SUGGESTED SKILL

Mathematical Routines

6.C

Calculate an accurate numeric answer with appropriate units.

ESSENTIAL KNOWLEDGE

ENG-3.B.1

The use of energy resources is not evenly distributed between developed and developing countries.

ENG-3.B.2

The most widely used sources of energy globally are fossil fuels.

ENG-3.B.3

As developing countries become more developed, their reliance on fossil fuels for energy increases.

ENG-3.B.4

As the world becomes more industrialized, the demand for energy increases.

ENG-3.B.5

Availability, price, and governmental regulations influence which energy sources people use and how they use them.

Introduction to Energy

- ***Energy***
  - The ability to do work.
  - ***Kinetic energy***
    - Energy that is actively being used to do work.
  - ***Potential Energy***
    - Stored energy; energy that has potential to do work based on the position or arrangement of matter
- The Laws of Thermodynamics govern energy transformations.
  - ***1st Law of Thermodynamics***
    - Energy cannot be created or destroyed, only transformed.
  - ***2nd Law of Thermodynamics***
    - Energy transformations increase the entropy of the universe
      - Energy conversions are never 100% efficient, they will result in a decrease in the order and organization of energy.

Kinetic Energy	Potential Energy
• Electric	• Chemical Bonds
• Motion	• Nuclear
• Radiant	• Elastic
• Sound	• Gravitational
• Thermal	

Energy Efficiency

- Energy delivered compared to energy supplied
- output/input x 100 = % efficiency

Energy and Power

- ***E = P x t***
  - E= Energy
  - P= power
  - t = time

- ***Power (P)***
  - The rate at which energy is used.
  - Commonly measured in the units of ***watts (w)*** or ***kilowatts (kw)***
    - 1 watt = 1 joule/sec
    - 1kw = 1000 joules/sec
    - 1 kw = 1000 watts

- ***Energy (E)***
  - The ability to do work.
  - Commonly measured in units of watt-hours (***wH***) or kilowatt-hours (***kwH***).
    - 1 wH = 3600 joules
    - 1 kwH = 3.6×10^6 joules
    - 1kwH = 1000 wH

Practice

- An APES students has a 100 watt incandescent floor lamp and a 50 watt incandescent desk lamp in his bedroom. When he gets home this evening he turns on the floor lamp, which remains on until he goes to bed 3 hours later. He also has a desk lamp that he turns on while he diligently studies APES.
  - How much energy, in kwH, was consumed by the lights above?
  - LED bulbs are much more efficient than incandescent bulbs; typically producing equal amounts of light while using one tenth of the power. How much energy would be consumed by these lamps if they had been using LED's instead of incandescent bulbs?
  - If SDG&E charges $0.25/kwH how much would changing to LED's save his parents?
  - Incandescent bulbs like those in the APES students home are very inefficient; only about 5% of the electrical energy is actually converted to heat. How much light energy is actually produced by the students lights?
  - What happens to the rest of the energy?

Nature offers a variety of energy sources

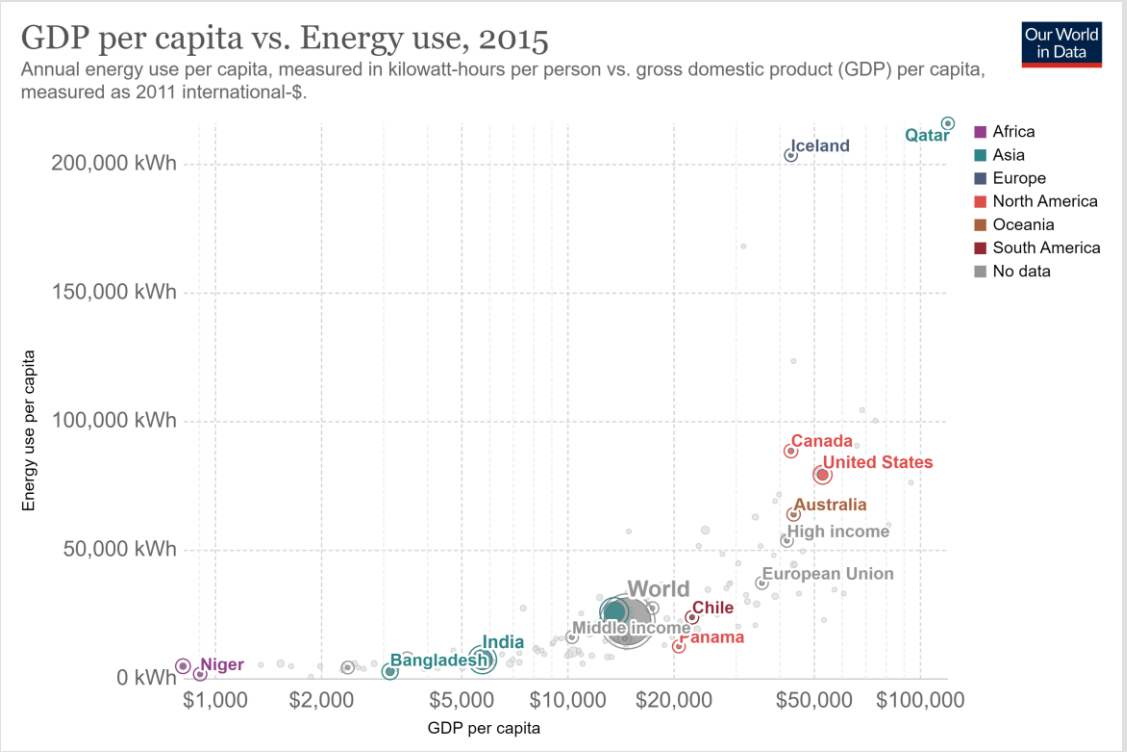
- ***Renewable energy***: can be replenished by natural processes at a rate > the rate they are consumed
  - Sunlight, wind, geothermal energy, and tidal energy, biomass
    - ***Depletable Renewables***: Can run out of them if overused. (Biomass; wood, charcoal, ethanol)
    - ***Non-Depletable Renewables***: Energy resulting from continuous, ongoing processes. Can never run out of as long as the process can continue (solar, wind, geothermal, tidal)
- ***Nonrenewable energy***: exist in relatively fixed amounts on Earth as a result of very slow geologic processes that have created current reserves slowly over geologic time.
  - Oil, coal, natural gas, nuclear
  - To replenish the fossil fuels we have depleted so far would take millions of years

TABLE 19.1 Energy Sources We Use

ENERGY SOURCE	DESCRIPTION	TYPE OF ENERGY
Crude oil	Fossil fuel extracted from ground (liquid)	Nonrenewable
Natural gas	Fossil fuel extracted from ground (gas)	Nonrenewable
Coal	Fossil fuel extracted from ground (solid)	Nonrenewable
Nuclear energy	Energy from atomic nuclei of uranium	Nonrenewable
Biomass energy	Energy stored in plant matter from photosynthesis	Renewable
Hydropower	Energy from running water	Renewable
Solar energy	Energy from sunlight directly	Renewable
Wind energy	Energy from wind	Renewable
Geothermal energy	Earth's internal heat rising from core	Renewable
Tidal and wave energy	Energy from tides and ocean waves	Renewable

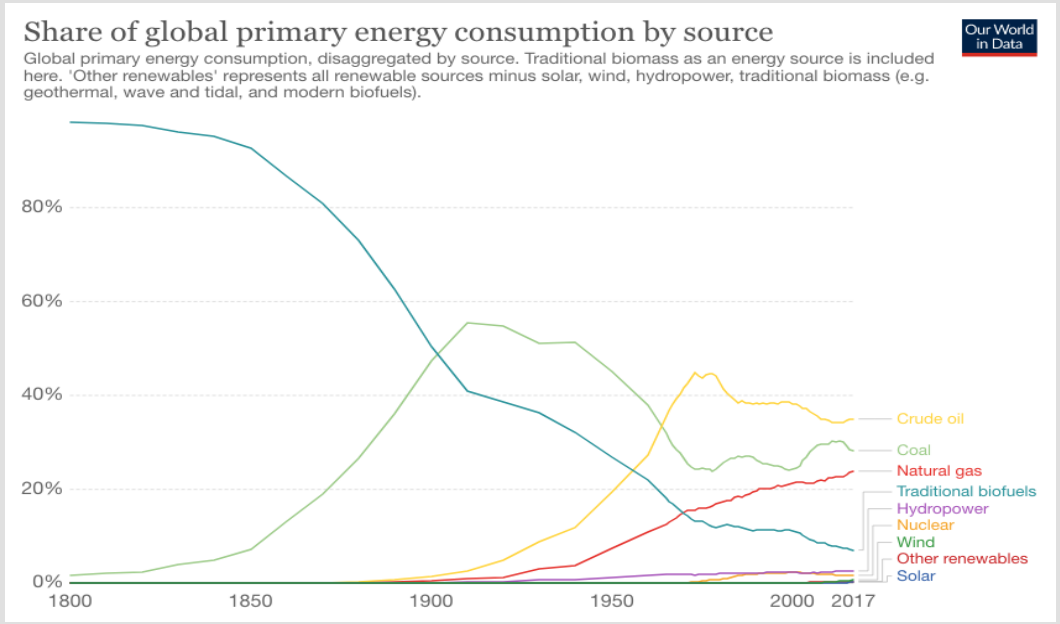
The use of energy is not evenly distributed

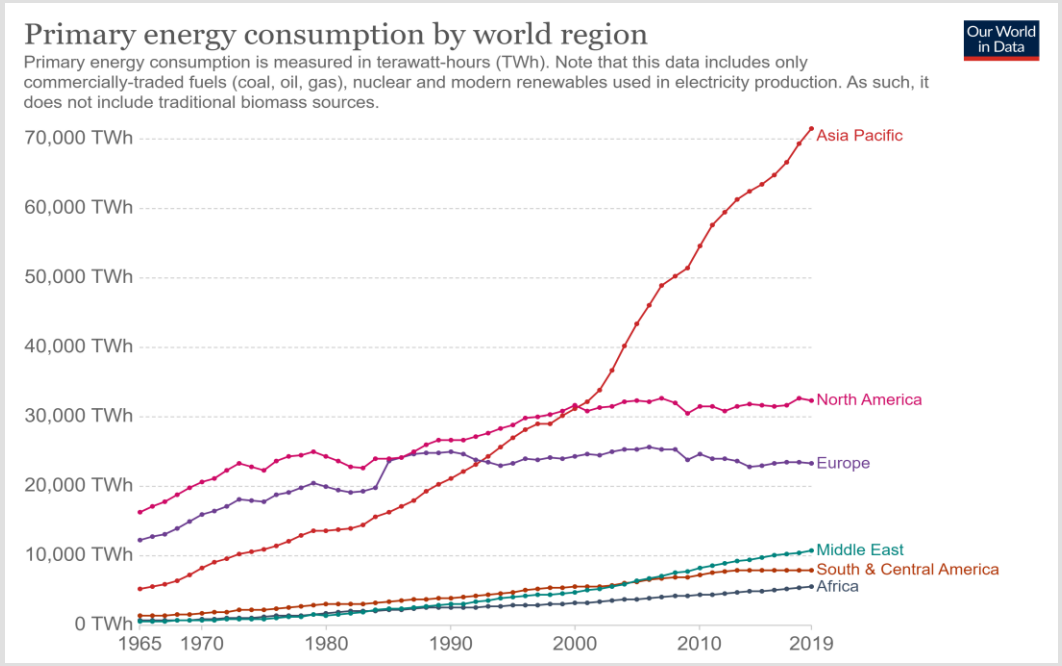
- Developing nations use a greater portion of energy for subsistence activities.
  - Food preparation and home heating powered by traditional forms of biomass (wood, charcoal, animal dung)
  - Agriculture powered by manual or animal labor.
  - Can lead to deforestation.
- Industrialized nations rely more on vehicles and electricity which depend on fossil fuels
  - Most electricity is generated at large, high capacity, centralized locations by burning coal or natural gas and then transmitted to other locations.
  - Vehicles are more common in developed nations, resulting in greater consumption of oil, which is refined to make gasoline.
  - Fossil fuels supply 82% of the U.S. energy demand.
- People in developed countries use more energy per capita, but developing nations use more energy in total. (U.S. is 4% of worlds Population, but consumes 19.% of world energy)

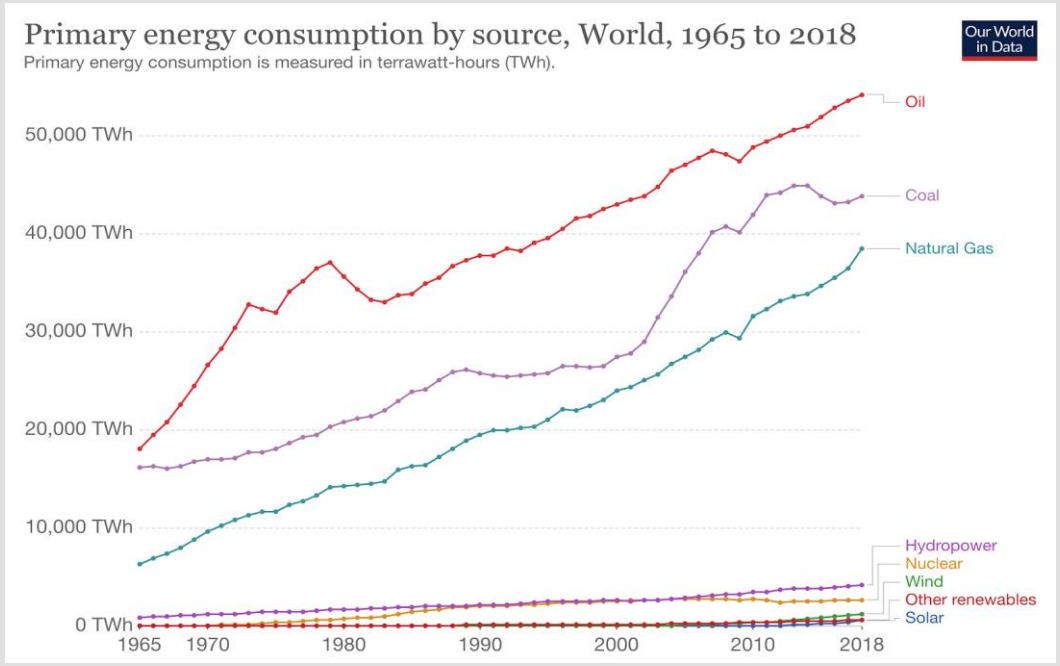


Fossil Fuels are the most widely used source of energy

- As the world becomes more industrialized, the demand for energy increases.
- As nations have developed, they have increased their dependence on fossil fuels.

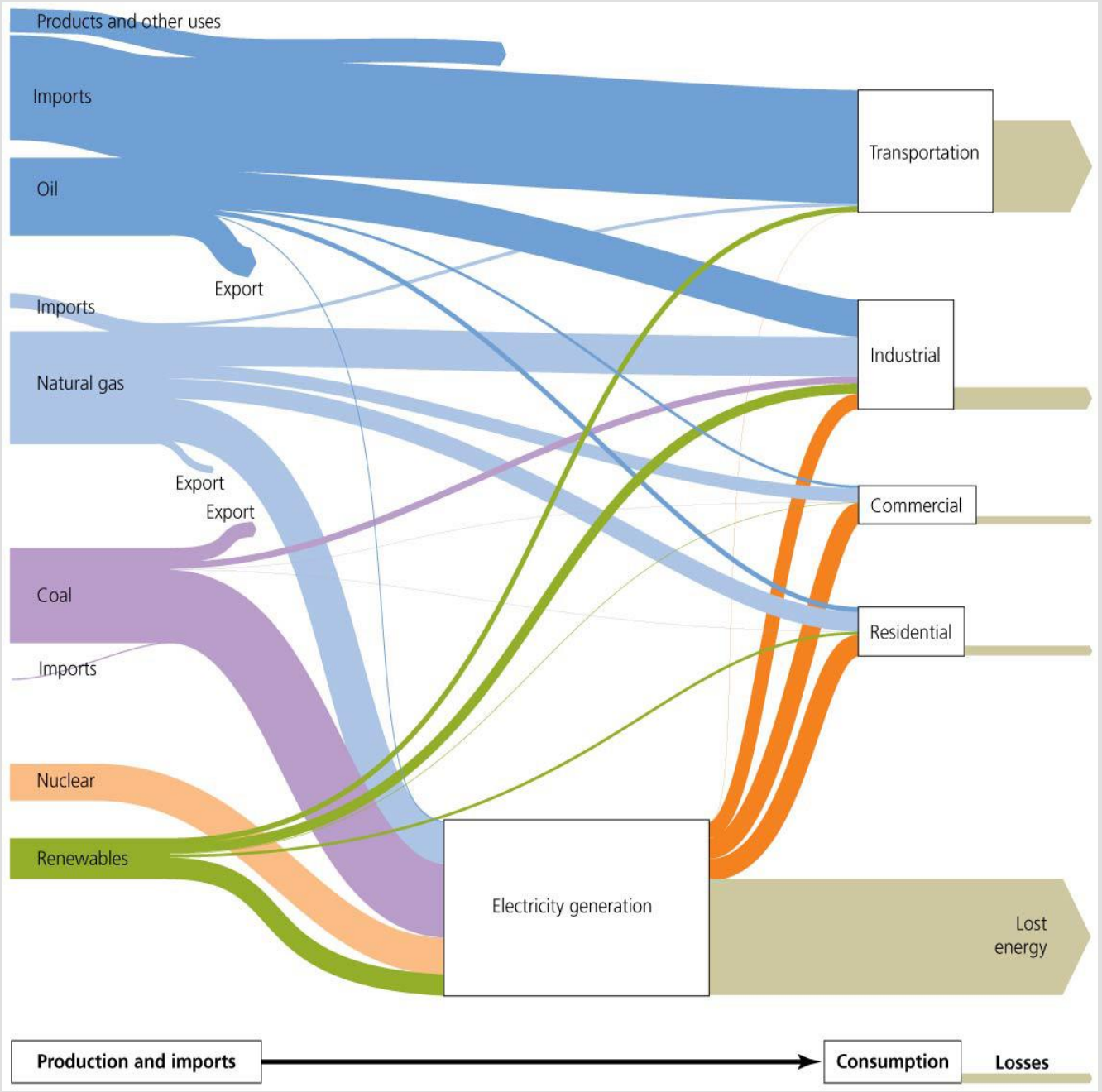






Total energy flow of the United States

- The United States is heavily dependent on fossil fuels for transportation and Electricity generation
- Oil is refined to produce gasoline for our vehicles.
- Natural Gas and Coal are burned in power plants to produce electricity.
  - Electricity is a secondary form of energy that is easy to transfer and apply to a variety of uses.
  - Producing electricity generates a large amount of waste heat.
- Nuclear and renewable forms of energy currently represent a small portion of overall energy production in the U.S.

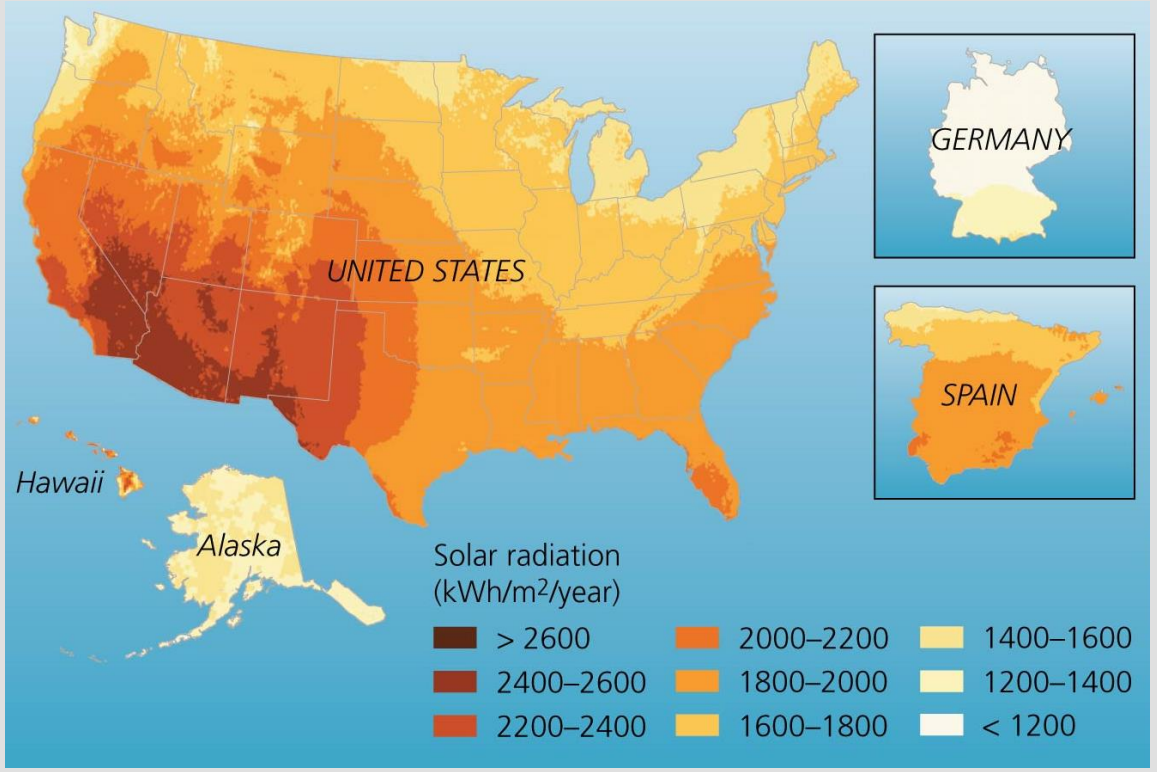


Availability, price, and regulation determine our mix of energy sources

- Availability depends on the size of reserves and the accessibility of reserves.
  - Coal, oil, natural gas, uranium, geothermal
  - Mostly determined by a regions geologic history.
- Availability depends on climate and geographic conditions in a region.
  - Amount of solar insolation (solar), average wind speed (wind turbines), size and abundance of rivers (hydroelectric), NPP (biomass), coastal location and shape of tidal basin (tidal power).
- Availability depends on the existing infrastructure for utilizing the energy source.
  - ability to convert the energy source to electricity or vehicle fuel.

TABLE 19.2 Nations with the Largest Proven Reserves of Fossil Fuels

OIL (% world reserves)		NATURAL GAS (% world reserves)		COAL (% world reserves)	
Venezuela*	17.9	Russia	21.4	United States	27.6
Saudi Arabia	16.1	Iran	15.9	Russia	18.2
Canada*	10.6	Qatar	12.0	China	13.3
Iran	9.1	Turkmenistan	11.7	Australia	8.9
Iraq	8.7	United States	4.1	India	7.0



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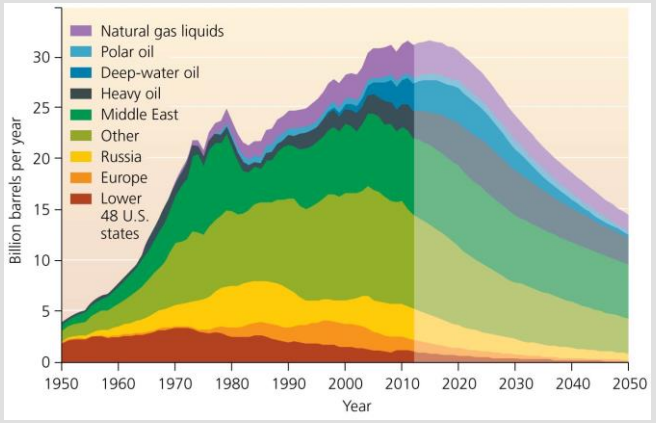
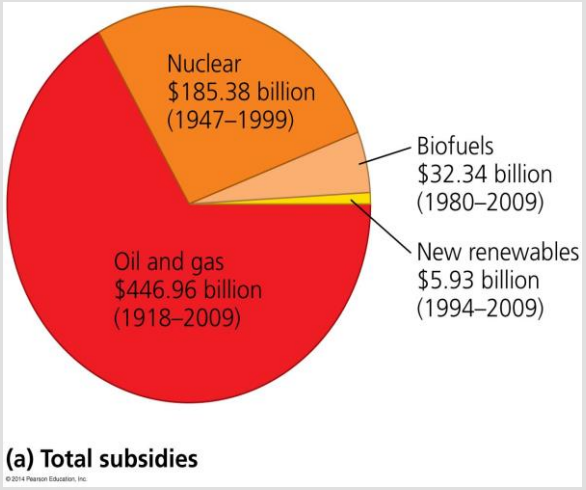


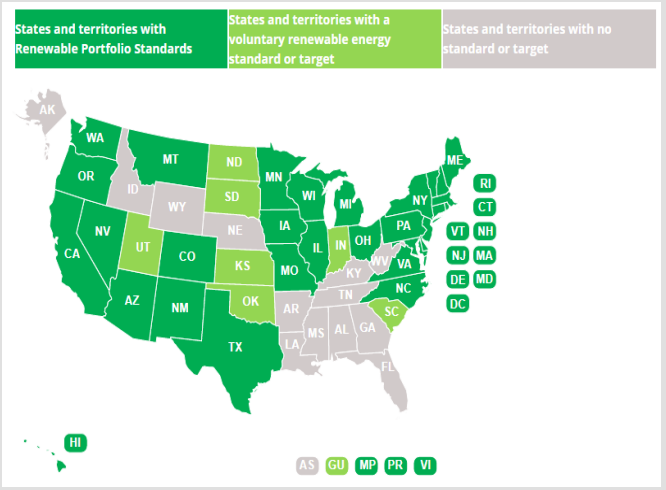
- It takes energy to make energy, and therefore it takes money to make energy.
  - There is a large input of energy that goes into mining, refining, transporting/distributing, and building infrastructure for energy resources.
  - The energy returned by an energy source must be greater than the energy invested
    - ***EROI (energy return on investment)*** is the ratio of energy invested compared to energy returned.
    - The higher the EROI the more valuable the energy source is.
    - Ranges from 30:1 (some oil reserves) to 1.1:1 for some tar sand deposits.

- Prices fluctuate dramatically with discovery or depletion of reserves.
  - ***Reserve to production ratios (R/P ratio)*** predict remaining supplies of energy reserves (oil 54 years, natural gas 64 years, coal 112 years)
  - ***Peak oil***: when reserves drop by 50%, production will decline, and prices will skyrocket.
    - Peak production of oil will occur well before deposits are depleted.

- Development of new technologies for accessing existing reserves can extend supply.
  - Fracking, tar sands, deep offshore drilling, and secondary extraction have allowed exploitation of new deposits and increased reserves of oil and natural gas.



Availability, price, and regulation determine our mix of energy sources



- Government subsidies prop up the unsustainable, but powerful, and highly profitable fossil fuel industry.
  - ***Subsidies*** are payouts (tax breaks, low interest loans, investments in research, development of technology, etc.)
  - Subsidies make it so the price of fossil fuels (gas and utility bills) don't even cover the cost of producing the fossil fuel energy we use.
  - Historically, a strong energy sector has led to U.S. economic strength, national security and a position of international influence.
  - If the U.S. is to remain a global leader, the U.S. will have to begin shifting subsidies towards renewable energy.

- ***Renewable energy standards (RES)***
  - State level regulations requiring utilities to include a certain percentage of renewables in the energy they source for consumers.
  - Sets goals and incentivizes development of renewable energy sources
  - 38 states have RES, but terms vary widely.
  - California requires 44% renewable energy from utilities by 2024 and 100% by 2045.