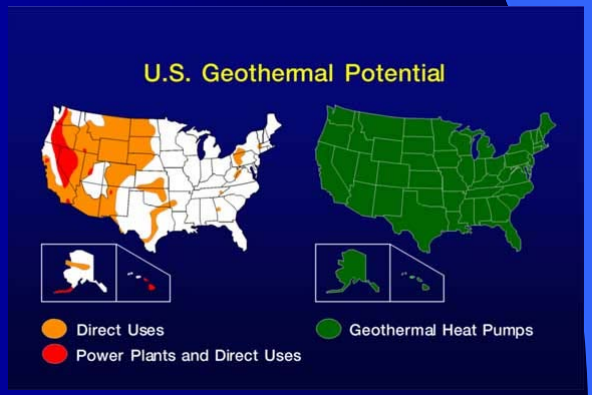
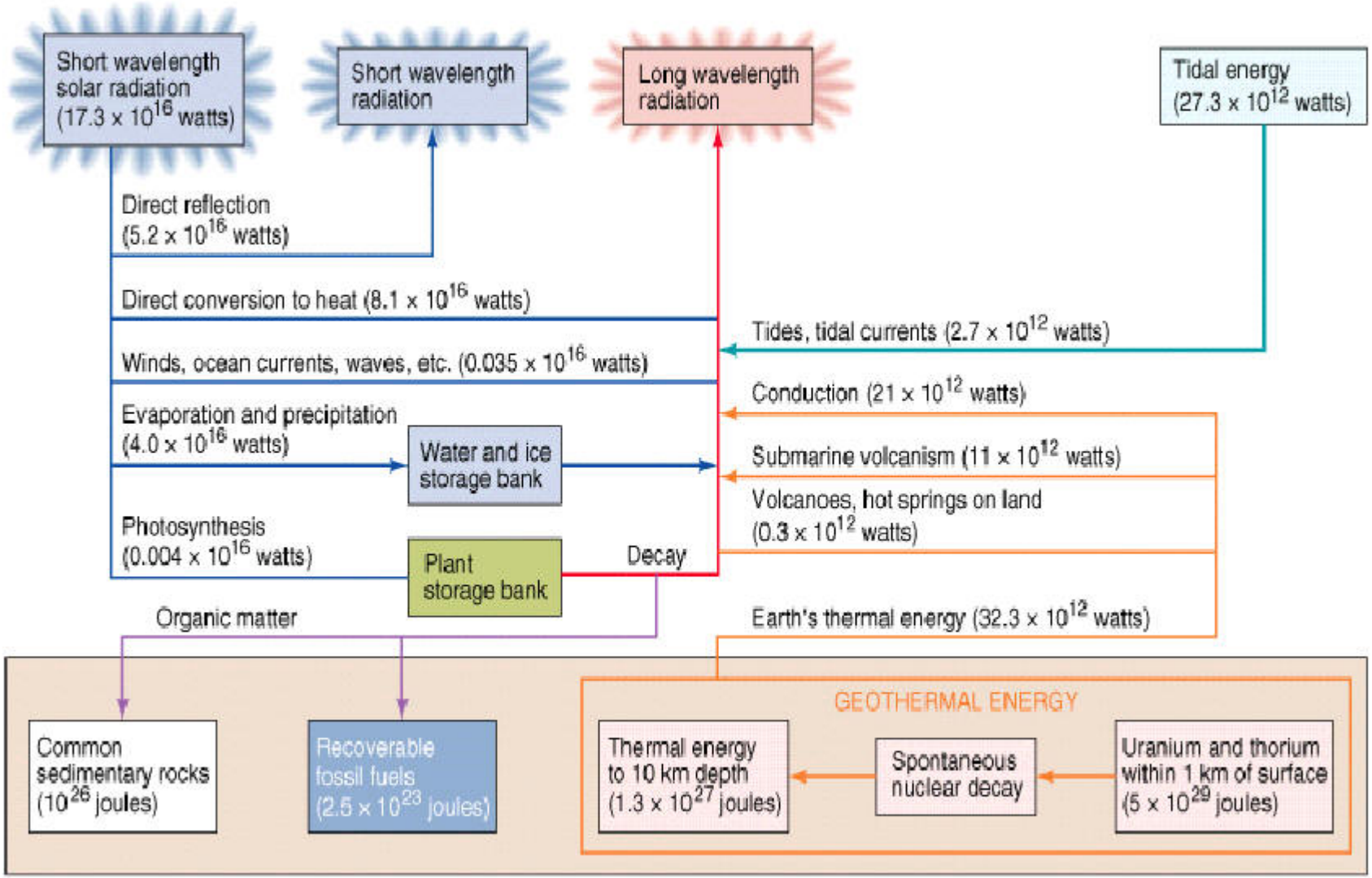
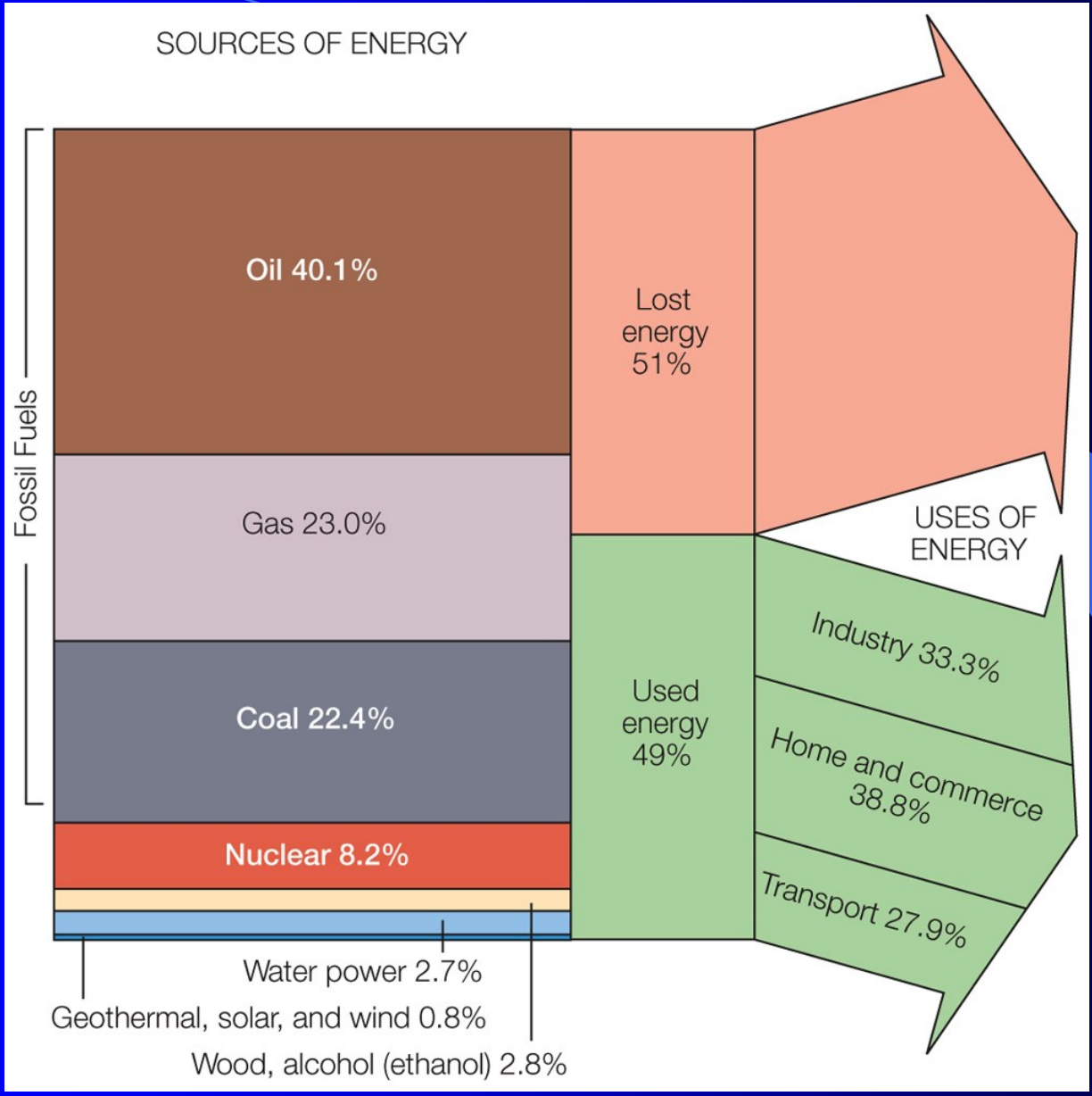
Energy Resources

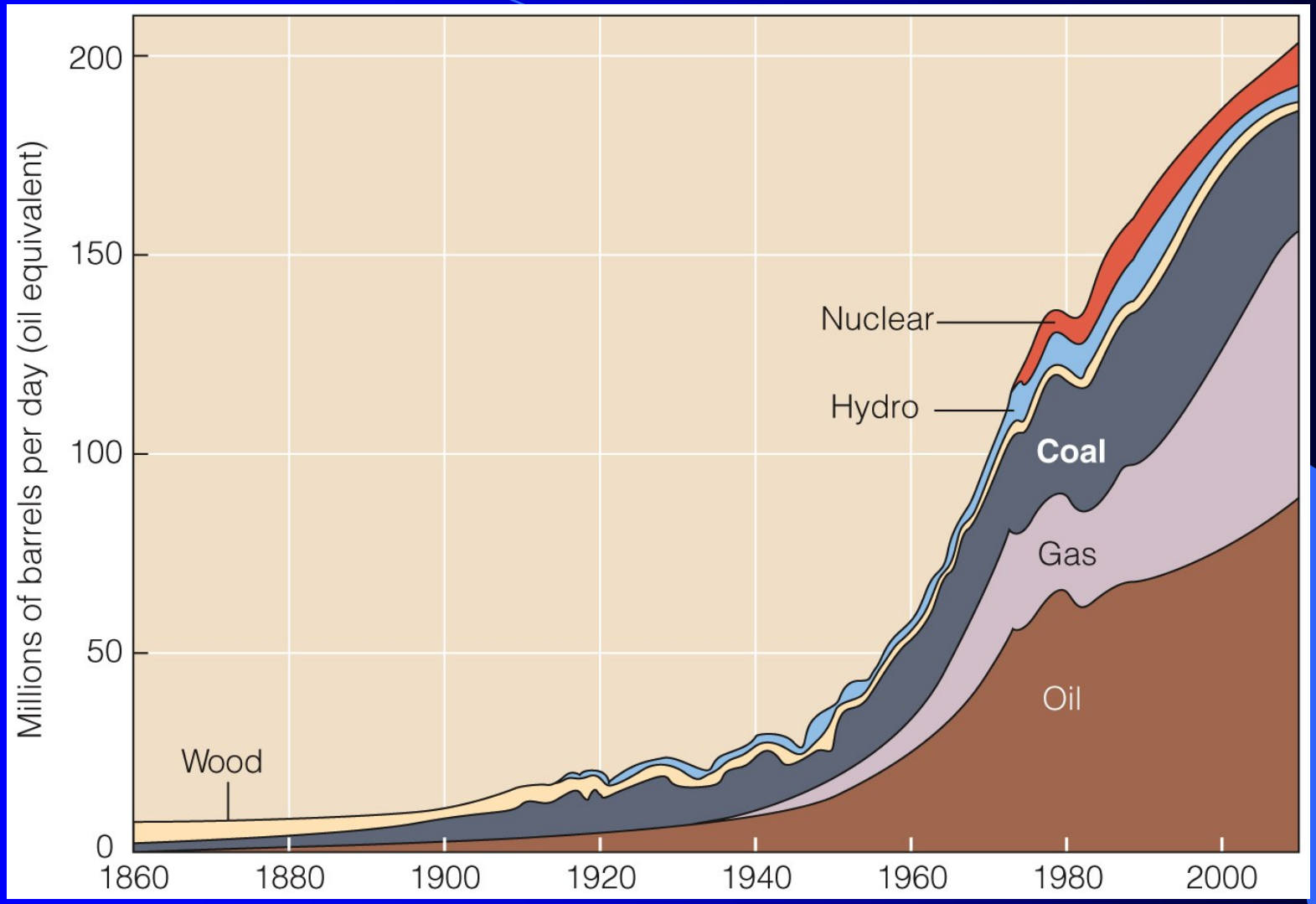
- Includes food energy and sources of energy used to sustain the activities and structures of modern society
  - Fossil fuels
  - Alternative energy sources
    - Hydroelectic
    - Nuclear
    - New renewables
- Earth's energy comes from three sources
  - Solar radiation
  - Geothermal energy
  - Tidal energy
- Circulates through the pathways and reservoirs of Earth's energy cycle
- All energy for human use is derived from the circulating energy in this cycle




Short wavelength solar radiation (17.3 x 10^16 watts)
Short wavelength radiation
Long wavelength radiation
Tidal energy (27.3 x 10^12 watts)
Direct reflection (5.2 x 10^16 watts)
Direct conversion to heat (8.1 x 10^16 watts)
Winds, ocean currents, waves, etc. (0.035 x 10^16 watts)
Tides, tidal currents (2.7 x 10^12 watts)
Conduction (21 x 10^12 watts)
Evaporation and precipitation (4.0 x 10^16 watts)
Water and ice storage bank
Submarine volcanism (11 x 10^12 watts)
Volcanoes, hot springs on land (0.3 x 10^12 watts)
Photosynthesis (0.004 x 10^16 watts)
Plant storage bank
Decay
Organic matter
Earth's thermal energy (32.3 x 10^12 watts)
GEOTHERMAL ENERGY
Common sedimentary rocks (10^26 joules)
Recoverable fossil fuels (2.5 x 10^23 joules)
Thermal energy to 10 km depth (1.3 x 10^27 joules)
Spontaneous nuclear decay
Uranium and thorium within 1 km of surface (5 x 10^29 joules)


SOURCES OF ENERGY
Fossil Fuels
Oil 40.1%
Gas 23.0%
Coal 22.4%
Nuclear 8.2%
Water power 2.7%
Geothermal, solar, and wind 0.8%
Wood, alcohol (ethanol) 2.8%
Lost energy 51%
Used energy 49%
USES OF ENERGY
Industry 33.3%
Home and commerce 38.8%
Transport 27.9%

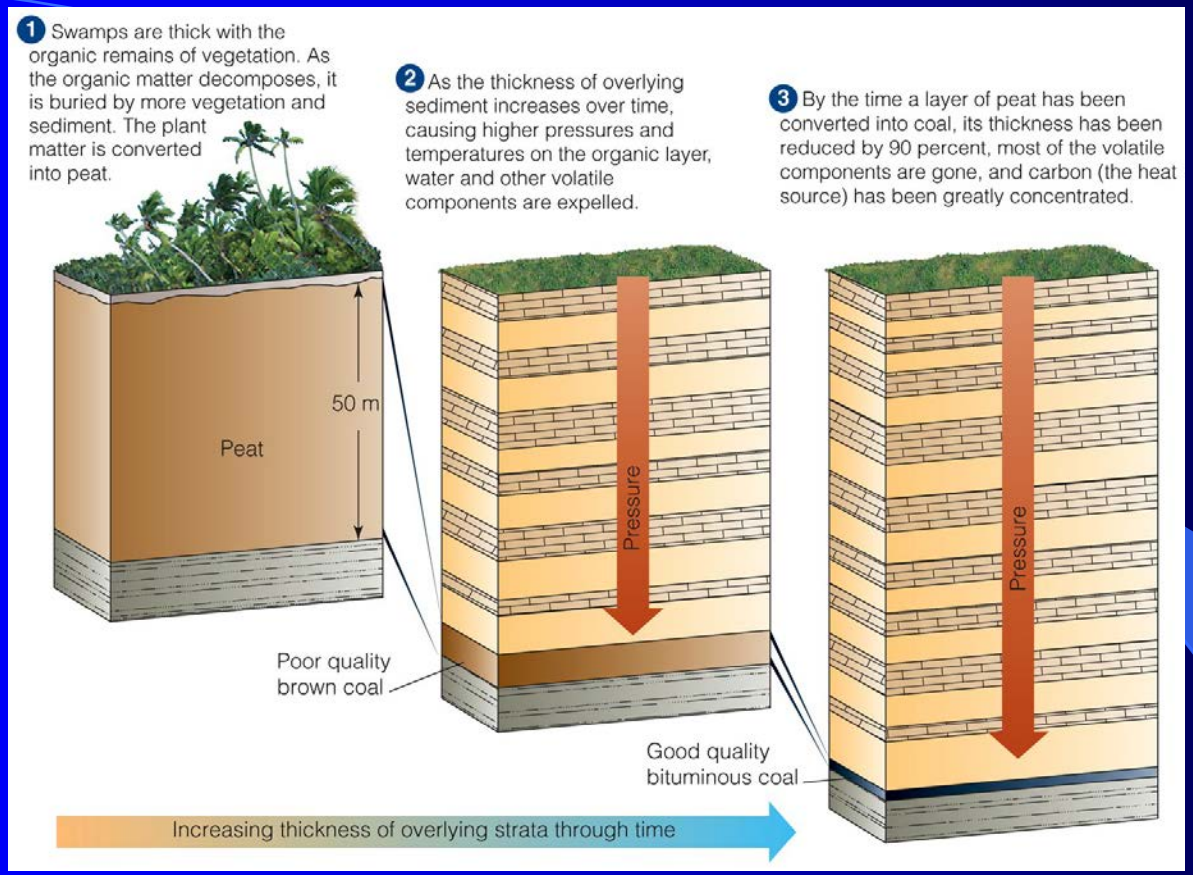
U. S. Energy sources over time

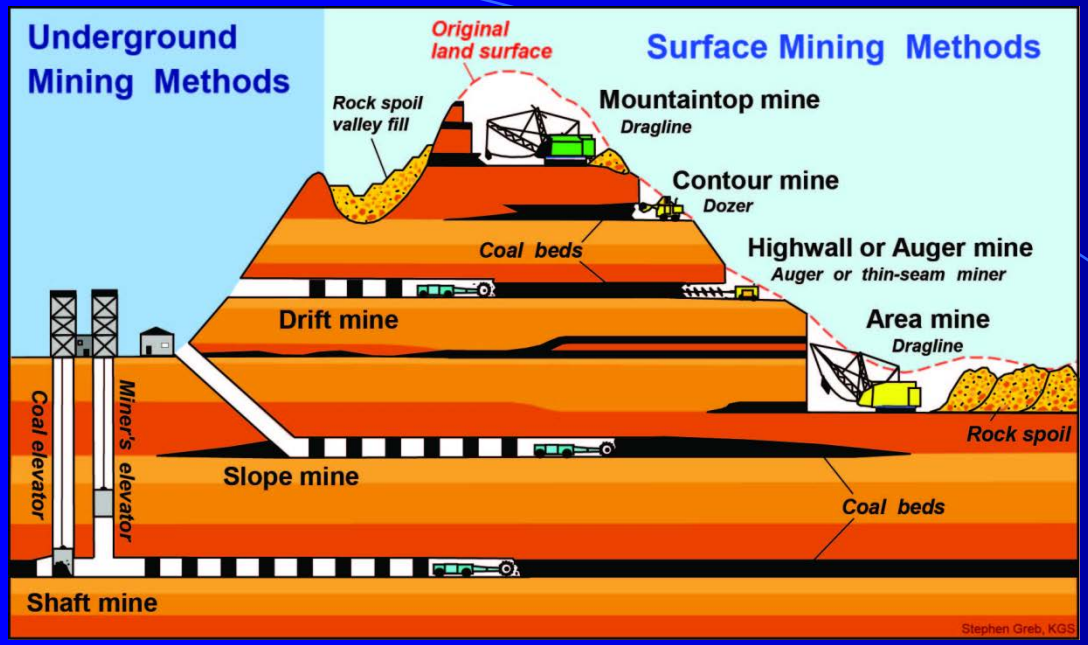


- Fossil fuels - hydrocarbons
  - Coal
  - Oil
  - Natural gas
  - Peat

- The main source of commercial energy worldwide today
- Consist of altered organic matter from the remains of plants or animals, trapped in sediment or sedimentary rock

- Coal
  - Solid fossil fuel derived from terrestrial organic matter
  - Peat forms in water-saturated places such as swamps and bogs
  - Coal forms from peat over millions of years in a process called coalification
    - Lignite, subbituminous, bituminous, and anthracite coal


1 Swamps are thick with the organic remains of vegetation. As the organic matter decomposes, it is buried by more vegetation and sediment. The plant matter is converted into peat.
2 As the thickness of overlying sediment increases over time, causing higher pressures and temperatures on the organic layer, water and other volatile components are expelled.
3 By the time a layer of peat has been converted into coal, its thickness has been reduced by 90 percent, most of the volatile components are gone, and carbon (the heat source) has been greatly concentrated.
50 m
Peat
Pressure
Pressure
Poor quality brown coal
Good quality bituminous coal
Increasing thickness of overlying strata through time

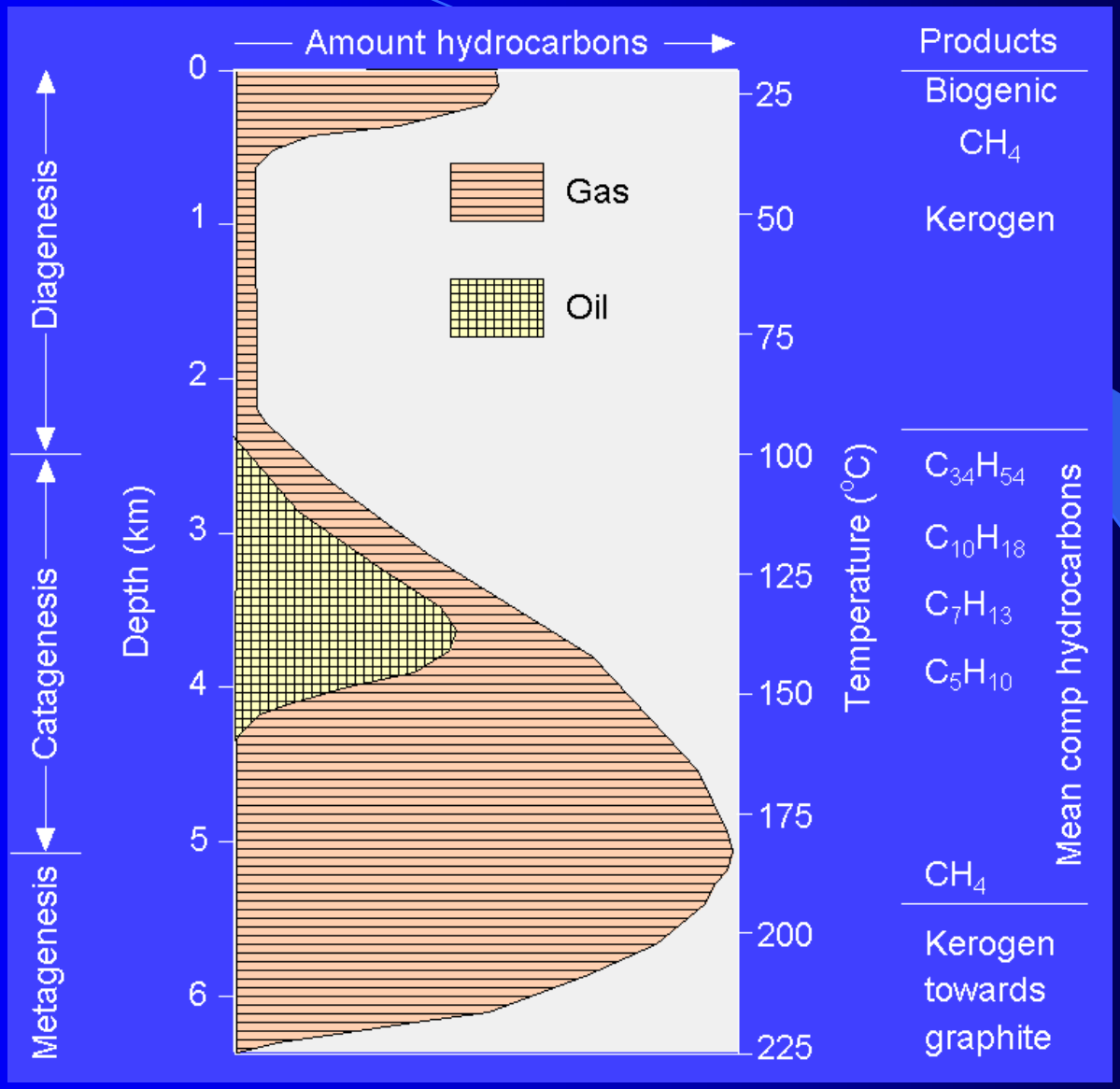

Underground Mining Methods
Original land surface
Surface Mining Methods
Rock spoil valley fill
Mountaintop mine
Dragline
Contour mine
Dozer
Coal beds
Highwall or Auger mine
Auger or thin-seam miner
Drift mine
Area mine
Dragline
Coal elevator
Miner's elevator
Rock spoil
Slope mine
Coal beds
Shaft mine
Stephen Greb, KGS

- Oil and Natural Gas - petroleum
  - Naturally occurring gaseous, liquid, and semi-solid substances that formed in a marine environment
  - During burial and conversion to rock, organic compounds are chemically transformed into petroleum: maturation
  - Without a trap, petroleum would migrate away, escaping, and not be mine-able

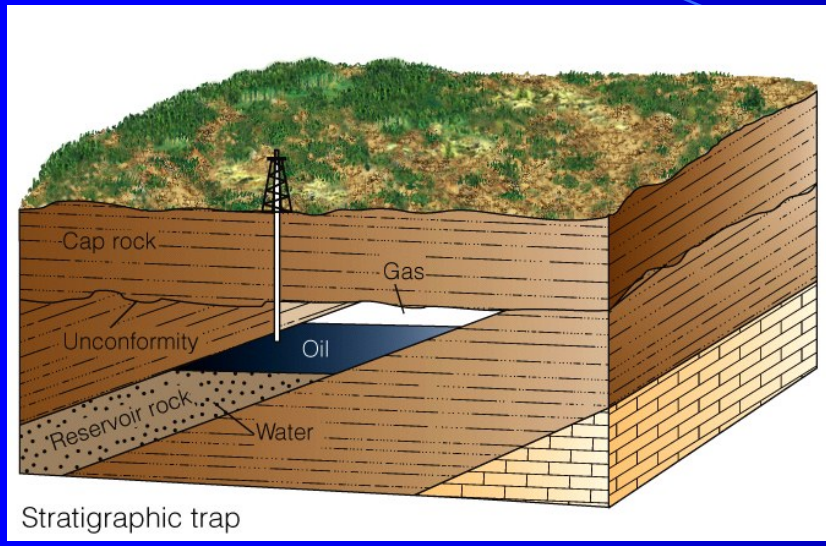
An economic petroleum deposit requires:

- Source rock – an organic-rich sedimentary rock, generally shale or limestone. Chemical processes convert the organic matter to petroleum.
- Reservoir rock – a formation, generally a sandstone or porous limestone, from which the petroleum is extracted.
- Trap – a geologic structure that traps the liquid hydrocarbons.

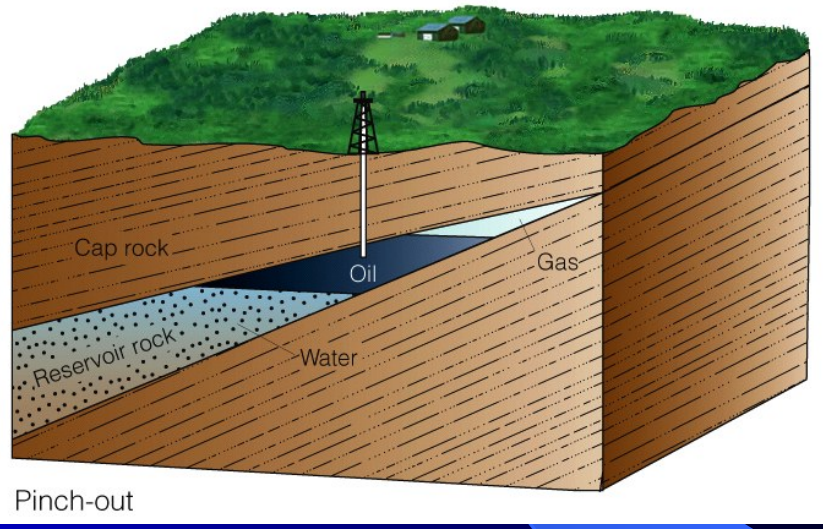
Production of liquid hydrocarbons



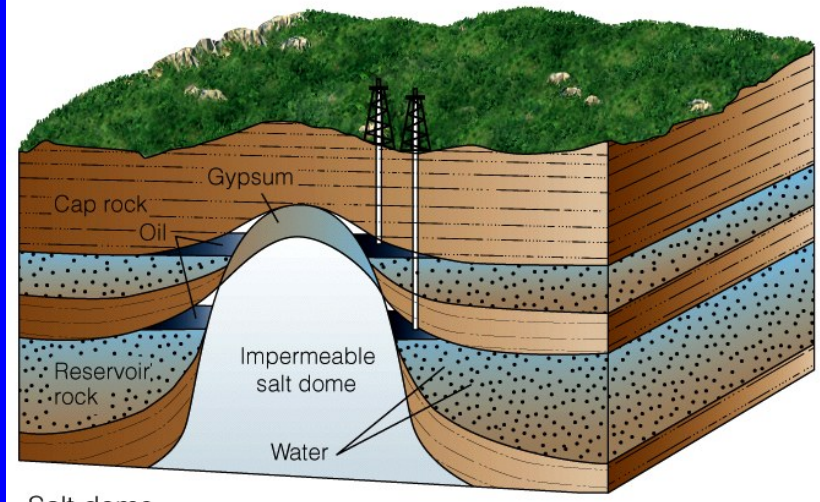
Types of traps



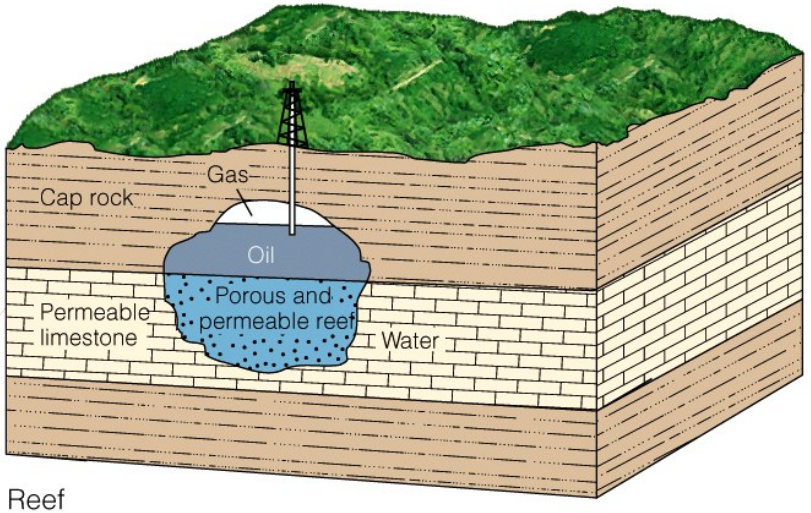
Stratigraphic trap



Pinch-out

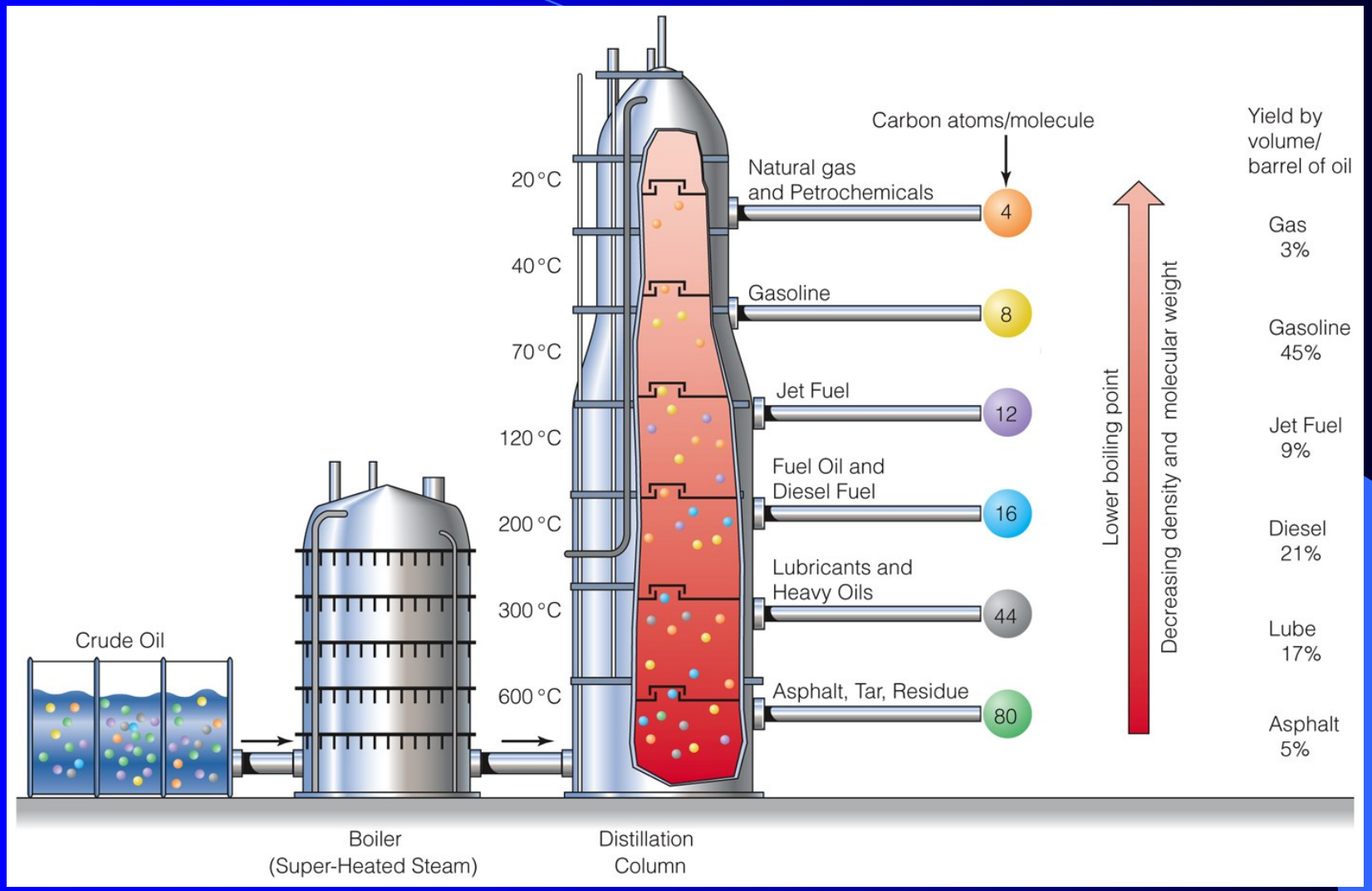


Salt dome

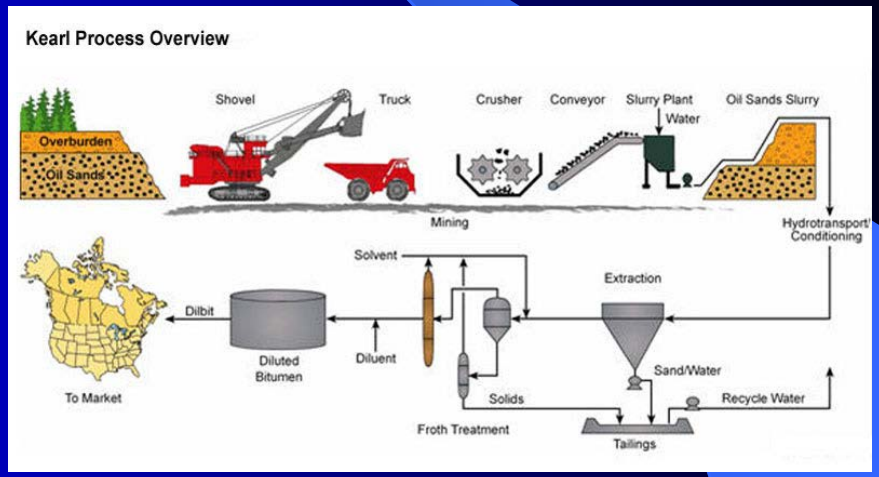


Reef

Cracking of petroleum

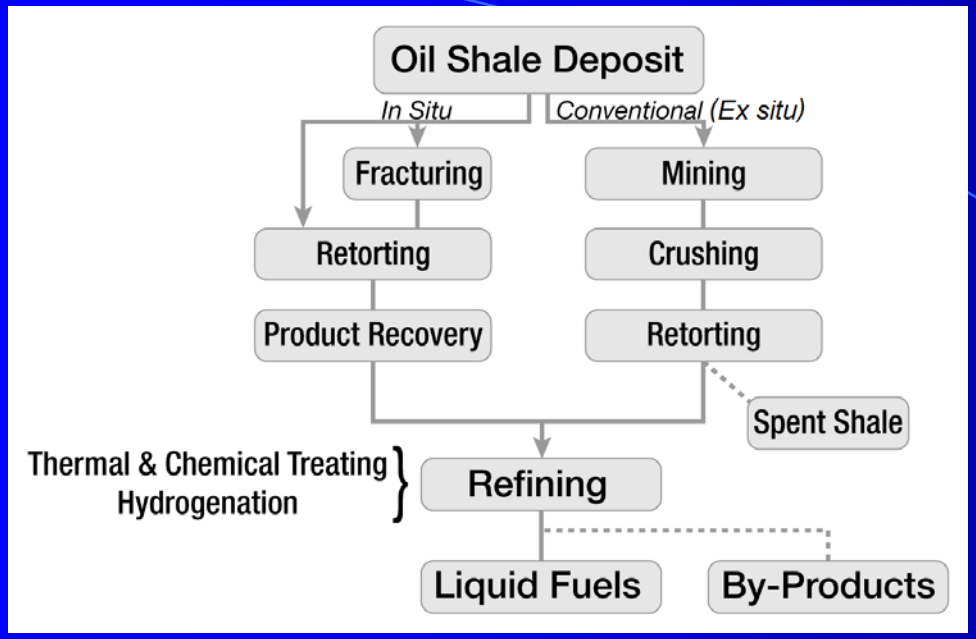


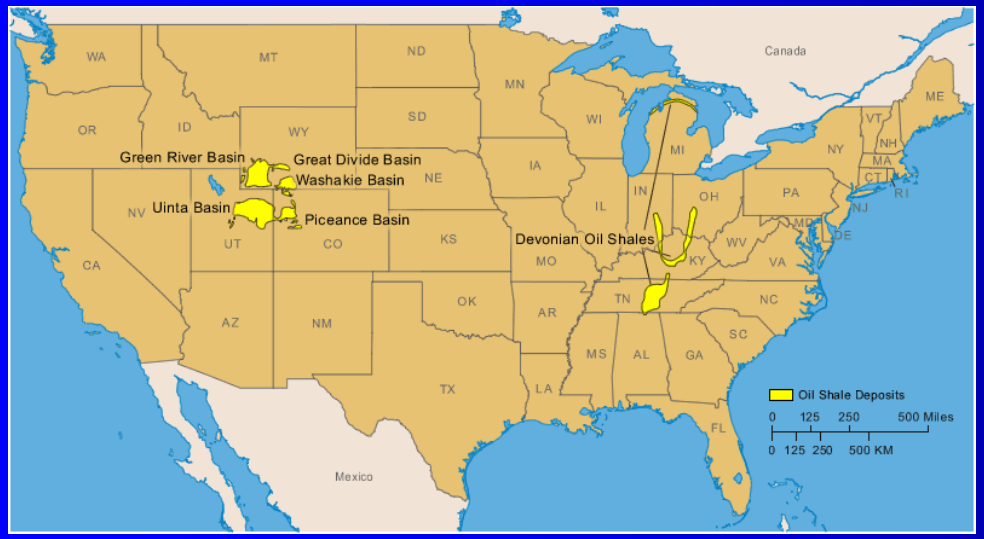
- Unconventional hydrocarbons
  - Tar sands: deposits of dense, thick, asphalt-like oil called tar
  - Oil shale: a wax-like compound called kerogen in fine-grained sedimentary rocks
  - Shale gas: natural gas trapped in shale
  - Gas hydrates: deposits of frozen methane in permafrost and seafloor sediments

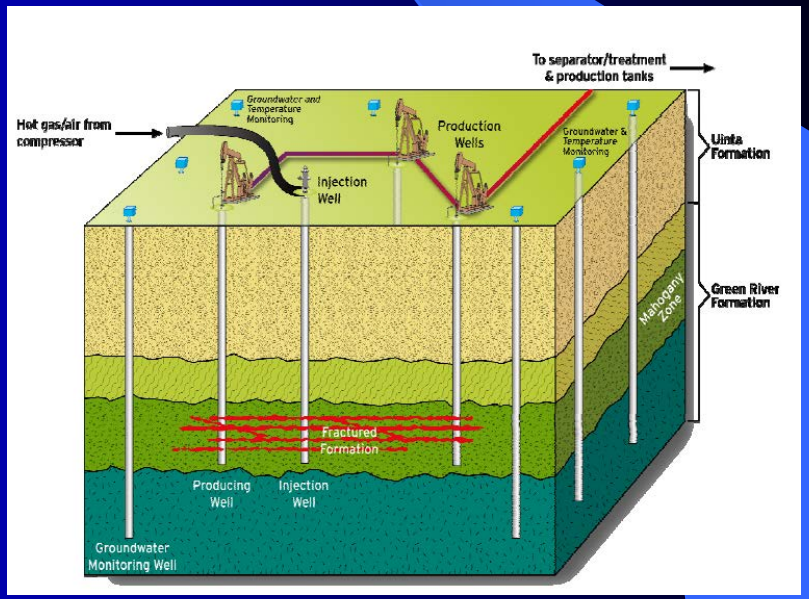


Alberta Tar Sands

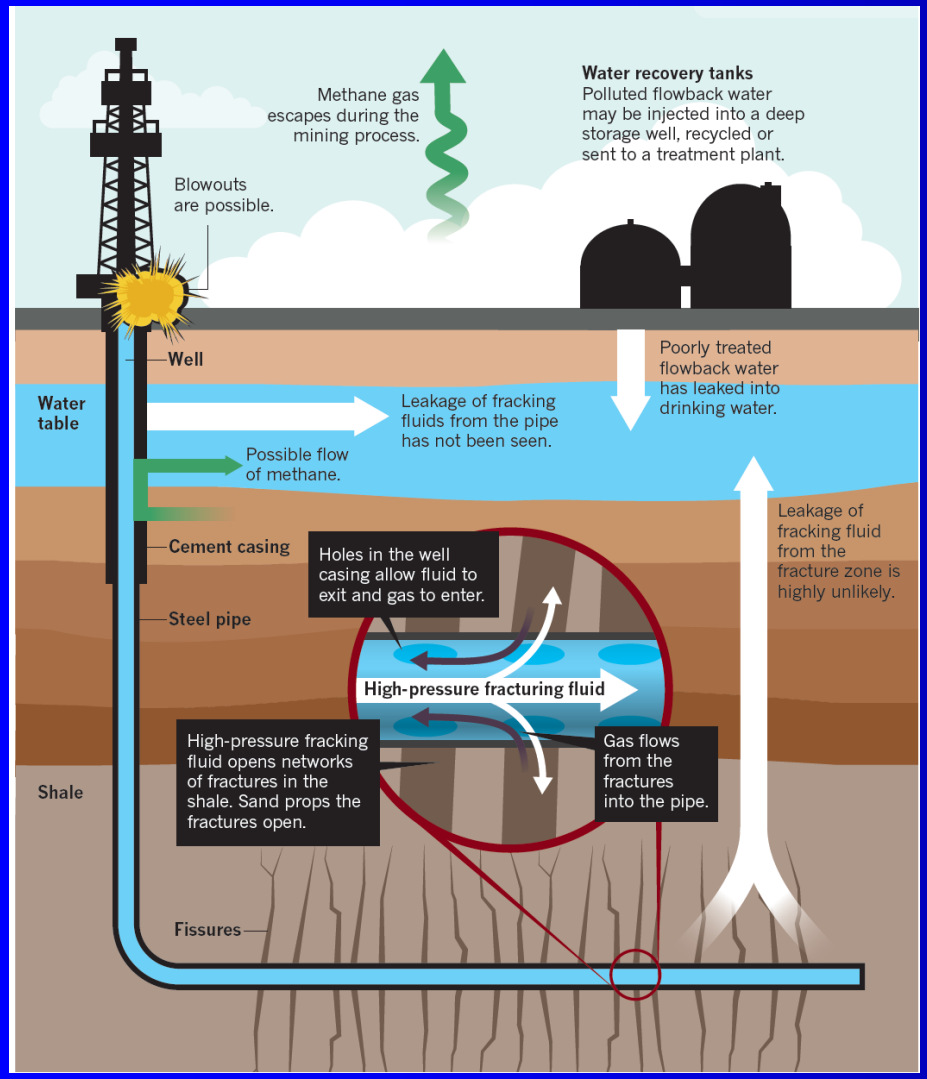
Oil shale

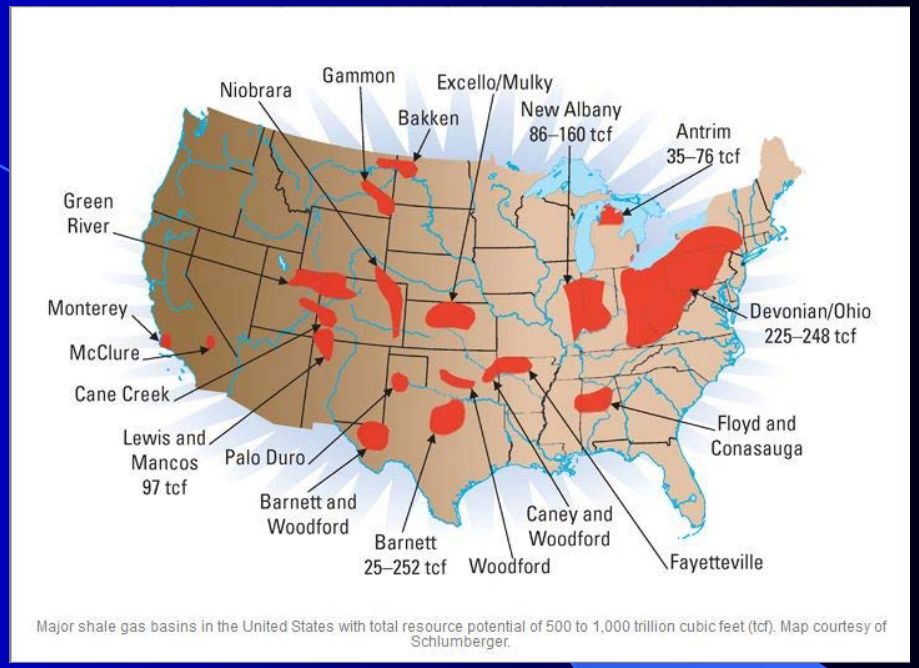

Oil Shale Deposit
In Situ
Conventional (Ex situ)
Fracturing
Mining
Retorting
Crushing
Product Recovery
Retorting
Spent Shale
Thermal & Chemical Treating
Hydrogenation
Refining
Liquid Fuels
By-Products


Green River Basin
Great Divide Basin
Washakie Basin
Uinta Basin
Piceance Basin
Devonian Oil Shales
Canada
Mexico
Oil Shale Deposits
0 125 250 500 Miles
0 125 250 500 KM

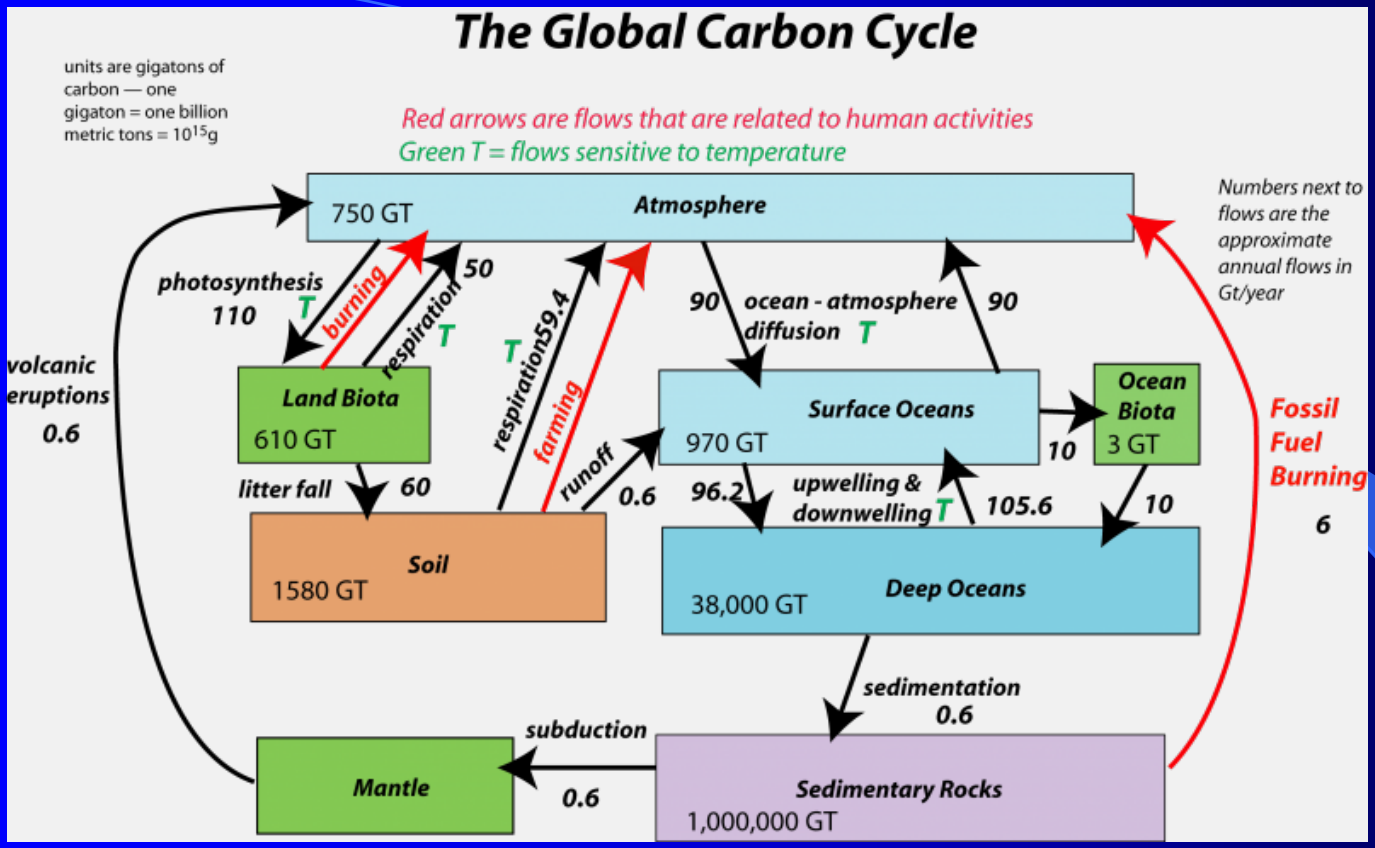

To separator/treatment & production tanks
Hot gas/air from compressor
Groundwater and Temperature Monitoring
Production Wells
Groundwater & Temperature Monitoring
Injection Well
Uinta Formation
Mahogany Zone
Green River Formation
Fractured Formation
Producing Well
Injection Well
Groundwater Monitoring Well

Shale gas and fracking

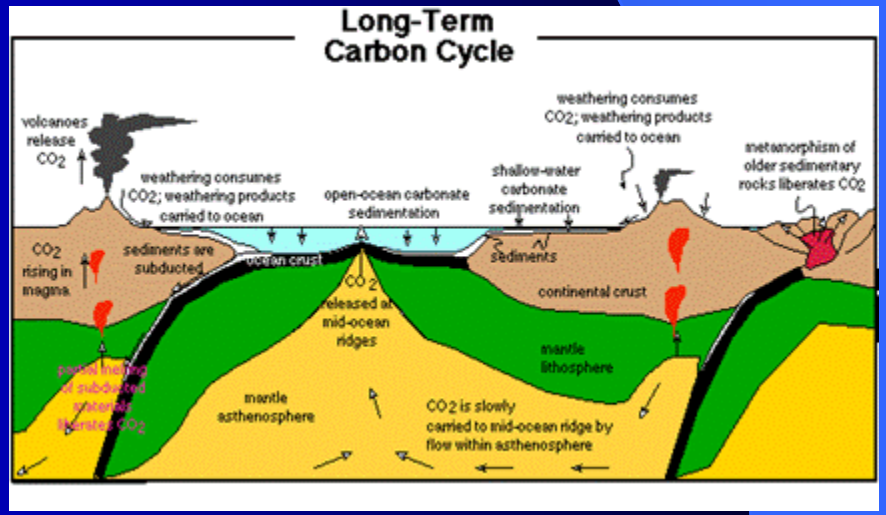




Major shale gas basins in the United States with total resource potential of 500 to 1,000 trillion cubic feet (tcf). Map courtesy of Schlumberger.



The long-term carbon cycle represents the formation of fossil fuels while the global carbon cycle represents the rate at which fossil carbon is being returned to the Earth's surface.

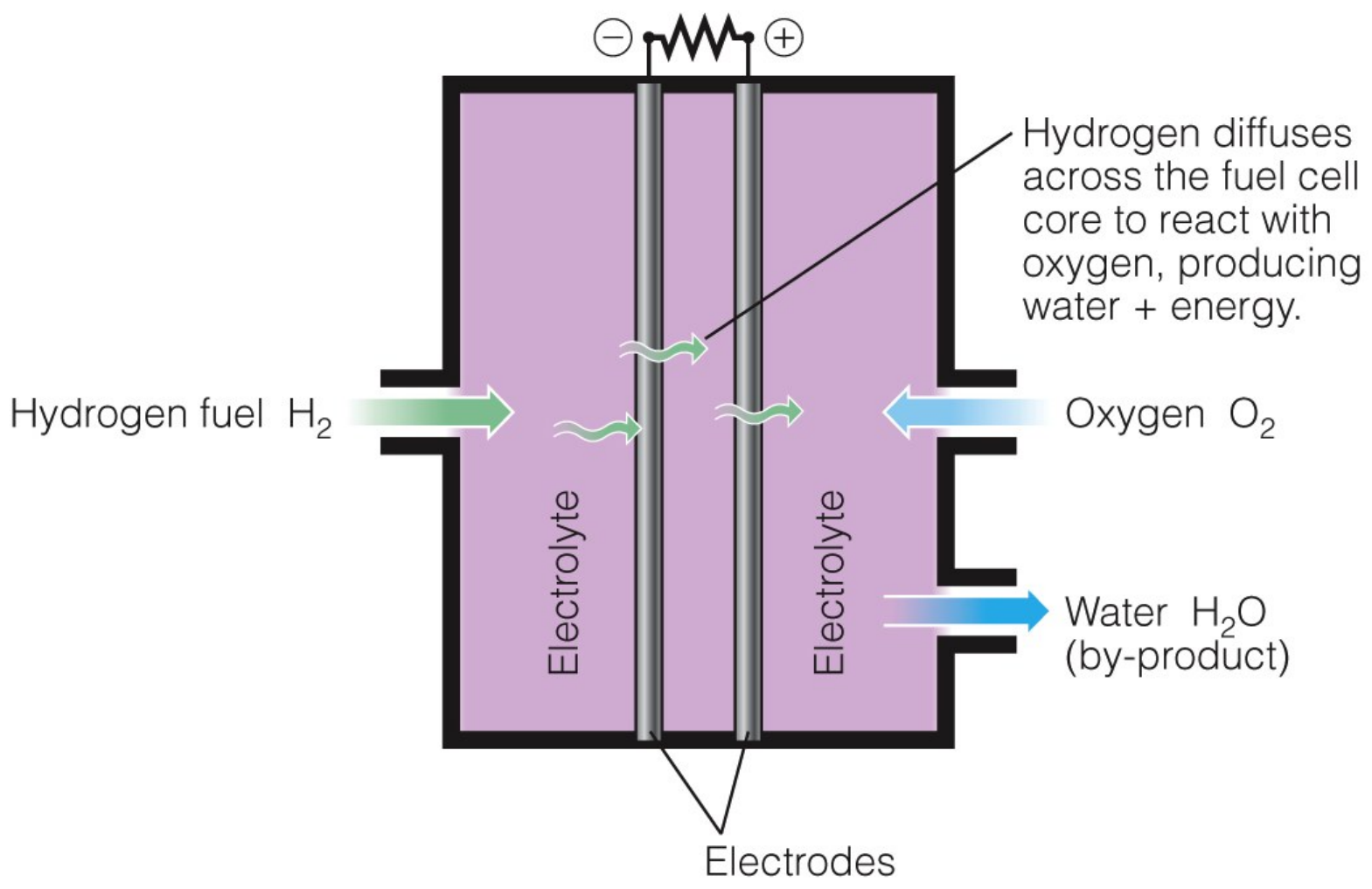


- Alternative energies to fossil fuels
  - Solar, hydrogen, and biomass
  - Wind and wave
  - Hydroelectic, tidal, and geothermal
  - Nuclear
- Solar energy and hydrogen
  - Can be used to supply heat
    - Passive or active solar heating
  - Can be converted into electricity through
    - Solar thermal electric generation
    - Photovoltaic cells
  - Can be used to split water into hydrogen and oxygen: electrolysis
    - Generates hydrogen for fuel cells

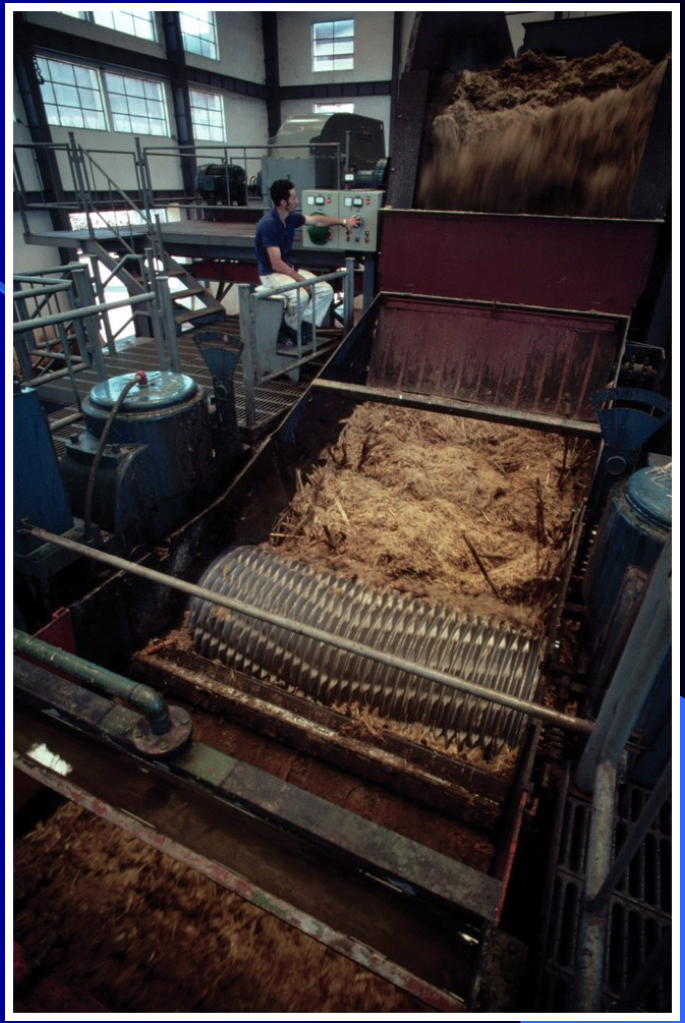
Active solar heating

Photovoltaic cells

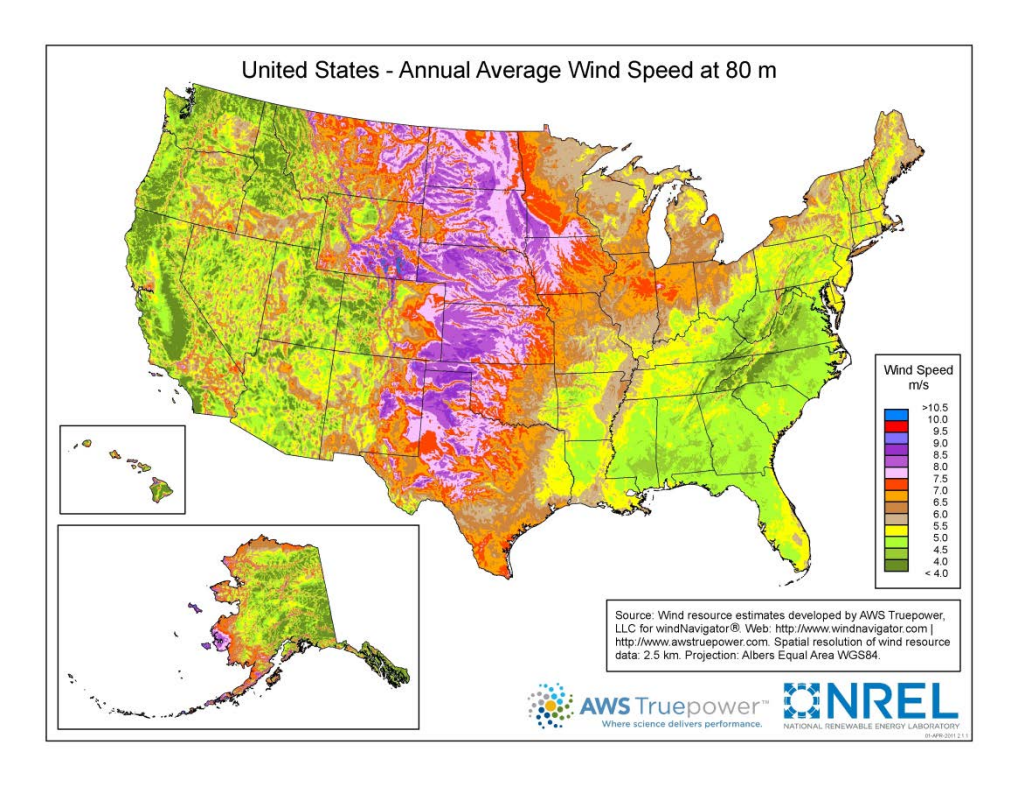
Hydrogen fuel cells

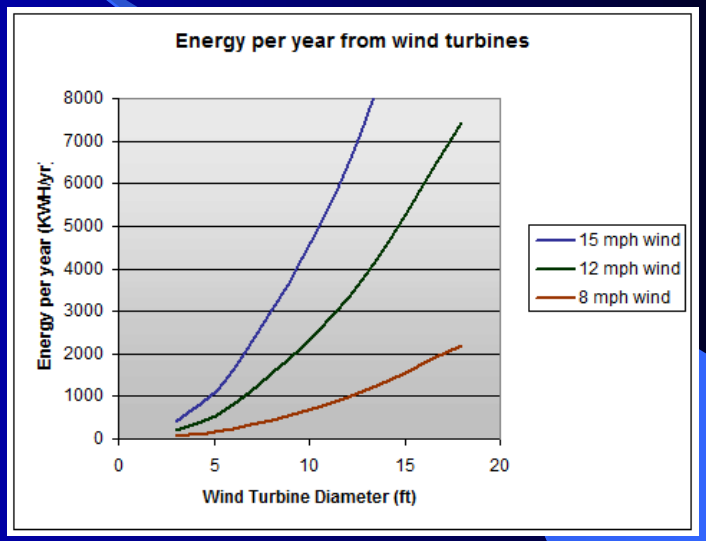


- Biomass energy
  - Derived from Earth's plant life
    - Fuel wood
      - 1 billion + people use this for cooking and heat
    - Peat
    - Animal dung
      - Converted into methane produces biogas
    - Agricultural waste
      - Methane gas can be collected from landfills
  - Can be converted into the liquid fuels ethanol and methanol

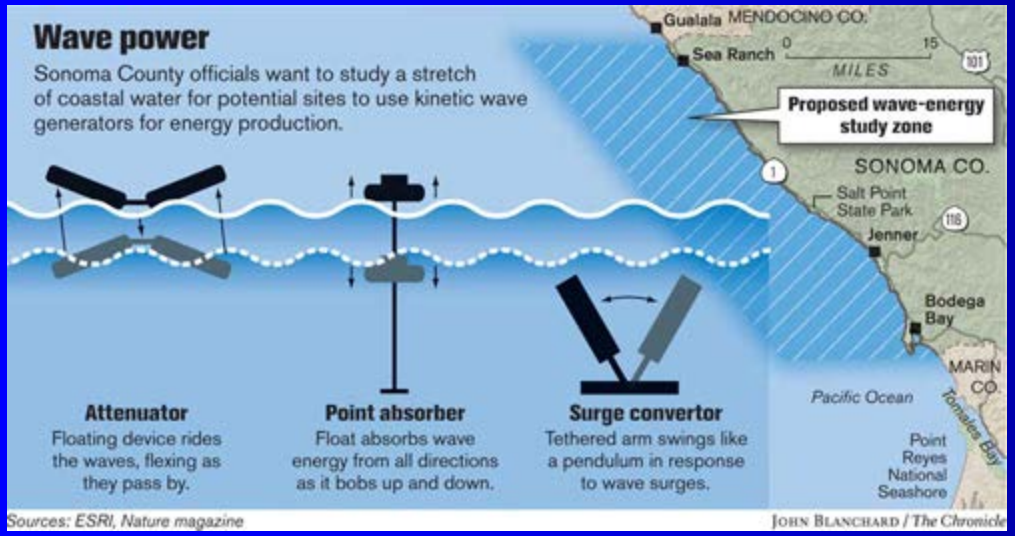


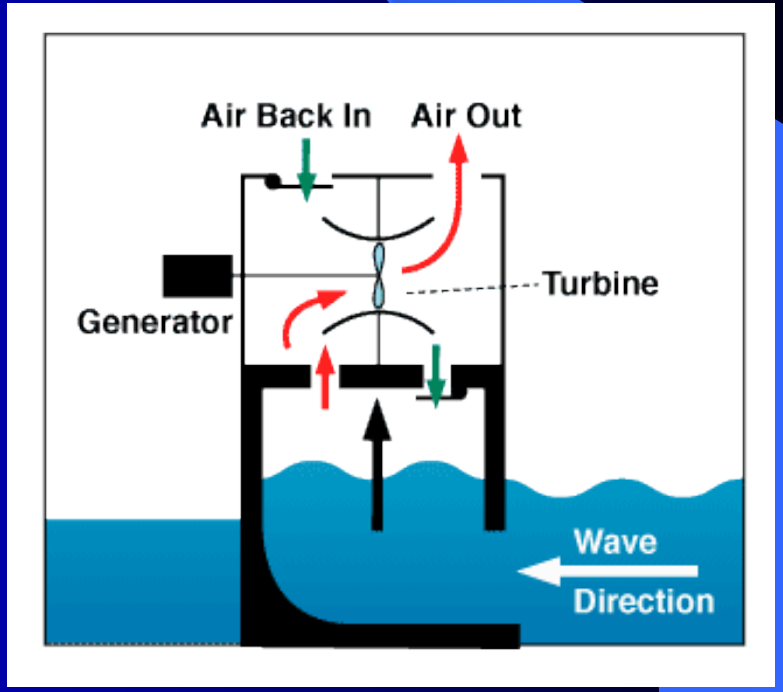
- Wind energy
  - An indirect expression of solar energy
  - Will soon be cost-competitive with coal-burning power plants
  - However existing power grids will not be able to bring electricity from production sites to where it will be used



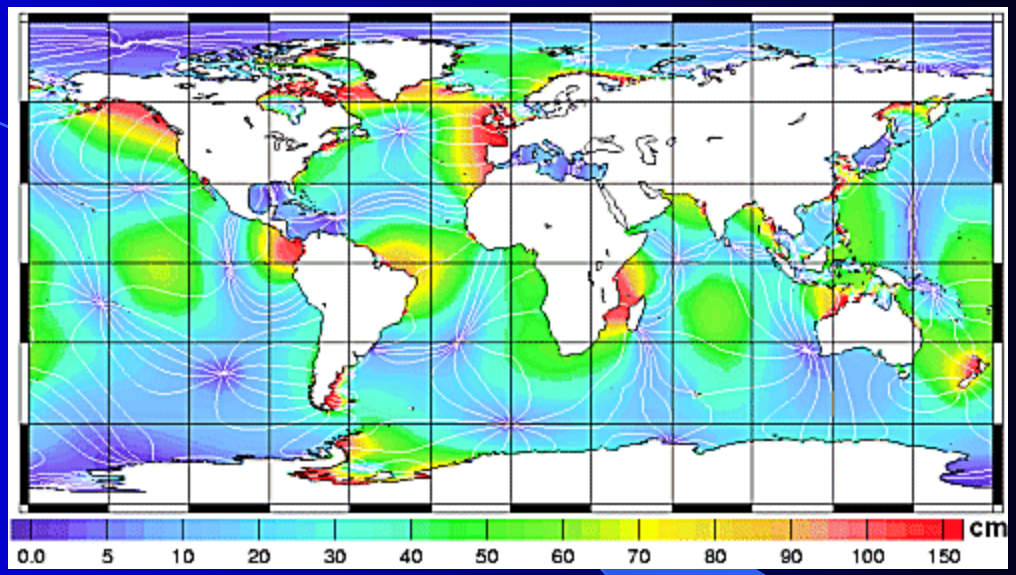


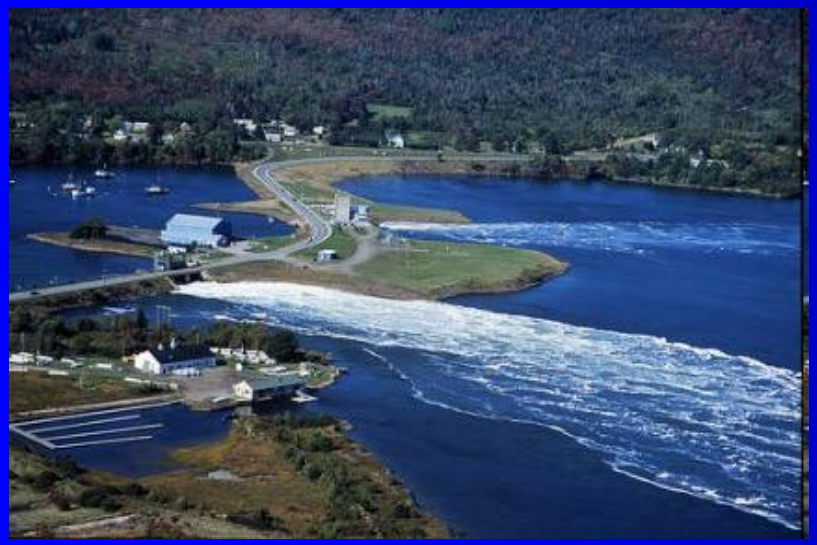
- Wave energy
  - Also an indirect expression of solar energy
  - Small-scale power stations produce electricity using a hollow, tubelike chamber containing a turbine
  - Waves push air into the chamber, spinning the turbine, generating electricity

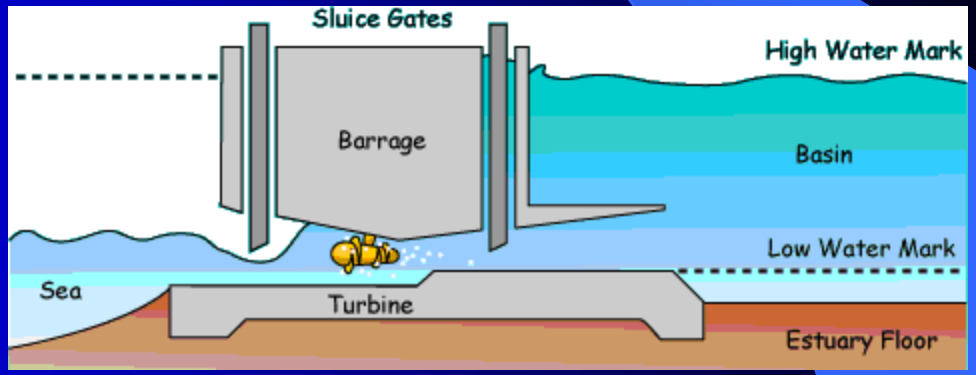




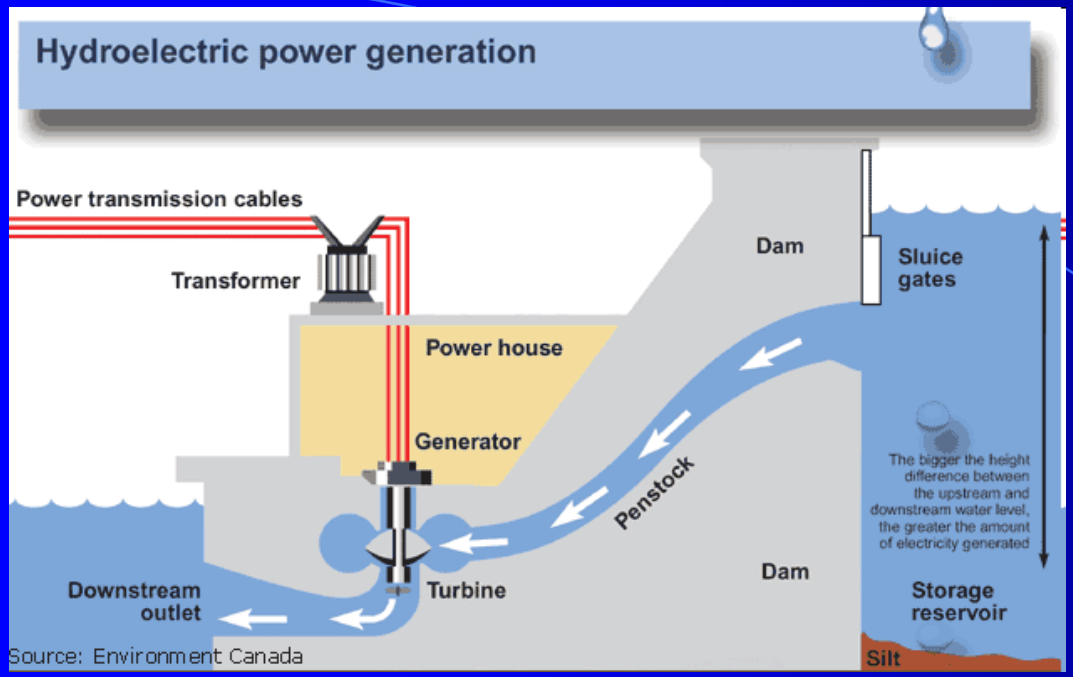
- Tidal energy
  - Also water and gravity based energy
  - A dam is constructed across the mouth of a narrow bay, water flows in during high tide and out during low tide
  - When water is released at low tide, it drives a turbine, producing electricity



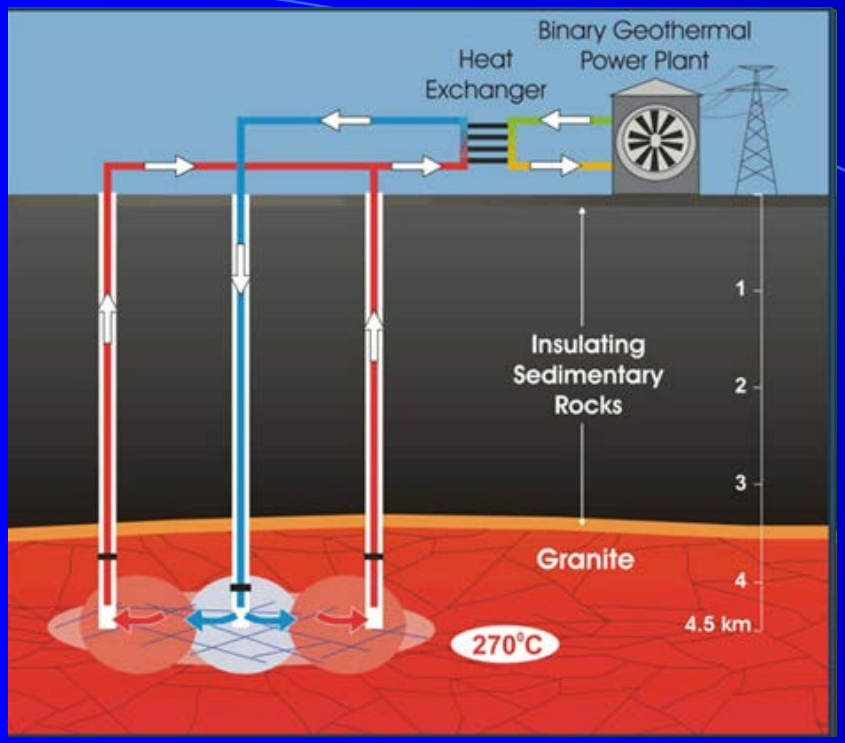




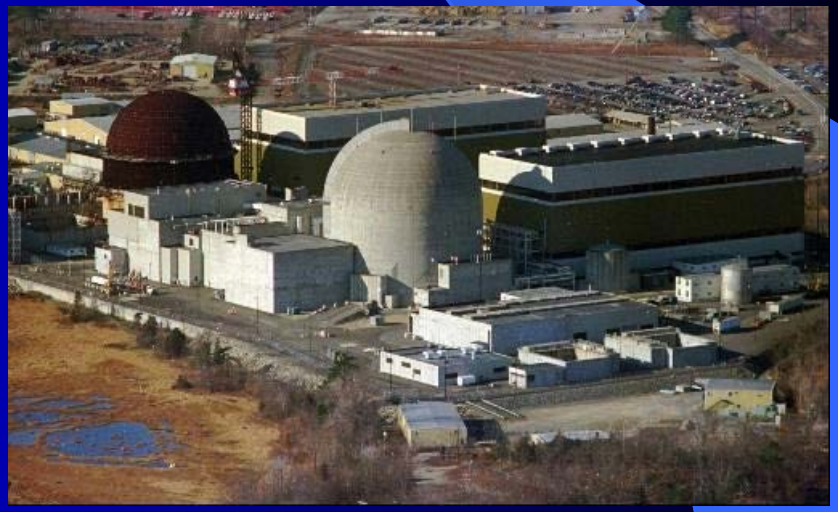
- Hydroelectric energy
  - Generated from the energy of a stream of water flowing downhill
  - The only form of water-derived energy that currently fulfills a significant portion of the world's energy needs
  - To generate hydroelectric power, it is necessary to build a dam

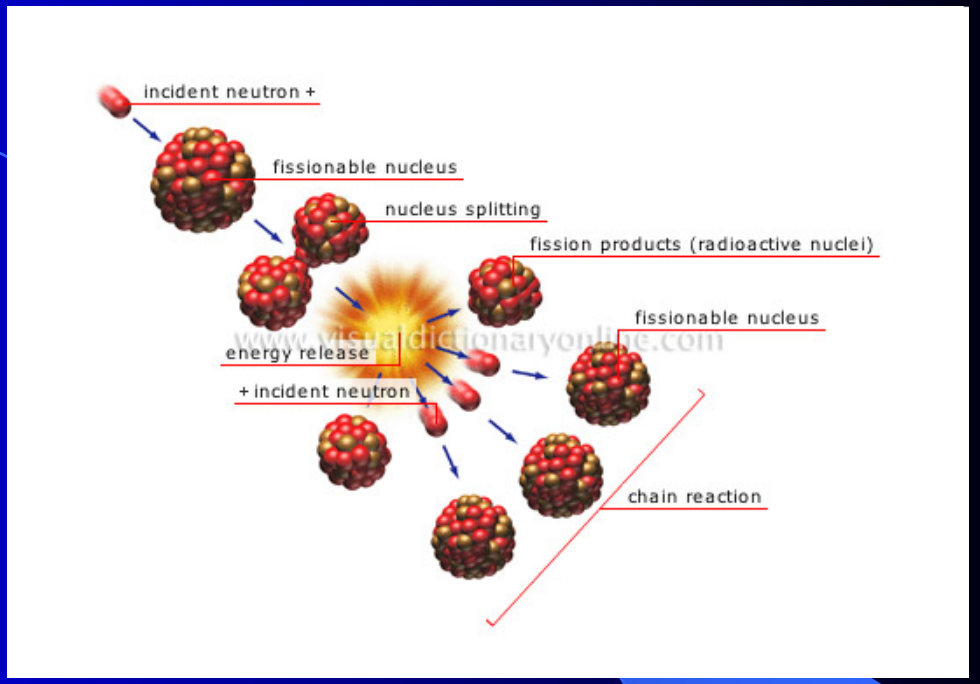

Hydroelectric power generation
Power transmission cables
Transformer
Power house
Generator
Penstock
Turbine
Downstream outlet
Dam
Sluice gates
The bigger the height difference between the upstream and downstream water level, the greater the amount of electricity generated
Dam
Storage reservoir
Silt
Source: Environment Canada

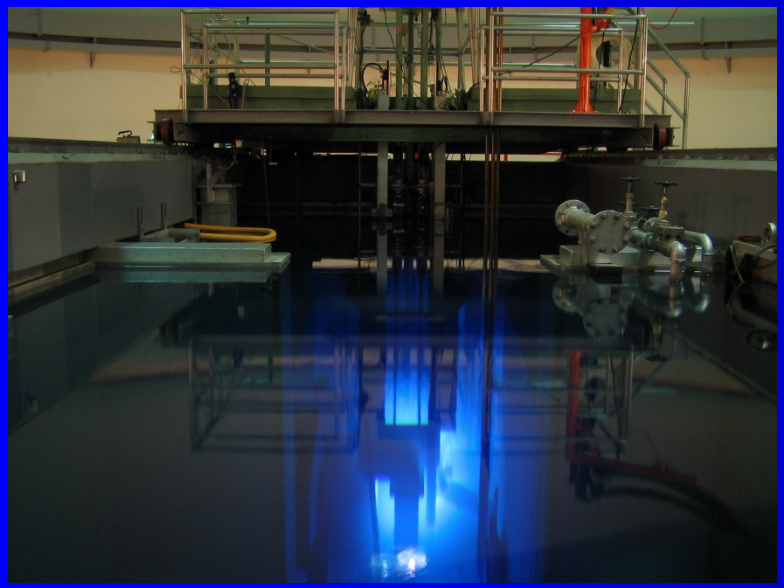
- Geothermal energy
  - Hot rocks can be used to heat water
  - Volcanically produced steam can turn a turbine to generate electricity
  - Hydrothermal reservoirs, 200˚C or hotter, are most easily and efficiently exploited
  - Ground source heat pumps use small temperature differences between the ground surface and the shallow subsurface


Binary Geothermal
Power Plant
Heat
Exchanger
Insulating
Sedimentary
Rocks
Granite
1
2
3
4
4.5 km
270°C

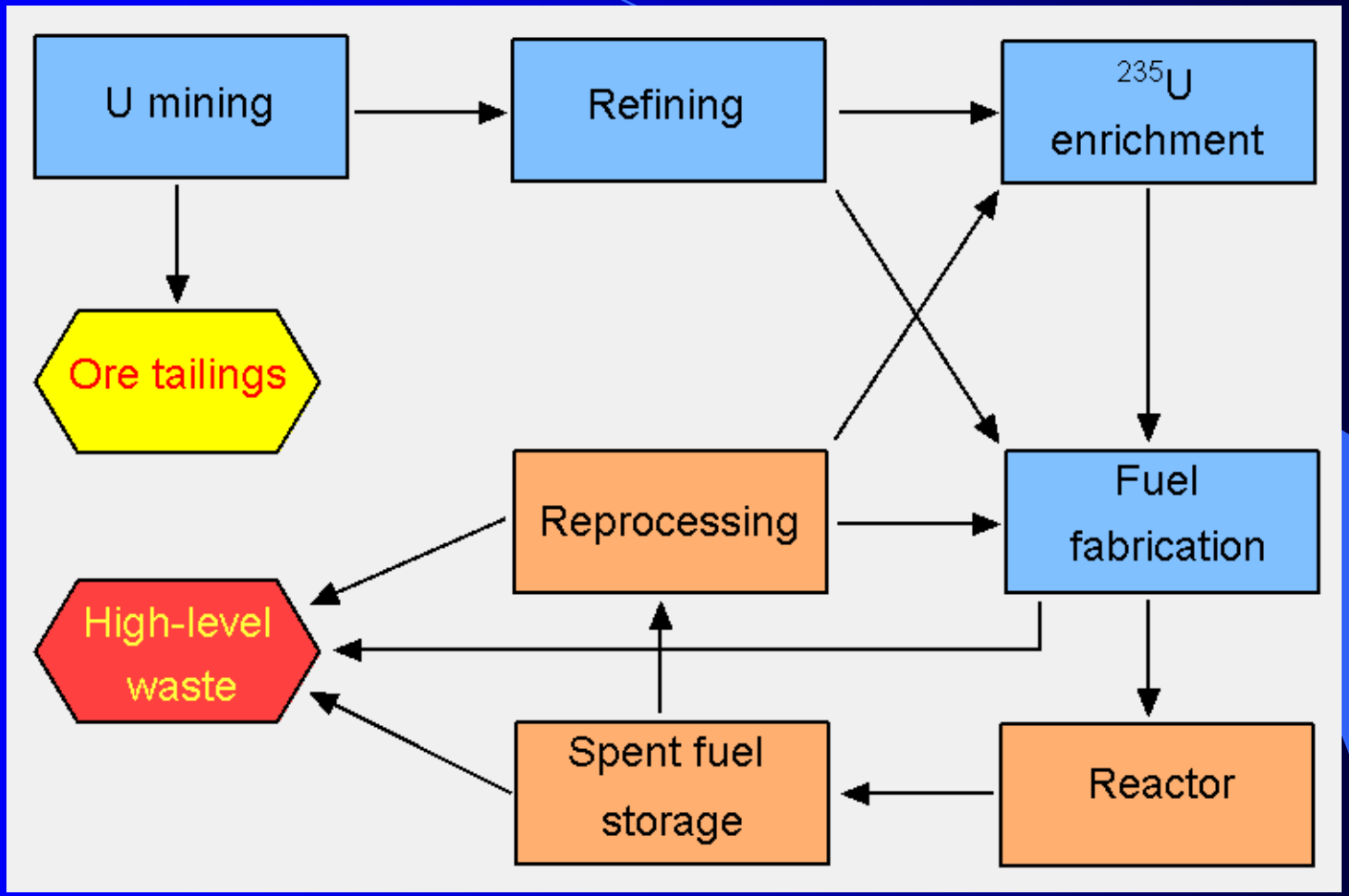
- Nuclear energy
  - Comes from the heat energy produced during the induced transformation of a chemical element into other chemical elements
  - Can be generated two ways
    - Fission: splitting heavy atoms into lighter atoms
    - Fusion: joining together of two small atoms to create a single larger atom - like the Sun - but not available with our current technology
  - Uranium-235 is primarily used as fuel in nuclear fission reactors
  - Current nuclear reactor technologies are designed to eliminate meltdowns
  - Considered clean energy because there are no harmful atmospheric emissions
    - However, highly radioactive nuclear waste must be isolated from the bio- and hydrosphere




incident neutron +
fissionable nucleus
nucleus splitting
fission products (radioactive nuclei)
fissionable nucleus
energy release
+ incident neutron
chain reaction



The nuclear fuel cycle



- We need to find sources of energy for the future that will meet society's needs in a way that is socially, environmentally, and economically acceptable
- Fossil fuels cause environmental impacts at every stage from extraction, refining, transport, and usage

- Increasing concerns about fossil fuel use will inevitably lead to greater interest in alternative sources of energy