Section C

Conventional Energy Sources: Selection of site, capacity calculations, classification, Schematic diagram and working of Thermal Power Stations, Hydro Electric Plant, Nuclear Power Plant and Diesel Power Stations.

Non-conventional Energy Sources: Wind, Solar, Tidal, Ocean , and Geothermal sources of Energy, fuel cell, Magneto Hydro Dynamic (MHD) system

Topic Covered

- CONVENTIONAL ENERGY SOURCES: Selection of site, capacity calculations, classification,
- Schematic diagram and working of Thermal Power Stations, Hydro Electric Plant, Nuclear Power Plant and
- Diesel Power Stations.

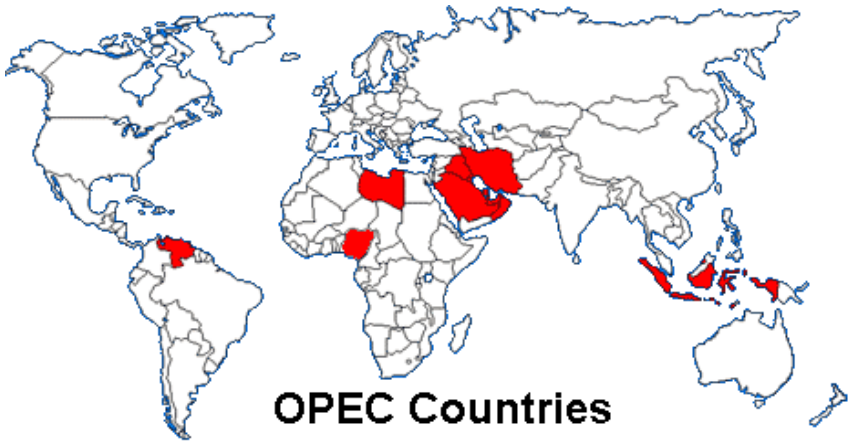
Conventional Energy Sources

Why do we need energy?

- Transportation
- Heating homes
- Cooking
- Power machinery used for agriculture, industry/business, homes
- What else?

Some terminology…

- ***Work-*** application of force thru a distance.
- ***Energy-*** capacity to do work
- ***Power-*** rate of flow of energy or rate at which work is done.
- ***OPEC-*** Organization of Petroleum Exporting Countries
  - Includes: Algeria, Ecuador, Gabon, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, & Venezuela
  - 13 countries that hold about 67% world oil reserves



Some conversion factors

- One calories is the amount of energy needed to heat 1g of water 1°C.
- A kilocalorie is 1,000 calories
- 1 BTU = energy to heat 1 lb of water 1°F
- 1 watt (W) = 3.412 Btu/hour
- 1 horsepower (hp) = 746 W
- Watt-hour- used to describe electrical energy. Usually use kilowatt-hour (kWh)/ it is larger.

Thermodynamics

- Laws of thermodynamics tell 2 things about converting heat energy from steam to work…
  - Conversion of heat to work is not 100% efficient because a portion of the heat is wasted
  - Efficiency of converting heat to work increases as the heat temperature increases.

History of Energy Usage

- Fire
- Muscle power from animals
- Wind & water usage
- Steam engines powered by wood fires
- Steam engines powered by coal
- Now we use oil more because it is easier to ship, store & burn.
- Oil use peaked in 1979, so did prices thanks to Arab oil embargo & Iranian revolution.
- 1980's began pursuing renewable energies but then oil prices fell and we went back to oil.
- In 2000, OPEC decreased production and prices went up to $30 per barrel
- Now oil costs $90-$100 per barrel

Energy Sources

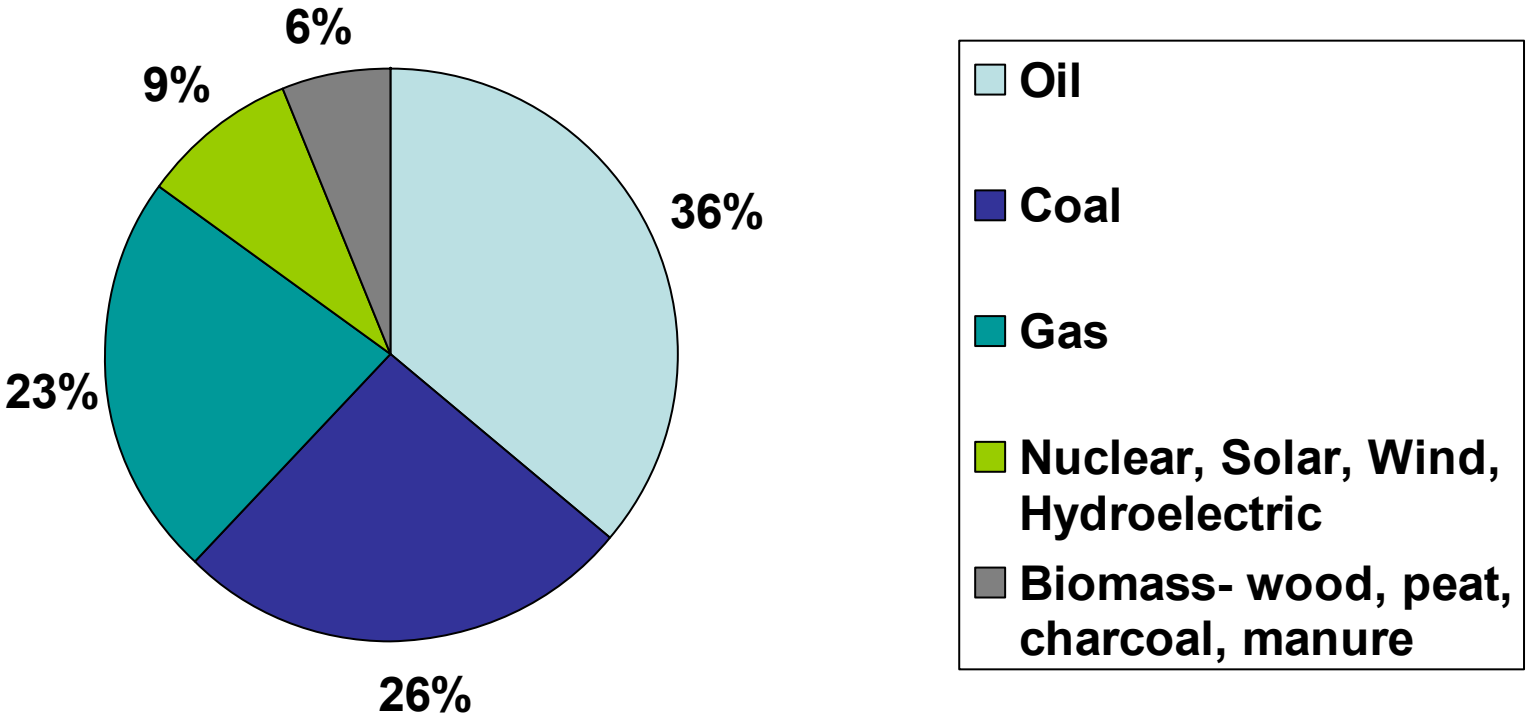
- **Primary Energy sources-**
  - Fossil fuels (oil, natural gas, coal)
  - Nuclear energy
  - Falling water, geothermal, solar
- **Secondary Energy sources-**
  - Sources derived from a primary source like…
    - Electricity
    - Gasoline
    - Alcohol fuels (gasohol)

A few facts…

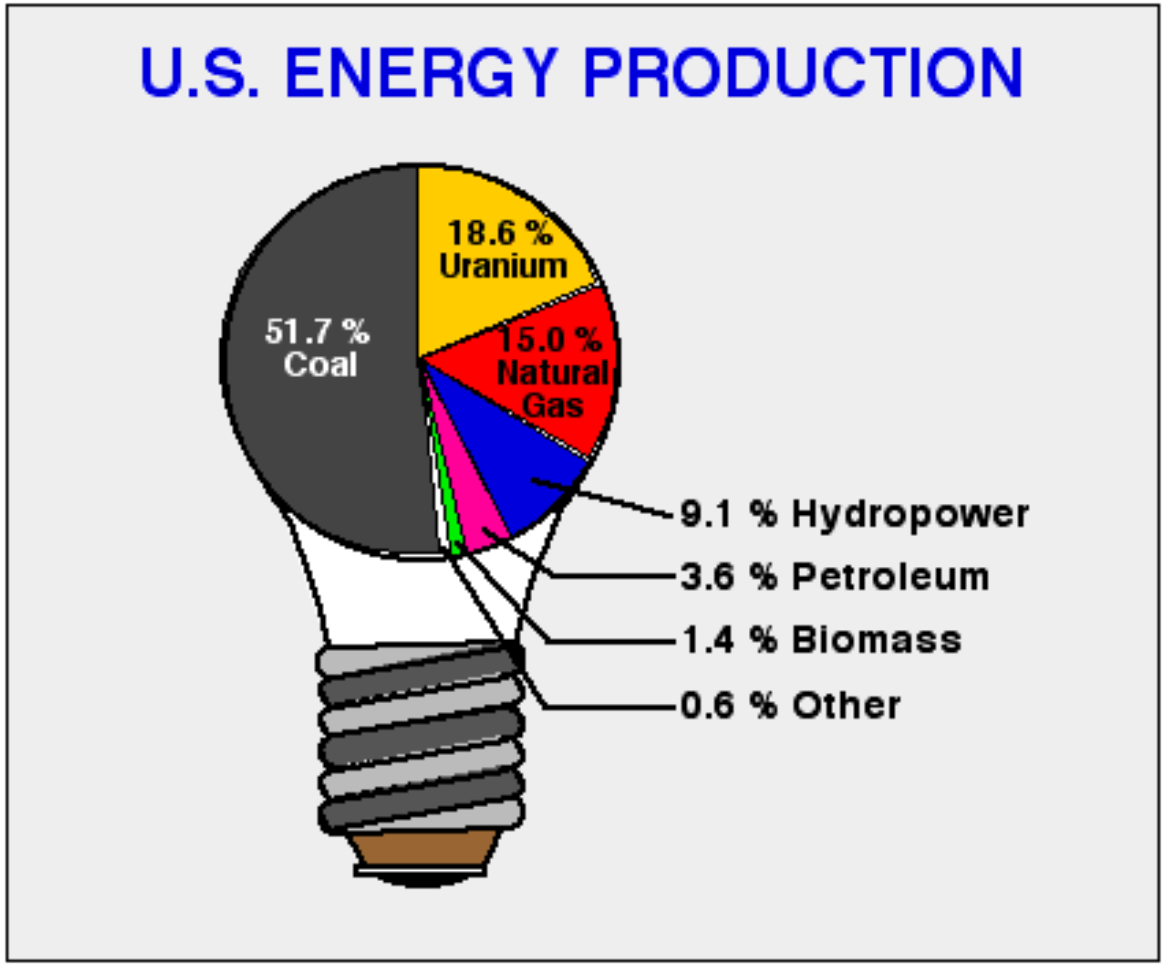
- One barrel holds 42 gallons of oil.
- About 20 gallons of gasoline can be made from one barrel of oil (through fractional distillation.)
- On average, each person uses 25 barrels of oil each year for their energy “needs”.
- The U.S. Strategic Petroleum Reserve stores 570 million barrels of oil in underground salt caverns along Gulf coast. This is about a 60 day supplies worth.
- We import ½ of our oil from unstable countries.

- The U.S. has 1/20th (5%) of the world's population (300 million people) but we consume 24% of the world's energy
  - 84% from fossil fuels (coal, oil, natural gas)
  - 7% from nuclear power
  - 9% from renewable resources (hydropower, geothermal, solar, and biomass).

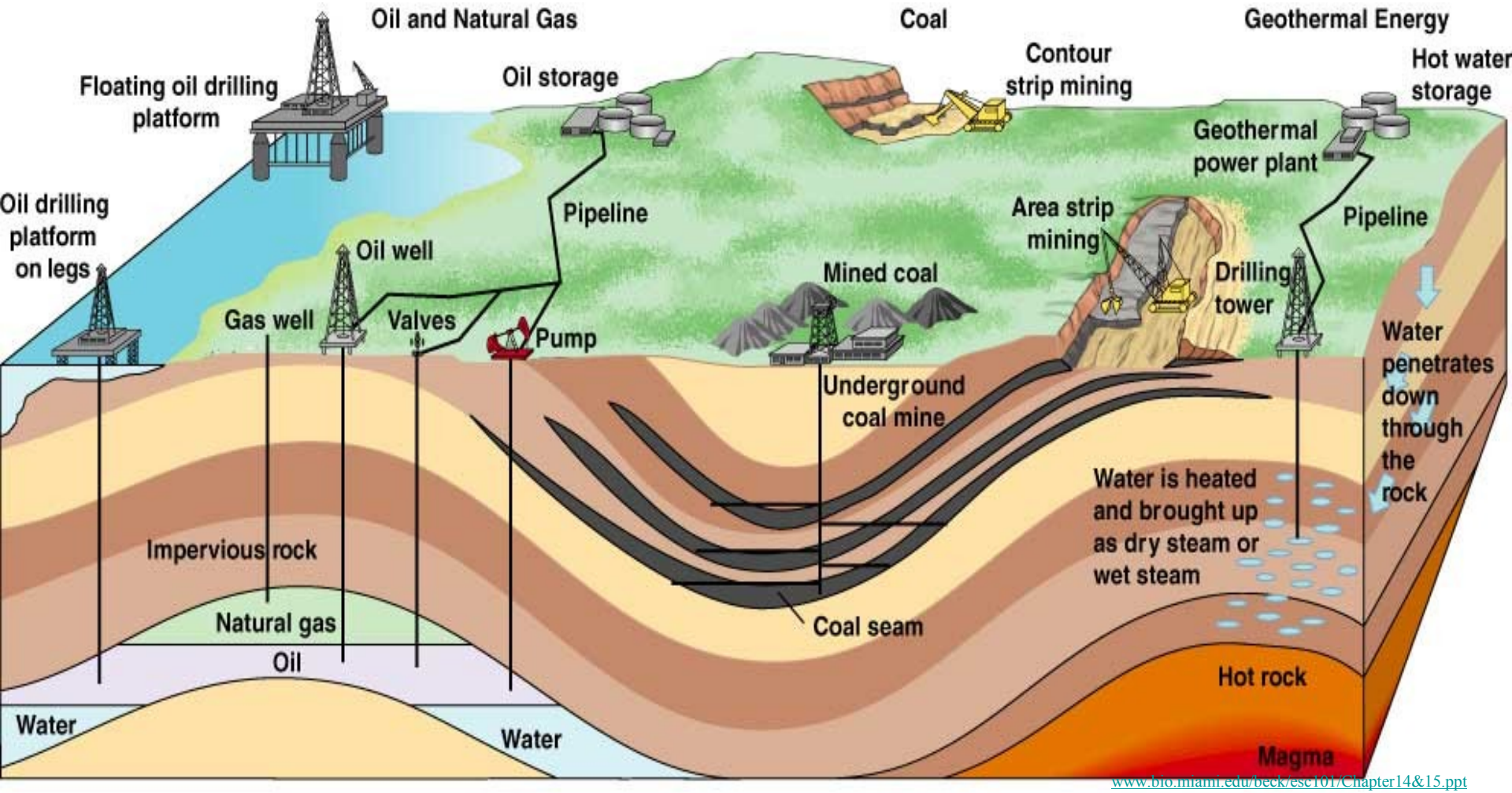
World Energy Production



U.S. Energy Production

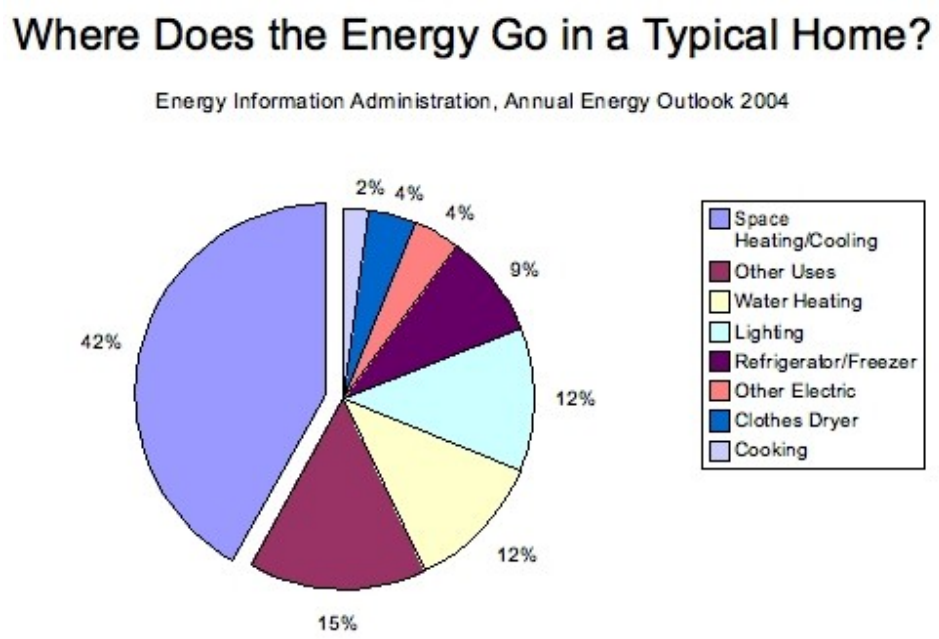


Energy resources removed from the earth's crust include: oil, natural gas, coal, and uranium



How is energy used in the U.S.?

- 38% used for industry
  - 1/4th used in mining, smelting of metals
  - Chemicals- some used in energy generation & some is raw material for making of plastic, solvents, lubricants
  - Foods, paper, tile, cement, glass production
- 36% is used for residential or commercial buildings
  - Space heating, air conditioning, lighting, water heating, small electrics
  - Could an office generate enuf heat from copiers, computers, lights, etc so they don't need to heat?
- 26% is used for transportation
  - 98% of this energy comes from petroleum (oil) refined into liquid fuels (gasoline)
  - 2% of this energy comes from natural gas and electricity.



How is energy lost?

- About ½ of all primary energy is lost when converted to more useful forms
- **Coal**
  - 66% is lost to thermal conversion when energy in coal is converted to electricity.
  - 10% is lost when transmitted to you at home.
- **Oil**
  - 75% lost during distillation, transportation, storage, combustion in vehicles
- **Natural Gas**
  - 10% lost in shipping & processing
  - Most efficient and least polluting (has more H than C so produces less CO_2 when burned so contributes less to global warming.)

Problems with Fossil Fuels

- Non-renewable
  - At projected consumption rates, natural gas & petroleum will be depleted by the end of the 21st century
- Impurities are major source of pollution
  - SO_2 travels on air currents & falls with precip. as acid rain
  - Mercury bio-accumulates & biomagnifies thru ecosystems when it travels on air currents and fall as particulate dust or with precipitation elsewhere.
- Burning fossil fuels produces large amounts of CO_2, which contributes to global warming
- Makes us rely on other countries for our energy needs. Makes us vulnerable.

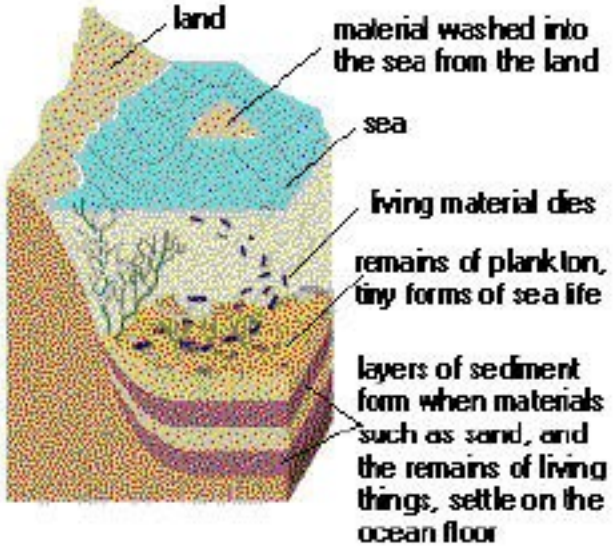
TYPES OF FOSSIL FUELS

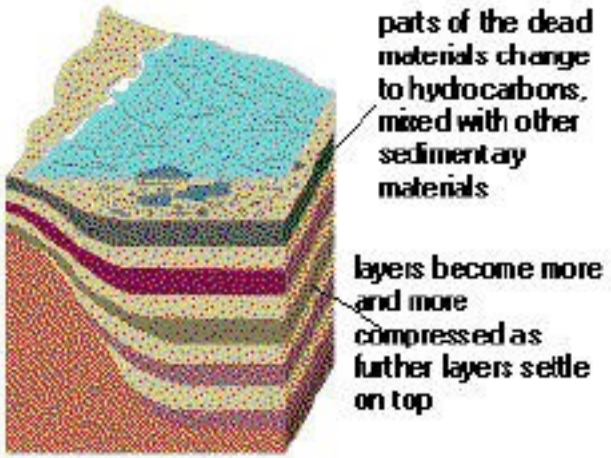
1. Liquid Hydrocarbons- Petroleum (oil)
2. Coal
3. Natural Gas

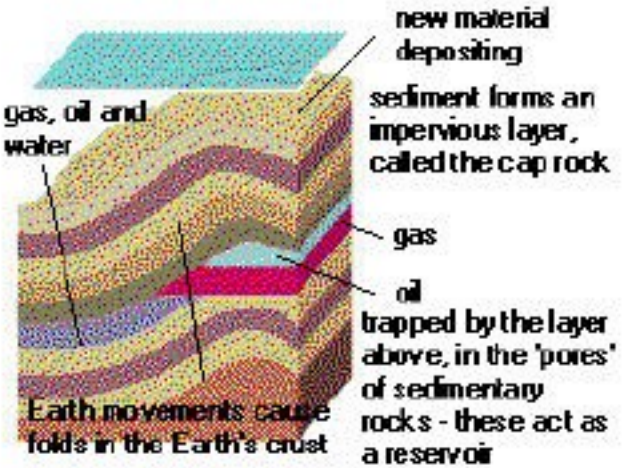
Photo credit: California Energy Commission

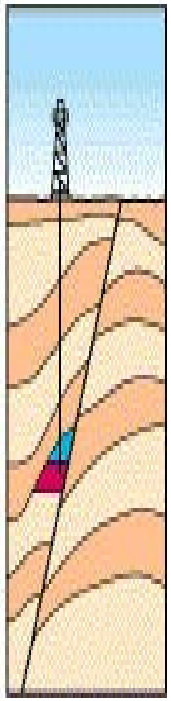
1. OIL

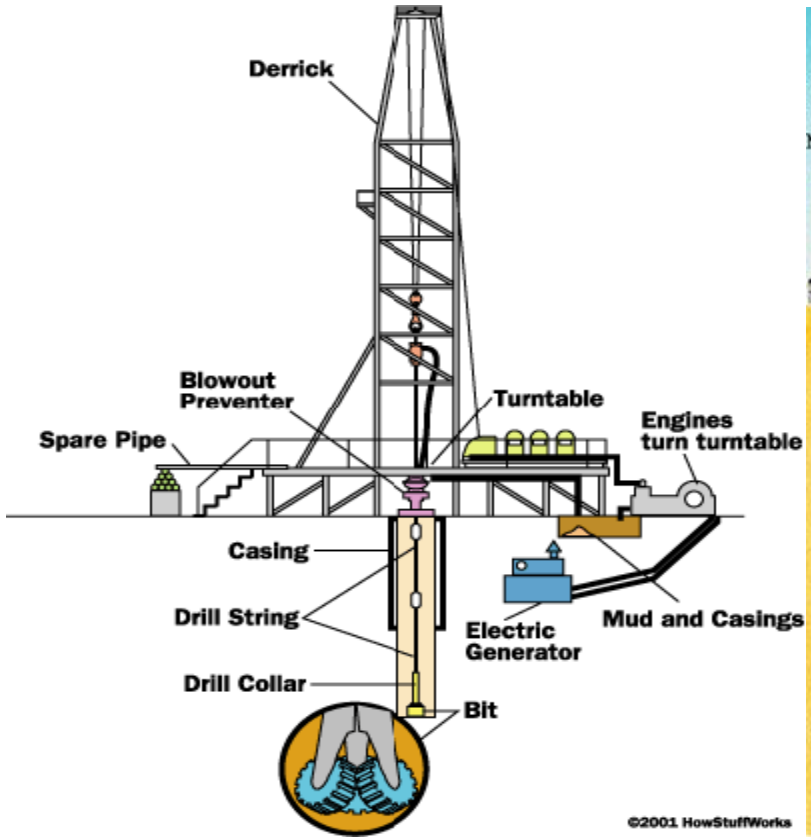
- Liquid mixture of hydrocarbons with S, O, N impurities
  - Impurities can create SO_2 and NO_x air pollution
  - Impurities increase efficiency of fuel
- Formed from remains of plankton, plants, animals in shallow seas millions of years ago.
- May be pumped up or may be under pressure
- Important producers: OPEC, Alaska, Siberia, Mexico

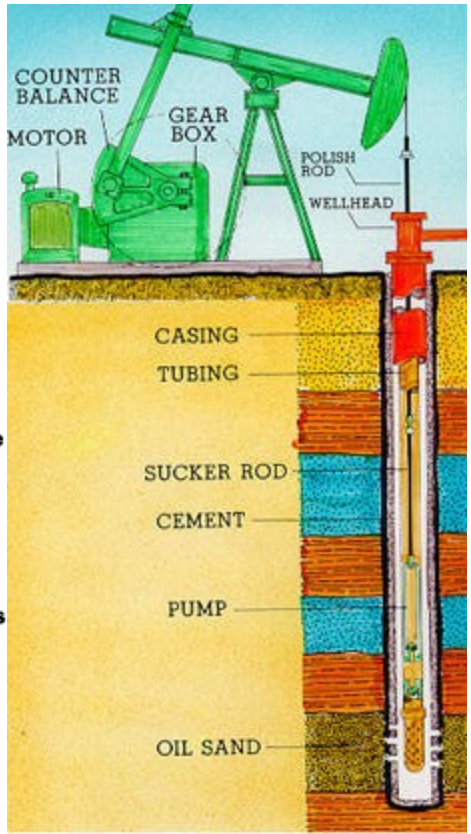

land
material washed into the sea from the land
sea
living material dies
remains of plankton, tiny forms of sea life
layers of sediment form when materials such as sand, and the remains of living things, settle on the ocean floor

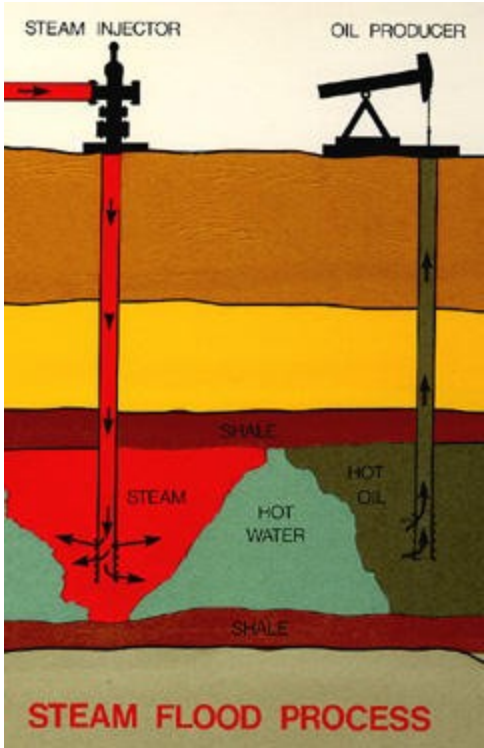

parts of the dead materials change to hydrocarbons, mixed with other sedimentary materials
layers become more and more compressed as further layers settle on top


new material depositing
gas, oil and water
sediment forms an impervious layer, called the cap rock
gas
oil
trapped by the layer above, in the 'pores' of sedimentary rocks - these act as a reservoir
Earth movements cause folds in the Earth's crust

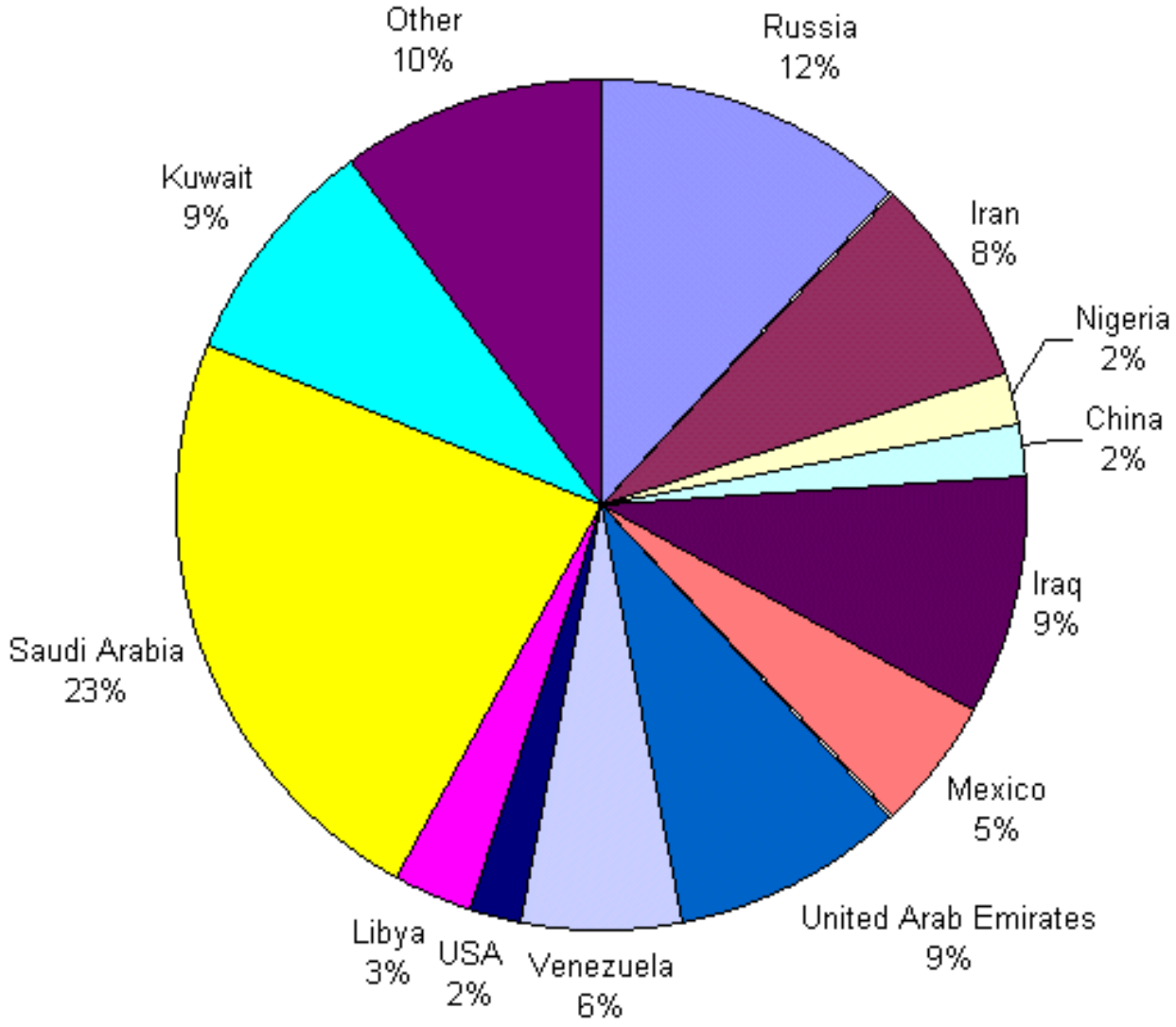



Derrick
Blowout Preventer
Spare Pipe
Turntable
Engines turn turntable
Casing
Drill String
Drill Collar
Bit
Electric Generator
Mud and Casings
©2001 HowStuffWorks


COUNTER BALANCE
MOTOR
GEAR BOX
POLISH ROD
WELLHEAD
CASING
TUBING
SUCKER ROD
CEMENT
PUMP
OIL SAND


STEAM INJECTOR
OIL PRODUCER
SHALE
STEAM
HOT WATER
HOT OIL
SHALE
STEAM FLOOD PROCESS

World Explored Oil Reserves



Oil in U.S.

- **2.3%** of world reserves
- uses nearly **30%** of world reserves;
- 65% for transportation;
- increasing **dependence on imports**.

www.bio.miami.edu/beck/esc101/Chapter14&15.ppt

Oil

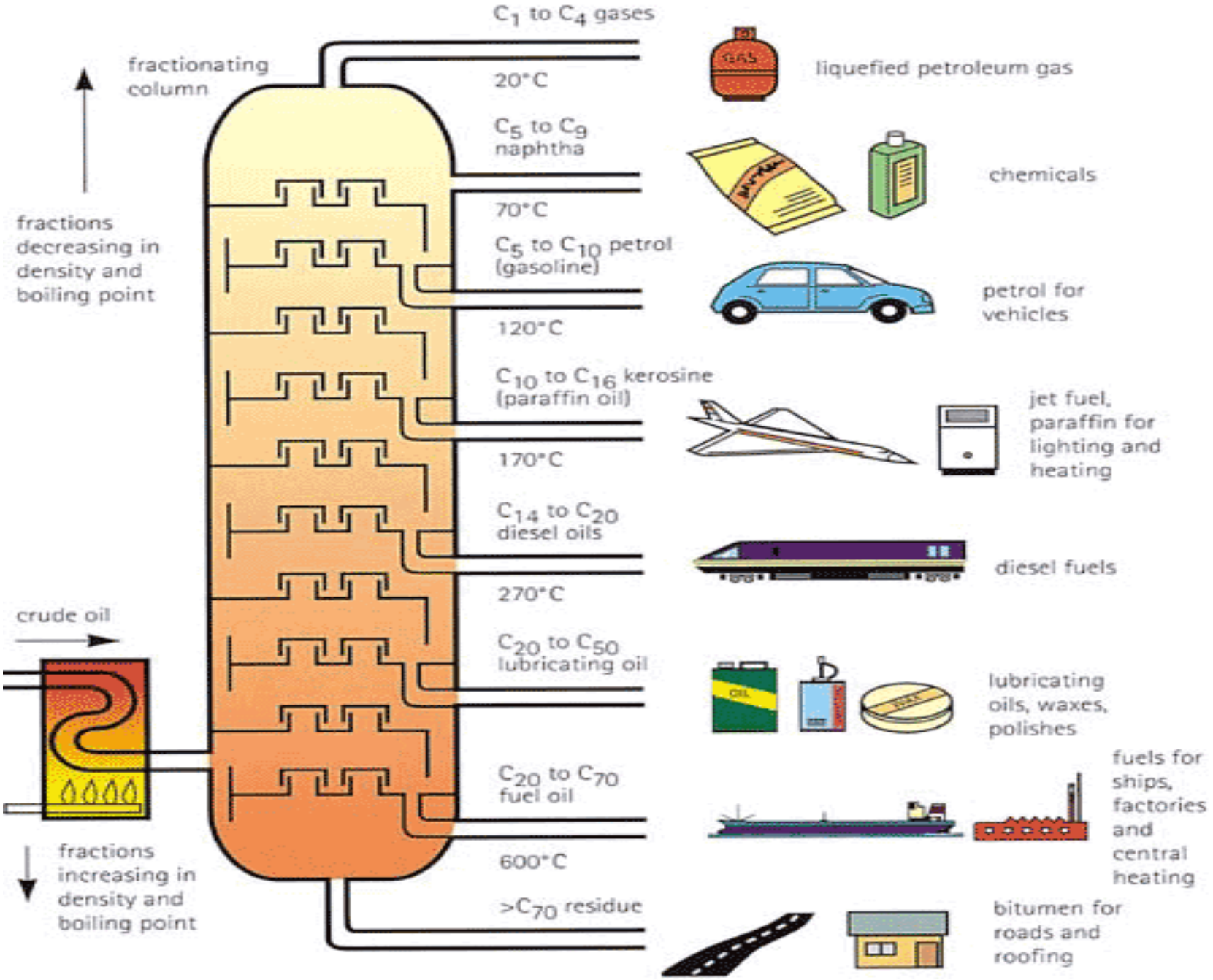
Crude oil is transported to a refinery where distillation produces petrochemicals

- How Oil Refining Works

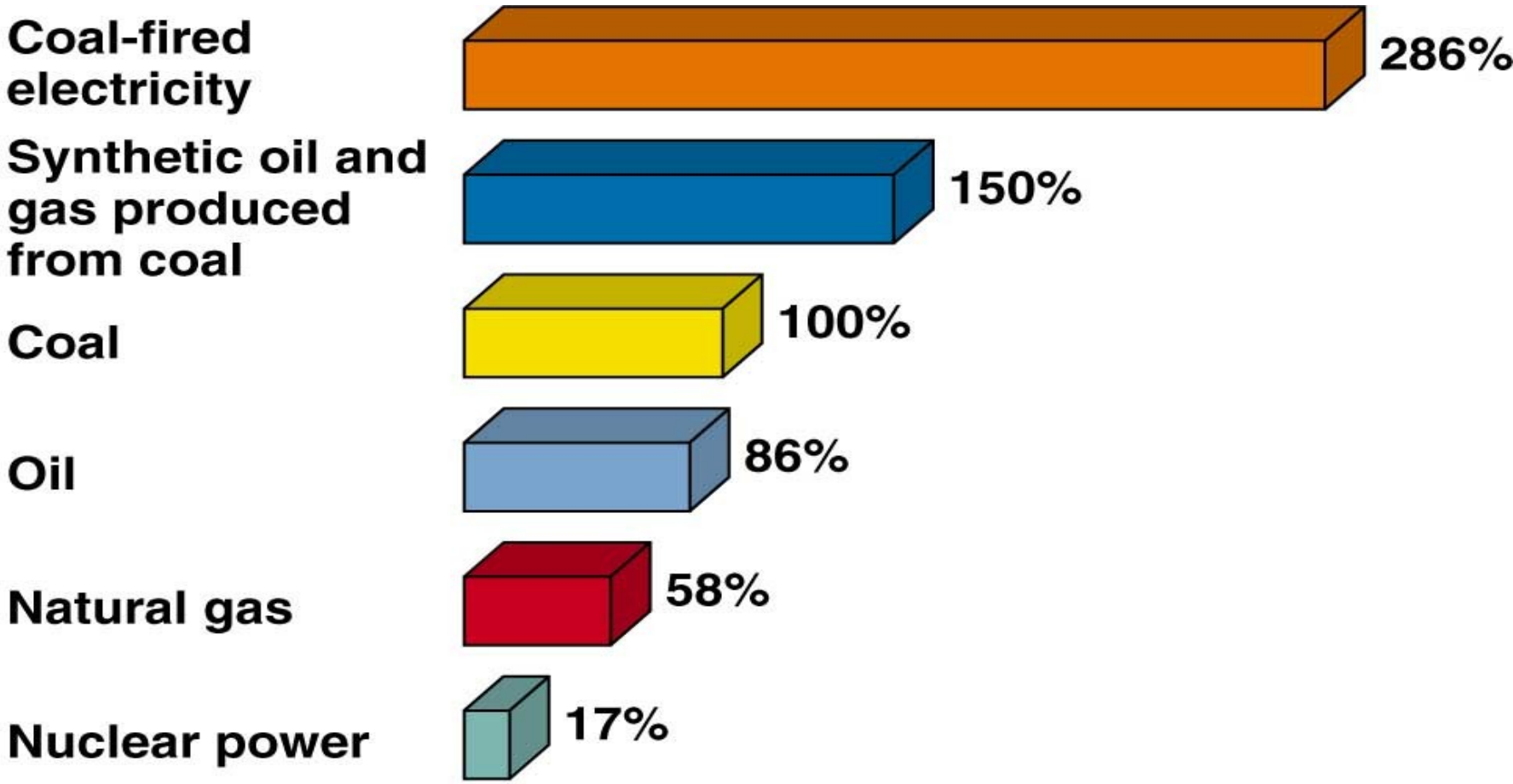
  by Craig C. Freudenrich, Ph.D.

Fractional Distillation

- Process that turns oil into different petrochemicals
- By heating oil, different hydrocarbon chains vaporize, are collected, condensed, then removed to be used in various products
- Longer chains = higher boiling points


C_1 to C_4 gases
fractionating column
20°C
liquefied petroleum gas
C_5 to C_9 naphtha
chemicals
70°C
fractions decreasing in density and boiling point
C_5 to C_{10} petrol (gasoline)
petrol for vehicles
120°C
C_{10} to C_{16} kerosine (paraffin oil)
jet fuel, paraffin for lighting and heating
170°C
C_{14} to C_{20} diesel oils
diesel fuels
270°C
crude oil
C_{20} to C_{50} lubricating oil
lubricating oils, waxes, polishes
C_{20} to C_{70} fuel oil
fuels for ships, factories and central heating
600°C
fractions increasing in density and boiling point
>C_{70} residue
bitumen for roads and roofing

- Burning any fossil fuel releases carbon dioxide into the atmosphere and thus promotes global warming.
- Comparison of CO_2 emitted by fossil fuels and nuclear power.



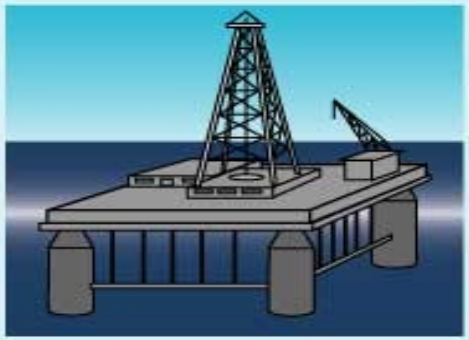
Advantages

Ample supply for 35–84 years

Low cost (with huge subsidies)

High net energy yield

Easily transported within and between countries



Disadvantages

Need to find substitute within 50 years

Artificially low price encourages waste and discourages search for alternatives

Air pollution when burned

Releases CO_2 when burned

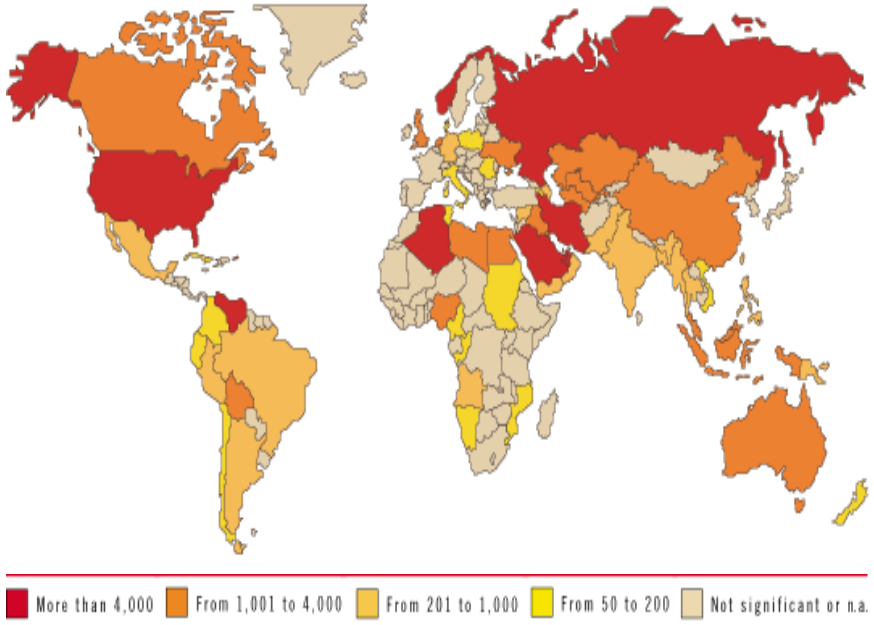
Moderate water pollution

2. NATURAL GAS

- Mixture
  - 50–90% Methane (CH_4)
  - Ethane (C_2H_6)
  - Propane (C_3H_8)
  - Butane (C_4H_{10})
  - Hydrogen sulfide (H_2S)

Natural Gas and World Production

- Russia Kazakhstan- 40% of world's supply
- 90-95% of natural gas used in US is domestic.



Advantages

Ample supplies (125–200 years)

High net energy yield

Low cost (with huge subsidies)

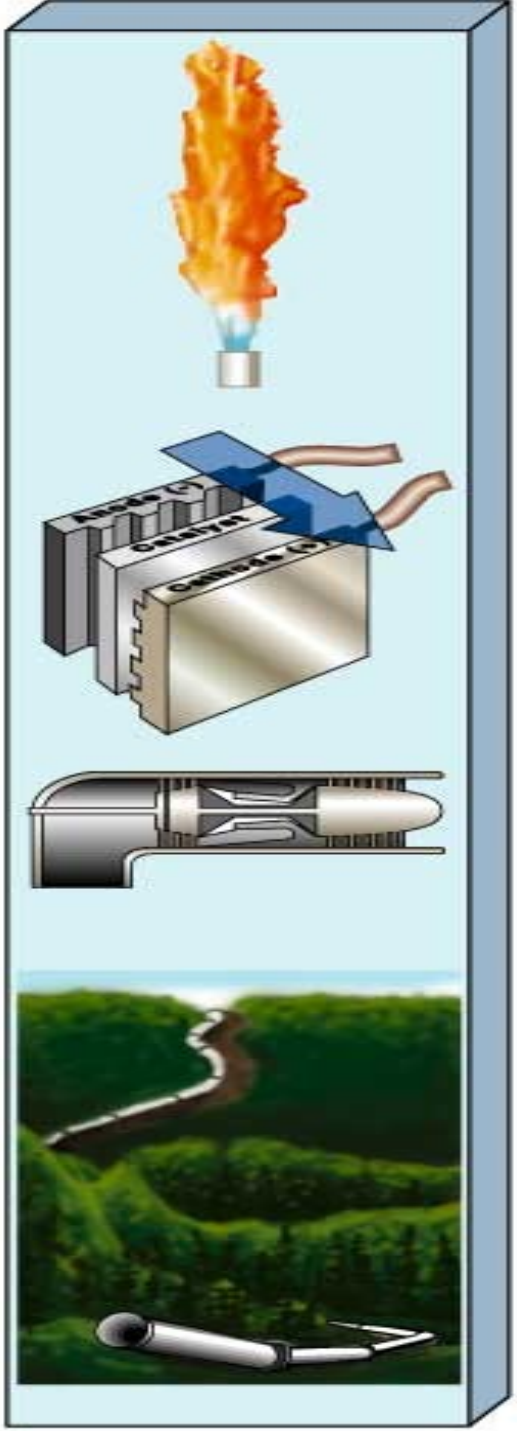
Less air pollution than other fossil fuels

Lower CO_2 emissions than other fossil fuels

Moderate environmental impact

Easily transported by pipeline

Good fuel for fuel cells and gas turbines



Disadvantages

Releases CO_2 when burned

Leaks of methane (a greenhouse gas)

Shipped across ocean as highly explosive LNG

Sometimes burned off and wasted at wells because of low price

Natural Gas

- Experts predict increased use of natural gas during this century

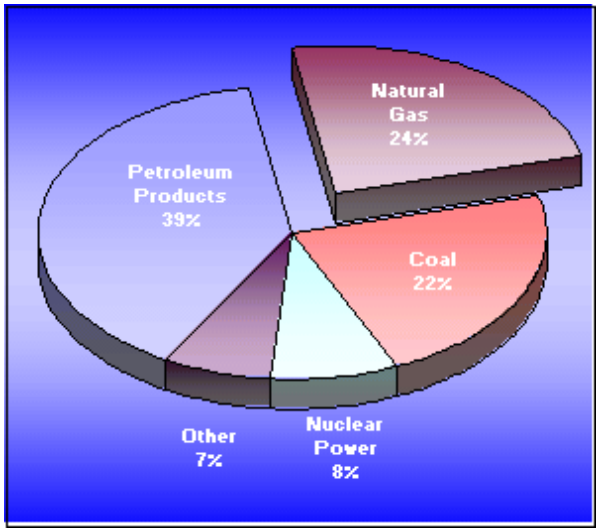
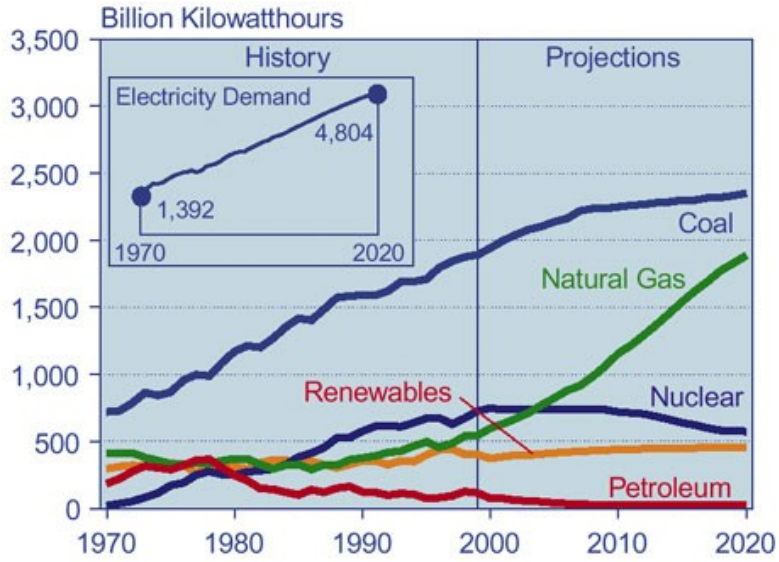


Figure 26. Electricity Generation by Fuel, 1970-2020



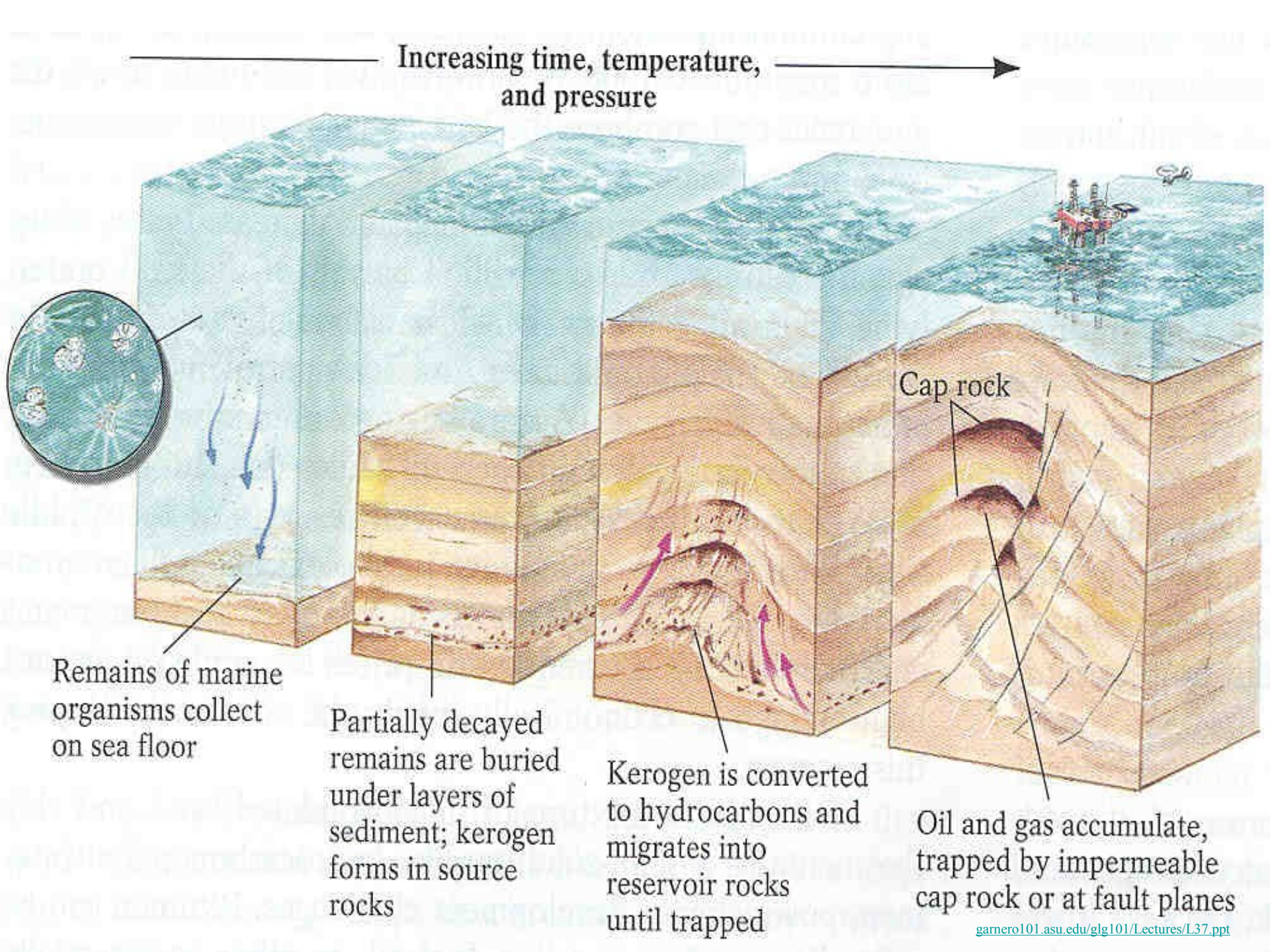
Sources: **History:** Energy Information Administration (EIA), Form EIA-860B, "Annual Electric Generator Report - Nonutility;" EIA, *Annual Energy Review 1999*, DOE/EIA-0384(99) (Washington, DC, July 2000); and Edison Electric Institute. **Projections:** EIA, *Annual Energy Outlook 2001*.

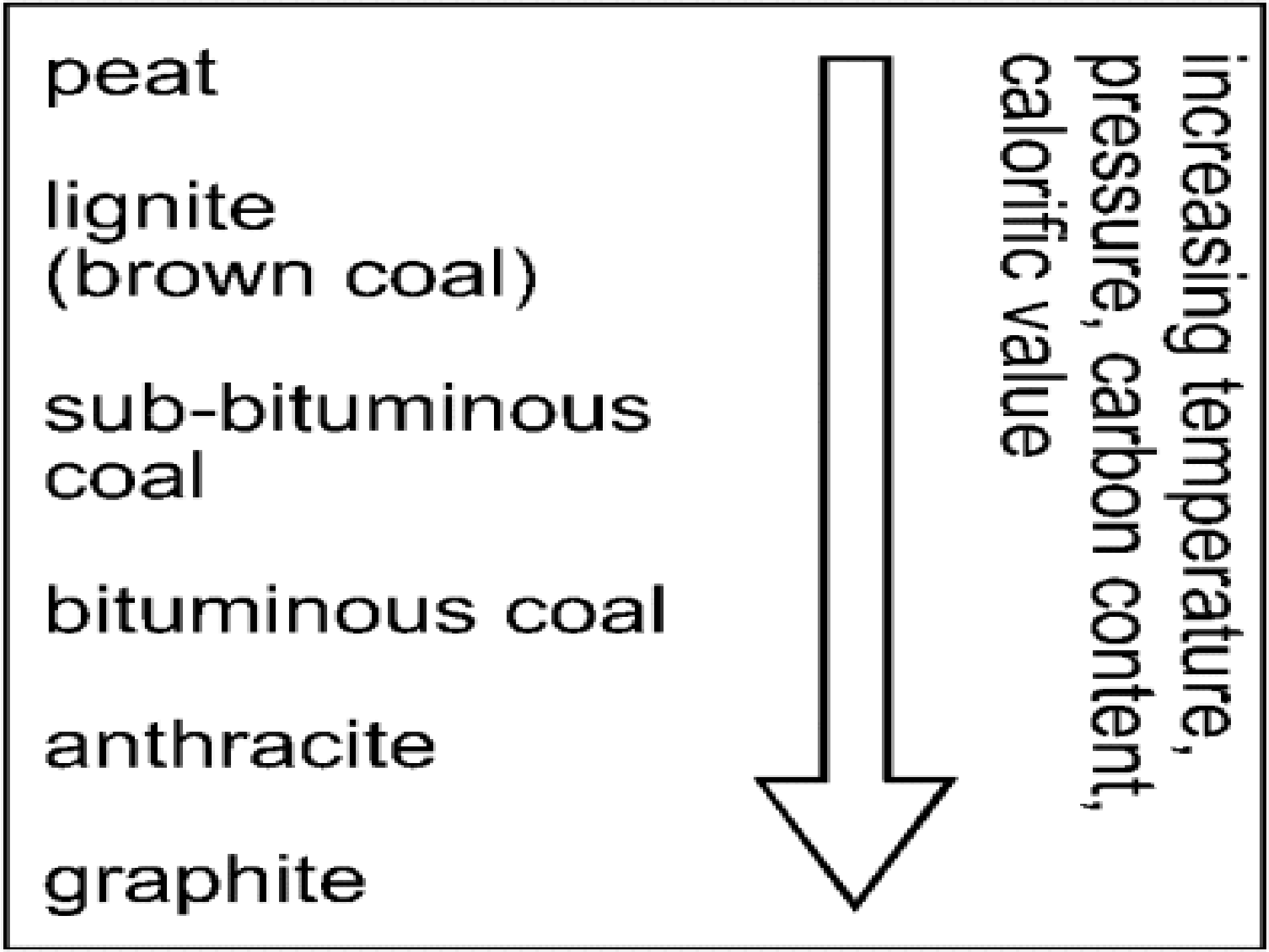
Natural Gas

- When a natural gas field is tapped, propane and butane are liquefied and removed as liquefied petroleum gas (LPG)
- The rest of the gas (mostly methane) is dried, cleaned, and pumped into pressurized pipelines for distribution
- Liquefied natural gas (LNG) can be shipped in refrigerated tanker ships

3. Coal

- Coal exists in many forms therefore a chemical formula cannot be written for it.
- Coalification: After plants died they underwent chemical decay to form a product known as peat
  - Over many years, thick peat layers formed.
  - Peat is converted to coal by geological events such as land subsidence which subject the peat to great pressures and temperatures.


Increasing time, temperature, and pressure
Cap rock
Remains of marine organisms collect on sea floor
Partially decayed remains are buried under layers of sediment; kerogen forms in source rocks
Kerogen is converted to hydrocarbons and migrates into reservoir rocks until trapped
Oil and gas accumulate, trapped by impermeable cap rock or at fault planes


peat
lignite
(brown coal)
sub-bituminous
coal
bituminous coal
anthracite
graphite
increasing temperature,
pressure, carbon content,
calorific value

Ranks of Coal

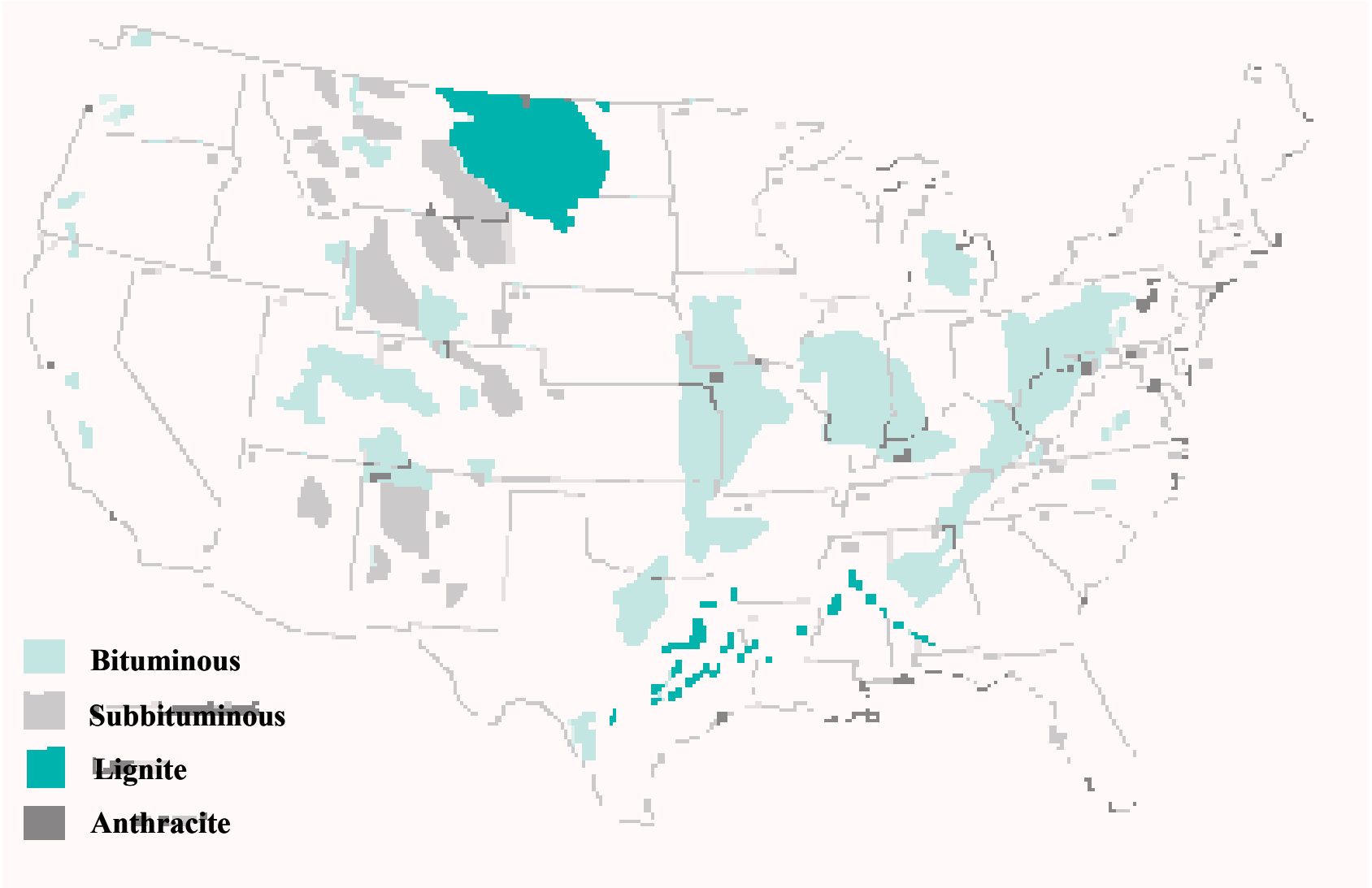
- Lignite: A brownish-black coal of low quality (i.e., low heat content per unit) with high inherent moisture and volatile matter. Energy content is lower 4000 BTU/lb.

- Subbituminous: Black lignite, is dull black and generally contains 20 to 30 percent moisture Energy content is 8,300 BTU/lb.

- Bituminous: most common coal is dense and black (often with well-defined bands of bright and dull material). Its moisture content usually is less than 20 percent. Energy content about 10,500 Btu / lb.

- Anthracite :A hard, black lustrous coal, often referred to as hard coal, containing a high percentage of fixed carbon and a low percentage of volatile matter. Energy content of about 14,000 Btu/lb.

Main Coal Deposits



Advantages and Disadvantages

Pros

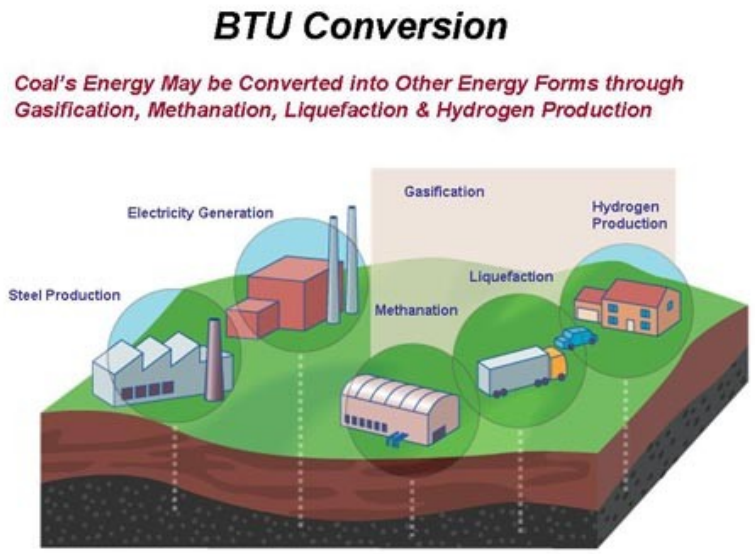
- Most abundant fossil fuel
- Major U.S. reserves
- 300 yrs. at current consumption rates
- High net energy yield

Cons

- Dirtiest fuel, highest carbon dioxide
- Major environmental degradation
- Major threat to health

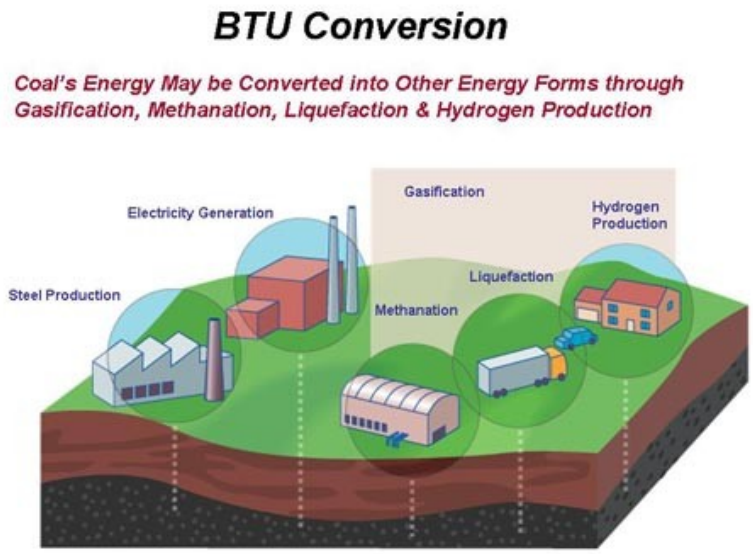
Alternate Uses of Coal

- Coal gasification → Synthetic natural gas (SNG) or Syngas (made up of CO and H_2)
- Coal liquefaction → Liquid fuels (oil) → gasoline
- Disadvantage
  - Costly
  - High environmental impact



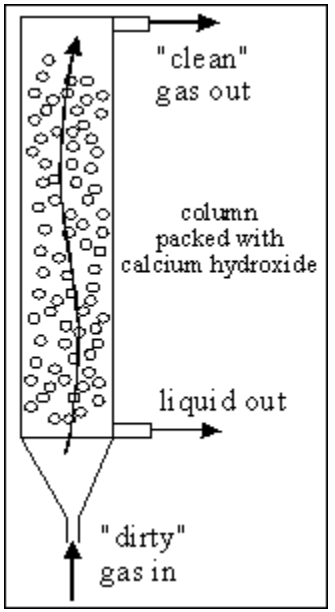
Sulfur in Coal

- When coal is burned, sulfur is released primarily as sulfur dioxide (SO_2 - serious pollutant)
  - Coal Cleaning - Methods of removing sulfur from coal include cleaning, solvent refining, gasification, and liquefaction
  - Two chief forms of sulfur
    - inorganic (FeS_2 or $CaSO_4$)
    - organic (Sulfur bound to Carbon)



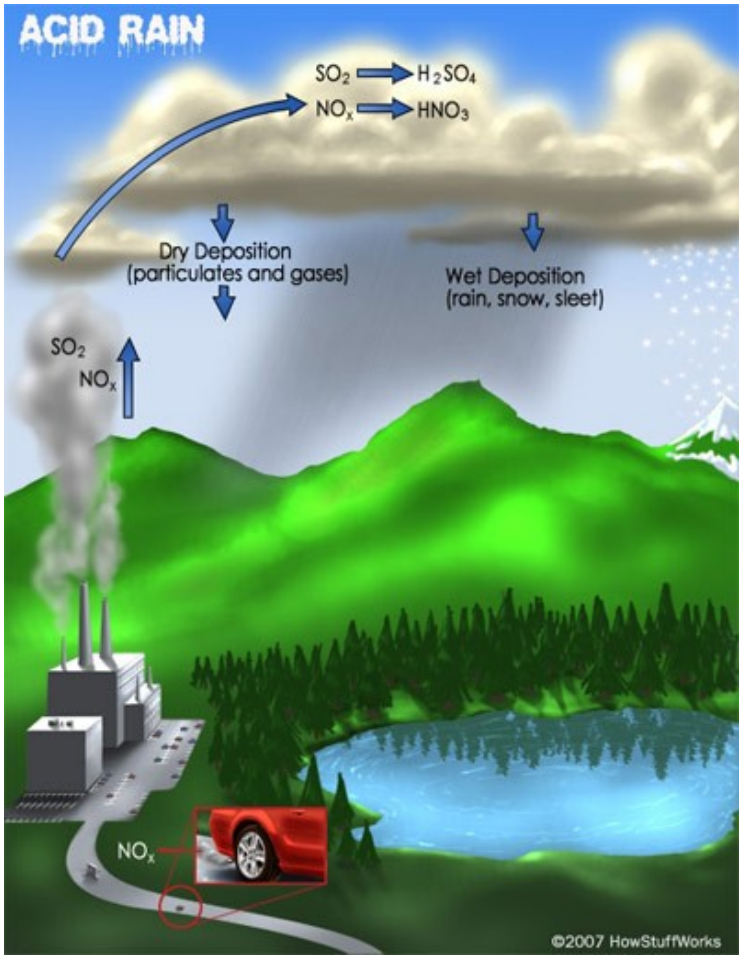
Removing Sulfur after Combustion

- Scrubbers are used to trap SO_2 when coal is burned.
- Like an air filter for a smokestack
- Dirty gas enters chamber where limestone or CaOH are used to neutralize harmful gases, clean gas leaves thru top.
- Not all coal fired powerplants have these.



Effects of Sulfur Pollution

- Sulfur combines with water in atmosphere to create sulfuric acid- acid rain
- Falls as fine particulate pollution- dry deposition
- Increased sulfur oxide aerosols absorb incoming UV radiation thereby cooling the atmosphere
- Sulfur oxide aerosols can irritate mucous membrane linings in respiratory system



Effects on Ecosystems of acid rain from sulfur dioxide.

- Acid rain leaches metals (Al) out of soil, settles on fish gills, causing suffocation.
- Leaches out soil nutrients
- Kills eggs, larvae, fry (baby fish), and some adult fish
- Changes in pH can make some chemicals more toxic- kills trees or aquatic life
- Decreases health of plants- more susceptible to disease
- As animals die from pH changes, other more hardy animals will fill those new niches
- Upsets food web when sensitive species die.
- If regional climate changes due to cooling from sulfur pollution
  - Changes in crops
  - Changes in vegetation which leads to changes in fauna distribution
  - Changes in precipitation patterns