Chapter 15—Miller

ENERGY RESOURCES

FOSSIL FUELS

- Partially decayed remnants of organisms formed millions of years ago.

- NONRENEWABLE
- Formation:
  - COAL:
    - Swamp plants died and fell into the water, which slowed their decay (little O_2)
    - Layers of sediment piled on top
    - Pressure formed carbon-rich coal between layers of sedimentary rock.
  - OIL:
    - Microscopic aquatic organisms died & settled to bottom.
    - Their decay lowered the O_2, further slowing decay.
    - Formed hydrocarbon mixture called Oil.
  - NATURAL GAS:
    - Same way as Oil, only at higher temperatures.

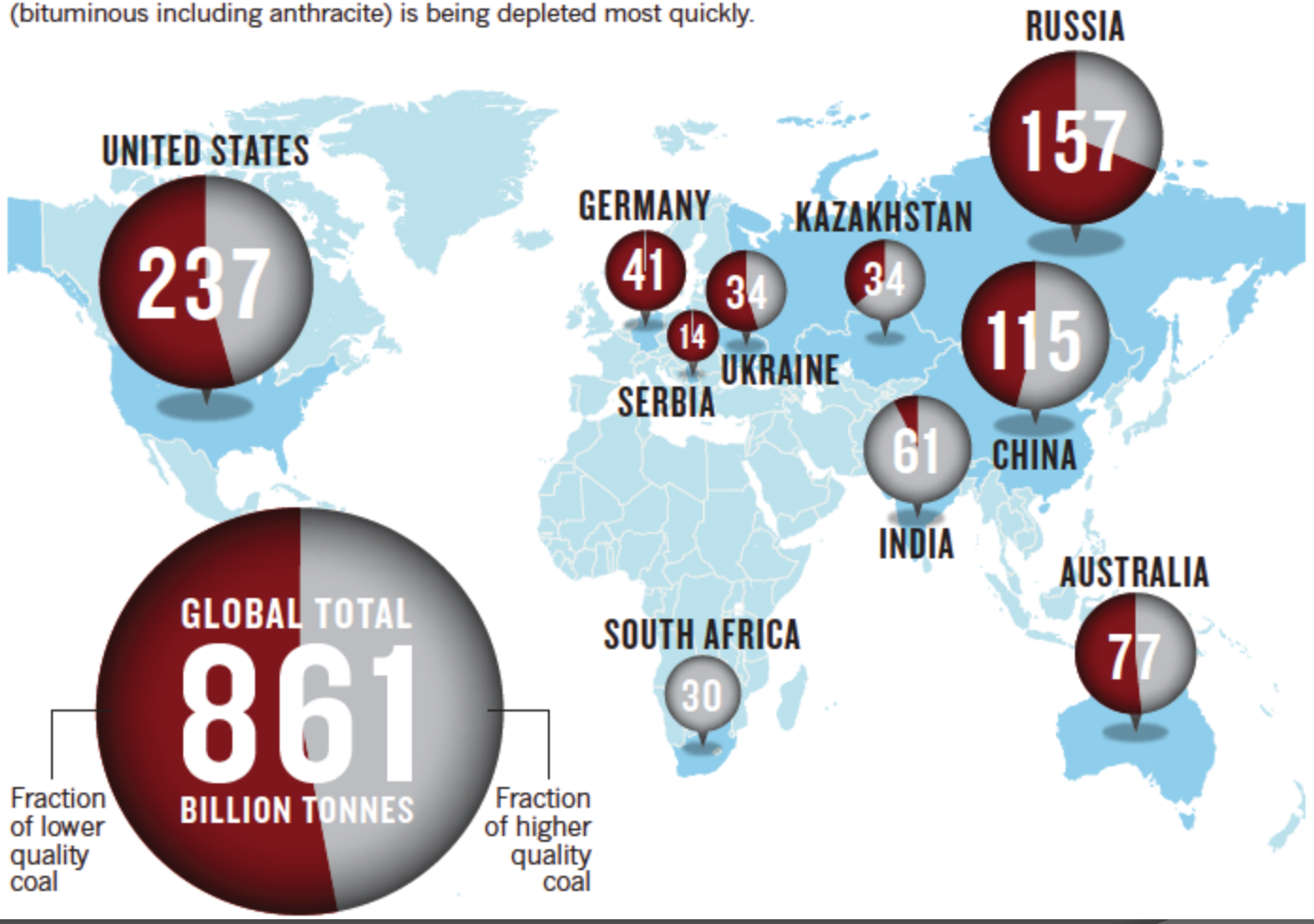
Coal

- Coal Formation: 4 stages

Peat (not coal)- Organic	**Lignite** (brown coal) —S	**Bituminous Coal** (soft coal)—S	**Anthracite** (hard coal) —M
• High moisture/ Low Heat	• Low heat, low sulfur, limited supplies	• Commonly used as fuel, high heat content, high sulfur, large supplies	• Highly desirable fuel , high heat, low sulfur, low moisture, limited supplies

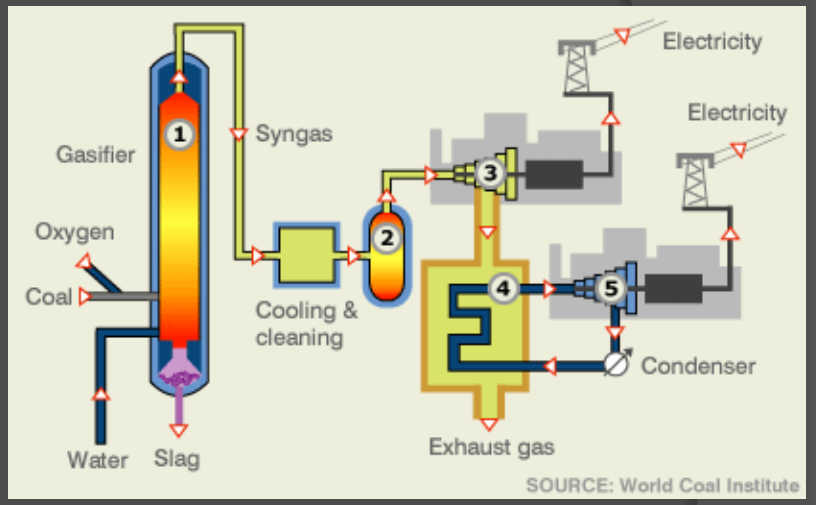
WORLD COAL RESERVES

Proven recoverable coal reserves reported to the World Energy Council by the top-ten coal-producing countries at the end of 2008. Coal of higher quality (bituminous including anthracite) is being depleted most quickly.



Coal→dirtiest

- Process: Coal Gasification
- Clean Coal: Captures CO2 emissions and pumps underground
- Most abundant proven resource
- Location: 66% (proven) and 85% (estimated undiscovered) are in United States



1. Coal burnt to produce syngas
2. Syngas burnt in combustor
3. Hot gas drives gas turbines
4. Cooling gas heats water
5. Steam drives steam turbine

Surface Mining Control & Reclamation Act (1977)

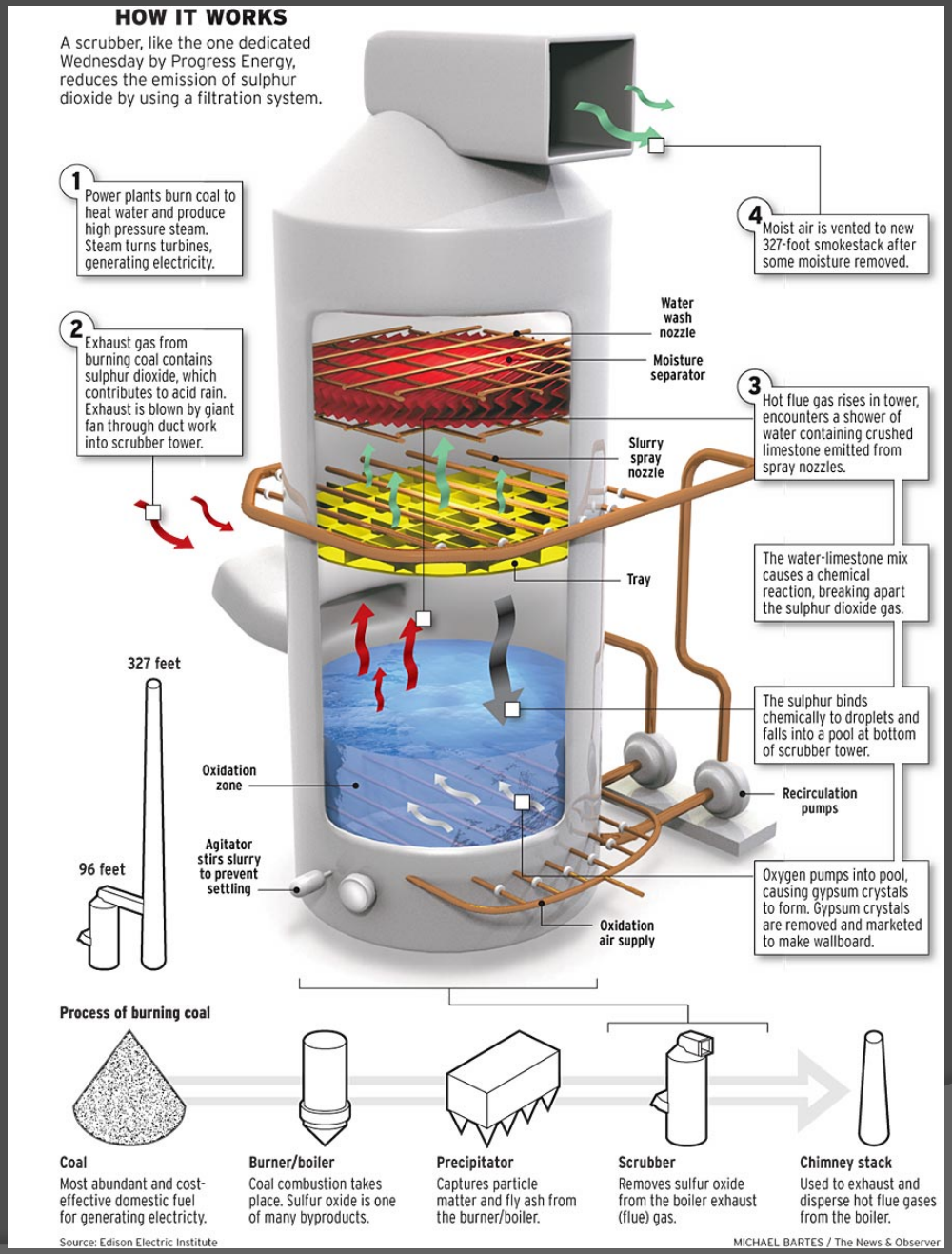
- Surface mines can have substantial effects on the environment
  - Large open pits or trenches
  - Acid and toxic mineral drainage
  - Dangerous landslides
- Restorations were half hearted
- SMCRA requires coal companies to restore areas. Reclamation begins during the mining process, not after mining ends

Making Coal a Cleaner Fuel

- SCRUBBERS
  - Recall: uses mist of water to remove precipitates
  - Can sell the sludge to manufacturers:
    - Sludge can make: Wallboard, soil conditioner
    - Fly Ash an make: lightweight concrete

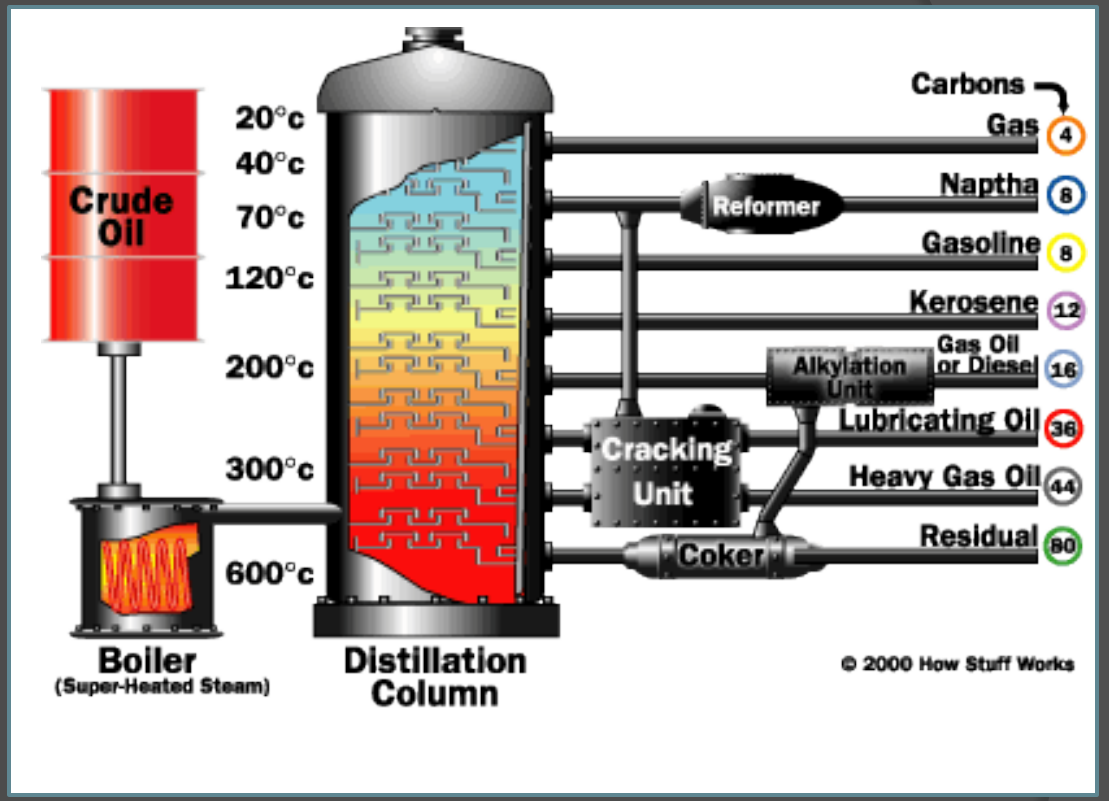
- CLEAN COAL TECHNOLOGIES
  - 1 – Fluidized-Bed Combustion
    - Mix crushed coal w/ limestone & O_2 at low temps.
    - Produces fewer nitrogen oxides
    - Produces NO sulfur oxides (sulfur mixes with the limestone)
  - 2 – Coal Gasification
    - Mix crushed coal w/ steam & air to produce CH_4 & CO_2!
    - Sulfur is naturally removed, so no scrubbers are needed.

NOTE: “Clean Coal” isn’t perfect – still have CO_2 released!


HOW IT WORKS
A scrubber, like the one dedicated Wednesday by Progress Energy, reduces the emission of sulphur dioxide by using a filtration system.
1 Power plants burn coal to heat water and produce high pressure steam. Steam turns turbines, generating electricity.
2 Exhaust gas from burning coal contains sulphur dioxide, which contributes to acid rain. Exhaust is blown by giant fan through duct work into scrubber tower.
3 Hot flue gas rises in tower, encounters a shower of water containing crushed limestone emitted from spray nozzles.
4 Moist air is vented to new 327-foot smokestack after some moisture removed.
Water wash nozzle
Moisture separator
Slurry spray nozzle
Tray
The water-limestone mix causes a chemical reaction, breaking apart the sulphur dioxide gas.
The sulphur binds chemically to droplets and falls into a pool at bottom of scrubber tower.
Recirculation pumps
Oxygen pumps into pool, causing gypsum crystals to form. Gypsum crystals are removed and marketed to make wallboard.
Oxidation air supply
Oxidation zone
Agitator stirs slurry to prevent settling
327 feet
96 feet
Process of burning coal
Coal
Most abundant and cost-effective domestic fuel for generating electricity.
Burner/boiler
Coal combustion takes place. Sulfur oxide is one of many byproducts.
Precipitator
Captures particle matter and fly ash from the burner/boiler.
Scrubber
Removes sulfur oxide from the boiler exhaust (flue) gas.
Chimney stack
Used to exhaust and disperse hot flue gases from the boiler.
Source: Edison Electric Institute
MICHAEL BARTES / The News & Observer

Oil

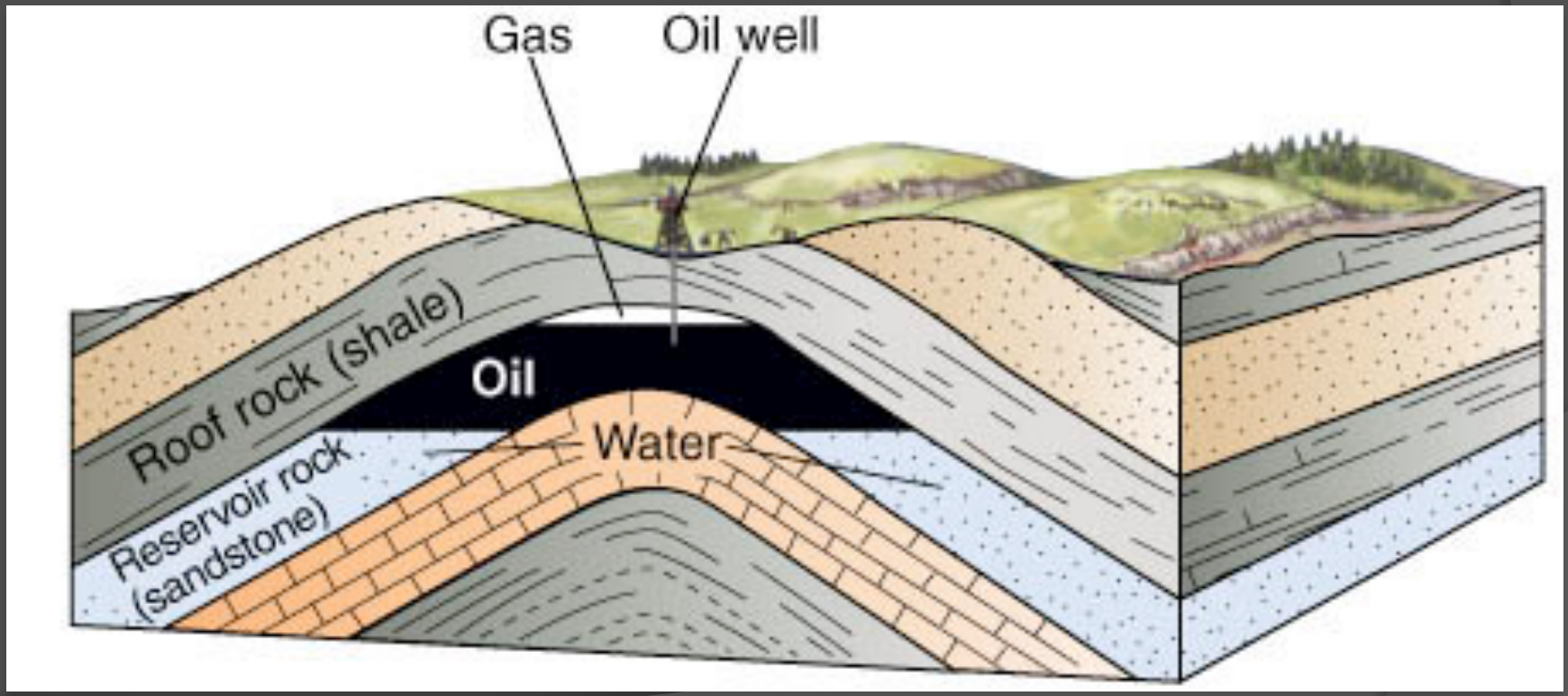
- Refining Process:

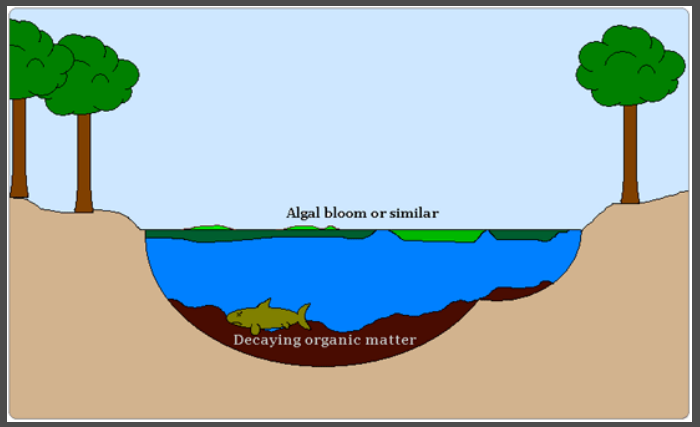


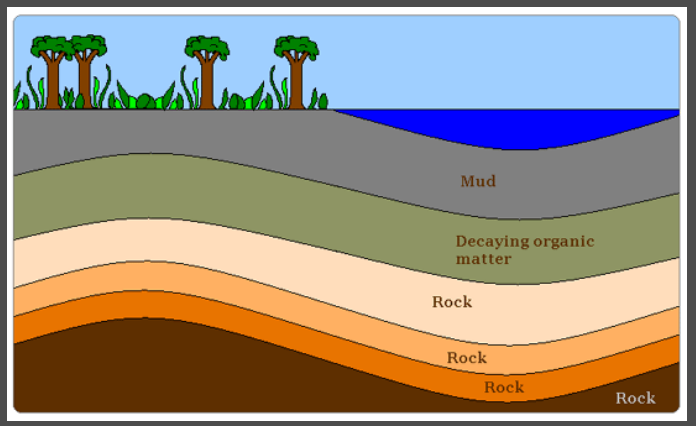
- Greatest Use: Fossil Fuels—Transportation
- Location: Saudi Arabia (26%), Iraq, Kuwait, Iran, UAE (9-10%)

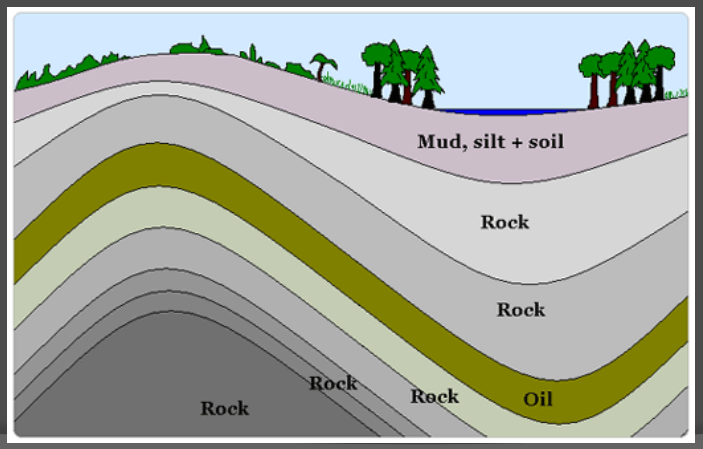
Structural Traps

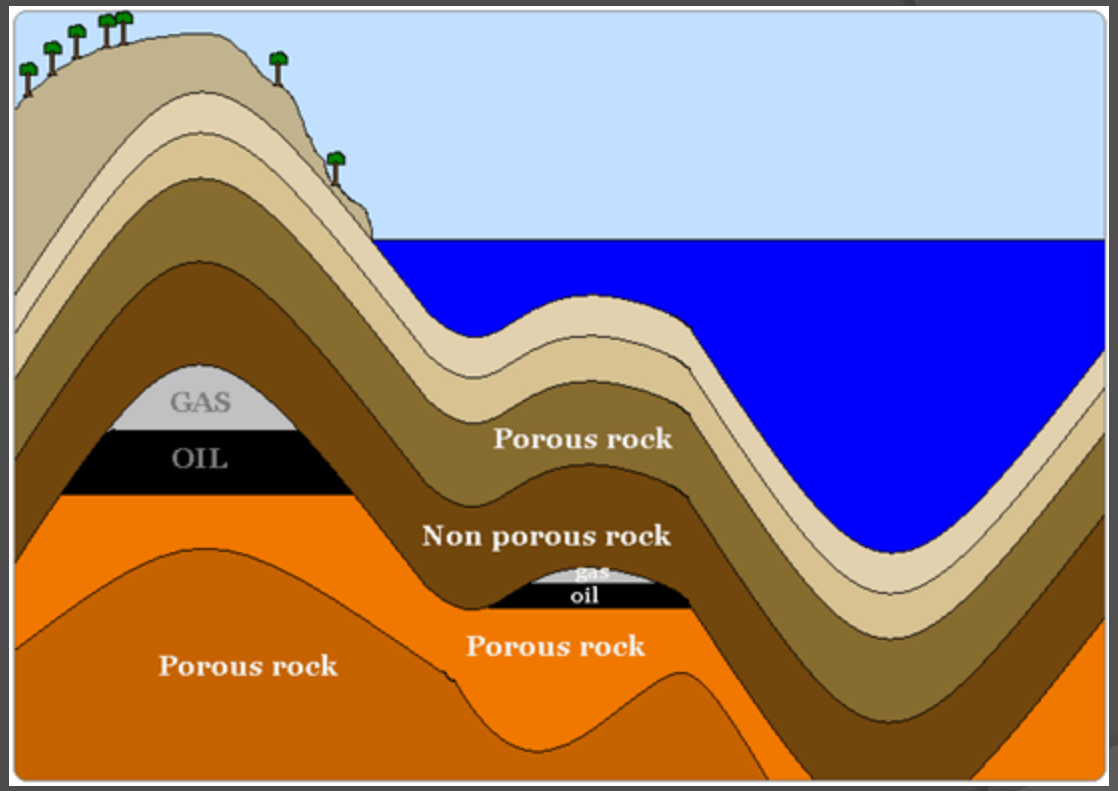
- How Oil & Natural gas form…
- They migrate upward (low density) and are trapped by impermeable rock layers.




Algal bloom or similar
Decaying organic matter

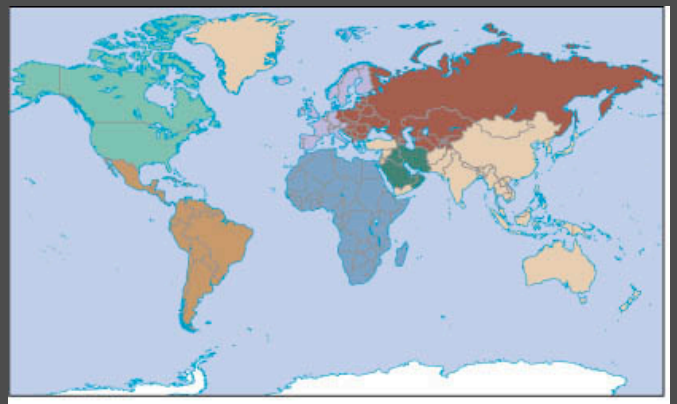

Mud
Decaying organic matter
Rock
Rock
Rock
Rock

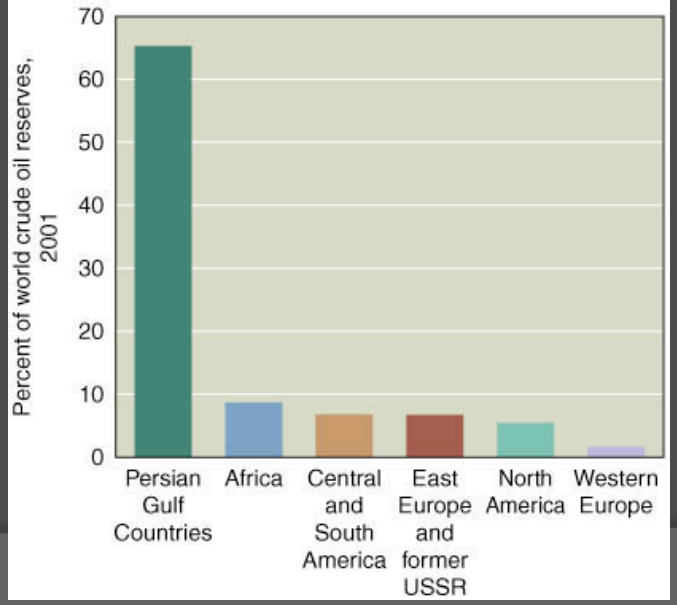

Mud, silt + soil
Rock
Rock
Rock
Rock
Rock
Oil


GAS
OIL
Porous rock
Non porous rock
oil
Porous rock
Porous rock

Who's got it??

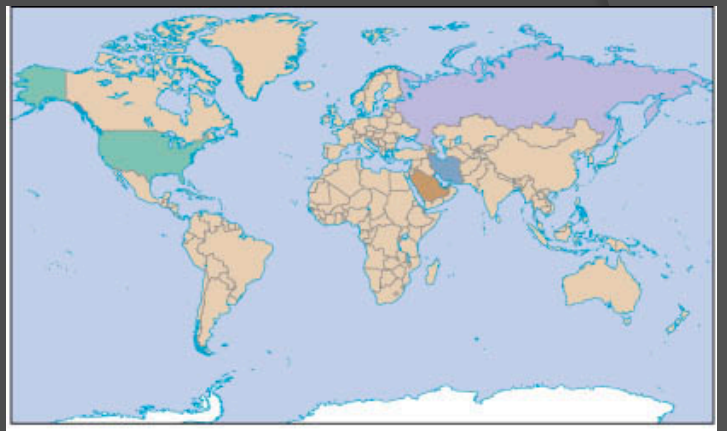
- OIL: mostly in the Persian Gulf

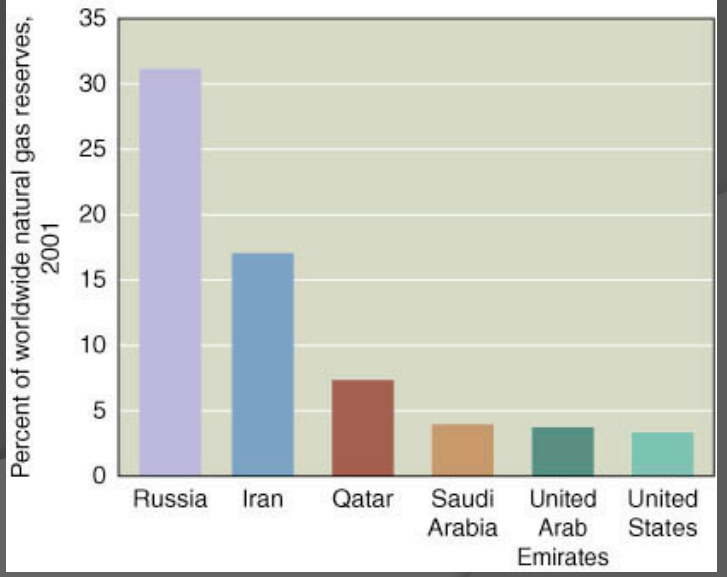




ALSO: Much may be found in the cont. shelf!

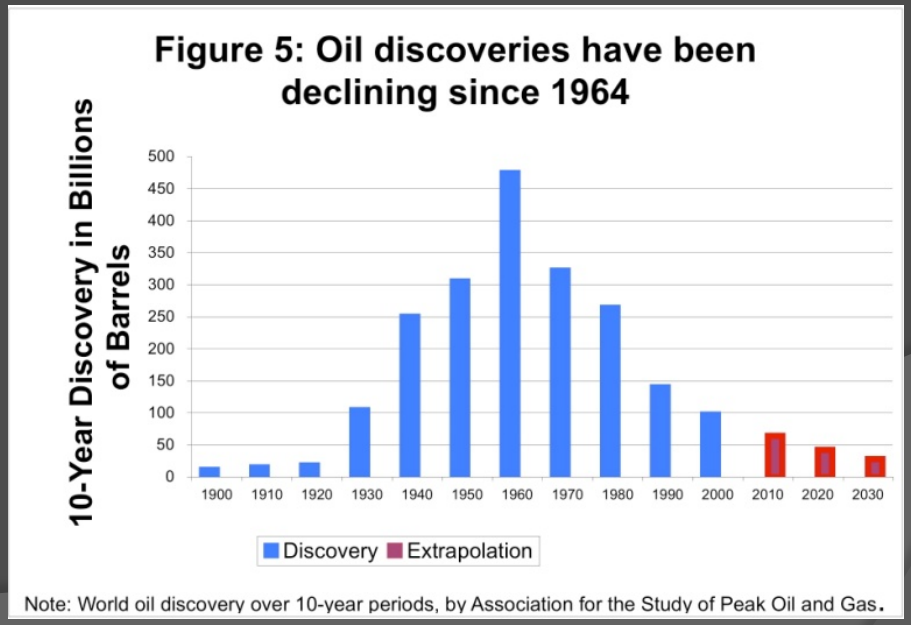
- NATURAL GAS: mostly in Russia & Iran



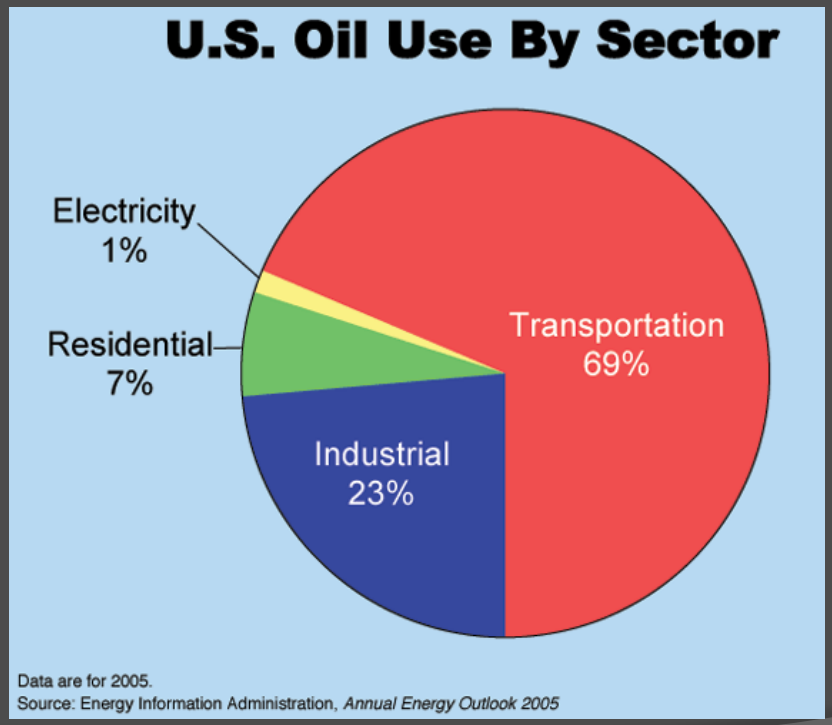


How long will it last?

- Difficult to say…
  - Oil production will peak between 2010 & 2020.
  - Improving tech will allow us to extract more & produce oil from natural gas, coal & synfuels.
    - Then the oil peak will move to 2050 – 2100

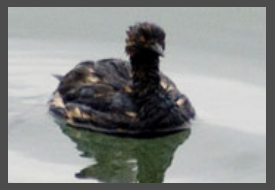


Dependence of the United States and other countries on Middle Eastern oil has potential international security implications as well as economic impacts.

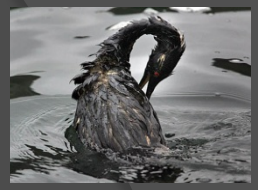


Environmental Problems with Oil & Natural Gas

- Burning (combustion), obtaining fuels (production & transport)
  - Increased carbon dioxide emissions
    - Every gallon of gas releases 20lb. of carbon dioxide
  - Acid deposition (No_x)
- Natural Gas does not pollute as much as oil
  - Relatively clean, efficient source with almost no S
  - Produces less CO_2, fewer hydrocarbons and few particulate matter



Exxon Valdez (1989)



- Supertanker hit Bligh Reef
- Spilled 10.9 million gallons of crude into Prince William Sound, Alaska
- Killed a LOT of wildlife
  - 30,000 birds (ducks, loons, cormorants, eagles)
  - 3,500- 5,000 sea otters
  - Killer whale & harbor seal population disrupted
  - Salmon migration disrupted
  - No fishing for the year in the area

- Cleaned the area using mechanized steam cleaning and rinsing (killed shoreline organisms)
- Cost estimated at 10 billion
- OIL POLLUTION ACT (1990)
  - Established liability for damages to natural resources resulting from spills
  - Requires double hulls on all oil tankers that enter US waters.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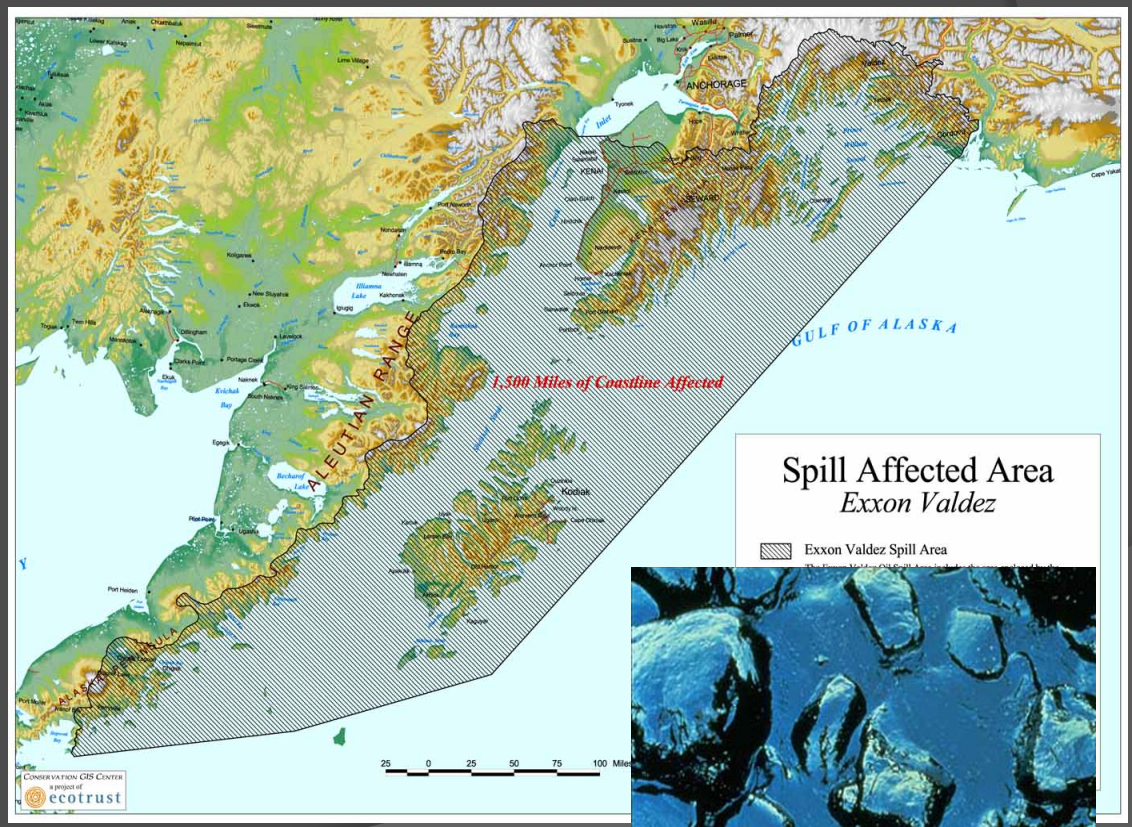
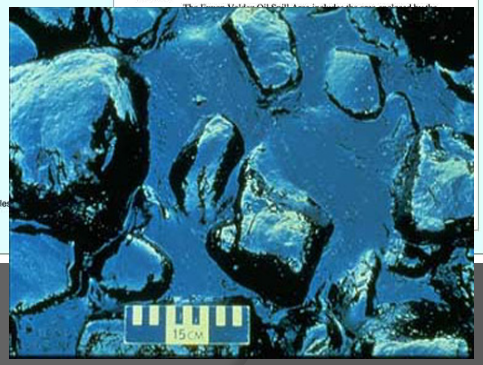
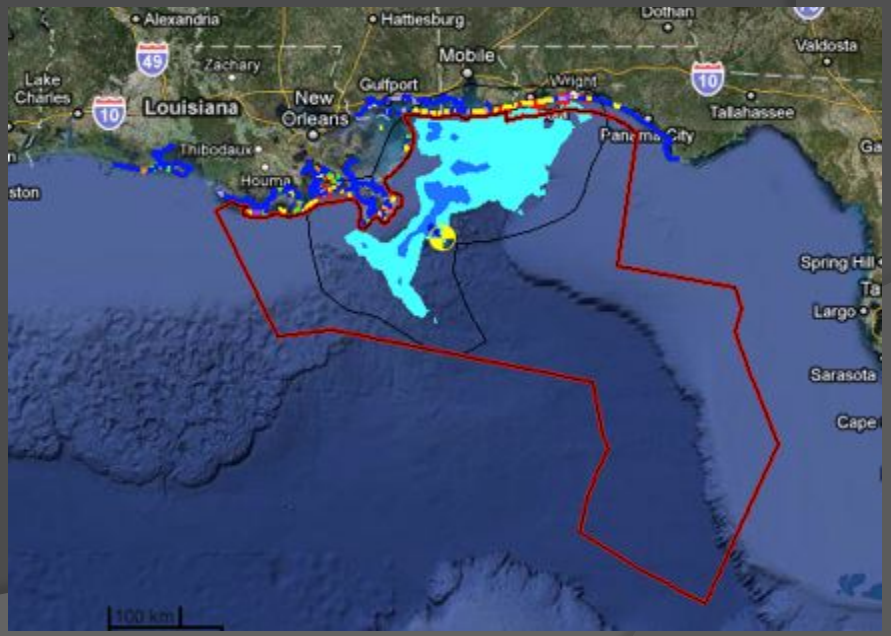

ANCHORAGE
GULF OF ALASKA
ALEUTIAN RANGE
1,500 Miles of Coastline Affected
Spill Affected Area
Exxon Valdez
Exxon Valdez Spill Area
Kodiak
25 0 25 50 75 100 Miles
Conservation GIS Center
a project of
ecotrust


15CM

Persian Gulf Oil Spill (1991)

- 250 mill gallons of crude were dumped into the Persian Gulf (6x that of Exxon).
- Oil wells were set on fire & lakes of oil spilled into the desert
- Initial cleanup efforts hampered by the war.

DEEP SEA HORIZON 2010



The Facts—Popular Mechanics

4.9 million: Barrels of oil (205.8 million gallons) leaked from the Deepwater Horizon well, about half the amount of crude oil the U.S. imports per day

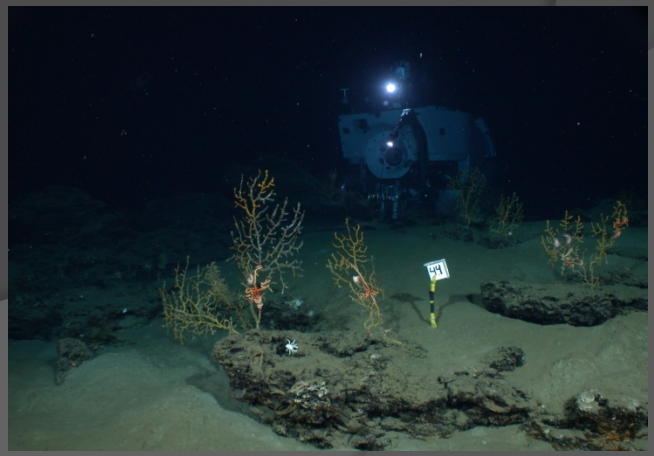
19: Times more oil leaked from Deepwater Horizon than spilled from the Exxon Valdez in 1989 (10.8 million gallons)

62,000: Barrels leaking per day when the wellhead first broke, roughly the amount of oil consumed in Delaware each day

53,000: Barrels leaking per day when the well was capped on July 15, roughly the amount of oil consumed in Rhode Island each day

397.7 million: Dollars' worth of the oil spilled at current market prices ($81.17 per barrel)

665: Miles of coastline contaminated by oil



The Cleanup

16.5 million: Gallons of oil chemically dispersed by National Incident Command
32.9 million: Gallons of oil naturally dispersed, which means it has broken into droplets smaller than the diameter of a human hair
51.5 million: Gallons of oil evaporated or dissolved. This differs from natural dispersion because instead of breaking down into small droplets, the oil breaks apart molecularly and dissolves into the water.
6.2 million: Gallons of oil skimmed off the Gulf by the more than 830 skimming vessels used in the response
35 million: Gallons directly recovered from the wellhead into ships through the riser pipe and top-hat systems
11.4 million: Gallons of oil has been removed by a series of 411 controlled burns
53.5 million: Gallons of oil still remaining in the water or washed ashore
95.6 million: Potential gallons of gasoline leaked from the wellhead (approximately 19.5 gallons of gas can be derived from one barrel of oil). That's about one-fourth of daily consumption in the United States.
10.4 million: Feet of sorbent boon (8.7 million) and containment boom (2.7 million) currently deployed to contain the oil
1.8 million: Gallons of both surface and subsea dispersant used by Unified Incident Command
28,900: Total number of personnel currently deployed in response to the spill. On July 8, 47,000 people had been deployed.
57,539: Square miles of Gulf waters that remain closed to fishing

In Perspective

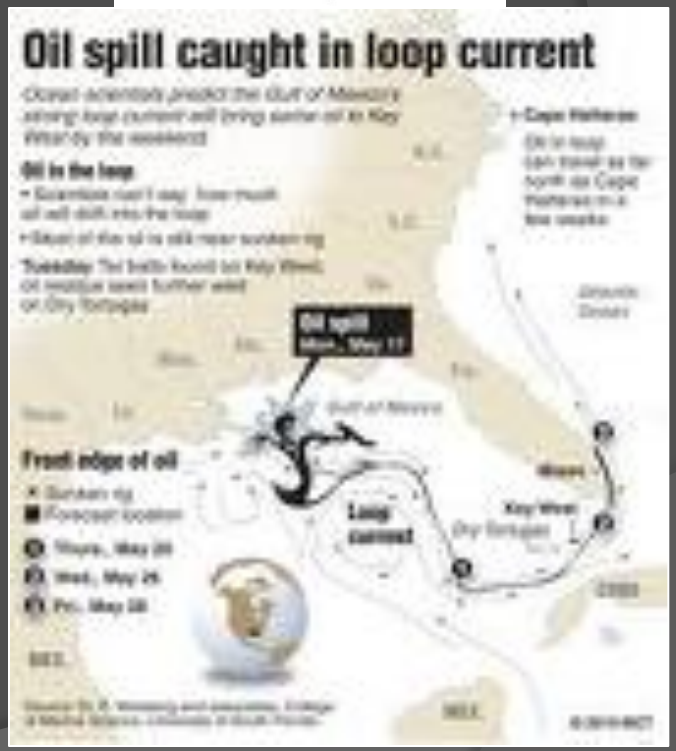
184,181: Times you could drive a Toyota Prius (48 mpg highway) around the Earth at the equator using the lost oil

69,068: Times you could drive a Hummer H3 (18 mpg highway) around the Earth

311: Olympic-size swimming pools that could be filled with the oil that leaked from Deepwater Horizon

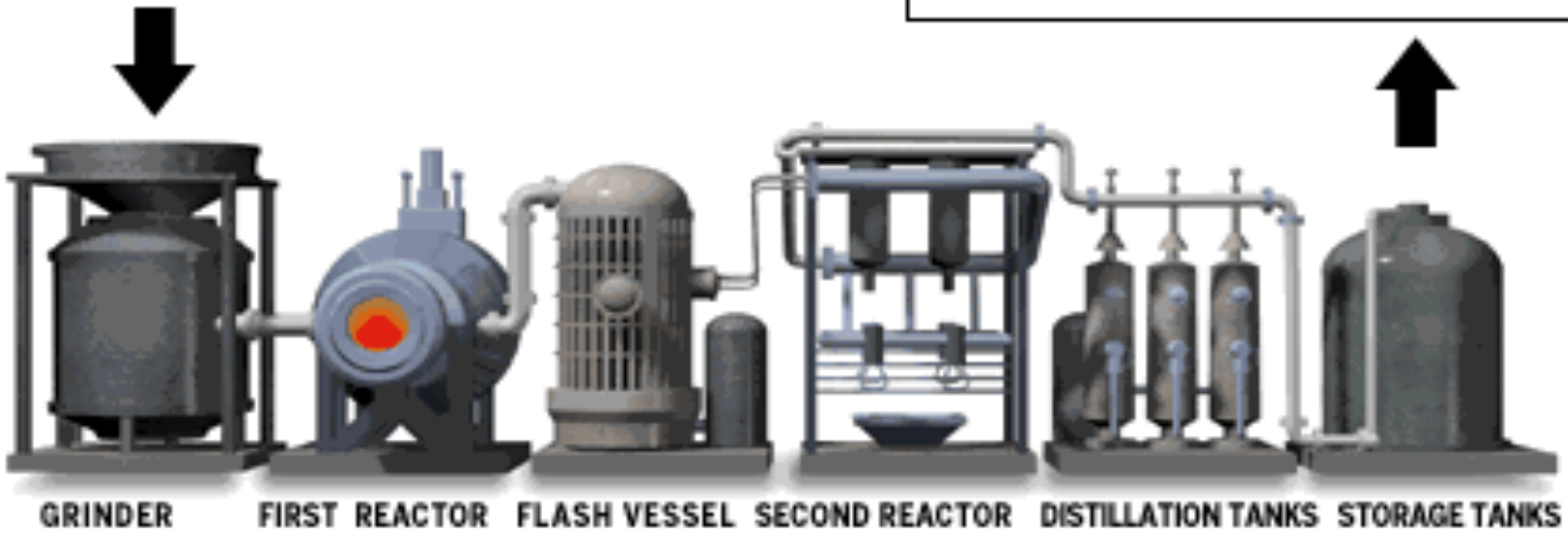
13,208: Homes that could have been heated for one year (approximately 2 gallons of heating oil are produced from one barrel, with an average

American household using 742 gallons per year)



The thermal depolymerization process can convert a wide range of waste materials into oil and other useful by-products, in proportions that vary according to the specific type of feedstock run through the works:

100 POUNDS OF:	
PLASTIC BOTTLES: Clear (polyethylene terephthalate) and translucent (high-density polyethylene)	PLASTIC BOTTLES: 70 pounds oil, 16 pounds gas, 6 pounds carbon solids, 8 pounds water
MUNICIPAL LIQUID WASTE: 75 percent sewage sludge, 25 percent grease-trap refuse	MUNICIPAL LIQUID WASTE: 26 pounds oil, 9 pounds gas, 8 pounds carbon and mineral solids, 57 pounds water
TIRES: All kinds, including standard rubber and steel-belted radials	TIRES: 44 pounds oil, 10 pounds gas, 42 pounds carbon and metal solids, 4 pounds water
HEAVY OIL: Refinery residues, heavy crudes, and tar sands	HEAVY OIL: 74 pounds oil, 17 pounds gas, 9 pounds carbon solids
MEDICAL WASTE: Transfusion bags, needles and razor blades, and wet human waste	MEDICAL WASTE: 65 pounds oil, 10 pounds gas, 5 pounds carbon and metal solids, 20 pounds water



GRAPHIC BY DON FOLEY

Arctic National Wildlife Refuge

- 1980 NE Alaska declared wilderness area.
- ~7.7 B barrels of oil within the refuge
- Bush supports opening refuge to drilling.
  - Senate voted against development 2002.
  - Continues to be debated today in congress.
- Conservationists believe that oil exploration posed permanent threats to the delicate balance of nature in the Alaskan wilderness.

Keystone Pipeline

- Pipeline system to transport syntheic crude oil from the oil sands of Alberta, Canada and crude oil from northern USA to refineries in Gulf Coast of Texas