

FOSSIL FUELS

A Burning Issue



ENERGY CONSUMPTION

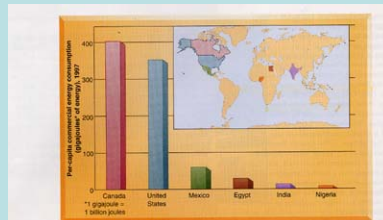


Figure 10-1
Annual per-capita commercial energy consumption in selected countries, 1997. Note that energy consumption per person in highly developed nations is much greater than it is in developing countries. (204 U.S. Dept. of Energy)

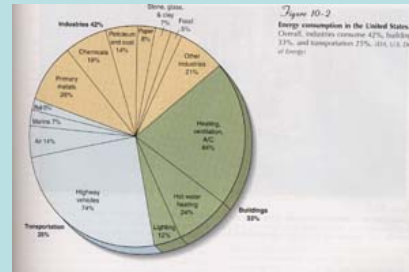


Figure 10-2
Energy consumption in the United States. Overall, industries consume 42%, buildings, 33%, and transportation 23%. (166 U.S. Dept. of Energy)

US and Canada have 5% of world population but use 25% of energy!

In US transportation uses 25% of energy (all oil)

COAL is a nonrenewable source of energy that fueled the Industrial Revolution

- Most abundant of fossil fuels
- Supplies 27% of energy.
- Used mainly for electric power generation
 - Generates 39% of electricity
 - Makes 75% steel

How Coal Was Formed

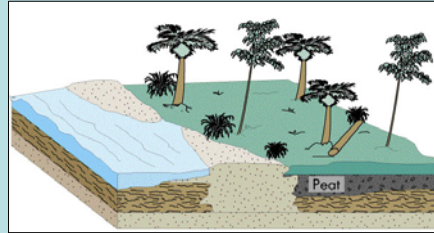
Three hundred million years ago vegetation growing in swamps died

Did not decompose and accumulated at the bottom of swamps to form spongy brown material called peat.

Geological forces buried the peat deep under the surface of the earth. There, the layers of peat were further compacted by pressure and heat into carbon-rich rock called coal.

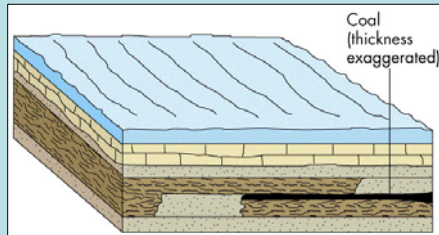
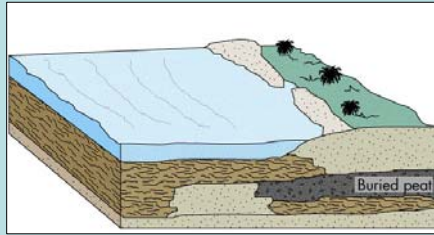


Coal Formation



1. Lots of plant material, limited O_2 because of saturation

2. Burial causes the squeezing out of water and gas



3. Mostly carbon, the original peat thickness is greatly compressed

This process takes a lot of time!!

Four Categories

Lignite: (softest coal) contains a lot of moisture.

It's brownish-black and crumbles easily.

It's primarily used at electricity generating plants.

Low energy content

Sub-bituminous (medium-soft coal) has much less moisture than lignite.

It's used mostly to produce steam for electricity generation.

Lower energy but also low sulfur

Bituminous (medium-hard coal) contains very little moisture

High heat value

It's widely used to generate electricity and to make coke used to make steel

Most abundant and cheapest to mine

Dirty and contains a lot of sulfur

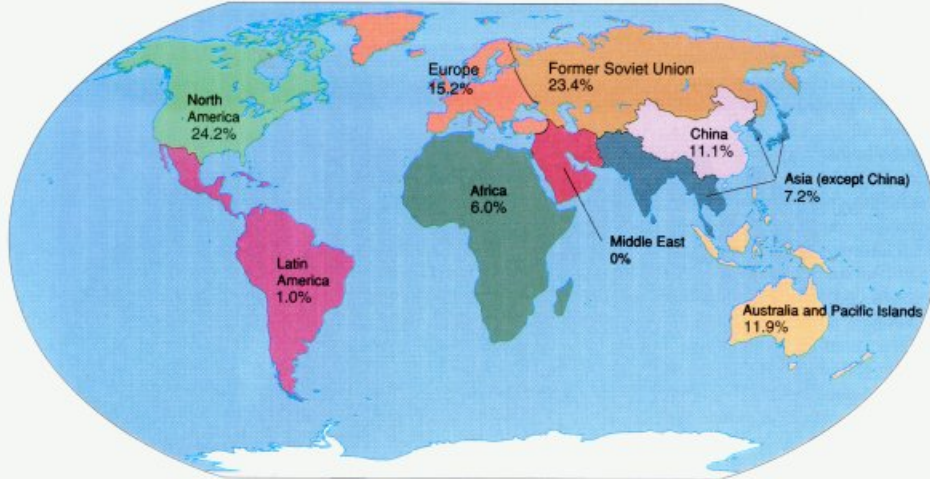
Anthracite (hardest coal) has a very high heat value.

It burns slowly and makes a good home heating fuel.

Expensive to mine

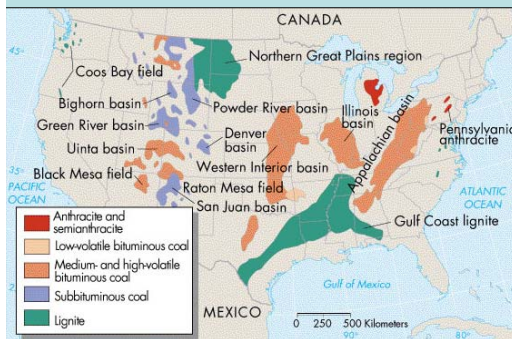
Cleanest burning

WORLD COAL RESERVES



UNITED STATES COAL RESERVES

State	Tons (billions)	Percent of U.S.
Montana	120	25.4
Illinois	78	16.5
Wyoming	68	14.4
West Virginia	37	8.0
Kentucky	30	6.3
Pennsylvania	29	6.1
Ohio	19	4.0
Colorado	17	3.6
Texas	13	2.7
Indiana	10	2.1
Other States	51	10.9
TOTAL	472	100.0



The Two Basic Ways to Mine Coal

SURFACE (STRIP) MINING is used when coal is found close to the surface or on hillsides. This is a safe and economical method that is used for over half the coal mining in the U.S.

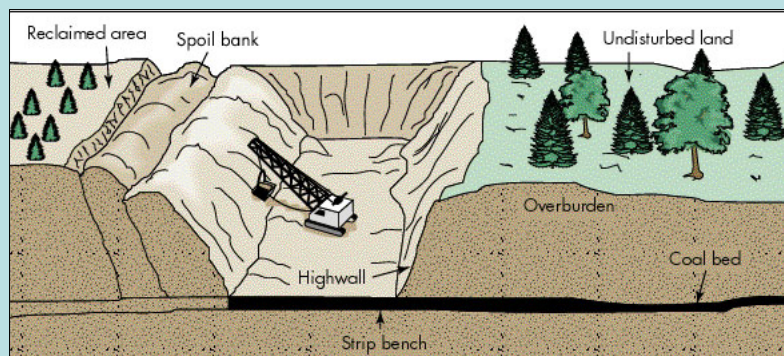
60% of coal mined today

COAL IS UNCOVERED by giant earthmoving equipment which strip off the earth and rock that covers coal (overburden). The topsoil is set aside and the rock goes into already mined areas

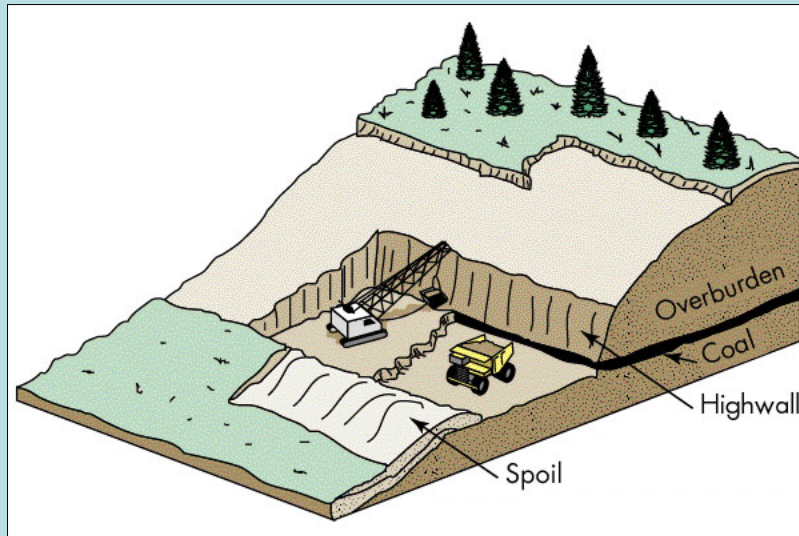
Three methods:

- Area strip mining
- Contour mining
- Mountain top removal

Area Strip Mining



Contour Mining



MOUNTAIN TOP REMOVAL

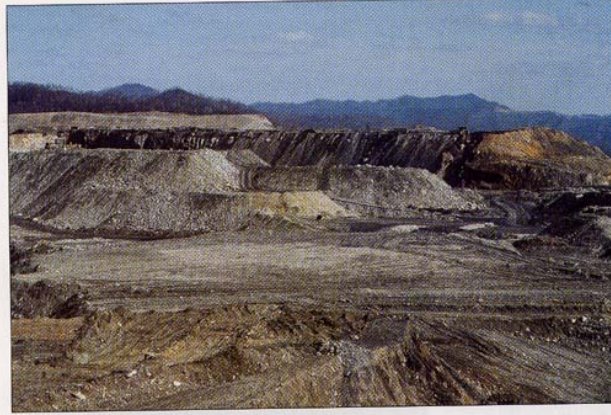


Figure 10-6
Mining for coal by mountaintop removal. This photo was taken in Spencer, West Virginia. (Ken Sherman/Appalight)

Used in KT, WV, PA, TN

Estimated that half of WV mountain tops will be removed by 2020

Where do the tops go?

COAL IS BROKEN into manageable sizes-usually with explosives which blast coal (and overburden) from the earth.

COAL IS REMOVED and loaded into trucks by smaller power shovels.

Localized dust problems



FIGURE 12.5 Some giant mining machines stand as tall as a 20-story building and can scoop up thousands of cubic meters of rock per hour. Note the pick-up trucks in the machine's shadow.

Reclamation - replace overburden. The area is then graded, covered with topsoil and reseeded.

1977 Surface Mining Control and Reclamation Act

Required companies to restore lands after 1977

Taxed coal at mine to provide funds to reclaim abandoned mines

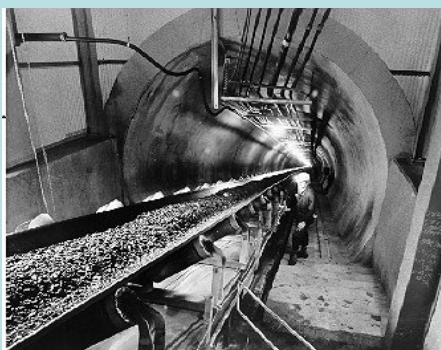
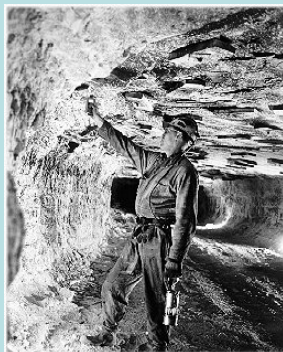


UNDERGROUND MINING is used to extract coal lying deep beneath the surface or in seams exposed to hillsides

COAL IS REACHED by drilling two openings into the coal bed.

COAL IS BROKEN by explosives and heavy machinery

COAL IS REMOVED cleaned, sorted and crushed to different sizes



Environmental Problems Associated with Coal Mining

Strip Mining

Destroys habitat

Soil erosion

Localized dust

Water polluted with acids, toxic substances and sediment.

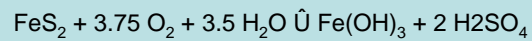


Underground Mining

Tailings

Contain acids and heavy metals

Acids leach heavy metals into streams



West branch Susquehanna River

Landslides

Reclamation - this is a tough one

Mines collapse

The burning of Centralia

Black lung disease



Transportation is Expensive

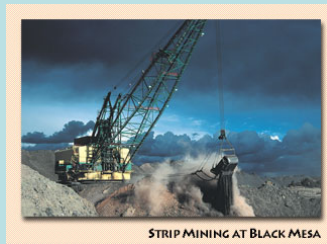
Rail is cheapest because coal is bulky and heavy

Ships and barges

Pipe lines

Arizona to Nevada

Wyoming and Montana



Usage problems

Sulfur (10% by weight) and nitrogen from proteins

Burning produces **acid precipitation** (e.g. rain and snow)

Particulates and heavy metals 25% of all atmospheric Hg

Unburned hydrocarbons

Radioactive isotopes of uranium & thorium

CO₂ and **global warming**

Carbon balance being disrupted

Coal releases more CO₂ per unit of heat produced than oil or gas

Technology Can Make Coal a Cleaner Fuel

Scrubbers can remove 98-99 % of sulfur

Account for 10-15 % of cost to generate power

Sludge to landfills.

Lime scrubbers produce calcium sulfate that can be used in farming and building industry.

Clean Coal Technologies

Fluidized-bed combustion

Burns coal with calcium to remove sulfur.

Burns at lower temperature so Nox not as much of problem.

Burns more efficiently thereby reducing CO₂ emissions.

SYNTHETIC FUELS

Coal Liquefaction is a liquid fuel derived from coal but not cost competitive with oil.

Coal Gasification produces methane from coal but is expensive and a byproduct is carbon dioxide.

OIL and NATURAL GAS

Unites States

Uses 30% of world supply (66% for transportation)

Use is leveling off

Until 1970 used domestic oil

70's & 80's used Mexico and Venezuela

90's Saudi Arabia and other Gulf States

Asia use growing rapidly

China using 10% more each year

By 2000 half OPEC production was going to Asia!

OIL and NATURAL GAS FORMATION

Oil: Microscopic aquatic organisms buried in sediments

Natural gas: Formed in similar way to oil only under higher temperature

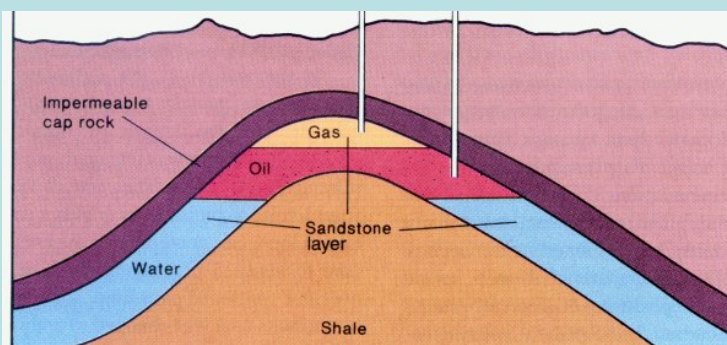


FIGURE 9.5 Crude Oil and Natural Gas Pool Water and gas pressure force oil and gas out of the shale and into sandstone beneath the impermeable rock.

Advantages over coal

Relatively easy to extract
Pumped from wells
Less environmental damage



Easily transported
Ship, truck, pipeline (especially gas)

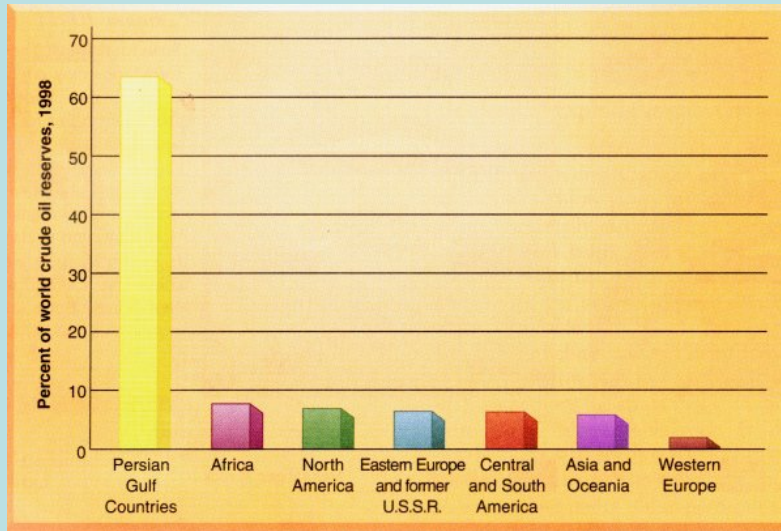


Processing (distillation) simple

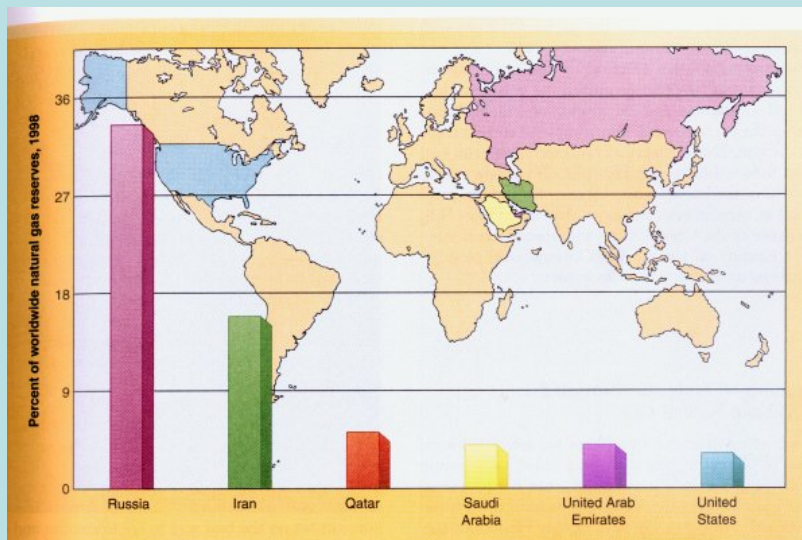


Supply: 50-100 year supply?

Where are the oil fields?



Where are the gas fields?



Uses

Petrochemicals

Industrial chemicals

- paint
- pesticides
- PCB's

Fertilizers

Synthetic polymers (plastic)

- fibers

Fuel

OIL: Kerosene, gasoline, #1 fuel oil, #2 fuel oil

GAS: Methane, ethane, propane, and butane

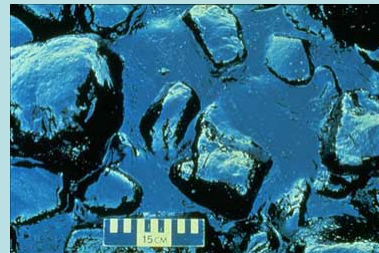
Asphalt

Hidden costs and Environmental Concerns

Oil spills pollute surface and ground water

Alaska Oil Spill and the Exxon Valdez (1989)

- 30,000 birds killed
- 5,000 sea otters
- Killer whale pop declined
- Salmon migration disrupted
- Exxon paid **billions**



Komi (Russia) spill in 1994

3X Exxon Valdez
Oil entered Pechora River
No money for cleanup



Oil Pollution Act of 1990 required double hulled ships in US waters by year 2015.

Offshore drilling

Expensive to clean up

Oil spills pollute the soil and air
Persian Gulf spill in 1991 and oil well fires

Burning oil & gas pollutes air
CO₂ (both)
NOx half of air pollution and acid rain (oil)
Sox (oil)

Petrochemical industry is BIG TIME air polluter

Wars to protect oil resources

Health problems



Wildlife

Arctic National Wildlife Refuge
 America's Serengeti
 Oil companies want to explore
 Clinton vetoed congress effort to open in 1995
 2001 – Bush wants to open – and so it goes!

