



ENVE203

Environmental Engineering Ecology
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Environmental Engineering Department

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‘Fossil Fuels’



Fossil Fuels

Fossil fuels

Combustible deposits in Earth's crust, composed of the fossils of prehistoric organisms that existed millions of years ago.

Three types of fossil fuel

- Coal
- Petroleum
- Natural gas



- Fossil fuels are nonrenewable resources
- Earth's crust has a finite, or limited, supply of them
- Depleted by use
- Fossil fuels still forming, but too slowly
- We will have to switch to other forms of energy



How Fossil Fuels Formed

- 300 million years ago, mild & warm climate
- Atmospheric CO₂ levels were higher
- Swamps filled with plant species, covered with water
- Not appropriate conditions for decomposition (oxygen-deficient environments)
- Changes in sea level, sediment accumulated, forming layers that covered the plant material

Nondecomposed plant material → carbon-rich rock 'COAL'





How Fossil Fuels Formed

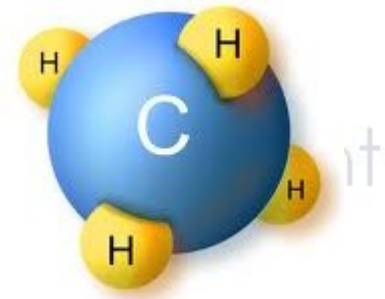
- Oil formed when large numbers of microscopic aquatic organisms died & settled in the sediments
- Their decomposition depleted O_2
- O_2 deficient environment prevented further decomposition
- Dead remains covered and buried
- Heat & pressure caused by burial converted remains to the mixture of hydrocarbons known as oil





How Fossil Fuels Formed

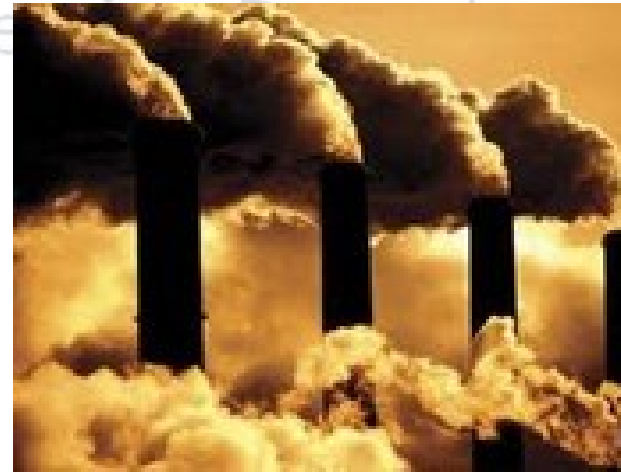
Natural gas, composed primarily of the simplest hydrocarbon, methane, formed in essentially the same way as oil, only at higher temperatures greater than 100°C



Fossil Fuels, the Carbon Cycle, and Climate

Burning of fossil fuels: completion of the carbon cycle, a part of a natural system

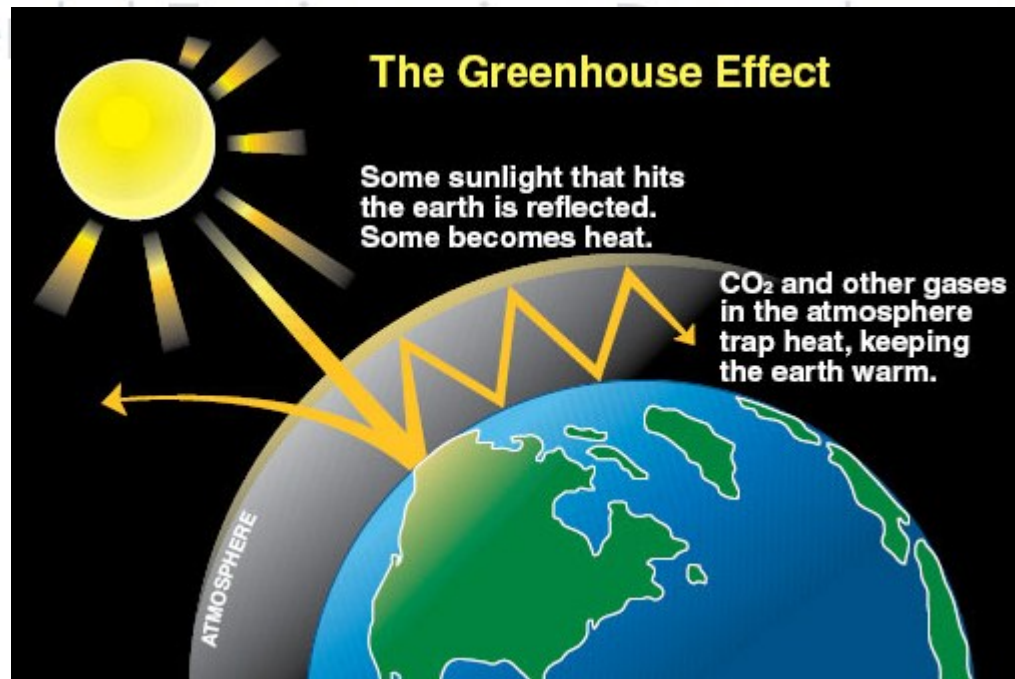
The energy & carbon accumulated over millions of years are being released in just a few hundred years!



Fossil Fuels, the Carbon Cycle, and Climate

Over the past century: so much CO₂ released into the atmosphere, and the Earth's CO₂ equilibrium has been disrupted

Global temperature has been affected because atmospheric CO₂ prevents heat from escaping from the planet





Coal

Lignite, sub-bituminous coal, bituminous coal, and anthracite are the 4 most common grades of coal

Energy density

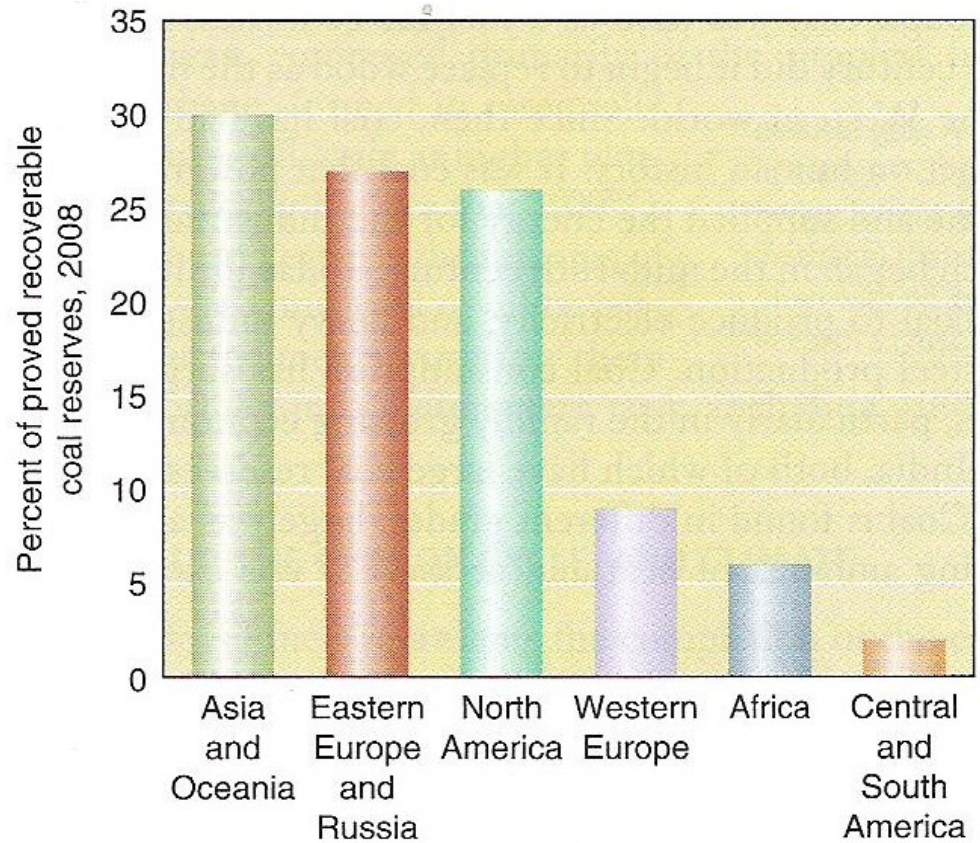
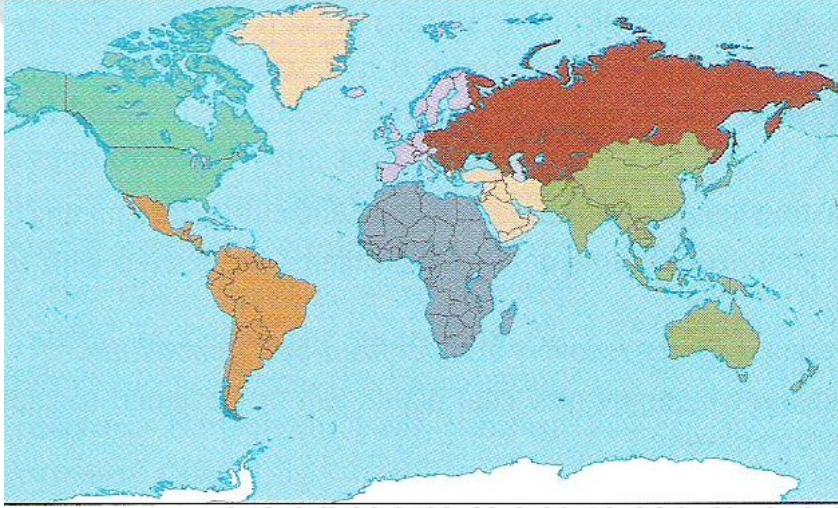
The amount of energy contained within a given volume of an energy source.

Energy density of
COAL

>

Energy density of
WOOD

Coal Reserves





Coal Mining

Surface mining

The extraction of mineral & energy resources near Earth's surface by first removing the soil, subsoil, and overlying rock strata

Subsurface mining

The extraction of mineral & energy resources from deep underground deposits





Coal Mining

Environmental Impacts of the Mining Process

Acid mine drainage

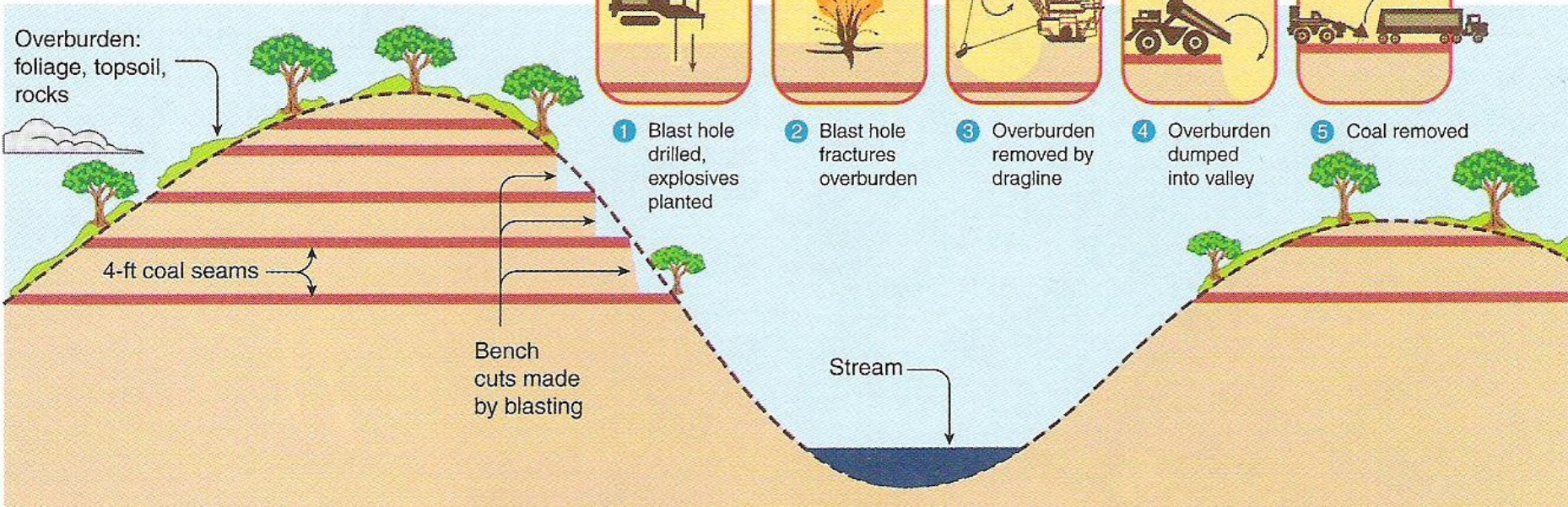
Pollution caused when sulfuric acid and dangerous dissolved materials such as Pb, As and Cd wash from coal and metal mines into nearby lakes and streams

Dangerous landslides

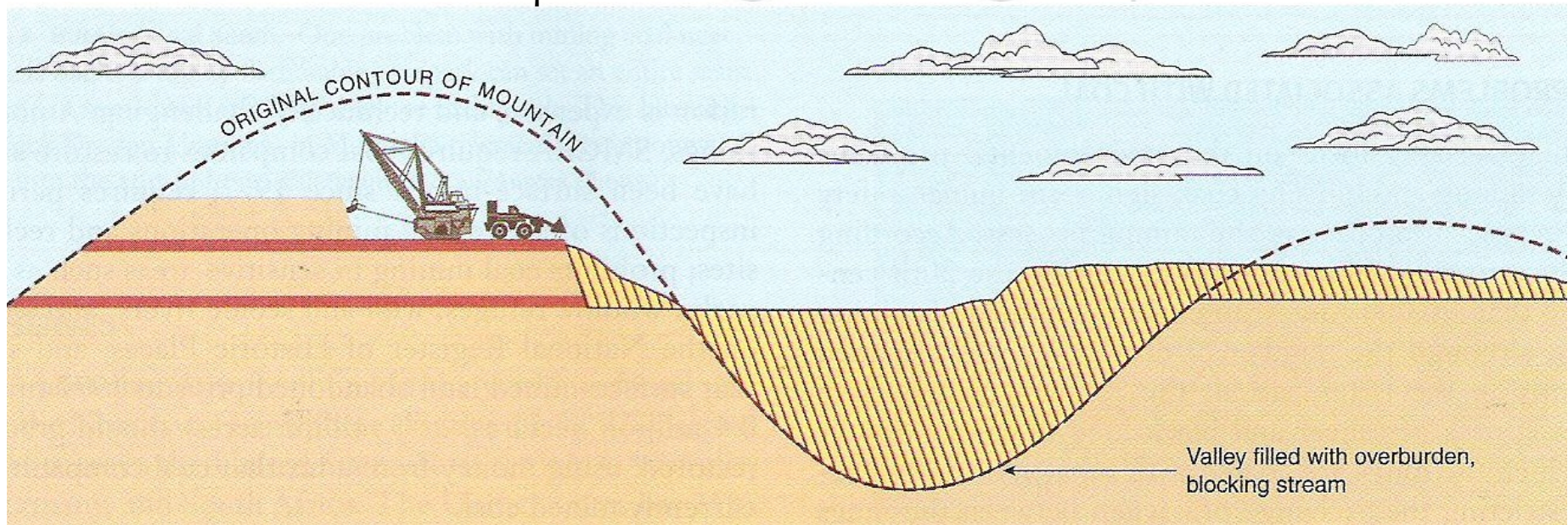
Unstable land, lack of vegetation

When coal is removed from mountains, the geography of a region can change

Cross section of a typical mountain before mining



Cross section after mountaintop has been removed





Coal

Environmental Impacts of Burning Coal

Affect air and water quality

Impacts range from local to global



Burning coal generally contributes more air pollutants (including CO₂) than does burning either oil or natural gas to generate the same amount of useful energy



Coal

Environmental Impacts of Burning Coal



Coal often contains Hg
Released into the atmosphere during
combustion

To atmosphere & land
Accumulates

Harmful humans as well as wildlife

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Coal

Environmental Impacts of Burning Coal



Coal contains sulfur & nitrogen

Burning releases

Sulfur oxides (SO_2 & SO_3)

Nitrogen oxides (NO , NO_2 , N_2O)

They form acids when react with water
'Acid deposition'

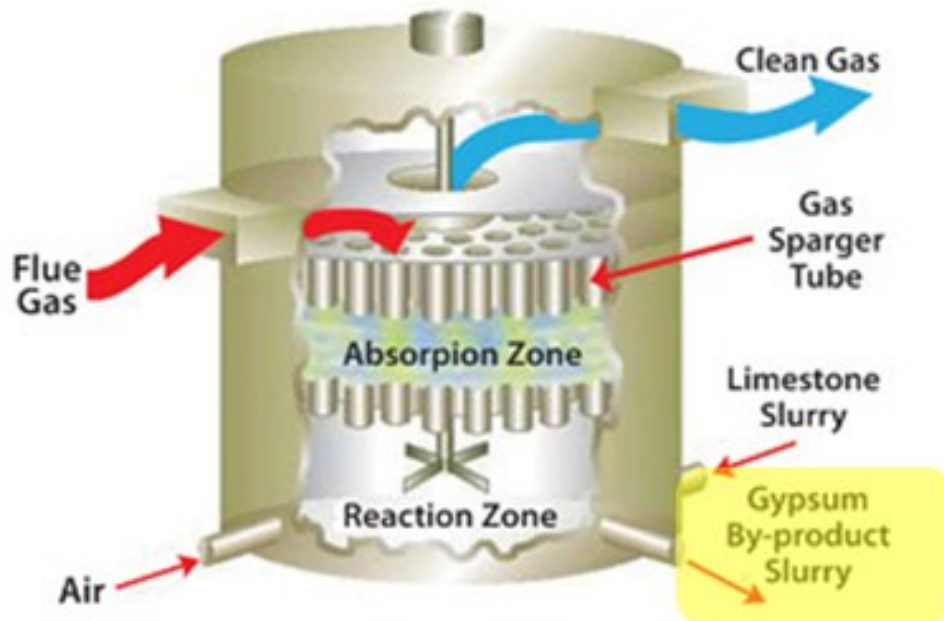




Making Coal a Cleaner Fuel

Resource Recovery

The process of removing any material from polluted emissions or solid waste and selling it as a marketable product



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Making Coal a Cleaner Fuel

Some utilities sell calcium sulfate from scrubber sludge to wallboard manufacturers

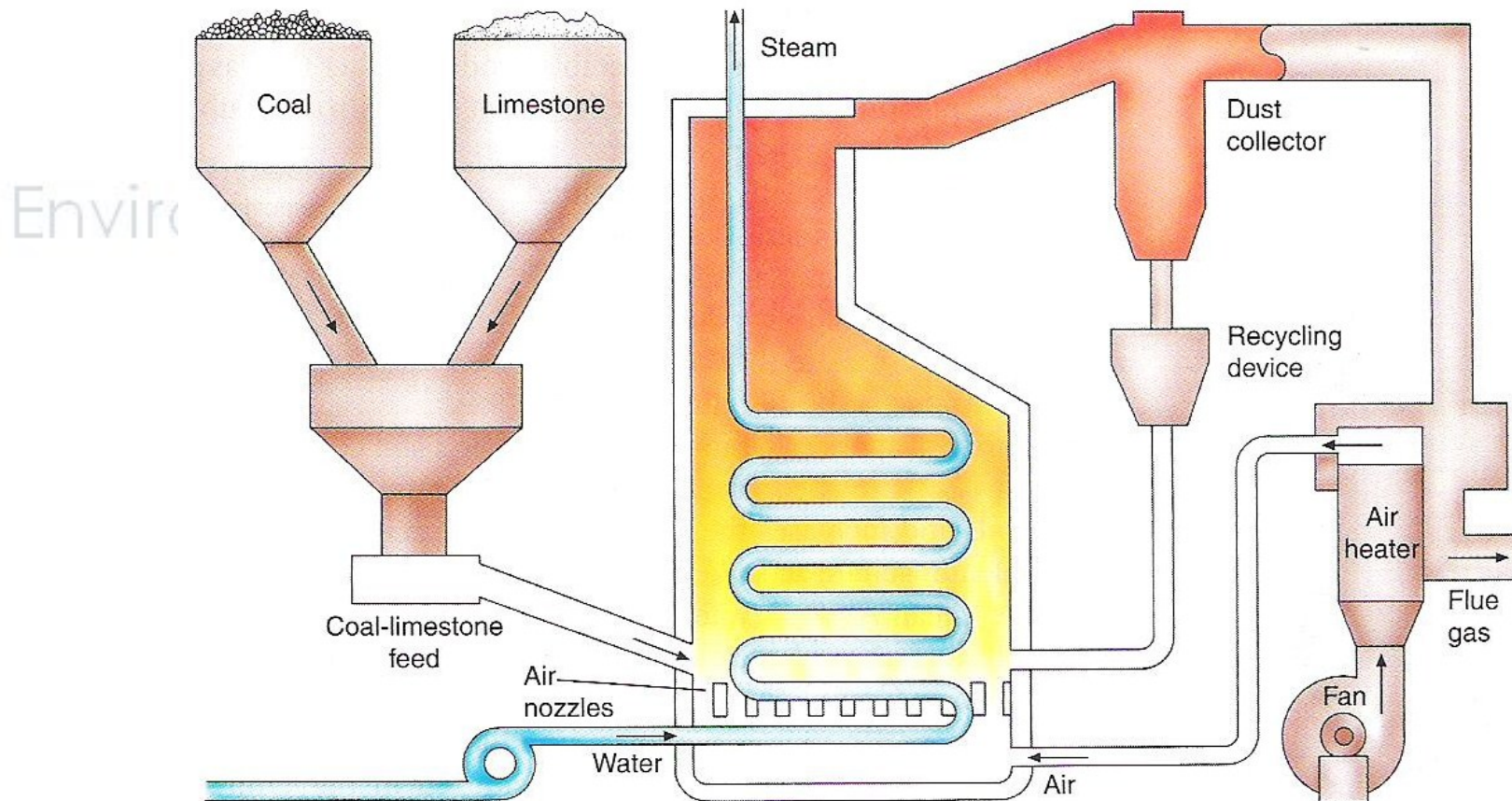
Other companies use fly ash from chimney flues, to make a lightweight concrete in the building industry

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Making Coal a Cleaner Fuel

Fluidized-Bed Combustion

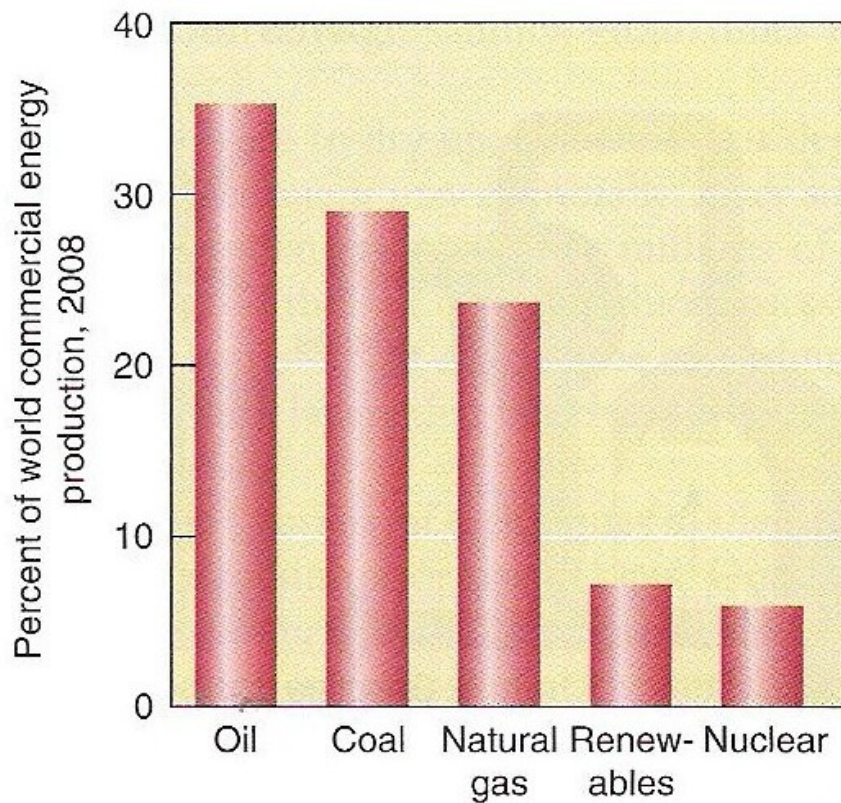
A clean-coal technology in which crushed coal is mixed with limestone to neutralize the acidic sulfur compounds produced during combustion





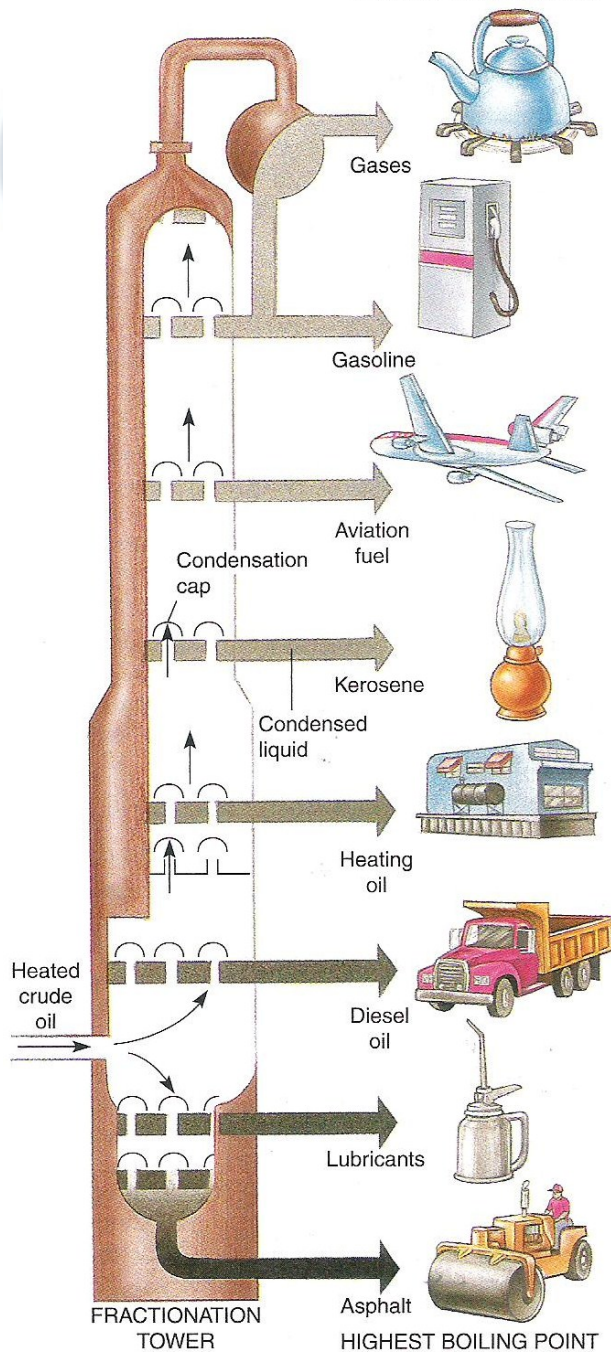
Oil & Natural Gas

Oil & natural gas are becoming increasingly important



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LOWEST BOILING POINT



Petroleum refining

- Crude oil is separated into a variety of products based on their different boiling points.
- After being heated, they are separated in a fractionation tower, which is about 30 m tall. The lower the boiling point, the higher the compounds rise in the tower



Oil & Natural Gas

Use of natural gas is increasing in 3 main areas

- Generation of electricity
- Transportation
- Commercial cooling

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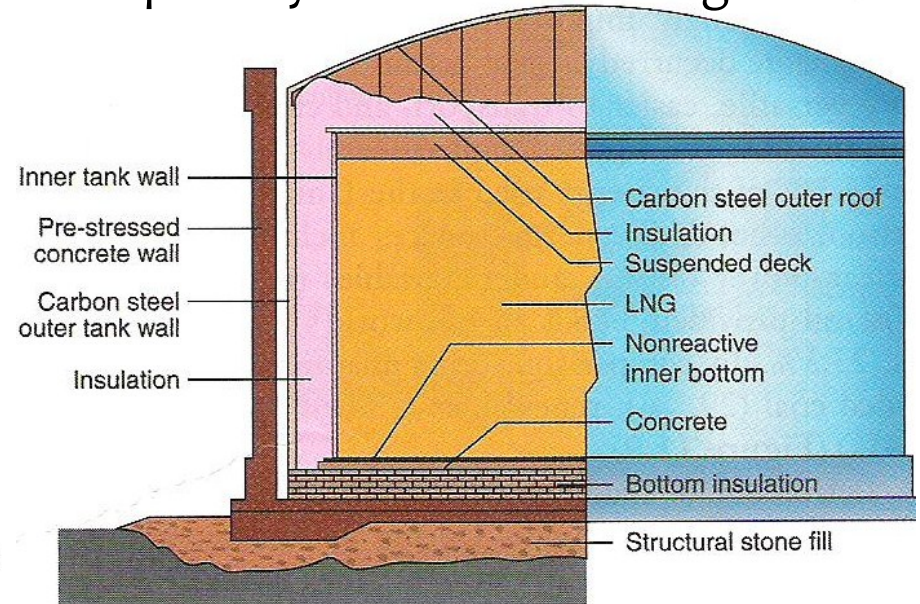
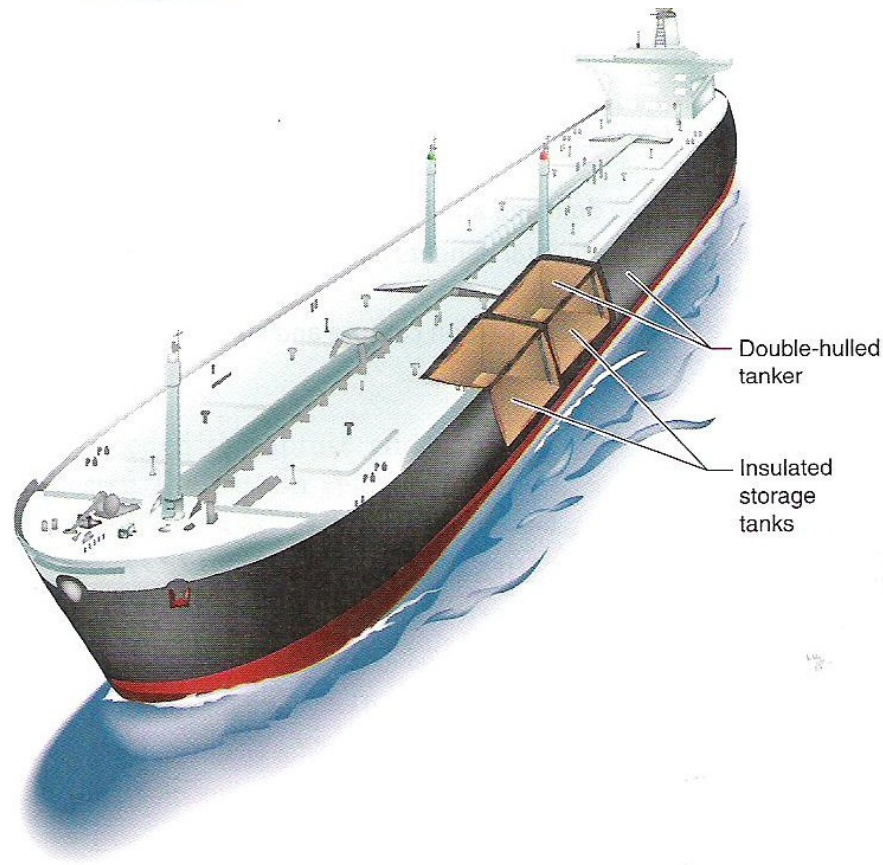
The main disadvantage of natural gas: Deposits are often located far from where the energy is used

It is a gas & less dense than a liquid:

Costs 4 times more to transport through pipelines than crude oil

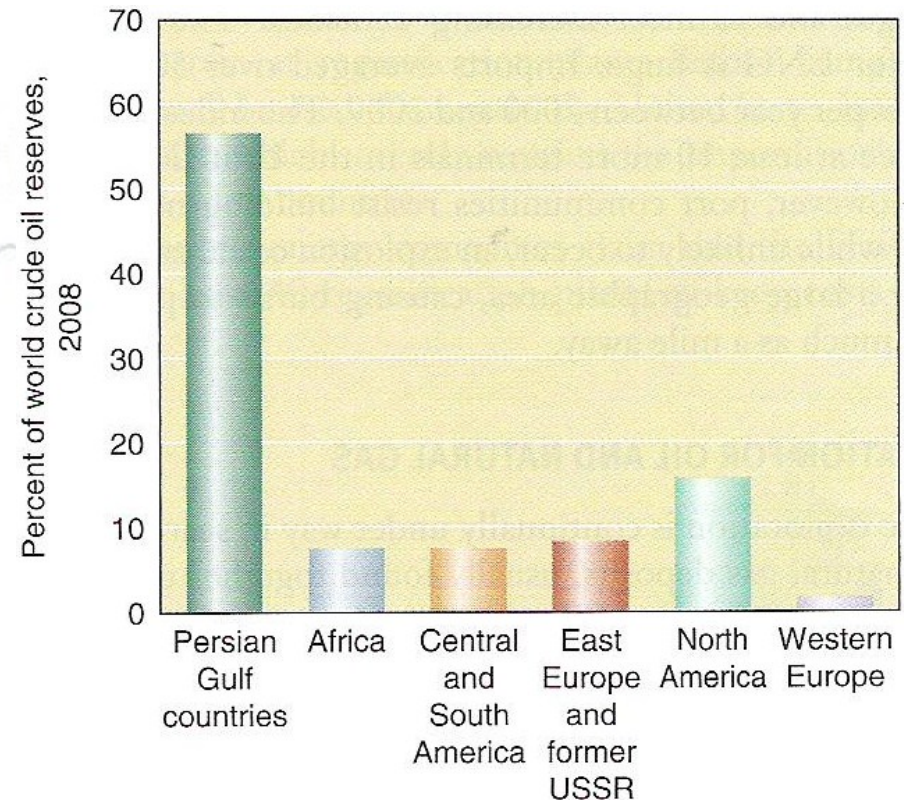
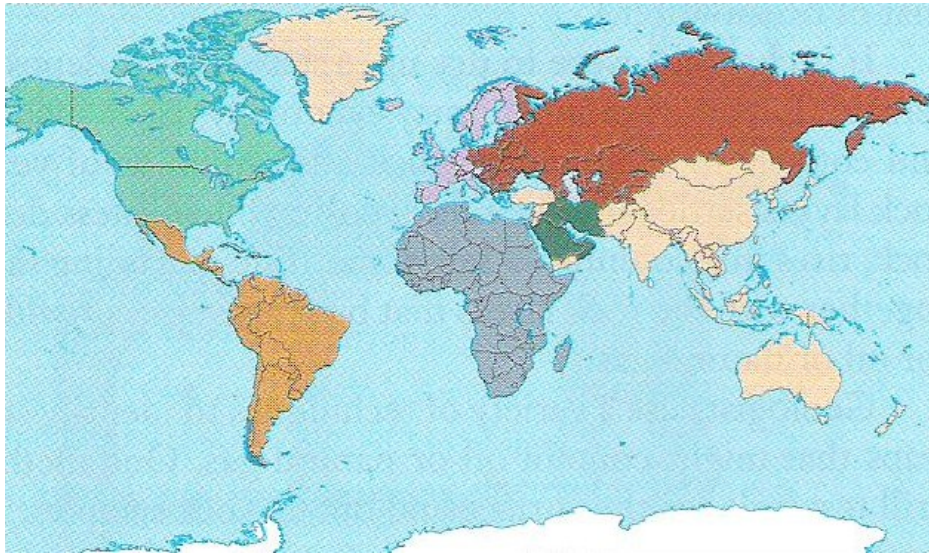


To transport natural gas over long distances it is first compressed to form liquefied natural gas (LNG) then carried on specially constructed refrigerated ships



Reserves of Oil & Natural Gas

Enormous oil fields containing more than half of the world's total estimated reserves are situated in the Persian Gulf region, which includes Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, Syria, the United Arab Emirates, and Yemen





Environmental Impacts of Oil & Natural Gas

Two kinds of problems:

1. Problems that result from burning the fuels (combustion)

CO₂ emissions, global warming, acid deposition

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2. Problems involved in obtaining them (production & transport)

During transport over long distances by pipelines or ocean tankers



Environmental Impacts of Oil & Natural Gas

Europe:

2002 oil tanker 'Prestige' broke up off the coast of Spain, contaminated hundreds of kilometers of coastline and bringing the large fishing industry there to a halt

United States:

April 22, 2010 Gulf of Mexico

1989 Exxon Valdez

Largest global oil spill

1991 Persian Gulf War (about 250 million gallons of crude oil)



April 22, 2010

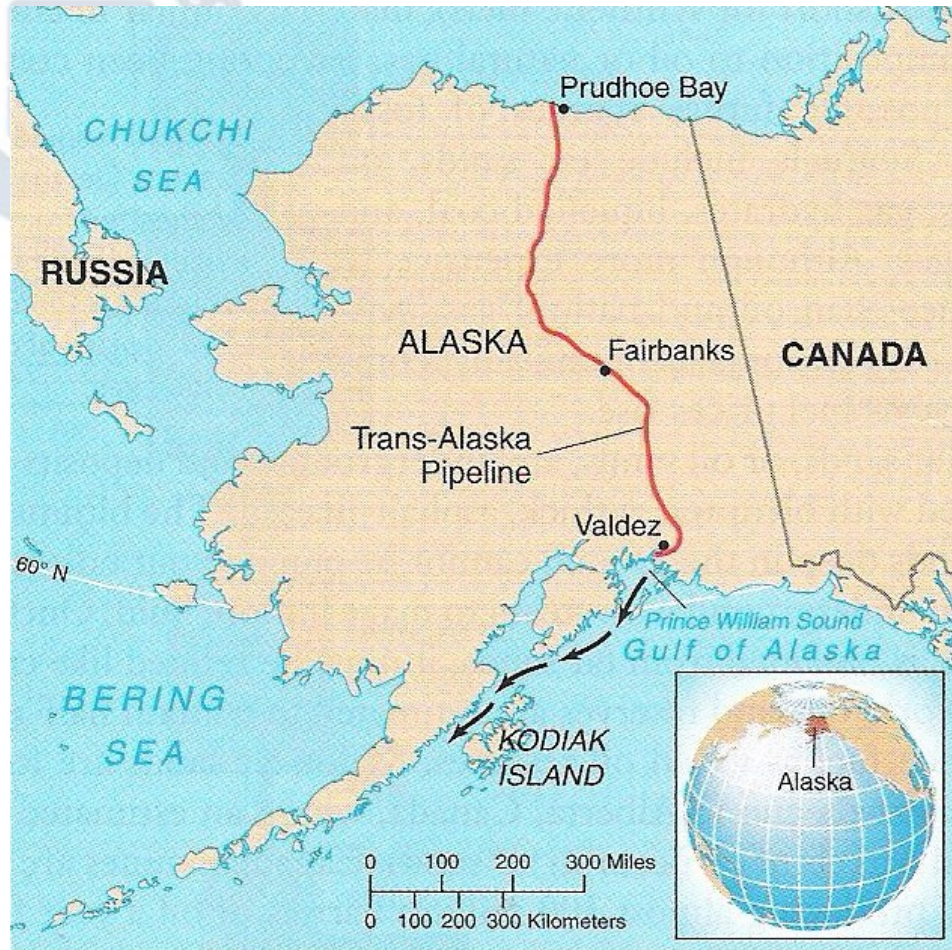
‘Deepwater Horizon’ a drilling platform in the Gulf of Mexico exploded

Between the explosion & July 15, when flow was completely stopped, around 210 million gallons of oil gushed from the well



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Exxon Valdez oil spill

The extent of the spill (black arrows).

Water currents caused it to spread rapidly over hundreds of kilometers.

Countless animals, such as sea otters and birds, died

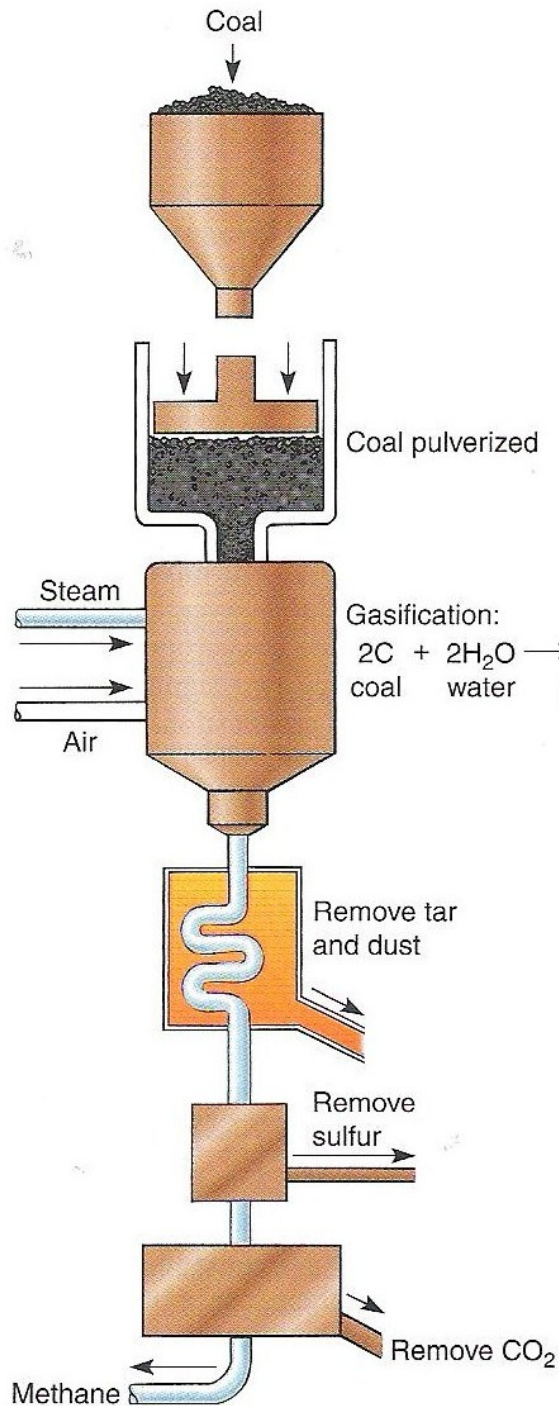


Synfuels & Other Potential Fossil-Fuel Resources

Synfuel (Synthetic fuels)

A liquid or gaseous fuel that is synthesized from coal and other naturally occurring resources and used in place of oil or natural gas

- Similar in chemical composition of oil & natural gas
- Tar sands, oil shales, gas hydrates, liquefied coal, and coal gas
- More expensive to produce than oil & natural gas
- May become economically competitive as fuel prices rise



Coal gasification
Combustible gas methane is generated from coal