

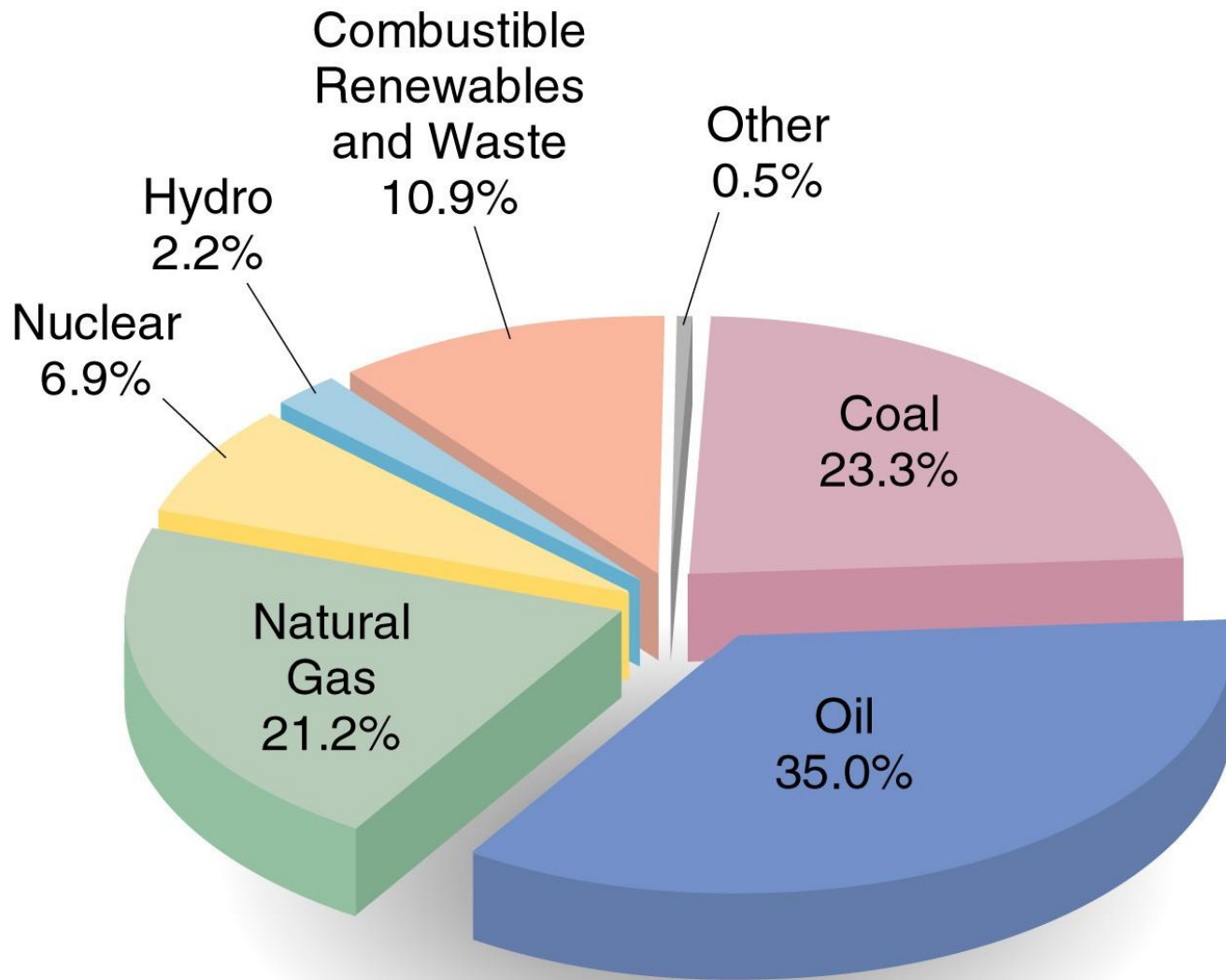
Energy Sources from Fossil Fuels

Energy Consumption in the United States

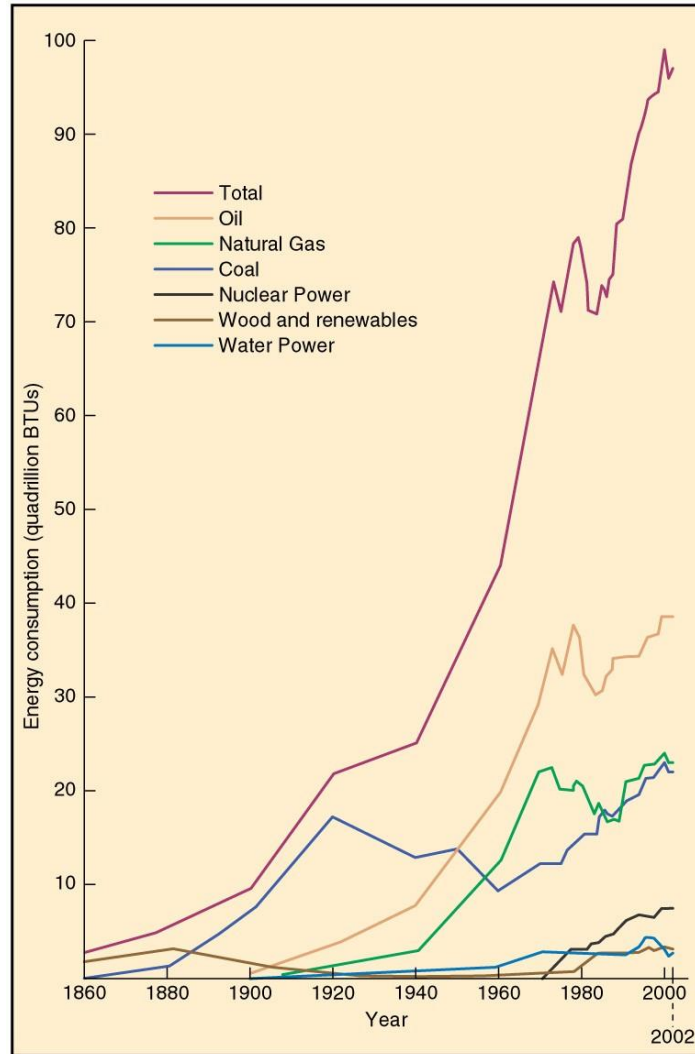
■ Sequence of use

1. Wood $\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} + 4.3 \text{ kcal}$
2. Water (steam)
3. Coal
4. Natural gas $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O} + 11.7 \text{ kcal}$
5. Oil
6. Nuclear power

3, 4, and 5 = 83.5% of U.S. energy consumption



Energy Consumption in the United



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table 12-1 Energy Sources for Generating Electrical Power (% of total)

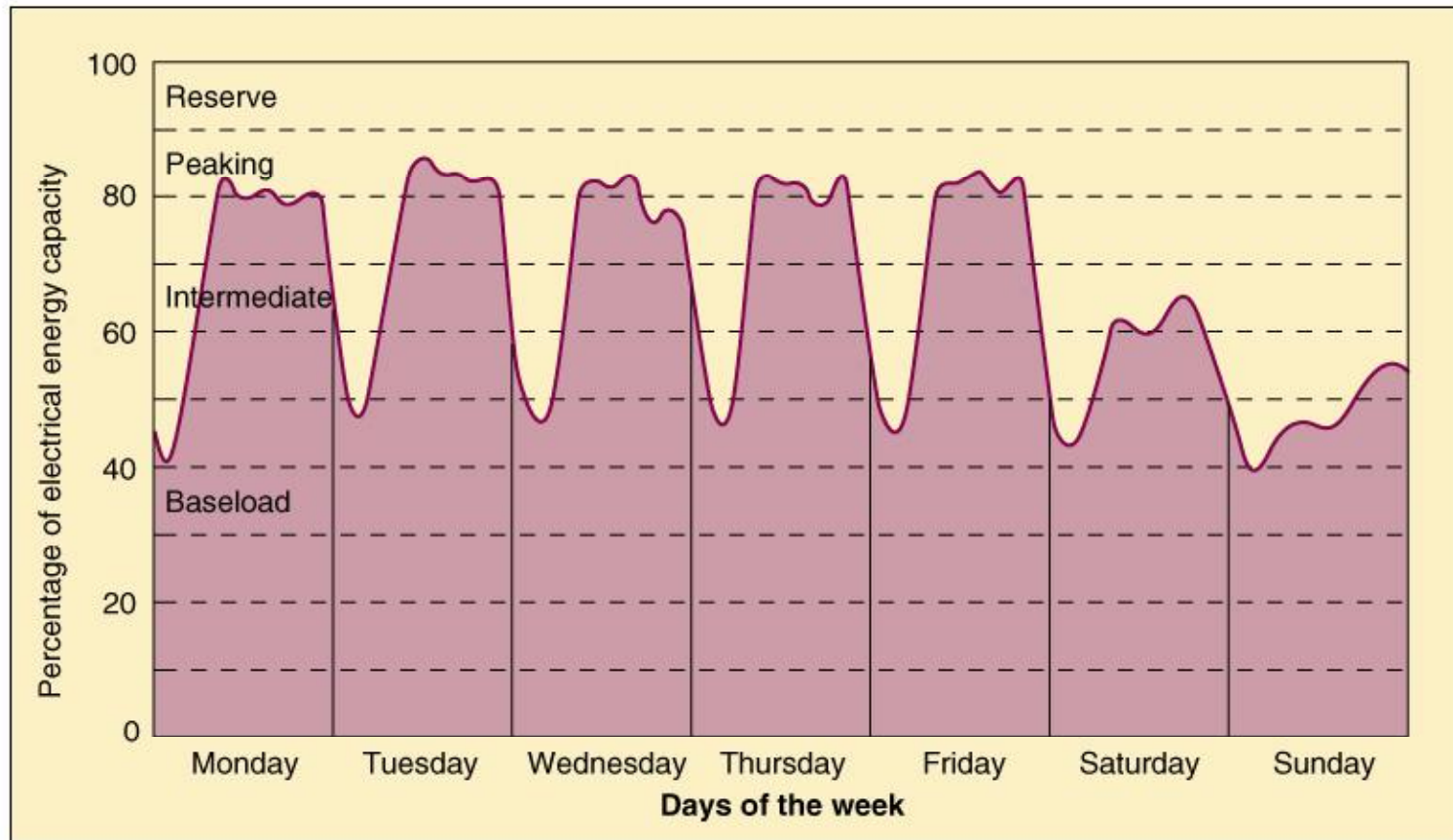
Source	New England*	United States	World
Nuclear power	29.1	20.7	16.9
Natural gas	29.4	16.8	17.4
Coal	15.3	51.2	39.1
Oil	14.2	3.4	7.9
Hydro	5.0	5.8	17.1
Other (wood, refuse, renewables)	7.0	2.1	1.6

*Does not include an additional 11.5% from national energy grid.

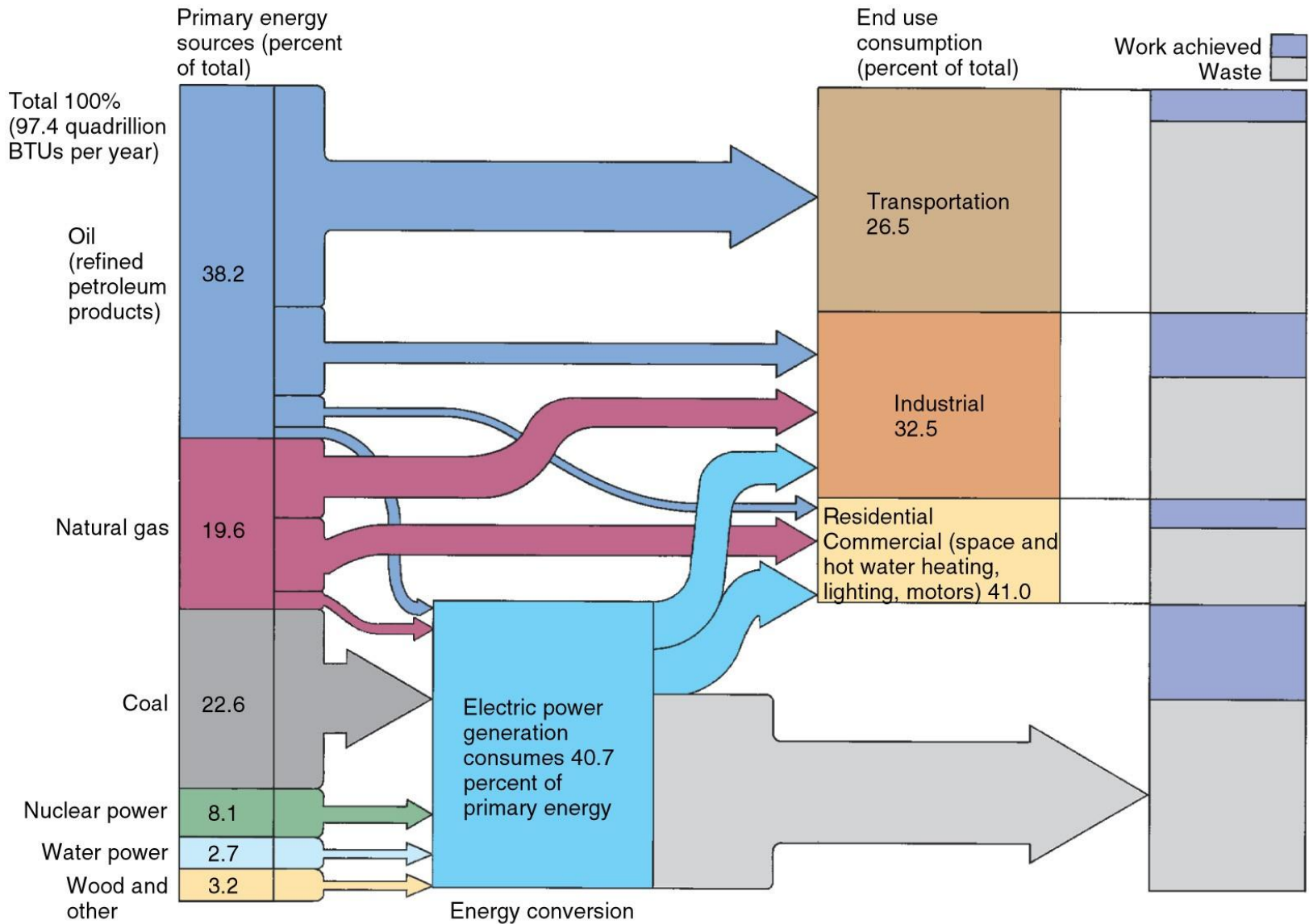
(Sources: ISO New England, U.S. Energy Information Administration, International Energy Agency.)

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Weekly Electrical Demand Cycle



U.S. ENERGY SOURCES AND END USES, 2002



Homes and cars make up
40% of US emissions

Homes- heating, air conditioning,
kitchen appliances, and electricity

Match Dominant Primary (Left) with Secondary (Right) Energy Sources

- oil-based fuels — transportation
- natural gas — industrial processes
- coal — space heating and cooling
- nuclear power — generation of electrical power

Crude-Oil Reserves versus Production

- Estimated reserves: educated guesses about the location and size of oil or natural gas deposits
- Proven reserves: how much oil can be economically obtained from the oil field
- Production: withdrawal of oil or gas from the oil field

7

Organization of Petroleum Exporting Countries: OPEC

- Algeria
- Indonesia
- Iran
- Iraq
- Kuwait
- Libya
- Nigeria
- Qatar
- Saudi Arabia
- United Emirates
- Venezuela

1973 OPEC oil embargo

- Little oil was held in storage.
- Spot shortages occurred.
- Panic made for long lines
- OPEC force up prices for oil at the pump
- Double digit inflation ensued with a recession and large unemployment rate followed
- Odd and Even license plates to get gas

What did the US do?

- Increase in domestic production of oil
- Have a strategic oil reserve created
- Increase in fuel efficiency of cars

Other Fossil Fuels

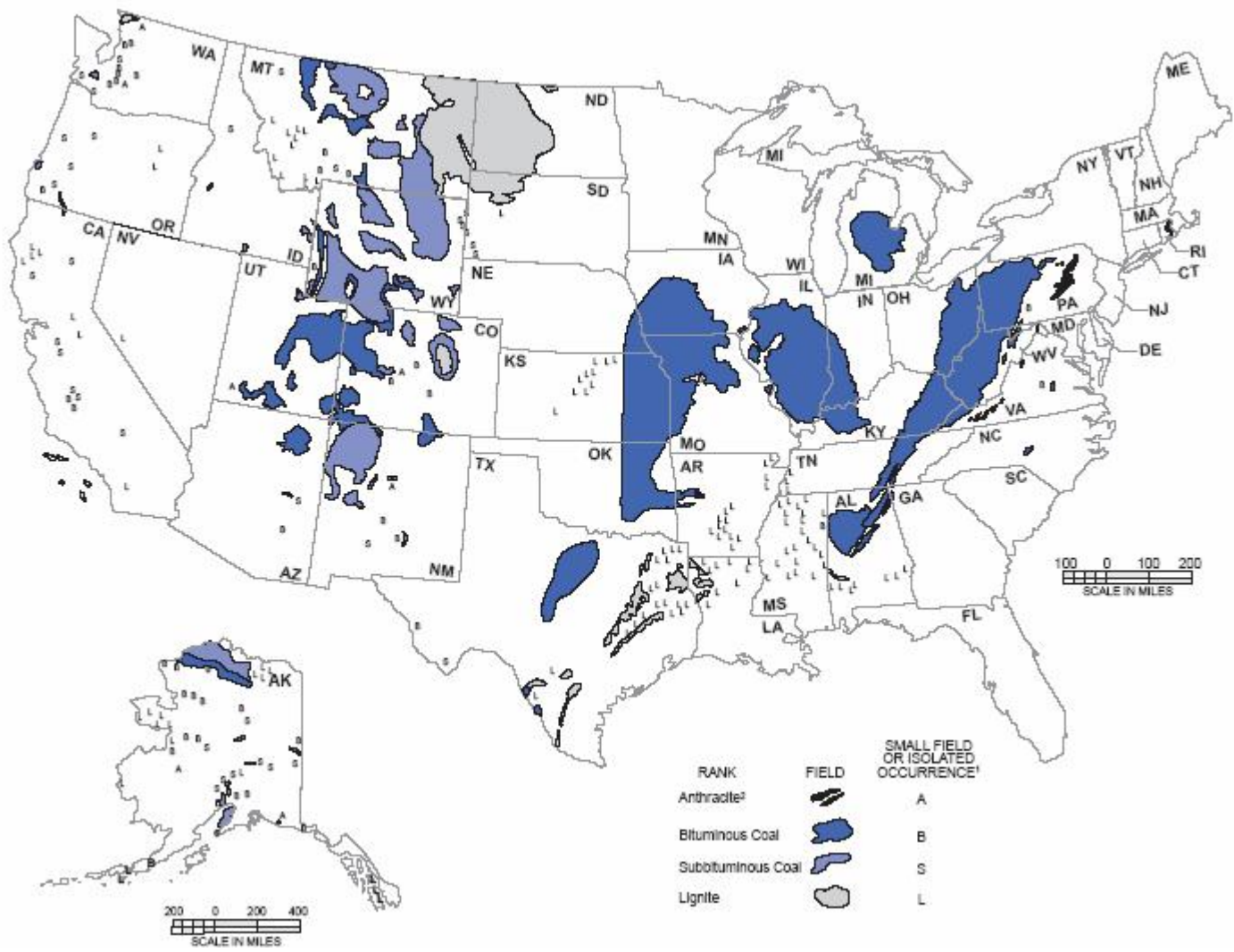
- Natural gas – 50-year supply
- Coal – 400-year supply
- Oil shales and oil sands – complex extraction technologies

table 12-2 Proven World Reserves and Annual Use of Fossil-Fuel Reserves, 2001

Region	Reserves		
	Petroleum (billion barrels)*	Natural Gas (trillion ft³)*	Coal (billion tons)*
North America	63.9	266.7	257.8
South and Central America	96.0	253.0	21.6
Europe	18.7	171.7	125.4
Former U.S.S.R.	65.4	1,982.6	230.0
Middle East	685.6	1,974.6	1.7
Africa	76.7	394.8	55.4
Far East and Oceania	43.8	433.3	292.5
Total	1,050.0	5,476.7	984.5
	Use		
	Petroleum	Natural Gas	Coal
World use, 2001*	27.5 billion barrels	84.9 trillion ft ³	5.26 billion tons
World use, 2001 (quads Btus)	157 quads	87 quads	93 quads

* The fuels may be compared by calculating their energy content in British thermal units (Btus). One billion barrels of petroleum yields ca. 5.7×10^{15} Btus, or 5.7 quadrillion (quads) Btus. One trillion cubic feet of natural gas yields ca. 1.02 quadrillion Btus, and 1 billion tons of coal yields ca. 17.65 quadrillion Btus.
Source: BP Statistical Review of World Energy, 2002, International Energy Annual, 2001.

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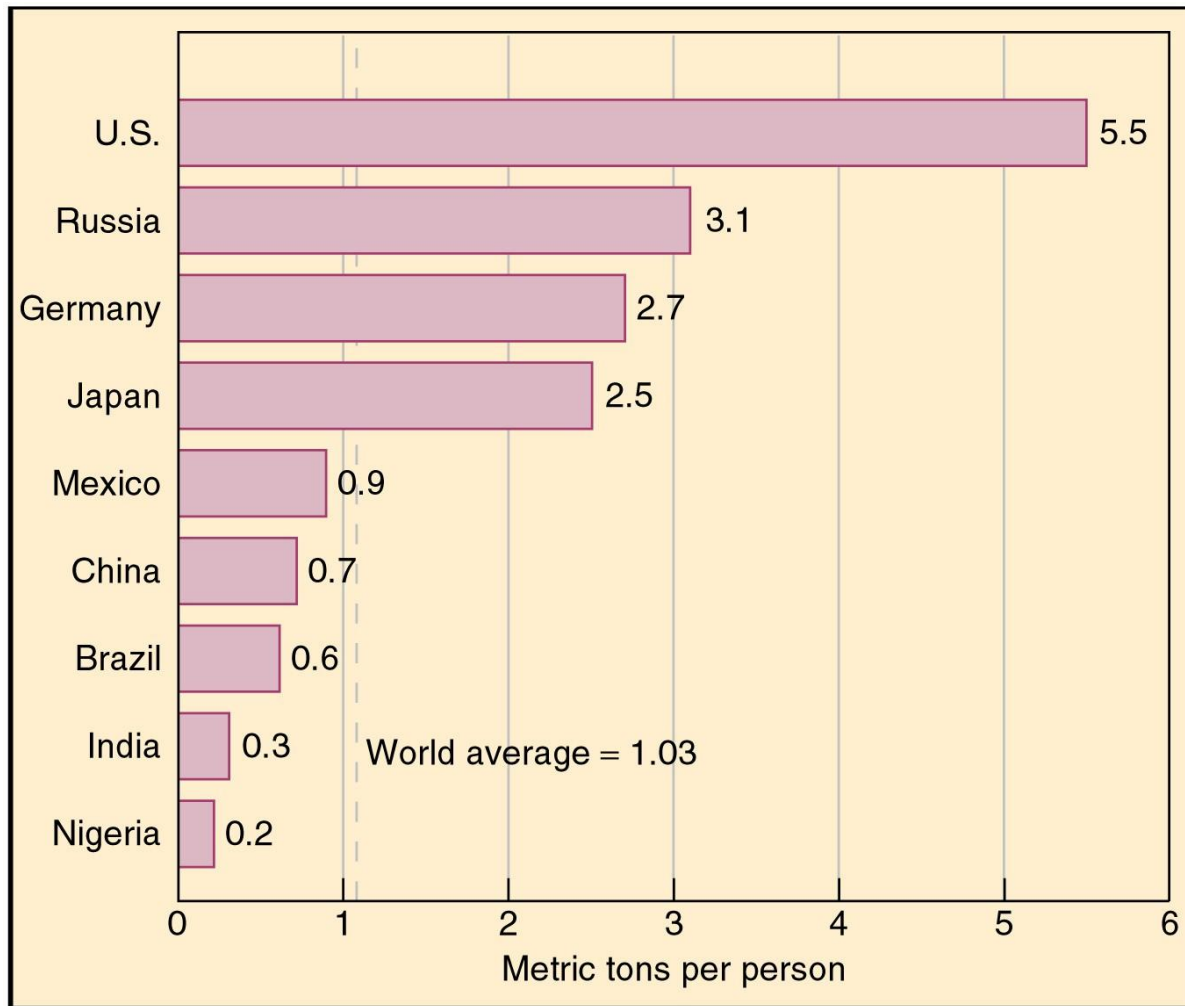
RANK	FIELD	SMALL FIELD OR ISOLATED OCCURRENCE ¹
Anthracite ²		A
Bituminous Coal		B
Subbituminous Coal		S
Lignite		L

table 12-3**CO₂ Emissions per Unit Energy for Fossil Fuels
(Natural Gas = 100%)**

Natural Gas	100%
Gasoline	134%
Crude Oil	138%
Coal	178%

Source: Data from Energy Information Administration, U.S. Department of Energy.

Carbon (CO₂) Emission Per Capita



France is the country that mostly gets all of its energy from nuclear power.

Electrical Power from Burning Coal

Advantages or Disadvantages?

- Pollution from secondary energy source
- Pollution from primary energy source
- Habitat alterations
- Environmental effects of mining
- Conversion losses

Global Warming

An increase in the average temperature of the atmosphere caused by the buildup of greenhouse gases such as carbon dioxide and methane.

Carbon dioxide is used by plants.

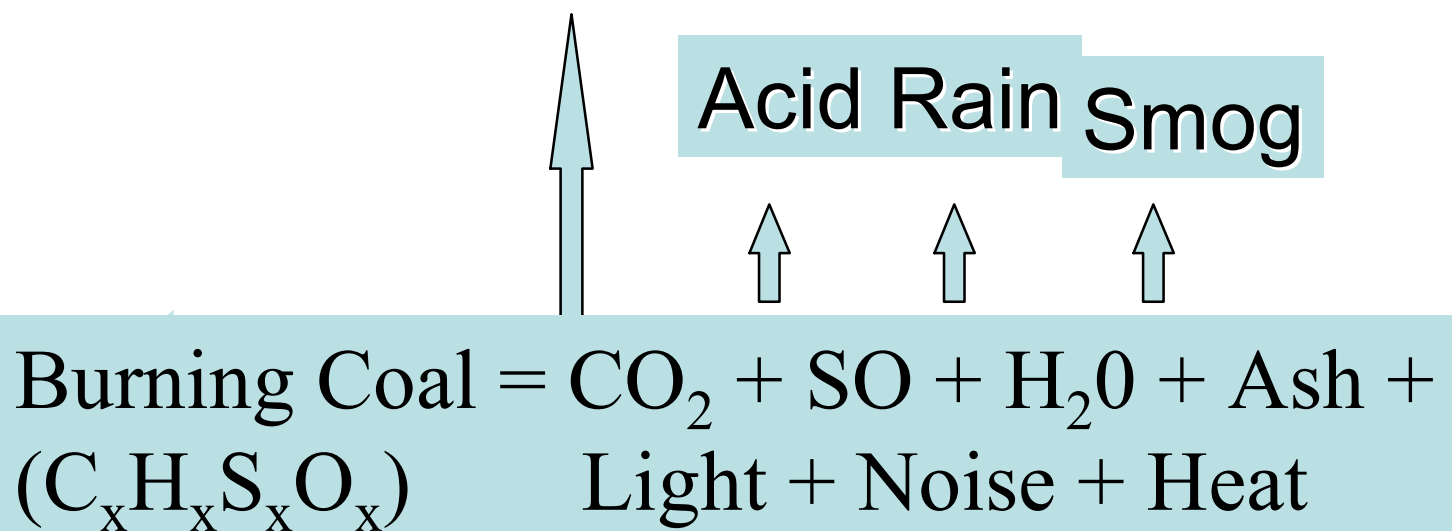
Methane is used to heat homes.

Primary and Secondary Effects from Burning Coal produces 7.4 kcal of heat

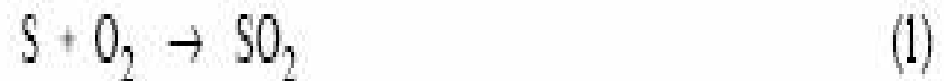
Global Warming

Acid Rain Smog

Burning Coal = $\text{CO}_2 + \text{SO} + \text{H}_2\text{O} + \text{Ash} +$
 $(\text{C}_x\text{H}_x\text{S}_x\text{O}_x)$ Light + Noise + Heat



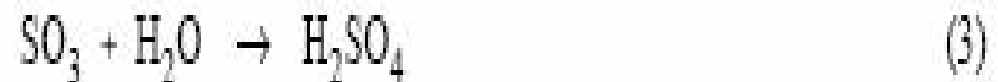
The contact process incorporates 3 basic operations, each of which corresponds to a distinct chemical reaction. First, the sulfur in the feedstock is oxidized (burned) to sulfur dioxide (SO₂):



The resulting sulfur dioxide is fed to a process unit called a converter, where it is catalytically oxidized to sulfur trioxide (SO₃):



Finally, the sulfur trioxide is absorbed in a strong 98 percent sulfuric acid solution:

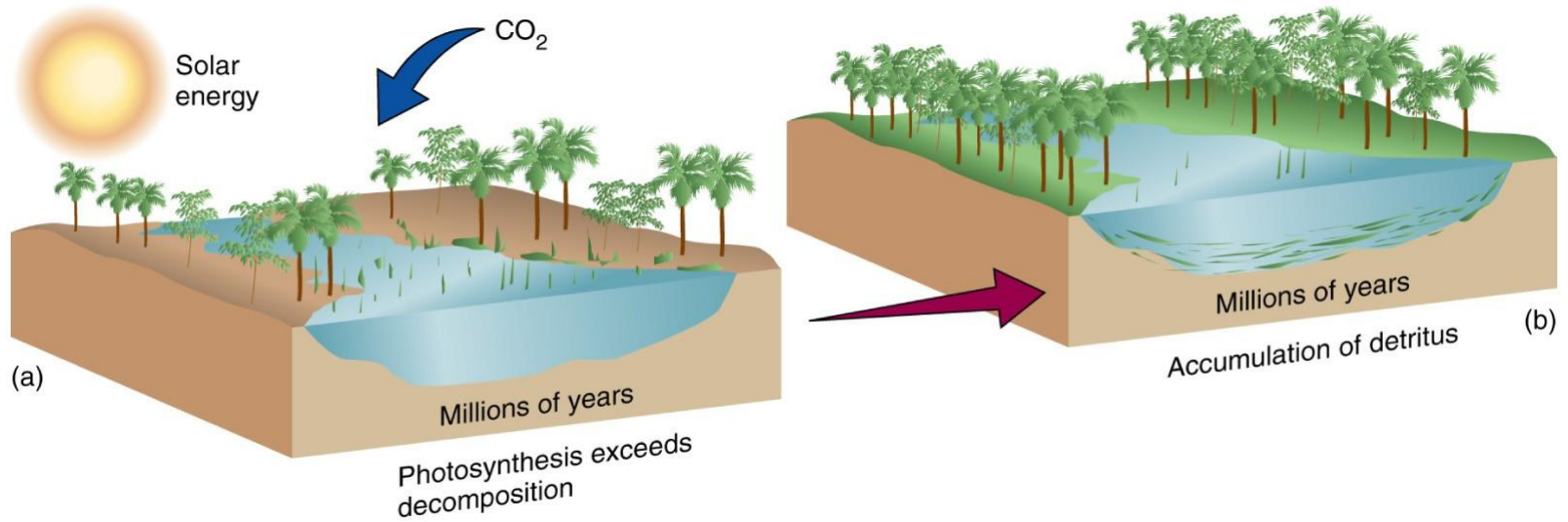




Fossil Fuels

- Derive from the remains of living organisms such as vegetation and phytoplankton
- Anaerobic conditions in the lowest layers of these bodies of water impeded the respiration of decomposers and hence the breakdown of detritus.

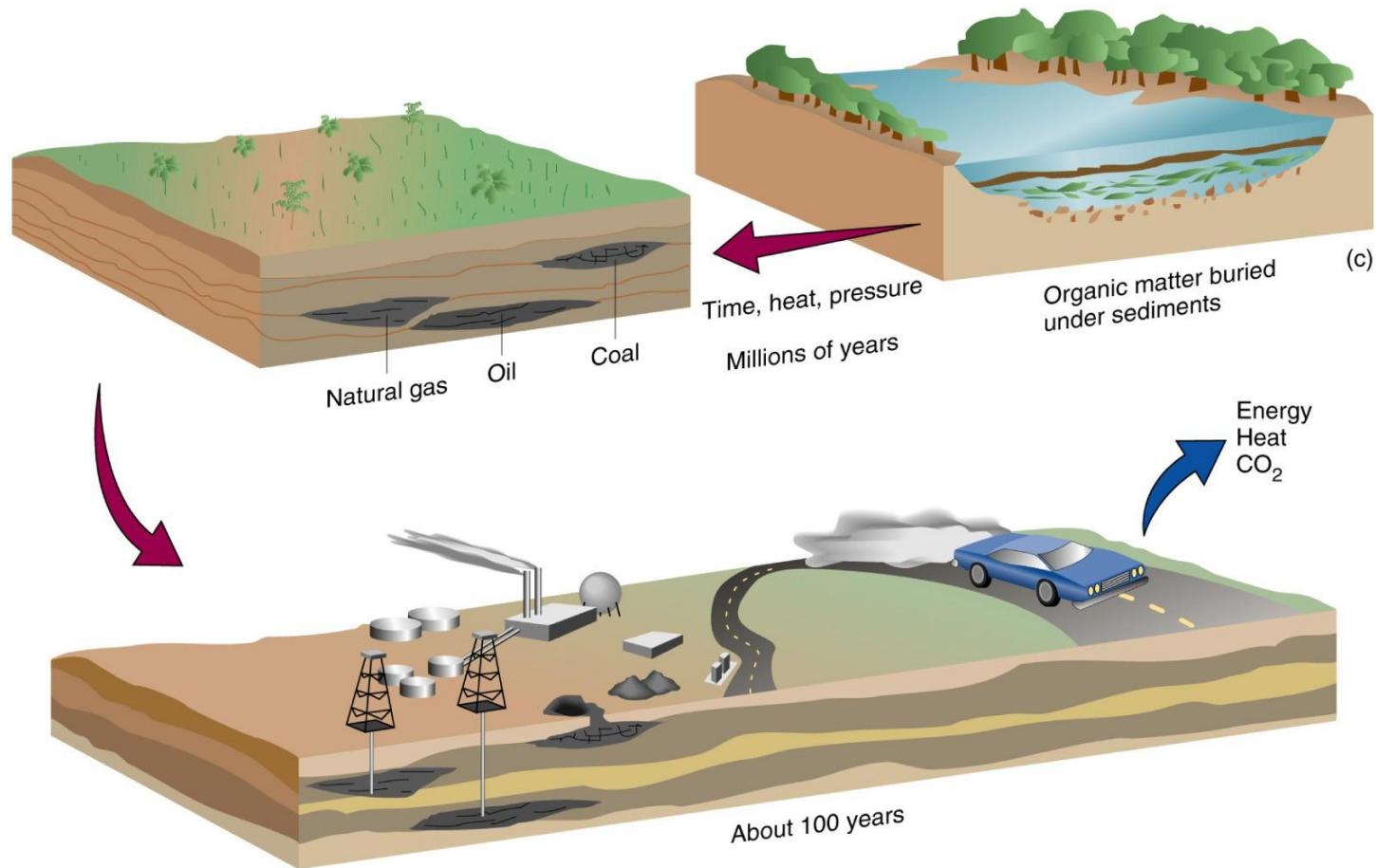
How Fossil Fuels Are Formed: Part I



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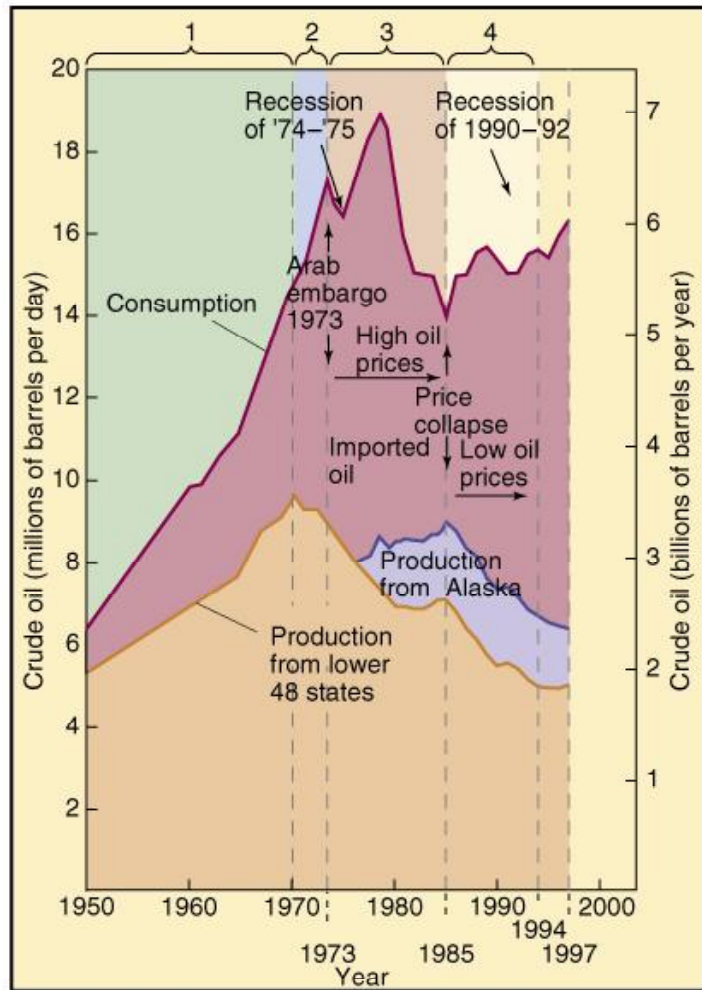
- As a result massive quantities of dead organic matter accumulated.
- Over millions of years, the organic matter gradually buried under layers of sediment and converted by pressure and heat to coal crude oil, and natural gas.

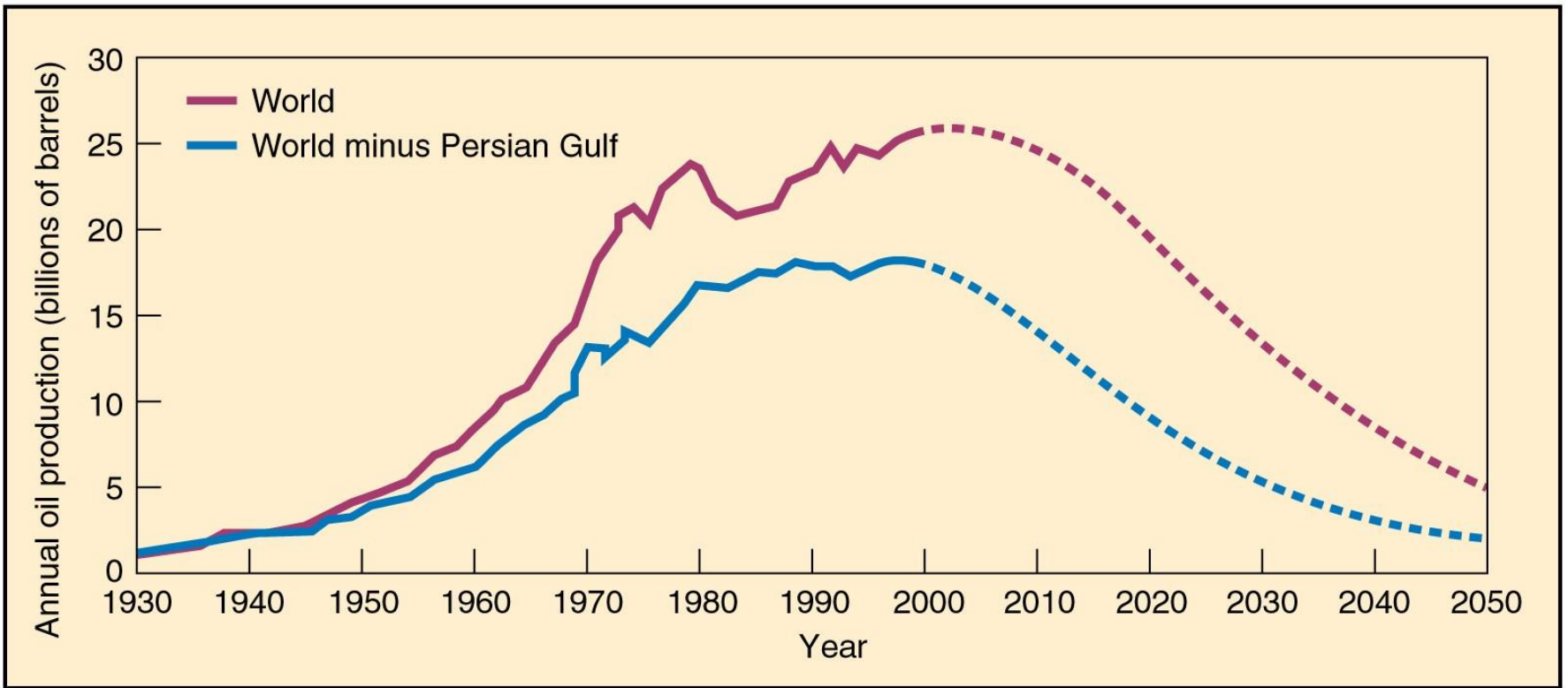
How Fossil Fuels Are Formed: Part II



- Which fuel formed depended on the nature of the organic material buried, the specific environmental conditions, and time involved.

- Natural gas is trapped methane
- Crude oil is represented by residual sludge
- Coal is compressed organic leafy and swamp vegetation matter





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Increased or Decreased since the 1970s?

- Consumption of fuels derived from oil
- Discoveries of new oil in the United States
- Production of oil in the United States
- The gap between production and consumption
- United States dependence on foreign oil

Increased or Decreased because of Higher Cost of Oil Imports?

- Rate of exploratory drilling and discovery of oil
- Renewed production from old oil fields
- Efforts toward fuel conservation
- Consumption
- Development of alternative energy sources
- Dependence on foreign oil

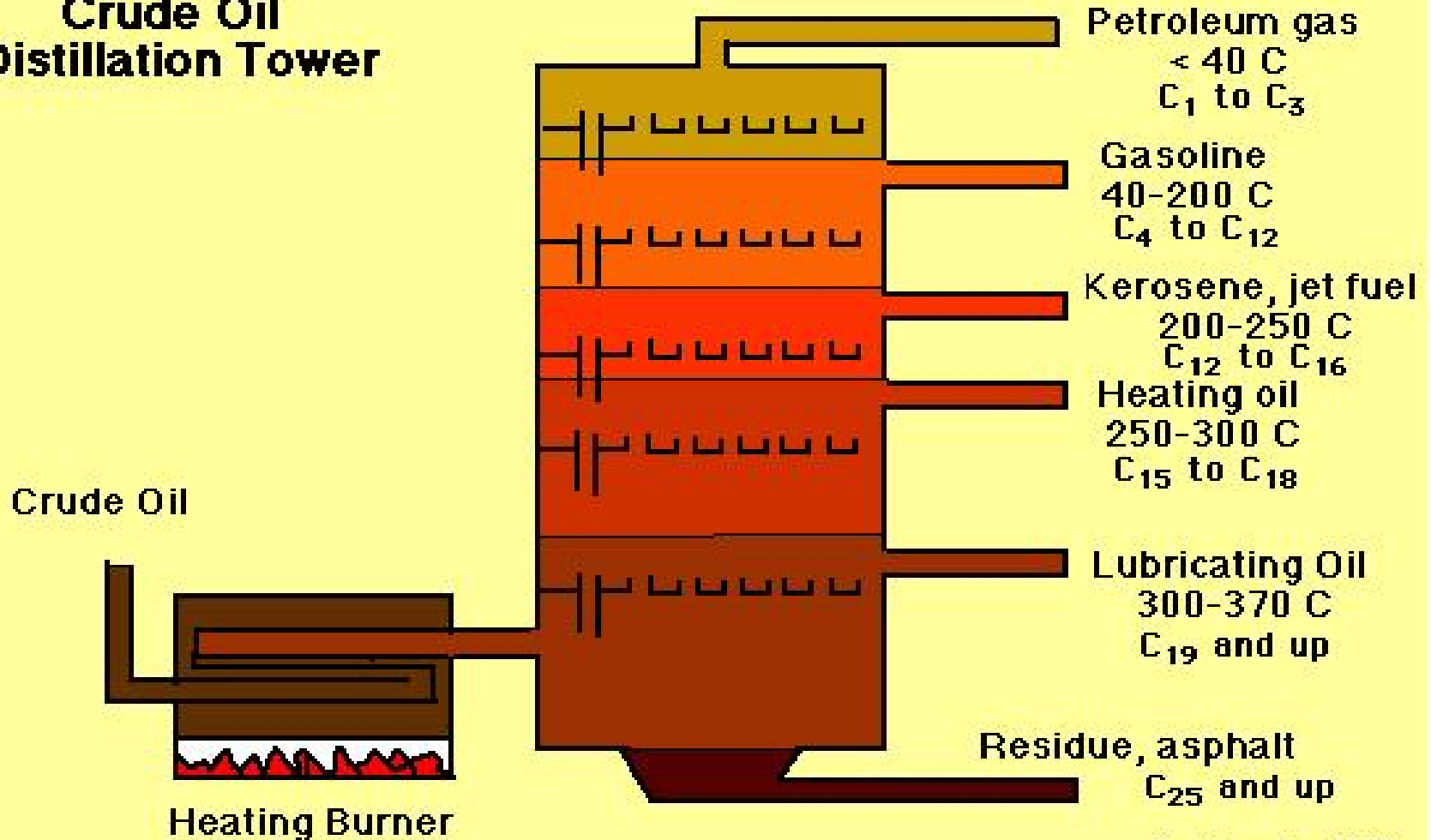
Increased or Decreased because of Collapse in Oil Prices?

- Rate of exploratory drilling and discovery of oil
- Renewed production from old oil fields
- Efforts toward fuel conservation
- Consumption
- Development of alternative energy sources
- Dependence on foreign oil

Distillation

Boiling of crude oil

Crude Oil Distillation Tower



C. Ophardt c.1998

Distillation of crude oil

- Methane CH_4
- Propane C_3H_8
- Gasoline C_4 to C_{12}
- Kerosene and Jet Fuel C_{12} to C_{16}
- Heating Oil C_{15} to C_{18}
- Diesel Oil C_{19} to C_{24}
- Lubricating oil C_{25} and up
- Slag used to pave roads

Cracking

Breaking of long carbon chains
into smaller pieces by pressure
and temperature

Persian Gulf Oil

Called sweet oil because it is lighter and takes less energy to distill off various components or crack long chain components into useable fuels.

Baltic Oil

Higher in sulfur content which can contribute to acid rain when distilled