

Ch. 13 Notes: Energy from Fossil Fuels

2004 STATS FROM GEOHIVE:

U.S. total energy consumption = 22.8% of the global total (rank: 1st)

U.S. oil consumption = 24.89% of the global total (rank: 1st)

U.S. coal consumption = 20.31% of the global total (rank: 2nd , behind China)

U.S. natural gas consumption = 24.05% of the global total (rank: 1st)

"Our country's leaders have three main choices: Taking over someone else's oil fields; carrying on until the lights go out and Americans are freezing in the dark; or changing our life style by deep conservation while heavily investing in alternative energy sources at higher costs."

— Charles T. Maxwell

"The *world* is not running out of oil—at least not yet. What our society does face, and soon, is the end of *abundant* and *cheap* oil on which all industrial nations depend." [emphasis added]

— Campbell and Laherrere

I. Energy Sources and Uses

A. overview timeline of energy sources

from <http://matse1.mse.uiuc.edu/~tw/home.html> & <http://instituteforenergyresearch.org>

- 1) *fire power*: ~1,000,000-500,000 B.C. – controlled use of fire for cooking, warmth, light, etc.
- 2) *animal power*: ~6000 B.C. – domestication of cattle; mules used to transport cargo, etc. (~4500 B.C. – invention of the ox-drawn plow in Mesopotamia)
- 3) *wind power*: ~3500 B.C. – Ancient Egyptians invented the sail
- 4) *solar power* (direct): ~3000 B.C. – Ancient Egyptians, Chinese, Phoenicians, Greeks, and Romans used solar power to evaporate water to obtain salt and to dry crops
- 5) *coal power*: ~1000 B.C.– coal used in China
- 6) *water power*: 100 B.C. – water wheels used in what is now Turkey
- 7) *wind power*: 65 B.C. – windmills used in Greece
- 8) *oil power*: 1959 – first drilling in the U.S. for oil (Pennsylvania) by Colonel Edwin Drake,
- 9) *electric power*: 1879 – Thomas Edison invented electric light bulb
- 10) *nuclear power*: 1952 – world's first nuclear reactor operational for commercial power (Pennsylvania)
- 11) *solar power* (indirect): 1954 – first silicon solar collectors constructed (U.S.)
other info...
 - 1970 – first the major oil find is discovered (U.K. North Sea)
 - 1973 – internet developed
 - 1980 – first solar-cell power plant is operational (Utah)
 - 1989 – World Wide Web established

B. electrical power production

- 1) **primary energy source**
 - a) an energy source *existing on its own*
 - b) can contribute to another (the secondary) being produced
 - c) examples: *coal, oil natural gas, solar energy, nuclear energy, geothermal energy*
- 2) **secondary energy source**
 - a) an energy source *dependent upon another source* for production
 - b) example: *electrical power*

- 3) 1831 – invention of the generator by Faraday; a moving magnet will cause a current in a coil of wire (flashlights that you shake for power have this exact setup)
 - 4) **turbine**—a wheel made of curved “vaness” on a rotating spindle
 - 5) *generator*—a machine converting mechanical energy to electrical energy
 - 6) **turbogenerator**—a turbine and a generator together
 - 7) *power grids*
 - a) three main *power grids* of the continental U.S.
 - Eastern Interconnected System (*Eastern Interconnect*)
 - Western Interconnected System (*Western Interconnect*)
 - Texas Interconnected System (*Texas Interconnect*)
 - b) 10 *North American Electric Reliability Council (NERC)* regions within the grid
 - ECAR - East Central Area Reliability Coordination Agreement
 - ERCOT - Electric Reliability Council of Texas
 - FRCC - Florida Reliability Coordinating Council
 - MAAC - Mid-Atlantic Area Council
 - MAIN - Mid-America Interconnected Network
 - MAPP - Mid-Continent Area Power Pool
 - NPCC - Northeast Power Coordinating Council
 - SERC - Southeastern Electric Reliability Council
 - SPP - Southwest Power Pool
 - WSCC - Western Systems Coordinating Council
 - 8) fluctuations in demand
 - a) **baseload**—constant supply of power available
 - b) *peak*—highest demand
 - c) **reserve capacity**—additional sources of power, drawn upon during peak hours
 - d) *brownout*—reduction in power
 - e) *blackout*—loss of power
 - f) about the *watt*
 - $1 \text{ W} = 1 \text{ J/s} = 1 \text{ Nm/s}$
 - conversions
 - $1 \text{ W} \approx 3.412141630 \text{ BTU/h}$
 - $1 \text{ horsepower} \approx 745.700 \text{ W}$
 - $1 \text{ horsepower (electrical British)} = 746 \text{ W}$
 - $1 \text{ horsepower (electrical European)} = 736 \text{ W}$
 - $1 \text{ horsepower ("metric")} = 735.498 \text{ W}$
 - *kilowatt hour (kwh)* is the amount of energy expended by a one kilowatt device over the course of one hour
 - 9) Clean energy?
 - a) Using electricity creates no new pollution...
 - b) but its production has effects on the environment because it has to be produced from using a primary source
 - c) *efficiency = useful power output / total power output*
 - thermal production of electricity is only 30-40% *efficient*
 - heat is lost in travel from the firebox and in the spent steam
 - *cooling towers* are used to condense the steam
- C. matching sources to uses
- a) *categories of primary energy use:*

- *transportation*
 - *industrial*
 - *commercial / residential*
 - *to generate electric power*
- b) how to decrease consumption
- conservation
 - efficiency
 - demand management

II. The Exploitation of Crude Oil

A. how fossil fuels are formed

- 1) decreased detritus formation in ocean depths (lack of O₂)
- 2) *compaction of dead organic matter* below layers of sediment
- 3) conversion by heat and pressure to *fossil fuels: coal, oil, and natural gas*
- 4) fossil fuels can still form but are considered *nonrenewable resources* because the replacement rate cannot keep up with demand

B. crude oil reserves vs. production

- 1) *oil resources*—total amount of crude oil remaining
- 2) **estimated reserves**—amount of crude oil *expected* to exist
- 3) *exploratory drilling*—a method of finding crude oil deposits
- 4) **oil field**—underground area containing oil deposits
- 5) **proven reserves**—an estimate of *how much oil can be extracted in an economically feasible way* from an oil field
 - a) 1 barrel of oil = 42 gal
 - b) proven reserves listed as *probabilities (Px)*, like P50
- 6) **production**—“harvesting” the oil or natural gas from the field by *extraction*
 - a) *nonconstant extraction rate from pore spaces in sedimentary rock*
 - b) *gusher*—quick flow from an oil well; not lasting
 - c) **primary recovery**—*conventional* pumping
 - d) **secondary / tertiary recovery**—*forcing* the oil up into the wells by injection of steam or brine into the reservoir

Stats: Crude oil, price per barrel

December 2004: ~\$46.00 December 2005: \$61.04 \$70.85 – a record price, set in 2005

C. declining U.S. reserves and increasing imports

- 1) in 1970, new exploratory drilling began to turn up *no new oil deposits*
- 2) shift from oil independent status to being dependent on imported oil
- 3) *Hubbart curve*
 - a) *bell curve* named for geologist M.K. Hubbart
 - b) based on his prediction that U.S. oil production would peak around 1965-1970

D. oil crisis of the 1970s

- 1) **OPEC**—*Organization of Petroleum Exporting Countries*
 - a) *11 member countries:*
Algeria, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela
- 2) OPEC formed a *cartel*, working together to raise prices

E. adjusting to higher prices

- 1) increase domestic production of oil
 - 2) decrease consumption
 - a) *increasing fuel efficiency standards* for vehicles and appliances
 - b) improving building *insulation*
 - c) development of *alternative energy sources*
 - 3) protect against another OPEC boycott by massing a *strategic oil reserve*
- F. consequences
- 1) exploration is expensive; older oil fields were shut down
 - 2) conservation incentives and efforts decreased; related tax incentives stopped
 - 3) conservation mindset was not a priority
- G. problems of growing U.S. dependency on foreign oil
- 1) costs of purchase
 - 2) risk of supply disruption
 - a) Middle East conflicts
 - b) Persian Gulf War, Desert Shield/Storm 1990-1991, Iraq War 2002-
 - 3) resource limitations
 - a) the U.S. is basically “tapped out”
 - b) geologists are still searching using computer mapping
 - c) global usage (2002 stats)
 - so far: *800 BB (billions of barrels)* used up, most in the 20th century
 - per day: ~ 27 BB / yr.
 - 850 BB – ~1100 BB “proven reserve estimate” range
 - USGS “unknown field reserves” estimated at 732 BB and “known undiscovered” at 688 BB
- H. solutions
- 1) use coal and natural gas instead of crude oil
 - 2) reduce demand through *conservation and energy efficiency*
 - 3) develop and use *alternative energy sources*