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ENVIRONMENTAL HEALTH

ECOLOGICAL PERSPECTIVES

Energy

Chapter 11

Traditional Fuels Used by Humans

- Wood
- Coal
- Petroleum

Oil in the Middle East

- It is more abundant and cheaper to produce than in the U.S.
- In the 1960s the price of crude oil was $3 per barrel
- In 1973 Syria and Egypt attacked Israel
- The Arab Oil Embargo prohibited the trade and sale of oil to countries supporting Israel (including the U.S.)

Energy Crisis in the 1980s

- When the Iran/Iraq War started (1979–1980), crude oil production dropped, increasing the cost of crude oil to $35 per barrel
- The U.S. supported Iraq, which possessed the second largest oil preserve in the world where oil can be produced for less than $1.50 per barrel

Middle East in the 1990s

- When Saddam Hussein attacked Kuwait, U.S. troops were deployed to the Gulf War of 1991
- In 2005, the price of crude oil was $46 per barrel
- These incidents have increased the importance of finding alternative sources of energy other than fossil fuels

Fossil Fuels

- Besides petroleum, other types of fossil fuels include natural gas and coal
- All are combustible and originated from ancient plant and animal life
- Fossil fuels are “nonrenewable”

The Need for Alternative Fuels

- In the 1970s there were long lines for gasoline and thermostats were set lower to conserve fuel
- When prices dropped in the 1970s, the Carter administration provided funding for alternative energy sources
- Today passenger cars need to be energy efficient
- Financial incentives are available for vehicles using alternative energy sources

The Need for Electricity

- If the present rate of population growth (and electricity consumption) continues, it will increase by 54% over the next 20 years
- Electricity is generated through use of a “primary fuel source” such as coal, oil, natural gas, and uranium
- Unfortunately fossil fuels do not completely burn, leaving behind pollution

Coal

- Coal is found underground and must be mined
- The U.S. is the world's second largest coal exporter
- The largest reserves are in Montana, Illinois, and Wyoming; others are in Alaska, Texas, North Dakota, and Gulf Coast states
- There is 12 times as much energy in U.S. coal reserves as all the oil in Saudi Arabia, but it is too costly to mine it all

Coal Mining

- The primary method of coal mining is surface mining (also known as strip mining)
- Underground mines are found east of the Mississippi, mostly the Appalachian Mountain states
- Two types of underground mines:
  - Shaft mine
  - Longwall mine

Coal for Energy

- Coal supplies half of the U.S.'s electrical power
- The rest is used by the steel industry
- Coal is considered a "dirty fuel" (fly ash, soot, sulfur oxides)
  - Emissions control techniques: precipitators and scrubbers
  - The coal can also be washed after it is mined and before it is burned
- Coal gasification helps control the production of SO_2 and CO_2
- The amount of energy available by unit of weight is expressed in British thermal units (BTUs) per pound

Petroleum

- Globally, nearly 3 billion gallons are used every day
- Prior to the 1800s, candles, torches, and oil-burning lamps provided light
- The best oil was from the right whale or sperm whale
- Approximately 15,000 whales were killed per year so they were considered endangered species

Other Sources of Oil

- In 1854 Benjamin Silliman found crude oil could be refined and made into kerosene (also known as coal oil)
- In 1878 Thomas Edison invented the light bulb reducing the need for kerosene
- In 1859 the first oil well in the U.S. was discovered in Titusville, Pennsylvania

The Need for More Oil

- In the 1950s the demand for coal lessened and propane gas became popular
- In the 1970s, the production of domestic oil in the U.S. declined
- By the 1990s the U.S. imported more oil than it produced
- Today the U.S. is the world's largest consumer of oil
- Crude oil must be refined before it can be used for fuel

Fuel Oils

- Includes petroleum products such as kerosene
- They are used for heating, lighting, engines, and as solvents
- They have aliphatic and aromatic hydrocarbons
- They are liquid at room temperature and evaporate

More Sources of Oil

- The largest producers of oil in the world are Saudi Arabia and the former Soviet Union
- One-third of the world's oil comes from offshore wells in the North Sea, the Persian Gulf, and the Gulf of Mexico
- Ways to decrease oil consumption include taxation, rationing, and improving energy efficient engines

Nonfossil Fuels

- Natural gas
  - Provides 25% of all energy in the U.S.
  - The largest producer is the former Soviet Union
  - More expensive than fuel oils or electricity
  - The largest sources are in Alaska, Louisiana, New Mexico, Oklahoma, and Texas
- Uranium
  - A radioactive source that has a half life
  - Used to for nuclear power

Problems with Fossil Fuels

- Coal and uranium operations
  - Abandoned or orphan mines
- Petroleum production
  - Pollution of land, waterways, oceans, and the atmosphere
  - Abandoned oil fields, oil storage facilities, and transportation accidents
- Both have negative environmental impact

Oil Spills

- The transportation of oil is the primary cause of oil spills
- Oil tankers are the largest ships built
- Oil spills at sea destroy marine life and water quality
- The oil floating on the surface is flammable

Problems with Power Plants

- Most are built along rivers, streams, or lakes
  - The heated water kills aquatic life
- Nuclear power plants provide 20% of U.S. electricity
- The possibility of radiation exposure is low, but a major consideration
- The disposal of spent nuclear fuel rods is necessary, but unpopular among local residents

Regulation of Nuclear Power Plants

- Each nuclear power plant was built with a 40-year license to operate
- The Nuclear Regulatory Commission (NRC) implements radiation exposure standards
- They conduct regular inspections to be sure each power plant is in compliance with regulations for facilities, training, and procedures
- When they are not in compliance, they suffer penalties

Renewable Energy Sources

- Wood
- Waste incineration
- Hydropower
- Geothermal energy
- Solar power
- Wind power

Wood

- From forests, private land, urban tree removal, and landscaping
- Can be renewed by planting trees
- Hard wood (walnut, oak, elm) burn longer than soft woods (pine, cedar)
- Wood should be “cured” (dried) before burning
- It is inefficient because it takes 10–30 years to replace one tree

Waste Incineration

- The burning of solid waste reduces the volume by 90%
- Two ways of burning solid waste:
  - Mass burn
    - Waste is dropped into a storage pit, then removed and burned
  - Refuse-derived fuel
    - The waste is stored, shredded, and “fluffed” and water is added before it is burned
    - It can be stored in the form of pellets
- There is still noise associated with the process, ashes, and emissions (particulate matter and dioxin)

Hydropower

- Generated by large quantities of water from a reservoir that turn large turbines and generate electricity
- The world's largest source of renewable energy
- It is considered a "clean source" (no waste or air pollution)
- The U.S. is second in the world, behind Canada, in hydropower production
- There are some along Niagara Falls, the Colorado River, and the Columbia River
- Environmentalists do not like them because land is flooded, vegetation is ruined, and water is diverted away from farms, ranches, streams, waterfalls, and wildlife

Geothermal Energy

- Heat is found naturally in rock formations like hot springs, geysers, and fumaroles (holes in or near volcanoes where vapor escapes)
- The steam is directed to turbines that generate electricity
- Most of the U.S. sites are west of the Mississippi River
- Geothermal plants are expensive
- Sometimes arsenic or boron are found in geothermal waste

Solar Power

- Energy from the sun can be collected from passive or active systems
  - Passive systems absorb heat through windows
  - Active systems use solar collectors, pumps, and valves
- Solar collectors are clear or translucent with a dark surface that soaks up heat
  - Solar panels last a long time
- The heat is transferred to a “working fluid” and transferred by vents and pipes to a storage facility
- This is usually done on-site

Solar Thermal Energy System

- This system collects solar energy at a central location to be used by several customers
- The sunlight is intensified to heat water and create steam to power an electric generator
- At this time solar power costs three times more than fossil fuel energy

Photovoltaic Cells

- Photovoltaic (PV) cell solar energy systems convert sunlight into electricity
- The PV cells last up to 20 years
- They store power while the sun is shining
- Small PV cells are used in calculators or watches
- Larger PV cells are used for household, recreational, or business use
- The energy is stores in either DC (direct current) or AC (alternating current)

Wind Power

- It is a form of solar energy because wind is created when there is uneven heating in the atmosphere by the sun
- Early wind machines were called windmills
- Wind turbines take up considerable space
- They must be placed on open plains, hilltops, or mountain terrain
- They are good because they can generate power at night as well as daytime
- The main problem is the wind does not always blow

New Fuel Sources

- Bioenergy
- Landfill gas recovery

Bioenergy

- The use of biomass materials (wood, plant and animal waste, seaweed, algae, solid waste, garbage)
- The by-products can be used for fertilizer and chemicals
- Two types of biomass conversion
  - Thermochemical (wood and agricultural waste)
  - Biochemical (enzymes, fungi, or microorganisms to convert manure, paper, and algae to fuel)
    - This is used when methane gas is converted from sewage treatment facilities
- Another process uses fermentation to decompose sugar cane, grains, potatoes, and other starchy crops to make ethyl alcohol (ethanol) and carbon dioxide

Landfill Gas Recovery

- As garbage decomposes methane is produced
- Methane is flammable and can be used for fuel like natural gas

Fuels for Automobiles

- Oil
  - The primary product is gasoline (a by-product of kerosene distillation)
  - Gasoline burning engines became common after WW I
  - Gasoline consumption increased significantly after WW II
- Electricity
- Hydrogen cells

Problems with Gasoline Engines

- Most gasoline engines are not efficient, using only 35–55% of the fuel passing through
- In the 1980s, fuel injectors were developed to control the air/fuel mix and improve fuel efficiency

Components of Gasoline

- The formulation of gasoline is important to fuel efficiency and environmental impact
- Gasoline engines “knock” unless there are higher octane levels
- The octane level tells how much the fuel can be compressed before it ignites
- The higher the octane level in fuel, the slower the fuel is burned
- This means better fuel economy and cleaner emissions

Leaded Gasoline

- During WW II it was discovered that adding tetraethyl lead to gasoline (known as ethyl, or leaded gasoline) significantly improved the octane rating
- The lead polluted the atmosphere from automobile emissions, posing health problems
- Lead was phased out of gasoline production since the 1970s

Other Gasoline Additives

- Methyl tertiary butyl ether (MTBE) has been used since 1979
- It is a suspected carcinogen, but used in areas with high levels of unhealthy air pollution
- Ethanol is a popular fuel additive but more expensive than MTBE
- Reformulated gasoline (RFG) is blended with oxygen compounds to burn cleaner and reduce air pollutants and smog

The Need for Fuel Efficient Machines

- The supply and price of oil drives the need for vehicles that get more miles per gallon (mpg)
  - There were smaller vehicles with less horsepower and acceleration
- Automobile efficiency standards have been in place
  - In 1978 the minimum for passenger cars was18 mpg for passenger cars it was increased to 22.2 by the year 2007
  - For light trucks and SUVs in 2002 it was 20.7 mpg

Strategies to Reduce the Demand for Gasoline

- Ways to reduce consumer use
  - Reducing speed limits
  - Gasoline taxes
  - Incentives for carpools
  - Alternative fuels
  - Alternative fuel vehicles

Gasoline Taxes

- A way to encourage drivers to buy less gasoline
- Reduces the average consumption by 10%

Carpools

- A group of individuals with the same destination who take turns driving to work
- Save money on gas, toll fees, and parking space
- Alternatives to carpooling:
  - Public transportation (subway, train, bus)
  - Bicycles
  - Walking

Alternative Fuels

- Alcohol
- Propane
- Natural gas
- Batteries
- Hydrogen cells
- Water
- Compressed air
- Renewable energy sources

Alcohol Fuels

- Ethanol
  - Made from fermented corn (biomass)
- Gasohol
  - A blend of 10% ethanol and 90% unleaded gasoline
  - Agricultural states promote its use but it is limited in availability and costly
- Methanol
  - Increases formaldehyde emissions while reducing ozone formation
  - Harmful to the skin
  - More is needed than gasoline to propel an engine

Natural Gas

- Cleaner than coal or oil to burn
- Consists of methane, but includes propane, butane, and pentane
- Reduces hydrocarbons and CO emissions, but increases NO_2

Hydrogen

- Used by NASA since the early Apollo space missions. Used to power homes, buildings, and automobiles
- The “fuel of the future” because it is abundant, clean, and inexpensive
- Can be stored as a fuel cell of almost any size
- A hydrogen fuel cell uses 45–58% of the fuel to make the vehicle move (twice as efficient as gasoline)
- Low heat, no combustion, carbon-free, no pollution
- Problems:
  - Easier to make from fossil fuels than from water or biomass
  - High cost
  - Lack of refueling stations

Alternative Fuel Vehicles (AFVs)

- Electric cars
  - Available since the 1830s
  - The design was improved upon in the 1970s
  - Needed to be recharged every 70–100 miles
  - No air conditioning
- Hybrid cars
  - Available since 1999
  - Combine gasoline engine with a battery-powered electric motor
  - The battery packs are heavy, contain lead, have high voltage, and cost $1,000 to $2,000 more
  - The cars can cost $3,500 to $6,000 more