

## Notes for Final

4/15/13

### Non-Renewable Energy - Fossil Fuels

- We use a variety of energy sources
  - We use energy in our homes, machinery, and vehicles and in products that provide comfort and convenience
  - Overall, most energy in the Earth system comes from the sun
    - Solar, wind, hydroelectric, photosynthesis, biomass
  - Fossil Fuels: highly combustible substances from the remains of organisms from past geologic ages
    - Oil, coal, natural gas
- Non-renewable and renewable
  - Energy sources are considered non-renewable if they cannot be replenished in a short period of time.
  - In wide-spread use:
    - Crude oil
    - Natural gas
    - Coal
    - Nuclear
  - Alternative fossil fuels
    - Oil sands
    - Oil shale
    - Methane hydrates
  - Renewable energy sources can be replenished naturally in a short period of time
    - Wind
    - Geothermal
- It takes energy to make energy
  - To harness, extract, process, and deliver energy requires substantial inputs of energy
    - Drilling for offshore oil
    - LNG facilities
    - Tar sands processing
  - Net energy: the difference between costs in energy invested and benefits in energy received
- Energy return on investment
  - Energy returned/energy invested
    - Higher ratios mean we receive more energy than we invest
    - Fossil fuels have high EROI
  - EROI ratios can change
    - They decline when we extract the easiest deposits first

- Reserves and use are unevenly distributed
  - Some nations have large reserves, others don't
  - The Middle East has 67% of the world's crude oil
    - Russia holds the most natural gas
    - US has most coal
  - People in developed regions consume the most energy
  - Developing nations use energy for subsistence
    - Agriculture, food preparation, and home heating
- Fossil fuels are created by fossils
  - Fossil fuels were formed from organisms that lived 100-500 million years ago
  - Anaerobic decomposition occurs with little or no air
    - Deep lakes, swamps
    - Produces fossil fuels
  - Kerogen - mixture of organic compounds in sedimentary rocks that is the source of fossil fuels
- Coal
  - Solid fuel formed in several stages from remains of buried plants and animals
  - 300-400 million years old
  - Consists mostly of carbon and trace amounts of sulfur, mercury, and radioactive materials
  - Most abundant fossil fuel
- Coal acquisition and use
  - Strip mining for deposits near the surface
  - Subsurface mining for deposits deep underground
  - Mountaintop removal: entire mountaintops are cutoff
    - Environmentally destructive
    - Common in the Appalachian mountains
  - Coal helped drive the industrial revolution
  - Coal is used to generate electricity
    - Converting water to steam, thus turning a turbine
- Natural gas
  - Mainly methane CH<sub>4</sub>
    - The most efficient greenhouse gas
  - Also, Ethane, Propane, and Butane
  - Two types of natural gas
    - Biogenic - formed in shallow waters under anaerobic decomposition of organic matter by bacteria - swamp gas, land fill
    - Thermogenic gas - formed deep underground in fossil fuel deposits - domes, shale
- Natural gas use is growing rapidly
  - The fastest growing fossil fuel in use today

- 25% of global commercial energy consumption
  - Used to generate electricity, heat homes, and cook
  - Liquefied natural gas: gas converted to liquid at very low temperature – transported in condensed form in tankers
  - Used to produce steel, clothing, brick, electricity, and as an essential raw material for many common products
- Gas shale
  - Shale – a very fine-grained sedimentary rock – easily broken into thin, parallel layers
  - Can contain a large amount of natural gas, difficult to get at
  - Extensive efforts often needed to achieve satisfactory production
  - One of a number of “unconventional” sources of natural gas; other unconventional sources of natural gas include natural gas produced from coalbeds and from “light” sandstone or chalk formations
- Methane Hydrates
  - An ice like substance formed when methane combines with water at appropriate temperature and pressure
  - Widespread in lacustrine, marine, and permafrost sediments
    - Fills pore spaces, can occur in chunks and veins in sediments
  - Abundant – more organic carbon than the world’s coal, oil, and other forms of natural gas combined
  - No commercial-scale technologies demonstrated to date – research is underway
- We drill to extract oil
  - Oil accounts for 1/3 of the world’s energy use
  - Exploratory drilling: small, deep holes to determine whether extraction could be done
  - Oil is under pressure and often rises to the surface
    - Drilling reduces pressure, so oil is harder to extract
  - Primary extraction: the initial extraction of available oil
  - Secondary extraction: solvents, water, or steam used to remove additional oil and gas
- Refineries create petroleum products
  - Once extracted, oil is refined
    - Hydrocarbons are sorted for different uses
  - Oil is used for fuel, plastics, tar, asphalt, fabrics
- We may have depleted half our petroleum reserves
  - Reserves to production ratio
    - The total remaining reserves divided by the annual rate of production
  - We only have 40 years left
- Oil sands
  - Sand deposits with bitumen
    - A form of petroleum rich in carbon, poor in hydrogen
    - Degraded and chemically altered crude oil deposits
  - Removed by strip mining