GLG 110 – Chapter 14 – Energy Resources

- ***U.S. currently has 5% of world population, but consumes 25% of the energy resources***

- Approximately 86% of the energy used by the U.S., at present, is in the form of fossil fuels: coal, natural gas, and oil/petroleum

    - U.S. energy consumption rose sharply in the post-WWII era until the onset of duel energy crises in 1974 and 1980
    - Energy usage increase then flattened out until the boom years of the 1990s (extremely cheap oil prices), and began to flatten again in the past couple of years due to economic losses and a subsequent energy price spike from 2001 through 2004

- **Fossil fuels** originate as organic matter that does not completely decay before it is buried by sediments
    - Organic matter contains carbon bonds that essentially store solar energy (originally gathered via photosynthesis)
    - Fossil fuel exploration and extraction *can* result in significant environmental disruption, particularly if it is handled carelessly; however, exploration and exploitation of such resources does not *necessitate* poor environmental care and massive habitat disruptions

- **Coal** is the most abundant fossil fuel resource in the U.S.
    - Coal burning accounts for about 20% of the energy used by the U.S.
        - Approximately 50% of U.S. electrical power generation comes from coal-fired power plants.
    - U.S. has the largest coal reserves of any country in the world
        - About 20% of the world reserves

- Coal forms from buried, compressed peat laid down in warm, oxygen-poor swamp waters, which is compacted and dewatered at depth, concentrating the carbon content and thus raising the energy content per kilogram

- Coal is characterized by grade (higher equals more energetic per kilogram) and sulfur content (low, medium, or high):

    - Lignite (low-grade)
    - Subbituminous
    - Bituminous
    - Anthracite (highest grade)

- Strip mining is now more common than underground mining
    - Strip mining has, in the past, caused large amounts of environmental damage, including the removal of soil, resulting in a barren wastelands

after mining is completed, and of acidic drainage from exposed coal and coal-waste piles
        - *Reclamation* efforts involving replacing the overburden rock and removed topsoil after mining is completed has potential to greatly reduce the negative environmental impacts

- Coal burning produces ash (about 5% by volume vs. that of the original coal) that must be disposed of, and large quantities of CO_2, a greenhouse gas that contributes to global warming

- Perhaps several centuries-worth of coal remain in world reserves, at current use rates

- **Crude Oil** and **natural gas** (hydrocarbons) are made up of Carbon, Hydrogen, and Oxygen

        - Natural gas is primarily methane, CH_4
        - Hydrocarbons form from burial of incompletely decomposed organic matter to depths and temperatures that are greater than those that form coal
        - ***Source rocks*** (fine-grained sedimentary rocks rich in organic matter) buried to depths of 1-3 km are the primary source of hydrocarbons
        - ***Reservoir rocks*** are porous, permeable sedimentary rocks in which rising hydrocarbons get concentrated at ***traps***

- Petroleum is primarily produced by wells drilling into petroleum traps

- Nearly all such petroleum occurs in sedimentary rocks that are less than 500 million years old

- Most petroleum is produced in a very few giant fields, especially in the Middle East

- Coal-bed methane and methane hydrate deposits are large potential resources that are in the initial stages and theoretical stages of production, respectively

- Major environmental impacts of oil production, transportation and refining include:
        - Disposal of salty brines extracted along with crude oil
        - Spills and leaks from oil tankers and pipelines
        - Air pollution from oil refineries

- Current debate of whether or not to drill for large oil reserves in the Alaskan National Wildlife Reserve (ANWR) is an example of the relationship between science and values

- **Oil shales** and **tar sands** are likely future sites of hydrocarbon extraction (in fact, extraction in Canada is already underway), but most are currently marginally economic or sub-economic in nature

- World oil supply will likely reach its peak between 2020 and 2050, with large declines following soon thereafter, leading to potentially catastrophic shortages and economic problems

- Current estimates suggest that oil production worldwide cannot continue beyond the end of the 21st century

- If we begin a serious committed phasing-out of petroleum in favor of natural gas and further ramp up alternative energy resources in the near-term, a hard landing of economic and energy crisis looming within this century can be greatly reduced or avoided entirely

- **Acid** deposition from coal-burning power plants and automobile emissions can be a significant environmental hazard, damaging forests, lakes, soil, and human structures

- **Nuclear energy** is primarily produced by fission of U-235, which results in radioactive waste products after the fuel is spent

- The heat energy from decaying U-235 is used to heat water to steam to turn turbines in order to create electricity

- Today, only about 16% of the world's electricity – at this rate, the total available supply of U-235 would be used up in about 75 years

- **Breeder reactors** produce Pu-239 from formerly unfissionable U-238 and are incredibly efficient, such that 50% of the world's electricity could be supplied for 2000 years using such systems

- Nuclear accidents, such as those at 3-mile island in 1979 (minor) and Chernobyl in 1986 (catastrophic), underscore the inherent risks associated with fission reactors, and have fueled public concern that has greatly curtailed nuclear power expansion worldwide. The U.S. has not built a new nuclear power plant in nearly 30 years.

- Radioactive waste disposal is also very controversial, as the waste remains deadly for as long as hundreds of thousands of years. Disposal sites have been studied and argued over for decades, and disposal of moderately radioactive waste has begun in NM, and high-level waste may finally begin being disposed of in NV in the next several years

- Fusion power, although incredibly difficult to harness due to the incredibly high temperatures involved, is extremely promising, as it produces non-radioactive He as a by–product, and used H as fuel, which is in nearly limitless supply

- **Geothermal energy** is literally using the heat from the rocks and water within Earth's crust to turn turbines or directly heat buildings

    - Clean, aside from hot, salty water waste
    - Reinjection of such waste can activate faults
    - Removal of water from ground can lead to land subsidence

- All energy sources other than fossil fuels are designated as **alternative energy** resources

- *Non-renewable* **alternative energy** resources include nuclear power and geothermal energy

- *Renewable* **alternative energy** resources include solar power, hydropower, hydrogen, wind power, and biomass-derived energy (e.g., burning wood or waste)

- ***Passive*** *and* ***active*** *solar energy systems* involve directly heating buildings through sunlight or circulation of fluids (e.g., water) heated by the sun

- ***Photovoltaics*** are systems that convert sunlight into electricity

    - Useful to power lights and small appliances, but typically not able to power entire modern household from roof-mounted panels

- Hydrogen could be used as a direct fuel for burning, yielding only water vapor as a waste product, so it is entirely clean

- **Hydrogen** can also be used in the form of fuel cells, which act like batteries

- **Hydroelectric power** makes up about 10% of U.S. electrical supply, but it is nearly maxed out, as all available sizable streams/rivers are already dammed

- **Wind power** is also a completely clean power source, but it can only be generated in areas with consistently high winds; clean power source; largely untapped; growing quickly in importance worldwide

- **Biomass** fuel can be renewed as it comes from burning wood and agricultural wastes, as well as some municipal waste

    - Does produce greenhouse gases and, in the case of municipal waste, potentially toxic waste products

- **Conservation** is reducing our energy demands by being more efficient and sparing

- **Efficiency** can be increased by producing and using equipment that requires less energy to complete a given task

- **Cogeneration** refers to using the waste heat generated in power generation for heating

- **Hard path** – continuing to develop ever greater fossil fuel resources and larger, more centralized power plants; utilizing the easiest and cheapest energy resources to their greatest possible degree to minimize current sacrifice

- **Soft path** – decentralized energy generation (kind of a 'home grown' approach at the household and industrial site level), maximizing the use of renewable, flexible, and environmentally benign energy resources as much as possible

- A **sustainable energy policy** is one which utilizes maintainable (ideally, renewable) energy resources that produce significantly negative environmental effects or risk to human life