Energy Concepts
- 1st Law of Thermodynamics: Energy is not created or destroyed; transferred from one form to another
- 2nd Law of Thermodynamics: Entropy; No energy transformation is 100% effiecient
- Electricity Generation
  - Fuel sources (steam) → turbine (mechanical energy) → generator (electrical energy) → grid
- OIL supplies most of the commercial energy in the world today
- COAL supplies most of the energy for *electricity* in the USA

Non-Renewable Fuel Sources: Fossil Fuels (Coal, Oil, & Natural Gas) and Nuclear
- **Coal**
  - 30% efficient
  - US, Russia, China = most coal reserves
  - Peat → Lignite → Bituminous → Anthracite ("People Like Being Awesome")
  - *Extraction*
    - Surface Mining (mountaintop removal & strip mining)
      - Habitat destruction → disrupts food webs → decrease biodiversity
      - Acid Mine Drainage (due leaching of spoil heaps by rainwater)
        - Sulfur in spoil heaps + water (from rain) = sulfuric acid
        - Decrease in pH of aquatic systems = species w/ a low range of tolerance to pH may die → disrupts food webs → decreases biodiversity
    - Subsurface Mining
      - Better for environment, worse for human health (ex. black lung)
  - *Combustion of coal → steam → turbine → generator → grid*
    - Emissions
      - **CO_2**, a greenhouse gas → can lead to global climate change
        - *Solutions*: Rely less on fossil fuels, more on renewable energy (ex. solar & wind); plant trees (photosynthesize = take in CO_2); Conservation of electricity (ex. turn off lights)
      - **SO_2** = a pollutant that combines with water in the atmosphere → sulfuric acid → acid rain → decrease pH of aquatic & terrestrial systems → species w/ a low range of tolerance (ie. trout) may die → disrupting food webs → decreasing biodiversity
        - *Solutions*
          - **Clean Coal Technology**
            - Wet Scrubber Units, Fluidized gas combustion, add limestone to coal when burned

- ▪ Clean Air Act
  - **Mercury**: majority of atmospheric mercury (Hg) comes from coal burning power plants
    - ○ Effects: neurotoxin = may cause mental retardation; bioaccumulates in the food webs (ex. fish)
- **Oil**
  - ○ Used for electricity, heating, & transportation; 50 years left
    - ▪ also used to make plastics ("petrochemicals"), make-up, paints, asphalt, etc...
  - ○ Most reserves located in the Middle East
  - ○ *Extraction:* drill for oil
    - ▪ Impacts: Habitat destruction, possibility of oil spills
  - ○ *Transportation* (pipeline, trucks, oil tankers)
    - ▪ Impacts: Habitat destruction, decreases gene flow between species, possibility of oil spills
      - **B**ooms, **B**oats, **B**acteria to clean up oil spills
  - ○ *Refinery*: oil is separated into components based on different **B**OILING POINTS
  - ○ *Emissions*
    - ▪ **CO_2**, a greenhouse gas → can lead to global climate change
      - *Solutions*: Rely less on fossil fuels, more on renewable energy (ex. solar & wind); plant trees (photosynthesize = take in CO_2); Conservation of electricity (ex. turn off lights)
    - ▪ **CO**, a pollutant – binds to red blood cells = decreases O_2 in body
    - ▪ **NOx & VOC**, pollutants- + Sunlight = photochemical smog (made up primarily of ozone [O3])
      - Decreases photosynthesis in plants
      - Causes respiratory distress in humans (aggravates bronchitis & asthma)
- **Natural Gas**
  - ○ Used for electricity, heating, & transportation
  - ○ Most reserves located in Middle East & Russia
  - ○ *Cleanest fossil fuel
  - ○ *Extraction:* drilling
    - ▪ *Hydraulic Fracturing aka "Fracking"*
      - Large inputs of water and chemicals → may contaminate groundwater with chemicals &/or methane
      - May cause earthquakes
      - Economic benefit: provides jobs; US energy independence
  - ○ Methane (CH_4) = a greenhouse gas → can lead to global climate change
    - ▪ *CH_4 is 23X stronger than CO_2 (as a ghg, meaning it absorbs more outgoing IR radiation in troposphere) effect = greater warming
- *Nuclear*
  - ○ 10-14% efficient

- o *Extraction: Mining* for Uranium (a rock); Fuel source = U235
- o *Be able to identify & describe parts of a power plant
    - Containment structure: protection
    - Control rods: control RATE of nuclear fission by absorbing excess neutrons
    - Reactor core: where fission takes place
- o *Issues*
    - Thermal Pollution (species w/ a low range of tolerance to temperature may die → disrupts food webs → decreases biodiversity)
    - NIMBY
    - Wastes are stored at reactor sites
    - Case Studies: Chernobyl, Ukraine: 3 Mile Island, PA, USA; Fukushima, Japan
    - Effects of Radiation: mutates DNA, birth defects/miscarriages, cancer
- o *Review ½ life equations in powerpoint

Renewable Fuel Sources
- **Biomass**
    - o Used for electricity, heating, cooking, & transportation fuel (ex. ethanol)
- **Hydroelectric**
    - o Water → turbine → generator
    - o Advantages of Dams: Recreation (ex. swimming & fishing); decrease likelihood of floods downstream; hydropower
    - o Disadvantages of dams:
        - Silt gets stuck in dams (doesn't make it downstream) = farmers apply fertilizers → NPK runoff into aquatic systems = eutrophication (algal bloom → compete for resources & die → aerobic bacteria break them down → decrease in DO (dissolved oxygen) → species w/ a low range of tolerance die
        - Fish can't swim upstream to spawn
            - Solution: Fish Ladders
    - o *Largest Hydroelectric Dam in the world: Three Gorges Dam on the Yangtze River in China
    - o TIDAL Power – use tides to turn turbine → generator
- **Solar**
    - o **Thermal**
        - **Passive**
            - South facing homes; triple-paned windows; heat absorbent floors
        - **Active**
            - Use a pump (requires energy input) to move water. Solar energy HEATS water
    - o **Electric**

- Photovoltaic (PV) cells on rooftops: photons in sunlight knock electron lose; DC → AC
- Solar Power Plant → parabolic mirrors focus light → heat → steam → turbine → generator
- **Geothermal**
  - Dig a shaft underground to a steam reservoir → steam → turbine → generator
- **Wind**
  - Wind → turbine → generator
  - Pros: clean (no CO2 or pollutants [ex. SO2]), cheap, predicable
  - Con: bird hazard, noise pollution, visual pollution, NIMBY
- **Hydrogen Fuel Cell**
  - H^+ protons diffuse through membrane while e^- can not and therefore create a current of electricity as they go around the membrane.
    - May be used as a transportation fuel in the future &/or homes/Industry (ex. combine w/ solar- day; H- night)

Transportation
- Types of vehicles
  - Internal Combustion Engine
    - Powered by gasoline = emits CO_2 (a ghg → gcc) and NO_x & VOC (pollutants that form photochemical smog in presence of sunlight. Disrupts photosynthesis in plants and causes respiratory distress [ie. aggravates bronchitis & asthma] in humans)
    - Solutions: carpool, walk, ride a bike; Eco-driving tips (ex. don't accelerate rapidly)
  - Electric Vehicle
    - Powered by electricity (plug in & recharge at night)
    - Clean (no harmful emissions) while driving vehicle, although of course there are pollutants released in the mining of the raw materials and assembly of vehicle + emissions if electricity comes from coal
  - Hybrid (internal combustion engine + generator & batteries)
    - Powered by gasoline, but uses less gasoline and therefore emits fewer greenhouse gases (CO_2) and pollutants (NO_x & VOC)
- CAFÉ Standards- gov regulations for mile per gallon (mpg) that vehicles must get

Improving Energy Conservation & Efficiency
- Use CFL/LED rather than incandescent light bulbs
- Turn off lights
- Insulate & plug leaks
- Turn thermostat down in winter, up in summer
- Buy energy star appliances
- Unplug electric appliances/use a power strip
- Triple-paned windows
- Shorter/less frequent showers
- Use public transportation, carpool, ride a bike, walk

FRQ's

1998 Q3 Nuclear Power Plant

1999 Q2 Nonrenewable vs Renewable Energy; Resource use in developing vs developed countries

2000 Q1 Energy Math; Coal/Sulfur

2001 Q1 Energy Math; energy efficiency

2002 Q1 Electric Cars

2004 Q2 Energy Math; Coal vs Wind power

2004 Q3 Low vs High level radioactive waste

2005 Q3 Coal Mining

2005 Q4 Oil extraction; ANWR

2006 Q1 Solar

2007 Q2 Energy Math; energy efficiency

2008 Q1 Energy Math; biodiesel (biomass)

2009 Q2 Energy Math; using methane from cows --> electricity

2011 Q3 GDP vs annual electricity use

2012 Q1 Natural Gas (fracking)

2012 Q2 Energy Math; energy conservation

2013 Q2 Energy Math; cars