Energy

I. **Energy**
   a. **Energy** is defined as the capacity to do **work**, which is defined as the application of force through a distance.
      i. **Power** is the rate of flow of energy, or the rate at which work is done.
      ii. The energy we use to move our muscles, to think and carry out metabolic functions comes from stored chemical energy in our food.
         1. Food energy is measured in calories
            a. One **calorie** is the energy it takes to heat 1 g of water 1°C
            b. Actually our food is measured in kilocalories (or food Calories) which is 1000 calories.
      iii. A **joule (J)** is the amount of work done when a force of 1 **newton** is exerted over 1 meter
          1. The **newton** is the basic unit of force, or the amount of force necessary to accelerate 1 kg 1 meter per second.
      iv. A **watt (W)** is equal to one joule per second
          1. A **kilowatt-hour (kwh)** is a thousand watts exerted for 1 hour.
      v. A **barrel of oil (bbl)** is equal to 42 gallons
   b. **Current Energy Sources**
      i. **Fossil Fuels**
         1. Petroleum, natural gas, and coal
         2. About 79% of all commercial energy
      ii. **Biomass Fuels**
         1. Wood, peat, charcoal, and manure
         2. About 9.5% of commercial energy
         3. May be 90% of domestic energy in some poorer nations.
      iii. **Renewable sources**
         1. Solar, wind, geothermal and hydroelectricity
         2. About 4.5% of commercial energy
      iv. **Nuclear Power**
         1. About 5% of commercial energy
         2. About 20% of all electric power in developed countries
   c. **PerCapita Consumption**
      i. The 20 richest countries consume
         1. 80% of natural gas
         2. 65% of oil
         3. 50% of coal
         4. U.S. and Canada are <5% of world’s population, but consume about 25% of the available energy
            a. Some of which does go to grow crops, which are shipped around the world
      ii. Average U.S. citizen
1. 300 gigajoules (60 barrels of oil)/ year
   a. average Nepali = 1 gigajoule/year
   b. On average we consume as much energy in one day as they do in one year.

d. How we use energy
   i. Industry
      1. Biggest share 36.5%
      2. Mining milling and smelting use most
   ii. Residential and commercial
      1. Roughly 34%
   iii. Transportation
      1. 26%
      2. 98% of that comes from petroleum products
      3. 75% of all freight traffic in the U.S. is carried by trains barges, ships and pipelines, but only use 12% of transportation fuel.

e. Fossil Fuels
   i. Organic chemicals created by living organisms million of years ago and buried in sediments, where high pressures and temperatures concentrate and transform them into energy-rich compounds
      1. Coal
         a. World reserves are vast, about 10x greater than conventional oil and gas resources combined
         b. About 10 trillion metric tons
         c. Could provide several thousands of years worth of energy if used at current levels
   d. Difficulties
      i. Dirty
         1. Emits large amounts of air pollution
         2. Sulfur dioxide, nitrogen oxides, hydrocarbons and CO₂
      ii. Destructive Extraction
         1. Mining is very dangerous
         2. Surface mining (strip mining) includes mountaintop removal, which destroys the surrounding landscape.

2. Oil
   a. About 600 billion metric tons, about ½ of which is recoverable.
   b. In 2000, proven reserves were about 650 billion bbl (barrels), enough for the next 30 years
   c. Largest oil reserves are in the Middle East, with about 2/3 of known reserves
      i. Saudi Arabia alone has 1/4 of world’s oil
d. The U.S. has used about 40% of its oil reserved, which would be depleted in about 10 years if we used only it.
e. Problems
   i. Contains high sulfur
   ii. Oil pollution accounts for 3 to 6 million metric tons discharged into the ocean every year.

3. Natural Gas
   a. Third largest commercial fuel, about 23% of global energy consumption
   b. Produces only $\frac{1}{2}$ the CO$_2$ as oil
   c. Very difficult to ship or store in large quantities.
   d. 41% of all gas reserved are in Central Asia
   e. Total Natural gas reserves are about 80% of crude oil reserves
   f. Because gas consumption is about $\frac{1}{2}$ that of oil, current gas reserves could last about 60 years.

4. Nuclear Power
   a. Power derived from the splitting of atoms
   b. Produces relatively cheap energy without CO$_2$ emissions.
   c. Problems
      i. Radiation kills and causes cancer
      ii. Nuclear Waste
         1. Currently about 200 million tons of radioactive waste in piles around mines and processing plants in the U.S.
         2. Plans are to bury the waste at a repository one a barren desert ridge near Yucca Mountain, NV

ii. Energy Conservation
   1. Best way to avoid energy shortages and relieve environmental and health effects is to use less energy.
   2. More efficient use of energy
      a. Increase fuel efficiency
         i. Raising average fuel efficiency by 1 mpg would cut oil consumption by almost 300,000 bbls/day
         ii. In one year, this would be more than would be gained from drilling in ANWR
      b. Improve domestic energy use
         i. Household energy losses can be reduced by $\frac{1}{2}$ to $\frac{3}{4}$ by improving insulation, purchasing
thermally efficient curtains and sealing cracks and loose joints.

ii. Passive solar energy gain in winter and cooling trees in summer also helps.

c. Industrial energy savings
   i. In the early 1980’s, with oil prices so high, U.S. business saved $160 billion/year through conservation. When oil prices dropped, they went back to being wasteful.

iii. Alternative Energy Sources
   1. Solar energy
      a. **Passive Solar Heat** uses natural materials or absorptive structures with no moving parts to simply gather and hold heat.
         i. Ex: Thick stone walls and adobe slowly collect heat during the day and release it at night.
         ii. Ex: Greenhouses on the south sides of buildings, or areas filled with water, collect heat during the day and reradiate at night.
      b. **Active solar systems** generally pump a heat-absorbing fluid (air, water, antifreeze) through a relatively small collector rather than passively collecting heat in a stationary medium
      c. Active solar collectors are usually located on or next to buildings.
         i. Can be used to heat water for space heating or hot water.
         ii. Water heating consumes 15% of U.S. domestic energy.
   2. **Photovoltaic Cells**
      a. **Photovoltaic cells** capture solar energy and convert it directly to electrical energy
      b. Used to be very expensive, but are more reasonable now.
         i. In 2002, they cost about $5 per watt, by 2020, they may coast $1 per watt, producing electricity at about $0.06/ kilowatt hour, roughly the same as coal fired electricity or nuclear power.
   3. **Fuel Cells**
      a. Devices that use ongoing electrochemical reactions to produce an electrical current.
         i. Similar to batteries, but instead of recharging them, you add more fuel.
      b. Uses Oxygen and hydrogen.
i. Oxygen is plentiful in the atmosphere, but hydrogen is quite dangerous.
ii. Produces water as a byproduct.
c. About as efficient as the best fossil fuel engines

4. **Biomass**
   a. Wood and other plant matter
   b. Burns much cleaner than fossil fuels, especially coal
   c. A renewable fuel source
   d. 40% of the world’s population uses wood for fuel
      i. Has led to serious deforestation

5. **Hydropower**
   a. Falling water has a lot of energy
   b. In 1925, 40% of world’s energy came from hydropower.
   c. Totally destroys ecosystems and can displace people

6. **Wind Energy**
   a. Advantages
      i. Very clean
      ii. Very abundant
   b. Disadvantages
      i. Requires expensive storage during peak production.

7. **Geothermal, Tidal and Wave Energy**
   a. Geothermal is only useful in a few places
      i. However, the earth’s constant temperature can be used to help maintain temperatures
   b. Tides have tons of energy, but it’s difficult to harness and can have huge environmental impacts
      i. The inconsistent nature of the tides also makes them hard to integrate.