Chap 14 Energy

Energy is the ability to do work. $W = F \times D$

US, 5% of population but use 25% of all energy generated.

1st law of thermodynamics- energy is not created or destroyed.
2nd Law of thermodynamics- energy does not flow spontaneously from a cold to hot object.
Most of Earth’s energy comes from the fusion rxn inside the sun.
We want useful energy types. High grade energy is degraded into low-grade forms.

Mechanical energy $\rightarrow$ heat energy $\rightarrow$ cools off.

Units of energy- calorie-heat 1 g of water 1 C. 1 cal = 4.184 J J= 1 joule

1. Molecular level of chemical rxns

\[
\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O} + \text{energy}
\]

\[
2\text{H}_2\text{O} + \text{energy} \rightarrow \text{O}_2 + 2\text{H}_2
\]
\[ C_{\text{diamond}} + O_2 \rightarrow CO_2 \]

a) Kinetics - how quickly a rxn takes place.
   1. As temp rises, more collisions and more successful collisions.
   2. Concentration of reactants. More molecules, more collisions.
      Ex. A spark in pure oxygen.
   3. Catalyst or enzyme - lower activation energy and is not consumed in
      the rxn.

b) Energy of rxn - endo exo rxns.
   1. exothermic rxn - give off energy. energy of products is lower than the
      energy of reactants-
      \[ CH_4 + 2O_2 \rightarrow CO_2 + H_2O + 192 \text{ kcal} \]
   2. endothermic rxn - requires energy - products are higher in energy than
      reactants.
      \[ 2H_2O + 137 \text{ kcal} \rightarrow 2H_2 + O_2 \]

   Ex.
   1. Hails
   2. photosynthesis
   3. explosion of dynamite
   4. metabolism

Fuel Sources -
   1. History -
      a) burning of wood.
      b) Egyptians used water power - 2000 years ago.
   2. Fossil Fuels - 90% sustain our way life. Three major ones coal, petroleum,
      natural gas.
Fossil fuels are being consumed rapidly, depletion occurs 50,000 times faster than being formed. In 1 century have used up more than 50% of fossil fuels.

a) Coal- most abundant fossil fuel. US has 25% of the world's supply. 52% of electricity comes from coal. 75,000 miners dig 1 billion tons of coal a year.

   1) Source- 600 million years ago Earth was warmer, plant life flourished, some became buried under mud and water. Cellulose could not decay fully \((\text{C}_6\text{H}_{12}\text{O}_6)\) Under high pressure molecules broke down and small molecules rich in \(\text{H}\) and \(\text{O}\) escaped. Remaining material became rich in \(\text{C}\). Peat is young coal, partially covered. Anthracite- almost completely carbon.

2) pros and Cons

<table>
<thead>
<tr>
<th>Pros-</th>
<th>Cons-</th>
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<tbody>
<tr>
<td>a) Jobs-</td>
<td>a) piles of waste</td>
</tr>
<tr>
<td>b) Cheap</td>
<td>b) destroys landscape</td>
</tr>
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<td>c) Large supply</td>
<td>c) water and air pollution-</td>
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   | 60% of US \(\text{SO}_2\) emissions |
   | 33% of mercury |
   | 25% of \(\text{NO}\) |
   | 33% of \(\text{CO}_2\) |

US does not back the Kyoto Climate treaty to help limit greenhouse gases. Scientist believe these gases are responsible for global warming.

b) natural gas- \(\text{CH}_4\) methane

\[
\text{rxn}\quad \text{CH}_4 + \text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O} + \text{energy}
\]

can also get \(\text{CO}\) and \(\text{C}\)(soot) natural gas can also include \(\text{N}\) and \(\text{S}\).
North America
60% CH4
5-9% CH3
3-18% CH3CH2CH3
2-14% butane pentane

use ethane and propane to crack and get ethylene and propylene to make plastics.

origin: Possibly formed from heat and pressure on buried organic material. Is stored in impenetrable rock.

c) Petroleum- liquid hydrocarbons- In 1950 replaced coal as the primary fuel.
Mixture of organic compounds.

$\text{Rxn } 2\text{C}_8\text{H}_{18(l)} + 25\text{O}_2 \rightarrow 16\text{CO}_2(g) + 18\text{H}_2\text{O}_2(g) + \text{energy}$

Combustion also produces nitrogen oxides.
Incomplete combustion yields soot and CO.
Small amounts of S produce SO2.
Remaining hydrocarbons are used for plastics, solvents, and synthetic fibers.

1) Origin- animal in origin, primarily from fats of ocean dwelling microscopic animals, in rocks of ocean origin.
2) Refining og crude oil. Boil in a distillation column- heavier ones on bottom.
   Take high boiling fractions- which are in high concentration and subject them to cracking (heating in the
absence of air). Break them into smaller hydrocarbons that are more useful.

1) Gasoline- internal combustion engines, in cars not very efficient and get lots of pollution.

Mixture of hydrocarbons from $\text{C}_5\text{H}_{12}$ to $\text{C}_{12}\text{H}_{26}$

a) octane rating- prevents premature ignition.

\[ \text{1927} \]

\[ \text{heptane} \quad 0\% \quad \text{iso-octane} \quad 100\% \]

90% octane rating means the fuel behaves as 90% iso-octane and 10% hexane

Ways to increase octane rating:

1) isomerization- rearrangement to more branches.

\[ \text{AlCl}_3 \quad \text{or H}_2\text{SO}_4 \quad \text{heat} \]

2) alkylation- small molecules form larger ones.

3) Lead as an additive. 1mL per 1 L raises octane rating by 10. However lead is toxic to the brain and fouls catalytic convertors. US phased it out in 1976.
4) Catalytic reforming.

\[
\begin{array}{c}
\text{catalyst} \\
\text{heat} \\
\end{array} \rightarrow \begin{array}{c}
\text{H} \\
\text{C} \\
\text{C} \\
\text{CH}_3 \\
\text{CH}_3 \\
\end{array} + 4\text{H}_2 \\
\text{106 rating}
\]

Benzene is a health risk.

5) MTBE- methyl tertbutyl eher. Oxygenated additive that helps decrease CO2 emissions. However, not as effective as other additives in octane rating so need to add lots more. Run into solubility problems. Also, is considered a potential carcinogen and the EPA has recommended a ban.

\[
\begin{array}{c}
\text{CH}_3 \\
\text{H}_3\text{C} \text{O} \text{CH}_3 \\
\end{array}
\]

3. Nuclear power- US electricity 51% coal 60% lost to heat.

1) Fission- US 20% of electricity comes from nuclear power plants. Number 15 in world.

Belgium 55%
France 76%
Lithuania 77%

A) How it works- use a fissionable material- U-235 3-4% a bomb needs 90%.

B)

Pros-
no airborne pollution.

Cons-
Radioactive waste
Generate thermal pollution
Nuclear accidents- In US have containment domes to prevent radioactive leaks.
Mining waste and damage

* Note- 20 year study of 70,000 nuclear shipyard workers had 24% lower mortality. Highest chronic radiation exposure had the lowest mortality.

C) Breeder reactors- make more fuel than they consume.

Take more abundant uranium-238 and bombard it with neutrons from the fission reaction it makes plutonium-239 which is fissionable.

Pros-
make more fuel than consumed.

Cons-
1) Plutonium is low melting so need to keep the reactor cooler at 640 C, this is inefficient and need Na metal as a coolant that is explosive on contact with
air or water. Not sure if backup cooling systems works to stop Pu from melting.

2) PU is highly toxic. 1/2 life of 25,000 years and emits alpha particles.

3) Easy to make bombs with PU-339.

3) Fusion- coming together of two hydrogens to make helium. Happens in the sun,

\[
\begin{array}{c}
\frac{2}{1}H + \frac{3}{1}H \rightarrow \frac{4}{2}He + \frac{1}{0}n + \text{energy}
\end{array}
\]

pros-

1) Fuel source is unlimited and readily available (H)

2) Unlimited power.

3) Little to no pollution or radioactive waste.

Cons-

1) huge technical difficulties. Temp must be 50,000,000 C. At this temp molecules do not hold together and would form a free floating mixture of nuclei and electrons called a plasma. Trying to use magnets to control the reaction.

4. Renewable energy sources-

1. Solar-
A) Heating- Can collect heat to heat water. The water in turn can be used to heat the air in the house. Use a black panel to absorb heat and then try to prevent heat loss. Usually 30% of the energy is remitted to space.

B) Electricity from sunlight- photovoltaic cells.
Take an e rich atom (As) and an e deficient atom (B) put them together and use the sunlight to move the e. Not very efficient, about 10%. Need large surface area to generate relatively little power.

Pros-
1) no air pollution, no greenhouse gas, nothing to truck, no waste.
2) Less grid failure, produced at times of high need.
3) Can install in dense areas.
4) Price is fixed.

Cons-
1) In US, 10X more expensive than coal.
   4x natural gas. 2x nuclear.
2) Need large infrastructure.
3) Need large surface area.

World use of PV. Solar power up 32% from 2002. Japan 45%, Europe 43%. Can provide up to 10-15% of world's energy use in 2050.

EX. In Japan in 1994 began a program called “Solar Roofs”. Advocated the use of solar power by giving low interest loans,
advertising, residential rebates. Gov. will phase out subsides. Now have 0 energy bills that rolled into the mortgage. Sell excess power back into the grid.

2. Bio-mass- use the power of the sun to grow plants for the use as a fuel. Often use genetically modified fast growing plants or trees.

Can use the sugars of the plants to ferment to get ethanol or methanol. Very inefficient as compared to burning directly.

Cons-
Land is needed to grow food.
Land is far from the plants
3% overall efficiency