IB ENERGY, POWER AND CLIMATE CHANGE
DEFINITIONS AND CONCEPTS

DEGRADED ENERGY: Energy which is spread out or disordered. The most degraded form of energy is thermal energy.

ENTROPY: A measure of disorder of a system

SECOND LAW OF THERMODYNAMICS: There are many different statements of this law:

- heat always flows spontaneously from hotter to colder bodies, and never the reverse, unless external work is performed on the system
- the entropy of an isolated system never decreases, because isolated systems always evolve toward thermodynamic equilibrium, a state with maximum entropy.

SANKEY DIAGRAMS: Energy flow diagrams whose dimensions also give a measure of the proportions of the different types of energy.

ELECTROMAGNETIC INDUCTION: When the magnetic field cutting a conductor changes, a voltage is induced in the conductor.

GENERATOR: A rotating coil in a magnetic field (or field rotating about a coil) produces an alternating voltage by electromagnetic induction.

RENEWABLE ENERGY SOURCES: Sources which will not be exhausted over time.

FOSSIL FUELS: Oil, gas, coal made over millions of years from plants and organisms. Non-renewable. Produce CO_2 when burned.

BIOMASS: Plants grown for fuel. E.g. wood, sugarcane alcohol, household waste

ENERGY DENSITY: The amount of useful energy which can be released from 1 kg of a fuel. Unit: MJ kg^{-1}. Oil/gas 40-50; Coal 30; Biomass 15

SOURCES: Oil 40%; Gas 25%; Coal 25%; HEP 5%; Nuclear 5%; Renewables 1%

RENEWABLES: Solar 45%; Wind: 30%; Geothermal 15%; Biofuel 10%

ELECTRICITY: Coal 40%; Gas 20%; Nuclear 15%; HEP 15%; Oil 10%

POWER STATION EFFICIENCY: Coal 40%; Gas 60%; CHP 80%

NUCLEAR CHAIN REACTION: Nuclear fission produces neutrons. If one neutron can produce, on average, one other fission, there will be a chain reaction.

CRITICAL MASS: The mass of fissile material needed to sustain a fission reaction.

MODERATOR: A material which slows down fast neutrons to KE of 1eV. Necessary for nuclear fission. Examples: graphite, water

CONTROL RODS: Material which absorbs neutrons. Used to control chain reaction. Example: Boron

URANIUM: Naturally occurring uranium contains 99.3% U-238

FUEL ENRICHMENT: Process to raise proportion of U-235 in nuclear fuel from 0.7% to 3%.

UNCONTROLLED CHAIN REACTION: With high concentration U-235 (20%).

ATOM BOMB: Uses weapons-grade uranium (80% U-235) and two sub-critical masses forced together to create nuclear explosion.

HEAT EXCHANGER: Water flows in pipes through nuclear core, carries away heat.

PLUTONIUM: By-product of uranium fission. Can be used in another type of nuclear reactor or in nuclear weapons.

NUCLEAR MELTDOWN: Uncontrolled nuclear reaction due to failure of control rods or cooling cause overheating of nuclear core and melting of fuel rods.

LOW LEVEL NUCLEAR WASTE: Result of normal use, enrichment process or decommissioned reactors. Disposal for 100s of years.

HIGH LEVEL NUCLEAR WASTE: Spent fuel rods need to be disposed of for many thousands of years due to long half-lives and intense radiation.

ADVANTAGES OF FISSION: No contribution to global warming.

NUCLEAR FUSION: How the Sun produces energy. Joining of two light nuclei which release energy. Requires high-density plasma at extremely high temperatures contained by magnetic fields. Not yet commercial.

SOLAR CONSTANT: Intensity (power per unit area) of the Sun (1380 Wm^{-2}).

$$I = \frac{\text{power}}{A}$$

PHOTOVOLTAIC CELL: Converts solar radiation into electrical energy.

SOLAR HEATING PANEL: Water flows in pipes and is warmed by the Sun.

HYDROELECTRIC POWER: Downward flowing water converts gravitational PE to electrical energy. Uses dams, fast rivers, pumps or tides.

WIND POWER: Turbines are rotated by the KE of moving air to generate electricity.

$$\text{power} = \tfrac{1}{2} A \rho v^3$$

WAVE POWER: Energy in water waves converted, for example by water oscillating in a column.

$$\text{power per unit length} = \tfrac{1}{2} A^2 \rho g v$$

ALBEDO: The ratio of reflected to incident light. Snow 90%; dark ground: 10%. Earth's average: 30%.

$$\text{albedo} = \frac{\text{total scattered power}}{\text{total incident power}}$$

GREENHOUSE EFFECT: The Earth's atmosphere is warmed by absorbing some of the heat radiation emitted by the ground.

GREENHOUSE GASES: Gases in the atmosphere which absorb heat radiation. E.g. carbon dioxide, methane, water vapor

RESONANCE: A molecule can absorb radiation energy if it has the same natural frequency of oscillation as the photon.

GAS ABSORPTION: Different gases absorb different frequencies of radiation depending on their chemical bonds. Ozone absorbs UV; CO_2 absorbs IR.

BLACK-BODY RADIATION: A theoretical body which absorbs and emits all wavelengths of EM radiation. The graph is characteristic and its peak varies with temperature of the body.

STEFAN-BOLTZMANN LAW: Relation of power per unit area (Wm^{-2}) to temperature (K). Stefan-Boltzmann constant, $\sigma = 5.67*10^{-8}$

$$\text{power} = \sigma A T^4$$

EMISSIVITY: How much energy a body radiates compared to a black body.
e = Energy radiated by body/ Energy radiated by a black body

$$\text{power} = e\sigma A T^4$$

SURFACE HEAT CAPACITY: The amount of heat, required to raise the temperature of 1 m^2 of a surface by 1 K. eg Earth: $4*10^8$ $Jkm^{-2}K^{-1}$

$$C_s = \frac{Q}{A\Delta T}$$

GLOBAL WARMING: The result of more solar radiation or less re-radiation from Earth.

ENHANCED GREENHOUSE EFFECT: A change in the amount of greenhouse gases would change the radiation balance which would change the temperature of the atmosphere.

$$\Delta T = \frac{(I_{\text{in}} - I_{\text{out}})\Delta t}{C_s}$$

COMBUSTION OF FOSSIL FUELS: Produces CO_2, a greenhouse gas. Likely to be causing heating of the Earth.

ICE CORES: Long cylinders of ice from Antarctica are analysed and show a close correlation between Earth's temperature and CO_2 levels.

COEFFICIENT OF VOLUME EXPANSION: A measure of how volume of a liquid changes with temperature. They are proportional. Unit: K^{-1}

Topic 8: Energy, power and climate change

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