ForumIAS

CA - S&T - 0417

Fuels, Cells and Batteries

Fossil Fuels

- Coal: Plant biomass + compression + time: Contains Hydrogen, Sulphur, Nitrogen; flue gas;
- Petrol, diesel: Animal (marine) biomass + time + compression;
- Gas:

Petroleum

Crude – Refining products: Propane/Butane; Petrol; Diesel: Fuel oil
Energy density: Coal - Natural gas - Hydrogen - Uranium

Emission control – BS VI norms

EMISSION STANDARDS PETROL ENGINES

BS IV		BS VI
1.0-2.27	Carbon Monoxide (CO)	1.0-2.27
0.1-0.16	Hydrocarbons (HC)	0.1-0.16
0.08-0.11	Nitrous Oxides (NOx)	0.060-0.082
NA	Particulate Matter (PM)	0.0045

EMISSION STANDARDS DIESEL ENGINES

BS IV		BS VI
0.50-0.74	Carbon Monoxide (CO)	0.50-0.74
0.30-0.46	HC + NOx	0.17-0.215
0.25-0.39	Nitrous Oxides (NOx)	0.08-0.125
0.025-0.06	Particulate Matter (PM)	0.0045

Catalytic convertor: convert PM, HC, CO to CO and Water; NOx into N2 and Oxygen;

Alternative fuels

Converting fuels

- Coal gasification: Producer gas - CO + N2 (thermal reduction under limited oxygen); Syn gas - CO + H2 (HC + Steam);
- Coal liquification: Syn gas -> Compress -> Methanol;

Gas

- Natural gas – Mixture of methane and ethane; Sources – Gas wells, Gas hydrates, Coal bed methane;
- CNG: Methane – compressed;
- LNG: Methane – liquified; Cryogenics;
- LPG: Propane. Butane – compressed;

Liquid

- Liquid hydrocarbons: Dimethyl ether, LPG, LNG, Liquid H2
- Alcohol: Ethanol
    - Methanol: Syn gas (CO + H2) – compress;
- Biodiesel

Hydrogen

- H2: Combustible, non GHG,
- **Advantage**: Non GHG, Non-polluting, easy availability
- **Challenge**: Non-economic extraction methods; low density per unit volume (options – compress or liquify);
- **Sources**: Fossil fuels, water;
- **Usage**: Direct combustion (ICE), Mix with fuels, Fuel cells;

Methods:

1. Hydrocarbon based:
   - HC + Steam = (Catalyst – platinum) Syn gas;
   - Challenge: Polluting; Black, Grey Hydrogen;
2. Water:
   - Electrolysis;
   - Green Hydrogen;

Usage:

- Direct combustion: Low efficiency
- Fuel Cells: Advantages- Increased efficiency; direct power to EV;

Battery

Chemical reaction -> electrical energy (DC Current)

Lithium-Ion battery

- Important terms: Graphite, Lithium oxide, electrolyte;
- Advantages: High potential (voltage), high energy density, low self-discharge;
- Fire: Electrostatic potential – Li inherently unstable; Liquid & flammable electrolyte; Temperature;
- Recent deposits found in J & K;

Alternatives

- Sodium Ion batteries:
- Solid State batteries:

Biofuels:

Advantages: Carbon – GHG;

Usage

- Direct burning – biomass
- Alcohols – fermentation;
- Biodiesel – Transesterification
- Biogas

Alcohols

- Methanol and Ethanol; Substitute of petrol;
- Use: Direct replacement or blending;
- Fermentation: Yeast on sugar (anaerobic);
- Sugar source: Edible part (sugarcane, starch, corn, wheat); Non-edible: cellulosic matter-complex sugars, Complex sugar – hydrolysis -> Simple sugars -> fermentation;

Biodiesel

Replacement of diesel;

Methods:

- Pyrolysis (heating); Cracking; Hydrogenation, transesterification;

Energy density: Ethanol – Petrol – Biodiesel – Diesel;

Biofuel Generations

- 1st generation: source – edible; e.g. rice, wheat etc;
- 2nd Generation: Non-edible e.g. grass, leaf; Ligno-cellulosic – wood; Agricultural waste – rice husk, corn stalks;
- 3rd Generation: Algal based – macro algae, micro algae, aquatic plants;
- 4th Generation: Genetic engineering;

Nuclear Science

Important Terms

- **Fertile material** - isotopes that are non-fissionable by neutrons, but can be converted into fissile isotopes.
- **Fissile material** - fissionable isotopes that are capable of undergoing nuclear fission.
- **NUCLEAR ENRICHMENT** - increasing the concentration of one isotope relative to another is called "enrichment.
- **Transmutation**: Converting fertile material to fissile
- **MODERATOR:** To slow down the neutron, the reactors use moderator; Water, Heavy water;
- **CONTROL RODS:** Control rods absorb neutrons but do not release energy in the process.

Nuclear Fission

3 Stage nuclear program of India

HEAVY WATER REACTOR

- Referred to as CANDU reactor.
- Use of heavy water (D2O) as both moderator and coolant.
- Can be used with unenriched uranium fuel.

FAST BREEDER REACTORS

- Produce more fuel than they consume.
- Uses fast neutrons for transmutation.

- Uses a coolant that is not an efficient moderator, such as liquid sodium, so the neutrons remain high-energy.
- They are designed to maximize plutonium production.

Nuclear Fusion

Sun: Hydrogen fuses to form helium;

Experiments on earth: Methods

- Magnetic confinement: Tokamak; ITER, EAST
- Inertial confinement: Laser: NIF California

ITER (INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR)

- Fusion reactor; Location: Saint-Paul-les-Durance in southern France; joint collaboration of 35 countries; Hydrogen gas is in plasma state; Magnets are used to which confines the hydrogen.

Governance structure

DEPARTMENT OF ATOMIC ENERGY

It is apex body under the direct charge of Prime Minister.

ATOMIC ENERGY COMMISSION

It is the governing body of Department of Atomic Energy.

ATOMIC ENERGY REGULATORY BOARD (AERB)

Regulatory authority responsible for safe operations of nuclear reactors as well as regulation at all other nuclear facilities in India.

PUBLIC SECTOR INSTITUTIONS

NPCIL: Nuclear Power Corporation of India (NPCIL), Mumbai, Maharashtra (PSE for generation of electricity from nuclear power)

Important Non-proliferation treaties

PTBT, CTBT, NPT;