Biogas:

→ One of the most important bioenergy to solve environmental issues and to replace natural Gas & transportation fuel.
→ Mainly comprises of methane (55-65%), CO_2 (30-40%) and impurities.
→ Impurities → produced from plants, animal & Human waste
→ Can be used directly in cooking.
→ Reduces the need of firewood & LPG Gas.
→ The material from which it is produced retains its value as a fertilizer and can be returned to the soil.
→ Also called Gobar Gas.
→ Wastes include crop residues, kitchen wastes, paper wastes, etc.
→ Produced by digestion, pyrolysis or Hydro Gasification.
→ Digestion is the biological process that occurs in the absence of oxygen and in the presence of anaerobic organisms at ambient temp & pressure.
→ The container in which it takes place is called digestor.

Energy from biomass:

→ India produces about 450 - 500 million tonnes of biomass per year.
→ Current share of biofuels in total fuel consumption is very low.
→ It is not sold in Indian fuel market.
→ Govt. plans to meet 20% of the country's diesel requirements using biodiesel.
→ Plants like neem are potential sources for production of biodiesel.
→ 63 biomass cogeneration projects have been planned in the last 4 years.
→ 11 have been completed.
→ Biomass is renewable energy source derived from the waste of various human & natural activities.
→ Derived from waste materials (same as biogas).
→ Types: It is renewable b/c waste residues will always exist we will always have crops & residual biological matter from these crops.

→ Types of biomass → Based on the site of origin

(a) Field and Plantation biomass: Includes organic materials like crops and trees grown specifically to be used as a source of energy, such as corn or sugarcane.

(b) Industrial biomass: Organic waste materials generated by factories and businesses which can be used for energy production. Eg. Wood scraps from furniture industry.

(c) Forest Biomass: Organic matter found in forests. Eg. leaves, branches, trees, etc. They can be used to produce energy or make paper products.

(d) Urban waste Biomass: Organic waste materials generated in cities eg. food scraps, etc. Can be converted into energy through processes like composting or biogas production.

(e) Aquatic Biomass: Consist of organic waste from water environment, such as aquatic wastes. Can be used as a food source in aquaculture.

Photosynthesis:

→ Conversion of light energy to chemical energy which is later used in cellular activities.

→ The chemical energy is stored in the form of sugar which is created from water and CO_2.

→ It produces glucose which is utilised to power several cellular functions.

→ Produces oxygen as a by-product -

$$6CO_2 + 6H_2O + \text{sunlight} \rightarrow C_6H_{12}O_6 + 6O_2$$

(Carbon Dioxide + water + sunlight) → (Glucose (simple sugar) + oxygen).

6 CO_2 molecules ~~are~~ using sunlight mix with 12 water molecules to produce 6 Glucose molecules & 6 Oxygen ~~molecules~~ molecules each.

(*) Factors affecting anerobic digestion:

① Basic ② Environmental

①. Basic:

(a). Bacteria: Depending on end product produced by the bacteria, they are classified as:

① Acid formers: less sensitive to environmental changes & fast growing. ph → 4.5 to 6.5

② Methane formers (Methanogens):

②. Food: Food consists of complex organic material. Control over organic characteristics is difficult.

③. Contact: Stabilization cannot occur without actual contact of food with bacteria. This contact several ways, most common is mixing. Effective. By artificial mixing or by natural means. Artificial. Mixing → contents are stirred continuously.

④. Time: Time taken by the solid & liquid waste to convert into biomass

②. Environmental factors:

(a). Temperature: Time required for stabilization of organic matter depends on the temperature of digestion. Rate of stabilization increases and decreases with temperature.

(b). PH: PH of the contents of the digester. Relationship btw the alkaline and acidic percentage. Optimum pH ranges b/w 6.8 to 7.2.

(c) Toxics: Materials that have bad affect on digestion if their quantity is high.

(*). Classification of biogas plants:

①. Continuous and batch types:

→ fed and emptied continuously.

→ Substrate must be fluid and Homogeneous.

→ Emptied by themselves when the container overflows when material is filled

→ Suitable for rural households
→ Gas production is constant & higher than batch plants.
→ Nearly all biogas plants operate in continuous mode.
→ Single digester. Process goes on except for repairing & cleaning.
→ May be single stage or double stage process.

digestion in single chamber — Digestion in 2 chambers. 1st stage in seperate chamber & rest in other.

(ii) Batch Plants:
→ Plant is emptied once the process of digestion is complete.
→ Charged and emptied one by one in synchronous manner which maintains a regular supply of the gas.
→ Expensive unless operated on large scale.
→ filled and emptied after a fixed time.
→ High labour input. Gas output is not steady.

(iii) floating gas holder type:
→ Mixing tank, digester tank, 2 cement pipes, inlet [illegible] slurry [illegible] tank in, outlet for overflow tank.
→ Gas holder, an inverted drum on top of the digester. Drum can move up & down (float). Gas holder has outlet which can be connected to gas stoves.
→ Slurry is prepared in mixing tank and fed into the input chamber through the pipe. Plant is left unused for 2 months and introduction of slurry is stopped.
→ During this time, anaerobic fermentation of biomass produces biogas.
→ Biogas being lighter rises up starts collecting in gas holder.
Gas holder rises up and cannot rise more than a certain level, Gas ↑ pressure ↑ on slurry.
→ Spent slurry is forced into the output chamber, excess → overflow tank.
→ Gas outlet is opened for supply.

(2) Fixed dome Gas Holder type
→ Brick and cement structure
→ Mixing tank opens underground into the inlet chamber.
→ Inlet chamber opens into digester couch is huge and dome shaped ceiling. Ceiling has an outlet valve for gas supply.
→ Digester opens into outlet chamber which opens is to overflow tank.
→ When the digester is partially filled with slurry it is stopped and it is left unused for about 2 months.
→ Anaerobic bacteria decomposes; biogas is formed which starts collecting in the dome.
→ More biogas, pressure forces the spent slurry into outlet & overflow chamber
→ Spent slurry is manually removed from the overflow tank.
→ Gas valve is opened for biogas supply.

Advantages:
① Reduces burden of forest and fossil fuels.
② Helps in controlling pollution (air) & water.
③ Provides manures for plants.

Disadvantages / Limitations:
① High cost.
② Waste is insufficient sometimes.

(3) Factors affecting bio digestion:
① Particle size: Amount of solid material & should be moderate & particle size should be small.
② Carbon to Nitrogen ratio should be maintained.
③ More organic matter in the waste leads to more production of biogas.
④ Type of material you put and how easily it breaks down.
⑤ Right level of moisture (60-80%) is important.
⑥ Also depends on the time for which the matter stays in the digester.

(v) Cofiring: Process of burning a mixture of biogas and other fuels such as ~~Biogas~~ natural gas, biomass, etc. in the same combustion system to generate energy.

→ Promotes sustainable energy by using biogas, a renewable resource alongside other fuels.

→ Reduces greenhouse gas emission and dependence on non-renewable sources

→ Can improve the efficiency of power plants.

→ Less pollution as compared to that caused by fossil fuels alone.

→ Helps to maintain cleaner environment & more sustainable energy production.

(vi) Dry Processing: Involves the use of solid state fermentation / digestion where the organic waste is in a dry or semi-dry form.

→ Includes agriculture residues, food waste, etc (organic material with low moisture content).

→ It requires less water, making it more water-efficient.

→ Reduces the need for storing and transporting liquid slurry, which can be expensive.

→ Slower digestion rate and slower biogas yield compared with wet digestion methods.

→ Can contribute to sustainable waste management.

(vii) Pyrolysis: Heating biomass in a closed vessel in the absence of oxygen. Temp above 500°C. No combustion.

→ Can process all forms of organic materials (rubber, plastic, etc).

→ Gases produced are a mixture of nitrogen, methane, CO_2, carbon monoxide, etc

→ Can be used to produce solid, liquid & gases.

→ Liquids produced are oil like and solids are like charcoal.

→ Bio oil can be used in transport. Cheaper.
→ Bio-char (solid) can help in improving soil.

Biomass fuels:

1. woody fuels.
2. Forestry Residues
3. Mill Residues
4. Agricultural Residues.
5. Urban wood and Yard wastes.
6. Dedicated Biomass Crops.
7. Chemical recovery fuels.
8. Animal wastes.

(A) Biomass Power Plants:

→ Most plants are relatively small & often found in US and Europe
→ Biomass power capacity is expected to increase in coming years.
→ Current way to convert biomass into electricity is through combustion.
→ Alternate methods include gasification, anaerobic digestion. These methods are not widely used.
→ work like coal fired power plants. They store biomass & preprocess it and then burn in a combuster to generate steam that powers a turbine & generator.
→ Co-firing is used for cost effectiveness (Biomass + ₹ coal). Coal is easier to transport.
→ Coal power plants are often much larger and more efficient than biomass power plants.
→ Convert organic material into electricity.

(B) Biogas Digester design

→ Chamber is made from High density polyethylene plastic, Inlets & outlets are of bricks and cement.
→ Goal is to overcome issues like leakage.
→ Biogas is produced through anaerobic digestion.
→ Biogas contains methane and CO_2.
→ Traditional digesters made of cement experience issues like leakage, ~~etc~~, UV

radiations damage, etc.

→ High density plastic (HDPE) is used because its non-corrosive, insulating, cost effective, easy to maintain, etc.

→ More affordable and efficient way to construct biogas digesters

(*) Cogeneration: Generating together. Used to generate heat and electricity from the same fuel at the same time.

CHP → Combined Heat & Power.

→ Fuels used include coal, natural gas, Biomass, etc.

① Steam turbine → Back Pressure
→ Extraction condensing.
② Gas turbine → open cycle → closed cycle.
③ Reciprocating Engine.

heat source that.

Steam turbine → Principle of Rankine cycle, Heat source that converts water into high pressure steam.

Steam is expanded and transported to a condenser → water

Back pressure: Steam is extracted at ↑ or equal to atmospheric pressure → Sent to thermal load where heat is required. Steam releases heat & gets condensed into water. Water returns to the system.

Extraction condensing: Steam is extracted at one or more intermediate stages at required pressure & temp. Remaining steam transported to condensor at low pressure.

Gas turbine → Brayton cycle. Atmospheric air is compressed, heated & expanded

Open cycle: Compressor takes air from atmosphere → combustor. Heat ↑ temp. Steam is produced → Run turbine. Exhaust gases → atmosphere

Closed cycle: working fluid circulates in closed circuit. Heat is supplied through Heat Exchanger (No direct combustion. On exiting turbine, the fluid cools down, releasing Heat & Electricity.