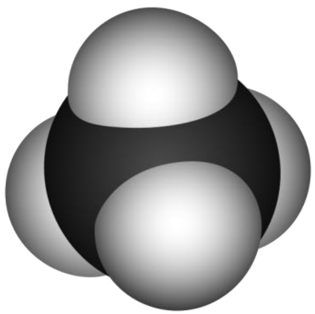
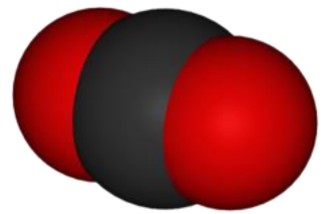
Lect.-4
Biogas production techniques and various uses of biogas.

What is biogas?



CH_4 +

(50-70%)



CO_2

(30-40%)

Hydrogen = 5-10 %
Nitrogen-=1-2 %
Water vapour= 0.3%
Hydrogen sulphide = Traces

Biogas

It is a mixture of gas produced by the microorganisms during the anaerobic fermentation of biodegradable materials.

Anaerobic fermentation is a biochemical process in which particular kinds of bacteria digest biomass in an oxygen-free environment resulting in production of CH_4, CO_2, H_2 and traces of other gases along with decomposed mass.

Properties of biogas

Properties	Range
Net calorific value (MJ/m^3)	20
Air required for combustion (m^3/m^3)	5.7
Ignition temperature (^0C)	700
Density (kg/m^3)	0.94

Microbiology of biogas production:

The biogas production process involves three stages namely:

- Hydrolysis
- Acid formation and
- Methane formation

Hydrolysis

The complex organic molecules like fats, starches and proteins which are water insoluble contained in cellulosic biomass are broken down into simple compounds with the help of enzymes secreted by bacteria.

This stage is also known as polymer breakdown stage (polymer to monomer). The major end product is glucose which is a simple product.

Acid formation

The resultant product (monomers) obtained in hydrolysis stage serve as input for acid formation stage bacteria.

Products produced in previous stage are fermented under anaerobic conditions to form different acids.

The major products produced at the end of this stage are acetic acid, propionic acid, butyric acid and ethanol.

Methane formation:

The acetic acid produced in the previous stages is converted into methane and carbon dioxide by a group of microorganism called "*Methanogens*". In other words, it is process of production of methane by methanogens.

Methanogenesis is sensitive to both high and low pH and occurs between pH 6.5 and pH 8.

Major reactions occurring in this stage is given below:

$$CH_3COOH \longrightarrow CH_4 + CO_2$$

Acetic acid → Methane + Carbon dioxide

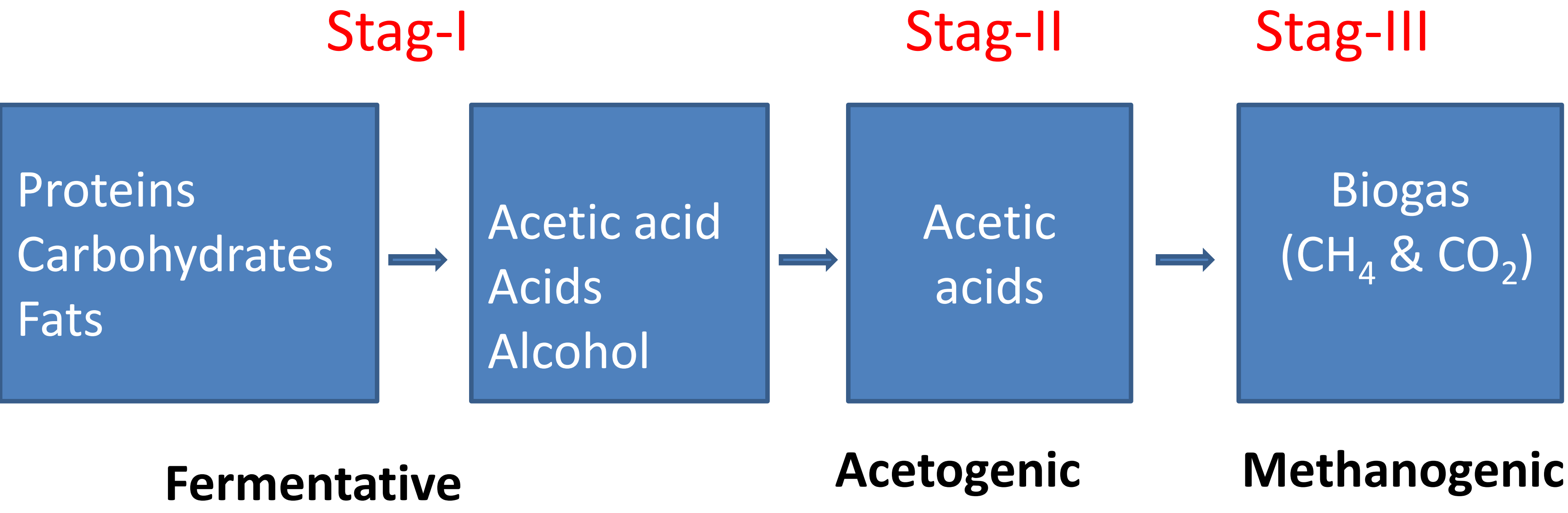
$$2CH_3CH_2OH + CO_2 \longrightarrow CH_4 + 2CH_3COOH$$

Ethanol + Carbon dioxide → Methane + Acetic acid

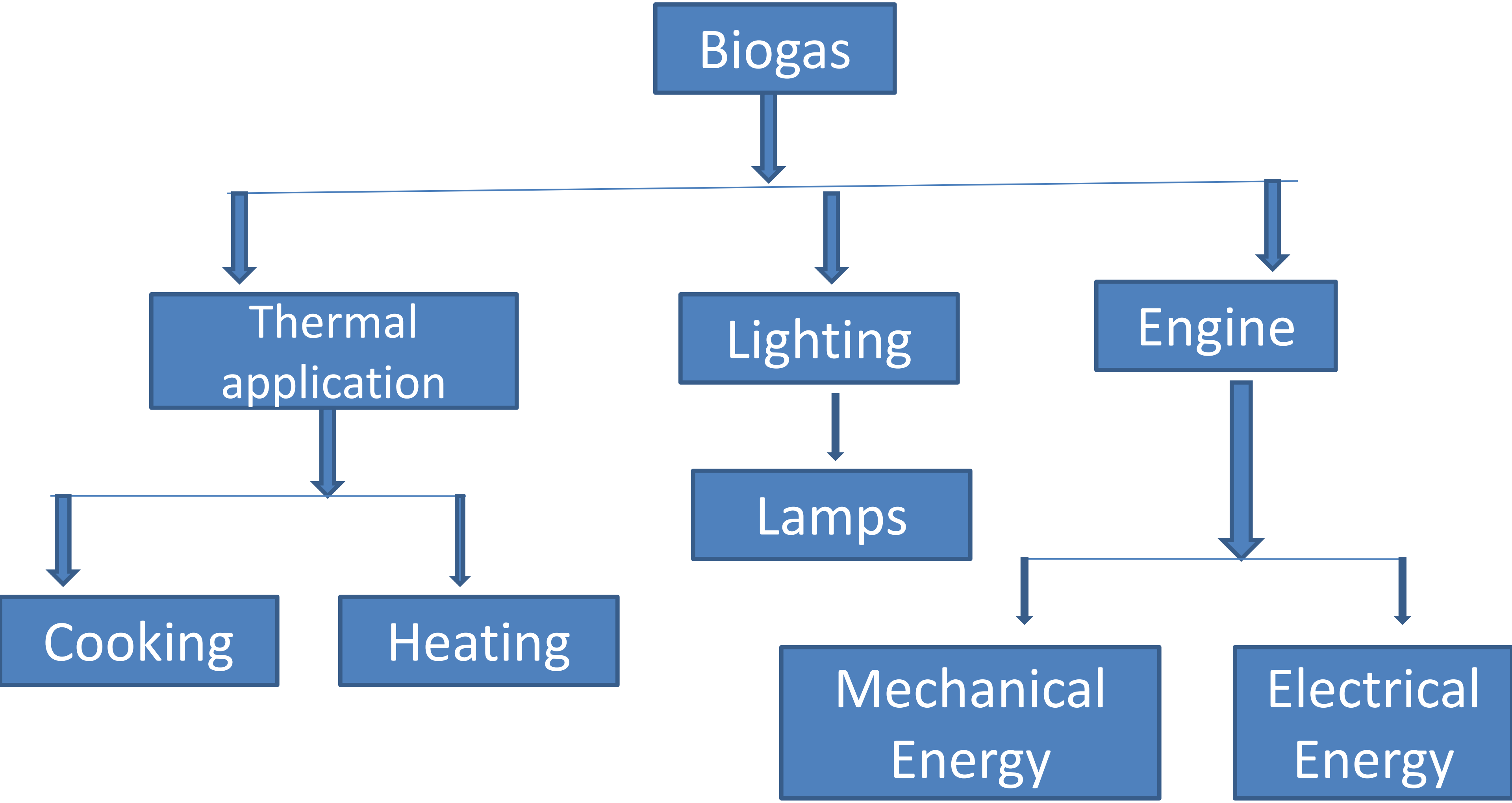
$$CO_2 + 4\,H_2 \longrightarrow CH_4 + 2\,H_2O$$

Carbon dioxide + Hydrogen → Methane + Water

The process of biogas formation through different stages:



Flow chart of different applications of biogas.



Uses of biogas

Biogas serves as a suitable alternate fuel for satisfying the energy needs of human society. It can be used for production of power, for cooking,

Cooking:

Biogas is available at low pressures (4 - 8 cm water) so it's stoves are different from LPG stove.

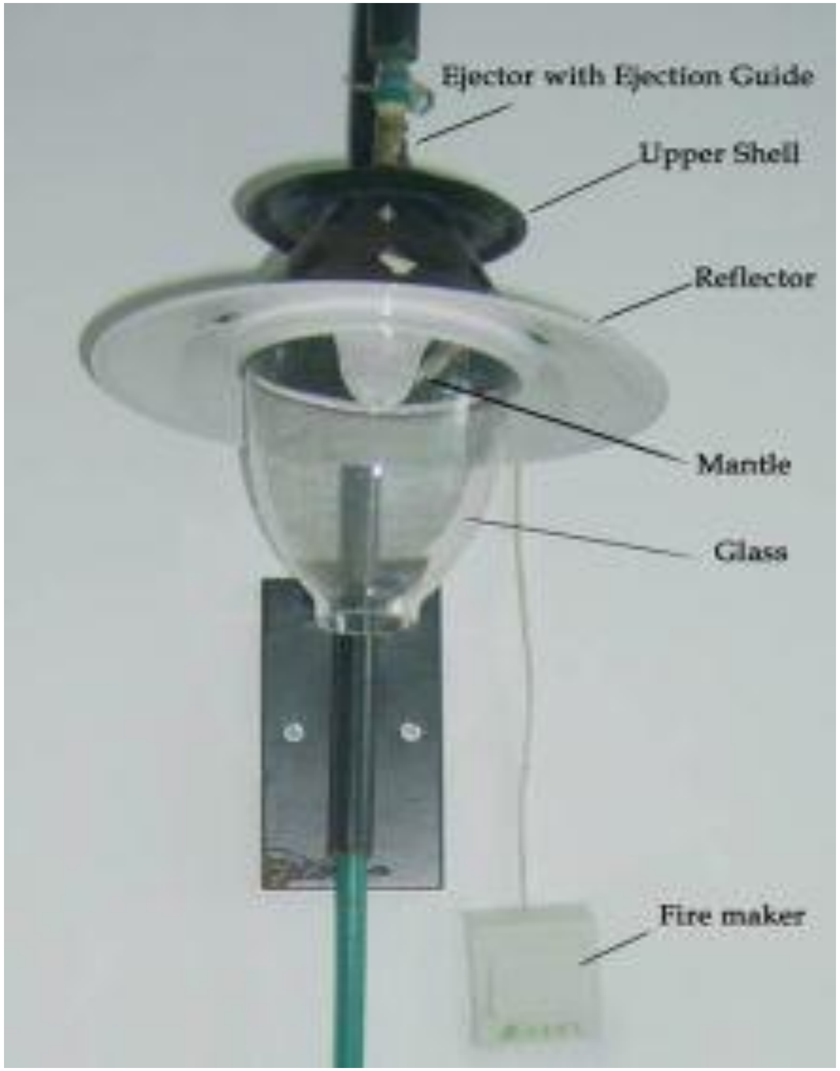
Biogas burns with blue flame and without any soot and odour.

Biogas burner

Lighting

Lighting can be provided by means of a gas mantle, or by generating electricity.

Biogas mantle lamps consume 0.13 cum gas per hour having illumination capacity equivalent to 40 W electric bulbs at 220 volts. This application is predominant in rural and un-electrified areas.


Ejector with Ejection Guide
Upper Shell
Reflector
Mantle
Glass
Fire maker

Biogas as an Engine Fuel

Biogas can be used as a fuel in stationary and mobile engines.

It can be used to operate four stroke diesel and spark ignition engines.

Electricity generation using biogas is a commercially available and proven technology.

When biogas is used to fuel such engines, it may be necessary to reduce the hydrogen sulphide content if it is more than 2 percent otherwise the presence will lead to corrosion of engine parts.

For electricity production, small internal combustion engines with generator can be used to produce electricity.

Biogas Generator

Use of biogas as vehicular fuel

The presence of CO_2 is unsatisfactory.

It lowers the power output from the engine, takes up space in the storage cylinders and

it can cause problems of freezing at valves and metering points, where the compressed gas expands, during running. Therefore CO_2 is to be removed from the raw biogas to prepare it for use as fuel for vehicles and for compression of the gas into high-pressure cylinders, carried by the vehicle.

Uses of bio-digested slurry

The slurry after the digestion will be washed out of the digester which is rich in various plant nutrients such as nitrogen, phosphorous and potash.

Well-fermented biogas slurry improves the physical, chemical and biological properties of the soil resulting qualitative as well as quantitative yield of food crops.

The cow dung slurry after digestion inside the digester comes out with following characteristics and has following advantages:

- When fully digested, effluent is odourless and does not attract insects or flies in the open condition.
- The effluent repels termites whereas raw dung attracts them.
- Effluent used as fertiliser reduces weed growth with about 50%. When FYM is used the undigested weed seeds cause an increased weed growth.
- It has a greater fertilising value than FYM or fresh dung. The form in which nitrogen available can be easily assimilated by the crops.

Numerical

Q1. Design an appropriate size of biogas plant for a family of 6 members owing 2 cows, 2 buffaloes and 2 calves. One candle lamp is used for lighting purpose for 2 hours.

Solution:

Availability of dung: Cow = 2 x10 kg = 20 kg

Buffalo = 2 x 15 kg = 30 kg

Calf = 2 x 5 kg = 10kg

Total available dung = 60 kg

We know that potential gas production of 60 kg per day

= 0.04 x 60 cum = 2.4 cum

Consumption of gas:

Cooking for 6 persons = 0.24 x 6= 1.44 cum/day

Lighting one lamp for 2 hours =0.13 x 2 =0.26 cum/day

Total consumption of gas per day = 1.70 cum/day

Here, potential gas production is 2.4 cum/day, while consumption of gas is 1.70 cum/day. So, plant size will be 2 cum.

Q2. Design a digester of biogas plant from following data:

1. Capacity of plant = 2 cum
2. Diameter to depth ratio = 1.75 : 1
3. Hydraulic Retention time= 50 days
4. Density of slurry = 1020 kg/cum

Solution:

We know that 1 kg of dung produces 0.04 cum gas per day.

Dung requirement for 2 cum capacity plant = 2/0.04 = 50 kg.

Now, volume of daily feed = $\frac{Weight\ of\ (dung + water)}{density\ of\ slurry}$

Or $\frac{50+50}{1020}$ = 0.098cum/day

Volume of digester = Retention time x Loading rate per day

= 50 day x 0.098 cum/day = 4.9 cum

But, volume of digester = $\frac{\pi}{4}$ x D^2 x H

Comparing both, $\frac{\pi}{4}$ x D^2 x H = 4.9

Since D = 1.75 H

So, $\frac{\pi}{4}$ x $(1.75H)^2$ x H = 4.9

Or H^3 = 2.036

Therefore, H=1.27 m

And D = 1.75 x 1.27 = 2.22 m

So diameter of digester = 2.22 m and depth = 1.27m