Biochemical Gasification Technique

Biochemical Conversion

In biochemical processes the bacteria and micro organisms are used to transform the raw biomass into useful energy like methane and ethane gas. Following organic treatments are given to the biomass:

1) Fermentation of biomass (Aerobic digestion)
2) Anaerobic digestion of biomass

Fermentation

Fermentation is a process of decomposition of complex molecules of organic compound under the influence of micro-organism(ferment) such as yeast, bacteria, enzymes etc.

The example of fermentation process is the conversion of grains and sugar crops into ethanol and CO_2 in presence of yeast.

Anaerobic digestion

The anaerobic digestion or anaerobic fermentation process involves the conversion of decaying wet biomass and animal waste into biogas through decomposition process by the action of anaerobic bacteria.

The most useful biomass for production of biogas are animal and human waste, plant residue and other organic waste material with high moisture content.

Biogas Generation

Biogas contains 55-65% methane, 30-40% CO_2, and the remainders are impurities like H_2S, H_2, N_2 gases.

Cattle dung can produce 0.037 m^3 of biogas per kg of cow dung. The calorific value of gas is 21000 to 23000 kJ/kg or about 38000 kJ/m^3 of gas. The material from which biogas is produced retains its value as fertilizer or as animal feed which can be used after certain processing.

Biogas Generation

Biogas can be produced by digestion pyrolysis or hydro gasification. Digestion is a biological process that occurs in absence of O_2 and in presence of anaerobic organisms at atmospheric pressure and temperatures of 35^oC-70^oC. The container in which the digestion takes place is called digester.

When organic matter undergoes fermentation, the anaerobic bacteria extracts oxygen by decomposing the biomass at low temperatures up to 65^oC in the presence of moisture. (80-95%), the gas so produced is called biogas.

Principle of biogas production

Biogas production takes place in three stages:

1)Hydrolysis: In this stage, matters with heavy molecular weight are disintegrated into lower molecular weight. This process takes place by hydrolytic bacteria.

2)Acid Formation: In this stage, organic matters are converted into acetates and H_2. This conversion takes place by acetogenes. Then H_2 and C are converted into acetate by acetogenes.

Principle of biogas production

3) Methane Gas Formation: In this stage, acetates and simple CO_2 are converted into CH_4. This is carried out by methanogenes.

Composition of Biogas

Type of gas	% in the mixture by volume
Methane	50–80
Carbon dioxide	15–45
Water	5
Other gases including hydrogen	0–1
Hydrogen sulphide	0–3

Factors affecting biogas

(1) pH value: pH value of input mixture in the digester is between 6 and 7.

- In the initial period of fermentation, as large amounts of organic acids are produced by acid forming bacteria, the pH inside the digester can decrease to below 5.
- This inhibits or even stops the digestion or fermentation process.
- Methanogenic bacteria are very sensitive to pH and do not thrive below a value of 6.5.

(2) Nitrogen Concentration:

↑ N_2- ↓ growth of bacteria - ↓ CH_4

(3) Temperature: The methanogens are inactive in extreme high and low temperatures.

- The optimum temperature is 35 degrees C.
- Temperature goes down to 10 degrees C, gas production virtually stops.
- Satisfactory gas production takes place in the mesophilic range, between 25 degrees to 30 degrees C.
- Proper insulation of digester helps to increase gas production in the cold season.

(4) Loading Rate:

- Loading rate is the amount of raw materials fed per unit volume of digester capacity per day.
- If the plant is overfed, acids will accumulate and methane production will be inhibited.
- Similarly, if the plant is underfed, the gas production will also be low.

(5) Retention time:

- Retention is the average period that a given quantity of input remains in the digester to be acted upon by the methanogens.
- A digester should have a volume of 50 to 60 times the slurry added daily.
- the higher the temperature, the lower the retention time.

(6) Carbon-nitrigen (C:N) ratio: improper C:N ratio lowers methane production. Maximum digestion occurs when C:N ratio is 30:1.

(7) Creation of anaerobic conditions: it is obvious that methane production takes place in strictly anaerobic condition, therefore, the digesters should be totally airtight.

Classification of Biogas Plants:

Biogas plants are mainly classified as:

1.Continuous and batch type(as per the process)

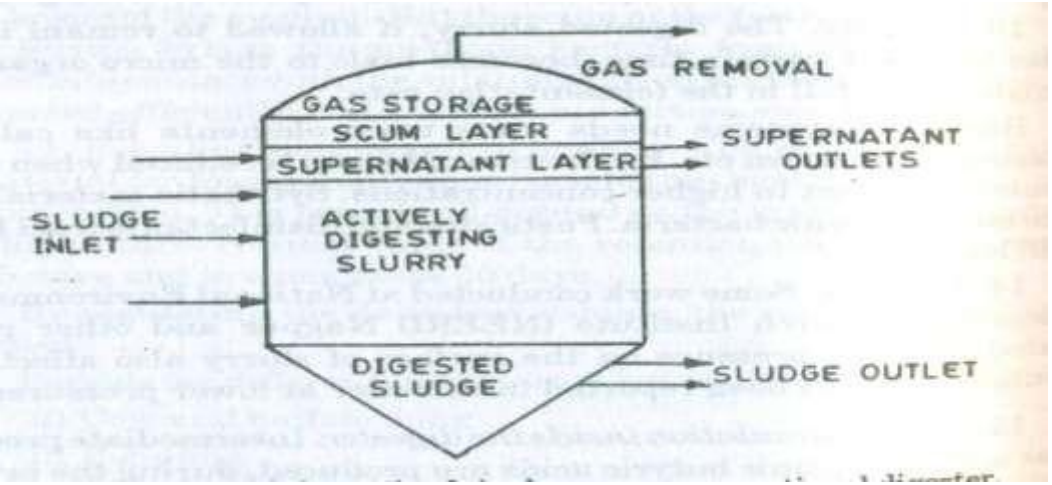
   a)Single stage process

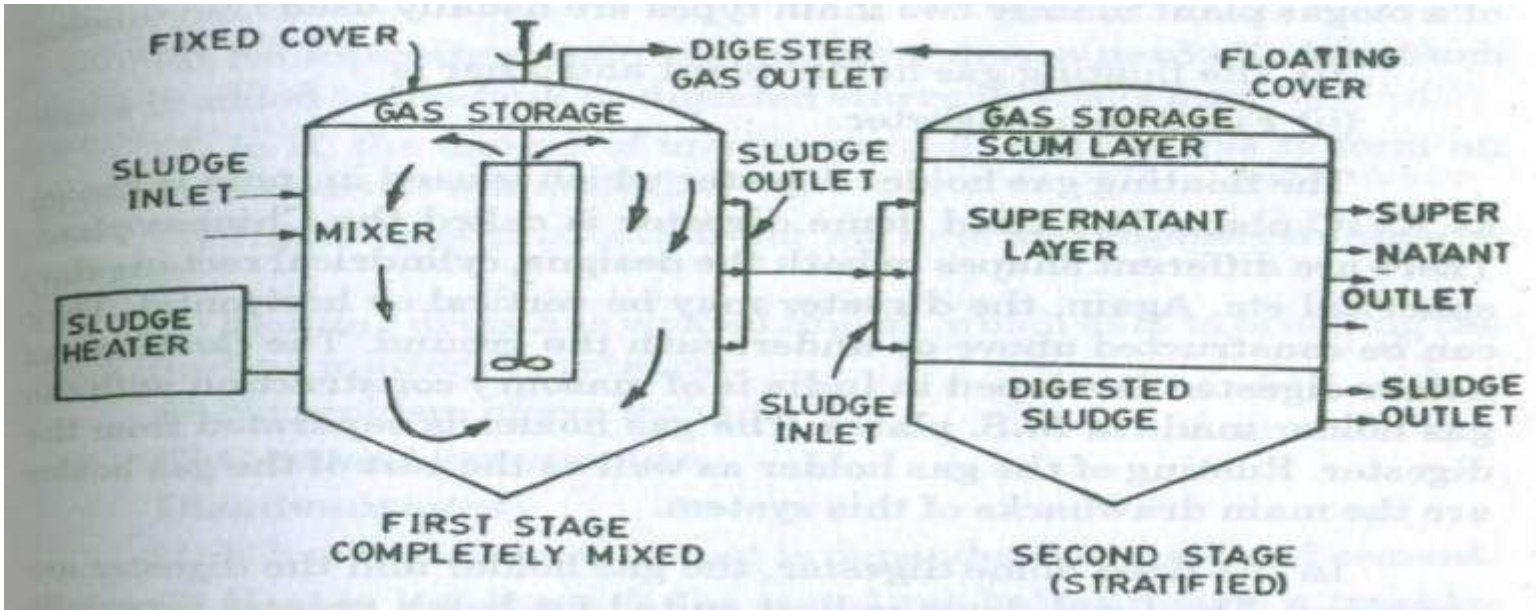
   b)Double stage process

2. The dome and drum type

3. Different variation in the drum type

Schematic diagram of Single stage and Double stage Continuous Plant:





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The main features of continuous plant are as follows:

1. It will produce gas continuously.
2. It require small digestion chambers.
3. It needs smaller period of digestion.
4. It has less problem compared to batch type and it is easier in operation.

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The main features of Batch type plant are:

1.The gas production is intermittent, depending upon the clearing of the digester.

2.It needs several digesters or chambers for continuous gas production, these are fed alternately.

3.Batch plants are good for long fibrous materials.

4.This plant needs addition of fermented slurry to start the digestion process.

5.This plant is expensive and has problems comparatively, the continuous plant will have less problems and will be easy for operation.

The Dome and the Drum Type

Mainly two types of biogas plants are normally used:

1. The floating gas holder plant (**Also known as KVIC plant)and other is :**

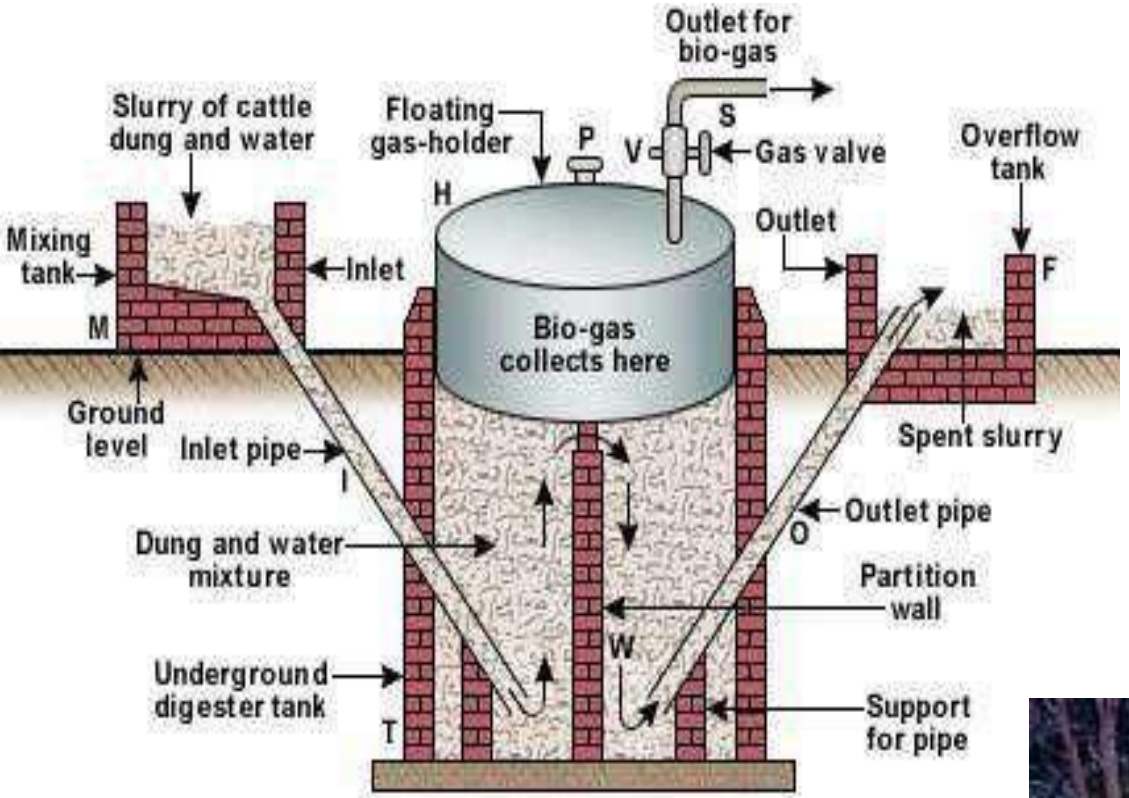
2. Fixed dome digester. **(Also known as Chinese Plant)**

In a floating gas holder, gas holder is separated from the digester. While in fixed dome digester, the gas holder and the digester are combined.

The fixed dome is best suited for batch process especially when daily feeding is adopted in small quantities.

The fixed dome type plant is generally built below the ground level and is suitable for cooler regions.

Floating Drum plants



Floating gas-holder type bio-gas plant.

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Components of biogas plant

- **Inlet pipe:** The slurry is moved into the digester through the inlet pipe/tank.
- **Mixing tank:** The feed material like dung is gathered in the mixing tank. Using sufficient water, the material is thoroughly mixed till a homogeneous slurry is formed.
- **Digester:** Inside the digester, the slurry is fermented. Biogas is produced through bacterial action.
- **Gas holder or gas storage dome:** The biogas thus formed gets collected in the gas holder. It holds the gas till the time it is transported for consumption.
- **Outlet pipe:** The slurry is discharged into the outlet tank. This is done through the outlet pipe or the opening in the digester.
- **Gas Pipeline:** The gas pipeline carries the gas to the utilization point like a stove or lamp

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Characteristics of floating drum type

- Consists of a deep well, and a floating drum (usually made of mild steel).
- Drum rises as gas collects.
- *Constant gas pressure* due to the drum weight. (The pressure is equivalent to the weight of gasholder over unit area)
- Inlet is higher than the outlet tank, creating hydrostatic pressure which helps slurry to move through the system.
- Maxing gas pressure attained - 8-10 cm water column.

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Floating-drum plants consist of a digester and a moving gasholder.

The gasholder floats either direct on the fermentation slurry or in a water jacket of its own.

The gas collects in the gas drum, which thereby rises.

If gas is drawn off, it falls again. The gas drum is prevented from tilting by a guide frame.

Advantages

High gas yield.

No problem of gas leakage.

Works under constant pressure naturally.

No problem of mixing of biogas with external air, thus no danger of explosion.

Disadvantages

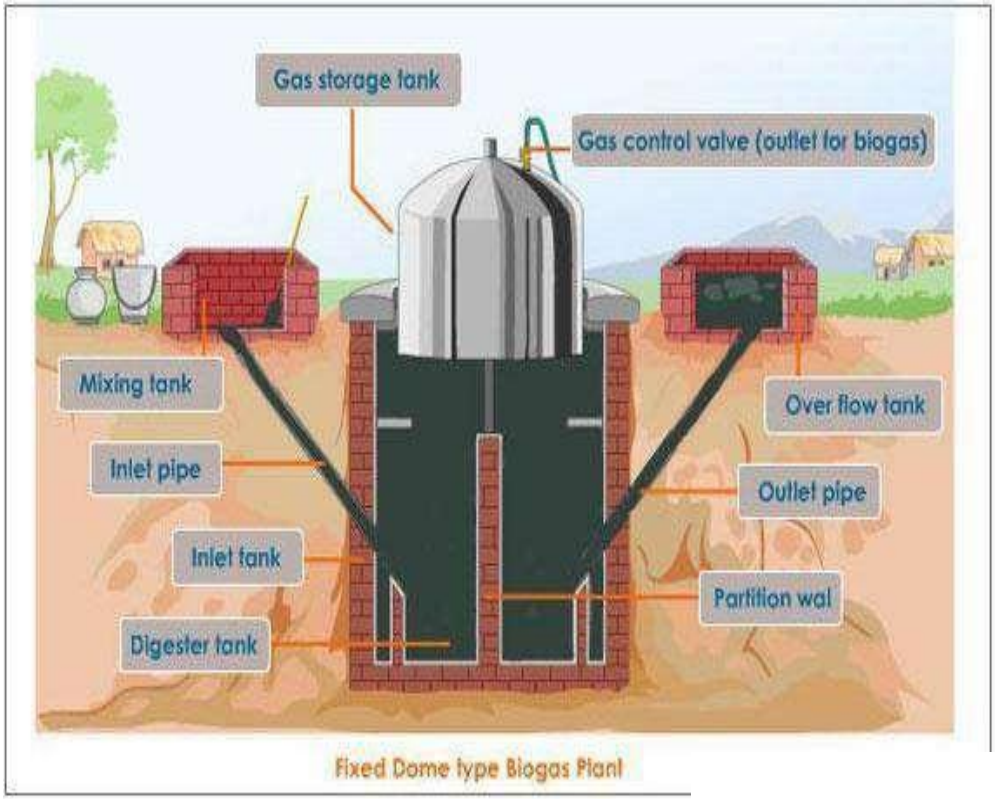
It has higher cost.

Heat is lost through metal gas holder.

Requires painting of drums to avoid corrosion at least twice a year.

Requires maintenance of pipes and joints.

Fixed-Dom Type



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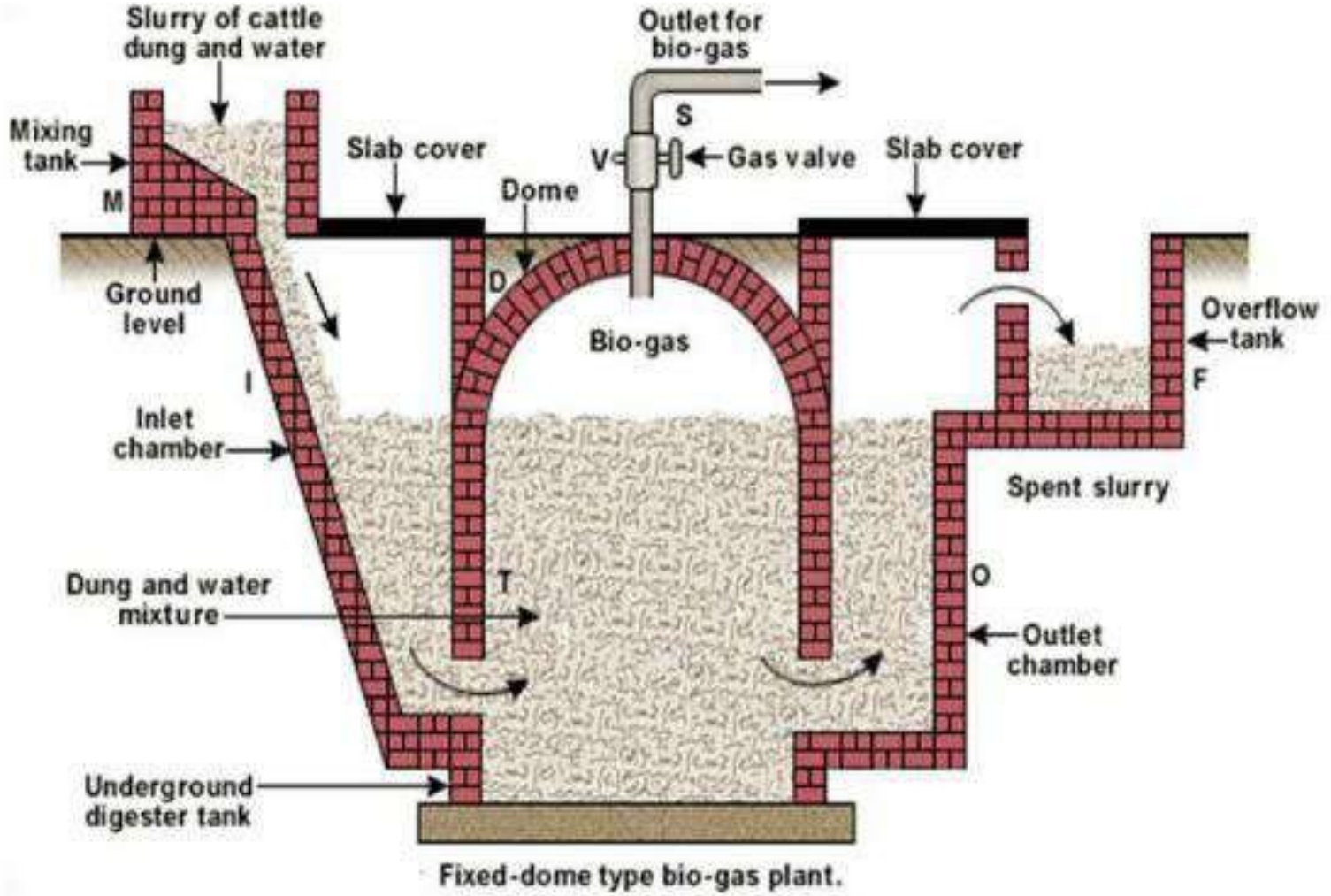

Fixed-dome type bio-gas plant.

Fixed dome type biogas plant

(Janta biogas plant)

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Characteristics of fixed dome type

- ✓ Invented in China in 1930's.
- ✓ Underground brick masonry compartment (fermentation chamber) with a dome on the top for gas at the storage.
- ✓ Fermentation chamber and gas holder are combined as one unit.
- ✓ Movement and weight of digested the slurry decides the gas pressure.
- ✓ *Variable gas pressure* (0-90 cm water column)
- ✓ Less expensive and requires less maintenance than floating drum type.

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A fixed-dome plant consists of an enclosed digester with a fixed, non-movable gas space. The gas is stored in the upper part of the digester.

When gas production commences, the slurry is displaced into the compensating tank.

Gas pressure increases with the volume of gas stored; therefore the volume of the digester should not exceed 20 m^3. If there is little gas in the holder, the gas pressure is low.

Advantages

Cost of plant is less compare to floating drum type plant.

Loss of heat is negligible since these are constructed underground.

No corrosion problems as in fixed dome type.

It is maintenance free.

Disadvantages

Needs skilled labour to operate.

Gas production per m^3 of digester volume is less.

Gas is produced at variable pressure.

Different variations in the drum type

There are mainly two variation in floating type plant. One with water seal and other without water seal.

Water sealing makes the plant completely anaerobic.

Cylindrical shape of the digester is preferred because cylinder has no corners and so that there will be no chances of cracks due to faulty construction. This shape also needs smaller surface area per unit volume, which reduces heat losses also.

Moreover the scum formation may be reduced by rotating gas holder in the cylindrical digester.

Advantages of biogas

Cost of equipments used for making biogas is less and equipments used are very simple.

Biogas can be used for lighting, running the engines, farm's machine and cooking gas in the kitchen.

Biogas is the best medium for cooking food.

Organic feed stocks used in the plants are easily available at all places.

Biogas plant gives efficiency as much as 60%.

Distribution of gas has no problems of any gas leakage and fire.

Waste product obtained from digester is best quality of fertilizer and gives best yields.

Disadvantages of biogas

Biogas produced from biogas plant has to be used at near by places only. It can’t be transported over long distances.

Biogas can’t be filled in the bottles.

Biogas plant requires more area.

It can be established in urban area where availability of land is limited.

Application of biogas

Biogas is used as cooking fuel.

Biogas is mental light gas burner for lighting purpose.

Biogas is used for water heating.

It is used as fuel in I.C. Engine.

It is used as fuel to run agricultural machineries.

It is used to run diesel engine generator set to produce electricity.

Application of biogas

Heat of biogas is utilized in the dryer for drying the agricultural products.

Heat of biogas is used to heat ammonia of refrigerating plant.

It is used for running pumps for irrigation purpose.

Methane and carbon dioxide are used as raw chemical feed stock to manufacture various chemicals.

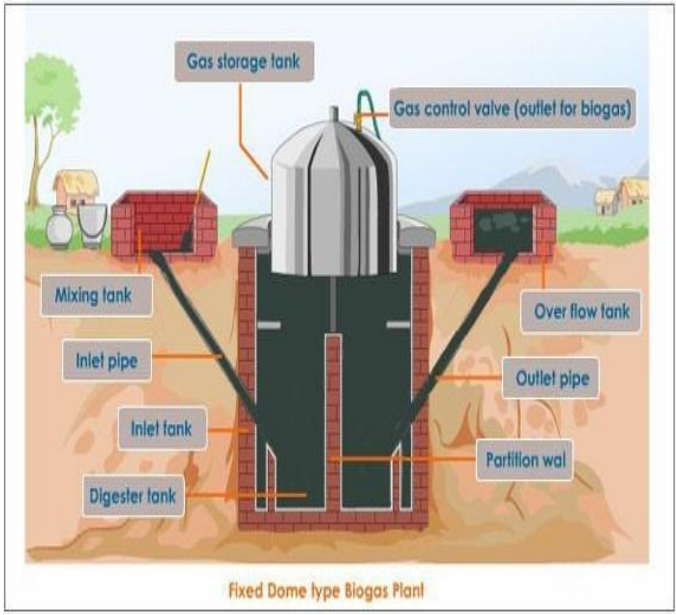
Gas holder

Cylindrical container

Above digester

Collect gas

The gas pipe carries the biogas to the place where it is consumed.



Site selection

Following factors must be considered while selecting the site for a biogas plant:

1.Distance

2.Minimum gradient

3.Open space

4.Water table

5.Seasonal run off

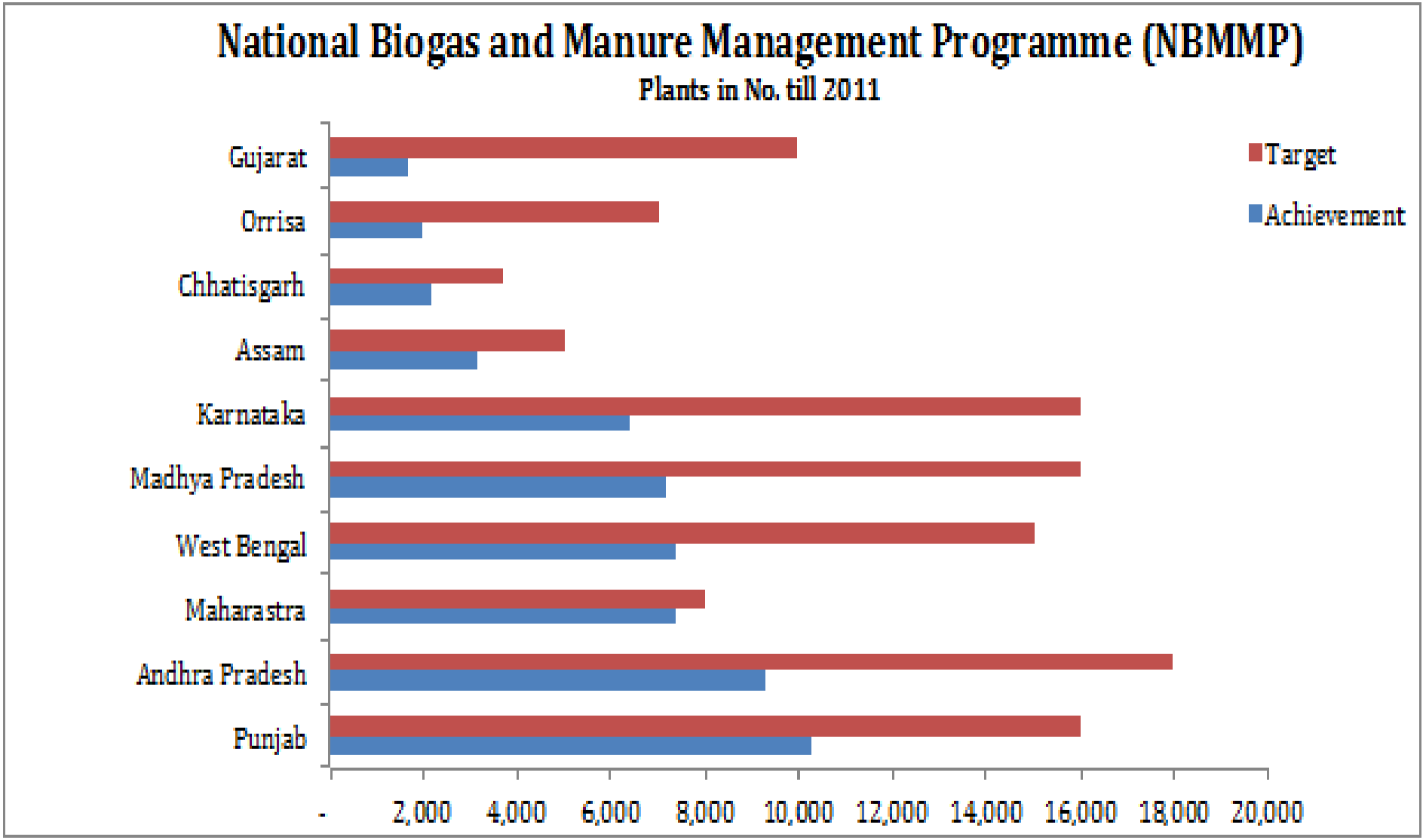
6.Distance from wells

7.Space requirements

8.Availability of water

9.Sources of cow dung/materials for biogas generation

Prospects of biomass in India



Advantages of biomass

Biomass is perennial source of renewable energy and it can be repeatedly grown and obtained as biomass.

Biomass is non pollutant of atmosphere.

Production of biomass not only gives fuels but it also gives good quality organic manures which when used in farms give bumper crops.

Methane gas produced from biomass is used as domestic fuel in gas stoves.

Biomass is available everywhere and no needs of any transportations.

Advantages of biomass

Methane gas can be used to run engines and generator and electricity can generate.

The biomass can be grown in near by seas and lakes. The lands can be spread for food crops.

I.C. Engines can be run on biogas produced from biomass.

Biomass can be used for plastics and pharmaceutical products.

Use of biomass keeps surroundings clean and healthy without insects and pests.

Advantages

- Putting residual materials to use is wise
- Help lessen the demand on earth's fossil fuel resources

Disadvantages

- Collection and availability of is not guaranteed

Disadvantages of biomass

Biomass contains 50-90% water and it is heavy. Hence transportation if needed is very difficult.

Direct combustion of biomass produces smokes and smells.

Calorific value of biomass if burnt in the raw form is very less.

Biogas plants need lots of care and maintenance for its successful operations.

It is economical if raw biomass such as cow dung is not freely available.

Disadvantages of biomass

Biomass conversion plants such as biogas are necessary to convert raw biomass into useful energy forms.

Biogas plants occupy larges land areas.

If the biomass is required to be transported over long distances, the cost transportaion is very high.

Biogas plants can’t be used in urban areas where the space availability is limited.

Application of biomass

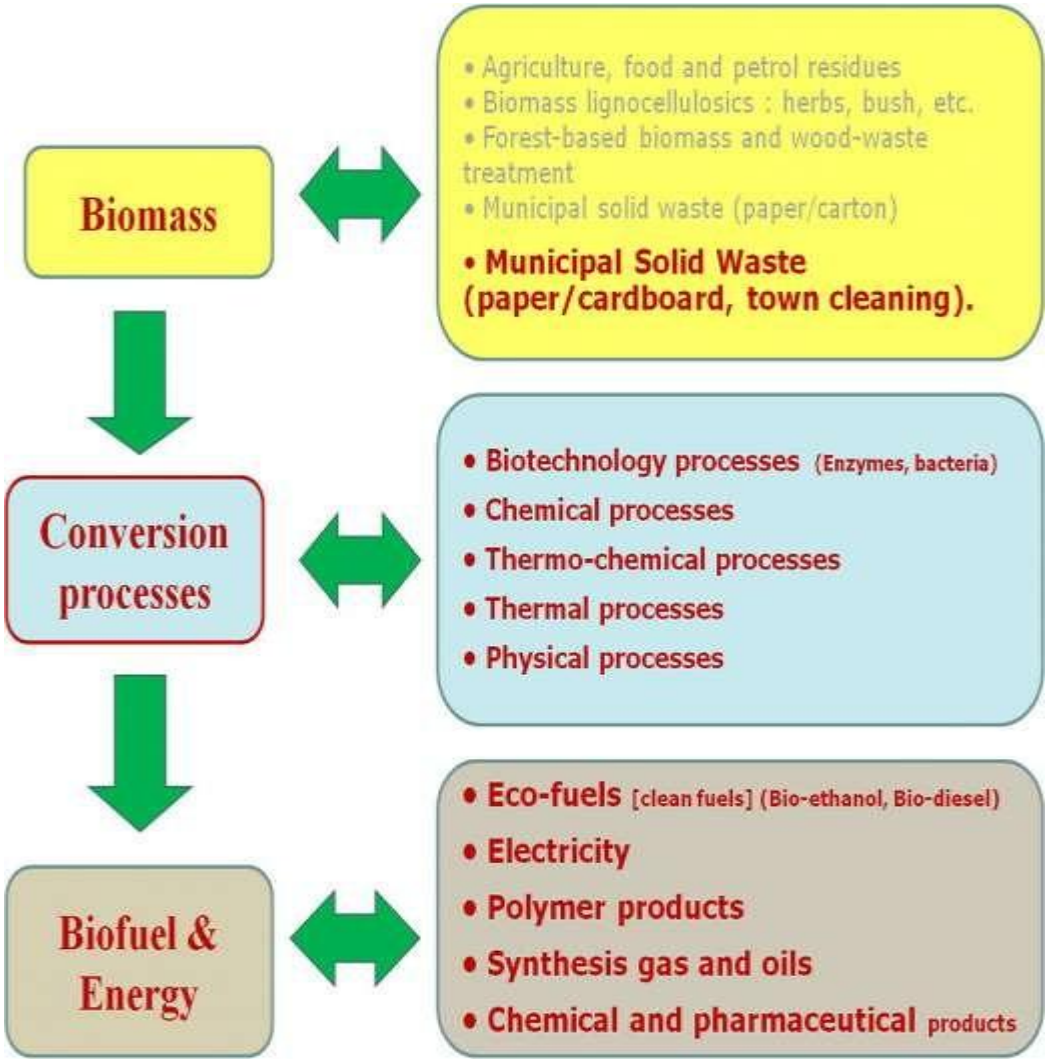
Waste organic biomass can be directly used as domestic fuels.

Biogas is used as domestic fuels in gas stoves like LPG.

Biogas can be used to run the engines, boilers and turbines.

Methane gas produced from biogas plants can be used to run the gas engines and farm machineries.

It is used for heating the water.



Historical Era &Future

Historically, humans have harnessed biomass derived energy products since the time when people began burning wood to make fire. In modern times, the term can be referred to in two meanings. In the first sense, biomass is plant matter used either to generate electricity (via steam turbines or gasifiers), or to produce heat (via direct combustion).

Historical Era &Future

The adoption of biomass-based energy plants has been a slow but steady process. Over the past decade, the production of these plants has increased 14%. In the United States, alternative electricity-production sources on the whole generate about 13% of power; of this fraction, biomass contributes approximately 11% of the alternative production.

Historical Era &Future

According to a study conducted in early 2012, of the 107 operating biomass plants in the United States, 85 have been cited by federal or state regulators for the violation of clean air or water standards laws over the past 5 years. This data also includes minor infractions.

In fact, many are based on technologies developed during the term of President Jimmy Carter, who created the Department of Energy in 1977.

Historical Era &Future

The Energy Information Administration projected that by 2017, biomass is expected to be about twice as expensive as natural gas, slightly more expensive than nuclear power, and much less expensive than solar panels. In another EIA study released, concerning the government's plan to implement a 25% renewable energy standard by 2025, the agency assumed that 598 million tons of biomass would be available, accounting for 12% of the renewable energy in the plan.

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