

Unit 3:- Biomass Energy



Syllabus...Unit 3

- Energy from Biomass, Thermo-Chemical, Bio-Chemical Conversion to fuels. Bio-gas and its applications

Books ...

- Gilbert M. Masters, *Renewable and Efficient Electrical Power Systems*, Wiley - IEEE Press, August 2004.
- Godfrey Boyle, *Renewable Energy*, Third edition, Oxford University Press, 2012.
- Chetan Singh Solanki, *Solar Photovoltaics-Fundamentals, Technologies and Applications*, PHI Third Edition, 2015.

Supplementary Reading:

- D.P.Kothari, K.C.Singal, Rakesh Rajan, *Renewable Energy Sources and Emerging Technologies*, PHI Second Edition, 2011.

Lecture 4

- Bio-Chemical Conversion
- Methods
- Fermentation
- Anaerobic Digestion
- Types of Anaerobic Digestion
- Stages of Anaerobic Digestion
- Bio gas How useful?
- Bio gas statistics
- Bio gas Generation
- Principle of Bio Gas
- Factors affecting Bio Gas Production

Biochemical Energy Transform

Biomass to Energy Conversion Pathways

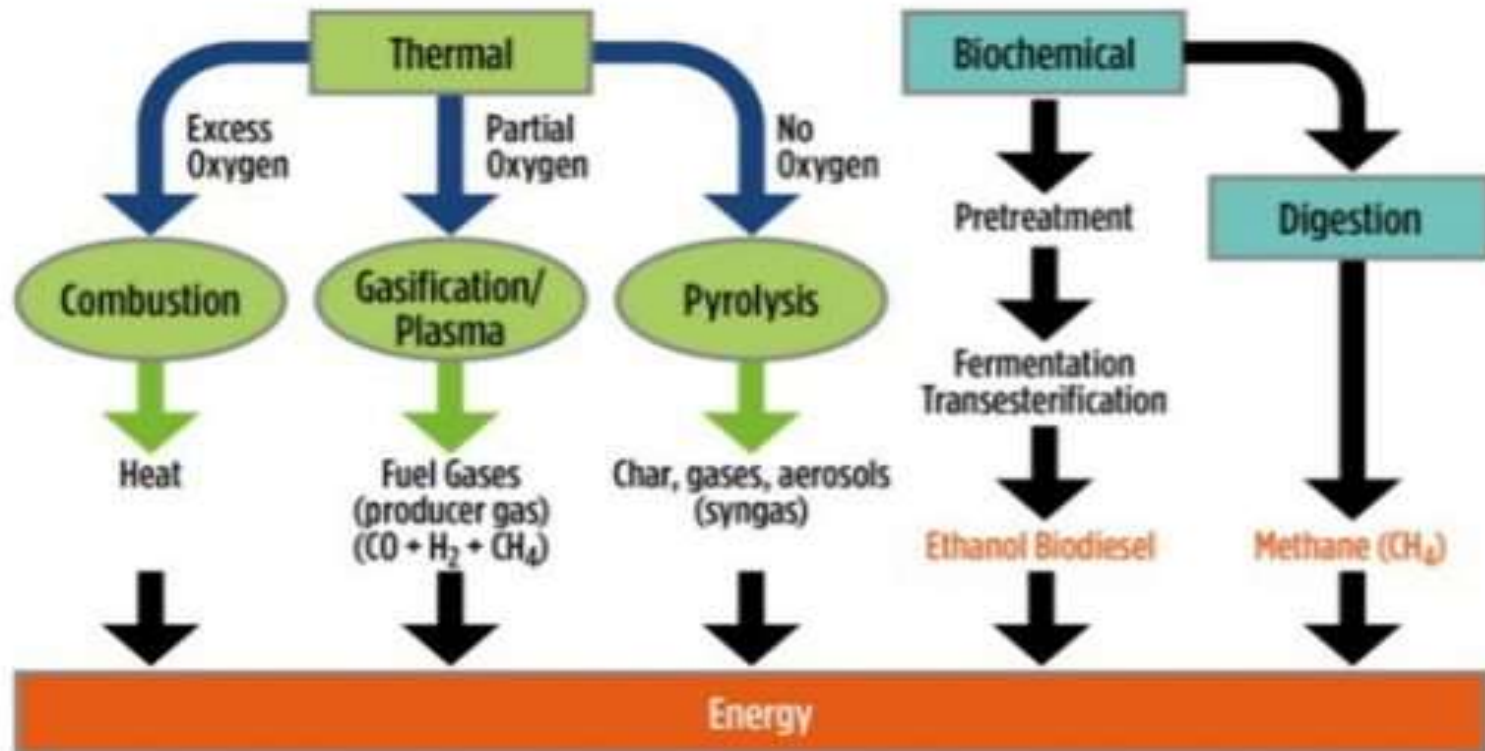
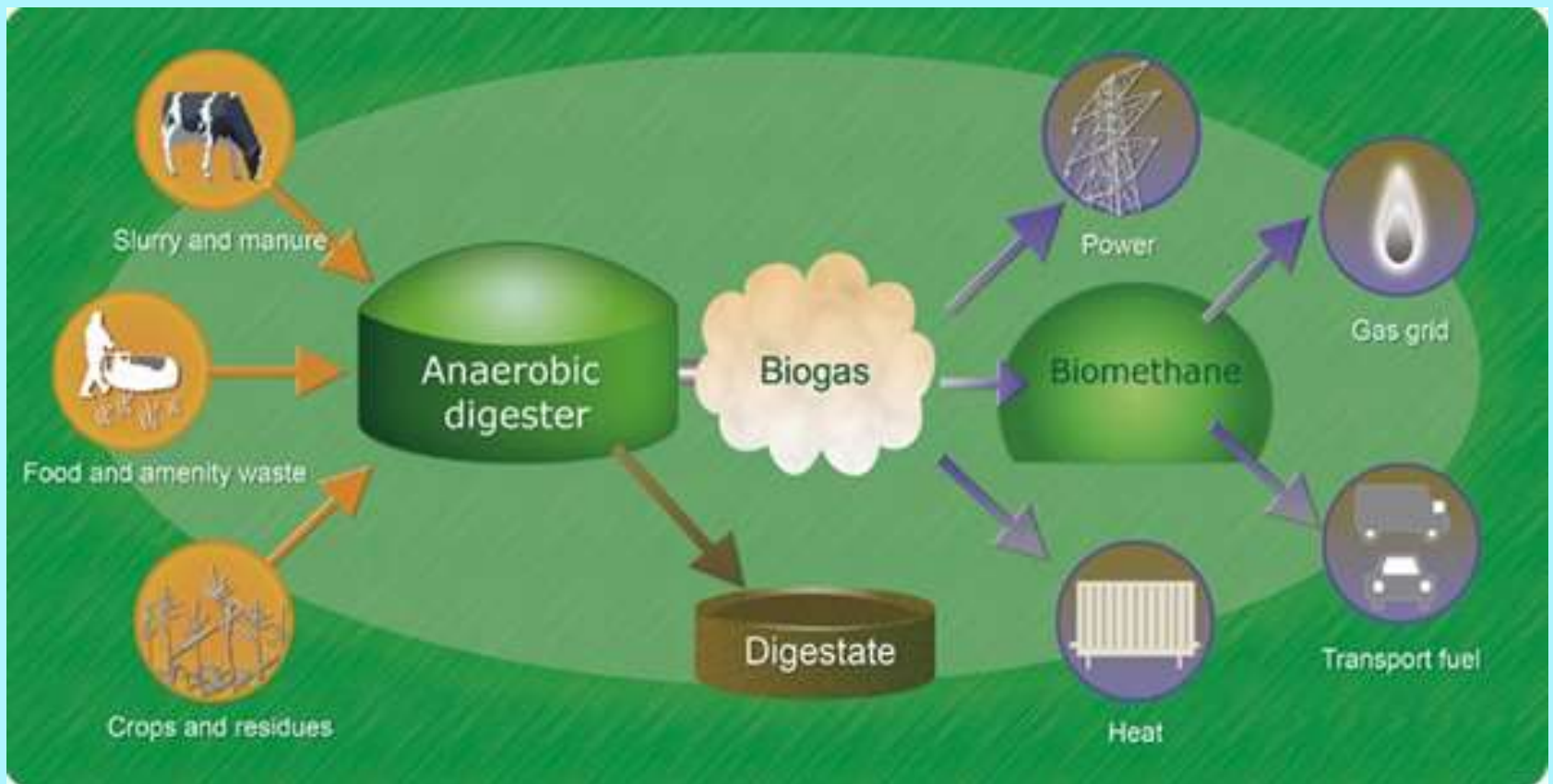


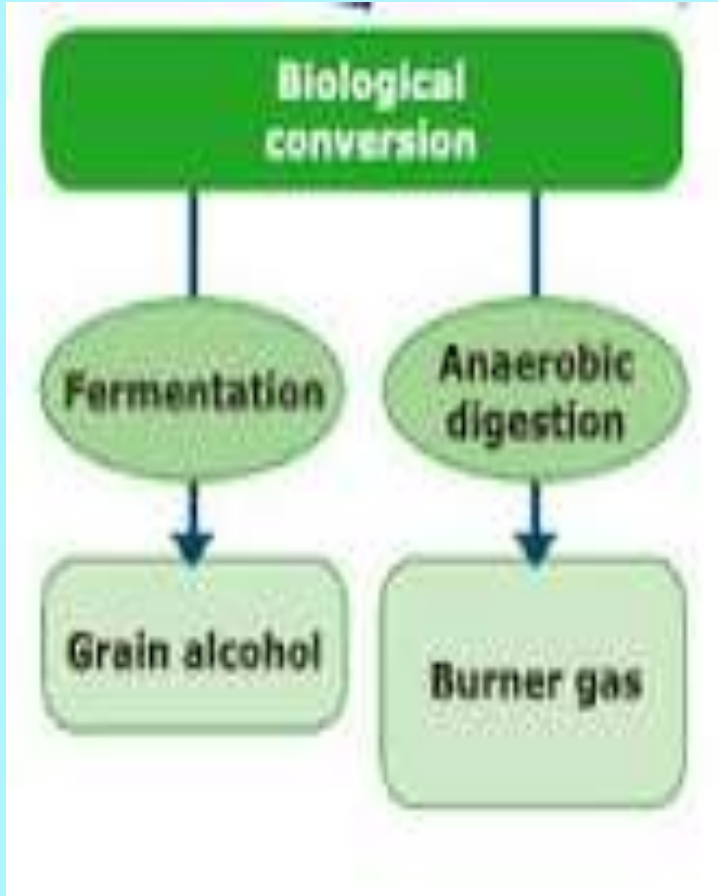
Illustration by NREL

Biochemical conversion of Biomass

Biochemical conversion of **biomass** involves use of bacteria, microorganisms and enzymes to Breakdown **biomass** into gaseous or liquid fuels, such as biogas or bioethanol.



Biochemical Energy Transform

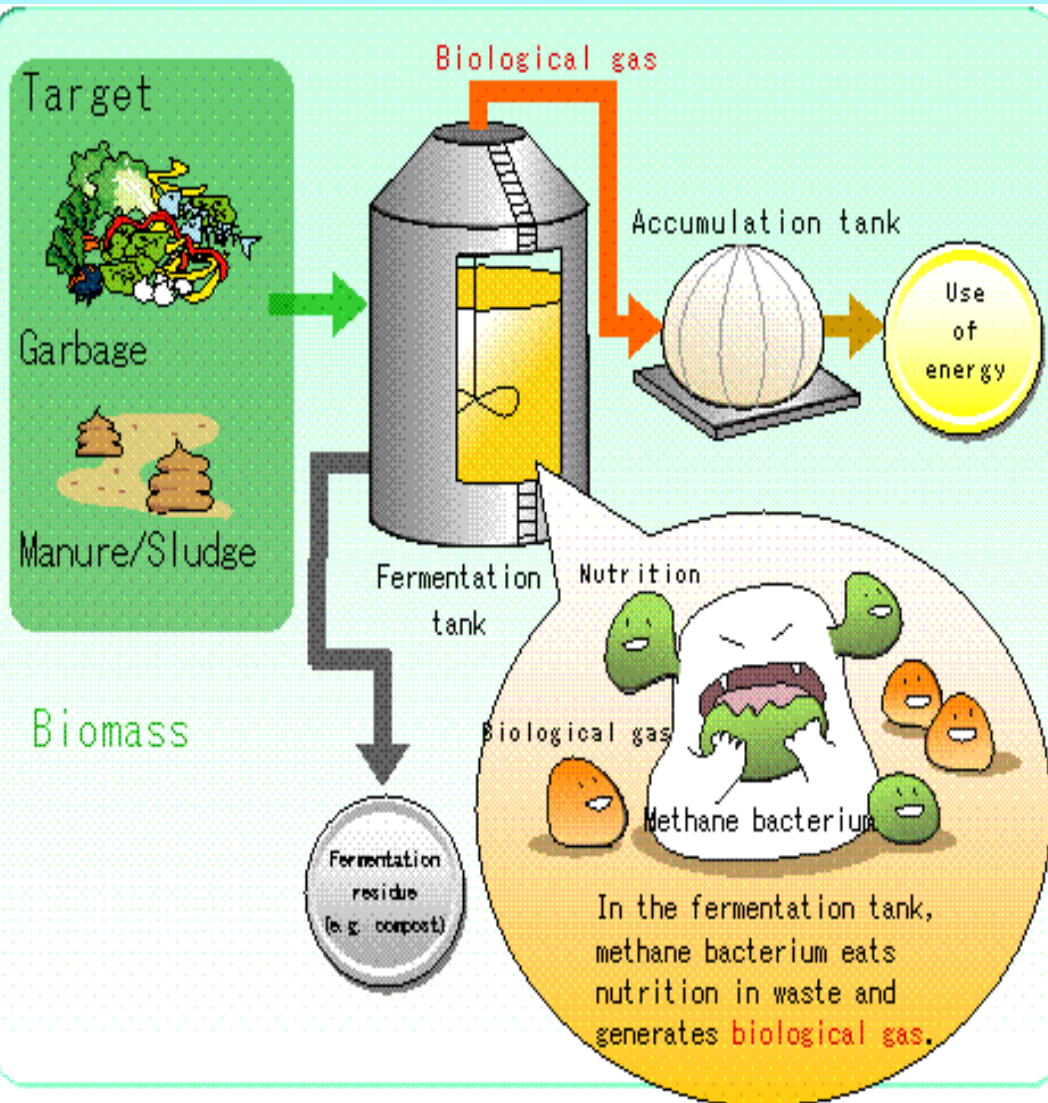


In Biochemical processes the bacteria and micro organisms are used to transform the raw biomass into useful energy like *Methane and Ethane gas*.

Following organic treatments are given to the biomass:

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

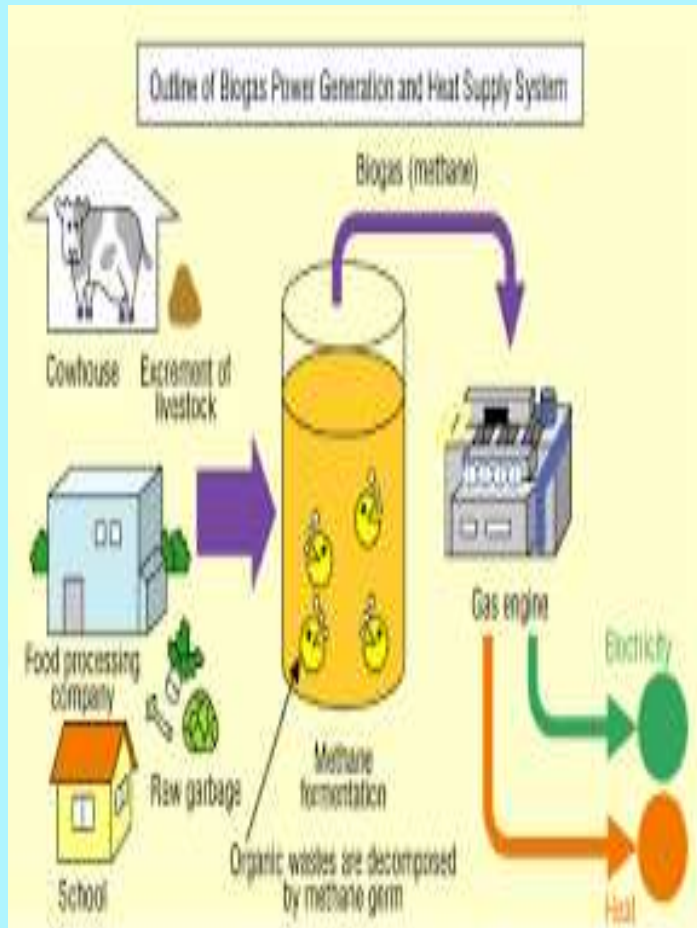
Fermentation.....



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 CO₂ in presence of yeast.

Fermentation.....



- The conversion of a plant's glucose (or carbohydrate) into an alcohol or acid.
- Yeast or bacteria are added to the biomass material, which feed on the sugars to produce ethanol (an alcohol) and carbon dioxide.
- The ethanol is distilled and dehydrated to obtain a higher concentration of alcohol to achieve the required purity for the use as automotive fuel.
- The solid residue from the fermentation process can be used as cattle-feed and in the case of sugar cane can be used as a fuel for boilers

Anaerobic Digestion.....

Definition:

Bio digestion or Anaerobic Digestion (AD) is a biological process that occurs when organic matter is decomposed by bacteria in the absence of oxygen to create biogas.

It is a 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.



Types of Anaerobic Digestion.....

There are two basic anaerobic digestion processes, which take place over different temperature ranges:

Mesophilic digestion:

The most commonly used process for anaerobic digestion. It takes place between 20°C and 40°C and can take a month or two to complete, produces less biogas and requires additional sanitation.

Thermophilic digestion:

Less common and more expensive technology. Typically takes place from 50-65°C, it requires additional energy to maintain the higher operating temperature. It produces more biogas in a shorter period faster but the bacteria are more sensitive.

Stages of Anaerobic Digestion.....

Anaerobic digestion has a defined process flow that consists of four distinct phases.

1.Pre-Treatment: In pre-treatment, wastes may be processed, separated, or mixed to ensure that they will decompose in the digester.

2.Digestion: During digestion, waste products are broken down by bacteria and biogas is produced and collected.

3.Biogas Processing: Biogas produced is either combusted or upgraded and then used to displace fossil fuels. During upgrading, scrubbers, membranes or other means are used to remove impurities and carbon dioxide (CO₂) from biogas.

Stages of Anaerobic Digestion.....

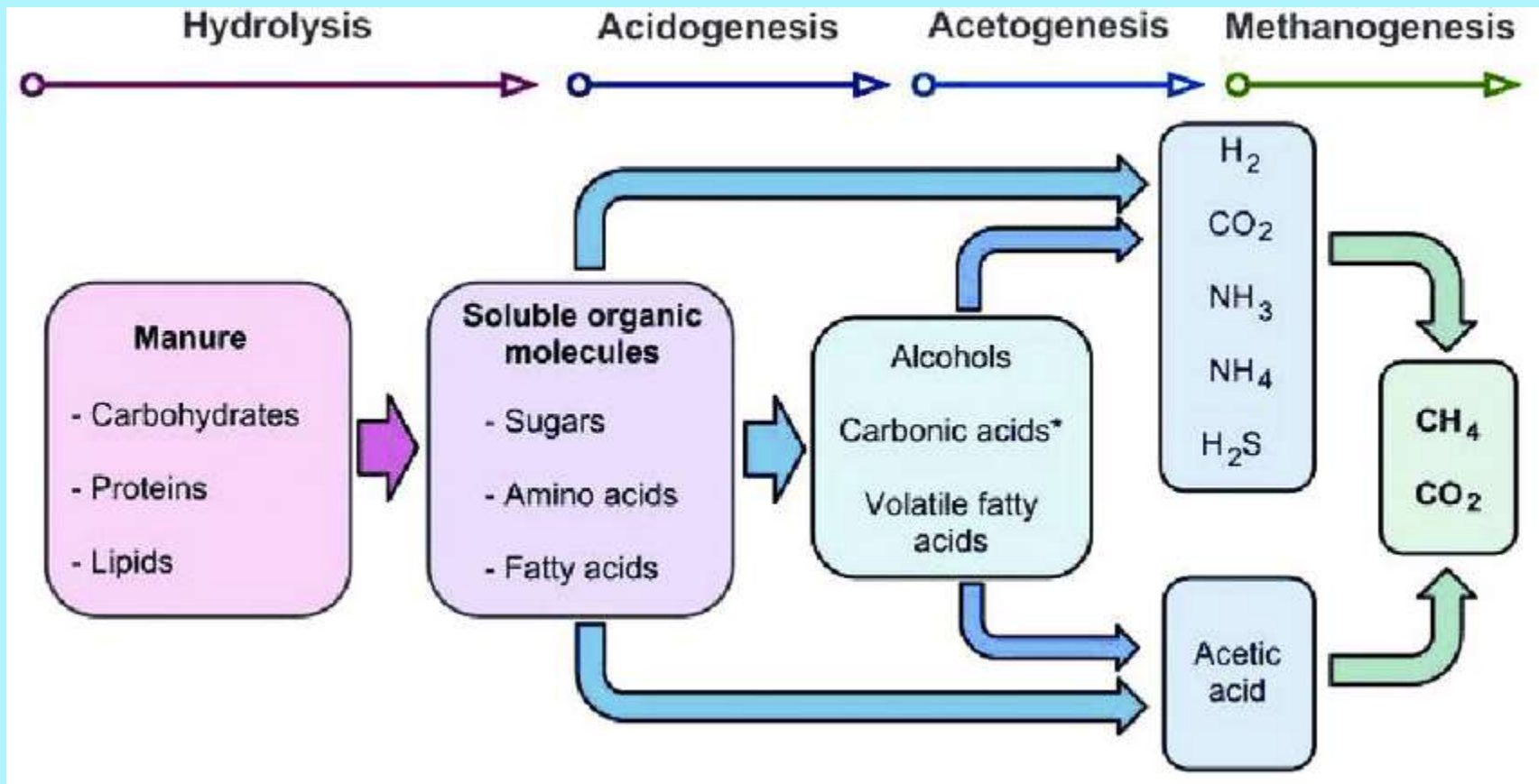
4. Reuse or disposal of solid digested waste: Digested waste has a high nutrient content and can be used as fertilizer so long as it is free of pathogens or toxins, or it can be composted to further enhance nutrient content.

Anaerobic digestion systems are often referred to as “anaerobic digesters”, “biodigesters” or “biogas recovery systems”.

Four stages can also define as

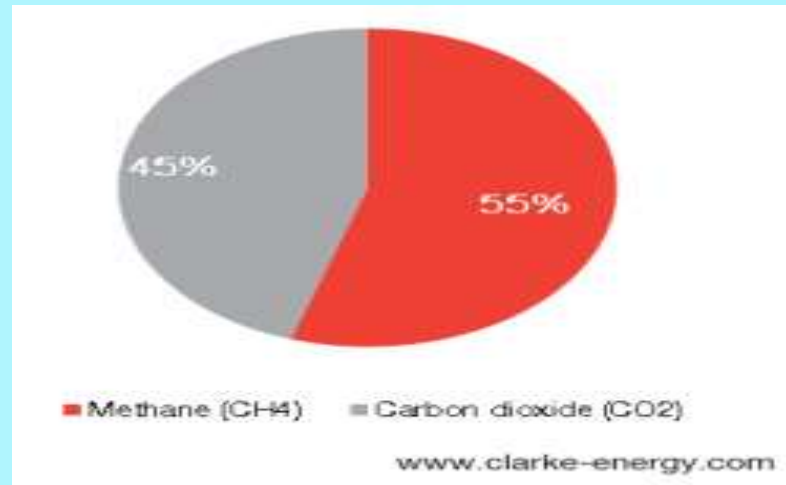
1. Hydrolysis
2. Acidogenesis
3. Acetogenesis
4. Methanogenesis

Stages of Anaerobic Digestion ...



Bio Gas How Useful?

- Bio Methane is composed mainly with Methane and carbon dioxide.
- Bio Methane can completely replace Natural gas.
- Bio Gas produced using cow dung is called as Gobor Gas
- Gobar gas comprises of 60% Methane and 40% Carbon dioxide.

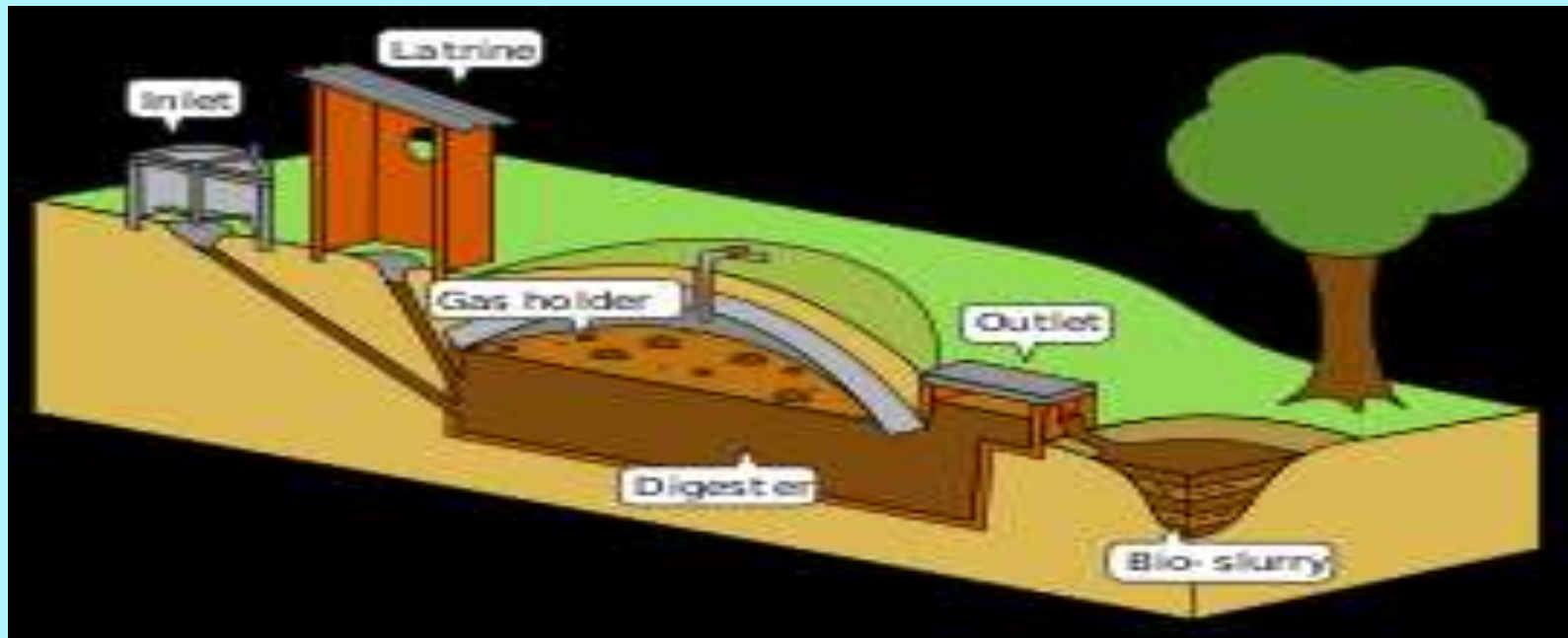


Bio Gas statistics

25 kg Fresh Dung		
Direct Burning		Biogas
5 kg dry dung	Product	1 cu m biogas
10460 kCal	Gross energy	4713 kCal
10%	Device efficiency	55%
1046 kCal	Useful energy	2592 kCal
None	Manure	10kg air dried manure

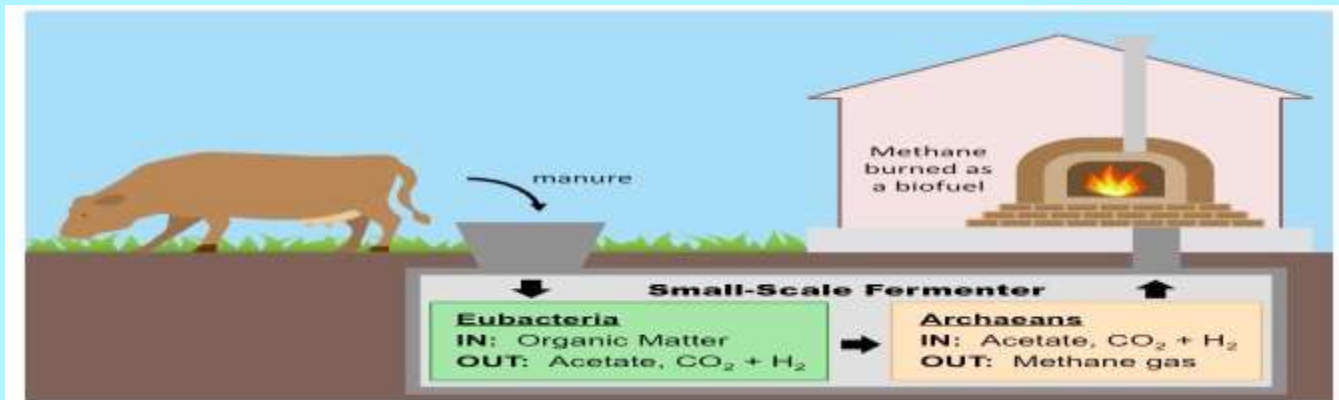
Biogas Generation.....

- Biogas contains 55-65% methane, 30-40% CO₂, and the remainders are impurities like H₂S, H₂, N₂ gases.
- Cattle dung can produce 0.037 m³ of biogas per kg of cow dung. The calorific value of gas is 21000 to 23000 kJ/kg or about 38000 kJ/m³ of gas.



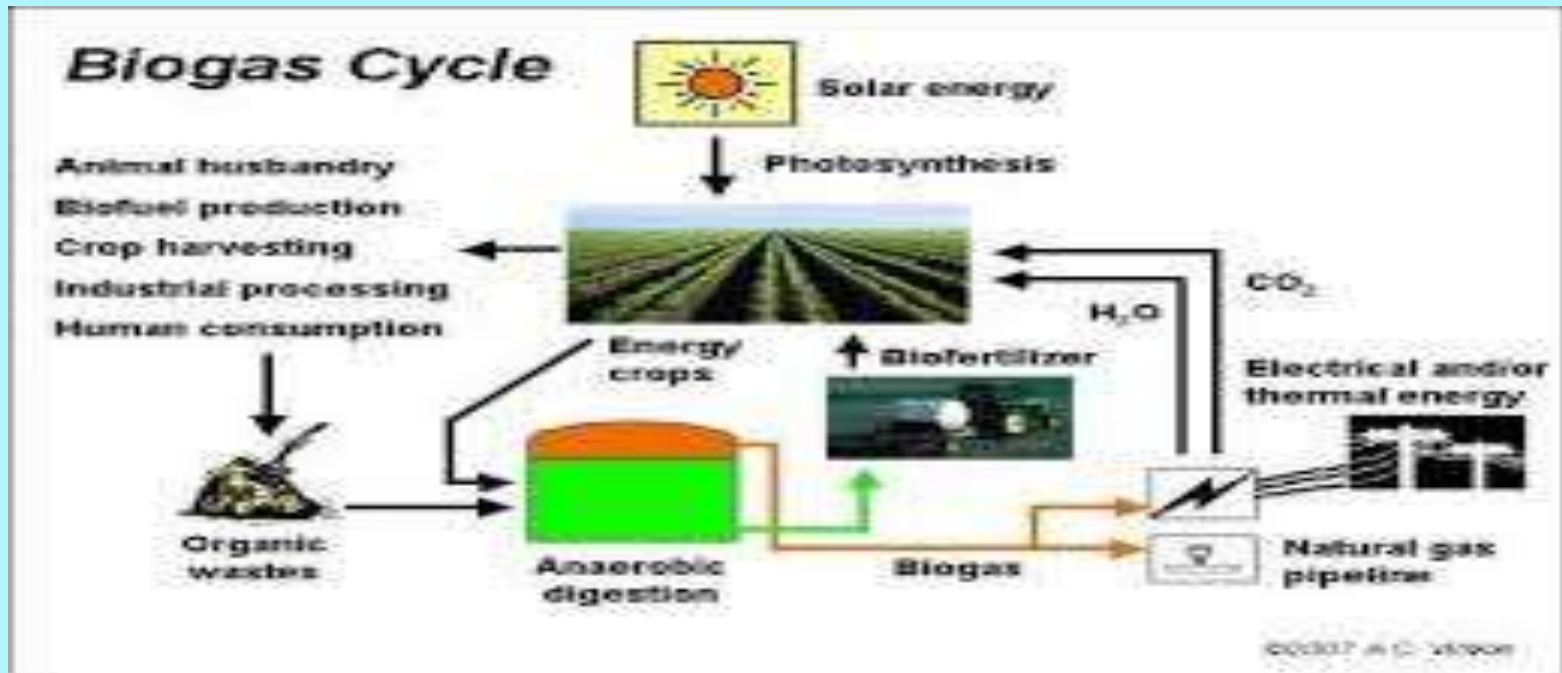
Biogas Generation.....

- The material from which biogas is produced retains its value as fertilizer or as animal feed which can be used after certain processing.
- 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 $35^{\circ}C$ - $70^{\circ}C$. The container in which the digestion takes place is called digester.



Biogas Generation.....

- When organic matter undergoes fermentation, the anaerobic bacteria extracts oxygen by decomposing the biomass at low temperatures up to 65°C in the presence of moisture. 80-95% of 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.

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

Factors Affecting Biogas Production.....

The rate of production of biogas depends on the following factors:

- 1) Temperature & Pressure
- 2) Solid concentration & Loading rate
- 3) Retention period
- 4) pH value
- 5) Nutrients composition
- 6) Toxic substances
- 7) Digester size & shape
- 8) Stirring agitation of the content of digestion

Thank You