Value Chain of Biogas

(Production, Gas upgrading, Grid injection and Utilization)

SAARC workshop on Application of on-grid Biogas Technologies

May 16-17, 2016
Kabul, Afghanistan

Presentation by Ramana Reddy, RE Expert, India

Bio-Methanation Process

Raw Biogas

Bio-Digester

Scrubbers for H_2S and CO_2 Removal

Purified Biogas

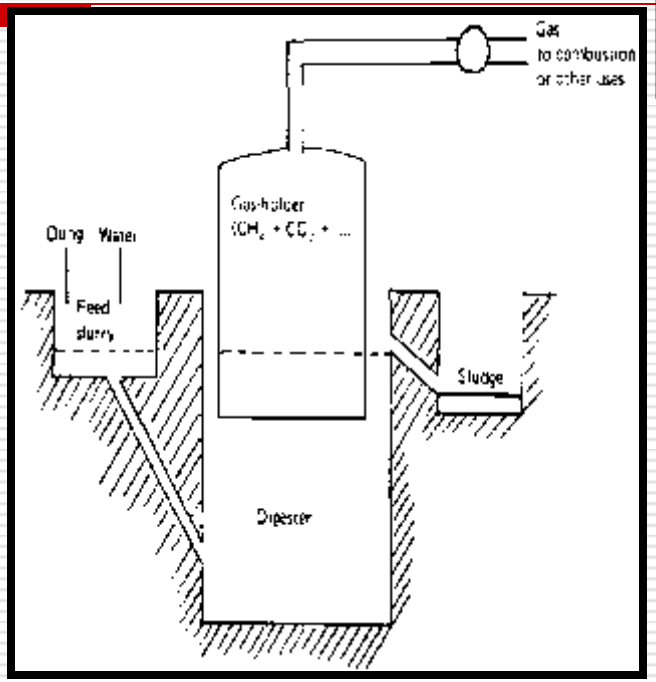
Power Generation

Cooking

Industrial Applications

Bio-manure

Traditional Digester - FLOATING DOME



Traditional Digester - FIXED DOME MODEL

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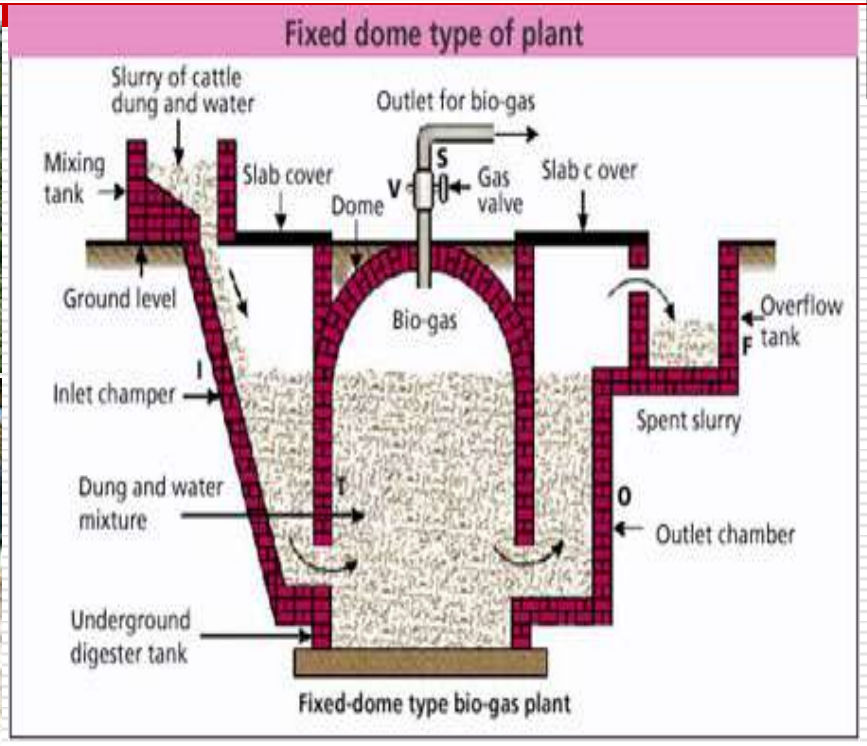


Simple Floating Type Digester

High Rate Biometanation Technology

High Rate Biometanation Technology

Input Sources for Biogas

- Poultry Litter
- Cattle / Buffalo Dung
- Waste from Sugar plants
- Leather Industry Wastes
- Abattoir (Slaughter house) / Industry Wastes
- Fruit/ Food Processing Wastes
- Pulp & Paper Industry Wastewater
- Municipal Wastewater / Sewage
- Vegetable Market Yard Wastes
- Animal / Agro Residue

- Molasses Distillery
- Grain Based Distillery
- Yeast Manufacturing
- Sugar Factory
- Brewery
- Common Effluent Treatment Plant
- Pharmaceutical
- Food Processing Industries
- Gelatin Manufacturing
- Confectionary Manufacturing
- Palm Oil Mill

- Dairy & Ice Cream manufacturing unit
- Polyester Industry
- Vegetable Oil Refinery
- Poultry & Hatchery
- Leachate Treatment
- Starch Industry
- Paper Industry
- Malt based distillery
- STP/Others
- Ethyl Acetate
- Polyester Yarn
- Acetic Acid Plant

ANAEROBIC DIGESTION

or

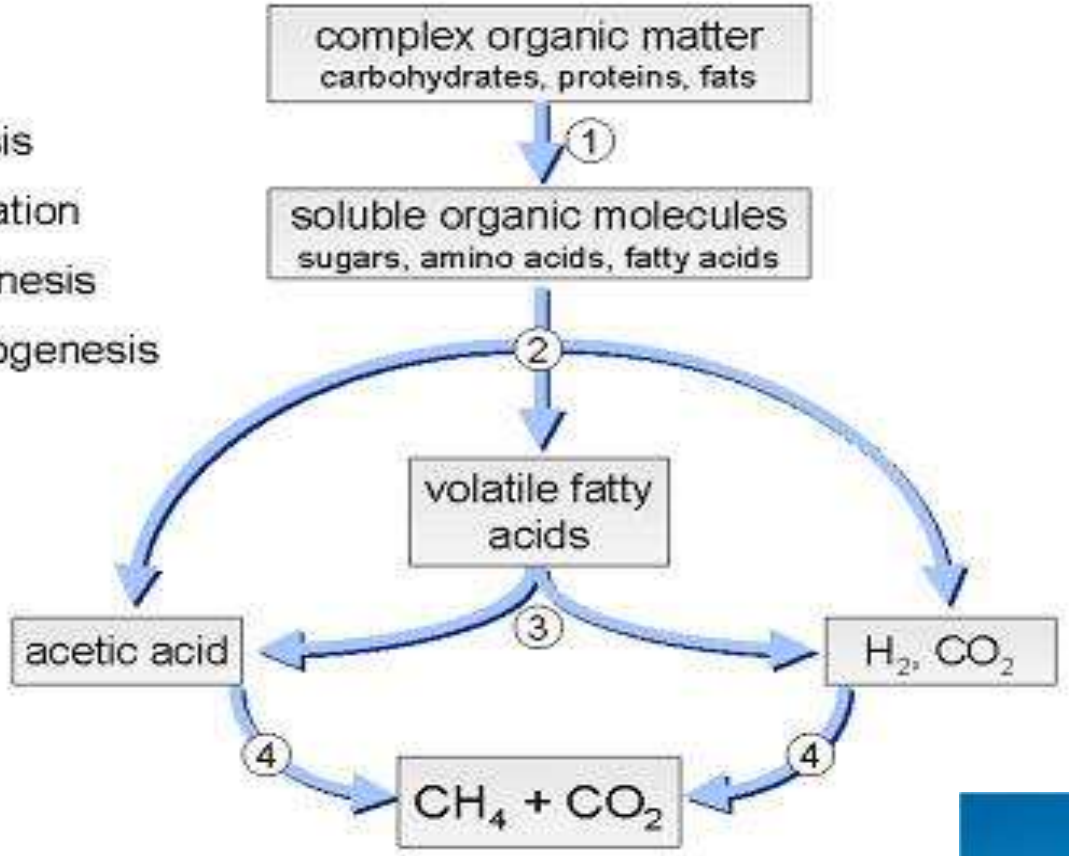
BIO-METHANATION

It is a biological process carried out by a set of bacteria in the absence of molecular oxygen

During the process complex organic solids are converted to Bio-gas and Bio-manure

MECHANISM OF BIO-METHANATION

① hydrolysis
② fermentation
③ acetogenesis
④ methanogenesis



Factors affecting Biogas Production

- pH (Best : 7-8)
- Temperature (Best : 33–42^{0}C)
- Total Solids / Concentration of Slurry (10-15%)
- Loading Rate (1 – 10 kg/m3)
- Hydraulic Retention Time (HRT)

  (24-60 days for dry waste) (2-6 days Liquid Waste)
- C/N Ratio (Best : 25-30 :1)
- Volatile Solids (7-8%)

Typical Composition of Biogas

1.	Methane (CH_4)	:	60%
2.	Carbon dioxide (CO_2)	:	38%
3.	Nitrogen (N_2)	:	0.8%
4.	Hydrogen (H_2)	:	0.7%
5.	Carbon-monoxide (CO)	:	0.2%
6.	Oxygen (O_2)	:	0.1%
7.	Hydrogen Sulphide (H_2S)	:	0.2%

Cal Val epf Biogas : 4,700 Kcal / m3

Cal Val bio CNG : **8,000 Kcal / m3

BIO-METHANATION PROCESS

Essentially it is carried out in sealed container or digester

Digesters are classified into CONVENTIONAL and HIGH RATE digesters based on their engineering design

The size of a single digester can vary from 1m^3 to 7000 m^3

Capacity of a digester is expressed in kilogram of dry solids fed per m^3 per day (Organic Loading Rate - OLR)

Efficiency of a digester is expressed in terms of percentage solids reduction (digestion) or degree of digestion

Retention time is the time given for unit quantity of feed to undergo a desired degree of digestion (HRT)

CONVENTIONAL DIGESTERS

Floating dome and fixed dome models are the most popular among conventional digesters

They are designed for cattle dung digestion and serious operational problems are reported for other solids

No control over operational parameters & generates secondary effluents

They are slow rate digesters & maximum size of a single digester is restricted (100 m^3)

Not suitable for large scale application

Digestion takes place in single stage

Simple design and low capital cost

FACTORS INFLUENCING DIGESTION

MIXING

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- SIZE REDUCTION
- MULTIPLE STAGES
- TEMPERATURE
- ENRICHMENT OF BACTERIA

MIXING OF DIGESTER CONTENTS IS THE MOST IMPORTANT FACTOR

IMPORTANCE OF MIXING

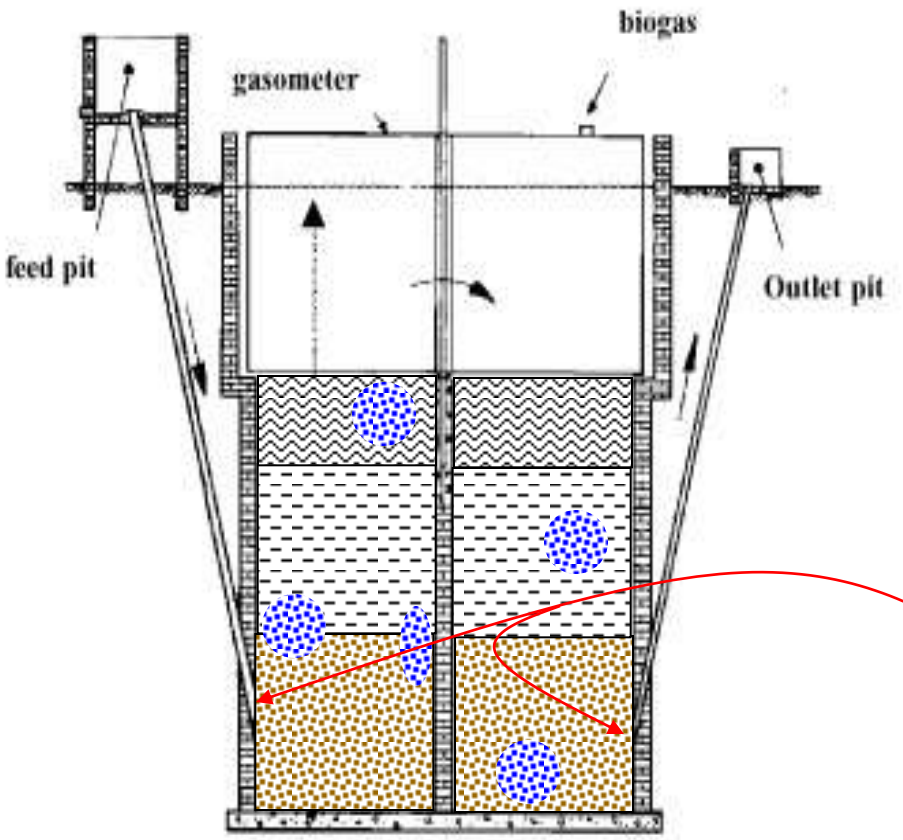


Figure 1 - Indian-type digester.

Slurry separates into three phases

Bacteria form clusters

Seriously affects the treatment efficiency

Inorganic substances and sludge accumulates in the bottom leads to choking

MANY DIGESTERS ARE ABANDONED AFTER A FEW YEARS OF USE

HIGH RATE BIO-METHANATION

Digestion accomplish faster and specially designed digesters are used for the purpose

All high rate digesters employ an efficient mixing system

Digestion takes place in multi stages and plant operations are mechanized

Classified into slurry digesters (10 to 15% solids) and dry anaerobic digesters (25 to 50% solids)

It is also more efficient in terms of degree of digestion

It is the most popular and environment friendly technology for solid waste management

M/s Kompogas, Valorga, Dranco, Bima and Pearth are the leading technologies

There are five installations in India based on BIMA

CONVENTIONAL	HIGH RATE
Requires 50 to 60 days to complete the digestion	Digestion completes within 15 to 25 days
Treatment efficiency is less than 50%	Efficiency in terms of solids digestion is 80-90%
Loading rate less than 1 kg/m^3 vol. of digester	Loading rate up to 10 kg/m^3 vol. of digester
Suitable ONLY for small installations	Suitable for any size
High water consumption and generate secondary effluents	Minimum water consumption and no secondary effluents
Choking, Scum formation & many operational problems	No operational problems
Entire operations manual	Fully mechanized

MIXING SYSTEMS & HIGH RATE DIGESTERS

Mechanical stirrer is not practical because digesters have large volume

Mechanical stirrer invites power consumption and frequent maintenance

All high rate digesters employ unique mixing system

Many high rate digesters derive their brand name from respective mixing system (Ex: Bio-gas Induced Mixing Arrangement is BIMA, M/s Entec Austria)

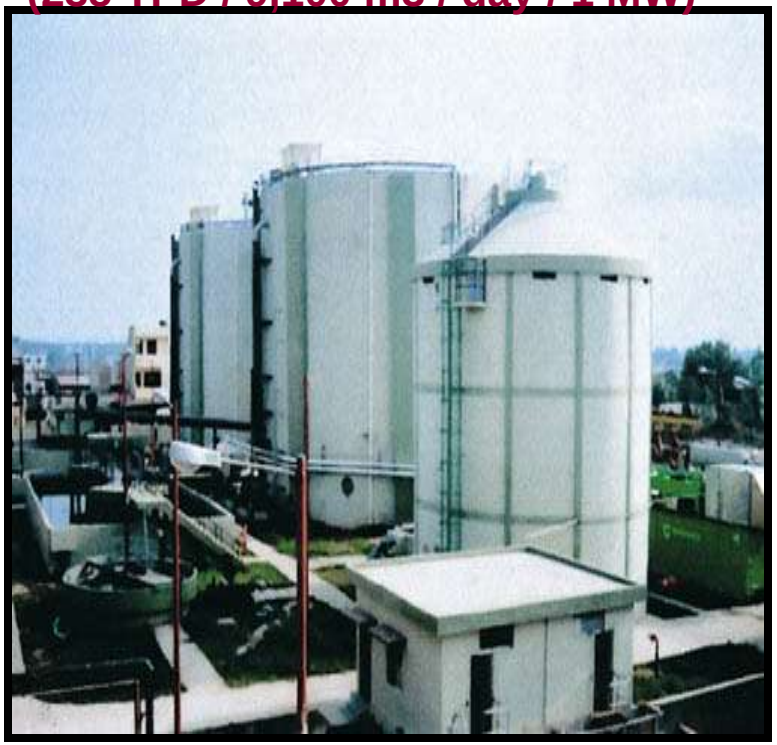
Self Mixing Anaerobic Reactor Technology (SMART- IICT India) employs differential pressure created by Bio-gas across multiple compartments to accomplish mixing

Example of High Rate Bio Methanization Technologuies

HIGH RATE DIGESTER INSTALLATIONS IN INDIA

FOR CATTLE DUNG LUDHIANA

(235 TPD / 9,100 m3 / day / 1 MW)



FOR VEGETABLE WASTE CHENNAI (30 TPD / 2,500 m3/day / 250 kW)

BIMA TECHNOLOGY FROM AUSTRIA

HIGH RATE DIGESTER INSTALLATIONS IN INDIA

Warana Sugar Mills Bottlign Plant – Spectrum RE Pvt Ltd

HIGH RATE DIGESTER INSTALLATIONS IN INDIA

Warana Sugar Mills Bottlign Plant – Spectrum RE Pvt Ltd (2012)

Input: 100TPD Pressmud

Output: 10,000 m3/day Biogas

Extra Input: 12,000 m3 from spent wash

Output:

8 T/day Bio CNG

0.36 MW CHP;

30 T/day Bio Manure (Rs 4000 per T)

0.7 T/day Sulphur (purchased by farmers @ Rs 12,000 per T as micro nutrient)

Project Cost : USD 5.5 million (Equivalent to 2 MW Project)

Payback Period : 4-5 years

HIGH RATE DIGESTER INSTALLATIONS IN INDIA

Warana Sugar Mills Bottlign Plant – Spectrum RE Pvt Ltd (2012)

HIGH RATE DIGESTER INSTALLATIONS IN INDIA

•Effluent of Starch and Glucose Industry - Yashwant Shakari Glucose Karkhana Limited, Kolhapur, Maharashtra

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Effluent of Starch and Glucose Industry - Yashwant Shakari Glucose Karkhana Ltd, Kolhapur, Maharashtra

- Starch Industry Effluent and Power Generation System
- 180 Tons Maize per day Plant
- Final Products: Starch and Glucose

Problem: Effluent with Chemical Oxygen Demand (COD) of 22,000 mg/ lit is brought down to the desired level of less than 200 mg / lit, courtesy biogas plant.

By Products from Effluent: 1 MW Biogas based Plant

- 3,000 m^3 of digester
- 7,000 - 8,000 m^3 gas per day
- Project Cost : USD 1.80 million (2013 figures)

  (Digester + Scrubber + Engine and Controls)
- Electricity Savings per annum for Starch

  and Glucose Factory : US$ 0.44 million

Young Entrepreneurs getting into small size High rate Biogas Digesters

HIGH RATE DIGESTER INSTALLATIONS IN INDIA /

Experimental Set Up at Hyderabad / IICT Desings

HIGH RATE DIGESTER INSTALLATIONS IN INDIA

- Treating 1 ton of food and vegetable waste per day / Gujarat
- Treating 1000 liters of Ganji water per day (Akshyapatra)

HIGH RATE DIGESTER INSTALLATIONS IN INDIA

Gas upgrading, Grid Injection & Utilization as Eco-friendly fuel

- ⇨ Gas Upgrading : Through Scrubbers

- ⇨ Grid Integration: Is Possible in 2 ways

  With Biogas Grid / With Electricity Grid

- ⇨ Utilization as Eco friendly Fuel

  (Calorific Value : 3,000 -4,200 KCal / m^3):

  Cooking Fuel (Homes, Hotel)

  Fuel for Thermal Heating

  Power Generation

  Off-grid application, Vehicle Fuel

Thumb Rules

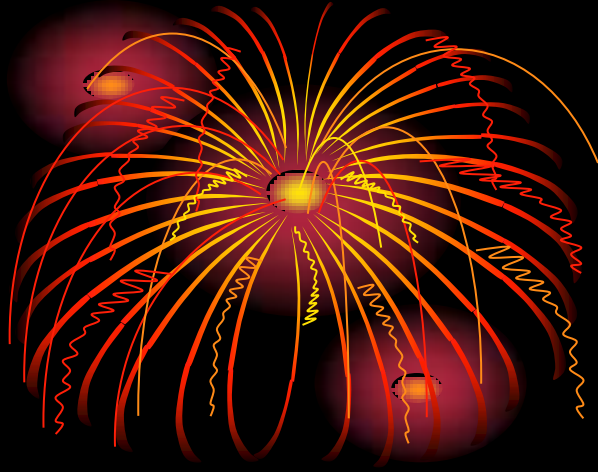
- 1,000 m^3 Bio gas per day = 450 Kg of Methane per day
- Each bird per day releases waste of 100-120 grams.
- 10,000 Chicken produce about 1 Tonne litter per day.
- Every 6 Kg of Poultry litter generates 1 m^3 gas
- Each Ton of Litter Produces: 160-170 m^3 of Biogas/day
- Every 20 kgs Gober waste generates 1 m3 gas
- Each Cattle releases 10 Kgs of dung per day,
- 2,000 Cattles : 1,000 m3 Biogas

Thumb Rules

- Each human releases 200 grams of excreta per day,
- 1 Tone of Press mud gives a bio gas of 70-80 m^3
- 0.5 m^3 of Biogas per Kg of CoD reduced from Effluent
- Kitchen Waste:
  1,000 Kg/day = 120-140 m^3/day = 55 Kgs of LPG (4 Cylinders)
- Each 1 m^3 Biogas gas (0.45 Kg CNG) generates 2 kWh electricity
- 12,000 m^3 per day Biogas Plant = 1 MW
- Viable Option for Biogas Plant (Bio-CNG Route): 1,500 to 2,000 m^3 per day
- Bio CNG is stored at 200-250 bar pressure

Conclusions

- ⇨ Biogas is very much proven Technology
- ⇨ Techno-economically Viable Technology for heating applications and Power Generation.
- ⇨ Helps in keeping environment clean, helps mitigate Global Warming.
- ⇨ Can be used for creating (rural/urban) employment
- ⇨ Availability of biogas would reduce the use of firewood and hence trees could be saved.
- ⇨ Prevents the health hazards of smoke in poorly rural households that use dung cake and fire-wood for cooking.
- ⇨ Byproducts: Nutrient Organic manure, SO_2, and CO_2
- ⇨ CDM Benefits



COOLING TECHNOLOGY
AGAINST GLOBAL WARMING

Thank You

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