Value Chain of Biogas
(Production, Gas upgrading, Grid injection and Utilization)

SAARC workshop on Application of on-grid Biogas Technologies

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Bio-Methanation Process

Scrubbers for H₂S and CO₂ Removal

H₂S Removal
CO₂ Removal

Purified Biogas

Power Generation

Cooking

Industrial Applications

Raw Biogas

Bio-Digester

Bio-manure

Purified Biogas

Power Generation

Cooking

Industrial Applications
Traditional Digester - FLOATING DOME
Traditional Digester - FIXED DOME MODEL
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
ANAEOROBIC 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

- Complex organic matter: carbohydrates, proteins, fats
- Soluble organic molecules: sugars, amino acids, fatty acids
- Volatile fatty acids
- Acetic acid
- $\text{H}_2$, $\text{CO}_2$
- $\text{CH}_4 + \text{CO}_2$
Factors affecting Biogas Production

- pH (Best: 7-8)
- Temperature (Best: 33–42°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$_2$S) : 0.2%

Cal Val epf Biogas : 4,700 Kcal / m$^3$
Cal Val bio CNG : **8,000 Kcal / m$^3$**
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 $7000m^3$.

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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MIXING

SIZE REDUCTION
MULTIPLE STAGES
TEMPERATURE
ENRICHMENT OF BACTERIA

MIXING OF DIGESTER CONTENTS IS THE MOST IMPORTANT FACTOR
IMPORTANCE OF MIXING

Inorganic substances and sludge accumulates in the bottom leads to choking. Many digesters are abandoned after a few years of use.

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

• 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)

- 120-150 m$^3$ Biogas
  = 4 LPG Cylinders (14.2 kg each)
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 / m³):
  - Cooking Fuel (Homes, Hotel)
  - Fuel for Thermal Heating
  - Power Generation
  - Off-grid application, Vehicle Fuel
Thumb Rules

• 1,000 m³ 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 m³ gas

• Each Ton of Litter Produces: 160-170 m³ 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 m³

• 0.5 m³ of Biogas per Kg of CoD reduced from Effluent

• Kitchen Waste:
  1,000 Kg/day = 120-140 m³/day = 55 Kgs of LPG (4 Cylinders)

• Each 1 m³ Biogas gas (0.45 Kg CNG) generates 2 kWh electricity

• 12,000 m³ per day Biogas Plant = 1 MW

• Viable Option for Biogas Plant (Bio-CNG Route): 1,500 to 2,000 m³ 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
Thank You

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