BioGas Basics
By David Cilliers
What is BioGas?

• This gas production occurs naturally through decomposition in the absence of oxygen (Anaerobic).
• A methane rich gas.
• Commercially generated from waste.
  – In some countries crops are grown for the specific purpose of producing biogas.
• Used to replace fossil fuels.
What is BioGas?

• It is also called Marsh or Swamp gas.
  – Naturally occurs in these places.
• Most organic waste left to decompose will produce BioGas.
BioGas description

- BioGas is not a single gas.
  - Methane 45-65%
  - Carbon Dioxide 35-55%
  - Other gasses less than 5%
  - Water vapour
  - Hydrogen Sulphide
  - Nitrogen
  - Oxygen
  - Ammonia
BioGas description

• Methane is the most important gas.
  – Combustible and therefore valuable as fuel.
  – Tasteless, odorless and colorless.
  – Lighter than air, safety bonus compared to LPG.
  – Often people think they are smelling methane, but are in fact smelling H₂S.

• Hydrogen Sulphide (H₂S) is foul smelling and corrosive gas.
Organic Waste

• Organic $^{def.}$ – Relating to or derived from living matter.

• With the exception of a few substances all organic matter is suitable for BioGas production. Incl:
  – Fruit and Veg (and related waste).
  – Agri waste (Plant matter).
  – Manures.
  – Waste waters (containing organics).
Triple Benefit of BioGas

- It is important to view the BioGas process with regard to it’s three benefits and not purely as fuel.
  1. Combustible gas for fuel
  2. Responsible waste disposal
  3. Nutrient rich by-product used as fertilizer
- In rural applications also has major health benefit when compared to wood burning.
Completing the cycle

[Diagram showing the cycle of photosynthesis and its components: light, CO₂, O₂, H₂O, animal manure, vegetable biomass, fertiliser, organic wastes, anaerobic digestion, biogas, electricity and heat.]
Anaerobic Digestion (AD)

- Organic matter broken down by microorganisms in the absence of air.
- Air is toxic to bacteria.
- Many different variable to control in order to maintain efficiency.
- Waste and bacteria housed in air-tight tanks – digesters.
- Importance of quality development.
Organic Waste → Digester → BioGas → Fertilizer
The potential of one cow

1 Dairy Cow

- **Electricity**
  - 791 kWh/Cow/Yr
  - Value @ R1/kWh = R791

- **Heat**
  - 1144 kWh/Cow/Yr
  - Value @ R0.25/kWh = R286

- **Solids**
  - 4 ton/Cow/yr
  - Value of Phosphate R900

- **Liquid Effluent**
  - 14 ton/Cow/yr
  - Value of N,K R1100

Potential value of ONE dairy cow = R3 077
3 phases of AD

- Different bacteria play different roles.
- Generally 3 phases happen concurrently.
  1. Hydrolysis
  2. Acidification
  3. Methanogenesis
- Each stage requires specific bacteria.
- Each bacteria requires correct conditions.
3 phases of AD

Hydrolysis
- Complex compounds made water soluble

Acidification
- Formation of acids from simple compounds (Acetic and other)

Methanogenesis
- Acids converted into CH$_4$ and CO$_2$
3 phases of AD

• Each of these phases requires their own set of parameters.
• What is good for one phase may not be good for the other.
• A fine balance is important to achieve best results.
• Phases can be done concurrently or separately.
Variables

- A digester is considered a living organism.
- NB parameters:
  - Temperature
  - pH
  - Rate at which organic are loaded
  - Time spent in digester
  - Solid content
  - Degree of mixing
  - C:N ratio
Variables

- Process parameters differ based on:
  - Feedstock
  - Digester design
  - Climate
The stomach analogy
The stomach analogy

• Easy to look at digester like a stomach.
• We take in liquid and solids – output liquid, solid and gas!
• To keep our stomach’s healthy we need the right amount of solid and liquid, acids and bases.
• Durban Curry = Just Flames, no gas.
Digester Design

• As with most technologies, there are a variety of designs available to accomplish a task with varying degrees of success.

• Choice is based on:
  – School of thought
  – Budget
  – Required efficiency
  – Application
Digester design

- Two main categories of digester:
  1. Continuously fed
  2. Batch fed

- Both of which can be:
  - Underground
  - Above ground
Continuously Fed

- Waste added at consistent intervals.
- Digester can hold 15-40 ‘intervals’.
- When waste is added, slurry is removed.
- Waste is generally in liquid form.
- Solid content of 8-15%.
- Commonly
  - CSTR type
  - UASB type
Batch Fed

• Waste in added, and then left to completely digest.
• For applications when waste not available every day.
• Digester is big enough for one ‘batch’
• Once digested, emptied and filled with new waste.
• Often higher solid content.
Chinese fixed dome
Indian Floating Drum
Advanced Designs

• CSTR
• UASB
• Multi-stage reactors
CSTR
BioGas purification

• Reasons for purification:
  – H₂S is poisonous in certain quantities.
  – H₂S is a corrosive gas.
  – CO₂ has no calorific value and therefore consumes storage space for no benefit.
  – When H₂S is combusted is releases harmful SO₂ into the atmosphere.
Storage

- CO$_2$ prohibits large volumes of storage.
- If CO$_2$ removed, biomethane can be compressed and stored in the same way as natural gas. High energy req.
- Domestic applications may store up to 60% of daily produce.
- Commercial generally only 5%.
- All depends on application.
Uses of BioGas

• Fed into appliances for cooking fuel.
• Scrubbed and used in CHP engine (elec.)
• Scrubbed, Purified for natural gas pipeline.
• Scrubbed, Purified, Compressed for vehicle fuel (CNG)
• Further compressed for easier and more efficient use (LNG)
Uses - Cooking
Uses – Electricity Gen.
Uses – Vehicle Fuel
Why does BioGas suit SA?

• Can be very simple or very technical, depending on application.
• Cheap and effective means of rural energy
• Brownie points and financial gain for commercial installations.
• Waste mitigation.
• Ease dependency on National generator.
Thank you!

Biogas is the answer, not a question!