Renewable Energy generation
Anaerobic digestion

Renewable energy generation
Anaerobic digestion

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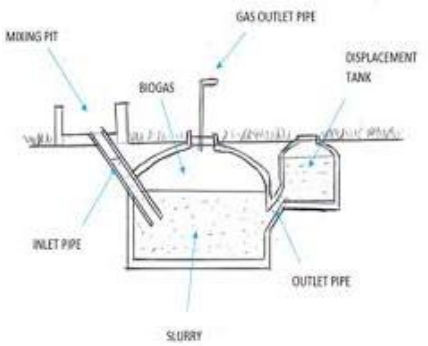
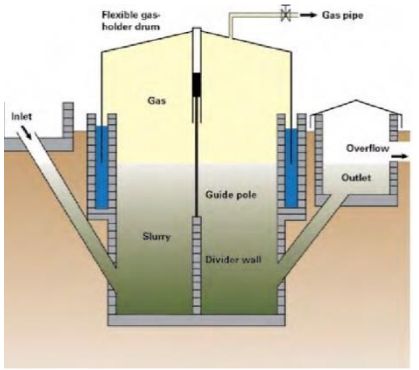
- Convert wet waste to methane and carbon dioxide
  - Usually from animal dung
- Slow continuous process of methanation
- Gas builds up in a gas holder for later use
  - Low calorific value
- Competing use for clean cooking
  - Indoor air pollution one of the world's biggest killers
- Some struggle to maintain the bacterial culture in the digester
- Helps to improve hygiene
- Hydrogen sulphide must be removed





Renewable energy generation
Digester designs

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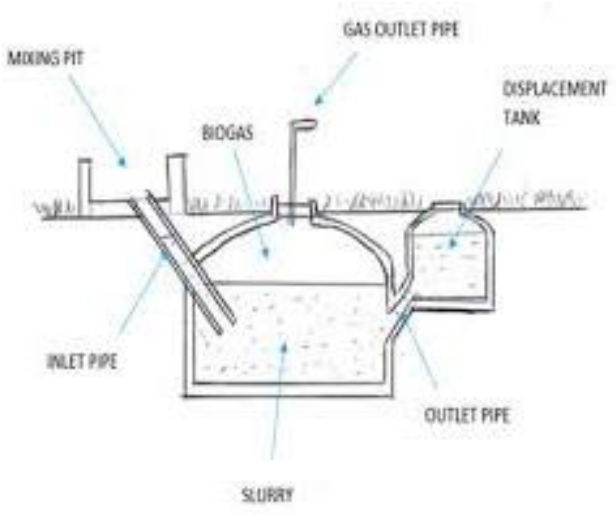
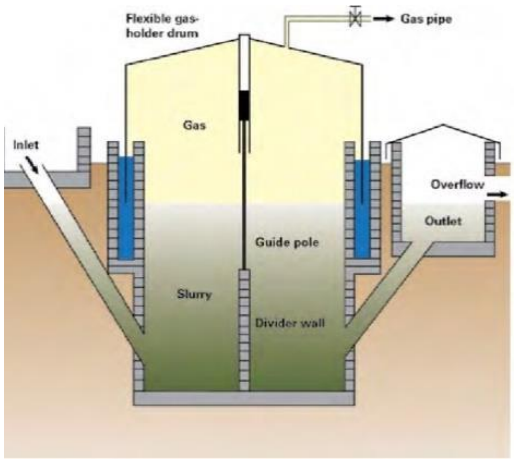


Fixed Dome Digesters

Balloon Digesters



Floating Dome Digesters

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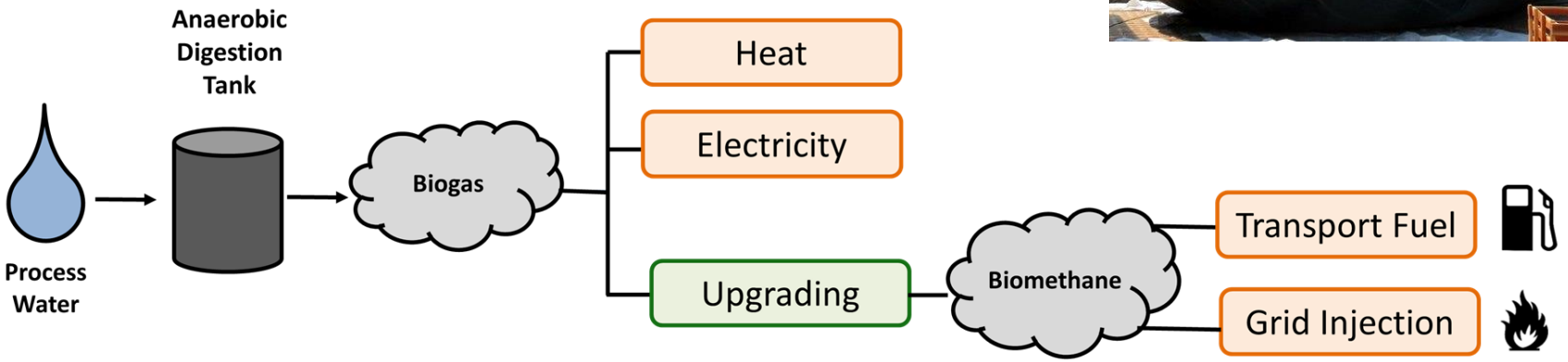
Biogas can be used for cooking, electricity or can be upgraded to produce higher quality gas for use as a transport fuel or for GRID injection

If linked to a Gen-Set, AD can generate power all day or biogas can be stored in balloons for when needed.



The utilisation of biogas for power generation diverts its use as a **renewable clean cooking fuel** which in some developing countries may not be beneficial

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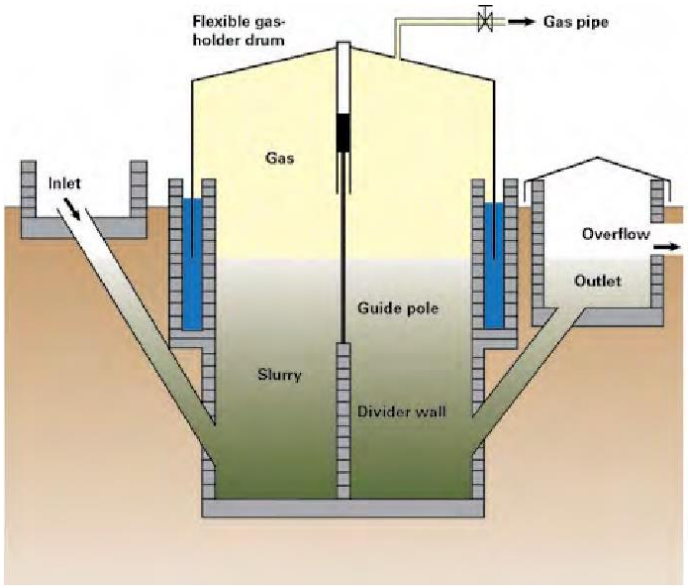
Biogas is produced by the breakdown of organic matter in the absence of oxygen. This is by a process called anaerobic digestion.

Typical composition of biogas

Methane	50% - 75%
Carbon dioxide	25% - 50%
Nitrogen	0% - 10%
Hydrogen	0% - 1%
Hydrogen sulphide	0% - 3%
Oxygen	0% - 2%



Feedstocks: sewage sludge, food waste, agricultural wastes, manure etc

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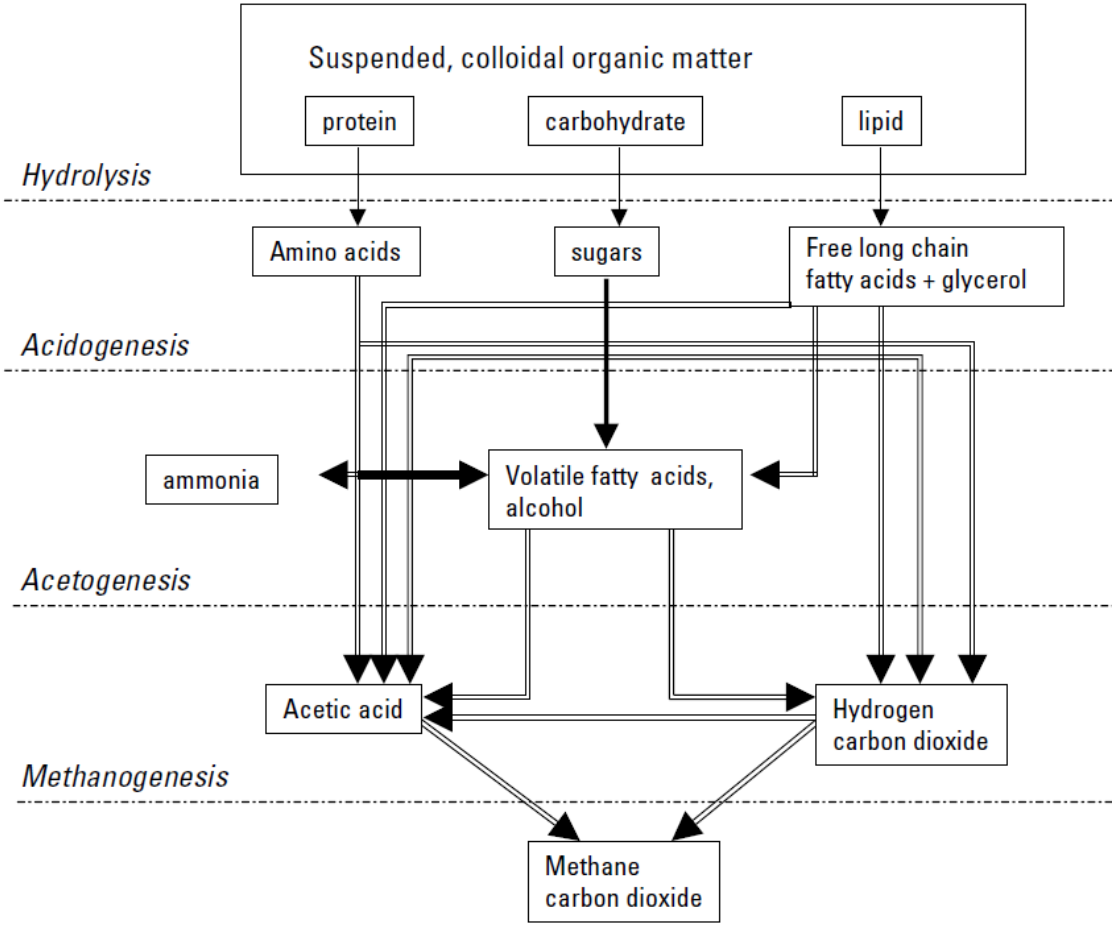

Anaerobic digestion proceeds in **4 defined stages**

- **Hydrolysis,**
- **Acidogenesis,**
- **Acetogenesis**
- **Methanogenesis**

Source: Wageningen University

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What sources of biomass could be used?

Cow Dung, Food waste, human fecal matter, Agricultural residues, Energy crops (e.g.) miscanthus, Aquatic biomass (e.g. Water hyacinth)







Availability: Some seasonal and some available all year round

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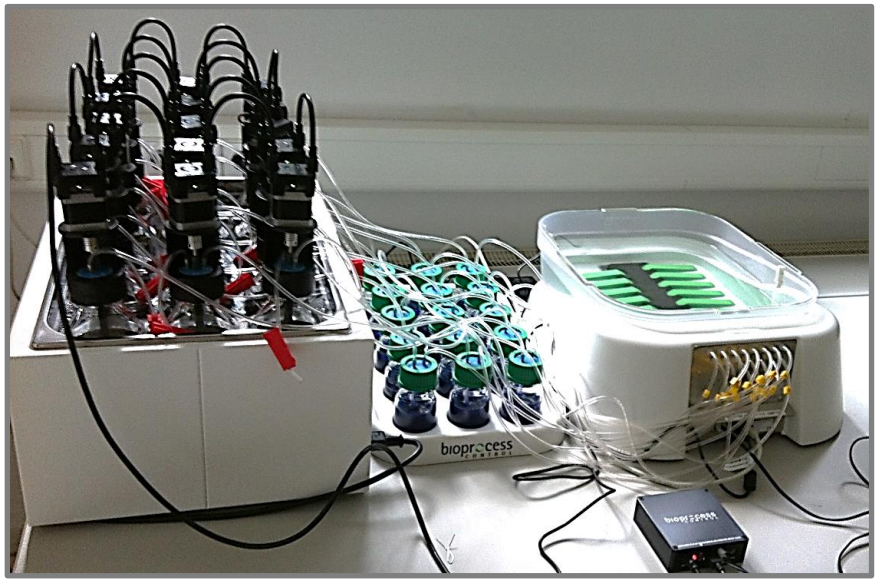
Measurement of Biochemical methane potential (BMP)



- BMP conditions:
  - AMPTS at Mesophilic 37 °C for 30 days (500 ml bottles)
  - Ratio 2:1 inoculum to substrate (400 ml total volume)
    - 4 g COD in 200 ml water + 2 g SVS in 200 ml (10 g/L concentration)
  - Inoculum from WWTW (sludge fed)

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What is biomass potential availability?

Biomass	Seasonal variation	Amounts
Cow manure	All year round	~20-30kg (wet wt.) /cow/d
Food Waste	All year round	~0.2-0.5 kg (wet wt.) /person/d
Human fecal matter	All year round	~0.25 kg (wet wt.)/person/d
Water Hyacinth	Seasonal (Jan-Jun)	0.5 kg (wet wt.)/m^2/day
Miscanthus	Seasonal (Nov-Feb)	1.5 Kg m^2/year/harvest
#Cereal crops (straws)	Seasonal (Jul-Sept)	0.3 kg (wet wt.)/ m^2/harvest
Rice straw	Seasonal (2-3 harvests)	0.1 kg (wet wt.)/m^2/harvest

#Some used for paper pulping, lot of it is burnt in the fields

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How much biogas can be generated based on realistic production rates?

Feedstock	BMP (ml CH_4 /g VS) (dry basis)	Availability (wet wt.) (kg)	Ash (%)	H_2O (%)	Biogas l/kg feed (wet wt.)
Food waste	200#	0.5	10	90	36
Fecal matter	100	0.15	4	80	38
Cow Dung	200	20 /cow/d	10	80	72
Water Hyacinth	180	0.5 kg/ m^2	20	90	29
Cereal straw	150	0.3 kg /m^2	5	10	260
Miscanthus	180	1.5 kg/ m^2	3-4	40	216
Rice straw	120	0.2 kg /m^2	15-20	10	160

depends on composition
Assuming 50/50 methane/CO_2

Source: Phyllis2

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Santa Rosillo anaerobic digester, Peru

- 16kW capacity for 224 people (50 HH)
- Access is $6/month
- $130,000 cost
- Communal farm of 67 animals
- Slurry is the most valuable product of the system