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Challenges of biogas production in the wet fraction in Ghana

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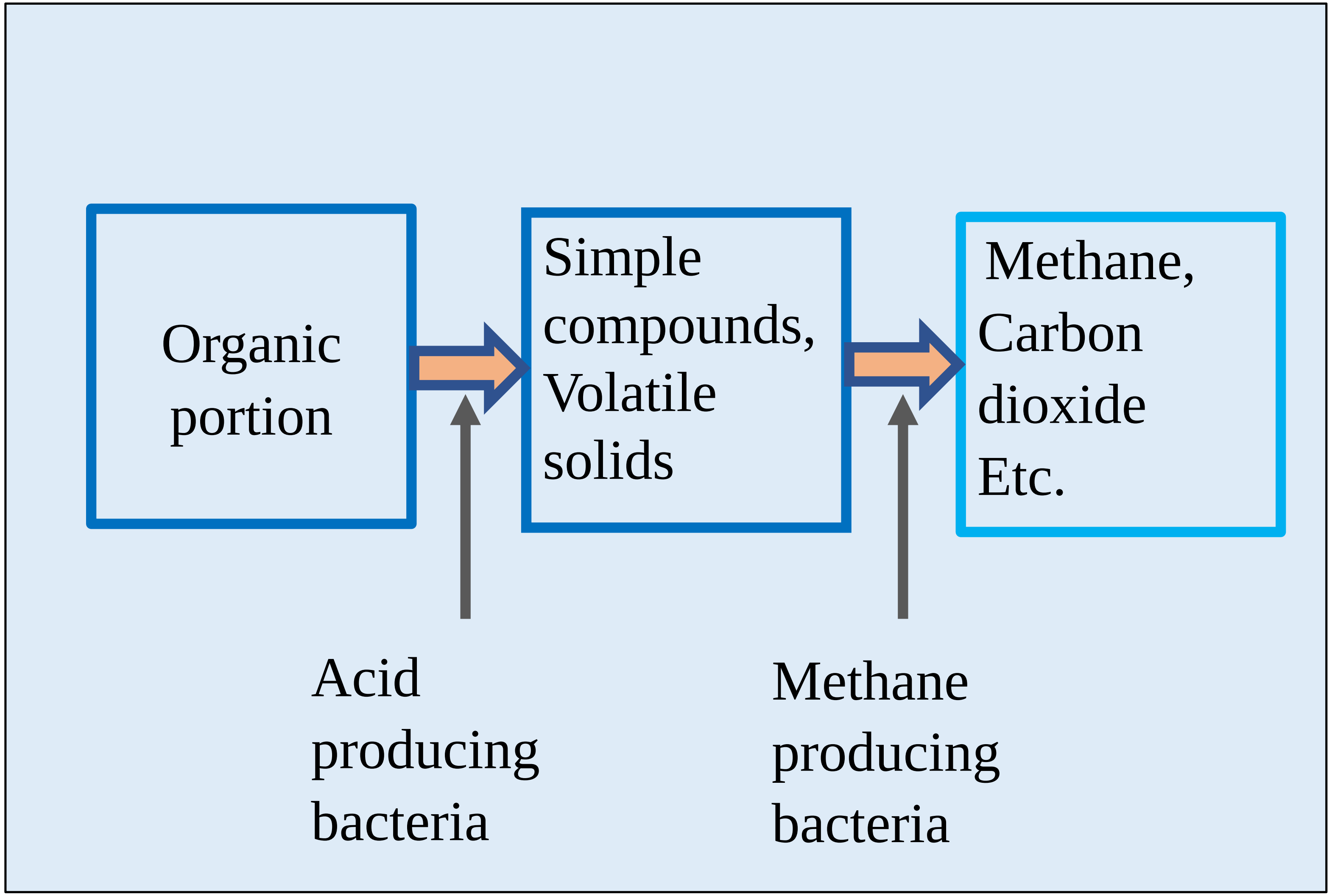
Outline

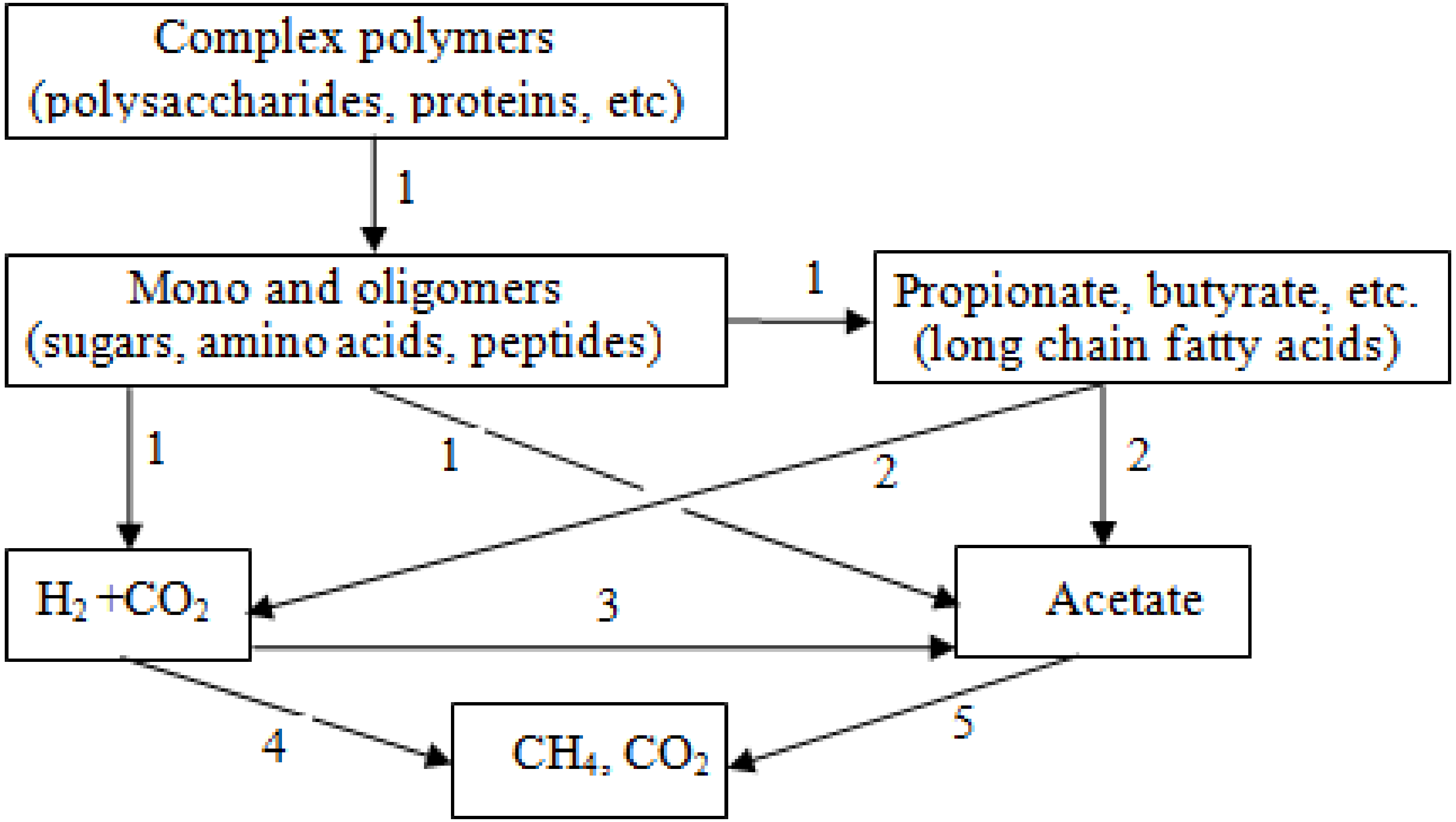
- Anaerobic digestion
- Nature of biogas industry in Ghana
- Major challenges of the biogas sector
- Case studies: successes and challenges
- Conclusion and way forward

Principles of Anaerobic digestion



Principles of anaerobic digestion

Pathways for biogas production



1. Fermentative bacteria
2. Obligate hydrogen-producing acetogenic bacteria
3. Hydrogen-oxidizing acetogens
4. Hydrogen-oxidizding methanogens
5. Aceticlastic methanogens

Nagamani and Ramasany, 2007

Digestion options: Wet or dry fermentation

Parameter	Wet fermentation	Dry fermentation
Moisture content of feed	≥ 75%	< 25%
Pretreatment	Pretreatment of waste is done before waste enters digester	No pre-treatment of waste is required.
Agitation	Usually required	Feed is stationary
Groundwater contamination	High risk of groundwater contamination	Low risk of groundwater contamination
Biofertilizer	Higher storage demand	High cost of separation biofertilizer from inorganics
Suitability/applicability	Wastewater, organic wastes (homogenous or non-homogenous)	Municipal solid waste (sorted or unsorted)

Promising sectors for industrial biogas development

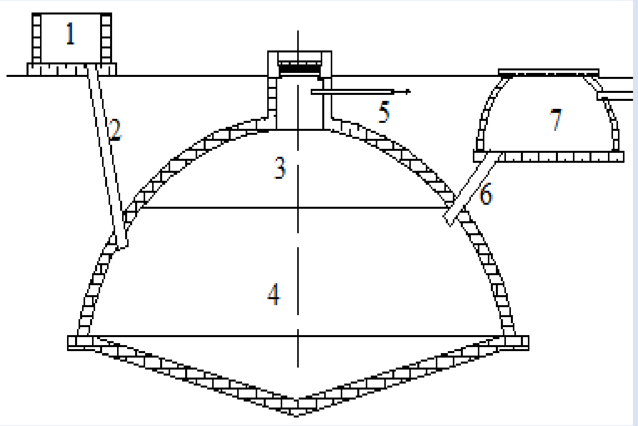
Animal farms	• Piggeries, poultry farms, cattle farms, etc.;
Edible oil extraction and processing	• Oil-palm, coconut, shea-nut, and groundnut
Crop processing	• Rice, cashew, cocoa, shea-nut, etc.
Fruits and vegetables processing companies	• Pineapples, oranges, mango, and pawpaw; etc.
Municipal waste	• Household, market, slaughterhouses, etc.
Industrial wastewater	• Beverage, rubber, pharmaceutical, etc.

The biogas digester

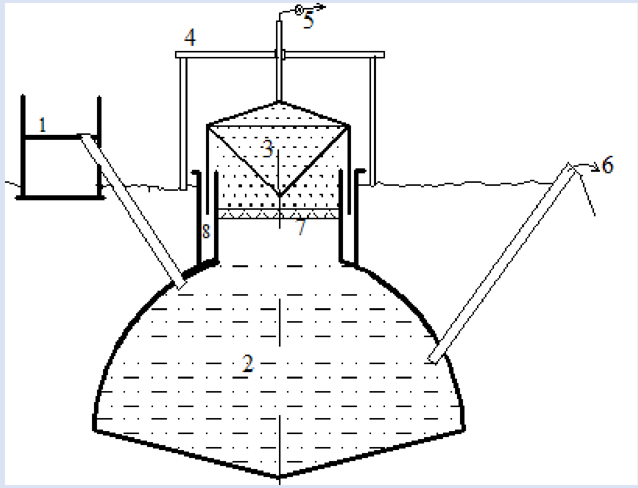
- BIOGAS DIGESTER
  - Simple digesters
    - Small volumes ($\leq 60\ m^3$)
  - High rate reactors
    - Large volumes (usually $> 500\ m^3$)

Simple digesters

Fixed-dome

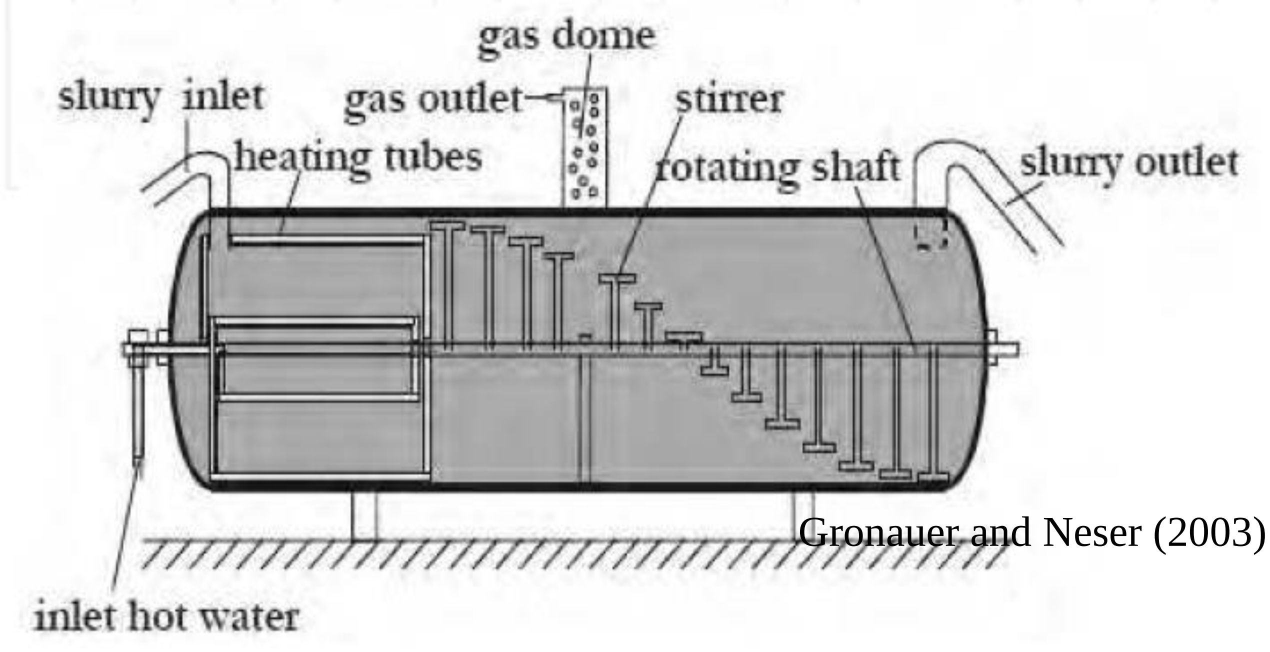


Floating-drum



Horizontal high rate digesters

Plug flow digester



Gronauer and Neser (2003)

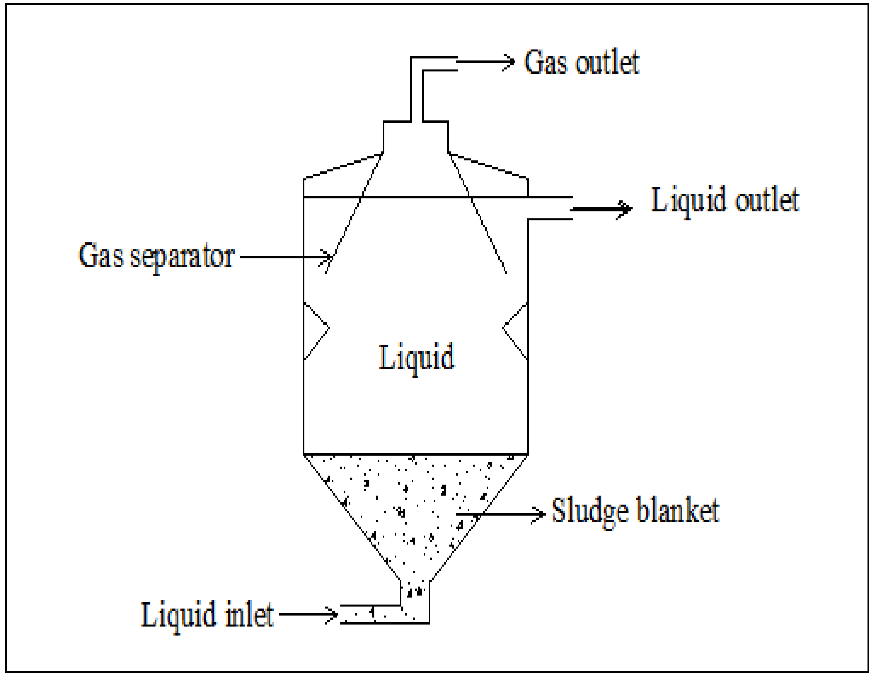
- Construction: concrete, steel, fiberglass, etc.
- May be heated and/or agitated

A: Plug flow digester in Princeton, Minnesota (Source: Rosalie)

B: Plug flow digester made of stainless steel (Krieg and Fische Ingenieure, Germany)

Vertical high rate digesters

Upflow anaerobic sludge blanket (UASB)

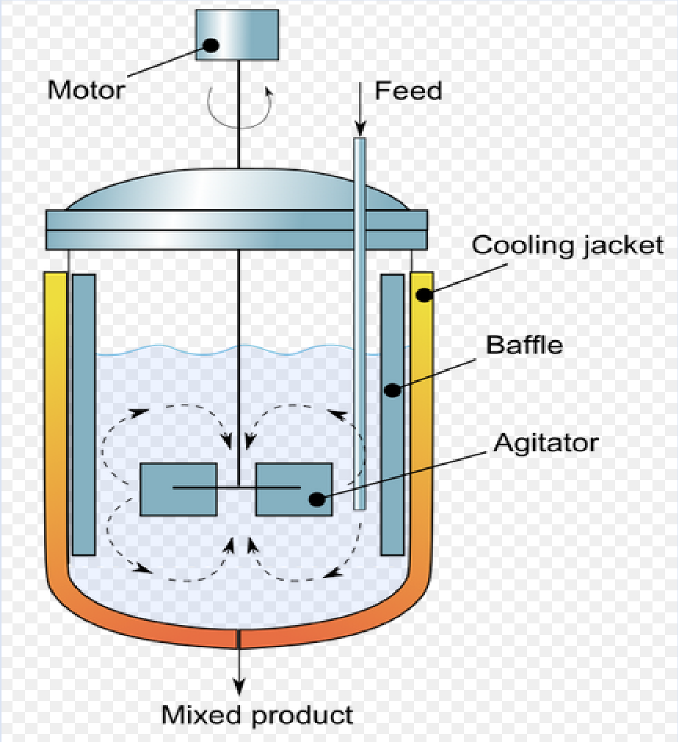


UASB, Guinness Ghana Ltd – Kumasi

- Contains immobilized bacteria (sludge blanket)
- Ideal for dilute wastewater

Vertical high rate digesters

Stirred tank (complete-mix) digester

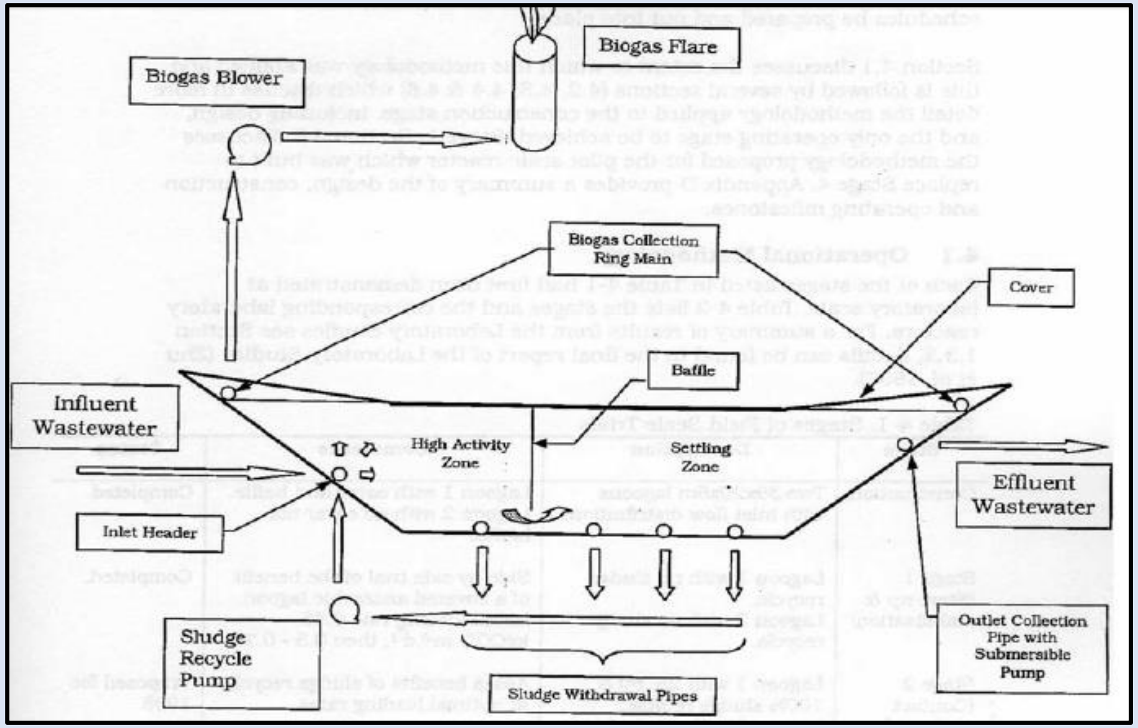


Stirred-tank digester, HPW Fresh & Dry Ltd., Adeiso, Ghana

- Ideal for wastewater with solids concentration of 3 to 10 %

Other high rate digesters

Covered anaerobic pond (The lagoon)



AMPC, 2013

Lagoon, GOPDC, Kwae, Ghana

- Ideal for feed materials containing less than 2 % solids

Highlights of biogas sector in Ghana

- Number of plants installed was estimated at about 250 in 2008 and 400 in 2015
- About half of installed plants were not operating in 2008
- Biogas digesters installed are mainly fixed-dome for treating blackwater from households and institutions
- Current number unknown; Estimate by Ministry of Energy puts the number of functional plants at about 160
- Construction of plants dominated by unregistered artisans
- No clear policy on the sector though targets are set in REMP, SEForAll Action Plan, etc.
- Biogas Association of Ghana (BAG) formed in 2017 to promote advocacy

Key barriers to biogas development and growth

- High investment cost (USD 235- 446 per cubic meter for simple plants)
- Absence of flexible financing schemes
- High operational cost of large (high rate) plants
- Low level of technical expertise
- High numbers of malfunctioning plants
- Weak regulation of sector (EPA, EC, etc.)
- Low knowledge level of industrial players on the energy and fertilizer potential of their waste
- Inadequate support from government
- Lack of efficient procedure for feeding biopower to grid and uncertainties on receiving payments from off-takers of power

Case studies of selected plants

HPW fresh and dry limited (Adeiso, Eastern Region)

Feedstock	**About 10 tonnes/day of fruit waste**
Technology	Two STRs operating in series.
Digester capacity, m3	900
Operational temperature	Mesophilic
Daily gas production	About 800-1000 m^3 of biogas (52 - 54% methane)
Gas utilisation	Power production or process steam generation
Challenges	Low power generation efficiency (9%) due to low methane content. Digestate not fully utilised; farmers not interested in slurry. Low digestion pH due to high sugary feed; poor digestion efficiency; low gas yields; low methane content.
Possible solutions	Co-digestion with other waste such as poultry will improve methane yield and fertilizer value. Education and training of local farmers to use slurry in agriculture


A: Fresh fruit waste


C: Biogas gasholders


B: Two CSTRs in series


D: Gas generator

Case studies of selected plants

Kumasi abattoir, Kumasi

Company	Kumasi Abattoir Company Limited
Waste generation	About 21 tonnes of dung/intestinal contents; 180 m^3 wastewater daily.
Technology	Stirred tank digester (under construction)
Operational temperature	Thermophilic
Daily gas production	About 1000 m^3
Gas utilisation	Power production
Challenges	Expected challenges relate the operation of the sophisticated system; technical challenges
Possible solutions	Local engineers are expected to be trained on the operation and management of the facility.

A: Rumen content

C: Singeing using LPG

B: Final pond before discharge of effluent into public drain

Case studies of selected plants

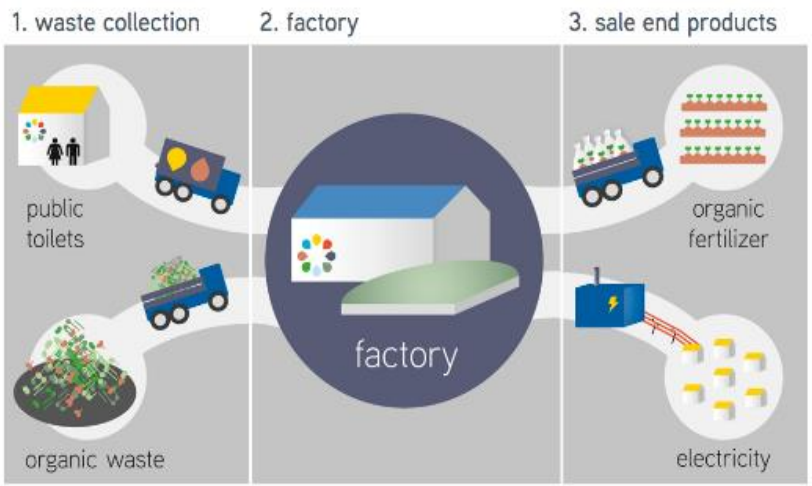
Zoomlion wastewater treatment plants, Accra

Feedstock	2000 m^3 septage/day (Lavender Hill); 1000 m^3 septage/day (Kotoku); 1800 m^3 blackwater/day (Mudor)
Technology	UASB digesters
Investment cost	USD 40 million (entire plant, Lavender Hill); 20 million (Mudor); 15 million (Kotoku)
Gas utilisation	Expected to be used for electricity and heat
Power output	Estimated at 400-500 kW (Lavender Hill)
Use of electricity and heat	To be internally used for plant operation
Digested slurry	To be post-treated, dried and used for agricultural purposes
Challenges	High investment and operational cost; low revenue to defray investment cost

Case studies of selected plants

Safi Sana biogas plant, Adjei-Kojo, Ashaiman

Feedstock	**About 30 t/d of excreta, market waste, agricultural residues, slaughterhouse waste, etc.**
Technology	CSTR (one stage)
Investment cost	EUR 400,000 (digester and power systems)
Operational temperature	Thermophilic (40 - 45 ^{o}C)
Gas production	2000 m^3/d
Gas utilisation	Power generation
Power output	100 kW
Use of electricity	Electricity fed to the grid
Heat use	Heating of digester
Digested slurry	Post-treated using stabilisation ponds and drying beds; for farming
Challenges	Lack of source sourcing of waste demands separation of waste which is time-consuming. Inadequate supply of feed



ACTIVITIES TO OVERCOME BARRIERS

- Awareness creation
- Exchange of knowledge and know-how
- Development of standardised plants (for fixed dome and other simple plants)
- Enforcement of regulations on discharge of wastewater
- Set-up of flexible financing mechanisms
- Streamlining of process for supply of small-scale power to grid

CONCLUSION: TRAINING REQUIREMENTS OF KEY ACTORS

Industrial actors	Biogas service providers	Knowledge based institutions
Estimation biogas energy potential	Design, development, construction and management of large scale biodigesters.	Modern biogas technologies and digesters
Basic financial and sensitivity analysis of their waste potential using simple software	Collaboration with leading global companies should emphasize training and skills transfer	