Teknik för biogasproduktion i kvarteret – exempel från Indien

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2013-03-20

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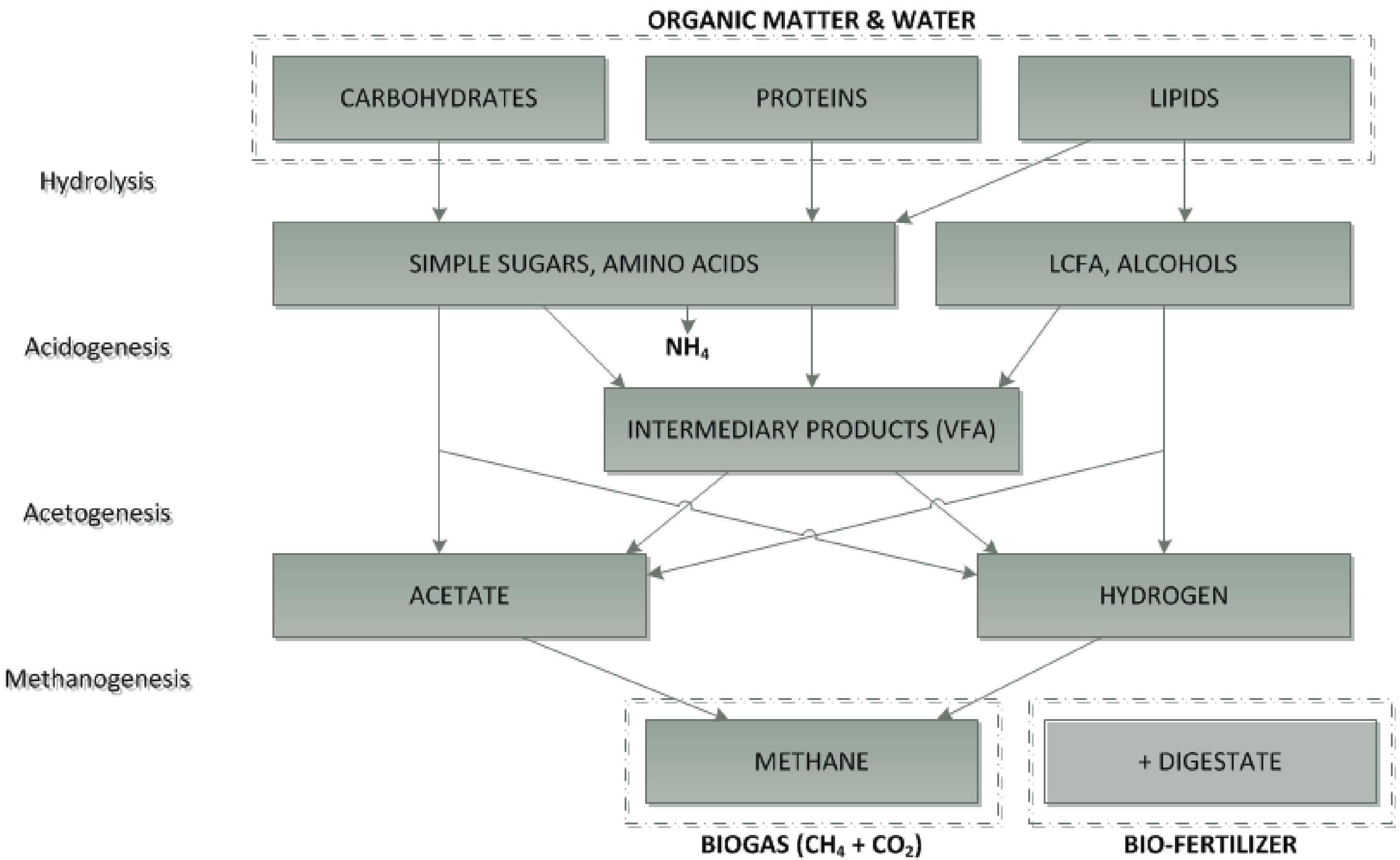
Introduction

- The background of our study is to explore the possibility of producing biogas from kitchen wastes from KTH to be used in the Polygeneration lab

Content

- What is anaerobic digestion?
- Factors affecting the anaerobic digestion process
- Design, sizing and choice of biogas plant
- Problems encountered and lessons learned
- Setting up a permanent digester at KTH – Implications
- Conclusions

Steps of the digestion process



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Factors affecting the process

- Temperature and pH
- Inhibition and hydrogen partial pressure
- Pre-treatment
  - Milling/ crushing/ removal of grit and non-renewables
  - Sanitisation
  - Start-up Inoculum
- Technical and operational factors
  - Mixing
  - Hydraulic Retention Time
  - Organic Loading Rate
  - Feed Substrate

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Factors to consider for implementing a biogas plant

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- Good substrate?
- Required gas quality
- Temperature control
- Operating parameters
- One or two stages of digestion
- Continuous or batch process
- Choice of materials for the digester and auxiliaries
- Leakage control
- Permissions required for setting up of plant

Setting up a biogas plant -Sizing

- Restaurant wastes: 100-130 kg/ day from local restaurants on the campus area

- There are two ways of getting to a first estimate of the size of the digester

  Assuming a Hydraulic retention time (HRT) of 22 days and the daily input of 100kg of waste as well as 100 litres of water, as a general rule of thumb, would require a reactor volume of:

  22 days x 200 litres = 4.4 m^3

  Adding a safety factor of around 10%, a reactor volume of 5m^3 has been selected.

  As a general rule of thumb, for a proper digestion process, an organic loading rate (OLR) of about 3.5kg VS/ m^3 of digester is required. Therefore a food waste having 20% Dry matter content (DMC)/wet weight and 90% VS/kg DM, then 100kg of fresh substrate would require 5m^3 digester

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Example of DIY digester

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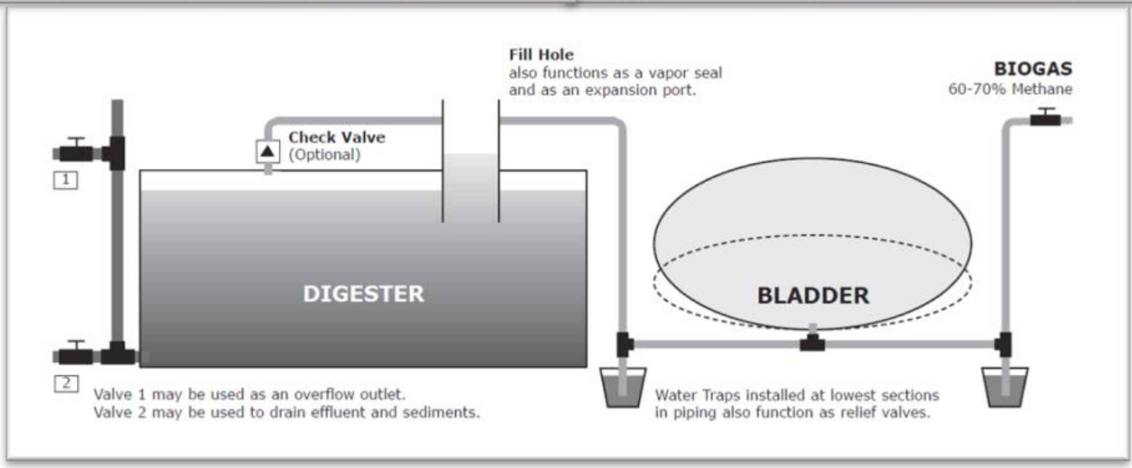

Design / Technologies available – Cont'd

- Low-cost readily available digesters
  - Small compact design
  - Suitable for small-scale plants
  - Can be supplied with upgrading equipment/ CHP
  - Economical design material (fibreglass lined PVC)
  - Clean and sanitary
  - Simple to operate and functional

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Design / Technologies available – Cont’d

- Containerized digesters
  - Small compact design
  - Transportable
  - Suitable for small-scale plants
  - Integrated system

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Choice of biogas plant for tests at KTH

- Safety regulations and European certification
- Total delivery period
- Ease of installation
- Cost of equipment
- Availability of equipment

- Choice: **JTI mobile research unit**
- Availability of equipment
- Already acquired certificates and approvals for running
- Complete with pre-treatment, hygienisation, digester and flare
- Interesting studies possible

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Lessons learnt

The plant was run for a period of two weeks.

- Mode of waste collection of wastes inadequate and waste was not usable (organic part not recoverable)
- Heating of inoculum to process temperature as soon as possible to stimulate the bacterial activity - slowed down during transportation
- Storage time for digestate should be short as possible (logistics to minimize odour)
- The valves have to remain always open when the system is not in use to prevent pressure build up
- Due to short running period, it was impossible to see whether the substrate will cause any problems on the long run such as

  Ammonium nitrogen formation, Foam/ scum formation in the digester, CO_2 increase in biogas, H_2S level increase

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Operatign schedule

SN	Description	Frequency	Responsibility
1	Fill the digester with inoculum	First day of operation	KTH – rental of a sewage truck
2	The inoculum is heated to a constant temperature of 55°C	First day of operation	JTI/ Operator
3	Run a process to understand the procedure (part of training)	Every day or 2 times daily ensuring an interval of at least 10 hours between the loadings	Operator
4	Separate organic wastes from other wastes, if necessary	Every four days	Operator
5	Test a sample of raw waste to find VS and DS content to find the appropriate loading rate	Once at early stage	
6	Cut wastes to a size to fit the entrance slot of the grinder Weigh the wastes before feeding the grinder, where water is added to form a slurry which is pumped to the buffer tank	Every four days	Operator
7	Test for DMC and VS of the input slurry to ensure proper dilution	Every four days	Operator
8	Sampling of digestate to test for pH, ammonium ammonia, VS, DMC, VFA	As and when necessary	Operator
9	Ensure disposal of digestate by registered sewage truck	Every 2 to 4 days, or as and when necessary	Operator
10	Take daily readings from the software to ensure proper processing conditions are respected.	At least once daily	Operator
11	Emergency shutdown of the flaring equipment in case of thunderstorm	When alarm is activated or when forecasted thunderstorms.	Standby-operator

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Biogas plant – Savings analysis

- Bill of materials
  - Grinder at the plant or grinders at the kitchens to convert semi-solid/ solid waste into slurry
  - Pumps (Pumping of wastes, addition of water, Re-circulation pumps)
  - Stirrers (preparation/ buffer tank, hygienisation tank, biogas tank
  - Piping and Valves
  - Emergency flaring device
  - Gas blower
  - Safety methane gas sensor apparatus
  - CHP plant (small plants- the dual fuel engine and larger plants- the Otto engine)
  - PLC system (for automation and remote control and monitoring of plant)

- Savings
  - (Replacement of purchased gas for lab use)
  - (Replacement of heating fuel/ electricity)
  - (Transportation of wastes to the landfill)
  - (Selling of digestate as natural fertilizer)

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Conclusions

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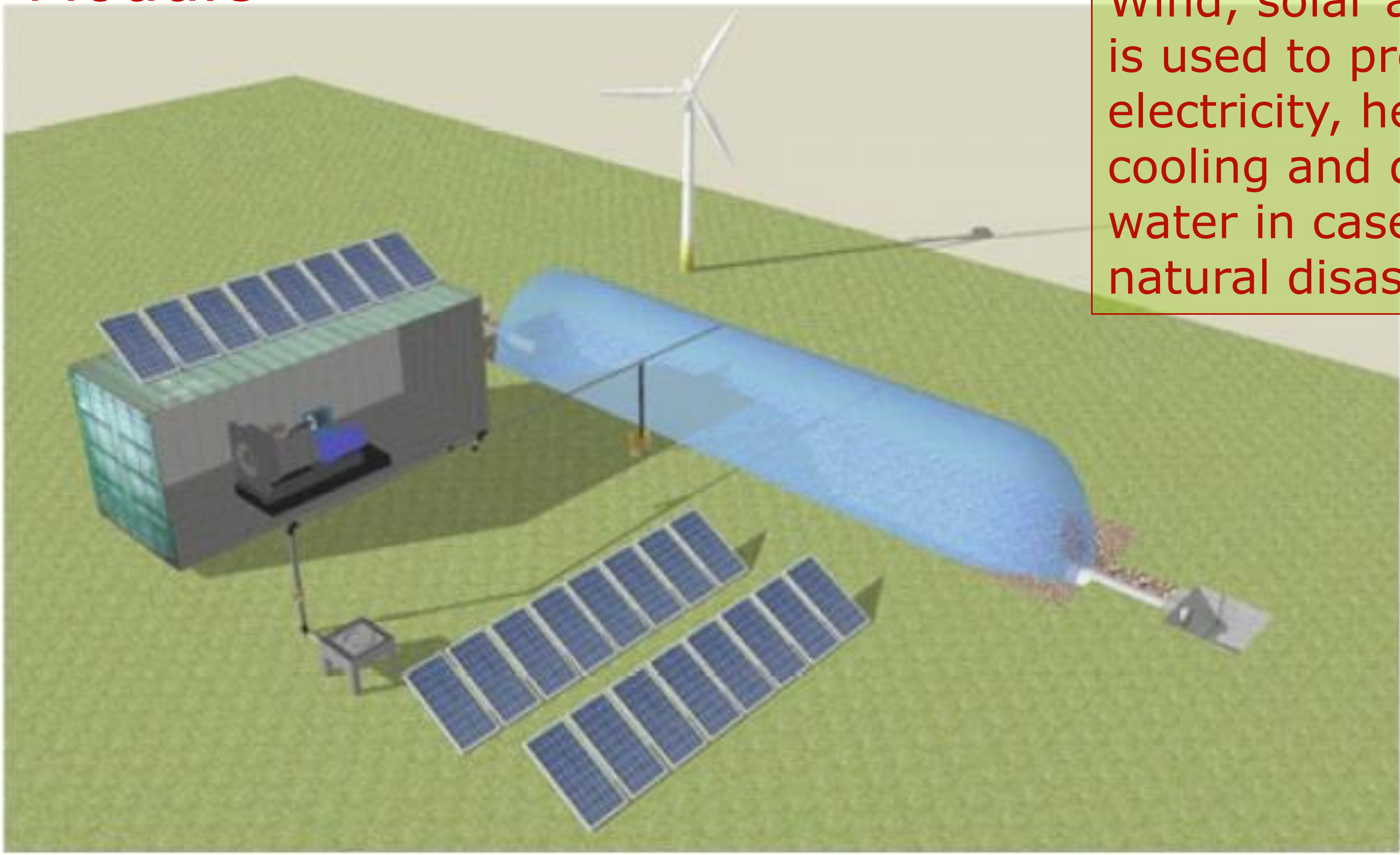
- The implementation of a biogas plant at KTH is feasible technically and economically
- The sustainability of such a project will require the participation of all stakeholders (staff, facilities management and students)
- The operation of a biogas plant requires basic skills in the digestion process

EXPLORE Polygeneration – Emergency Energy Module



Wind, solar and biogas is used to provide electricity, heating/ cooling and drinking water in case of natural disasters

Thanks for your attention! www.explore-polygen.com

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Extra slides

Why anaerobic digestion of wastes

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- Fuel prices
- Renewable energy
- Waste management solution
- Non-expensive energy solution for local areas, rural areas, off-grid areas
- Production of biogas that contains 50-70% methane
- Production of the liquid digestate, a natural and rich fertilizer

Mobile biogas plant basic data

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Function	Capacity
Digester volume	5 m^3 (6 m^3 total incl gas volume)
Processing temperature	30 - 70 °C
Residence time	10 - 50 days
Process capacity	100 - 500 kg wet weight/ day, 0.5 to 25 Nm^3 of biogas/ day (65/35)
Hygienisation capacity	50-600 kg / round (pasteurization - max 80 °C)
Decomposition	Selectable (on board or external)
Heating system	Electric boiler on board 26 kW
Valve Drive	Automatic compressor on board
Emergency gas treatment	Gas monitoring unit and automated flare on board
Gas volume measurement	Continuous online flow rate measurement
Gas quality measurement	Continuous online - CH_4, CO_2, O_2 and H_2S
PLC Management	Fully automatic with remote management and logging via 3G

Main components of the unit

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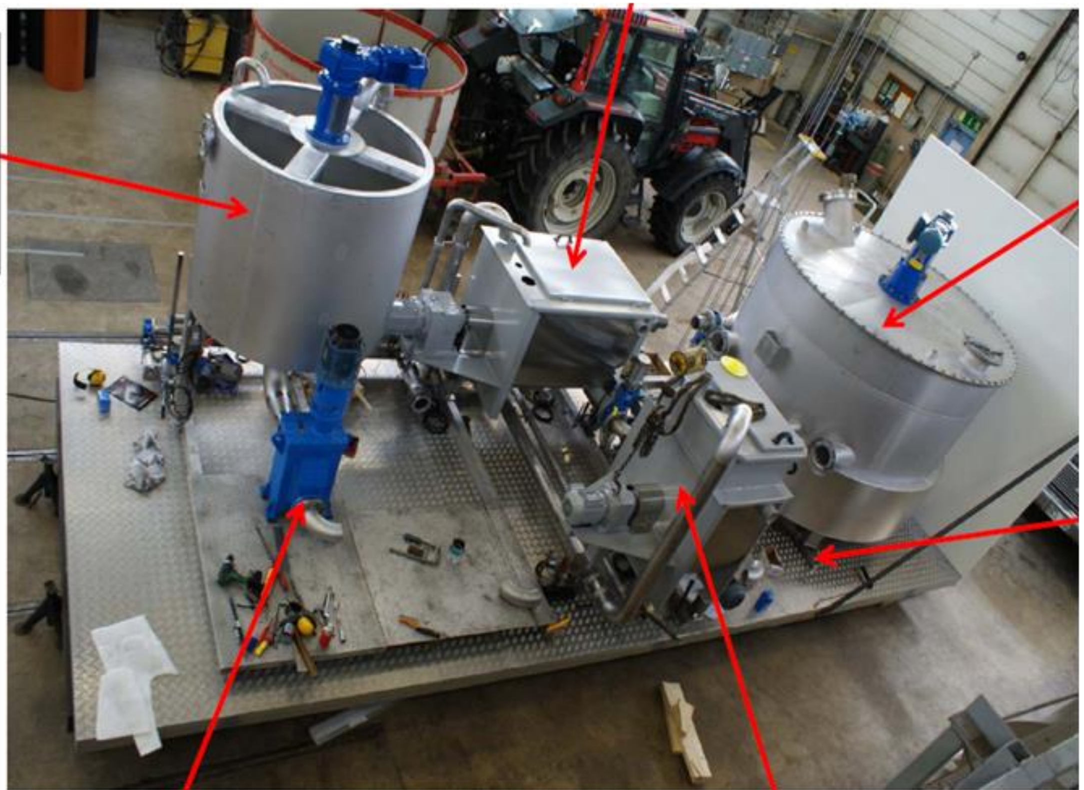
600 litres hygienisation tank
- For dry substrate
- Heavy duty mixers
- Dilution of sewage sludge

Receiving tank
- Buffer
- Mixture
- Dilution with sludge



Digestion tank
5000 litres

Load cells
- All four tanks are on load cells for accurate "Flow Measurement"

Cutting Equipment
- Interchangeable - space for alternative treatment, such as dispersion or polymer dosage

300 litres hygienisation tank
- For light liquid substrate

Problems encountered

- Mode of waste collection of wastes inadequate and waste was not usable (organic part not recoverable)
- High levels of CO_2 in he biogas, indicating imbalance in the bacterial activities
- Increasing levels H_2S formation
- Alarms for high pressure in gas tank (automatic startup of flaring device shut off due to thunderstorms)
- The energy analysis could not be done on this unit (high investment research unit not meant to be energy efficient, short running period)
- Biogas produced could not be tested on any of the laboratory engines due to the amount of gas produced.

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