Biogas Scrubbing- Technologies, Efficacy & Economics

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Cornell | PRO-DAIRY | Dairy Environmental Systems

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Task Force 1

Cornell CALS
College of Agriculture and Life Sciences

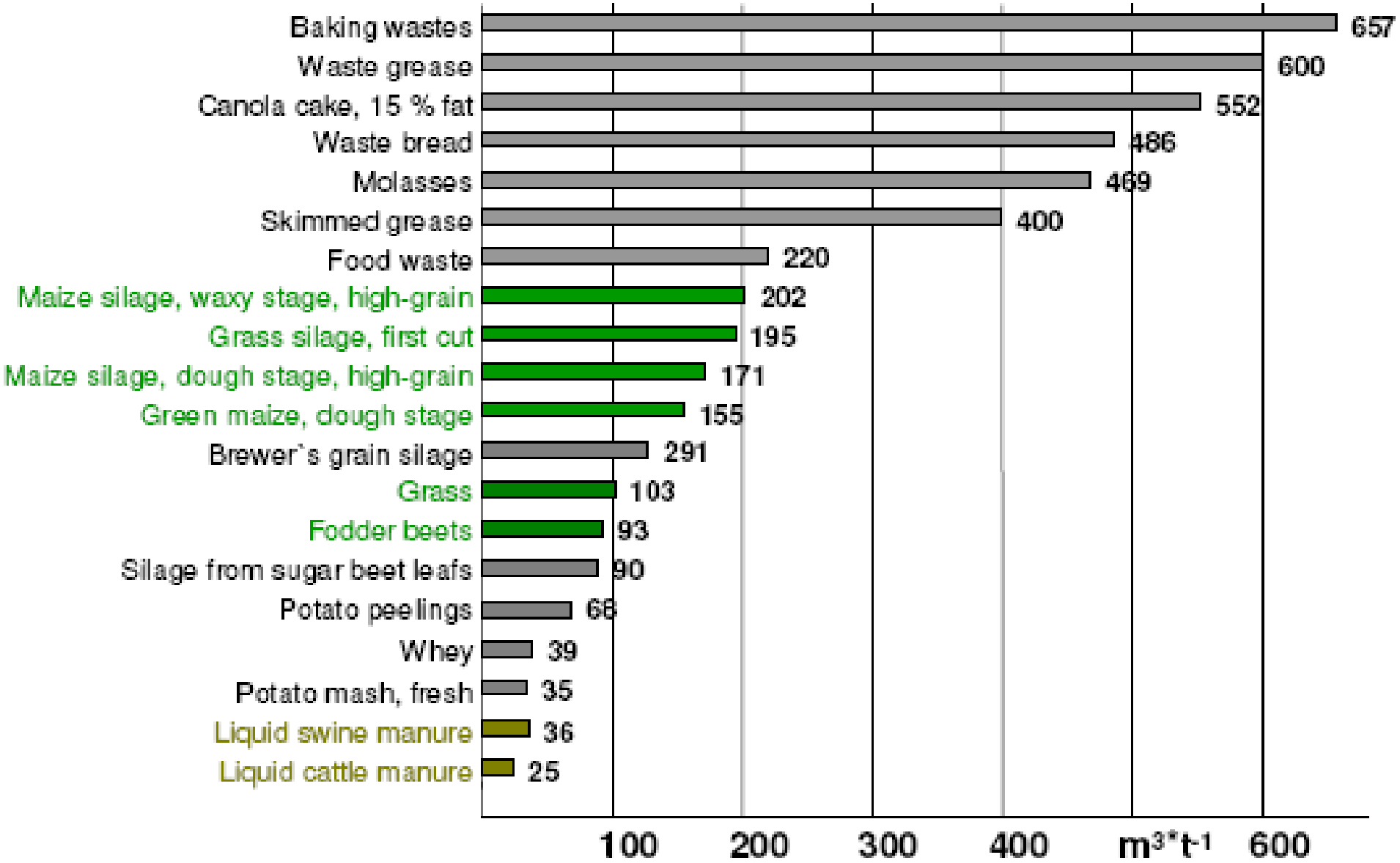
PRO DAIRY
Education & Applied Research

Biogas Yields for Clean-up System Sizing

- Cow manure only anaerobic digester systems: 60 to 100 ft^3 biogas per lactating cow equivalent on a volatile solids basis ($LCE_{vs\ basis}$)

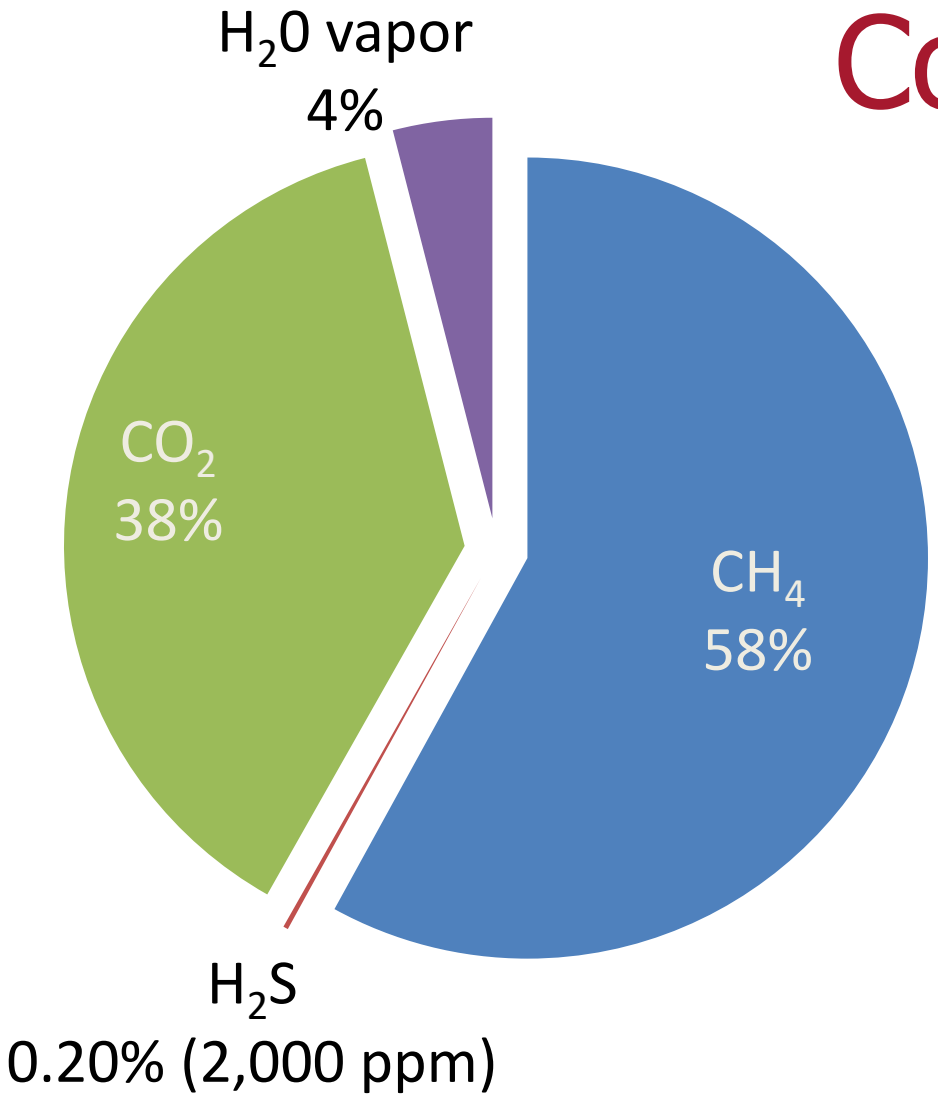
- Co-digestion anaerobic digester systems: 2 – 3x cow manure only systems on a $LCE_{VS\ basis}$ or more

Potential Biogas Yields



Source: Mathias Effenberger, 2006

Dairy Manure Derived Biogas: Raw Composition



- Methane (CH_4); 55 to 68 percent
- Carbon Dioxide (CO_2); 32 to 45 percent
- Hydrogen Sulfide (H_2S); 1,500 – 5,000 ppm
- Ammonia (NH_3); 0 – 300 ppm
- Water Vapor (H_20); saturated gas

Landfill Biogas:
Raw Composition

Dairy Manure Derived Biogas Components plus various other contaminates such as:

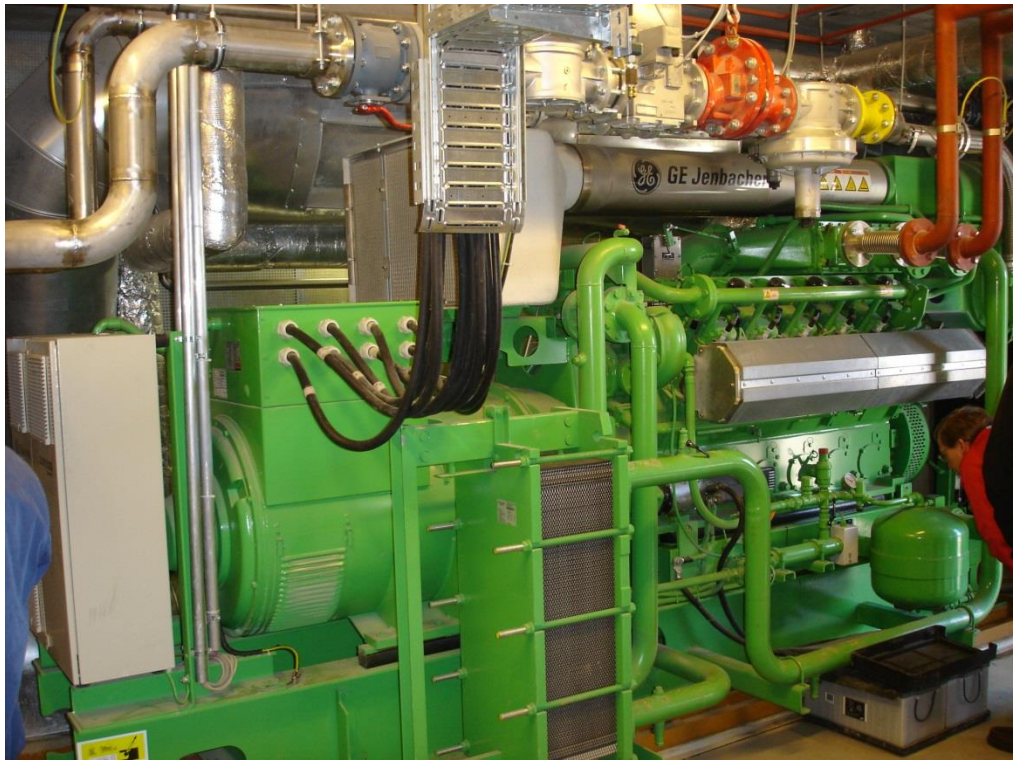
- Siloxanes
- CFCs
- Oxygen
- Nitrogen

Biogas Cleanup – Level 1 of 3

Moisture removal for local pipeline transport

Biogas Cleanup – Level 2 of 3

H_2S and moisture reduction for on-site combustion



Biogas Cleanup – Level 3 of 3

H_2S, H_2O, CO_2, & NH_3 removal for pipeline injection or transportation fuel → "biomethane" and "RNG"

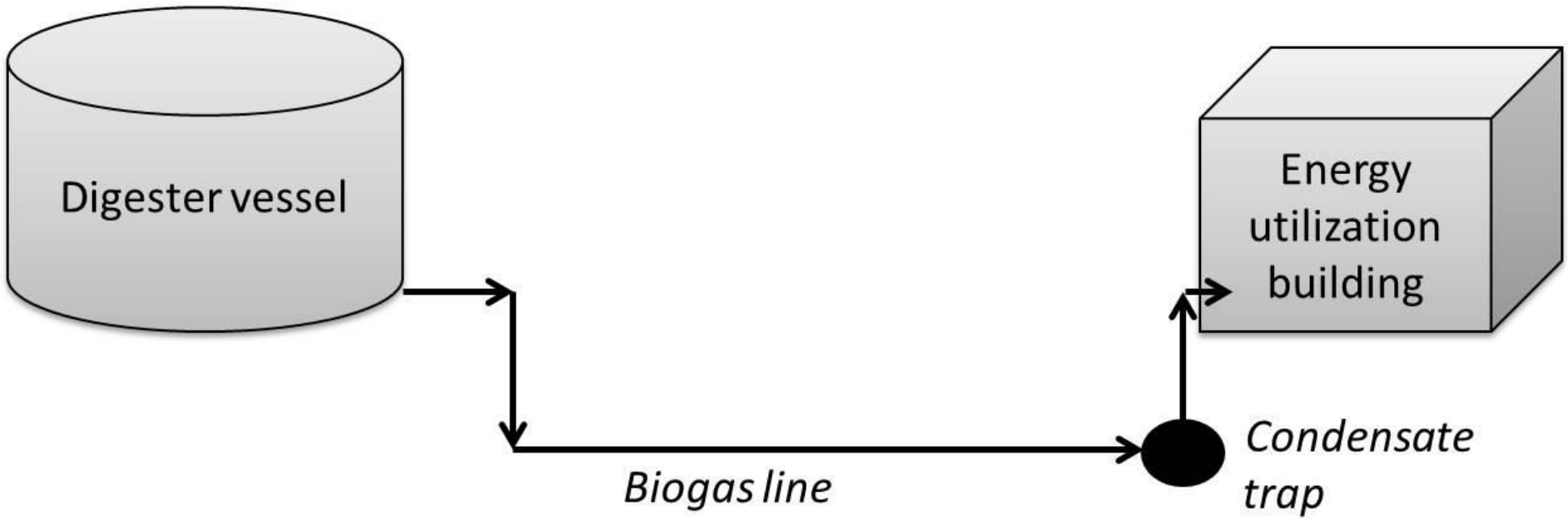
Biogas as Liquid Fuel Replacement

Source: Mike McCloskey, 2012

Level 1: Moisture Removal

1. Passive condensation
2. Refrigeration/chilling
3. Adsorption

Level 1 - Moisture Removal:
Passive Condensation



Level 1 - Moisture Removal: *Refrigeration*

- Heat exchangers used to cool biogas to desired dew point

- Biogas pressurized to increase further dryness
- Condensate removed from system and disposed of as wastewater

Level 1 - Moisture Removal: *Adsorption*

- Adsorption agents used to capture moisture
- Silica gel or aluminum oxide used when biogas used for vehicle fuel
- Two vessels are used for continuous treatment

Level 2: Hydrogen Sulfide (H_2S) Reduction/Removal

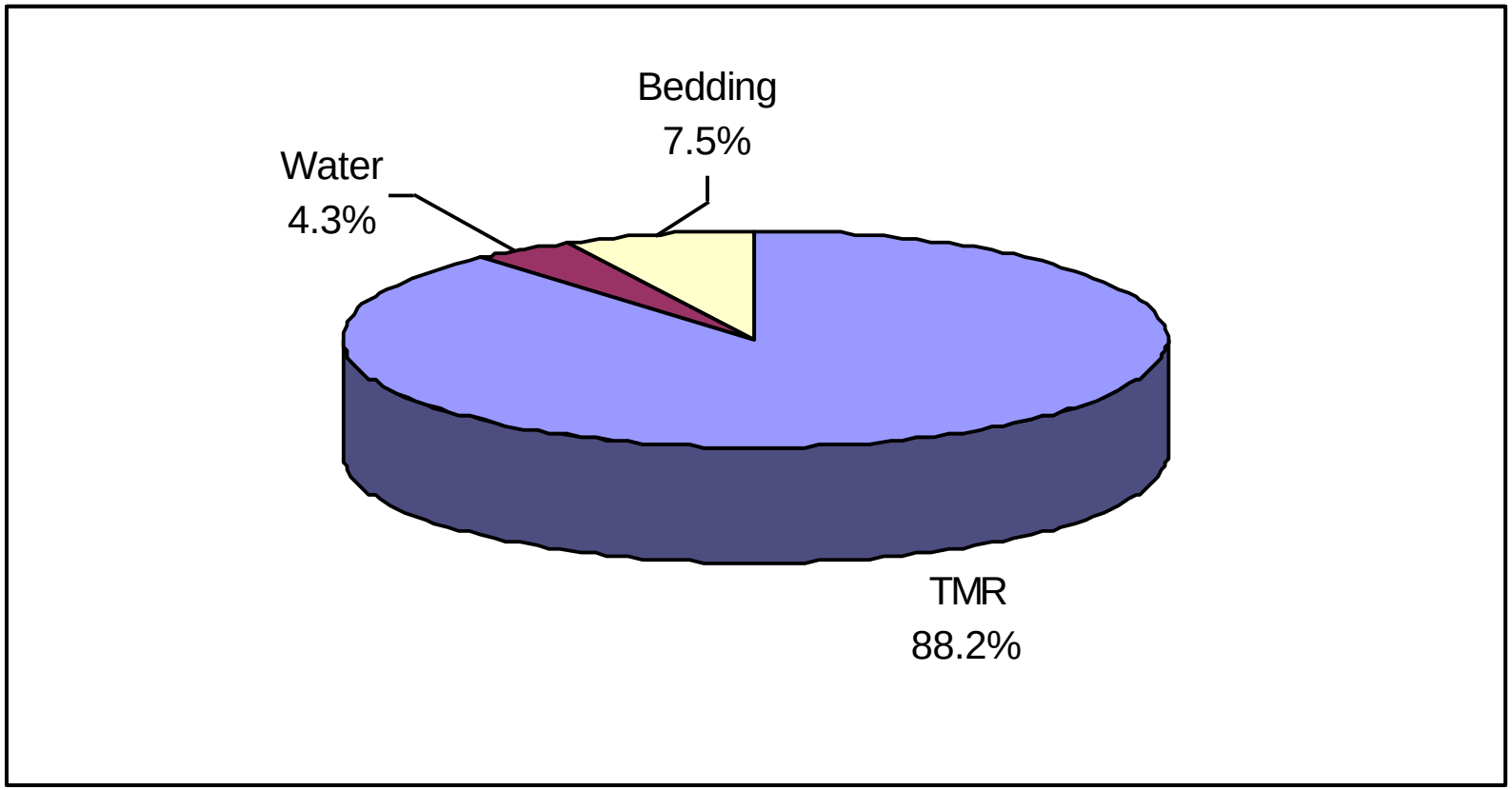
1. Sources

2. Max concentrations for various biogas end usages

3. Reduction options

Hydrogen Sulfide (H_2S)

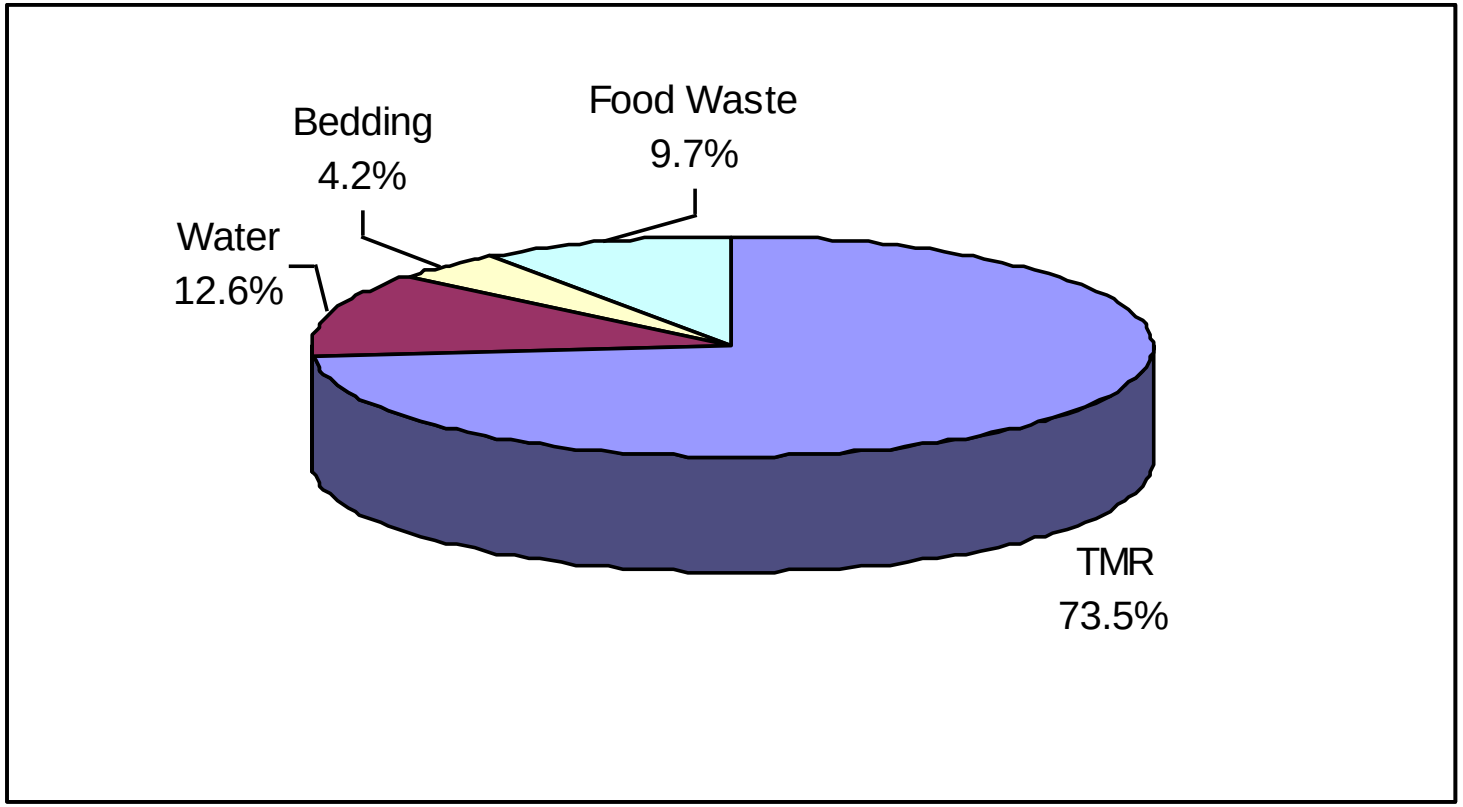
Sources of Sulfur on Farms Not Importing Food Waste for Co-digestion



Source: Ludington and Weeks, 2009

Hydrogen Sulfide (H_2S)

Sources of Sulfur on Farms Importing Food Waste for Co-digestion



Source: Ludington and Weeks, 2009

Hydrogen Sulfide (H_2S)

Max. Concentration for Various Biogas End Uses

Designated End Use	Max. [H_2S], ppm
Boiler	1,000
Engine-Generator	500
Vehicle Fuel	23
Pipeline Injection	4
Fuel Cell	1

Source: Electrigaz Report, 2008

Biogas Hydrogen Sulfide (H_2S) Reduction Options

1. Digester Influent Additives
   - Iron Chloride Dosing
   - Ferric Hydroxide Dosing
2. Biogas: Physical/Chemical
   - Iron Sponge
   - Activated Carbon
3. Biogas: Microbial
   - Biological Fixation

Digester Influent Additive:
Iron *Chloride ($FeCl_2$)*

- Liquid form - Injected directly into digester by an automated dosing unit
- Good for high initial [H_2S] as a first stage of a multistage H_2S removal process
- Comparatively low capital expenditure (CAPEX)
- Comparatively high operating expenditure (OPEX) due to chemical cost


09/18/2009


09/18/2009

Digester Influent Additive:
Ferric *Hydroxide - $Fe(OH)_3$*

- Granular, powder, and liquid forms
- Application rate – nonlinear, depends on $[H_2S]$ and digester size
- Use started this summer by NE farm with very good results (3.5 bags/day)
- Google Search reveals price $600 - $1,500/tonne

Ferric Hydroxide
NE Dairy Farm AD

Ferric Hydroxide - Results