RNG WORKS

THE COALITION FOR RENEWABLE NATURAL GAS

RNG from Co-Digestion: *Constituents NOT of Concern*

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Outline of Talk

- Introduction: Process of Anaerobic Digestion
- Added Co-Substrates/Impact
- Previous Testing of Biogas and Biomethane: GTI Dairy Waste Study
  - What we did
  - Why we did it
  - What we determined
- Supportive Recommendations

Potential RNG by Source

- Landfills
  - 284 billion scfm
  - Enough for 1.86 million homes or to make 22.5 billion kWh of electricity/year
- Livestock Manure
  - 257 billion scfm
  - Enough for 1.09 million homes or to make 13.1billion kWh of electricity/year
- Wastewater Treatment (WWT)
  - 113 billion scfm
  - Enough for 539,00 homes or to make 5.6 billion kWh of electricity/year
- If fully realized, 3.5 million homes and reduce emission equivalent = 800K – 11 million passenger vehicles from the road

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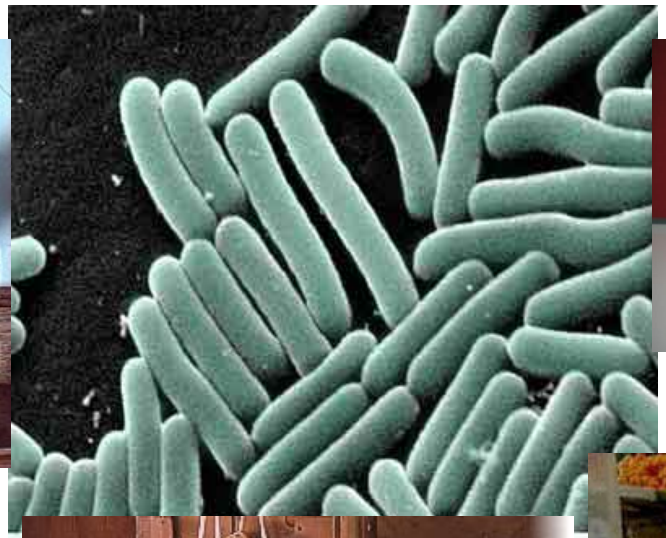
Microbes Do The Work!



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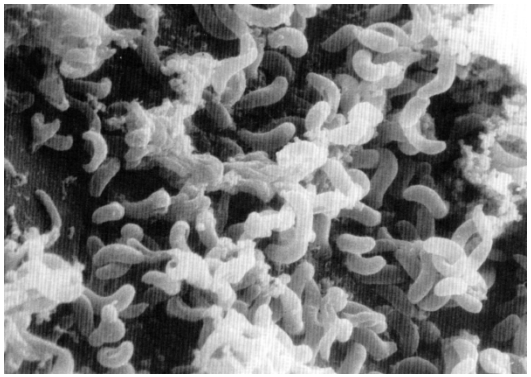
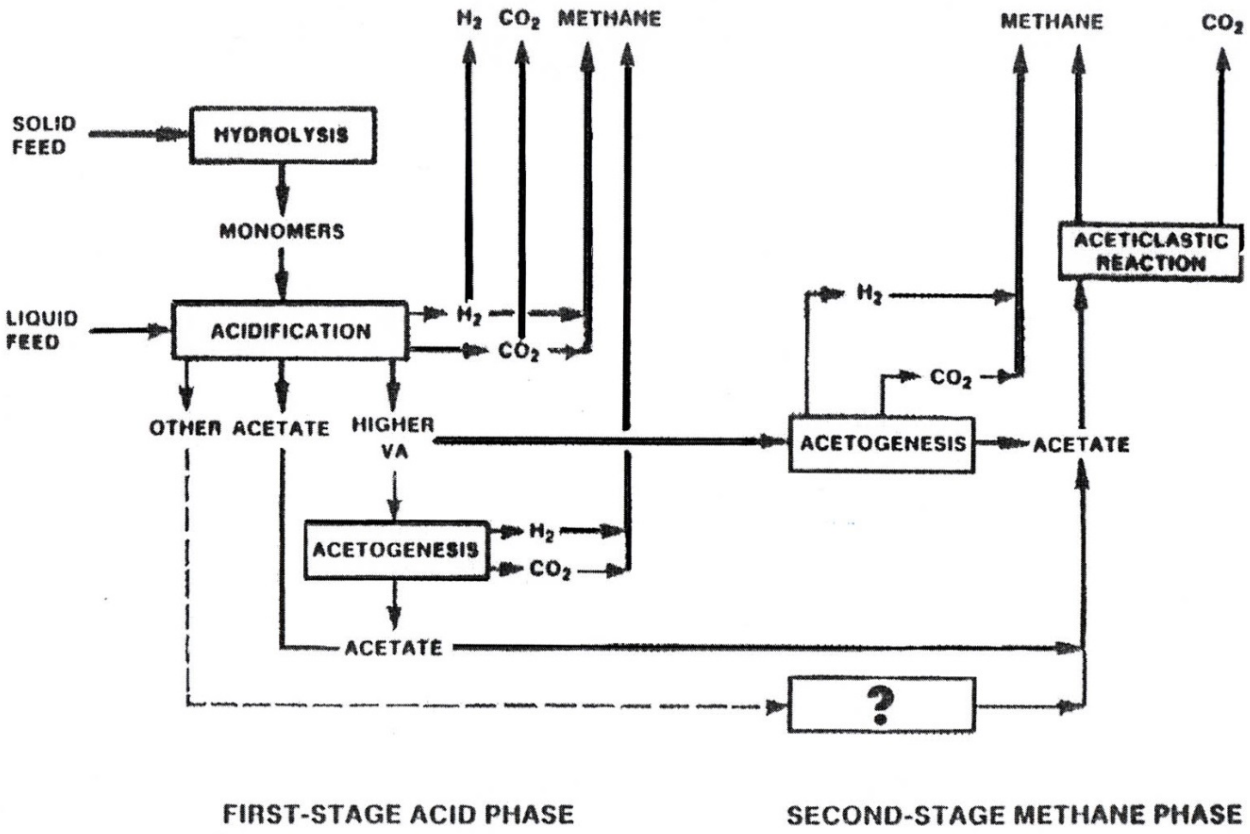
Anaerobic Digestion of Waste to Produce Biogas is a Multi-Step Process

It is MEDIATED by Several Microorganisms:

- **Hydrolytic - Acidogenic**
- **Sulfate - Reducing**
- **Denitrifying**
- **Acetogenic**
- **Syntrophic**
- **Acetoclastic Methanogenic**

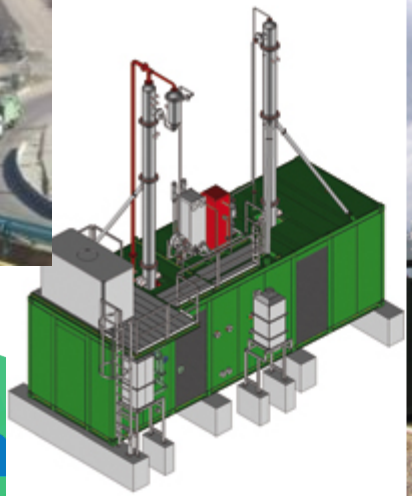


Digestion to Methane is a Two-Phase Process



Anaerobic Digestion of Waste Yields Methane – *but what quantity and quality?*

- Quantity of gas
  - Depends on what goes in the digester
  - Calories in = gas out
- Quality of gas
  - What goes into the digester matters
  - Specific to types of materials digested
  - May be influenced by digester process



Co-Digestates/Substrates Added to Digester Produce More Biogas

- Many high caloric substrates:
  - Cheese Whey
  - Slaughterhouse wastes
  - Pastas
  - FOGs
  - Ice Cream
  - Dog Foods
  - Potatoes/Corn products
  - Industrial Grade Food Wastes
- High energy crops
- Invasive plants

What Goes in the Digester, May Come Out of the Digester…

- Higher Organic Compounds
- VOCs/SVOCs
- Halocarbons
- Pesticides/Herbicides
- Siloxanes
- Pharmaceuticals
- Heavy Metals
- ???

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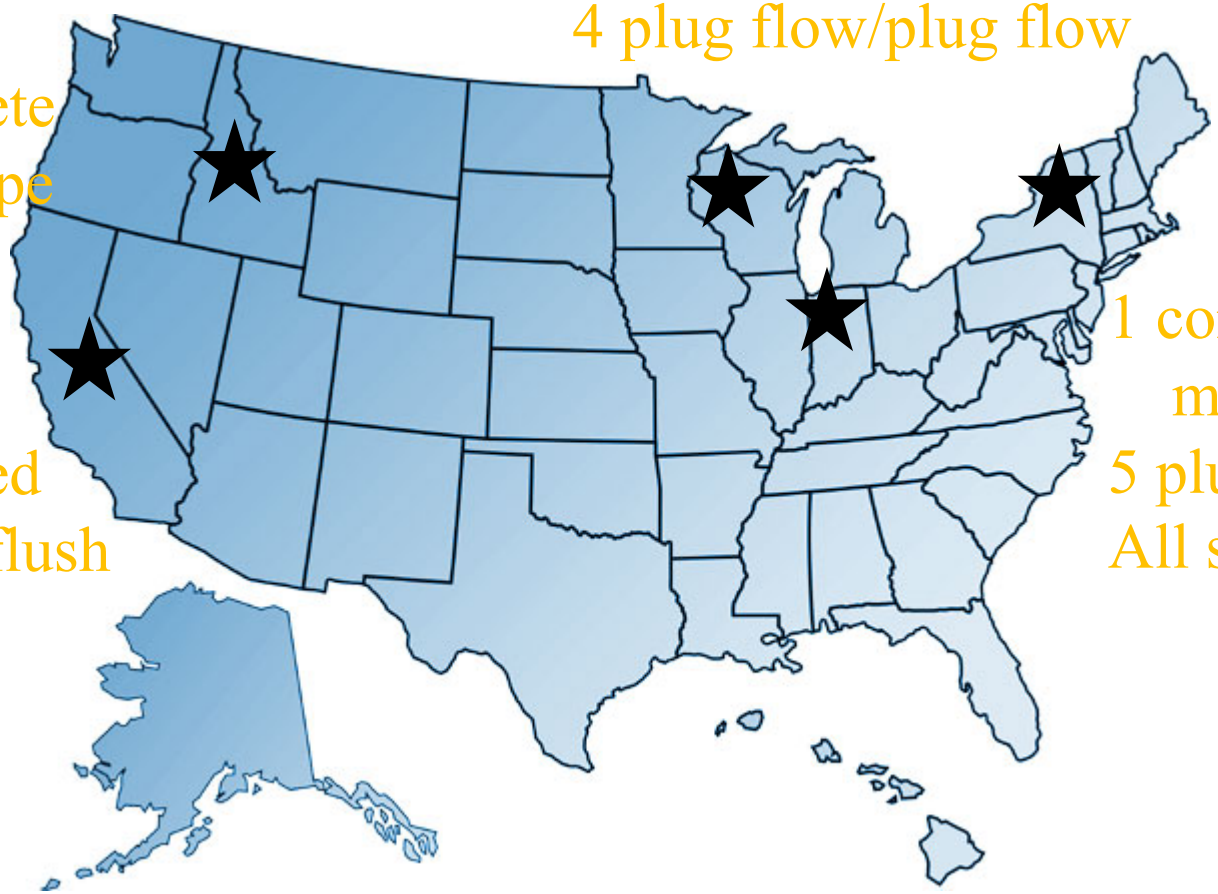
GTI Study Objectives

- To conduct:
  - Extensive sample collection program
  - Laboratory Analysis
    - Tier I and Tier II analysis (Major Components and Trace Constituents)
- To determine the gas quality of:
  - Raw biogas
  - Partially cleaned biogas
  - Biomethane

Sampling Locations: 14 Farms Total



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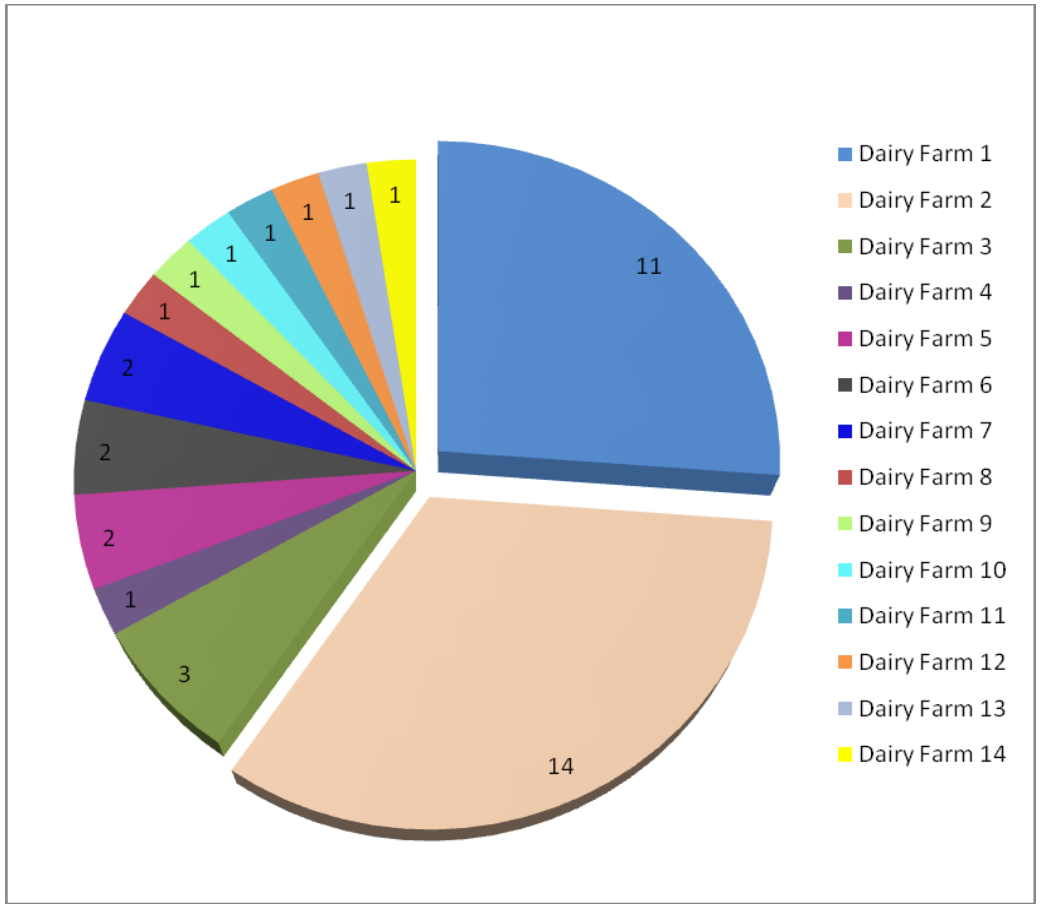
GTI Sampling and Analysis Program



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Testing Protocol

- Major Components
  - Methane
  - Sulfurs (H2S, Mercaptans, Total Sulfur, etc.)
  - Inerts (CO2, N2, O2)
  - Extended hydrocarbons
  - All components typical to natural gas testing
- Trace Constituents
  - Halocarbons
  - Metals
  - Siloxanes
  - Pesticides
  - Pharmaceuticals
  - PCBs
  - VOCs/SVOCs
- Go to www.reethink.net for complete report (Technical Reports)

TESTING IS EXPENSIVE

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Major Components Testing Results: Biomethane

- All Tier 1 constituents within required range and within tariff profile
- Extended Hydrocarbons - one sample contained trace amounts of extended hydrocarbons - 0.0001% to 0.0006% (1 – 2 ppmv)

Results from Major Components Analysis for 23 Biomethane Samples

Compound	Samples Above Detection Limit	Detection Limit(Mol%)	Average (Mol%)	Standard Deviation (Mol%)	Min (Mol%)	Max(Mol%)
Carbon Dioxide	23	0.03	0.54	0.35	0.06	0.95
Oxygen/Argon	10	0.03	0.91	0.51	0.39	1.99
Nitrogen	23	0.03	1.80	2.08	0.20	7.81
Methane	23	0.002	97.26	2.89	89.35	99.63
Ethane	1	0.002	0.11	NA	0.111	0.11
propane	1	0.002	0.028	NA	0.028	0.028
i-Butane	1	0.002	0.005	NA	0.005	0.005
n-Butane	1	0.002	0.005	NA	0.005	0.005
i-pentane	1	0.002	0.002	NA	0.002	0.002
Hexane Plus	1	0.0001	0.0021	NA	0.0021	0.000021
Carbonyl Sulfide	13	0.000005	0.000013	0.000016	0.000005	0.000053

Trace Constituent Testing Results: Biomethane

- Halocarbons, metals, siloxanes – all BDL
- PCBs and Pharmaceuticals – all BDL
- VOC/SVOC concentrations very low
- Only one sample collected from contained pesticides
  - 0.52 ppbv of gamma-chlordane
  - The OSHA REL for gamma-chlordane is 30 ppb.

Results from VOCs/SVOCs Analysis for 13 Biomethane Samples

Compound	Samples Above Detection Limit	Average (ppbv)	Standard Deviation	Min (ppbv)	Max (ppbv)
Benzene	1	27.09	NA	27.09	27.09
Carbon Tetrachloride	12	1.24	0.50	0.66	2.01
Toluene	13	12.52	28.91	1.67	107.54
Ethylbenzene	4	1.83	1.10	0.53	3.04
m/p-Xylenes	12	2.60	3.03	1.17	11.25
o-Xylene	5	1.54	1.30	0.48	3.36
1,3,5-Trimethylbenzene	1	0.69	NA	0.69	0.69
1,2,4-Trimethylbenzene	1	0.71	NA	0.71	0.71
Benzyl Alcohol	1	2.10	NA	2.10	2.10
N-nitroso-di-n-propylamine	7	2.92	0.75	1.45	3.60
Naphthalene	4	1.19	0.70	0.41	2.06
Di-n-butylphthalate	12	0.96	0.69	0.22	2.29
bis(2-Ethylhexyl)phthalate	13	0.44	0.19	0.20	0.81

Halocarbons Analysis - EPA TO-14 GC/ELCD

Biogas Type		raw	raw	Raw	Raw	raw	raw	raw	raw
Dairy Farm		2	3	6	7	8	9	10	11
Sample ID		081227-001	081079-003	081289-003	081303-001	081055-001	081182-001	081188-002	081189-001
Sampling Date		4/16/2008	2/5/2008	5/14/2008	5/15/2008	1/24/2008	3/26/2008	3/27/2008	3/27/2008
Halocarbons (ppmv)	Detection Limit (ppmv)								
Dichlorodifluoromethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,2-Dichlorotetrafluoroethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1,2-Trichloro-1,2,2-trifluoroethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Trichlorofluoromethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chloromethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Dichloromethane (Methylene Chloride)	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chloroform	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Carbon Tetrachloride	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chloroethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1-Dichloroethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,2-Dichloroethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1,1-Trichloroethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1,2-Trichloroethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1,2,2-Tetrachloroethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chloroethene (Vinyl Chloride)	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1-Dichloroethene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
cis-1,2-Dichloroethene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Trichloroethene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Tetrachloroethene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,2-Dichloropropane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
3-Chloropropene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
cis-1,3-Dichloropropene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
trans-1,3-Dichloropropene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Bromomethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,2-Dibromoethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chlorobenzene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,2-Dichlorobenzene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,3-Dichlorobenzene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,4-Dichlorobenzene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,2,4-Trichlorobenzene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Hexachloro-1,3-butadiene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total TO-14 Halocarbon Components:	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Halocarbons Analysis - EPA TO-14 GC/ELCD

Biogas Type		biomethane	biomethane	biomethane	biomethane	biomethane	biomethane	biomethane	biomethane
Dairy Farm		1	1	1	1	1	1	1	1
Sample ID		081048-001	081215-001	081215-002	081215-003	081215-004	081215-005	081215-006	081215-007
Sampling Date		1/22/2008	4/7/2008	4/7/2008	4/8/2008	4/8/2008	4/9/2008	4/9/2008	4/10/2008
Halocarbons (ppmv)	Detection Limit (ppmv)								
Dichlorodifluoromethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,2-Dichlorotetrafluoroethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1,2-Trichloro-1,2,2-trifluoroethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Trichlorofluoromethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chloromethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Dichloromethane (Methylene Chloride)	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chloroform	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Carbon Tetrachloride	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chloroethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1-Dichloroethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,2-Dichloroethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1,1-Trichloroethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1,2-Trichloroethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1,2,2-Tetrachloroethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chloroethene (Vinyl Chloride)	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1-Dichloroethene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
cis-1,2-Dichloroethene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Trichloroethene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Tetrachloroethene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,2-Dichloropropane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
3-Chloropropene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
cis-1,3-Dichloropropene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
trans-1,3-Dichloropropene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Bromomethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,2-Dibromoethane	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chlorobenzene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,2-Dichlorobenzene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,3-Dichlorobenzene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,4-Dichlorobenzene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,2,4-Trichlorobenzene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Hexachloro-1,3-butadiene	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total TO-14 Halocarbon Components:	0.10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Mercury Analysis - ASTM D5954
Metals Analysis - ICP EPA Method 29 Mod.

Biogas Type		**raw**	**raw**	**raw**	**Raw**	**raw**
Dairy Farm		**10**	**11**	**12**	**13**	**14**
Sample ID		**081188-002**	**081189-001**	**081242-001**	**081288-001**	**071735-001**
Sampling Date		**3/27/2008**	**3/27/2008**	**4/23/2008**	**5/13/2008**	**11/16/2007**
	Detection Limit					
Metals ($\mu g/M^3$)	($\mu g/M^3$)					
Mercury	0.02	BDL	BDL	BDL	BDL	BDL
Arsenic	20	BDL	BDL	BDL	BDL	not tested
Cadmium	2	BDL	BDL	BDL	BDL	not tested
Copper	20	BDL	BDL	BDL	60	not tested
Lead	20	BDL	BDL	BDL	BDL	not tested
Molybdenum	2	BDL	BDL	BDL	BDL	not tested
Selenium	20	BDL	BDL	BDL	BDL	not tested

Mercury Analysis - ASTM D5954
Metals Analysis - ICP EPA Method 29 Mod.

Biogas Type		biomethane	biomethane	biomethane	biomethane	biomethane	biomethane	biomethane	biomethane
Dairy Farm		1	1	1	1	1	1	1	1
Sample ID		081048-001	081215-001	081215-002	081215-003	081215-004	081215-005	081215-006	081215-007
Sampling Date		1/22/2008	4/7/2008	4/7/2008	4/8/2008	4/8/2008	4/9/2008	4/9/2008	4/10/2008
	Detection Limit								
Metals ($\mu g/M^3$)	($\mu g/M^3$)								
Mercury	0.02	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Arsenic	20	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Cadmium	2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Copper	20	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Lead	20	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Molybdenum	2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Selenium	20	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Siloxanes Analysis - GC/AED

Biogas Type		raw	raw	raw	Raw	Raw	raw
Dairy Farm		1	2	3	6	7	8
Sample ID		081048-004	081227-001	081079-003	081289-003	081303-001	081055-001
Sampling Date		1/23/2008	4/16/2008	2/5/2008	5/14/2008	5/15/2008	1/24/2008
Siloxanes (ppmv)	Detection Limit						
1,1,3,3-Tetramethyldisiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL
Pentamethyldisiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL
Hexamethyldisilane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL
Hexamethyldisiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL
Octamethyltrisiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL
Octamethylcyclotetrasiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL
Decamethyltetrasiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL
Decamethylcyclopentasiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL
Dodecamethylpentasiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL

Siloxanes Analysis - GC/AED

Biogas Type		raw	raw	raw	raw	Raw	raw
Dairy Farm		9	10	11	12	13	14
Sample ID		081182-001	081188-002	081189-001	081242-001	081288-001	071735-001
Sampling Date		3/26/2008	3/27/2008	3/27/2008	4/23/2008	5/13/2008	11/16/2007
Siloxanes (ppmv)	Detection Limit						
1,1,3,3-Tetramethyldisiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL
Pentamethyldisiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL
Hexamethyldisilane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL
Hexamethyldisiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL
Octamethyltrisiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL
Octamethylcyclotetrasiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL
Decamethyltetrasiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL
Decamethylcyclopentasiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL
Dodecamethylpentasiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL

Siloxanes Analysis - GC/AED

Biogas Type		biomethane	biomethane	biomethane	biomethane	biomethane	biomethane	biomethane	biomethane
Dairy Farm		1	1	1	1	1	1	1	1
Sample ID		081048-001	081215-001	081215-002	081215-003	081215-004	081215-005	081215-006	081215-007
Sampling Date		1/22/2008	4/7/2008	4/7/2008	4/8/2008	4/8/2008	4/9/2008	4/9/2008	4/10/2008
Siloxanes (ppmv)	Detection Limit								
1,1,3,3-Tetramethyldisiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Pentamethyldisiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Hexamethyldisilane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Hexamethyldisiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Octamethyltrisiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Octamethylcyclotetrasiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Decamethyltetrasiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Decamethylcyclopentasiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Dodecamethylpentasiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Siloxanes Analysis - GC/AED

Biogas Type		biomethane	biomethane	biomethane	biomethane	biomethane	biomethane	biomethane	biomethane
Dairy Farm		2	2	2	2	2	2	2	2
Sample ID		071759-001	071789-001	081168-001	081220-001	081227-002	081247-001	081266-001	081290-001
Sampling Date		11/27/2007	12/11/2007	3/18/2008	3/18/2008	4/16/2008	4/23/2008	4/30/2008	5/14/2008
Siloxanes (ppmv)	Detection Limit								
1,1,3,3-Tetramethyldisiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Pentamethyldisiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Hexamethyldisilane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Hexamethyldisiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Octamethyltrisiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Octamethylcyclotetrasiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Decamethyltetrasiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Decamethylcyclopentasiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Dodecamethylpentasiloxane	0.5 ppmv Si	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Summary of Second Tier Chemical Testing Data

SVOCs/VOCs (ppb)	Detection Limit Min	Detection Limit Max	Avergage			Maximum			OSHA PEL TWA (ppb)	NIOSH REL TWA (ppb)
			Raw Biogas	Partially Clean Biogas	Clean Biogas	Raw Biogas	Partially Clean Biogas	Clean Biogas		
Di-n-octylphthalate	0.11	0.79	BDL	BDL	BDL	BDL	BDL	BDL		
Benzo[b]fluoranthene	0.18	1.22	BDL	BDL	BDL	BDL	BDL	BDL		
Benzo[k]fluoranthene	0.18	1.22	BDL	BDL	BDL	BDL	BDL	BDL		
Benzo[a]pyrene	0.18	1.22	BDL	BDL	BDL	BDL	BDL	BDL		
Indeno[1,2,3-cd]pyrene	0.16	1.12	BDL	BDL	BDL	BDL	BDL	BDL		
Dibenz[a,h]anthracene	0.16	1.11	BDL	BDL	BDL	BDL	BDL	BDL		
Benzo[g,h,i]perylene	0.16	1.12	BDL	BDL	BDL	BDL	BDL	BDL		
Pesticides (ppb)										
a-BHC	1.68E-04	7.57E-04	BDL	BDL	BDL	BDL	BDL	BDL		
b-BHC	1.68E-04	7.57E-04	BDL	BDL	BDL	BDL	BDL	BDL		
g-BHC	1.68E-04	7.57E-04	BDL	BDL	BDL	BDL	BDL	BDL		
d-BHC	1.68E-04	7.57E-04	BDL	BDL	BDL	BDL	BDL	BDL		
Heptachlor	1.31E-04	5.90E-04	1.33E-02	1.33E-02	BDL	1.33E-02	1.33E-02	BDL	33	33
Aldrin	1.34E-04	6.03E-04	BDL	BDL	BDL	BDL	BDL	BDL		
Heptachlor epoxide	1.26E-04	5.66E-04	1.33E-02	3.41E-02	BDL	1.33E-02	3.41E-02	BDL	33	33
g-Chlordane	1.19E-04	5.37E-04	BDL	BDL	5.17E-01	BDL	BDL	5.17E-01	30	30
Endosulfan I	1.20E-04	5.41E-04	1.52E-03	7.97E-03	BDL	1.52E-03	7.97E-03	BDL	6	6
a-Chlordane	1.19E-04	5.37E-04	BDL	BDL	BDL	BDL	BDL	BDL		
Dieldrin	1.28E-04	5.78E-04	BDL	BDL	BDL	BDL	BDL	BDL		
4,4'-DDE	1.54E-04	6.92E-04	BDL	BDL	BDL	BDL	BDL	BDL		
Endrin	1.28E-04	5.78E-04	1.22E-03	BDL	BDL	1.22E-03	BDL	BDL	6	6
Endosulfan II	1.20E-04	5.41E-04	BDL	9.96E-03	BDL	BDL	1.24E-02	BDL	NA	NA
4,4'-DDD	1.53E-04	6.88E-04	1.50E-03	1.82E-02	BDL	1.57E-03	2.52E-02	BDL	NA	NA
Endrin aldehyde	1.28E-04	5.78E-04	3.19E-03	2.08E-02	BDL	5.87E-03	2.08E-02	BDL	NA	NA
Endosulfan sulfate	1.16E-04	5.21E-04	BDL	1.04E-02	BDL	BDL	1.04E-02	BDL	NA	NA
4,4'-DDT	1.38E-04	6.21E-04	1.12E-02	1.14E-02	BDL	1.58E-02	1.42E-02	BDL	69	35
Endrin ketone	1.28E-04	5.78E-04	BDL	BDL	BDL	BDL	BDL	BDL		
Methoxychlor	1.42E-04	6.37E-04	1.51E-02	4.62E-02	BDL	4.71E-02	1.89E-01	BDL	1062	NA
PCBs (ppb)										
PCB 1	2.72E-03	8.04E-03	BDL	BDL	BDL	BDL	BDL	BDL		
PCB 2	2.72E-03	8.04E-03	BDL	BDL	BDL	BDL	BDL	BDL		
PCB 3	2.72E-03	8.04E-03	BDL	BDL	BDL	BDL	BDL	BDL		
PCB 4	2.30E-03	6.80E-03	BDL	BDL	BDL	BDL	BDL	BDL		
PCB 10	2.30E-03	6.80E-03	BDL	BDL	BDL	BDL	BDL	BDL		
PCB 7	2.30E-03	6.80E-03	BDL	BDL	BDL	BDL	BDL	BDL		
PCB 9	2.30E-03	6.80E-03	BDL	BDL	BDL	BDL	BDL	BDL		
PCB 6	2.30E-03	6.80E-03	BDL	BDL	BDL	BDL	BDL	BDL		
PCB 8	2.30E-03	6.80E-03	BDL	BDL	BDL	BDL	BDL	BDL		
PCB 5	2.30E-03	6.80E-03	BDL	BDL	BDL	BDL	BDL	BDL		
PCB 19	2.00E-03	5.89E-03	BDL	BDL	BDL	BDL	BDL	BDL		
PCB 12	2.30E-03	6.80E-03	BDL	BDL	BDL	BDL	BDL	BDL		
PCB 13	2.30E-03	6.80E-03	BDL	BDL	BDL	BDL	BDL	BDL		
PCB 18	2.00E-03	5.89E-03	BDL	BDL	BDL	BDL	BDL	BDL		
PCB 17	2.00E-03	5.89E-03	BDL	BDL	BDL	BDL	BDL	BDL		
PCB 15	2.30E-03	6.80E-03	BDL	BDL	BDL	BDL	BDL	BDL		
PCB 24	2.00E-03	5.89E-03	BDL	BDL	BDL	BDL	BDL	BDL		
PCB 27	2.00E-03	5.89E-03	BDL	BDL	BDL	BDL	BDL	BDL		
PCB 16	2.00E-03	5.89E-03	BDL	BDL	BDL	BDL	BDL	BDL		
PCB 32	2.00E-03	5.89E-03	BDL	BDL	BDL	BDL	BDL	BDL		
PCB 34	2.00E-03	5.89E-03	BDL	BDL	BDL	BDL	BDL	BDL		
PCB 29	2.00E-03	5.89E-03	BDL	BDL	BDL	BDL	BDL	BDL		
PCB 54	1.76E-03	5.19E-03	BDL	BDL	BDL	BDL	BDL	BDL		

Study Conclusions:

- Conditioning systems can be designed to produce biomethane which fall within *typical pipeline tariffs ranges* (reported in AGA Report 4A).
- Particular tariff requirements (specific company) can also be met.
- Other target compounds, not commonly found in natural gas, were detected in biomethane samples in very low concentrations (parts per billion). The concentrations found were below NIOSH and OSHA exposure limits. There is some discussion on the application of these criteria to assess biomethane.
- H2S can be found in very concentrations in raw biogas, not in cleaned biomethane

Recommendations: Dairy/Co-Digestion Testing

- CCST Report:
  - No testing for siloxanes in dairy waste, ag waste, forestry residues
- Verification Programs (REEthink):
  - No testing for halocarbons
  - No testing for heavy metals
  - No testing for vinyl chloride
  - No testing VOCs/SVOCs
- DO test for:
  - Ammonia
  - Hydrogen sulfide
  - Hydrogen
  - Biologicals in pipe monitoring (filter/coupon in pipe), NOT bacterial enumeration

REE(think)

Comments Regarding Landfill and WWT RNG

- Specifications for RNG should be based on scientific reference:
  - Justification
  - Non-prejudicial
  - Scientific and sound reasoning
- Specification is supported by verification testing
- RNG testing is expensive but necessary
- RNG production is an emerging field and much needs to be examined/assessed for safety and performance

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