Renewable Natural Gas (RNG): Gas Quality Considerations

AGA/EPA Renewable Natural Gas Workshop
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Company Overview

- Independent, not-for-profit established by the natural gas industry
- GTI tackles tough energy challenges turning raw technology into practical solutions
- Downhole to the burner tip including energy conversion technologies

360+ EMPLOYEES

RESEARCH & DEVELOPMENT

PROGRAM MANAGEMENT

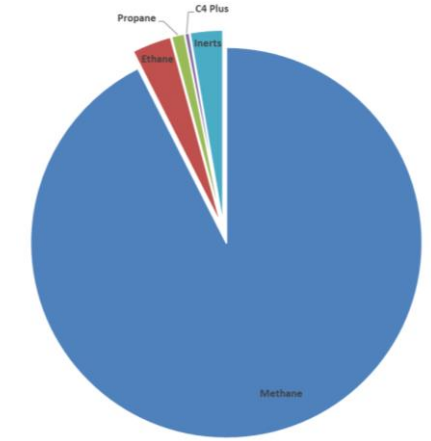
TECHNICAL/ ANALYTICAL

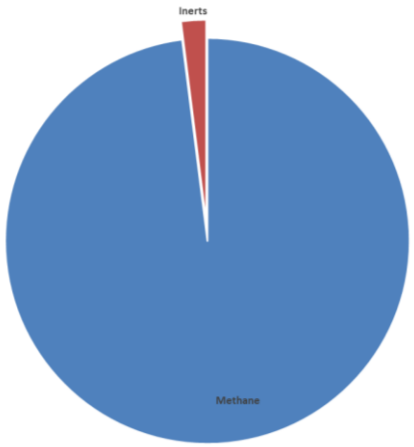
CONSULTING

TRAINING

What is the Difference between “Conventional Pipeline Gas” and “Renewable Natural Gas”?

- **Pipeline quality gas** is not a pure compound but instead is a mixture of different hydrocarbon compounds along with inert gases, diluent gases, and other trace constituents
- **Conventional Pipeline Gas is 90% - 98% methane (CH4)***
  - Trace constituents are understood
  - Utility and Interstate pipeline tariffs account for typical components
  - Methods for treating “raw” gas are proven and in-place
- **RNG is 95% - 98% methane* (post cleanup)**
  - Trace constituents are not as well understood
  - Utility and Interstate pipeline tariffs don’t typically address all potential components
  - Methods for treating “raw” biogas can be costly





Renewable Natural Gas Challenges

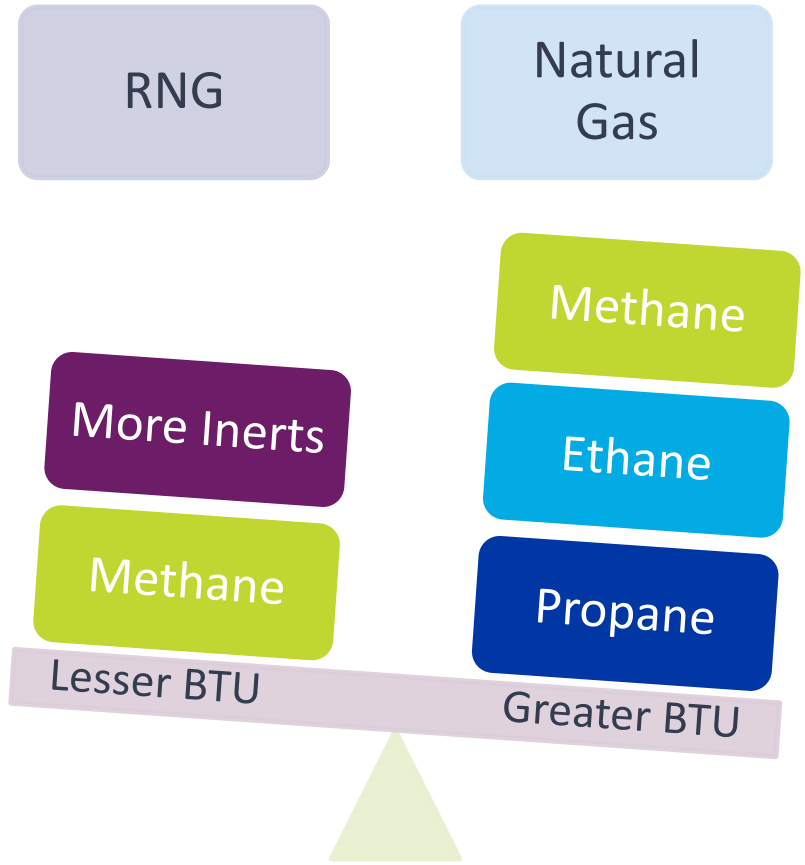
- Supply Stability: Variability in composition & supply
- What is the impact if constituents break through?
- Impact on Infrastructure / Pipeline integrity:
  - CO_2, water, H_2, sulfur compounds, NH_3, bacteria, etc.
- Impact on end use applications:
  - CO_2, CO, H_2 all impact flame stability, engine knock
  - Siloxanes
- Safety – Odorization and leak detection
- Contaminant Disposal – Cleanup media generally not recyclable
- Fuel cell applications?

Impact on Pipeline Infrastructure

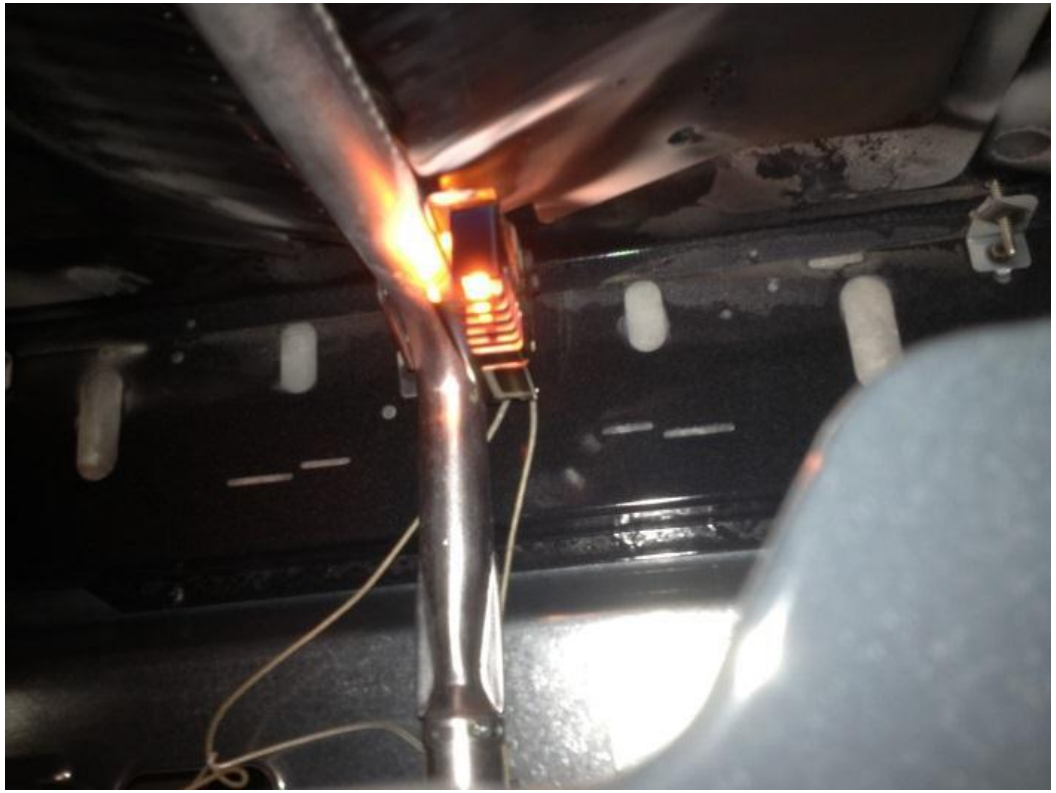
- Impact if constituents aren't cleaned from the gas
- Acid formation from constituents promoting corrosion
  - Sulfur compounds,
  - Carbonic acids,
  - Halocarbons,
  - MIC classified microbes (SRB, APB, IOB, SRA, methanogens)
- Deposits from contaminants
- Water accumulation in the pipeline

Impact on End Use Applications

- Impact if constituents aren't cleaned from the gas
- Gas heating value / Wobbe Number
  - Diminished by inerts in gas stream
  - Will be naturally lower for RNG
- Deposits from contaminants
- Emissions from VOCs introduced into pipeline
- NOx formation from ammonia compounds



Impact on End Use Applications from Raw Biogas



Silica deposits from siloxanes in a **raw biogas** stream on failing glow plug (left) and water heater burner (right)
Note that this is a worst case scenario using raw biogas siloxane concentrations.

Impact on Gas Odorization

- Impact if constituents aren't cleaned from the gas
- Aldehydes and ketones are found in raw biogas
- Known odor contributors
- Concern is interaction with odorants added to the gas per Federal Pipeline Safety Regulations (§192.625) for distribution lines and some transmission lines
- "Normal sense of smell"
- Odor masking or odorant interactions with these compounds may change the smell of the gas

http://heathus.com/products/odorator/

https://sensonics.com/smell-products/gas-company-smell-test.html

http://www.mybacharach.com/wp-content/uploads/pdf/mybacharach/0023-9125.pdf

Typical tariff constituents

Typical non-tariff constituents

Constituents of Interest in Renewable Gas

- Major hydrocarbons
- Major and minor non-hydrocarbons (CO_2, O_2, H_2, He, N_2)
- Sulfur compounds (H_2S, mercaptans, and others)
- Metals (mercury and other volatile elements)
- Water
- Halogenated hydrocarbons
- Volatile Organics (BTEX, VOC/SVOCs, aldehydes, ketones)
- Ammonia and amines
- Siloxanes
- Bacteria, microbes, and MIC

What Constituents Should We Look For???

Those found in natural gas for which tariffs exist.

Constituents that are known to be present in the processed biomethane, or are of interest, due to potential breakthrough, because of their presence in untreated biogas.

Any constituent that may pass through gas processing/purification equipment and that will have an impact on

- Pipeline integrity
- End use applications

Major Constituents

		High BTU Dairy		High BTU Landfill		High BTU WWTP		Pipeline Quality Natural Gas	
	DL	min	max	min	max	min	max	min	max
Methane, vol%	0.002	92.19	99.63	90.03	99.41	99.3	99.5	81.1	99.1
C2+ hydrocarbons, vol%	0.002	BDL	BDL	BDL	0.02	BDL	0.005	0.01	17.5
Hydrogen, vol%	0.1	BDL	BDL	BDL	1.0	BDL	BDL	BDL	0.18
Gross HV, dry, BTU/SCF, 60F/14.73		935	1011	913	995	1008	1009	885	1193
Wobbe, BTU/SCF, 60F/14.73		1213	1354	1180	1351	1345	1349	1135	1393

Tariffs Specific to Biomethane	Company A		Company B		Company C		Company D		Company E		Company F	
	min	max	min	max	min	max	min	max	min	max	min	max
Hydrogen, vol%		0.1		0.1		0.1		0.1		0.1		0.06
Gross HV, dry, BTU/SCF	990	1150	970	1130							980*	1100*
Wobbe, BTU/SCF	1279	1385	1300	1400			1250	1375			1290	1370

* Minimum methane is 94 vol%

Major Constituents

		high BTU Dairy		high BTU Landfill		high BTU WWTP		Pipeline Quality Natural Gas	
	DL	min	max	min	max	min	max	min	max
Carbon Dioxide, vol%	0.03	0.06	0.95	BDL	2.21	0.49	0.66	BDL	2.62
Oxygen/Argon, vol%	0.03	0.39	1.99	BDL	1.31	BDL	BDL	BDL	1.19
Nitrogen, vol%	0.03	0.26	5.61	0.51	9.49	BDL	BDL	BDL	0.62
Ammonia, vol%	0.001	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Tariffs Specific to Biomethane	Company A	Company B	Company C	Company D	Company E	Company F
Carbon Dioxide, vol%	3	3				2
Oxygen, vol%	0.2	0.001		0.01		0.2
Inerts, vol%	4	5		5		3.2
Ammonia, vol%	0.001	0.01	0.001		0.001	

Sulfur Compounds

		high BTU Dairy		high BTU Landfill		high BTU WWTP		Pipeline Quality Natural Gas	
	DL	min	max	min	max	min	max	min	max
H_2S, ppmv	0.05	BDL	BDL	BDL	0.53	BDL	0.16	BDL	6.00
total S, gr/100SCF	0.003	BDL	0.066	BDL	0.32	BDL	0.009	BDL	1.13
Mercaptans, ppmv	0.05	BDL	BDL	BDL	BDL	BDL	BDL	BDL	9.03
COS, ppmv	0.05	BDL	1.11	BDL	0.88	BDL	BDL	BDL	7.94

Tariffs Specific to Biomethane	Company A	Company B	Company C	Company D	Company E	Company F
H_2S, ppmv	4	4		4	4	4
total S, gr/100SCF	0.75	5.0		20		10
Mercaptans, ppmv	12				120	8
COS, ppmv						

Trace Organics

		high BTU Dairy		high BTU Landfill		high BTU WWTP		Pipeline Quality Natural Gas	
	DL	min	max	min	max	min	max	min	max
Vinyl Chloride, ppmv	0.1	BDL	BDL	BDL	0.33	BDL	BDL	BDL	BDL
Halocarbons, ppmv	0.1	BDL	BDL	BDL	4.67	BDL	BDL	BDL	BDL
BTEX, ppmv	1	BDL	BDL	BDL	2.4	BDL	0.003	BDL	597
N-nitroso-di-n-propylamine, ppmv	0.002	BDL	0.004	BDL	BDL	BDL	BDL	BDL	BDL
Other VOCs, SVOCs and PAHs, ppmv	0.002	BDL	BDL	BDL	0.03	BDL	0.006	BDL	13
Formaldehyde, ppmv	0.002	-	-	BDL	0.06	BDL	BDL	BDL	BDL
Aldehydes and ketones, ppmv	0.005	-	-	BDL	0.88	BDL	BDL	BDL	212

Tariffs Specific to Biomethane	Company A	Company B	Company C	Company D	Company E	Company F
Vinyl Chloride/p-dicloro-benzene, ppmv	0.33/0.95	1.17/0.1 (as other cmpds)	3.3/not mentioned		3.3/9.5	8.3/24
Toluene/E-benzene, ppmv	240/6.0	50 (as BTEX)			2400/60	12,000/150
N-nitroso-di-n-propylamine	0.006				0.06	0.15
Methacrolein, ppmv	0.37	0.1 (as A+K)			3.7	18

Siloxanes and Metals

		high BTU Dairy		high BTU Landfill		high BTU WWTP		Pipeline Quality Natural Gas	
	DL	min	max	min	max	min	max	min	max
Mercury, ug/m3	0.01	BDL	BDL	BDL	0.28	BDL	BDL	BDL	0.06
Arsenic, ug/m3	30	BDL	BDL	BDL	BDL	BDL	BDL	BDL	4
Antimony, ug/m3	30	-	-	BDL	32	BDL	BDL	BDL	BDL
Copper, ug/m3	30	BDL	BDL	BDL	250	BDL	BDL	BDL	76
Lead, ug/m3	30	BDL	BDL	BDL	155	BDL	BDL	BDL	67
Zinc, ug/m3	30	-	-	BDL	253	45	229	BDL	213
Siloxanes, mg Si/m3	0.1	BDL	BDL	BDL	6.2	BDL	BDL	BDL	BDL

Tariffs Specific to Biomethane	Company A	Company B	Company C	Company D	Company E	Company F
Mercury, ug/m3	80	0.01	80		0.08 ppm	
Arsenic, ug/m3	19	0.01	190		190	480
Other metals, ug/m3	60	0.01	600		90	3000
Siloxanes, mg Si/m3	0.01	0.1	1 ppm	None	1 ppm	0.4

Biomethane Gas Quality Tariffs and Guidance

- Some utilities have defined acceptance criteria for biomethane.
- Many have not.
- GTI has created biomethane guidance documents and performed research on trace constituent impacts.
- Our most recent project is to provide a fact-based, objective study on the quality, analysis, risk, and compositional variability of final end-use grade biomethane.
- The goal is to promote biomethane interconnect projects by using sound science and clear facts that demonstrate biomethane is safe to use if properly processed.