Biogas to Vehicle Fuel

"Lessons Learned Developing and Operating Systems"

Mark J. Torresani, P.E.
Cornerstone Environmental Group, LLC

10e Biogas Conférence of AWMA
Section Québec and Biogaz Québec
Montreal, Canada
May 24, 2012

BioCNG™

CORNERSTONE
Environmental Group, LLC

Overview of Lessons Learned Developing BioCNG Projects

- History / Why BioCNG
- Biogas to BioCNG Operations
- Fuel Quality
- CNG Vehicle Availability
- Vehicle Performance
- BioCNG Economics

CORNERSTONE
Environmental Group, LLC

History of BioCNG Development

- Purpose is to use biogas from various sources as CNG vehicle fuel on a small scale (50 to 400 scfm of biogas = 250 to 2,000 GGE/day)
- Worked closely with Unison Solutions in Dubuque, Iowa on design and fabrication, Patent pending Process
- Low tariffs from Utilities for electrical production make small projects difficult and uneconomic
- More CNG vehicles being operated in the USA
- 1st BioCNG System installation – Dec. 23, 2010
  - Rodefeld Landfill, Madison Wisconsin

CORNERSTONE
Environmental Group, LLC

Rodefeld Landfill System Delivery December 23, 2010

CORNERSTONE
Environmental Group, LLC

CNG Fueling Station, Fast Fill 60-GGE capacity,
Built in early 1980's

CORNERSTONE
Environmental Group, LLC

First Vehicle Fueled March 18, 2011

CORNERSTONE
Environmental Group, LLC

August 2011, Operating System

CORNERSTONE
Environmental Group, LLC

BioCNG System Operations
Lessons Learned

- System installation and startup 1-Week
- Need to consider permitting requirements
  - Air, Solid Waste, Waste Water
  - NFPA / Fire Department / Fueling Stations
- BioCNG production (24/7) sized to match CNG fueling station and vehicle fuel use
- Operated at -10° to 95°F (-23° to 35°C), need to consider ambient temperature extremes
  - Chiller Replacement was required
  - Need for heat tracing and heating

CORNERSTONE
Environmental Group, LLC

BioCNG System Operations
Lessons Learned

- Need to consider having natural gas as a backup or supplemental fuel
  - Blended BioCNG/Natural Gas Fuel
  - Backup fuel if biogas source is interrupted
- Methane capture efficiency (65% to 80 %), can be modified depending on biogas quality
  - Trade off between producing more BioCNG or higher Btu BioCNG

CORNERSTONE
Environmental Group, LLC

BioCNG and CNG Fueling Station Considerations

- Biogas and BioCNG produced 24 hours/day, may not match vehicle fuel use
- CNG storage is expensive, consider time and fast fill station, natural gas blending / backup fuel
- Sizing of systems: Present or future use of CNG? How many vehicles, How many fueling nozzles?
- BioCNG for sale as a potential source of revenue?
  - Additional quality control and liability concerns

CORNERSTONE
Environmental Group, LLC

Biogas to BioCNG Fuel Quality Lessons Learned

- **Biogas quality makes a difference**
  - High Methane, low O_2 and low N_2
  - Voc's, H_2S, Siloxanes Impact operating costs not fuel quality
- BioCNG Ideally suited for small or excess biogas quantities
  - Waste Water Digesters
  - Food Waste Digesters
  - Ag waste digesters
  - Landfills

CORNERSTONE
Environmental Group, LLC

Rodefeld Landfill / BioCNG
Gas Constituents

Constituent	Units	Inlet LFG (1)	BioCNG (1)	BioCNG Range (2)
CH_4	vol. %	55.0	90.0	80 - 95
CO_2	vol. %	39.5	0.3	0.0 - 0.5
O_2	vol. %	0.5	0.1	0.1 - 0.5
N_2	vol. %	5.0	9.6	5 -12
H_2S	ppmv	250	ND	ND

Notes:
(1) Data is compiled from field and laboratory analysis of samples collected on January 4, 2011.
(2) Based on periodic field measurements during system operations.

CORNERSTONE
Environmental Group, LLC

Biogas Constituents

Typical Landfill Gas		Typical Digester Gas	
CH_4	45 to 60%	CH_4	55 to 65%
CO_2	40 to 50%	CO_2	45 to 35%
O_2	0 to 2%	O_2	0 to 1%
N_2	0.5 to 10%	N_2	0 to 2%
H_2S	100 - 2,000 ppmv	H_2S	Up to 4,000 ppm
Siloxane	Up to 1,500 ppbv	Siloxane	< 10 ppb

Product BioCNG Fuel (SAE J1616)	
CH_4	88 to 99%
CO_2	0.2 to 6.0 %
O_2	0.0 to 1.0%
N_2	0 to 10 %
H_2S	Non Detect
Siloxane	Non Detect

CORNERSTONE
Environmental Group, LLC

St Landry Landfill BioCNG Reading - 99.1% CH4
March 28, 2012

CORNERSTONE
Environmental Group, LLC

CNG Vehicle Operations / Purchase Lessons Learned

- CNG vehicles to use BioCNG is a factor in project success, CNG Vehicles to use fuel are a must
- Demand for CNG vehicles is growing as CNG stations are established
- 19 Bi-fuel vehicles operated by Dane Co. on CNG or Rodefeld Landfill BioCNG
- GM, Ford, Chrysler – Offering CNG and Bi-fuel vehicles in the USA
- Engine Manufactures continue to develop more CNG engines / modifications

CORNERSTONE
Environmental Group, LLC

Fleet Size Per Unit

System Size	Biogas Inlet Flow (scfm)	Fuel Production (GGE/day)	Fuel Production (GGE/year approx.)	Fleet Size Per Unit	
				Small Autos	Large Trucks*
BioCNG 50	50	200 - 275	80,000	20 – 27	2 - 4
BioCNG 100	100	375 - 550	160,000	38 – 55	5 – 8
BioCNG 200	200	775 - 1100	320,000	77 – 110	11 - 17

* Waste trucks, 18-wheelers, school buses

CORNERSTONE
Environmental Group, LLC

Ford 2011 F350 CNG / Gasoline Pickup Truck
Delivered to Dane County January, 2012

CORNERSTONE
Environmental Group, LLC

Dane County Parks Department NGV Vehicles 3/8/2012

CORNERSTONE
Environmental Group, LLC

CNG Vehicle Performance Lessons Learned

- Drivers of pickup trucks and cars did not notice a difference when using gasoline, CNG or BioCNG
- CNG Vehicles operate on fuel with lower Btu's than Nat Gas
- Vehicle dynamometer testing, December 2011
  - 0-60 mph, 1/8 mile lap, peak torque, towing 2,500 lb, towing 6,000 lb
  - Noticeably lower emissions from CNG and BioCNG
- Test results indicate that CNG or BioCNG vehicle performance will be similar to gasoline

CORNERSTONE
Environmental Group, LLC

2002 Chevy 2500 Bi-fuel pickup truck being tested on a Dynamometer

CORNERSTONE
Environmental Group, LLC

BioCNG Economics Lessons Learned

- BioCNG can be cost competitive with other vehicle fuels (Gasoline, Diesel and CNG)
- BioCNG production US$0.60 to US$0.98 / GGE depending on biogas quality and quantity, financing charges and tax incentives not included
- Potential for Alternate Vehicle Fuel Credits
  - RINs (Renewable Fuel Credits) US$0.89/gal credit (actual Contract price)
  - RIN is short for Renewable Identification Number and is a renewable fuel credit. RIN credits were created by the USEPA as part of the Renewable Fuel Standard (RFS) to track progress toward reaching the energy independence goals established by the U.S. Congress. RIN credits are the currency used by obligated parties to certify compliance they are meeting mandated renewable fuel volumes.

CORNERSTONE
Environmental Group, LLC

Approximate BioCNG Pricing

Unit	BioCNG Gas Conditioning System Unit Cost	Complete Fueling System (BioCNG + optional add-ons)*
BioCNG 50	US$350,000	US$800,000
BioCNG 100	US$582,000	US$1,300,000
BioCNG 200	US$792,000	US$1,800,000

* Includes installation, CNG fast fill fueling station, winterization, storage tanks, permitting, training. Actual prices are dependent upon site-specific conditions.

CORNERSTONE
Environmental Group, LLC

Opportunities and Other Projects

- **Other projects being developed and starting up in 2012**
  - **St Landry Parish, Louisiana**
    - **Startup March 26-30, 2012**
  - **Janesville, WI WWTP**
    - **Initial fueling March 21, 2012**
  - **BioCNG 100 project under construction in Sacramento, California**
  - **Approximately 80 other facilities in the USA are considering BioCNG use**
- **Cost Effective Vehicles / Conversions are needed**
  - **USEPA regulates conversions for air emissions**
- **Public Awareness of CNG and BioCNG is growing**

CORNERSTONE
Environmental Group, LLC

St Landry Parish, LA BioCNG 50 February, 2012

CORNERSTONE
Environmental Group, LLC

St Landry Parish, LA BioCNG 50 February, 2012

CORNERSTONE
Environmental Group, LLC

St Landry Parish, LA BioCNG 50 February, 2012

CORNERSTONE
Environmental Group, LLC

St Landry Parish, LA BioCNG fueling Demonstration
March, 2012

CORNERSTONE
Environmental Group, LLC

St Landry Parish, LA BioCNG fueling Demonstration
March, 2012

CORNERSTONE
Environmental Group, LLC

St Landry Parish, LA BioCNG fueling Demonstration
March, 2012

CORNERSTONE
Environmental Group, LLC

Janesville, WI WWTP BioCNG System February, 2012 by AECOM

CORNERSTONE
Environmental Group, LLC

Summary
Using Biogas as a Vehicle Fuel

- Repeatable: Technically and Economically
- Biogas is ideally suited to produce BioCNG to meet fuel specifications
- Nitrogen in landfill gas can limit potential (5% MAX)
- CNG vehicles ready for use are likely to limit BioCNG development potential
- Education programs are needed, vehicle mechanics, system operators

CORNERSTONE
Environmental Group, LLC

Contact Information

Mark J. Torresani, P.E.
Senior Project Manager

Cornerstone Environmental Group, LLC
8413 Excelsior drive, Suite 160
Madison, Wisconsin 53717

(630) 633-5835 Office
(608) 334-2846 Cell
Mark.Torresani@biocng.us
www.biocng.us

BioCNG™

CORNERSTONE Environmental Group, LLC