

Wisconsin's Biogas to Vehicle Fuel Opportunity

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Wisconsin Natural Gas for Transportation
Roundtable

Appleton, Wisconsin
July 18, 2012



Why Use Biogas as a Vehicle Fuel?

- Can be the most economic vehicle fuel
- Can be used in a wide range of vehicle types
- Offers long term fuel price stability (20 year +)
- 24-7 biogas production “dependable”
- Greenhouse gas (GHG) emission reductions
- Energy independence

Sauk County
Landfill



Crave Brothers Dairy Farm Digester
Waterloo, Wisconsin.

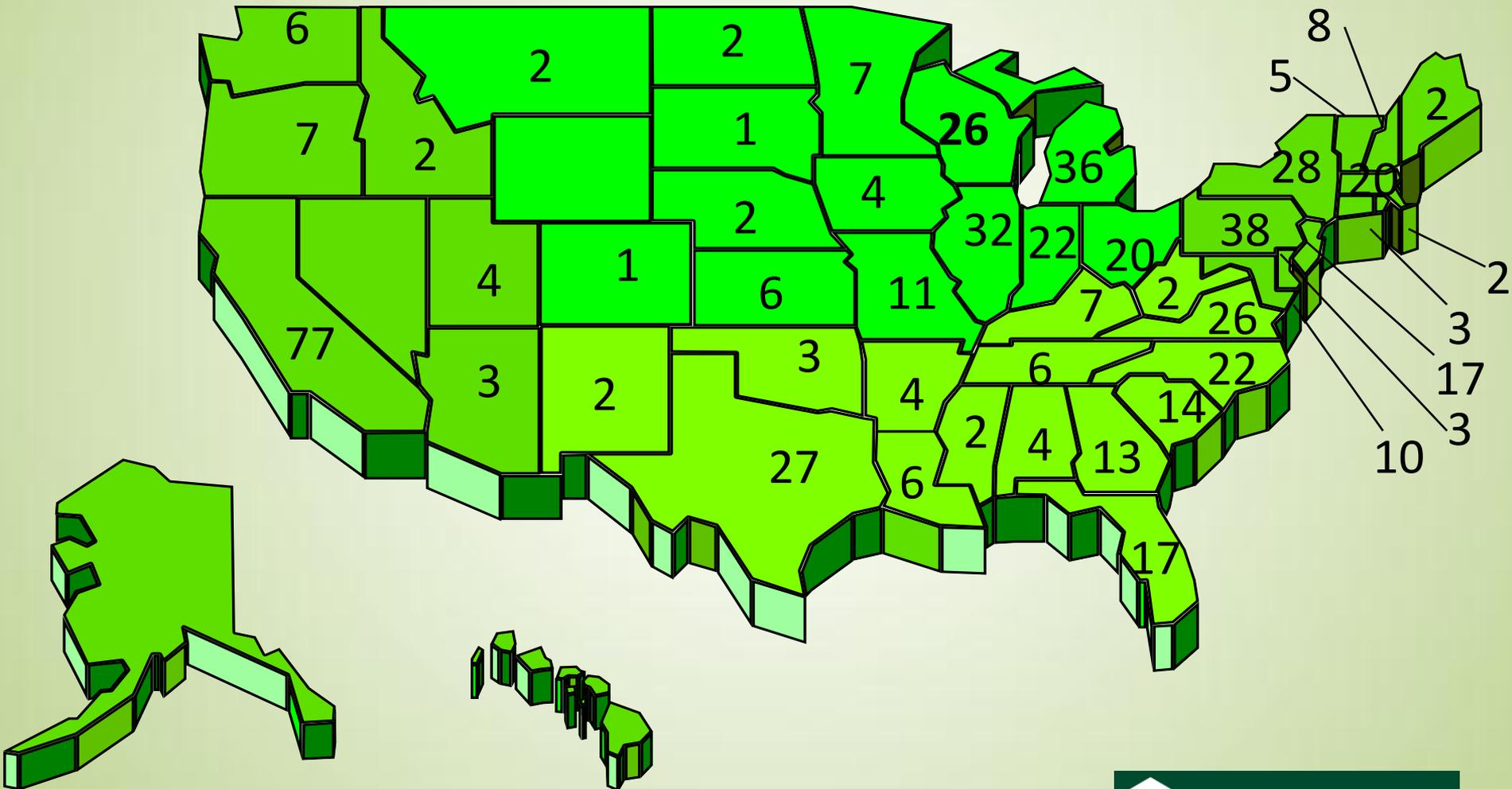


Sheboygan Waste Water Treatment
Plant

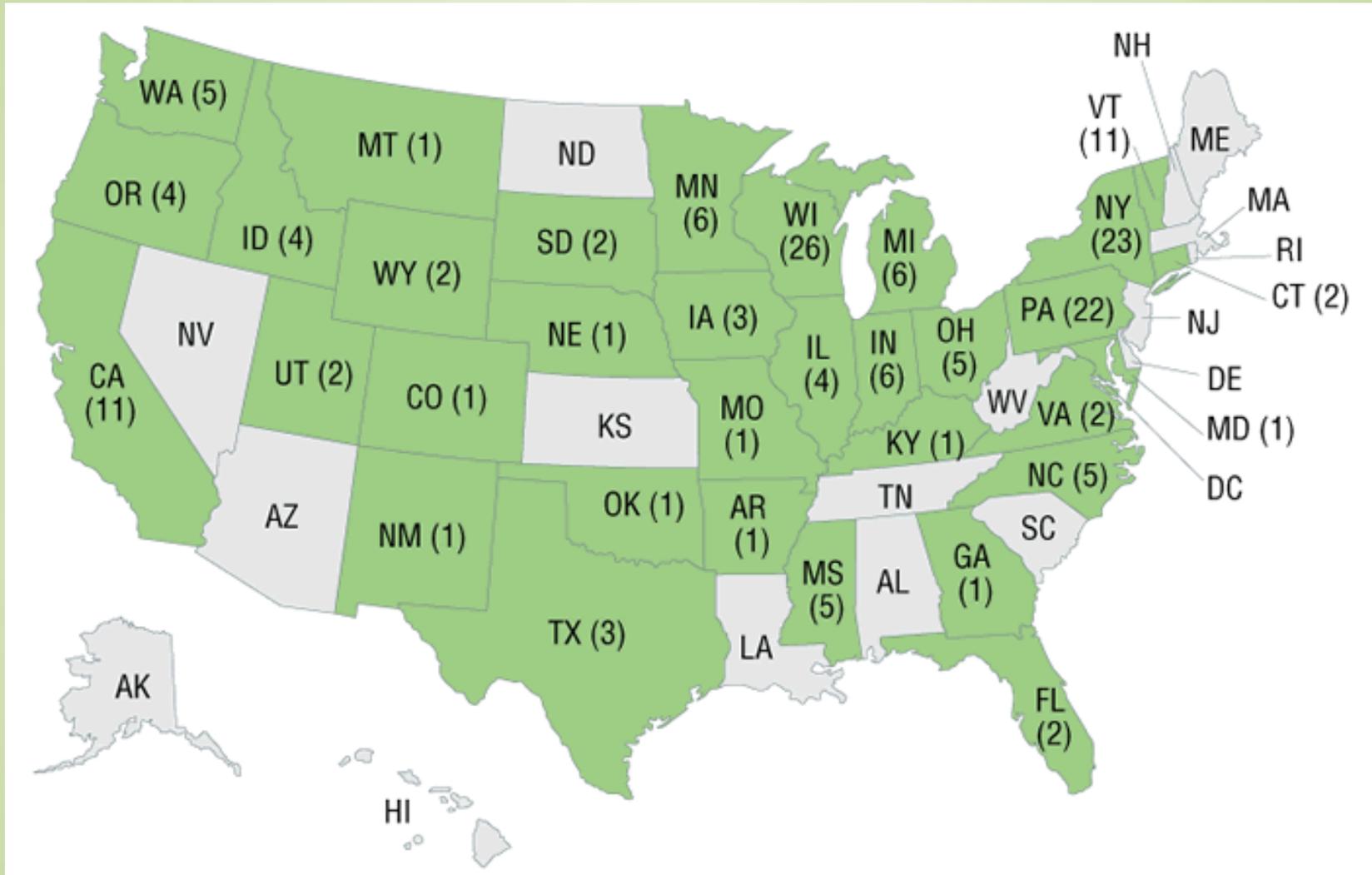


Operational LFG-to-Energy Plants (558)

Source: 7/2011 LMOP Data



Operating Agricultural Digesters



Total Farm Based Digesters: 159

Total regional/centralized or multiple-farm project: 12

Source: USEPA AgSTAR 7/2011



**Dane County, First BioCNG Vehicle Fueled
March 18, 2011**



Dane County Rodefild landfill BioCNG System
August, 2011



Janesville, WI WWTP BioCNG System February, 2012 by AECOM



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



St Landry Parish, LA BioCNG fueling Demonstration
March, 2012

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Biogas to Vehicle Fuel Workshop

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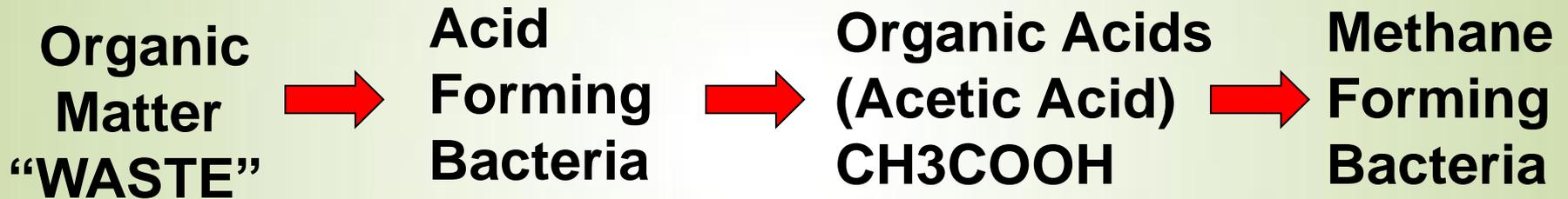
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Biogas to Vehicle Fuel Options

- **CNG** Compressed Natural Gas
 - (dozens of systems operating worldwide)
- **LNG** Liquid Natural Gas
 - (one system operating in the USA, Altamount Landfill, CA)
- **Blended Fuel** BioCNG/Natural gas blended together
 - Typical on BioCNG systems
- More CNG vehicles available and being operated in the USA

The Anaerobic Decomposition Process



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
 - Need for heat tracing and heating

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

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

Biogas to BioCNG Fuel Quality Lessons Learned

- **Biogas quality makes a difference**
 - High Methane, low O₂ and low N₂
 - Voc's, H₂S, Siloxanes Impact operating costs not fuel quality
- **BioCNG Ideally suited for small biogas quantities**
 - Waste Water Digesters
 - Food Waste Digesters
 - Ag waste digesters
 - Landfills

Typical Gas Cleanup Technologies

- **CO₂ removal**
 - Water scrubbing
 - Solvent scrubbing
 - Carbon molecular sieves
 - Membranes/PSA
 - CO₂ condensation (refrigeration)
- **Hydrogen sulfide removal**
 - Iron, carbon, biological, water scrubbing,
- **VOCs, Siloxane and halogenated hydrocarbons**
 - Carbon, chilling, CO₂ condensation, polymers

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 ₂ S	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.

Biogas Constituents

Typical Landfill Gas		Typical Digester Gas	
CH₄	45 to 60%	CH ₄	55 to 65%
CO₂	40 to 50%	CO ₂	45 to 35%
O₂	0 to 2%	O ₂	0 to 1%
N₂	0.5 to 10%	N ₂	0 to 2%
H₂S	100 - 2,000 ppmv	H ₂ S	Up to 4,000 ppm
Siloxane	Up to 1,500 ppbv	Siloxane	Up to 1,000 ppbv

Product BioCNG Fuel (SAE J1616)	
CH₄	88 to 99%
CO₂	0.2 to 6.0 %
O₂	0.0 to 1.0%
N₂	0 to 10 %
H₂S	Non Detect
Siloxane	Non Detect

CNG Vehicle Operations / Purchase

Lessons Learned

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



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

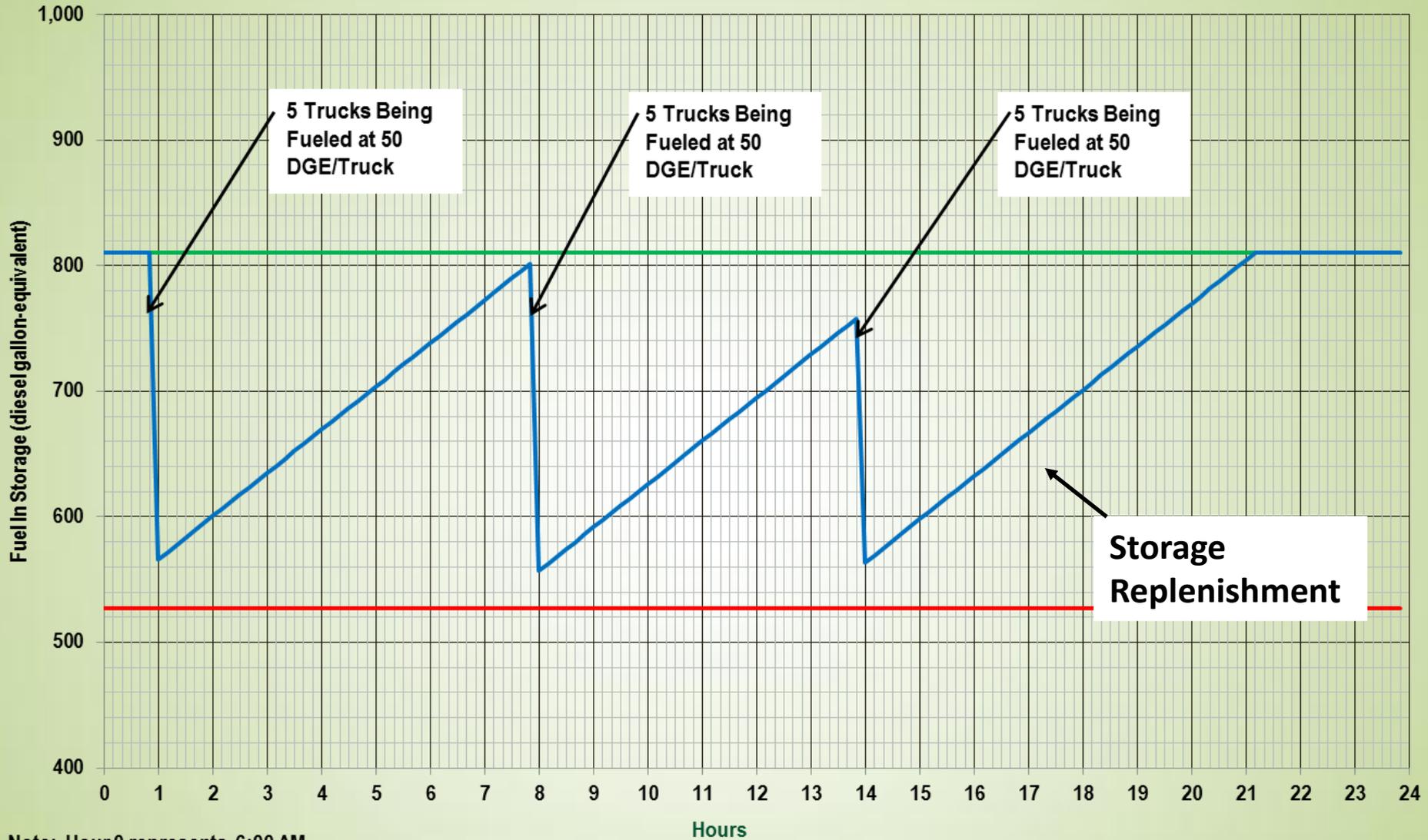


Dane County Parks Department NGV Vehicles 3/8/2012

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 use of CNG or future use of CNG, how many vehicles?
- Will local Utility / Pipeline consider net metering for Biogas meeting pipeline quality fuel?

BioCNG 200 Storage-Fueling Graph Fast-Fill Station SAMPLE



Note: Hour 0 represents 6:00 AM

— Minimum Fuel Required — Maximum Available Storage — Fuel In Storage

CNG Vehicle Performance

Lessons Learned

- Drivers of pickup trucks and cars do not notice a difference when using gasoline, CNG or BioCNG
- CNG Vehicles operate on fuel with lower Btu's than in Natural 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



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

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.

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

Approximate BioCNG Pricing

Unit	BioCNG Gas Conditioning System Unit Cost	Complete Fueling System (BioCNG + optional add-ons)*
BioCNG 50	US\$390,000	US\$800,000
BioCNG 100	US\$590,000	US\$1,300,000
BioCNG 200	US\$810,000	US\$1,800,000

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

Other Projects and Opportunities

- **Other projects being developed and starting up in 2012**
 - Food waste digester with BioCNG under construction in Sacramento, CA
 - Des Moines Iowa WWTP in final design, Will eventually produce 1,000,000 GGE /year of BioCNG
 - Approximately 300 other facilities in the USA are considering using biogas as CNG vehicle fuel
- **Cost Effective Vehicles / Conversions are needed**
 - USEPA regulates conversions for air emissions and impacts costs
- **Public Awareness of CNG and BioCNG is growing**



St Landry Parish, LA BioCNG fueling Demonstration
March, 2012



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Summary

Using Biogas as a Vehicle Fuel

- Repeatable: Technically and Economically
- Biogas is ideally suited to produce CNG 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

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