Natural Gas Vehicles – The Here and Now Technology: A Workshop for New England

Sponsored By:
Clean Cities Coalitions of Northern New England

November 20, 2014
Welcoming Remarks

Natural Gas Vehicles – The Here and Now Technology: A Workshop for New England
Our Presenters – Ron Gulmi and Barry Carr

Ron Gulmi, Managing Director, Emerald Alternative Energy Solutions, Inc.

Experience, Background and Qualifications – 28+ Years Experience with Alternative Fuels/Vehicles:

- 15 Years Fleet Manager of Mixed Utility Fleet
- 5 Years Gas Engineering
- 6 Years Business Development, Market Strategy, Sales and Product Management

Experience includes over 15 years in leadership positions with various local Clean Cities Coalitions part of the US Department of Energy (US DOE) Program
Our Presenters – Ron Gulmi and Barry Carr

Barry Carr, Project Mgr. Clean Communities of CNY

Experience, Background and Qualifications – 26+ Years Experience with Alternative Fuels/Vehicles:

- Provided support for major OEM alternative fuel vehicle programs
- Clean Cities Coordinator for Clean Communities of CNY, a US DOE Clean Cities Coalition
- Currently serving as Director of Business Development for Landi Renzo USA, a natural gas system supplier for Ford, General Motors, Isuzu, and Freightliner
Natural Gas Overview

- Compressed Natural Gas (CNG) Overview
- Target Markets
- What is Natural Gas?
  - Composition
  - How Does it Compare to Other Fuels?
- CNG Vehicle Basics
- CNG System Components
- Natural Gas Properties – Safety
  - Natural Gas Vehicle (NGV) Cylinder Safety
  - CNG Vehicle Components Safety Standards
- Video – Safety & Testing of NGV Cylinders
Natural Gas Overview - Continued

- Why Use Natural Gas Vehicles – Benefits
- Why the NGV Market Will Grow
- History of CNG Vehicles
- U.S. Overview
Compressed Natural Gas (CNG) Overview

- Pipeline Gas is Compressed to Higher Pressure and Stored in Cylinders Onboard the Vehicle
- The same gas used for cooking, space and water heating
- Higher pressure needed to provide ample range
- Storage cylinders are extremely rugged and safe
- Onboard regulator(s) drop pressure for combustion
- Internal Combustion Engines almost completely burn the natural gas mixed with oxygen with little emissions
- Utilize CNG infrastructure from local utilities, private fuel providers and customer owned on site facilities

**On an average annual basis, one natural gas garbage truck = 12-14 natural gas homes in gas usage**
Compressed Natural Gas (CNG) Overview

United States has vast gas pipeline system

- More than 305,000 miles interstate and intrastate transmission pipelines
- More than 2,100,000 miles of distribution pipelines
  - Owned by various regulated gas utilities – Local Distribution Cos. (LDCs)
- Multiple gas transmission pipeline projects underway in Maine and the entire Northeast

Source: EIA 2014
Target Markets

- Heavy-duty freight trucks:
  - Water ports and rail
  - “Less-than-Truck Load” (e.g., Yellow-Roadway, Forward Air, Swift)

- Transit buses/shuttle buses/school buses
- Major metro fleet management and public works departments
- Trash, recycling, cement and other vocational work trucks

- Medium-duty & Heavy-duty delivery and commercial service trucks:
  - Telecom — food — beverage — snack food — newspapers
  - linen/laundry — grocery — furnishings/appliances — office products

- Taxis and light-duty service vehicles
What is Natural Gas?

- Colorless, Odorless, tasteless, nontoxic, gaseous mixture of hydrocarbons called Methane. It is the simplest hydrocarbon:

  \[
  \text{CH}_4
  \]

  The simplest hydrocarbon – one atom of carbon

- Gas utilities or Local Distribution Cos. (LDC’s) add mercaptan odorants to be able to detect it for safety

- Society of Automotive Engineers (SAE) J1616 – Recommended Practice for Compressed Natural Gas Vehicle Fuel
Natural Gas Composition – SAE J1616

Gas Composition Standard February 1, 1994

- American National Standards Institute (ANSI) Approved
- Consists of generally 88 to 96 mole percent of methane
- Remaining composition decreasing proportion of non-methane alkanes such as ethane, propane, butanes, etc.

- Intent of SAE J1616 is to protect:
  - Interior surface of fuel container (storage cylinder)
  - Fuel system components - injectors, exhaust catalyst elements, engine, etc.
  - Protects the onset of corrosion, poisoning, the deposition of liquids or large dust particles, or the formation of water, ice particles, frost or hydrates.
### How Does Natural Gas Compare to Other Fuels? Composition & Energy Content

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Chemical Formula</th>
<th>Energy Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>C_{14}H_{30}</td>
<td>137,000 BTUs/gallon</td>
</tr>
<tr>
<td>Gasoline</td>
<td>C_{8}H_{18}</td>
<td>124,600 BTUs/gallon</td>
</tr>
<tr>
<td>Propane</td>
<td>C_{3}H_{8}</td>
<td>91,000 BTUs/gallon</td>
</tr>
<tr>
<td>Methanol</td>
<td>CH_{3}OH</td>
<td>60,000 BTUs/gallon</td>
</tr>
<tr>
<td>Methane</td>
<td>CH_{4}</td>
<td>100,000 BTUs/Therm</td>
</tr>
</tbody>
</table>

### Gasoline Gallon Equivalent – GGE

1. Therms/1.25 = GGE; 2. GGE x 1.25 = Therms

### Diesel Gallon Equivalent – DGE

1. Therms/1.37 = DGE; 2. DGE x 1.37 = Therms
How Does Natural Gas Compare to Other Fuels? Octane, Ignition Temp, Vapor Density

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Octane</th>
<th>Ignition Temp</th>
<th>Vapor Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel – C\textsubscript{14}H\textsubscript{30}</td>
<td>8 – 15</td>
<td>494\textdegree F</td>
<td>&gt; 1.0</td>
</tr>
<tr>
<td>Gasoline – C\textsubscript{8}H\textsubscript{18}</td>
<td>86 – 94</td>
<td>810\textdegree F</td>
<td>3.50</td>
</tr>
<tr>
<td>Propane – C\textsubscript{3}H\textsubscript{8}</td>
<td>104</td>
<td>950\textdegree F</td>
<td>1.53</td>
</tr>
<tr>
<td>Methanol – CH\textsubscript{3}OH</td>
<td>100</td>
<td>878\textdegree F</td>
<td>&gt; 1.0</td>
</tr>
<tr>
<td>Methane – CH\textsubscript{4}</td>
<td>130</td>
<td>1200\textdegree F</td>
<td>0.68</td>
</tr>
</tbody>
</table>

* NOTE: Vapor Density of Air = 1.0;
How Do NGVs Work?

Schematic of a Dedicated CNG Vehicle

Components of a CNG vehicle

Source: US DOE
How Do NGVs Work?

Schematic of a Dedicated CNG Vehicle

Natural gas is compressed and enters the vehicle through the natural gas fill valve (receptacle).

Source: US DOE
How Do NGVs Work?

Schematic of a Dedicated CNG Vehicle

It flows into high-pressure cylinders.

Source: US DOE
How Do NGVs Work?

Schematic of a Dedicated CNG Vehicle

When natural gas is required by the engine, it leaves the cylinders and passes through the master manual shut-off valve (required by NFPA 52 for converted vehicles).

Source: US DOE
How Do NGVs Work?

Schematic of a Dedicated CNG Vehicle

The gas goes through the high-pressure fuel line and enters the engine compartment.

Source: US DOE
How Do NGVs Work?

Schematic of a Dedicated CNG Vehicle

Gas enters the regulator, which reduces storage pressure from up to 3,600 psi to required vehicle fuel injection system pressure.

Source: US DOE
How Do NGVs Work?

Schematic of a Dedicated CNG Vehicle

The natural gas solenoid valve allows natural gas to pass from the regulator into the gas mixer or fuel injectors. The solenoid valve shuts off the natural gas when the engine is not running.

Source: US DOE
How Do NGVs Work?

Natural gas mixed with air flows down through the carburetor or fuel-injection system and enters the engine combustion chambers where it is burned to produce power, just like gasoline.

Source: US DOE
Natural Gas Properties – Safety Benefits

- Lighter than Air – Relative Density (vapor density) = .68
- Ignition Temperature = 1200° F
- Flammability Range 5%-15% (gas to air mixture)
- Non toxic

Natural Gas is compressed (CNG) to 3000 – 3600 pounds per square inch (psi) and stored in specially designed and constructed cylinders

CNG is approved for all tunnels and bridges – Ebasco Study
NGV Cylinder – Safety Benefits

Storage containers are designed, manufactured and tested to rigid specifications

- Bonfire test
- Pressure test for 18,000 cycles of pressurization and depressurization
- Gunfire test
- Crash test – cylinders dropped several feet (10ft)

Cylinders include a pressure relief device (PRD)
NGV – Safety Benefits

Dedicated OEM Crown Victoria – NYC Taxi Cab

- Demolished in Bus Accident
- No injuries
- No CNG problems
- Vehicle performed as designed
NGV – Safety Benefits

New York State DOT - Honda Civic GX

- Car Totaled by 10000 gal tanker
- Driver Walked Away
- No injuries
- Inspector credited driver’s life to strength of the CNG tank
- No CNG problems
- Vehicle performed as designed
NGV Cylinder Safety Standards & Types

- Four Cylinder Types
  - Type 1: All Metal
  - Type 2: Metal Lined, Hoop Wrapped
  - Type 3: Metal Lined, Fully Overwrapped
  - Type 4: Plastic Lined, Fully Overwrapped
CNG Vehicle Components - Safety


- P36 CT1000
- P36 CT5000 Type 1 180° Ball Valve
- Multiple Receptacles And Defueling

P36 CT1000  Weh
Pistol Grip WEH.com
CNG Vehicle Components - Safety

- The American National Standards Institute (ANSI) NGV 3.1 (ANSI, 2012) establishes requirements for newly produced compressed natural gas fuel system components, intended for use on natural gas powered vehicles:

  - This includes the check valve, manual valve, manual container valve, automatic valve, gas injector, pressure indicator, pressure regulator, gas flow adjuster, gas/air mixer, pressure relief valve, pressure relief device, excess flow valve, gas tight housing and ventilation, hoses, rigid fuel line, flexible fuel line, filter, fittings, and relief line closures.
Shop Maintenance Facilities - Safety

- International Code Council’s Intl Fire Code (IFC 2012)
- International Mechanical Code (IMC 2012)
- International Building Code (IBC 2012)

These national codes are voluntarily adopted by states and local jurisdictions. Local codes often are not the most recent versions of national model codes (adoption often lags behind). Local AHJ is final decision-making authority and may enforce additional requirements.
Shop Maintenance Facilities
Evaluate Shop Activities – Segregate, Modify

- IFC and NFPA 30A *exempt minor repair facilities* from code requirements specific to CNG and LNG.

- IFC 2211.7 exempts garages that do not work on fuel systems or do not use open flames or welding from all additional requirements.

- NFPA 30A exempts garages that do not perform:
  - Engine overhauls, painting, body & fender work, any repairs requiring draining of vehicle fuel tanks.

- NFPA 30A define minor repair facility maintenance activity as:
  - Lubrication, inspection, engine tune-ups, replacement of parts, fluid changes, brake system repairs, tire rotations and similar routine maintenance work.
Shop Maintenance Facilities
Evaluate Shop Activities – Segregate, Modify

- IFC and NFPA 30A exempt minor repair facilities from code requirements specific to CNG and LNG.

- To avoid costly modifications, consider:
  - Segregating major repair and minor maintenance activities into separate physical areas; adding NGV-specific bay(s) for major repairs
  - Defueling CNG and/or LNG vehicles before entering major repair area

Diesel and gasoline vehicle repair / maintenance
CNG/LNG minor maintenance and (defueled NGV) major repair

CNG/LNG major repair
Interior walls will have a 2-hr fire rating and be continuous from floor to ceiling.

For major repair area, at least one wall shall be an exterior wall and primary access shall be from the outside.

Interior access between minor and major repair areas shall be through self-closing fire door with AHJ approved rating.

The minor and major repair areas shall have separate ventilation systems.
Shop Maintenance Facilities - Safety

- No ignition source within 18” of ceiling (except where 4 Air Changes per Hour (ACH) is provided
- Methane detection
- Ventilation
- Heating System
- NFPA 30A – Motor Fuel Dispensing Facilities and Repair Garages; NFPA 88A – Standards for Parking Structures
- Check with your local permitting authority
Shop Maintenance Facilities – Safety Summary

- Current guidance is vague; many costly “myths” about requirements prevail; confusion within design, vendor and code enforcement community
- Guidance is based on assessing risks and modifying accordingly
- Modifications only if “major repairs” are to be performed
  - If no CNG system work is to be performed, i.e., basic maintenance (e.g. brakes, etc) – no modifications required
  - If CNG work is to be performed, modifications may be needed
  - Consider segregating major repair and minor maintenance areas
- Key considerations in whether or not – and to what extent – to modify:
  - Ventilation levels; properly designed ventilation should eliminate “ignitable mixture”
  - Elimination of hot surfaces above 750°F (e.g. indirect heat or AHUs)
  - Modification of electric only if within 18” of ceiling if minimum ACH is not achieved
  - Methane detectors not needed for CNG; only for non-odorized gas (i.e., LNG)
  - Not necessary to install “explosion proof” switches, sockets or redo all electrical systems
- R&D underway to determine PPM levels, dispersion models, etc
Liquefied Natural Gas (LNG) Overview

- LNG requires only approximately 30% the space as CNG
- LNG energy density is 60% of diesel and 70% of gasoline
- 1.66 gallons of LNG = 1 gallon of diesel
- 1.43 gallons of LNG = 1 gallon of gasoline
- LNG is less than ½ the weight of water – it floats if spilled on water
- Stored in vacuum-insulated storage tanks specifically built for LNG
Liquefied Natural Gas (LNG) Overview

- LNG is natural gas in a liquid form
- LNG is clear, colorless, odorless, non-corrosive, non-toxic and non-carcinogenic
- LNG is cryogenic – it is produced when cooled to -259° F via liquefaction (refrigeration and/or depressurization)
- LNG is at 0 psi at -259° F
- LNG systems operate at low pressure
- LNG is purified before liquefaction – i.e. hydrocarbons, water, carbon dioxide, oxygen and sulfur compounds are removed/reduced
- LNG takes up 1/600th the volume of gaseous natural gas
- LNG energy density is 2.4 times greater than CNG
**Why or When to Use LNG?**

- In applications where weight and range are critical
- LNG Considerations:

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fewer tanks/less space required</td>
<td>Complexity of Tanks</td>
</tr>
<tr>
<td>Greater fuel density</td>
<td>Complexity of pressure &amp; temp mgt. of fuel to engine</td>
</tr>
<tr>
<td>Lower weight storage</td>
<td>Higher maintenance cost of cryogenic parts</td>
</tr>
<tr>
<td></td>
<td>Use the fuel or lose it (weathering)</td>
</tr>
<tr>
<td></td>
<td>Reliability is challenging</td>
</tr>
<tr>
<td></td>
<td>Life cycle fuel cost over CNG may be higher</td>
</tr>
</tbody>
</table>
Why Use Natural Gas Vehicles - Benefits

- Economic
  - Price stability and cost less
  - Incentives & funding
  - No pilferage

- Environment - Cleaner Air
  - Reduction in Greenhouse Gases (GHG) CO2—go “Green”
  - Reduction is Diesel Particulate Matter (DPM), Oxides of Nitrogen (NOx), Oxides of Sulfur (Sox), Non Methane Hydrocarbons (NMHC) and other pollutants
  - Improved Work Environment for Employees

- Energy Security Improved - North American fuel reduces America’s dependence on Foreign Oil
- Reduction in Noise – engines are quieter (as compared to diesel engines)
- Renewable Forms – Bio Methane
  - Waste Water Treatment, Landfill Gas, Anaerobic Digestion

- Increased Vehicle/Equipment Product Availability
- Increases in Supply – Marcellus Shale: NY, PA, OH, WV
- Increased Industry Support
Why Use NGVs – Benefits Pricing

Natural Gas consistently costs $1 - $2.00 per GGE less

Average Retail Fuel Prices in the United States (US DOE, 2012)
Why Use NGVs – Benefits Pricing

Natural Gas consistently costs $1 - $2.00 per GGE less

Source: Clean Cities Alternative Fuel Price Reports; http://www.afdc.energy.gov/fuels/prices.html
Why Use NGVs – Benefits Pricing

Source: www.afdc.energy.gov/data/tab/fuels-infrastructure/data_set/10326
Why Use NGVs – Benefits Pricing

Projected Price of CNG and LNG Through 2035 - in DGE w/ Constant 2010 $

Why Use NGVs – Benefits Pricing

U.S. Diesel Fuel and Crude Oil Prices

Why Use NGVs – Benefits Pricing

What we pay for in a gallon of:

Regular Gasoline (December 2012)
Retail Price: $3.31/gallon

- Taxes: 13%
- Distribution & Marketing: 11%
- Refining: 8%
- Crude Oil: 68%

Diesel (December 2012)
Retail Price: $3.96/gallon

- Taxes: 12%
- Distribution & Marketing: 17%
- Refining: 14%
- Crude Oil: 57%

Why Use NGVs – Benefits Price Stability

What we pay for in a gasoline gallon equivalent (GGE) of CNG with gas commodity at $3.20 per MMBtu:

- Gas Commodity is only 21% of GGE, so any increase is not as significant on GGE price

Gas Commodity is only 21% of GGE, so any increase is not as significant on GGE price.
**Why Use NGVs – Benefits Price Stability**

Volatility of Crude Oil has a much more significant affect on the gasoline and diesel price.

Gasoline and Diesel are 80% of Crude Oil, while Natural Gas is only 21% of Crude Oil and Gas Commodity.

Gas Commodity is only 21% of GGE, so any increase is not as significant on GGE price.
Natural Gas – Substantial Air Quality Benefits

- As a low carbon fuel, NGVs produce less greenhouse gases (CO2):
  - 20 - 23% less than diesel vehicles*
  - 26 - 29% less than gasoline vehicles*
  - This is equal or better than some renewable fuels
  - So it addresses “you-are-a-fossil fuel” argument

- NGVs produce less criteria pollutants than gasoline and diesel vehicles (NOx, CO, VOCs, NMHC & PM)

* Source: DOE 2012
Natural Gas – Substantial Air Quality Benefits

NGV Emission Reductions Compared to Similar Diesel Vehicles

<table>
<thead>
<tr>
<th>Light-Duty Vehicles</th>
<th>TIAx–CEC</th>
<th>GREET MODEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatile Organic Compounds (VOC)</td>
<td>55%</td>
<td>45%</td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>11%</td>
<td>1%</td>
</tr>
<tr>
<td>Nitrogen Oxide (NOx)</td>
<td>54%</td>
<td>20%</td>
</tr>
<tr>
<td>Particulate Matter (PM 10)</td>
<td>42%</td>
<td>9%</td>
</tr>
<tr>
<td>Green House Gases (GHG)</td>
<td>30%</td>
<td>15%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Heavy-Duty Buses</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatile Organic Compounds (VOC)</td>
<td>46%</td>
<td></td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>Nitrogen Oxide (NOx)</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>Particulate Matter (PM10)</td>
<td>27%</td>
<td></td>
</tr>
<tr>
<td>Greenhouse Gases (GHG)</td>
<td>23%</td>
<td></td>
</tr>
</tbody>
</table>

We Have the Fuel – And It’s Ours

Historic barrier to NGV Growth: Concern over US Gas Supply:

Is the Supply Adequate?

That concern is now put to rest:

Navigant study
PGC Study
EIA projections

NGVs have the strongest foreign oil displacement message of all the alternative fuels
Supply - We Have the Fuel, And It’s Ours

Estimated Supply over 115+ Years in North America
Supply - We Have the Fuel, And It’s Ours

Shale Basins and the U.S. Pipeline Grid

Source: American Clean Skies Foundation
Only Natural Gas Can Displace Diesel

- Light-duty consumer vehicles use 500 gallons of gasoline per year (12,000 miles x 25 mpg)

- Diesel trucks and buses use much more:
  - e.g., 18-wheeler: 20,000 gallons (120,000 miles x 6 mpg)

- Trucks and buses use about 25% of on-road fuel:
  - Equivalent to 4.5 Tcf
Only Natural Gas Can Displace Diesel

Many options for light-duty vehicles:
- e.g., natural gas, ethanol, electricity, plug-hybrids

Only two available options for diesel trucks and buses: biodiesel and natural gas

Biodiesel is limited and has a small amount of displacement when used in diesel engines

That leaves natural gas as the only option
“Electrifying the auto fleet, using natural gas for the 18-wheelers and the heavy vehicles as a transition – then we can get off of all those imported liquid fuels that come from foreign oil and foreign products and solve the security and economic problem and put people to work in the process.”

-- Al Gore at the National Clean Energy Roundtable, Washington, D.C., 02/23/09
Only Natural Gas Can Displace Diesel

National Public Policy Developments

“We produce more natural gas than ever before’ and “the natural gas boom has led to … greater energy independence.” To help accelerate that shift toward energy independence, the President said that “tonight, I propose we use some of our oil and gas revenues to fund an Energy Security Trust that will drive new research and technology to shift our cars and trucks off oil for good.”

-- President Obama, 2014 State of Union Address

Washington, D.C.
Only Natural Gas Can Displace Diesel

National Public Policy Developments

2014 State of the Union – President Obama also said,

“Businesses plan to invest almost $100 billion in new factories that use natural gas. I’ll cut red tape to help states get those factories built, and this Congress can help by putting people to work building fueling stations that shift more cars and trucks from foreign oil to American natural gas.”

And these statements have led to………..
Only Natural Gas Can Displace Diesel

National Public Policy Developments

President Obama proposed a Federal Energy Security Trust:

- To Fund Development of alternative vehicle development by repealing oil & gas industry subsidies
- Funding would come from $4 billion in subsidies now given to the oil & gas industry.
- Deploy those funds as an investment in “cost-effective technologies – like advanced vehicles that run on electricity, biofuels, hydrogen, and domestically produced natural gas

President Obama also proposed a $200 million tax credit for alternative fuel infrastructure development
Only Natural Gas Can Displace Diesel

National Public Policy Developments (Continued)

Rep. Graves (R-Mo.) Introduced three bills into the House aimed at supporting the use of natural gas as a transportation fuel in the trucking sector. Rep. Terry (R-Neb.) is co-sponsor

H.R.3937 – create a task force to investigate how U.S. long haul fleet (26,000 lbs. GVWR or higher) could be shifted from diesel to natural gas

H.R.3938 – directs the Sec. of U.S. DOT to designate natural gas fueling corridors for long-haul truck traffic and within one year provide Congress with its plans to “establish an interconnection of natural gas fueling stations”. Stations could be no more than 200 miles apart.
Only Natural Gas Can Displace Diesel

National Public Policy Developments (Continued)

- Rep. Graves (R-Mo.) Introduced three bills into the House aimed at supporting the use of natural gas as a transportation fuel in the trucking sector. Rep. Terry (R-Neb.) is co-sponsor

Biomethane Makes GHG Case Stronger

- Biomethane (renewable natural gas) can be produced from any organic material:
  - landfill gas, sewage, animal and crop waste and even energy crops

- CARB: Biomethane reduces GHG emissions by almost 90 percent

- Blending a little biomethane with natural gas makes further reduces GHG benefits of NGVs
The Natural Gas Industry Has Reengaged with NGVs

- Northeast Gas Association – reestablished the NGV Working Group
- Gas Exploration and Production Companies “Gas Producers” formed American Natural Gas Alliance (ANGA)
- American Gas Association (AGA) – LDCs reengaging NGV Market
- Joint AGA/ANGA Transportation Collaborative – Drive Natural Gas Initiative
  - Legislative Advocacy
  - Infrastructure Development/Business Modeling
  - Fleet Conversions/OEM Outreach
  - Marketing and Education
The Natural Gas Industry Has Reengaged NGVs (continued)

- ANGA Joins Natural Gas Vehicle of America (NGVA) – 29 companies including:

  - released at ACT EXPO 5/17/12 & NGV Infra Expo 2/24/13

- Joint AGA/ANGA Transportation Collaborative – Drive Natural Gas Initiative Becomes Part of NGVA Through Reorganization
NGVs – Industry Support

- The Natural Gas Industry Has Reengaged NGVs (continued)


- DOE Clean Cities Coalitions – Massachusetts, Vermont, Maine, New Hampshire, Rhode Island
MONEY!!!

- NGVs always cost more to buy or convert, but …
  - They cost much less to operate
  - On a life cycle basis, NGVs can save a lot of money!!
Why the NGV Market Will Grow

- We Have the Fuel – And It’s Ours
- Substantial Air Quality: Urban Pollution
- Substantial Air Quality: GHGs
- Biomethane Makes GHG Case Stronger
- Only Natural Gas Can Displace Diesel
- NGVs are a Here-and-Now Technology
- Government Policymakers are (Finally) Recognizing the Value of NGVs
- Money – Economic Advantages
History of CNG Vehicles

Early natural gas vehicles (NGVs) used low pressure natural gas stored in bladders. These vehicles would be unable to carry sufficient fuel for today’s applications.

Low Pressure Storage – Circa 1930.

Source: US DOE
History of CNG Vehicles

The energy shortages during World War II made NGVs popular in Europe. Advancements in compressor technology allowed the use of higher pressure steel cylinders on the roof of this sedan.

Source: US DOE
The oil embargos of the mid 1970’s and the growing concern over energy security and cost in the 1980’s fostered the natural gas vehicle (NGV) industry in North America. Many early Compressed Natural Gas (CNG) vehicles were conversions of gasoline vehicles.

Source: US DOE
Since the early 1990’s, natural gas vehicles (particularly those built by vehicle manufacturers or OEMs) have provided significant emissions reductions as compared to conventionally fueled vehicles.

Energy security continues to favor use of domestically produced natural gas.

Source: US DOE
Growth in World NGV Market

Number of natural gas vehicles

- 2003 - 2.8 Million
- 2007 - 7.0 Million
- 2010 - 11.0 Million
- 2011 - 12.6 Million
- 2016 - 19.9 Million (Pike Research projection*)
- 2020 - 35.0 Million (Navigant Research projection)

* Annual NGV sales to reach 3.2 million by 2016
Growth in World NGV Market

Chart 1.1 Cumulative Natural Gas Vehicles in Use by Segment, World Markets: 2013-2020

(Source: Navigant Research)
U. S. Overview

- Number of Vehicles: ~ 142,000 (out of 255,000,000)
- Total vehicle count had been slightly decreasing but it is on the rise again. 19,500 NGVs added in 2013.
- Vehicle count masks volume growth since US focus is on urban fleets — especially, trucks and buses
- 12-14% annual fuel volume growth rate past 3 years
- In 2005 ~ 200 million GGE; In 2011: 325 million GGE
- In 2012: 350 million GGE
- In 2013: 400 million GGE
U. S. Overview

- Number of CNG Stations: ~1425
- Surpasses the late 1990’s peak of 1350, with the count has grown steadily in past 36 months
  - Attrition of older stations built in 1990’s is finished
  - New investment/upgrades to older stations
  - New stations are based on better economics, higher throughput with anchor accounts or aggregated loads (multiple fleets, consumers)
- New players, new business models
- Approximately 130 new CNG stations added in 2012
- Approximately 275 stations added 2013
- Potential for 250-275 new stations in 2014!
Natural Gas Overview

End of section 1 – Natural Gas Overview
Compressed Natural Gas (CNG) Vehicles

- CNG vehicle types
- Heavy Duty Engine and Vehicle Availability
- Heavy Duty - Dual Fuel
- Medium Duty Engine and Vehicle Availability
- Sedans, Lt Duty, Medium Duty Vehicle Availability
- Operation and Maintenance
CNG Vehicle Types

- Dedicated - single fuel
- Bi-Fuel – two different fuels which burn separately (typically CNG and gasoline)
- Dual Fuel – two different fuels which burn simultaneously (typically CNG and Diesel)
Engines – Heavy Duty
Primary supplier to OEMs in

**Refuse collection trucks**
(Crane Carrier LET, Autocar Xpeditor, Int’l Condor, Peterbilt LCF 320 and Mack TerraPro; many 2nd stage upfitters e.g. Heil, McNeilus, Amrep, Labrie, PennFlex)

**Buses, shuttles, trolleys**
(NABI, New Flyer, Orion, Thomas, ElDorado, Blue Bird, Optima, variety of shuttle/trolley 2nd stage upfitters using FCC MB55 chassis)

**Sweepers**
(Elgin, Tymco, Schwarze, Allianz-Johnston)

**Work / Vocational Trucks**
(Freightliner M2 tractor and straight truck; Freightliner Custom Chassis MT45/55 walk-in/step vans; Ottawa; Capacity yard hostlers; Kenworth T800, T470, Peterbilt 384 and 365)
GX (formerly known as ISX-G)

- Based on Cummins ISX platform
- 15L engine, 400-450 HP
- High-Pressure Direct Injection (HPDI) technology: 5% diesel pilot fuel, 95% natural gas (LNG)
- CARB certification @ .8NOx

**NOTE:** The GX engine has been discontinued by Westport & an HPDI engine is under development by Volvo.
## Natural Gas Engine Comparison

<table>
<thead>
<tr>
<th></th>
<th>ISL-G</th>
<th>ISX12-G</th>
<th>Westport GX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Ratings</td>
<td>320/1,000</td>
<td>400/1,450</td>
<td>475/1,750</td>
</tr>
<tr>
<td>Ignition</td>
<td>Spark</td>
<td>Spark</td>
<td>Diesel Pilot</td>
</tr>
<tr>
<td>Aftertreatment</td>
<td>Three Way Catalyst</td>
<td>Three Way Catalyst</td>
<td>DPF/SCR</td>
</tr>
<tr>
<td>Fuel Type</td>
<td>CNG or LNG</td>
<td>CNG or LNG</td>
<td>LNG only</td>
</tr>
</tbody>
</table>
Spark Ignited vs. High Pressure Direct Injected

Spark Ignited

Cummins Westport, Inc. (CWI)
ISLG & ISX 12 G

HPDI

Westport GX

84
CWI Natural Gas Engine Line-up

<table>
<thead>
<tr>
<th>Model</th>
<th>Displ.</th>
<th>Power</th>
<th>Torque</th>
<th>Certification</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISB6.7</td>
<td>6.7 L</td>
<td>~260 hp</td>
<td>~660 lb-ft</td>
<td>EPA 13, Euro 6</td>
</tr>
<tr>
<td>ISL G</td>
<td>8.9 L</td>
<td>320 hp</td>
<td>1000 lb-ft</td>
<td>EPA 13, Euro 6</td>
</tr>
<tr>
<td>ISX12 G</td>
<td>12 L</td>
<td>400 hp</td>
<td>1450 lb-ft</td>
<td>EPA 13</td>
</tr>
<tr>
<td>ISX 15 G</td>
<td>15 L</td>
<td>450 hp</td>
<td>1750 Lb-ft</td>
<td></td>
</tr>
</tbody>
</table>
Spark Ignited Emissions
Reducing Cost Complexity and Weight

- Three Way Catalyst (TWC) reduces three harmful emissions: NOX, CO, HC
- End products are: N2, CO2, H2O
- Simple, passive, maintenance-free
- Weight benefit vs. diesel = 225 lbs.
- No changes expected through 2019

Catalyst Inlet
NOX
CO
HC

Catalyst Outlet
N2
CO2
H2O

ISL G TWC - similar package size to current mufflers
NGV Motori LLC

7.6L Dedicated Spark Ignited Nat Gas engine
- Based on International’s DT466/MaxxForce DT block used in Int’l/Navistar trucks/ buses.
- Repower older DT466 units with 175-260 HP 460-760 ft-lb torque remanufactured

87 Engine change-out/retrofit in 5-7 days
- Food/beverage delivery, refuse trucks, school buses, utility/public works trucks

6.4L Mercedes MB906 Detroit Diesel Dedicated Nat Gas
Vehicles – Heavy Duty
Vehicles – Heavy Duty

- Freightliner
- Peterbilt
- CCC
- Autocar
- Volvo
- Mack
- Navistar
- Kenworth
- International
CNG Residential Collection Trucks

- American LaFrance Condor 830S/880S (ISL-G)
- Autocar Xpeditor ACX (ISL-G, ISX12)
- Autocar Xpert (ISL-G)
- Crane Carrier Company COE2 (ISL-G, ISX12)
- Crane Carrier Company LET2/LETCC (ISL-G, ISX12)
- International (Navistar) LoadStar (ISL-G)
- Mack TerraPro Cabover and Low Entry (ISL-G)
- Peterbilt 320 (ISL-G, ISX12)
CNG Dumpster Transport Trucks

- Freightliner 114SD (ISL-G, ISX12)
- Freightliner M2 112 (ISL-G)
- International (Navistar) DuraStar (ISL-G, ISX12)
- International (Navistar) WorkStar (ISL-G, ISX12)
- Kenworth T440/T470 (ISL-G)
- Mack Granite (ISX12)
- Peterbilt 365 (ISL-G, ISX12)
CNG Delivery Transport Trucks

- Freightliner Cascadia 114SD (ISL-G, ISX12)
- Freightliner M2 112 (ISL-G)
- International (Navistar) DuraStar (Phoenix)
- International (Navistar) LoadStar (Phoenix)
- International (Navistar) TranStar (ISL-G)
- International (Navistar) WorkStar (Phoenix)
- Kenworth T440/T470 (ISL-G)
- Kenworth T660 (ISX12)
CNG Delivery Transport Trucks (con’t)

- Kenworth T880 (ISX12)
- Kenworth T800WS and W900S (ISL-G, ISX12)
- Mack Granite (ISX12)
- Mack Pinnacle (ISX12)
- Peterbilt 382 (ISL-G)
- Peterbilt 365 and 384 (ISL-G, ISX12)
- Volvo VML (ISL-G)
- Volvo VNL (ISL-G, ISX12)
CNG Tank Configurations

- Roof Mounted on Body
- Behind the Cab
- Chassis Mounted – Frame Rail
CNG Tank Configurations

Manhattan Beer – Beverage Delivery Tractor/Trailer

Chassis Mounted  Driver Side  Chassis Mounted  Passenger Side
Manufacturers supporting CNG refuse trucks by incorporating CNG tanks into refuse body designs:

- **Amrep**: roof or chassis mounts
- **F.F. Gomez**: roof or chassis mounts
- **Heil**: behind the cab, roof, or chassis mounts
- **Labrie**: behind the cab mount
- **Leach**: behind the cab, roof, or chassis mounts
- **McNeilus**: behind the cab, roof, or chassis mounts
- **New Way**: roof mount
- **Wittke**: roof mount
Navistar, Inc

- Cummins Westport Inc ISL - G Engine
  - WorkStar 7300/7400 Models
  - 320 HP
- International Dealer Network
- Phase II DuraStar Chassis Availability
- Food/beverage delivery, refuse trucks, utility/public works trucks
Autocar

Autocar Tractor LNG ACX

- Cab over design
  - Turning radius
  - Visibility
  - Ergonomic
  - Tractor or Straight Truck
  - ISL G (CNG or LNG)
Autocar

Autocar Bridgeport Split Body
Crane Carrier Company

Low Entry Tilt (LET2) Rear Loaders

- Tilt Cab
- Low Entry 18” height
- LH, RH, Dual Steer
- ISL G Engine
- ISX12 G Engine 2013

Rooftop Mounted CNG Storage
Crane Carrier Company

Low Entry Tilt (LET2) Dump Truck

- Tilt Cab
- Low Entry 18” height
- LH, RH, Dual Steer
- ISL G Engine
- ISX12 G Engine 2013

Behind Cab Mounted CNG Storage
Mack TerraPro

- Cab Over
- Low Entry available
- ISL G Engine
- ISX12 G Engine 2013
- 6/12/12 – Mack announced expanding its CNG offerings with Pinnacle and Granite models in 2013
  - Pinnacle – Tractor
  - Granite – Roll Off, Dump, Concrete Mixer
Freightliner

Freightliner M-2 112 CNG

- Tractor LNG or CNG
- Straight Truck LNG or CNG
- ISL G (CNG or LNG)

Frito-Lay (Pepsico)
Freightliner

- Cascadia 113 Tractor
  - Q2 2013
  - ISX G (CNG or LNG)
  - 60,600 GVWR, 400HP, 1450 lb/ft

- M2 112
  - ISL G (CNG or LNG)
  - 62,000 GVWR, 260-320HP
  - 1000 lb/ft

- 114SD (Severe Duty)
  - ISL G (CNG or LNG)
  - 80,000 GVWR, 250-320HP
  - 1000 lb/ft
# Kenworth Product Offerings

<table>
<thead>
<tr>
<th></th>
<th>T440</th>
<th>T470</th>
<th>T660</th>
<th>T800B</th>
<th>T800SH</th>
<th>W900S</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISX12G</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>ISL-G</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Heavy Duty – Dual Fuel

- Starts on diesel
- Up to 85% Nat Gas at highest loads
- High reliability
- Easy Maintenance
- Payback in 12 – 24 mos.

Outside Useful Life (OUL) Certifications
- OUL Heavy Duty Diesel – 10 yrs, 435,000 miles or 22,000 hrs
- Some manufacturers developing full certifications
- No Range Anxiety – runs on 100% diesel if natural gas runs out
Heavy Duty – Dual Fuel

THE POWER OF A DIESEL
THE SAVINGS OF NAT GAS
DUAL FUEL
NATURAL GAS
DIESEL
Heavy Duty – Dual Fuel
What is Dual Fuel?

Air and Methane Gas enter the cylinder

Gas Injector

Methane

Air

Diesel Engine

Fyda Energy Solutions – System Operation
Dual Fuel General – System Operation

- Advanced, electronically controlled fumigation
- ECU ties into some system

- Starts on diesel
- Up to 65-85% Nat Gas at highest loads
# EPA’s Approval List for Outside Useful Life (OUL) Clean Alternative Fuel Conversion Systems

[http://www.epa.gov/otaq/consumer/fuels/altfuels/altfuels.htm](http://www.epa.gov/otaq/consumer/fuels/altfuels/altfuels.htm)

<table>
<thead>
<tr>
<th>Conversion Fuel</th>
<th>Original Fuel</th>
<th>Model Year</th>
<th>Conversion Manufacturer</th>
<th>OEM</th>
<th>OEM Test Group</th>
<th>OEM Evap Families</th>
<th>Eng Disp</th>
<th>Conversion Evap Family</th>
<th>Conversion Test Group</th>
<th>Conversion Models Covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel or Diesel/CNG</td>
<td>Diesel</td>
<td>2004</td>
<td>American Power Group, Inc.</td>
<td>Caterpillar</td>
<td>4CPXH0928EBK</td>
<td>4CPXH0928EBK</td>
<td>15.2</td>
<td>BAPGH15.2CP4</td>
<td>C15</td>
<td></td>
</tr>
<tr>
<td>Diesel/ CNG/ LNG</td>
<td>Diesel</td>
<td>2009, 2008, 2007, 2006, 2005, 2004</td>
<td>EcoDual LLC</td>
<td>Cummins</td>
<td>9CEXH0912XAK, 9CEXH0912XAL, 9CEXH0912XAM, 8CEXH0912XAK, 8CEXH0912XAL, 8CEXH0912XAM, 7CEXH0912XAK, 7CEXH0912XAL, 7CEXH0912XAM, 6CEXH0912XAK, 6CEXH0912XAL, 6CEXH0912XAM, 6CEXH0912XAJ, 5CEXH0912XAH, 5CEXH0912XAJ, 4CEXH0912XAH, 4CEXH0912XAJ</td>
<td>14.9</td>
<td>BEDGE14.9ISX</td>
<td>Cummins ISX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gasoline/LPG</td>
<td>Gasoline</td>
<td>2002</td>
<td>Parnell USA</td>
<td>Ford</td>
<td>2FMXH05.4BHF</td>
<td>2FMXH05.4BHF</td>
<td>5.4</td>
<td>BPRLE0155BAG</td>
<td>BPRL05.4BH2</td>
<td>F-350 2&amp;4WD</td>
</tr>
</tbody>
</table>
Dual Fuel EPA Certifications for OUL:

- 2004 - 2009 Detroit Diesel: 21 various OEM Test Groups/Families
- 1998 – 2006 Caterpillar: 34 various OEM Test Groups/Families
- To view complete listing go to: www.americanpowergroupinc.com
Landi Renzo – Diesel Dual Fuel (DDF)

Landi Renzo USA is proud to announce the availability of their technology for factory remanufactured Detroit Diesel S60 12.7L engine.

Technology

- Average Fuel Displacement up to 60%
- Noise reduction up to 40%
- Particulate Matter reduction from 40%
- CO2 reduction up to 14%

Benefit

Performance comparable to the original engine in terms of torque/power and drivability

- Maintaining/Improving the emission levels of original engine
- Flexibility for adaptation to different Diesel engines
- Ability to switch back to original full Diesel if needed
- Requires Less CNG storage compared to a Dedicated CNG vehicles
- Extended range compared to original Diesel system
Engines – Medium Duty
Medium Duty Dedicated Engines

Ford 6.8L Triton 3V V10 compressed natural gas-prepped engine

- Order code 98G
- 355 HP
- 455 lb/ft torque
- up to 20,000 GVWR
- QVM Upfitters
- Available as Bi-Fuel as Well
Medium Duty Dedicated Engines

GM Vortec 6.0L V-8 compressed natural gas-prepped engine

- Order code LC8
- 322 – 360 HP
- 373 – 382 lb/ft torque
- Isuzu NPR, Workhorse (Navistar) W42 & W62, Chevy Express/GMC Savana Cutaway 4500
- SVM Upfitters
Vehicles – Medium Duty
## Vehicles – Medium Duty

**Ford F650 & F59 6.8L 3V**
- Dedicated CNG
- CARB & EPA Certifications

<table>
<thead>
<tr>
<th></th>
<th>F650</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Engine</strong></td>
<td>6.8L 3-Valve V10</td>
</tr>
</tbody>
</table>
| **Manufacturer Stated Horsepower** | 357 @ 4750 RPM
|                  | 457 ft-lb torque @ 3250 RPM       |
| **Max GVWR**     | 29,000 lbs.                       |
Landi Renzo USA - 2014 Ford Product Overview

- **Ford E-150/E-250/E-350**
  - Cargo & Passenger *5.4L*
  - Dedicated CNG

- **Ford F-250/F-350**
  - Pickup/Chassis Cab *6.2L*
  - Bi-Fuel

- **Ford F-450/F-550**
  - Chassis Cab *6.8L*
  - Bi-Fuel & Dedicated CNG

- **Ford F-650**
  - Chassis Cab *6.8L*
  - Dedicated CNG

- **Ford F-59 Chassis**
  - Stripped Chassis *6.8L*
  - Dedicated CNG
Ford F450/550 6.8L
- Bi-fuel/Dedicated CNG
- CARB (Dedicated) & EPA Certifications

<table>
<thead>
<tr>
<th></th>
<th>F450</th>
<th>F550</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Engine</strong></td>
<td>6.8L 3-Valve V10</td>
<td>6.8L 3-Valve V10</td>
</tr>
<tr>
<td><strong>Manufacturer Stated Horsepower</strong></td>
<td>362 @ 4750 RPM 457 ft-lb torque @ 4500 RPM</td>
<td>362 @ 4750 RPM 457 ft-lb torque @ 4500 RPM</td>
</tr>
<tr>
<td><strong>Max GVWR</strong></td>
<td>16,500 lbs.</td>
<td>19,500 lbs.</td>
</tr>
</tbody>
</table>
Baytech 2014 Product Overview

- **Isuzu NPR HD**
  - 6.0L

- **Workhorse W62**
  - 6.0L

- **Freightliner MT45-55**
  - 6.0L

- **GMC Savana & Chevrolet Express**
  - Cutaway / 6.0L

- **GM Cab Chassis**
  - 6.0L
# Westport and Westport BAF 2014 Product Overview

<table>
<thead>
<tr>
<th>Bi-FUEL – EPA Certified</th>
<th>DEDICATED – CARB/EPA Certified</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ford F-Series</strong></td>
<td></td>
</tr>
<tr>
<td>F-250/350 with 6.2L</td>
<td>F-250/350 with 6.2L</td>
</tr>
<tr>
<td>In-bed and under-bed tanks</td>
<td>F-450/550 with 6.8L</td>
</tr>
<tr>
<td>F-350/450/550 Chassis</td>
<td>F-650 with 6.8L</td>
</tr>
<tr>
<td><strong>Service Bodies</strong></td>
<td><strong>Ford E-Series</strong></td>
</tr>
<tr>
<td>F-250/350 READY-link™</td>
<td>E-250/350 with 5.4L</td>
</tr>
<tr>
<td>F-350/450/550 Chassis</td>
<td>E-350 Cutaway with 5.4L</td>
</tr>
<tr>
<td></td>
<td>E-450 Cutaway with 6.8L</td>
</tr>
</tbody>
</table>
Dodge Ram Pick-up Natural Gas Bi-Fuel

- RAM 2500 CNG
- 5.7L HEMI V8 Bi-fuel engine. Special valves, valve seats, spark plugs
- 2 - 9.1 GGE tanks: 18.2 GGE of CNG; 8 Gallon Gasoline tank or optional 35 gallon gasoline tank
Sedans, Light Duty, Medium Duty - OEMs

Ford
Chevrolet
GM
RAM
Westport
Isuzu
Honda
Freightliner
Custom Chassis
Sedans, Light Duty, Medium Duty
American Honda Civic Natural Gas

- Natural gas version of Civic LX with 1.8L 4-cylinder, 16 valve, 12.7:1 compression ratio engine; 8 GGE tank: 225-250 mile range
- American-made – Manufactured in Greensburg, IN
- Part of Honda’s “Good, Better, Best, Ultimate” hierarchy of vehicle choices where “good” is high-mpg gasoline, “better” is hybrid, “best” is CNG and “ultimate” (future goal) is fuel-cell.
- Great for sales reps, document and medical lab couriers, transit route supervisors, social service workers, code officials, parking enforcement, security/police (non-pursuit), utility/meter readers, etc. etc.
- Sold through network of approved Honda dealers, expanded service network
Chevrolet Natural Gas Impala Bi-Fuel

- Model Year 2015 available August 2014
- Approximate $38,200 MSRP
- Driving range – 150 miles on CNG (7.7 GGE); 350 miles on gasoline
Chrysler 300C AWD Demonstration

CNG Display: LandiRenzo Combination Gauge: gasoline / CNG operation indicator and multi-LED CNG fuel level gauge.

CNG Capacity: 9 GGE @ 3600 psi (Usable 8.1 GGE)

Performance:
- 363 hp / 394 lb-ft (Gasoline mode)
- 363 hp / 394 lb-ft (CNG mode)

Driving Range:
- Gasoline: 371 miles
- CNG: 171 miles
- Total: 542 miles

MPG:
- Gasoline: 19
- CNG: 19

Weight: 4,496 lbs (4,236 lbs base)

Interior Volume: 122.6 cu ft (122.6 cu ft base)

Cargo Volume: 4.0 cu ft (16.3 cu ft base)

Engine: 5.7L V8 Cylinder / CNG Bi-Fuel Port Fuel Injection

CNG Control System: LandiRenzo Omegas™ Bi-fuel system
Dedicated NGVs

Westport/BAF; Landi Renzo E-250/350 Van

- Available on 5.4L V8 (E-250/350)
- Gaseous Prep Code 91G
- EPA/CARB Certified
- 20-25 GGE on dedicated model
- Bi-fuel CNG/Gasoline available
- CNG Option $12K - $20K
Dedicated NGVs

Westport / BAF F-Series Pickup
- Available on 6.2L V8 (F-250/350)
- Emergency Refueler option avail
- EPA/CARB Certified; Order Code 98G
- 18-40 GGE on dedicated model
- Bi-fuel CNG/gasoline available
Dedicated NGVs

Westport / BAF F- 450/550/650

- F-450/550 6.8L V10
- F-650 gaseous prep package ; EPA/CARB Certified
- Order Code 98G
- 60+ GGE
Dedicated NGVs

Westport/BAF E-450 Shuttle

- Available on 6.8L V10 with gaseous prep option 98G
- EPA/CARB Certified SULEV
- 29 GGE std; additional capacity available to 50+ GGE
IMPCO
Dedicated CNG Vehicles

GMC & Chevy Cutaway Shuttle
Dedicated GMC Sierra & Chevy Silverado
GMC Savana and Chevy Express Vans

Chevy Tahoe
Sedans, Lt Duty, Med Duty, Heavy Duty Upfitters

- OEM Systems of Okarche, Oklahoma;
- Venchurs Vehicle Systems of Adrian, Michigan;
- Alternative Fuel Solutions of Mahaffey, Pennsylvania;
- AVS of Salt Lake City, Utah;
- World CNG of Kent, Washington.
CNG Vehicle Availability

http://www.ngvamerica.org/pdfs/Available_Vehicles_and_Engines.pdf

- NGVAmerica.org website
  - Resources and Tools
    - Vehicle Information
    - Available Vehicles and Engines
Vehicle Maintenance

- Cleaner Burning Fuel
  - Less Oil Changes – Manhattan Beer every 25K miles
  - Less Frequent Spark Plug Replacement – Manhattan Beer every 50K miles

- Most other components are the same

- Majority of service performed by trained technicians at OEM dealerships
Vehicle Maintenance – NGV Cylinders

NGV Cylinders – visual inspection every 36 months or 36,000 miles and after vehicle accident or fire

Compressed Gas Association (CGA) - pamphlet entitled “Methods for External Visual Inspection of Natural Gas Vehicle (NGV) and Hydrogen Vehicle (HV) Fuel Containers and Their Installations”

acceptable practice in the industry for complying with the US DOT Safety Standard 304 and the American National Standards Institute NGV2

cuts, cracks, gouges, abrasions, discoloration, broken fibers, loose brackets, damaged gaskets or isolators, heat damage, or other problems

Various training programs available
Safety procedures and safe working environment essential, like any vehicle

Due to the gaseous fuel characteristics and pressures of CNG, there are special safety considerations that must be taken into account

SAE J2406: “Recommended Practices for CNG Powered Medium and Heavy-Duty Trucks” - provides guidance for the construction, operation, and maintenance of CNG powered medium and heavy-duty trucks.
Break
Fueling Infrastructure

- System Types and Components
- Available Technologies
- Sample Stations
- Fuel Infrastructure and Price Locator Websites
- Fuel Infrastructure - Mobile
- Fuel Station Ownership and Operations Options
- Fuel Station Design and Cost Considerations
- Fuel Station Costs
- Fuel Station Codes and Standards
Fueling Infrastructure

In North America, there are four predominant configurations of CNG Stations:

- Cascade Fast-Fill
- Buffer Fast-Fill
- Time-Fill
- Combination-Fill
Fueling Infrastructure

Cascade Fast-Fill

Source: ANGA TIAX Study “U.S. Canadian Natural Gas Vehicle Market Analysis: Compressed Natural Gas Infrastructure – Final Report”
Fueling Infrastructure

Buffer Fast-Fill

Source: ANGA TIAX Study “U.S. Canadian Natural Gas Vehicle Market Analysis: Compressed Natural Gas Infrastructure – Final Report”
Fueling Infrastructure

Time-Fill

Source: ANGA TIAX Study “U.S. Canadian Natural Gas Vehicle Market Analysis: Compressed Natural Gas Infrastructure – Final Report”
Fueling Infrastructure – Conclusions

Which is Right for My Fleet?

1. Cascade Fast-Fill
   - Sedan/Light Duty – vehicles not available in dedicated parking space for extended period of time and deliver 10-15 GGE in 4-6 minutes (also needed for public access)

2. Buffer Fast-Fill
   - Medium/Heavy Duty – vehicles not available in dedicated parking space for extended period of time and deliver 10 DGE per minute or approximately 40 DGE in 4-5 minutes (also needed for public access)

3. Time-Fill
   - Vehicles park in dedicated spaces and are available for an extended period of time
Fueling Infrastructure – Conclusions
Which is Right for My Fleet? (Con’t.)

1. Combination Fill (Cascade or Buffer Quick Fill and Time Fill)
   - Sedan/Light Duty – vehicles not available in dedicated parking space for extended period of time and deliver 10-15 GGE in 4-6 minutes (Cascade Quick Fill)
   
   OR

   - Medium/Heavy Duty – vehicles not available in dedicated parking space for extended period of time and deliver 10 DGE per minute or approximately 40 DGE in 4-5 minutes (Buffer Quick Fill)

   AND

   - Vehicles park in dedicated spaces and are available for an extended period of time (Time Fill)
Fueling Infrastructure

City of Long Beach Public Schools – LI New York
Fueling Infrastructure

City of Long Beach Public Schools – LI New York

Storage Cascade

Compressor

Dryer

Suction Gas

Meter Header
Fueling Infrastructure

City of Long Beach Public Schools – LI New York

Time Fill Posts - Hoses
Fueling Infrastructure

New York State Office of General Services – Clean Energy, Hauppauge, LI

Buffer Fast-Fill - 2 Fuel Islands with 4 Fuel Hoses Total
Fueling Infrastructure

Casella Waste Systems Time Fill CNG Station – Williston, VT
Fueling Infrastructure

Waste Management Time Fill CNG Station in Chicago, IL
Fueling Infrastructure

National Grid – Albany, NY funding by DOE thru CCofCNY and NYSERDA

Combination Station – Fast Fill and Time Fill “behind the Fence”
Fueling Infrastructure

Long Island – Kings Park, NY Municipal Service Facility

Town of Smithtown Natural Gas Vehicle Fueling Station
Fueling Infrastructure

FuelMaker Residential Fueling Appliance “Phill”
**Fueling Infrastructure - Mobile**

- Mobile fueling has emerged as an economic, viable alternative:
  - Provide fuel to small number of vehicles where permanent station is not justifiable
  - Provide fuel where gas distribution pipeline is inadequate or doesn’t exist
  - Customer/Fleet gets on site fuel and avoids capital station investment
Fueling Infrastructure - Mobile

Mobile fueling providers:

Mobile Fuel Solutions (MFS) “Virtual Pipeline”
OSComp Partners w/ Global for “Virtual Pipeline”
Ultimate CNG “Fuel Mule”

NG Advantage – Trucked Natural Gas
Fueling Infrastructure - Mobile

Mobile fueling techniques:
- “Wet Fueling” – from mobile source directly to vehicle
- Stationary Fueling – mobile storage connects to on-ground dispensing equipment

Mobile fueling - more than just transportation sector:
- Industrial/Institutional/Retail – large fixed users without access to pipelines
- Drilling & Fracking Site Refueling – supply to heavy horsepower (HHP) engines in oil & gas industry
Fueling Infrastructure & Price Locators

Smart phone apps

- CNG Now Fuel Finder
  www.cngnow.com/app/Pages/information.aspx
- MapMuse Alternative Fuel Finder
  http://find.mapmuse.com/apps/alt-fuel
Fueling Infrastructure & Price Locators

Online Interactive Maps

- US DOE Alternative Fuels and Advanced Vehicles Data Center Alternative Fueling Station Locator
  www.afdc.energy.gov/afdc/locator/stations/
- NGVAmerica CNG Stations
  www.ngvamerica.stone-env.net/
- Alternative Fuel Prices and Fill Stations
  www.altfuelprices.com
- MapMuse CNG Fuel Stations Location Map
  http://find.mapmuse.com/map/cng
Fueling Infrastructure

Compressed Natural Gas (CNG) Stations in Rhode Island

Public - Three Stations

- National Grid Cumberland – Operated by Clean Energy
  1595 Mendon Rd.
  Cumberland, RI 02864  Phone – 866.809.4869

- National Grid Providence – Operated by Clean Energy
  642 Allens Ave.
  Providence, RI 02905  Phone – 866.809.4869

- AVSG – TF Green Airport
  2000 Post Rd. (On Airport Grounds Adjacent to Long Term Pkg)
  Warwick, RI 02886  Phone – 401.737.8222
Fueling Infrastructure

Compressed Natural Gas (CNG) Stations in Rhode Island

Private – Three Stations

- Waste Management – Cranston Hauling
  1688 Pontiac Ave.
  Cranston, RI 02920

- University of Rhode Island
  9 Garage Rd.
  Kingston, RI 02881

- Rhode Island State Energy Office – Cranston Facility
  1375 Pontiac Ave.
  Cranston, RI 02920
Natural Gas Fuel Station Options

- **Offsite** – use existing public access station
  - Operated by independent retailer, utility, or other fleet
  - Least expensive option, ability to “pool” fleets

- **Onsite** – Private Access (i.e. – only for fleet operator)
  - Refuse or Municipal Fleets with restricted access
  - Time Fill only stations – always private access

- **Onsite** – Public Access
  - “Outside the Fence” dispensers – this is a growing trend
    - Economies of scale, promotes public network
  - Often Operated by Third Party
    - Allows operator to serve anchor with lower load while building additional load via sales to other fleets/consumers
Natural Gas Station Development Option #1

Fleet Owns & Operates Private Station

- Fleet builds & operates its own station. Fleet takes responsibility for development as prime contractor, working with vendors, and takes responsibility for maintenance.
- Includes design consultant, construction firms, and maintenance/service firms
- Works well for small to medium to fleets that don’t have offsite options available. Their fuel use doesn’t meet needs of independent developer
Natural Gas Station Development Option #2

Outsource station development, ownership, O&M to Independent Fuel Provider

- Fleet serves as anchor with long term pricing/fuel contract

- All capital, O&M costs & risks responsibility of independent fuel provider

- Fleet provides low/no cost lease for property

- Potential royalty to fleet for public access
Natural Gas Station Development Option #3

Fleet Owns/Leases Station and Contracts out Operations for a fee (monthly or GGE basis)

- Used by many large fleets who want ownership benefits but want to reduce risk, assure best O&M practices

- Fleet can use RFP process for O&M of station

- Third party expert provides technicians, training, parts, etc.
CNG Station Design Considerations

How Much Fuel in How Much Time?

- Need projected number of Vehicles/day and fuel/vehicle

- Fueling patterns:
  - All fueled at once?
  - Staggered throughout day?

- Maximum hourly/daily flow rate
  - affects equipment selection and/or amount of storage

- Availability of backup fueling
  - affects design requirements for redundancy
Station Design/Cost Considerations
Design Cost Factors *Not Related to Fuel Vs. Time*

Real Estate Design/Cost factors

- Location: Cost of property, traffic access/flow, competition for prime location from other businesses
- Size of property: Space requirements for equipment, adequate traffic pattern space
- Site Development: Availability of fuel, power, permitting, codes and regulations

CNG/LNG Station Enviro Express
Bridgeport, CT
Station Design/Cost Considerations
Design Cost Factors Impacted by Fuel Vs. Time

Fueling Equipment needs/costs

- Compression
  - Electric vs gas engine drive
    - Size of Electric Service?
    - Inlet gas psi and peak flow rates
  - Sizing is critical (HP and SCFM)
  - Enclosures for sound insulation
  - Type of control system

- GGE/Hr = 0.5 x SCFM (@ rated inlet psi)
  - i.e.: 200 SCFM = ~100 GGE/Hr
  - i.e.: 100 SCFM = ~ 50 GGE/Hr
Station Design Considerations
Design/Cost Factors Impacted by Fuel vs Time

Fueling Equipment/CNG Storage

- Is it needed? - Compression capacity vs storage costs
- Peak storage Requirements & dispensing projections
- Cascade vs buffer system
- Type of storage containers - spheres or cylinders
- Space availability
Station Design/Cost Considerations
Design/Cost Factors Impacted by Fuel vs. Time

Natural Gas Dryers

- Projected volume and flow rates
- Inlet gas pressure and pressure variables/weather
- Gas moisture content issues (gas analysis)
- Automated or manual regeneration
- Single vs. Double tower configurations

Long Beach Public Schools
Long Island, NY
Station Design/Cost Considerations

Design/Cost Factors Impacted by Fuel vs. Time

Dispensers
- Number and Type
- Training Verification

Fuel Management System
- Key/Card/Fleet/Public Card
- Time fill, fast fill, both?
Station Development Steps

- Assess funding needs, site requirements & feasibility, develop conceptual design and station performance expectations
- Determine project delivery process
  - Private Project: Engineer/Procure/Construct
  - Public Project: A/E proposal with public bid
- Identify potential qualified developers and interview
- Issue RFP, RFI, and RFQ
- Review, re-assess/adjust (but don’t value-engineer it to death) and award
- Complete station commissioning process and assure for PM/service contract for best performance
CNG Fuel Stations Cost: $5K - $2 million

CNG fueling stations with the same compressor flow rate have different costs and/or vehicle fueling capabilities. Combination-fill stations will incorporate cost elements from these stations.

<table>
<thead>
<tr>
<th></th>
<th>Fast Fill Station I:</th>
<th>Fast Fill Station II:</th>
<th>Time Fill Station:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component Cost</td>
<td>$500,000</td>
<td>$650,000</td>
<td>$375,000</td>
</tr>
<tr>
<td>Installation Cost*</td>
<td>$300,000</td>
<td>$350,000</td>
<td>$300,000</td>
</tr>
<tr>
<td>Total Cost</td>
<td>$800,000</td>
<td>$1,000,000</td>
<td>$675,000</td>
</tr>
</tbody>
</table>

Vehicle Fueling Scenarios

- 15 light-duty/15GGE consecutively fueling in a 1-hour peak period
- Randomly arriving light-duty/10 GGE
- 10 heavy-duty/20 DGE consecutively fueling in a 1-hour peak period
- Randomly arriving heavy-duty/DGE

A number of codes and standards govern U.S. CNG fueling station design and operation; a partial list is provided below.

<table>
<thead>
<tr>
<th>Code Agency/Organization</th>
<th>Primary Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANSI</td>
<td>Facilitates the development of certain codes and standards that govern the use of CNG and the manufacturing of CNG fueling components, including nozzles, receptacles, dispensers, hoses, breakaway devices, valves, and other related fueling components</td>
</tr>
<tr>
<td>ASME</td>
<td>Regulates high-pressure CNG storage vessels and piping</td>
</tr>
</tbody>
</table>
|  • Boiler and Pressure Vessel Code Section 8  
  • ANSI/ASME B31.3 Chemical Plant and Petroleum Refining Piping |  • Section 8 is the manufacturing standard for the pressure vessels used in the CNG station  
  B31.3 establishes the specifications for the piping throughout the CNG station |
| ASNT                     | Tests components for safety |
| NEMA                     | Establish standards for electrical component manufacturing |
| NFPA                     | Regulates the use of natural gas as a vehicle fuel, including stations and vehicles |
|  • NFPA 52  
  • NFPA 70  
  • NFPA 30A |  • Defines the boundaries of the hazardous areas inside the fueling station  
  • Establishes the NEC  
  • Governs the use of multiple fuels in one location |
| NFPA 70/NEC              | Defines the electrical classification of the hazardous areas within a CNG station |

CNG Fuel Stations – Codes and Standards

A number of codes and standards govern U.S. CNG fueling station design and operation; a partial list is provided below.

<table>
<thead>
<tr>
<th>Code Agency/Organization</th>
<th>Primary Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSHA</td>
<td>Regulates occupational safety and health in the work environment</td>
</tr>
<tr>
<td>SAE</td>
<td>J1616 establishes the recommended practice for fuel quality and water content</td>
</tr>
<tr>
<td>UBC, Local Jurisdiction</td>
<td>Regulates structures that contain CNG fueling equipment</td>
</tr>
<tr>
<td>UFC</td>
<td>Some states and/or localities use this code; often contains NFPA 52 within it</td>
</tr>
<tr>
<td>UPC</td>
<td>Governs the plumbing components of CNG stations</td>
</tr>
<tr>
<td>NIST</td>
<td>Establishes the unit of measurement for custody transfer of CNG from the retailer to the customer</td>
</tr>
<tr>
<td>UL</td>
<td>Tests components and publishes lists according to compliance</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standards</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANSI/IAS NGV4.1-99/CSA 12.5-M99(R09) Natural Gas Vehicle Dispensing Systems</td>
<td>Applies to the mechanical and electrical features of newly manufactured systems that dispense natural gas for vehicles, where such a system is intended primarily to dispense the fuel directly into the fuel storage container of the vehicle.</td>
</tr>
<tr>
<td>ANSI/IAS NGV4.2-99/CSA 12.52-M99(R09) Hoses for Natural Gas Vehicles and Dispensing Systems</td>
<td>Applies to compressed natural gas hose assemblies that are used for natural gas vehicle dispensing stations to connect the dispenser to the refueling nozzle, or used as part of a vehicle onboard fuel system and for gas lines that carry vented gas back to a safe location.</td>
</tr>
<tr>
<td>NGV 4.8-2002/CSA 12.8-2002 (R07) Natural Gas Fueling Station Reciprocating Compressor Guidelines</td>
<td>Details construction and performance requirements for natural gas compressors for use in compressed natural gas fueling stations service. The compressor package should include, but not be limited to, all necessary equipment from the inlet connection immediately upstream from the isolation valve to the packager-specified discharge connection.</td>
</tr>
</tbody>
</table>
CNG Economics

- Components of CNG Cost
- Simple Payback - Cargo Van
- Simple Payback – Delivery Van
- Simple Payback – Delivery Step Van
- Simple Payback – Refuse Truck
- Simple Payback – Long Haul Truck
- Incentives and Funding
- Other Considerations
CNG Economics – Cargo Van / Pickup

- Light Delivery, Parts Delivery, Service Vehicle
- MPG: 11.0 – 13.0, 26-28K miles/yr
- Fuel Use: 2150 - 2360 GGE/yr
- CNG Premium: $10,000 (assuming no offset from grants and/or tax credits)
- Simple Payback: 2.8 - 3.1 years
- Life-cycle cost savings: $22.6K - $24.7K!
  (based on 7-yr life & $1.50/GGE savings at public station)

NOTES: Calculations do not factor in any grants or incentives. Savings are exclusive of any avoided costs of diesel emission equipment and service.
CNG Economics – Delivery Step Van

- Courier, laundry/uniform, food service
- MPG: 5.0 – 6.5, 26-28K miles/yr
- Fuel Use: 4200 - 5000 DGE/yr
- CNG Premium: $25,000 (assuming no offset from grants and/or tax credits)
- Simple Payback: 2.7 - 3.2 years
- Life-cycle cost savings: $52.7K - $67.5K!

(based on 10-yr life & $1.85/DGE savings at Own & Operate station)

NOTES: Calculations do not factor in any grants or incentives. Savings are exclusive of any avoided costs of diesel emission equipment and service.
CNG Economics – Local / Short Haul Truck

- Food, Furniture, Appliance, Beverage Delivery
- MPG: 8.0 – 10 mpg, 30-40K miles/yr
- Fuel Use: 3750 - 5000 GGE/yr
- CNG Premium: $20,000 (assuming no offset from grants and/or tax credits)
- Simple Payback: 2.7 - 3.5 years
- Life-cycle cost savings: $45K - $60K!
  (based on 8-yr life & $1.50/GGE savings at Public station)

NOTES: Calculations do not factor in any grants or incentives. Savings are exclusive of any avoided costs of diesel emission equipment and service.
CNG Economics – Refuse

GVWR: >26,000 lbs.
Crane Carrier LET, Autocar Xpeditor, Peterbilt LCF 320, ALF – Condor & Mack TerraPro (all with CWI ISL-G engine);
MPG: 2.5 – 3.0 (lots of idle and PTO time)
Fuel Use: 35-40 DGE/day; 8500-10,500 DGE/yr
CNG Premium: $30,000 (assuming no offset from grants
Simple Payback: 1.75 – 2.0 years (based on $1.50/DGE savings)
Life-cycle cost savings: $93.8 - $123.4+!! (based on 8-yr life)

NOTES: Calculations do not factor in any incentives.
Savings are exclusive of any avoided costs of diesel emission equipment and service.
CNG Economics – Long Distance Truck

- Long Haul / Delivery
- MPG: 4 – 6 mpg, 80-100K miles/yr
- Fuel Use: 16,700 – 25,000 DGE/yr
- CNG Premium: $50,000 (assuming no offset from grants and/or tax credits)
- Simple Payback: 1.3 – 2.0 years
- Life-cycle cost savings: $400 K - $500 K!
  (based on 10-yr life & $1.50/DGE savings at Public station)

**NOTES:** Calculations do not factor in any grants or incentives. Savings are exclusive of any avoided costs of diesel emission equipment and service.
CNG Economics – Dual Fuel Application

- Long Haul / Delivery
- MPG: 3 – 4 mpg, 80-100K miles/yr
- Fuel Use: 26670 - 33330 DGE/yr ; 60% offset
- CNG Premium: $30,000 (assuming no offset from grants and/or tax credits)
- Simple Payback: 1.0 – 1.2 years
- Life-cycle cost savings: $120 K - $150 K!
  (based on 5-yr life & $1.50/DGE savings at Public station)

NOTES: Calculations do not factor in any grants or incentives.
CNG Economics – Components of CNG Cost

Gas Bill
- Gas commodity
- Pipeline transportation to utility’s city gate (transmission) + Local Gas Distribution Company (LDC) delivery service
- Any applicable federal, state, local taxes

Compression
- Electric used by primary mover (electric motor)

Station Maintenance
- PM, scheduled and demand repairs, compressor rebuilds

Capital Equipment Amortization (Depreciation)
- Actual cost of equipment or cost of capital factored into each GGE over life of station equipment

Profit Margin
Gas Bill – Gas Commodity Portion

- When NYMEX MMBtu was $12.00, commodity of CNG was $1.50/GGE
- When NYMEX MMBtu was $8.00, commodity of CNG was $1.00/GGE
- When NYMEX MMBtu was $3.20, commodity of CNG was $.40/GGE
- NYMEX MMBtu is ~$2.40; commodity of CNG is $.30/GGE
- Your local gas company (LDC) buys gas at various prices and uses a weighted formula to pass along commodity at cost – purchased gas cost adjustment (which helps to eliminate extreme swings in market price)

NOTE: One MMBTU = approximately 8.0 GGE of uncompressed natural gas
One MMBTU = approximately 7.2 DGE of uncompressed natural gas
Gas Bill – Gas Commodity Portion

- NY is a deregulated state and the customer has the right to choose a separate gas supplier called an Energy Services Company (ESCO) to purchase the commodity.
- In this case, the LDC or gas utility’s role is to deliver/transport the gas from the city gate to the customer’s meter.
- The LDC still provides a single bill for commodity and delivery charges.

Source: NGVAmerica & Clean Vehicle Education Foundation
CNG Economics – Components of CNG Cost

Sample Cost Components

- Gas Bill: $.66/DGE (based on avg MMBtu cost of $3.20)
- Electric compression costs: $.11/DGE
- Maintenance/Repair/Service: $.44/DGE
- Capital amortization of equipment: $.38-$0.71/DGE

SUB-TOTAL:

- $1.59 - $1.92 (sales to tax exempt entities)
- $1.773 - $2.103 (sales to taxable entities includes FET)

Note: There is no state tax on CNG in RI!

Source: NGVAmerica & Clean Vehicle Education Foundation
Assumptions:

- No grants or tax credits for fueling station
- 10-year depreciation of equipment
- No cost of capital
- No negotiated special contract rate with LDC
- Station is developed, owned and operated by end-user
CNG Economics - Incentives and Funding

Funding
- DOT Congestion Mitigation Air Quality (CMAQ)
- US EPA Diesel Emission Reduction Act (DERA)
- DOE Clean Cities
- EPAs SmartWay Clean Diesel Program
- National Grid – Advanced Gas Technology (AGT) Funds
- Potential State Funding – check with local Clean Cities
Incentives

- Local Distribution Company (gas utility) specific incentives
- Infrastructure developer/operator incentives
- American Taxpayer Relief Act (expired 12/31/2013)
  - Federal IRS Volumetric Excise Tax Credit - $.50/GGE
  - Alternative Fuel Infrastructure Tax Credit
    - 30% up to a maximum of $30,000; $1,000 on a residential fueling appliance
- RI State Sales Tax – currently CNG is tax exempt; LNG is taxed at $.544/DGE. Gasoline and diesel are taxed at $.32/gallon
- Potential State Incentives – check with local Clean Cities
Lunch Break – Safety & Testing of NGV Cylinders Video


“Setting the Standard for Safety”
CNG Resources

Websites
- Associations
- Tools
- Standards
CNG Resources

Ocean State Clean Cities Coalition  401.874.2792
www.web.uri.edu/ceoc/ocean-state-clean-cities-coalition-partners/

Natural Gas Vehicle for America (NGVA)
202.824-7360 www.NGVAmerica.org

Clean Vehicle Education Foundation (CVEF)
770.424-8575 www.cvef.org

American Gas Association (AGA)
202.824-7000 www.aga.org

Northeast Gas Association (NGA)
781.455-6800 x111 www.northeastgas.org
CNG Resources

National Grid
800.870.1664  www.nationalgrid.com
CNG Resources

CNG Now
www.cngnow.com

America’s Natural Gas Alliance (ANGA)
www.anga.us

DOE AFDC – Alternative Fuel Data Center/Natural Gas
www.afdc.energy.gov/afdc/fuels/natural_gas.html

U.S. DOE Clean Cities
www.eere.energy.gov/cleancities
CNG Resources

U.S. DOE Alternative Fuel Calculator (Payback)
www.afdc.energy.gov/afdc/calc

U.S. DOE Guide for Assessing the Business Case for CNG conversion of Municipal Fleets
www.afdc.energy.gov/afdc/pdfs/47919.pdf

U.S. DOE Excel Based Calculator Tool for Vehicle and Infrastructure Cash-flow Evaluation (VICE) model
www.afdc.energy.gov/afdc/docs/vice_model_w_intro.xlsx

NFPA52 - 2010 Vehicular Gaseous Fuel Systems Code
Fueling Options

- Expanding Infrastructure – Hubs
- Additional Players
- Multiple Models
- Truck Stops & Convenience Stores
Fueling Options
Expanding Infrastructure

1\textsuperscript{st} Phase:
Serve local/regional Trucking hubs

2\textsuperscript{nd} Phase:
Serve lanes that connect the hubs
Fueling Options

▲ Additional Players

▲ Local Gas Distributors
▲ Natural Gas Retailers
▲ Natural Gas Explorers
▲ Leasing Companies
▲ Traditional Retailers
▲ Customers

▲ Multiple Models

▲ Develop/Own/O&M
▲ Delegate Completely
▲ Own/delegate O&M
▲ Co-Develop/Co-Own
▲ Team with Competitors
▲ Public/Private Partnerships
Truck Stops are Hosting CNG Infrastructure

- Pilot/Flying J partnership with Clean Energy
- Shell & TA LNG Fuel Network
- Love’s partnership with Chesapeake

Quarles Commercial Fueling Site
Richmond, VA

- Additional CNG Corridors are being developed

Public-Access Fueling Infrastructure Now Being Embraced!!
Convenience Store Partnerships

- Kwik Trip – 15 stations in upper Midwest & 10 more planned by end of 2013 (collaborates w/ Centerpoint Energy)
- Lehigh Gas partners w/ Exxon/Mobil
- Giant Eagle
- Oncue Express – 12 stations in OK & AR (working w/ Chesapeake)
- Stripes, Midland, TX
- Dandy Markets
- Additional C-store chains evaluating similar options
Customers Win with Public Access!


- Transit Agencies and Municipalities will open for public and private fleets – collaborating to aggregate gas load to meet critical throughput thresholds.

Public-Access Fueling Infrastructure
Industry Best Practices
Fleet Assessment & Implementation

- Cost Calculator Tool (Payback Analysis)
- Key Attributes & Best Prospects
- Step by Step Implementation
- Implementation – Key Elements to a Successful Program
- Summary of How to Transition
- Summary of Specific Next Steps
Cost Calculator Tool - Payback Analysis

🔗 U.S. DOE Alternative Fuel Calculator - Vehicle Cost Calculator
http://www.afdc.energy.gov/afdc/calc/

🔗 New York State Energy Research Authority (NYSERDA)
CNG ROI Cost Calculator – Vehicles and Fueling Stations
http://www.nycng.org/

This Calculator is a Downloadable Excel Spreadsheet

1) Select “Event Materials”
2) Enter email address and name to proceed
3) Select CNG ROI Calculator (download excel file)
4) Select CNG ROI Instructions (download pdf file)
Cost Calculator Tool - Payback Analysis (Continued)

▲ U.S. DOE Excel Based Calculator Tool for Vehicle and Infrastructure Cash-flow Evaluation (VICE) model

http://www.afdc.energy.gov/afdc/docs/vice_model_w_intro.xlsx
Fleets That are Best Prospects

- High use vehicles that return to base, operate on a fixed route, or stay in a specific geographic area

- Freight Trucks: 20K – 30K GGE Annually
- Transit Bus Fleets: 12K – 15K GGE Annually
- Refuse Fleets: 8K – 12K GGE Annually
- Airport/Hotel Shuttle Fleets: 6K to 8K GGE Annually
- Food & Beverage Delivery Fleets: 4K to 6K GGE Annually
- Taxi Fleets: 4K to 6K GGE Annually
- Service Fleets: 3K to 5K GGE Annually
- School Bus Fleets: 2K to 3K Annually
Project Implementation – Step #1

- **Corporate Buy-In:** Explain benefits of natural gas vehicles and get corporate approval, emphasize both economic and environmental benefits of CNG.

- Identify and educate your internal support team, seek information from other fleet managers through trade associations and trade shows.

- Consider the use of any available financial incentives including grants, tax credits, leasing plans for both vehicles and infrastructure.
Project Implementation – Step #2

- Connect/Join your local Clean Cities Coalition, make contact with regional DOE/EPA offices, along with your state and local energy and development offices.

- Prepare a fleet inventory and replacement spreadsheet, consider utilizing an approved consultant to assist.

- Communicate with our local utility, infrastructure companies, and vehicle providers.

- Do NOT over-analyze, take action!
Step by Step Implementation

- Understand the basics of natural gas and CNG Vehicles
- Assess fleet vehicle characteristics
- Review CNG vehicle options
- Evaluate existing and planned CNG infrastructure
- Assess facility property
- Understand the corporate business strategy
- Examine infrastructure requirements
- Assess the business case
- Develop an implementation plan and complete it
Implementation – Key Elements to a Successful CNG Program & Next Steps

- Gather information from your current fleet
  - Collaborate, engage, seek advice from experts and other fleets that implemented CNG vehicle programs
  - Obtain and evaluate fuel use data
  - Complete financial analysis

- Communicate benefits to your staff and obtain “buy in”; provide information to upper management and obtain approval/support
  - Emphasize Economic Benefits
  - Emphasize Environmental Benefits
  - Seek funding assistance through local Clean Cities Coalition
Fleet Assessment & Implementation – How do we transition?

- Communicate benefits to your staff and obtain “buy in”; provide information to upper management and obtain approval/support
- Identify your internal champion, assemble stakeholders and resources; learn from others’ successes
- Use the resources of your local Clean Cities Coalition
- Maximize of Other People’s Money – funding/incentives; investigate creative financing/leasing and station operation options. Learn how to purchase gas to lower fuel costs
Specific Next Steps

- Join your local Clean Cities Coalition, get connected to your EPA regional Collaborative and state environmental and energy offices
- Prepare fleet inventory and replacement spreadsheet
- Ask your vehicle vendors about natural gas options
- Start communicating with your LDC, station developers and equipment vendors about their products and services
- Don't “study it to death” – take action!
Questions?

Ronald J. Gulmi, Emerald Alternative Energy Solutions, Inc.
Ronald.gulmi@eaesi.com
(516) 359-6038

Barry Carr, Clean Communities of Central NY
bcarr@cc-cny.com
(315) 278-2061

Stephen Russell, MA DOER, Clean Cities Coordinator
Stephen.russell@state.ma.us
(617) 626-7325

Michelle McCutcheon-Schour, Vermont Clean Cities Coordinator
mmschour.uvm@gmail.com
(802) 656-9864

Dolores Rebolledo, Granite States Clean Cities Coordinator
Dolores.rebolledo@des.nh.gov
(603) 271-6751

Steve Linnell, Maine Clean Communities Coordinator
slinnell@gpcog.org
(207) 774-9891

Wendy Lucht, Ocean State Clean Cities Coordinator
wluct@uri.edu
(401) 874-2792
Thank You!