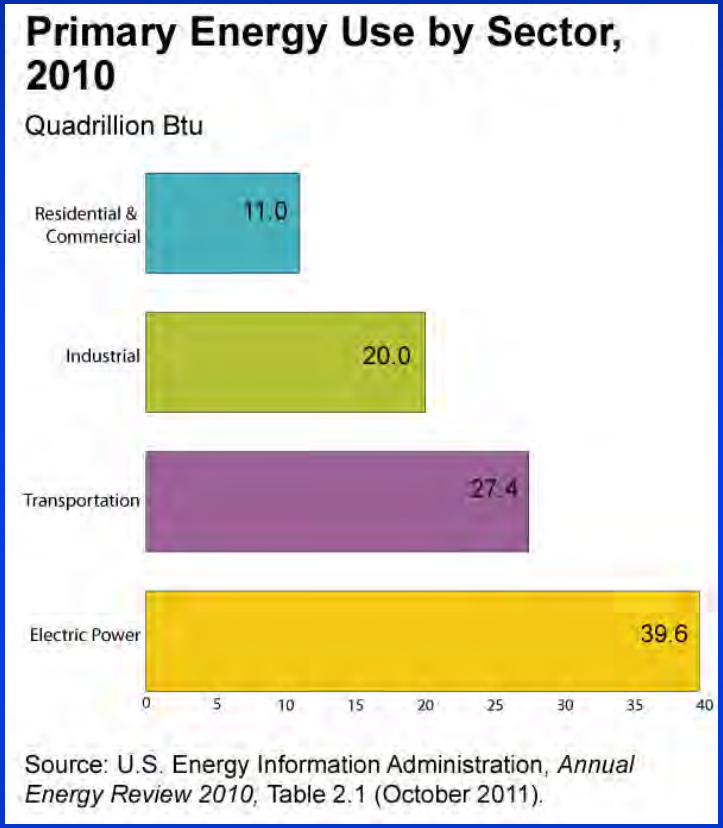
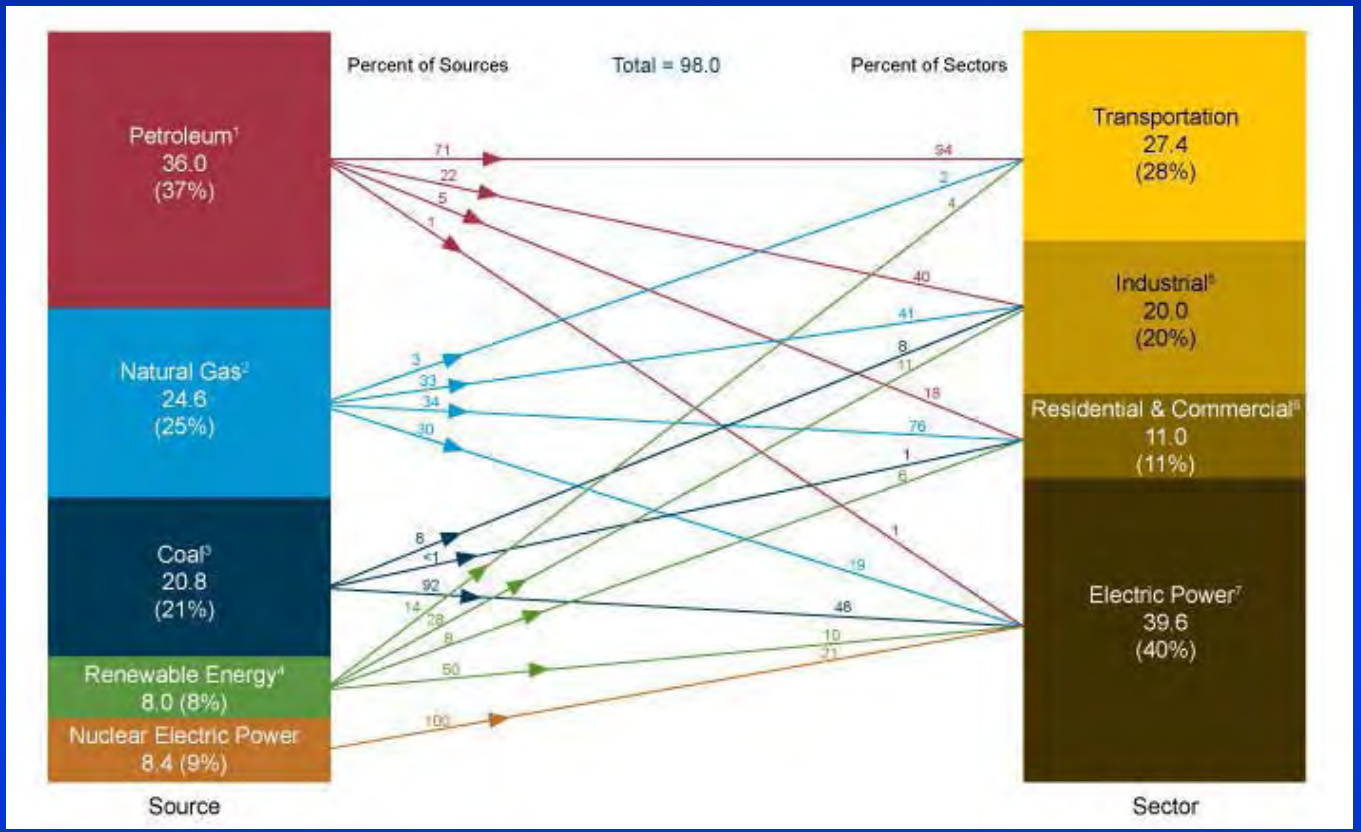
The Compelling Case for Greater Natural Gas Use in America's Transportation Sector

Stephe Yborra, Director
Clean Vehicle Education Foundation / NGVAmerica

Graham Mattison, Independent Energy Sector Analyst

Snapshot of Energy Supply and End Use





- Transportation comprises on-road, off-road, rail, marine and aviation
- ~65-70% of imported oil is for transportation
- LDVs :~58-60% of on-road use; HDVs: ~23-25% of on-road

NGVs in On-Road Applications

Factors Driving Public and Private Fleet Adoption,
The Consumer Market Potential,
Opportunities & Challenges

What is the Compelling Case?

- Environmental, energy security and – now, more than ever due to domestic natural gas abundance - ***economic*** market drivers are behind the trend toward greater use of NGVs. While fleet fuel use has been the primary focus, potential consumer market is now spurring additional investment in infrastructure. Parallel interest in off-road “HHP” applications may play pivotal role in LNG supply channel growth.

- A growing selection of light-, medium- and heavy-duty NGVs are available from OEMs and SVMs, delivering performance and reliability that are on par with gasoline and diesel counterparts.

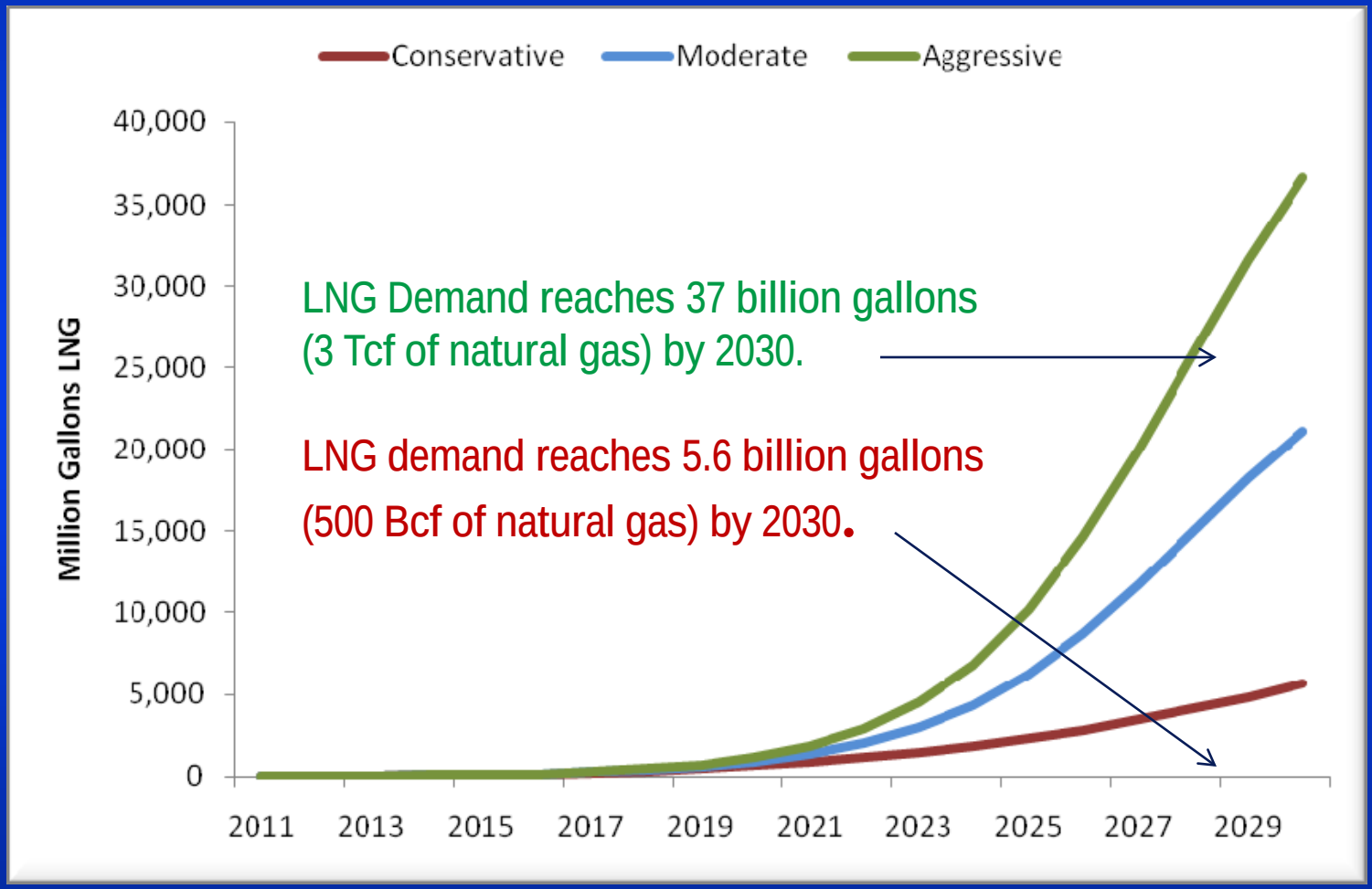
- A variety of fueling options are available – LDCs, E&Ps, leasing companies, other customers and independent fuel retailers – including both NGV-focused and, now, more traditional fuel retailers - are engaging to develop fueling infrastructure. Major energy companies are evaluating potential market growth and engaging

- Natural Gas: America’s Fuel for American Economic Prosperity

Snapshot of US NGV Market Today

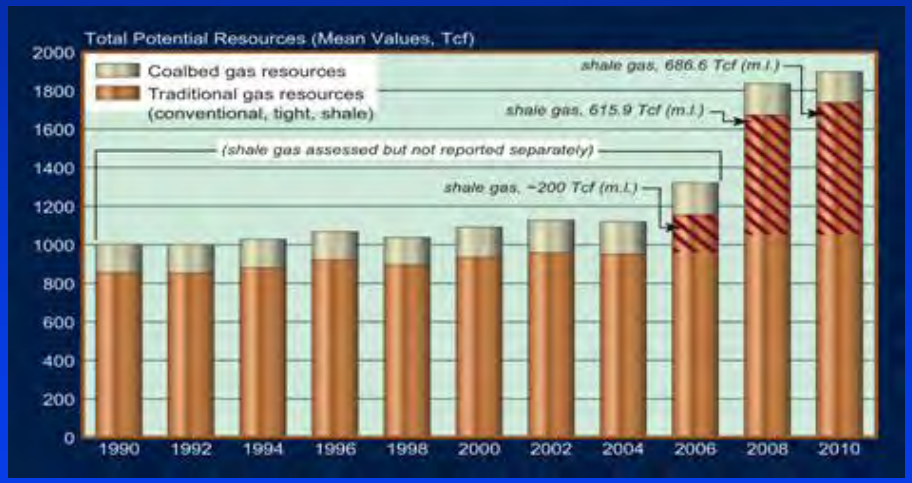
- Existing NGV inventory is estimated at ~120K
  - ~25-26,000 HDVs, ~17-20,000 MDVs, ~72-74,000 LDVs
- Station count is (~1100) has grown steadily in past 18-24 months and installed capacity is up significantly
  - Increased interest in LNG and L/CNG
  - New players / new business models
- Vehicular natural gas consumption:~10-12% AGR past 6 years
  - In 2005, ~200 million GGE;
  - In 2011: ~350 million GGE
  - In 2012: ~400-425 million GGE
  - Future: ????

Estimate of Potential for On-Road HD Trucking Use of LNG



Source: D. Schultz ppt; World LNG Fuels Conference – 01/2012

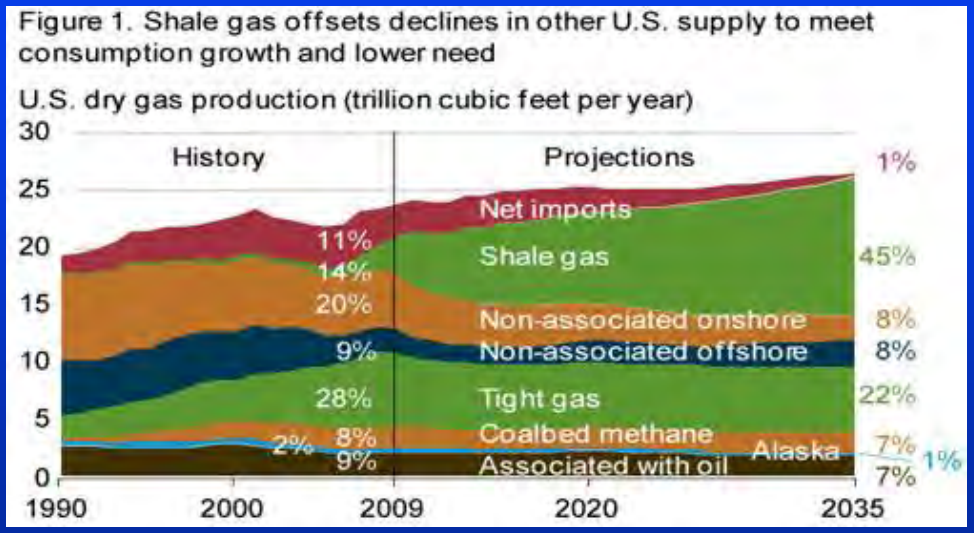
Natural Gas is an Abundant Domestic Fuel



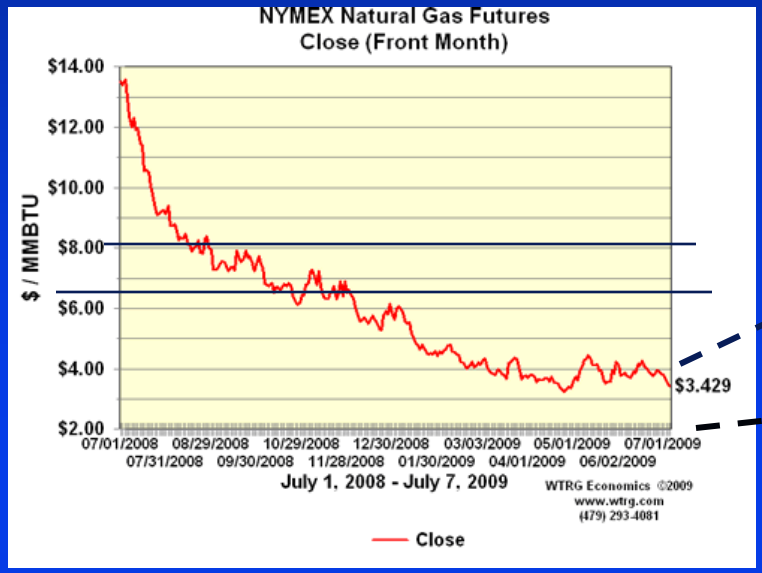
PGC Resource Assessments, 1990-2010

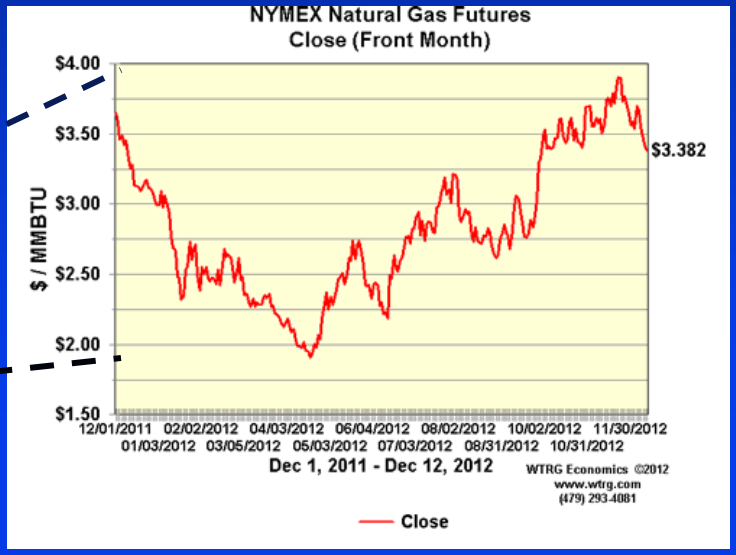
Shale Basins and the U.S. Pipeline Grid
Source: American Clean Skies Foundation.

- 98+% of US gas consumption is supplied from North America (~88% from US)
- Well-developed distribution infrastructure;
  - ~300K miles of interstate pipeline
  - 1.2 million miles of LDC distribution lines
- Technology improvements are expanding our economically recoverable base so much so that the estimated supply is now @ 115+ yrs!
- **Natural gas E&P activity is generating tens of thousands of quality jobs which gives direct and indirect economic boost to communities across America**



Translating Abundance into Savings



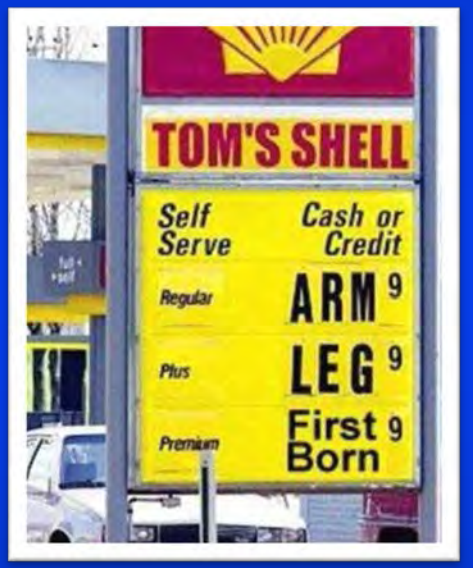


One MMBtu is ~8.0 GGE of (uncompressed) natural gas
One MMBtu is ~7.2 DGE of (uncompressed) natural gas.

If average MMBtu is ~$4.80 at city gate; commodity % is $.60/GGE ($.67/DGE) . Add LDC delivery, compression, maintenance, equipment amortization: ~$1.70-2.00/GGE. + fed and state taxes LNG pricing derived differently but base stock gas cost is same

Snapshot of US NGV Market Today

- On Btu basis, natural gas and oil prices are now decoupled.
  - BBL : MMBtu ration hit over 45:1 in 2012; spent good portion of 2010 and 2011 above 35:1; with oil prices now slightly depressed (~$87/BBL), now at 26:1.
  - This “new norm” is up from long-time 7:1 ratio

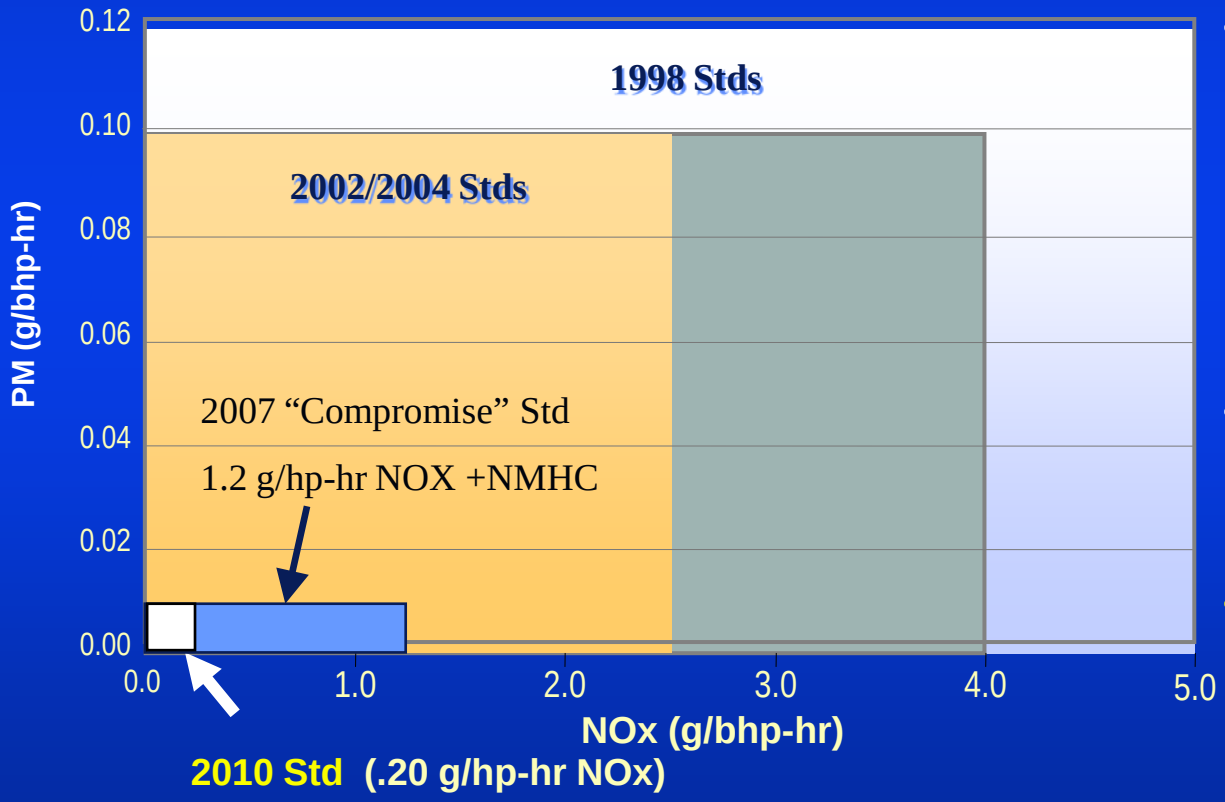


- **Currently, CNG savings compared to diesel are $1.50-1.80+ and (even more, in some areas) .**

- Favorable fuel cost differential between natural gas and petroleum is expected to improve further as economy recovers because fundamentals of oil supply-demand have not changed

Market Drivers for NGVs

- NAAQS and EPA Vehicle/Engine Emissions Requirements
- 2004 and 2007 diesel emissions strategies increased diesel truck purchase price and O&M costs; added complexity, more maintenance intensive.



- 2010 NOx reduction strategies using SCR technology further increased cost, complexity and O&M costs. Still ironing out "DEF" system issues
- 2014: phase-in of EPA GHG and DOT fuel efficiency requirements
- **HDVs produce 20-23% lower GHGs than cleanest diesels; LDVs reduce GHGs by 26-29%**

Liquefied Natural Gas (LNG)

- Cryogenically cooled to liquid @ ~(260)F, stored in liquid form onboard vehicle and vaporized before it enters engine cylinder
- Preferred by many heavy-duty fleets due to its energy density, space requirements

- Most vehicular LNG used *today* is produced at limited number of plants and trucked to fleets' onsite storage vessels. Transport distance/costs are major determinant of economic feasibility. However, new LNG plant development has been committed to based on demand

- Another application for LNG is L/CNG stations which dispense LNG (e.g., for OTR truck fleets) and have additional option to compress LNG and flash evaporate to provide CNG. This is also an option for locations without pipeline natural gas.

Additional LNG Supply Opportunities

Potential peak-shaving capacity available in some markets

- Dozens of supply points in areas that currently do not have LNG supply
- Does capacity exceed cold weather needs and will PSC allow (i.e. how will it treat regulated recovery of investment)

Growing interest in small-/mid-scale liquefaction plants

- Locate nearer to point of end-use to reduce transportation cost.
- Gas supply may be from pipeline, landfills, sewage, agricultural waste digesters

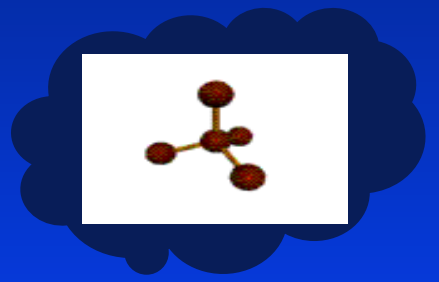
Compressed Natural Gas (CNG)

- Natural gas is delivered to the fueling site via the local gas utility's underground distribution system at low pressure, then compressed and stored on site for fast filling of vehicles

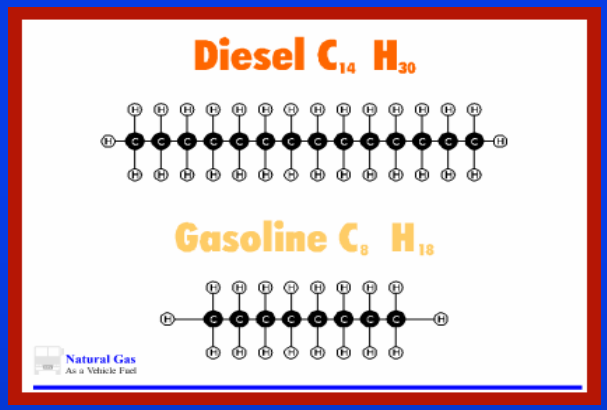
  …or compressed and distributed directly to vehicles' onboard storage cylinders (time-fill applications)

Benefits of Natural Gas/NGVs

- Natural gas is an inherently clean fuel
  - Natural gas is low-carbon fuel (CH4)
  - Less NOx, PM and GHGs
- Natural gas is very safe
  - Lighter than air; Limited combustion ratio (5-15%)
  - High ignition temperature: 1000+F
  - Colorless, odorless, non-toxic substance
  - Doesn't leak into groundwater
- NGVs are proven and reliable
  - 15+ million worldwide;
- NGVs are quiet
  - HDVs are 80-90% lower db than comparable diesel
- NGV life-cycle costs are significantly lower
  - Fuel costs are far lower!
  - Maintenance costs are =/< than gas or diesel



Methane Molecule



Key Attributes and Best Prospects

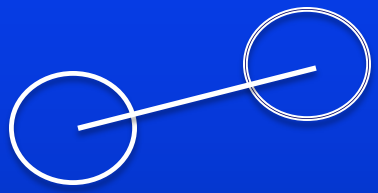
- High fuel use vehicles with return-to-base operations or repetitive route or pre-set geographic operating areas

Regional freight truck – 16-20K GGE
Transit buses – 12.5-15K GGE
Refuse /Concrete Trucks-– 7.5-10K GGE
Municipal sweeper – 5-6K GGE
Airport shuttle service – 5.5-7.5K GGE
Taxi - 4.5-5.5K GGE
F&B, Textile Svcs, Household Goods – 4-6K GGE
School Bus – 2-3K GGE
Courier sedan, newspaper van, utility/ telecom van, public works pick-ups – 1.2-1.5K GGE

- Consumers have already shown that they will adopt given sufficient infrastructure

Expanding Infrastructure: "Hub and Spoke" and Corridor Development

Step 1:
Serve local/regional fleets with hub+spoke operations. Build confidence for local consumer adoption.



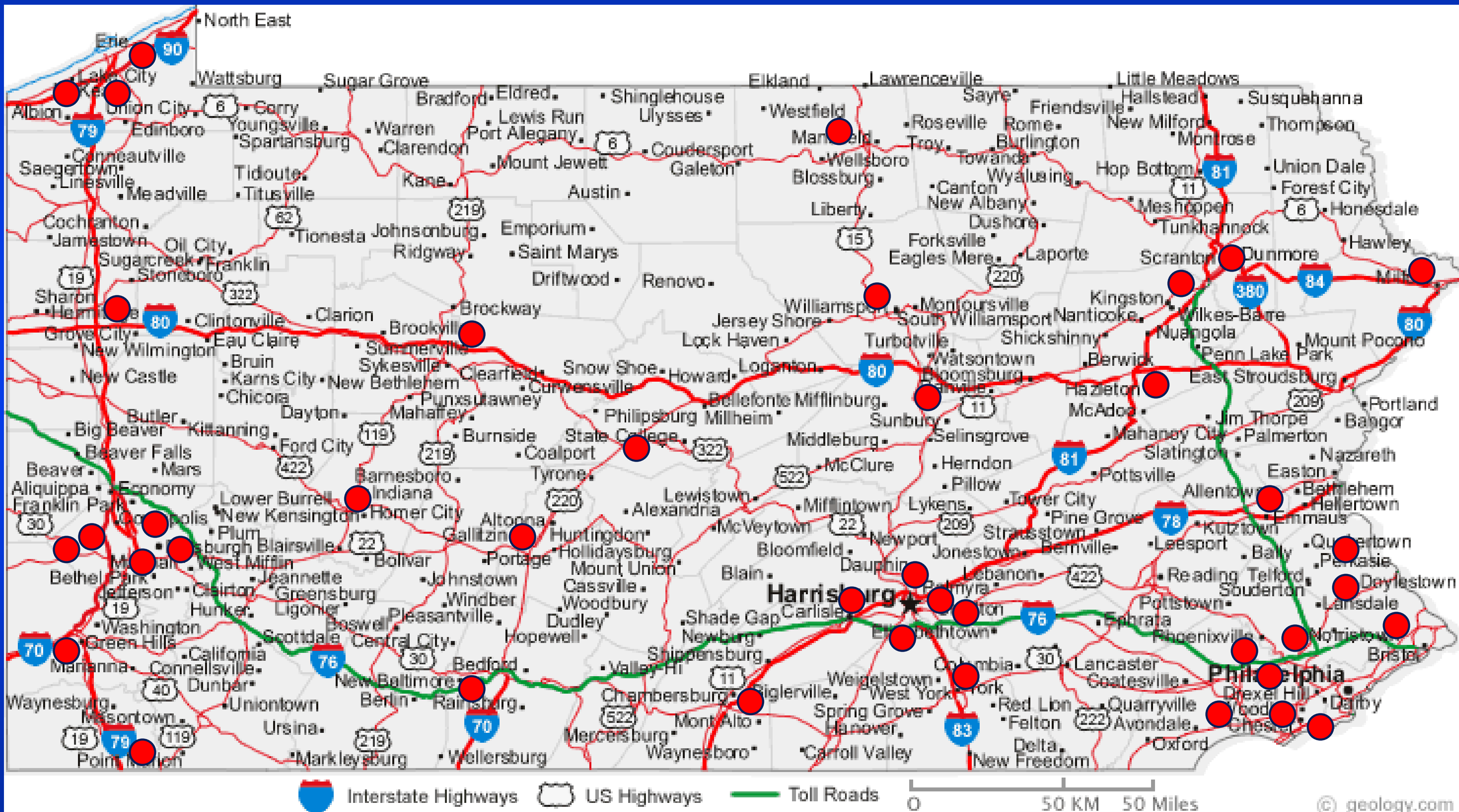
Step 2:
Serve lanes that connect the hubs

Clean Vehicle Education Foundation

NGVAMERICA
Natural Gas Vehicles for America

“Hub and Spoke” and Corridor Development

(Hypothetical Distribution For Illustration Purposes Only)



Clean Vehicle Education Foundation

NGVAMERICA
Natural Gas Vehicles for America

Growing Selection of NGVs from OEMs, SVMs

OEMs

- American Honda
- General Motors
- Chrysler Ram Trucks
- Vehicle Production Group
- Thomas Built Bus
- Blue Bird Bus
- Optima/NABI
- El Dorado
- New Flyer
- Motor Coach Industries
- Gillig
- Elgin
- Allianz/Johnston
- Schwarze
- Tymco

OEMs

- Freightliner Truck
- Freightliner Custom Chassis
- Volvo
- International/Navistar
- Kenworth
- Peterbilt
- Mack
- ALF Condor
- Crane Carrier
- Autocar Truck
- Capacity
- Ottawa

HD OEM/Repower Engines

- Cummins Westport
- Westport Innovations

SVMs (LDV/MDV/HDV)

- Altech-Eco
- BAF Technologies
- Landi Renzo USA / Baytech
- IMPCO Technologies
- NGV Motori USA
- NatGasCar
- Auto Gas America
- Go Natural CNG
- Greenkraft
- Westport LD
- PowerFuel Conversions
- EcoDual
- American Power Group
- Peake Energy Solutions

Retrofits of GM, Ford, Dodge, VW, Mitsubishi, Mazda, Workhorse, Isuzu, JAC, UtiliMaster, FCCC

LDVs Available from OEMs

LDVs Available Through SVMs













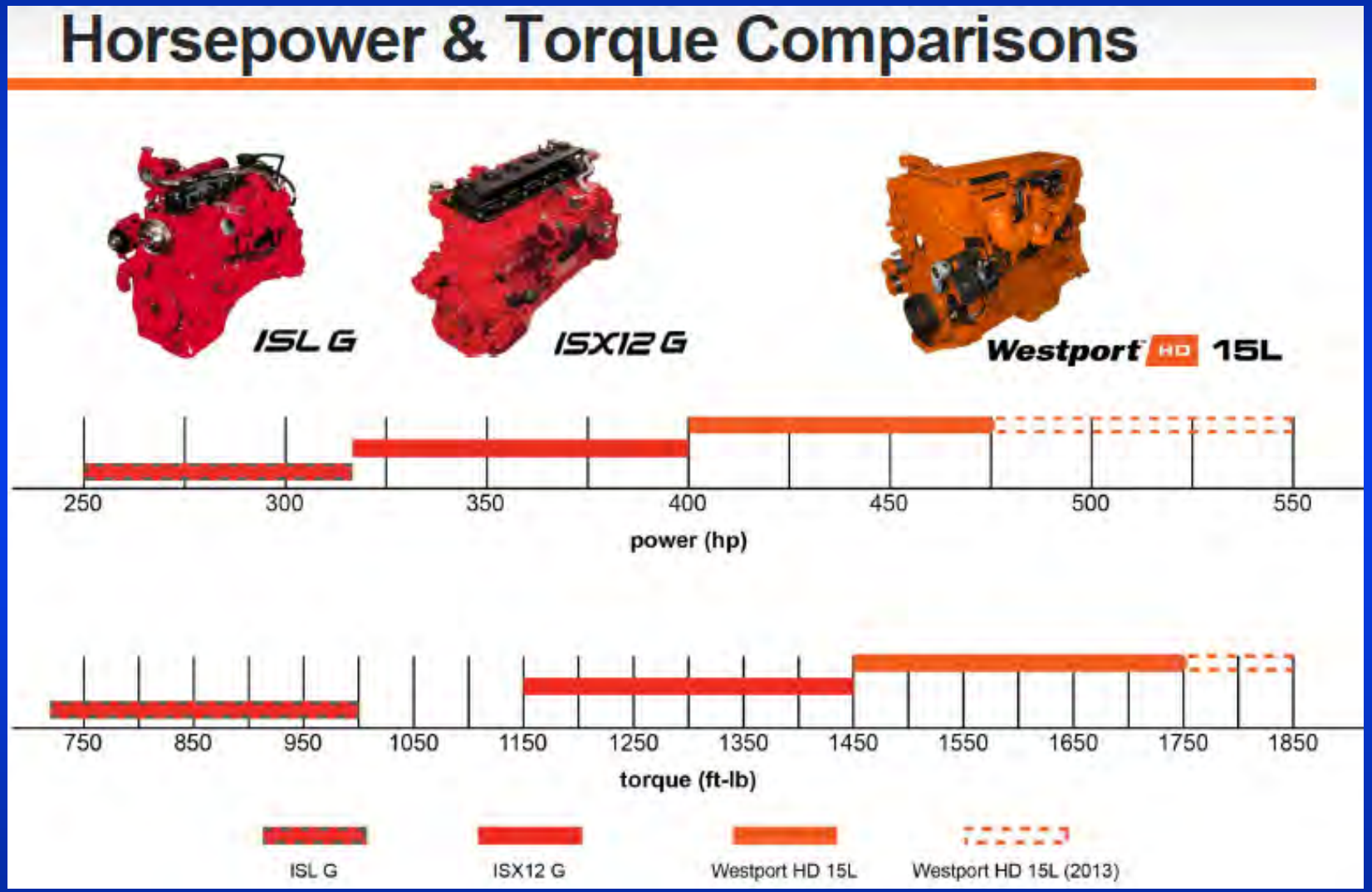






MDVs Available Through SVMs

HD Natural Gas Powertrain Options



Transit and School Bus Platforms

Vocational/Specialty/Work Truck

Local-Regional Haul/Line Haul

Dual Fuel Technologies: Re-emerging Opportunity

- Dual fuel technology is making a comeback: Varying amounts of diesel is displaced by natural gas during duty cycle
  - Primarily marketed to “Intermediate Use (IUL)” and “Out of Useful Life (OUL)” HD engine applications
  - Recently approved for use on new trucks
- 3/11 – Lower cost EPA “approval” process reduced cost/data burden, thus making this option economically attractive to legacy fleets
  - “Approval” process requires technical paper, supporting documentation, field data

- Took 6-8 months to see first “EPA listing.” Presently, 100+ engine families have been approved but more are added each month
  - e.g., EcoDual, American Power Group, Clean Air Power, Peake Energy

Filler' Up:
Addressing the "Chicken & Egg" Conundrum

Natural Gas Fuel Station Types
Development, Ownership and Operations Options
Sizing/Design Considerations

Q: How Do We Solve The "Chicken & Egg" Conundrum?

(A: Make a chicken-egg omelet*)

- Throughput (sales volume) is key to generating economies of scale for the public access station owner, thus allowing pump price differentials that drive reasonable payback and life-cycle savings for customers

- Minimum load thresholds vary based on a variety of factors including: station type, station size, fuel price differential, ability to amortize maintenance costs, equipment depreciation, grants …..ROI expectations

- Achieve minimum load thresholds by:
  - Identifying an anchor fleet that justifies the investment…or
  - Aggregate several semi-anchor fleets' loads if their depots or operating areas are geographically acceptable…or
  - Create retail public access for small fleets and consumers….or
  - All of the above

Station Options

- Station Location Options:
  - Offsite – use existing public access station if available, convenient and of sufficient capacity. Anchor fleets or ‘pooled loads’ create economies of scale.
  - Onsite - private access only or with public access “outside the fence”
- Different ownership & operations options available depending on throughput, funding:
  - Fleet owned & operated station
  - Outsource station O&O entirely via independent fuel provider and contract gas price
  - Fleet owned/leased station but contracted out operations for a fee (usually on a GGE basis)

Multiple Stakeholders Are Engaging NGV Fueling Infrastructure

- Local Gas Dist. Companies
- Independent NG Retailers
- NG Exploration & Production Cos.
- Leasing Companies
- Customers
- “Traditional” Fuel Retailers

Customers Are Embracing Public-Access Fueling Infrastructure

- Waste Management has been co-developing retail locations with PetroCard under the Clean-N-Green brand. WM fleet serves as anchor load inside the fence (primarily time fill) while promoting to public outside the fence (and extending their “green” messaging)

- Transit agencies, municipalities, F&B companies, small businesses are collaborating with other fleets to aggregate load to meet critical throughput thresholds.

Truck Stop Operators Are Embracing Public-Access Fueling Infrastructure

- Pilot/Flying J is working with third party natural gas fueling retailer Clean Energy to develop LNG and L/CNG stations at locations all across the country.
- Love's is working with Chesapeake Energy to co-develop CNG locations in the Midwest. Backyard and front-of-store retail options are both in the mix.
- TravelCenters of America has announced 100-location plan with Shell to install LNG capability

C-Stores Are Embracing Public-Access Fueling Infrastructure

- Kwik Trip installed LNG and CNG dispensing capability at its central warehouse/HQ in LaCrosse, WI and is deploying Class 7 & 8 trucks. Adding CNG and/or L/CNG at additional 20+ retail locations throughout their 3-state trading area (KT's fleet is serving as its own anchor)

- OnCue Express is building locations in OK and AR. Working with Chesapeake Energy, focus is on retail consumer sales.

- Additional C-store chains are evaluating similar options

Kwik Trip Station Roll-Out Plan

Source: C. Hollett ppt; Kwik Trip – 10/2012

- Just completed ninth station opening and ten more on track to open by next spring
- Recently opened Sturtevant station already exceeds 1000 GGE/day; this is before any comprehensive fleet outreach plan has been implemented
- Kwik Trip goal is to populate Chicago-Twin Cities corridor and supplement other Midwest corridor activities

Dollars & Sense: Components of CNG Cost

- Gas Bill:
  - Unregulated portion associated with purchasing gas
  - Regulated local gas utility distribution company (LDC) services
- Compression
  - Electric motor KWH and KW …OR engine driven unit's natural gas use
- Station Maintenance
  - Normal PM, scheduled replacement of parts, compressor rebuilds
- Capital /equipment amortization
  - Amortized cost of equipment or cost of capital factored into GGE price
- Federal, state and local excise fuel taxes (if applicable)
  - Tax is paid by the fuel seller; tax status of buyer determines
- Margin

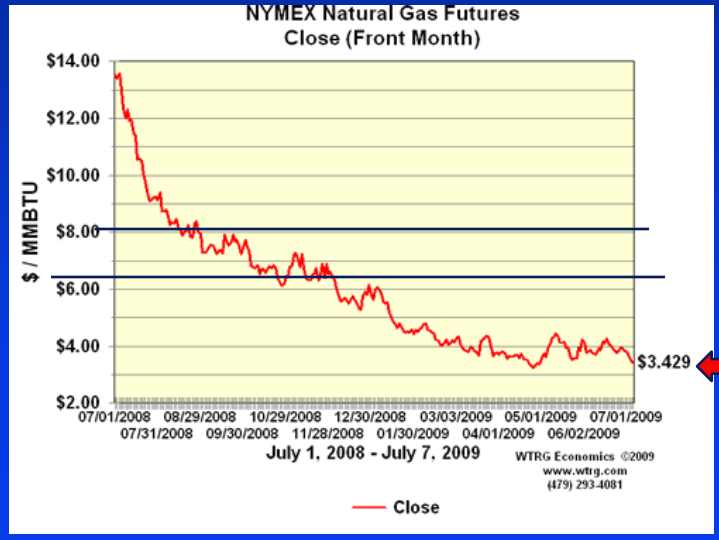
Components of CNG Cost

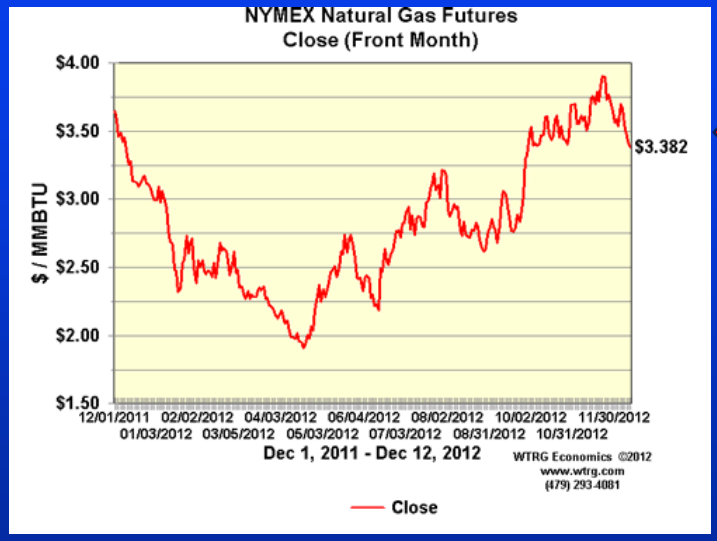
- Gas company bill (unregulated portion)
  - Commodity:

    Gas is drawn from wells, gathered/ pooled, stripped of impurities and “heavy” gases, then transported to “hubs” where it is available on the commodities market. Henry Hub (Louisiana) is used for NYMEX pricing.

    US DOE and industry long term price forecasts (prior to the economic collapse) pegged NYMEX natural gas at $6.50-8.00/MCF. Impact of shale gas is being reevaluated for next forecast.

    Future market projections for gas are still up in the air now that shale gas has changed the equation





Components of CNG Cost

Gas company bill (unregulated portion):

Gas Commodity:

- One cubic foot = ~1000 BTUs (Note: cf = volume, BTU = energy)
- One Mcf = 1000 cubic feet
- One Mcf = 1000x1000 = ~1,000,000 Btus (MMBtu or decatherm)
- US Gov't says 124,800Btu/GGE and 138,700Btu/DGE…therefore….
- **One MMBtu = roughly 8.0 GGE of (uncompressed) natural gas**
- **One MMBtu = roughly 7.2 DGE of (uncompressed) natural gas**.

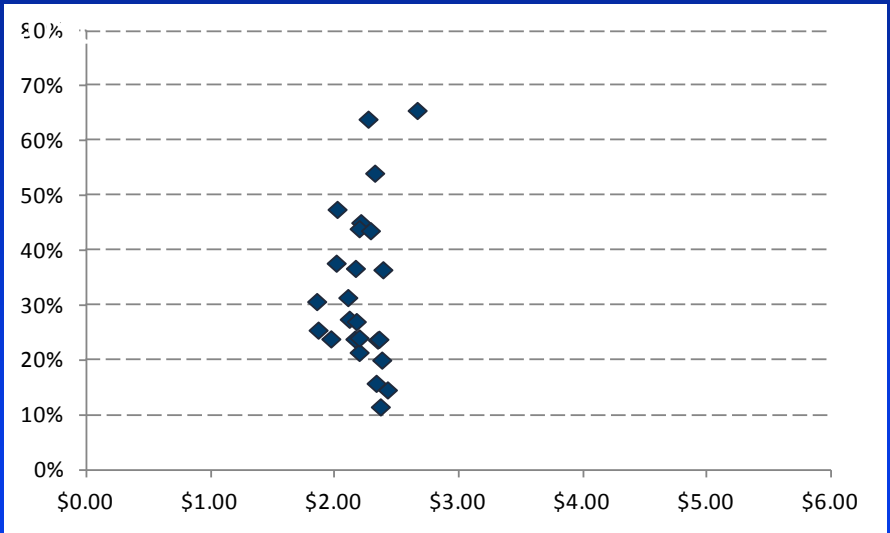
- When NYMEX MMBtu was $6.40, commodity portion of CNG was $.80/GGE
- When NYMEX MMBtu was $2.00; commodity portion of CNG was $.25/GGE
- NYMEX MMBtu is ~$3.36; commodity portion of CNG is $.42/GGE

- Add cost of procurement and delivery to LDC city gate: $.15-.25/GGE

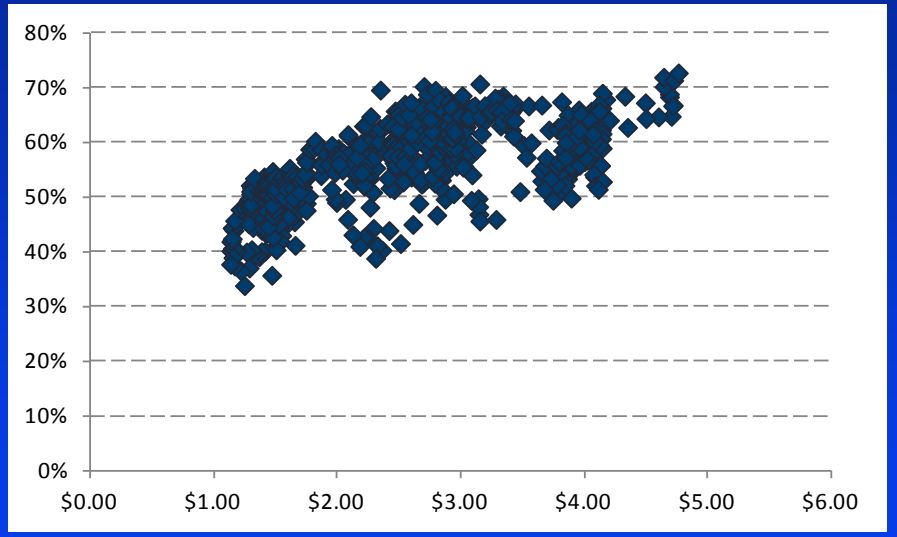
Components of CNG Cost

- **Gas Bill**: $.85/GGE (could be lower /higher in different markets)
  - Unregulated gas acquisition cost (assume loaded @ $4.80/MMBtu = $.60/GGE)
  - Regulated tariff (LDC service from city gate to customer's meter: $.25/GGE
- **Compression** - Rule of thumb: One fully-loaded kWh/GGE ($.10-15/GGE)
- **Station Maintenance** - Normal PM, repair/replace parts, rebuild ($.35-.45/GGE)
- **CAPEX/Equipment amortization** ($.40 - .55)
  - Cost of equipment or cost of capital factored into each GGE over life of station
- CNG: $1.70-2.00/GGE before taxes
- Add applicable motor fuels excise tax (if applicable)
  - Federal excise tax = $.183/GGE; states vary widely

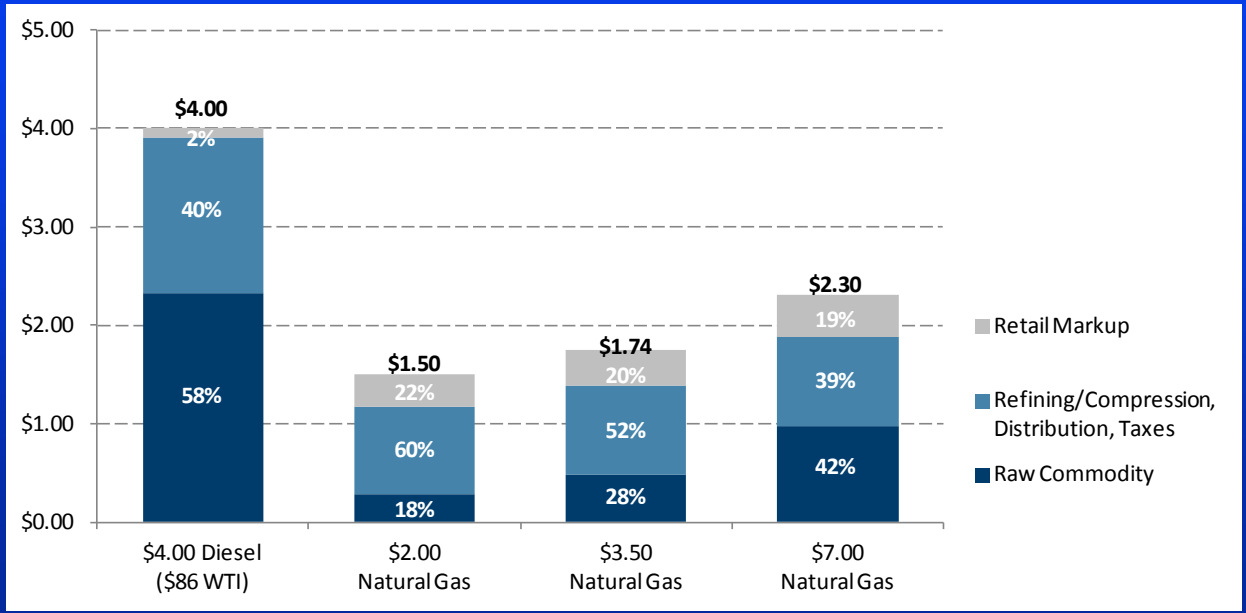
Historical natural gas contribution to CNG



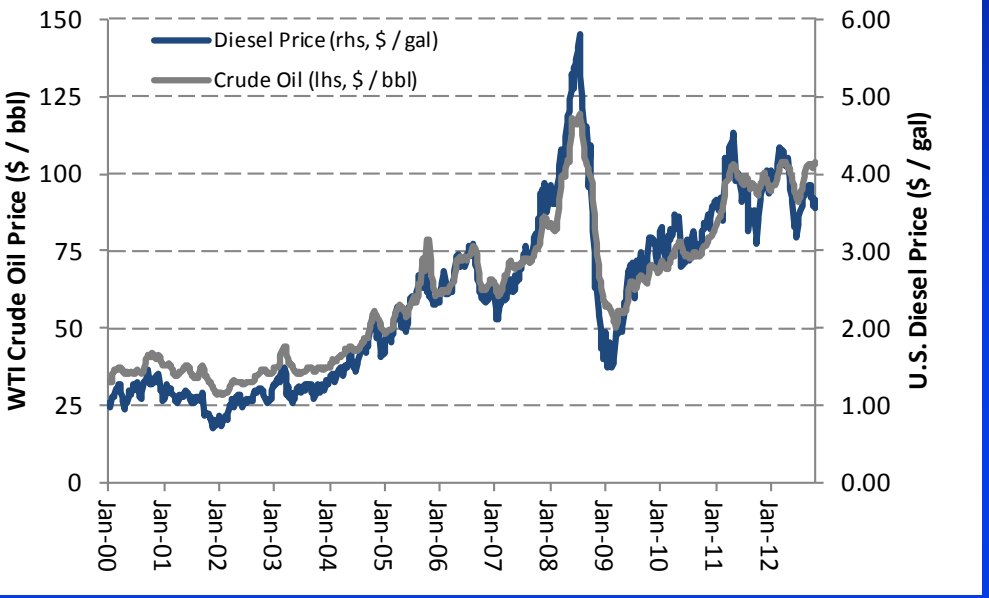
Historical crude contribution to diesel cost



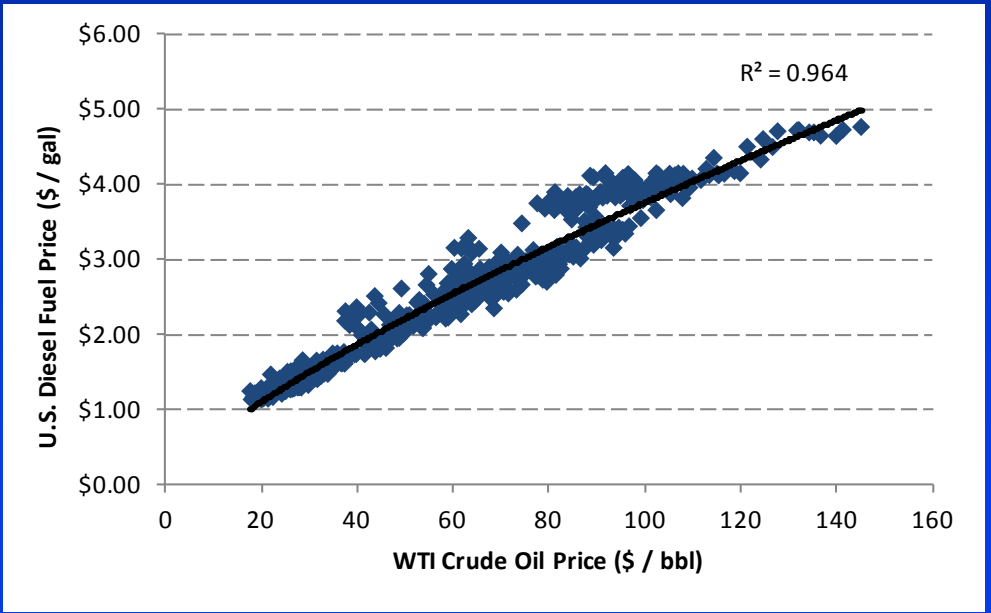
Comparison of raw commodity contributions to pump prices



Historical crude and U.S. diesel prices



Relationship between crude and diesel prices



Concrete Truck Payback/LCC Savings

- Fuel Use: 35-40dge/day; 8500-10,000dge/yr
- Premium over Diesel: $40,000
- Simple Payback: 2.4 - 2.75 years
  (based on 1.70 savings /DGE)
- Life-cycle cost savings: $75-95K (based on 8-yr life)
- Life-cycle cost savings: $47-62K (based on 6-yr life)

- If grants are available for vehicles and or fuel station, payback is even faster and LCC savings increase.

Step Van

- Sample Applications (e.g., textile rental service, comm. bakery)
- MPG: 5.0 – 6.5, 75-90mpd x6 dys/wk, 26-28K/yr
- Fuel Use: 13-16DGE/day; 4200-5000GGE/yr
- CNG Premium: $25,000
- Grant: $12,500
- Remaining premium: $12,500
- Simple Payback: 1.5-1.75 yrs
- Life-cycle cost savings: $59-72K !!!
  (based on 10 yr life and 1.70 savings/DGE fleet contract price)
- Without grant, simple payback = 2.95 – 3.5 years

Refuse Truck
(LCF model)

- Crane Carrier LET, Autocar Xpeditor, Peterbilt LCF 320, Condor , Mack TerraPro
- MPG: 2.5 – 3.0 (lots of idle and PTO time)
- Fuel Use: 35-40gge/day; 8500-10,000dge/yr
- CNG/LNG Premium: $32,000
- Grant $16,000
- Remaining Premium: $16K
- Simple Payback: 0.95 -1.1 years
  (based on 1.70 savings /DGE)
- Life-cycle cost savings: $99 - $120K+
- (based on 8-year life)
- If no grant, payback is 1.8 – 2.2 years.

Grocery Truck

- Volvo VNM, Freightliner M2, etc
- MPG: 5.6 miles/DGE; 68K miles /year
- 12,150 DGE/yr
- CNG Premium (w 84 DGE capacity): $60,000
- Grant $25K
- Remaining Premium: $35K
- Simple Payback: $20,655 yr savings = 1.7 yrs
  (based on 1.70 savings /DGE)
- Life-cycle cost savings: $130+K
- (based on 8-year /550,000 mile life before resale)
- If no grant, payback is 2.9 yrs
- Life-cycle cost savings: $105+K
  (based on 8-year /550,000 mile life before resale)

Passenger Van for Limo/Shuttle Service

- Ford E-350 passenger van, Chevy/GMC 3500 passenger van
- MPG: 13/15 City/Hwy, 75-90K miles/year
- Fuel Use: 16-19 GGE/day; 4700-5800gge/yr
- CNG Premium: $15,000
- Grant: $ 7500
- Remaining premium: $7500
- Simple Payback: 0.85-1.05yrs
- Life-cycle cost advantage: $27K – 35+K
  (based on 5yr life and $ 1.50/GGE savings at retail station)
- Without grant, simple payback 1.7 – 2.1years

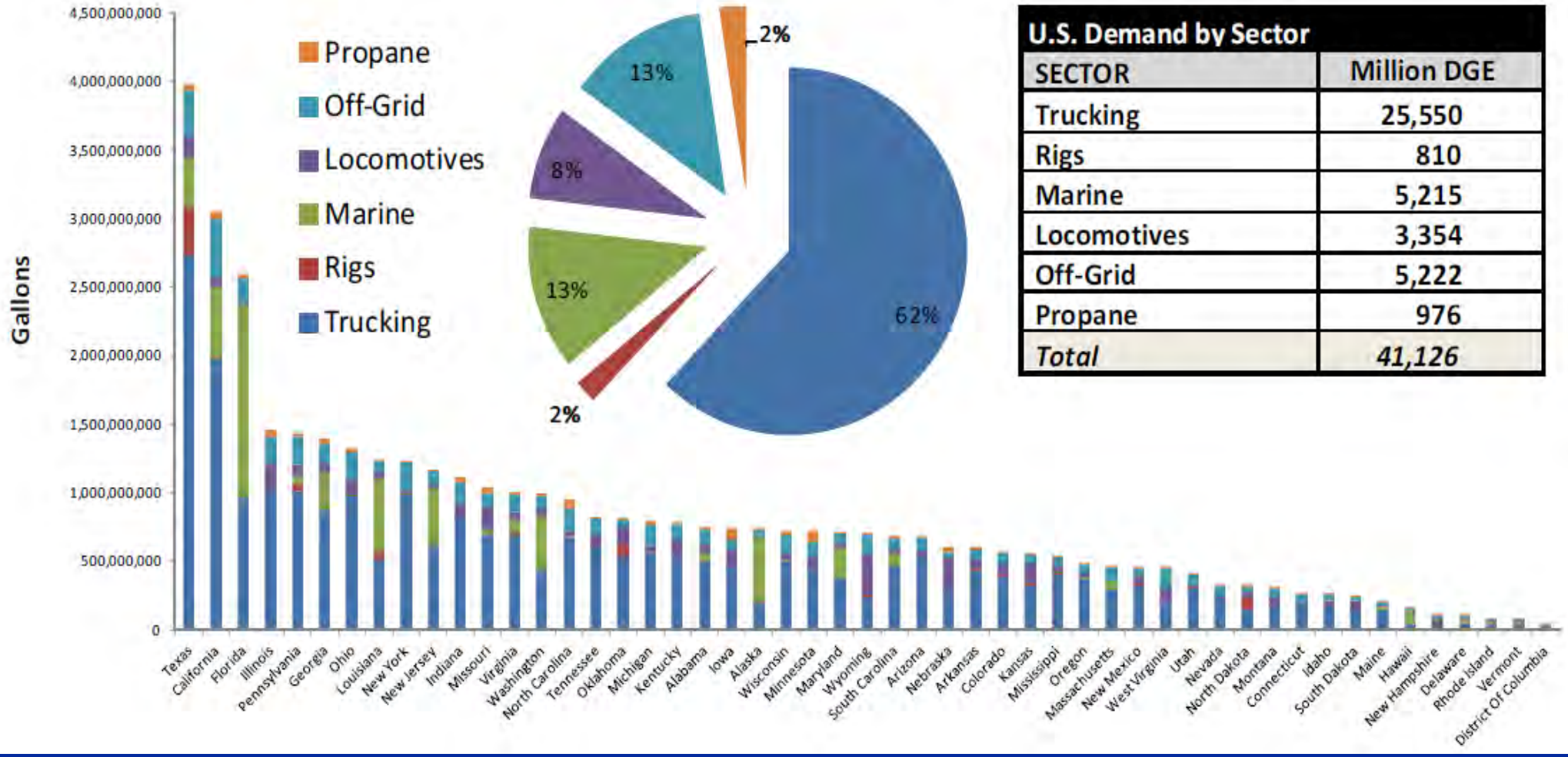
Medical Lab Courier Service

- Honda Civic Natural Gas sedan
- MPG: 19/30 City/Hwy, 30K miles/year
- Fuel Use: 4-6 GGE/day; 1000-1575GGE/yr
- CNG Premium: $6500
- Grant: $4000
- Remaining premium: $2500
- Simple Payback: 1.05 – 1.65 yrs
  (based on $1.50/GGE savings at retail station)
- Life-cycle cost advantage: $5000 – $9330
  (based on 5yr life)
- Without grant, simple payback = 2.75 – 4.3yrs

Summary of On-Road NGV Market

- Fleets offer greatest near-term potential
  - Higher fuel use provides faster vehicle premium payback and significant life-cycle savings
  - RTB and/or defined, repeatable operations facilitate fueling
  - Fleets drive station economics, fostering more infrastructure, thus building consumer confidence
- OEMs developing more platforms to meet expectations
  - Confidence in technology, sales/service channels
- Consumer market seems poised to adopt
  - Vehicle incremental cost is hurdle for many; economies of scale will reduce costs but significant premiums are likely to remain
- Capital markets responding to fueling infrastructure need

While Trucking Dominates Diesel Use, Off-Road Potential is Significant



U.S. Demand by Sector	
SECTOR	Million DGE
Trucking	25,550
Rigs	810
Marine	5,215
Locomotives	3,354
Off-Grid	5,222
Propane	976
Total	*41,126*

Off-Road Applications

HHP Potential:
Fewer Units But MUCH Higher Fuel Use

High Horsepower (HHP)

	Rail	**Marine**	**Mining**
	Mainline locomotives	Small to medium sized vessels	Large Mine Trucks (>100t)
Annual fuel use per engine unit [US gallons/year]	150,000 - 450,000	80,000 - 400,000	120,000 - 715,000
Units of interest in service [number of units]	46,000	30,000+	28,600

Even a just 1$ per gallon fuel savings……imagine.

Natural gas tandem in coal haul service. Burlington Northern's 7890 and 7149, equipped with ECI dual-fuel conversion systems. The locomotive pair, coupled to the 20,000 gallon LNG tender car, achieves full power and has a range of more than 800 miles between refueling.

Source: D. Purcelli , Encana Natural Gas Inc. ppt; World LNG Conference – 01/2012

New Regulations Governing Marine Emissions

- MARPOL73/78Annex VI– strict sulfur standards phase in starting in 2012
- Platform Supply Vessels, Tugboats, Short Sea
- Shipping, and Container Ships
- Requirements are being implemented gradually and will enter full force in 2015 and 2016

Source: DNV 2011 Report, Greener Shipping for North America

LNG Supply/Consumption Comparison

Source: D. Purcelli, Encana Natural Gas Inc ppt; World LNG Conference – 01/2012

Recent LNG Supply Chain Developments

- Shell building liquefaction unit in Alberta; signed deal with Travel Centers of America for 100 locations and eyeing potential shale play rig needs
- Clean Energy and GE building two liquefaction units
- ConocoPhillips looking at building a liquefier in Texas
- Multiple utilities announce plans to sell LNG from existing peak shaving plants
  - Must satisfy PSCs re cold weather capacity assurances, asset divestiture/compensation of ratepayers, and address technical issues

Existing Peak Shaver Capacity

Source: J. Beale, CH-IV ppt; World LNG Conference – 01/2012

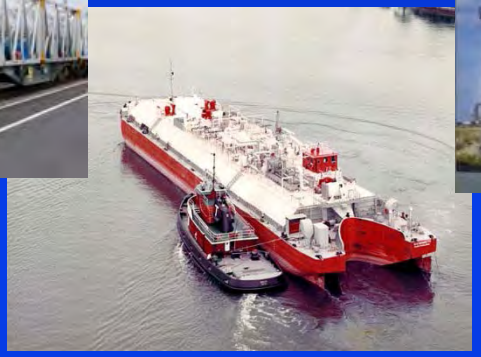
Photos courtesy of AGL Resources

Variety of Distribution Options Available
Intermodal Capability

Rail

Truck

Small Tanker



Barge

Tanker

- 50-70% of US population is reachable through water-based distribution
- Developing LNG station network on Interstates will facilitate distribution
- The LNG transportation cost component can be greatly reduced

Summary of Off-Road NG Market and Potential Impact on On-Road NGV Market

- HHP applications account for relatively small percentage of total US diesel fuel use but generate significant savings and have scale to encourage (LNG) fuel supply channel development
- Greater LNG supply and more developed distribution network will benefit on-road market
  - Primarily benefitting HD trucking but opportunities for L/CNG too
- HHP engine technology developments are already in the pipeline. Demonstration projects in rail, E&P, mining and marine already showing great technical and economic performance

Discussion Topics

- What is government's role? Are mandates and/or incentives needed? Helpful?
- What impact might environmental regulations have on greater/lesser use of NG in the transportation sector?
- Despite proven technical, economic and environmental benefits, transitioning to gaseous fuel from liquid fuel requires fleets and consumers to "get out of their comfort zone." What role will inertia / complacency play in the adoption rate?
- Will world demand for affordable energy "steal away" our opportunity before we take advantage of it here at home?