

Clean Cities

U.S. DEPARTMENT OF  
**ENERGY** | Energy Efficiency &  
Renewable Energy



# Natural Gas Vehicles: Status, Barriers, Opportunities

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## Petroleum, Emission, and Carbon Benefits

- Recent estimates indicate vast shale gas reserves, making natural gas a domestic fuel
- ~99% reduction in petroleum use compared to gasoline vehicles on a lifecycle basis
- Executed well, as in the Honda Civic GX & Cummins Westport ISL G engine, CNG has very low criteria pollutant emissions...
  - GX Air Quality Scores – Federal 9.0 (of 10.0); Civic – Federal 6.0
  - Cummins Westport ISL G – first HD engine to meet 2010 NOx standard
- And reduces GHGs by ~ 15% compared to gasoline
  - GX Annual CO2 Tons = 5.4; Civic Annual CO2 Tons = 6.3
  - Currently GHG emissions similar to diesel; as oil sands and other unconventional crudes become more prevalent, CNG's benefit will grow

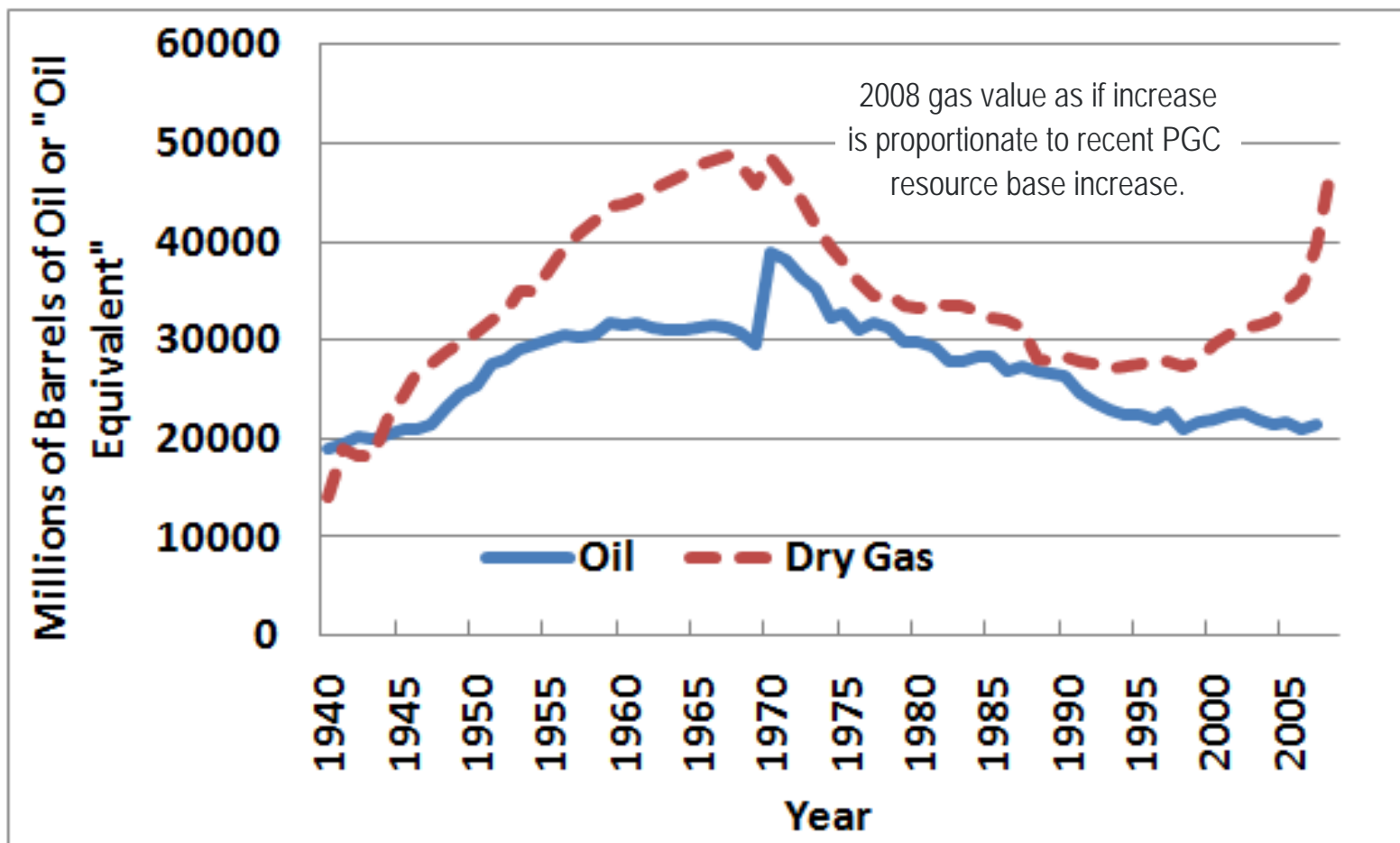
## Current Market Status

- 777 public and private CNG stations (mostly urban);  
36 LNG stations (as of 9/14/2009)
- Incremental Vehicle Prices
  - Honda Civic GX \$6,900
  - Medium and Heavy Truck CNG \$20-50,000
  - Clean diesel 2010
    - \$9,000 (Volvo AB)
    - \$6,000 Medium, \$8,000 Heavy (Navistar)
- Incremental Refueling Infrastructure Costs
  - \$0.59-\$1.15/GGE (includes compression, maintenance, and capital amortization of equipment)

## Types of Available Vehicles/Engine Models

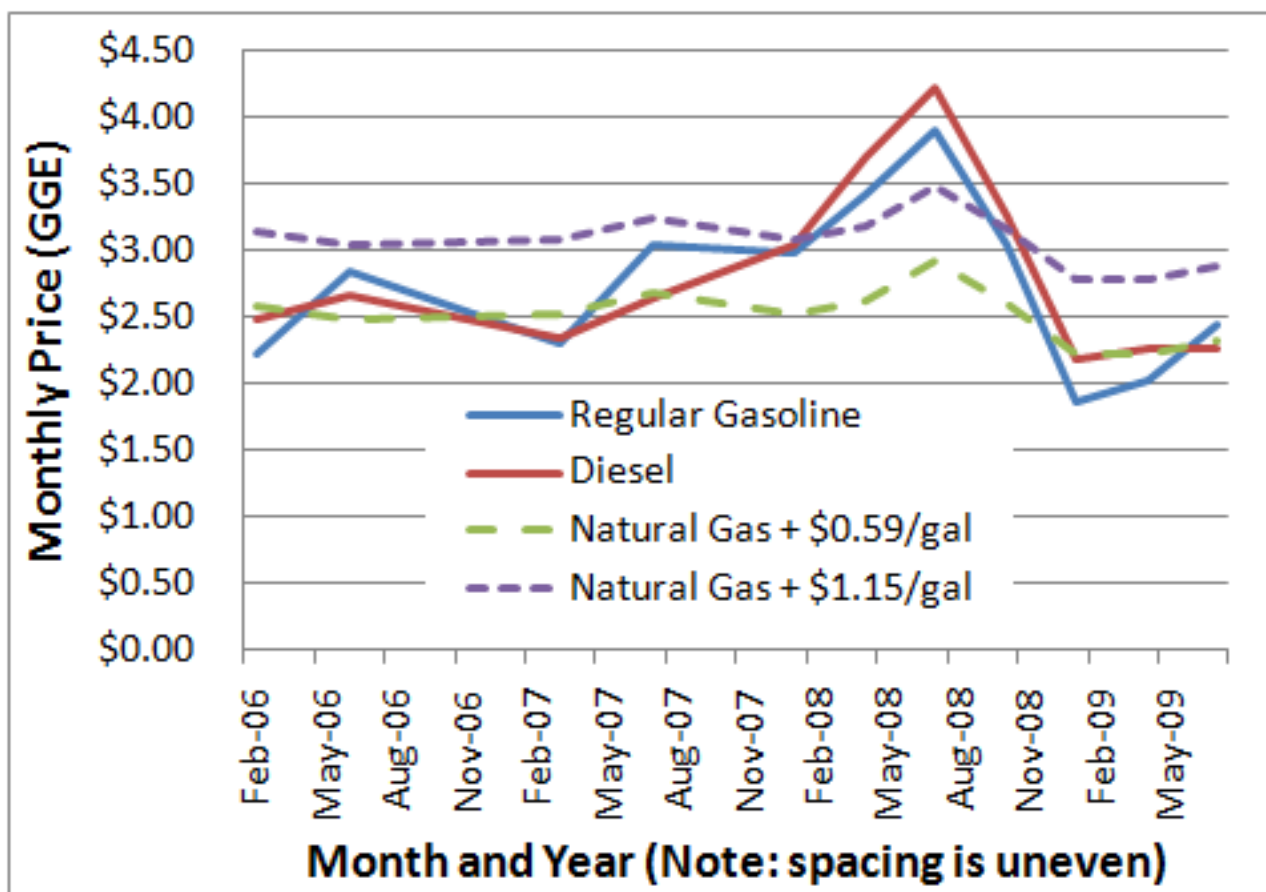
- Light duty vehicles
  - Passenger car: Honda GX
  - Trucks: None
- Medium and heavy duty trucks
  - Baytech GM 6.0L and 8.1L SI conversions (pickups, vans, etc)
  - Ford E-series vans w/ 5.4L and 6.8L SI engines
  - Emissions Solutions 7.6L Navistar diesel conversion
    - School buses, cutaway shuttles, work trucks
  - Cummins-Westport 8.9L Cummins diesel conversion
    - Refuse, transit, D4 school buses, street sweepers, yard hostlers

## Estimates of U.S. Gas Reserves Have Gone Up Recently, as Oil Reserves Declined

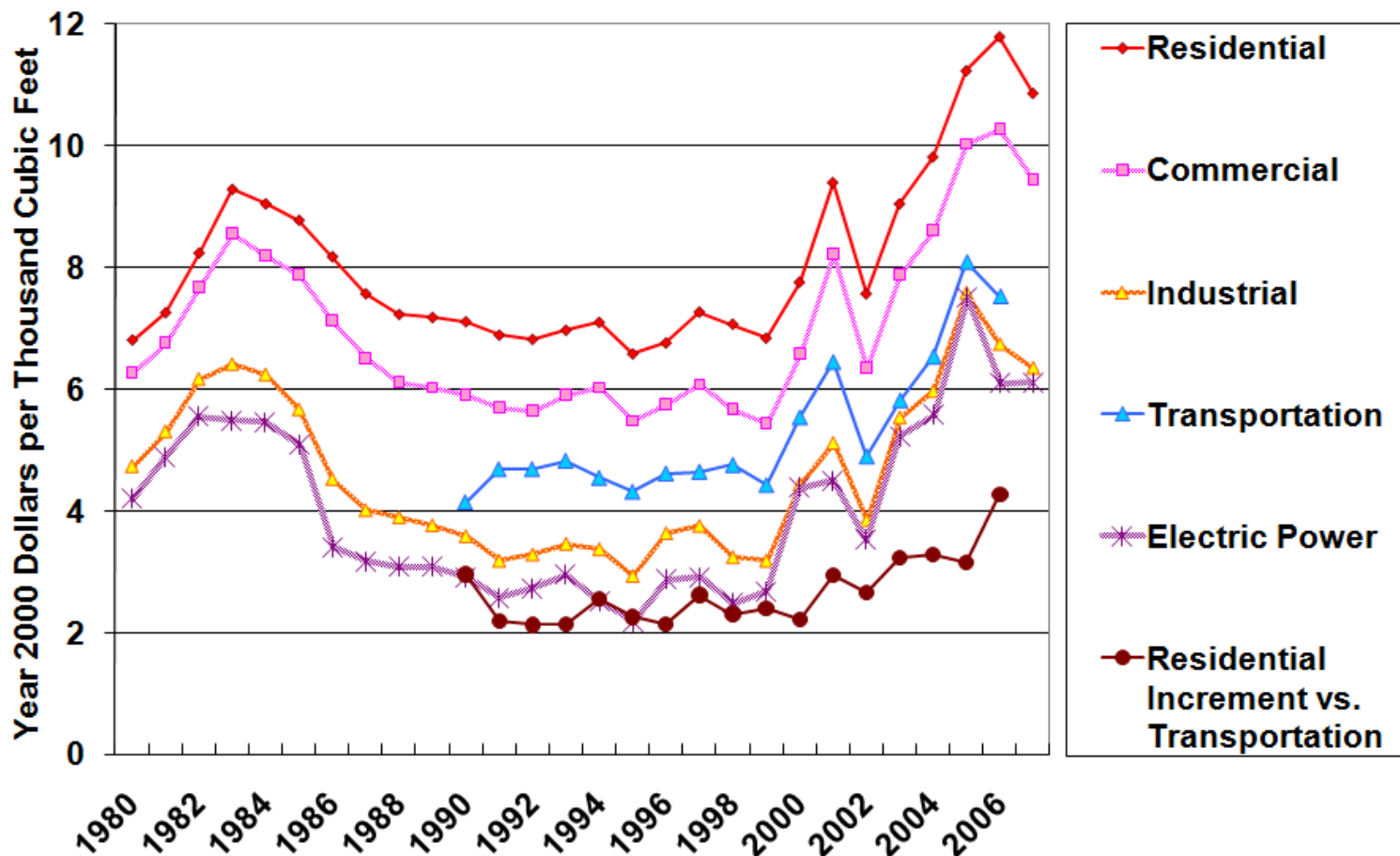


Source: 1940-2007, EIA. 2006 vs. 2008 36% gas resource base increase from Potential Gas Committee

- 2006-2009 - NG Prices Were More Stable than Diesel & Gasoline
- During the Price Shock, Gas Infrastructure Costs Were Offset
- For Wide CNG Success, Future Oil and Gas Prices Must Diverge Again



## CNG Success to Date has Been via Fleets Obtaining Prices Between Commercial and Industrial Rates



Real Price of Natural Gas by Customer Category, 1980 to 2007  
(Source: EIA AER, Table 6.8)

## Barriers and Technology Needs

- Product Availability
  - Only one passenger car, produced in 1,000s
  - No light truck under 8,500 lb GVW
  - 2 of 4 diesel engine conversions not available in 2010?
  - GM abandons medium duty – will engines for Baytech conversions remain?
  - Ford so far does E-series vans – Pickup trucks?
- Emissions Testing Data
  - Reliable on-road criteria and GHG emissions data on how HD NG compares with other fuels/technologies would be beneficial
  - Early tracking of this will be helpful since the best technologies meeting the standards will be in use for a decade or more

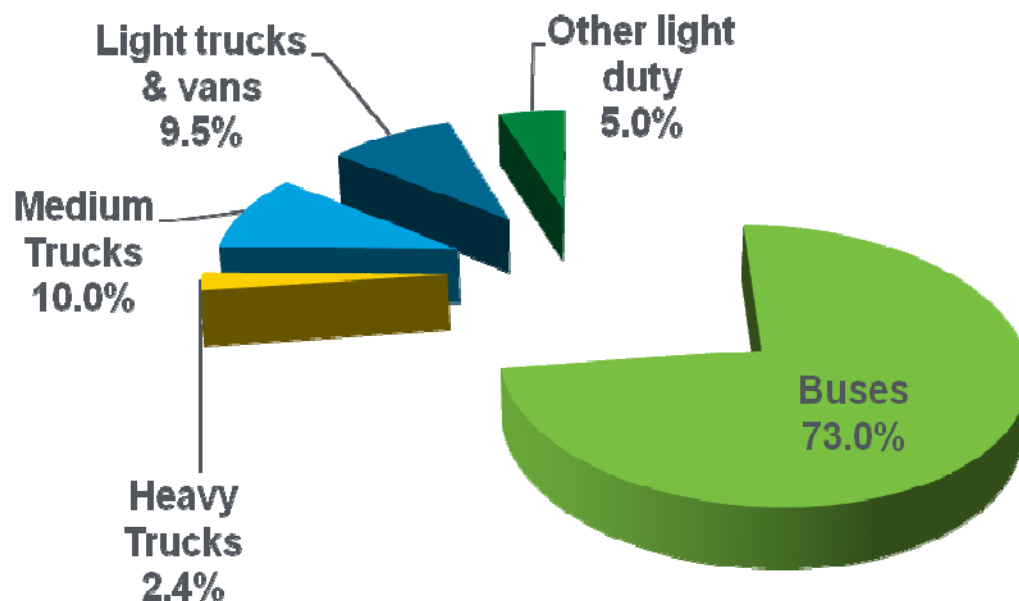
## Barriers and Technology Needs (cont'd)

- Water Issues for Shale Gas
  - Requires water for “hydrofracturing”
  - Some states are delaying development until standards reviewed
  - Many states (GWPC) claim water issues are addressed
  - Shale gas may need more water than gas, but less than other energy
- Disinterest of Utility Partners – how can they be reengaged?
- Perceptions – Reliability of:
  - Vehicles
    - Diesel — is diesel reliability assured with new aftertreatment?
    - Gasoline — what was reliability of CNG vs. gasoline? What will it be?
  - Government commitment (fluctuation of incentives)
  - OEM commitment (post 2002 collapse of offerings)

## Barriers and Technology Needs (cont'd)

- High Cost and Lack of Infrastructure
  - Partial absence of gas pipeline networks
    - Most rural areas
    - Some regions
    - City cores?
  - Cost of refueling equipment
    - *Phill* home refueling for Civic GX
      - \$3,000-\$4,000 capital cost
      - \$1,000-\$2,000 installation
    - Amortized fleet refueling facility costs
      - \$0.59/GGE best case
      - \$1.15/GGE worst case

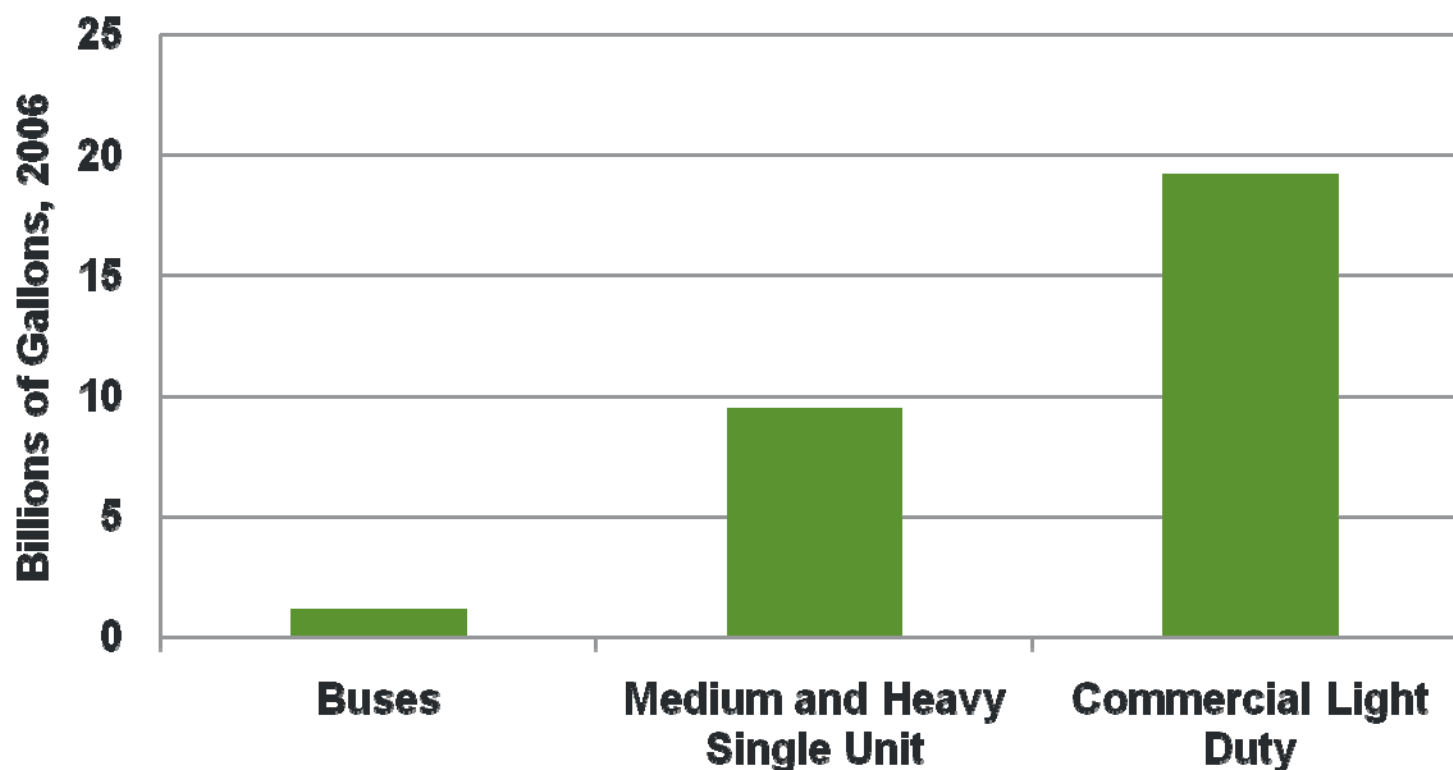
- Buses Dominate NG Use in Transport  
Medium & Light Trucks Represent Most of the Remainder



## Shares of Natural Gas Fuel Use by Vehicle Type, 2007

Source: EIA Alternatives to Traditional Transportation Fuels, 2007

## Commercial Urban Delivery Trucks are a Large Target Market vs. Buses



**Commercial "Single Unit" (Urban Delivery)  
Truck vs. Bus Total Fuel Use, 2006**

## Current Activities

- Local Clean Cities
  - Reported 53,200 natural gas vehicles (632,000 AFVs total) in 200
  - NG accounted for 60% of alt. fuel use (120,000 thousand GGEs)
- DOE Clean Cities
  - Clean Cities ARRA will fund approximately 3,567 natural gas vehicles and 137 stations
- Industry
  - Natural Gas Vehicle Technology Forum met in 2008 and developed recommendations for engines, vehicles, fueling infrastructure, and storage
  - Workshops on many areas including safety
  - Targeted niche market conferences

## Opportunities in the Marketplace

- CEC (2007), 17% natural gas in max. alt. fuel scenario
  - CNG in intra-city “return to base” heavy-duty fleets
  - 36% natural gas in heavy duty (interpret as > 8,500 GVW)
    - Includes transit buses and off-road vehicles
    - 1.6 million barrels of petroleum per day (4.5 million total)
- Bump in costs of 2010 clean diesel and reduction in diesel engine availability
  - Improves medium-light commercial truck gasoline and CNG marketability
- CNG can beat gasoline on GHGs
- LNG can augment CNG where urban delivery trucks need more range and pipeline infrastructure is available

## How Can Clean Cities Expand The Market?

- Deploy test fleets where durability and costs are evaluated
- Promote and support periodic emissions testing to evaluate on-road emissions and deterioration
  - Include “control” vehicles (with comparable conventionally fueled engines & HEVs)
- Evaluate effectiveness of various incentives
  - Encourage best incentives with duration parity with PHEVs (to 2014)
  - Vehicle, infrastructure, and fuel excise tax credit extensions?
  - Cash for Clunkers for old gasoline and diesel fleet vehicles
- Encourage development of < 8,500 GVW class 2 trucks that meet Tier II emissions standards
  - If development does not take place, focus on > 8,500 GVW

## How Can Clean Cities Expand The Market? (cont'd)

- Develop new tools including materials that address
  - Changed perspective on supply of natural gas
  - 2010 compliant product offerings attributes
    - results from tests of emissions and durability evaluations
    - fuel economy and performance
  - Safety information for fleets, small businesses, & consumers with regard to available refueling equipment
  - Payback period evaluation of the total investment by a fleet
    - Including the initial vehicle cost, operating cost (fuel, maintenance, product longevity, insurance rates, resale)

## How Can Clean Cities Expand The Market? (cont'd)

- Focus on off-road vehicles/equipment where infrastructure is available for on-road applications
  - Evaluate costs and benefits of off-road vehicles
- Evaluate work force potential of a robust NGV industry
- Examining market based trading of carbon emissions
- Developing a Corporate Imaging Program

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- Natural gas is a domestic fuel
- The residential market extremely challenging and only one OEM product remains
- 2010 diesel engine costs (clean diesels) are up sharply
- Both gasoline and diesel engine conversions to CNG are available for medium and heavy vehicles (2010 compliant)
- Post 2010 durability of (clean) diesels vs. CNG is unknown, must be proven — both emissions and lifetime
- The best target niches are (1) commercial urban fleets utilizing high fuel-use single unit trucks & vans and taxis (2) un-tapped potential of off-road vehicles (3) expanded use in transit buses, refuse trucks, and other attractive HD applications
- Current incentives for NG are inadequate to jump start the niche (or they are set to expire before significant market transformation can occur)