



# Honda' experience and perspective on CNG powered Vehicles

Ichiro Sakai  
American Honda Motor  
December 13, 2012  
MSTRS meeting

# Contents

---

- Overview
- Civic GX Technical Achievement
- Fleet Sale and Marketing
- Retail Consumer Market
- CNG Infrastructure and Fuel Quality
- Summary

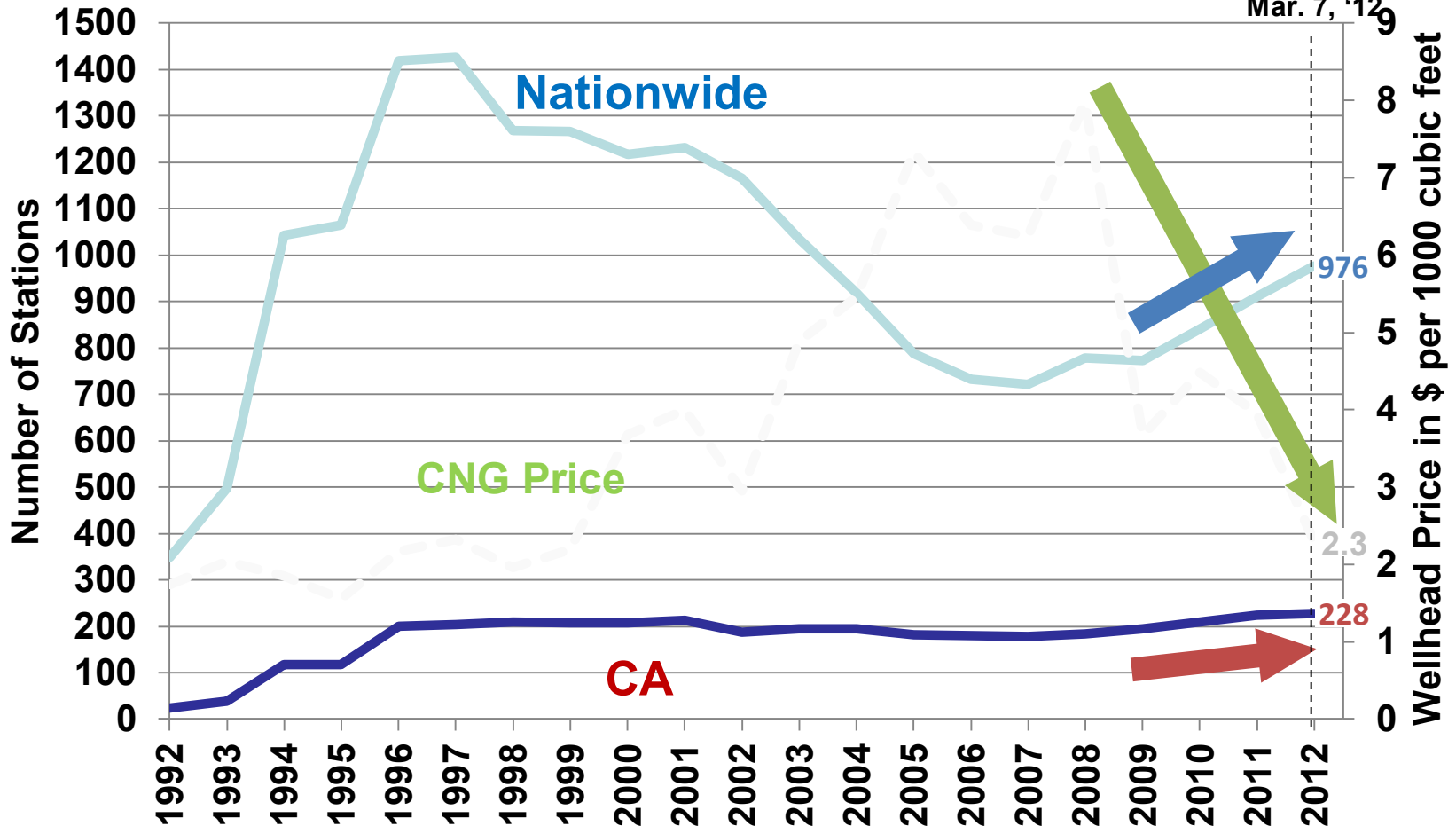


# Overview

Why Natural Gas is a great transportation fuel

# Circumstances

## Number of CNG Stations vs. CNG Price



***CNG price has dropped sharply and stations have increased gradually***

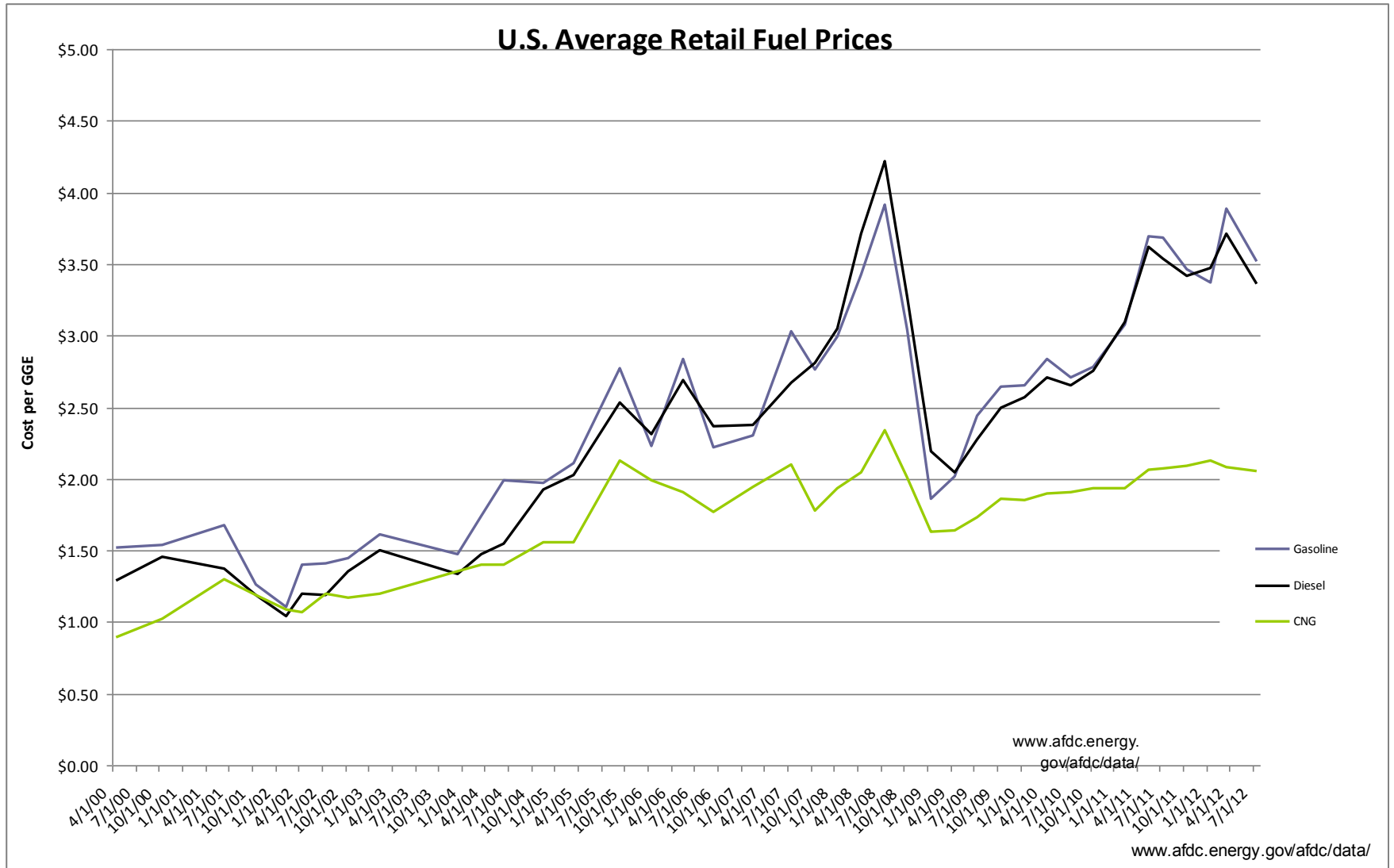
# U.S. CNG Station Infrastructure



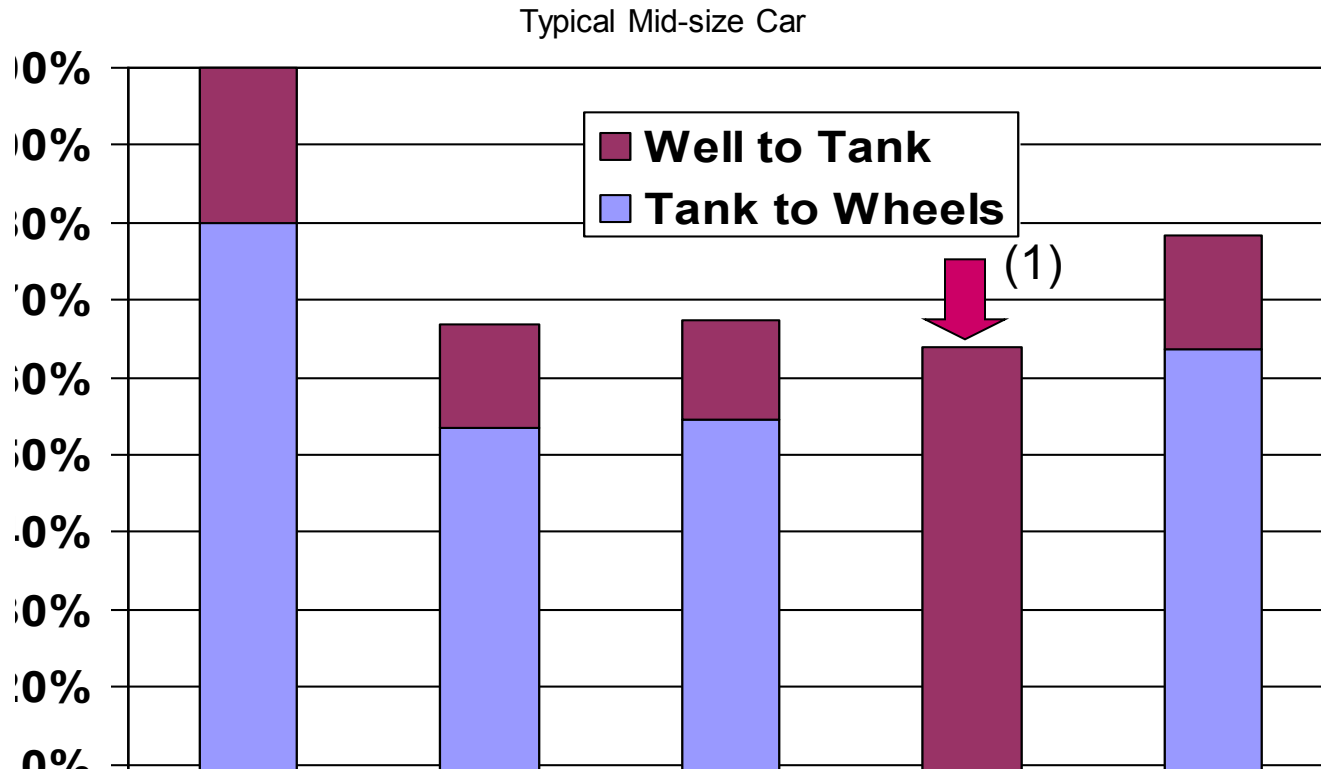
## Map Legend

Public and private  
CNG Station

# Retail Fuel Price Advantage



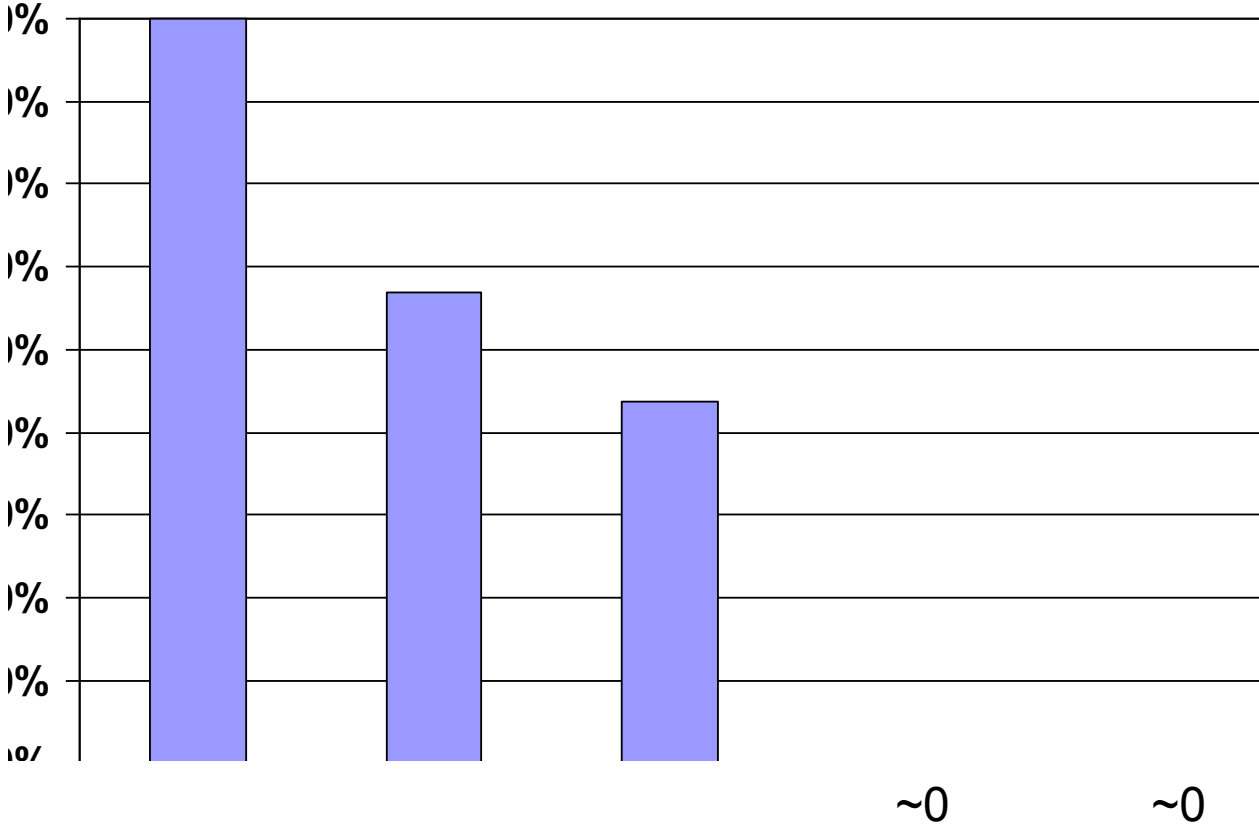
# Technology Pathway Comparisons – CO<sub>2</sub>



(1) Bar for BEV reflects 600 grams CO<sub>2</sub>e/kWh, which is EPA's "image" for 2016. Using the GREET model and today's averages, BEVs exceed HEVs.

# Technology Pathway Comparisons – Petroleum Consumption

---





# Natural Gas is a Great Choice

---

- Low carbon fuel
- North American fuel supply
- Fuel distribution network established (pipelines)
- Wide range of infrastructure possibilities
- High well-to-wheel efficiency
- Fuel cost < gasoline
- Wide applicability (autos, trucks, buses, forklifts, etc.)
- SULEV / ILEV / AT PZEV capable
- Proven performance, known costs
- Renewable fuel
- Pathway to hydrogen

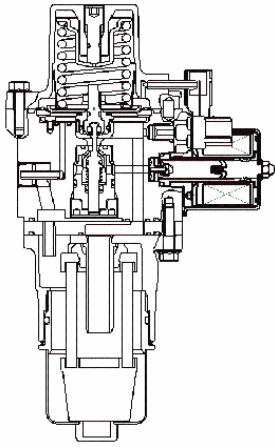


The Power of Dreams

# Civic GX Technical Achievements

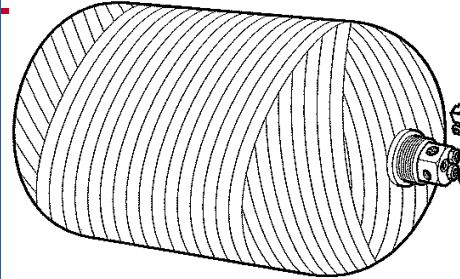


# 2006 -2012 Civic GX Technology: Fuel Supply System



## Pressure Regulator

Single stage,  
integral type with  
low pressure oil trap filter



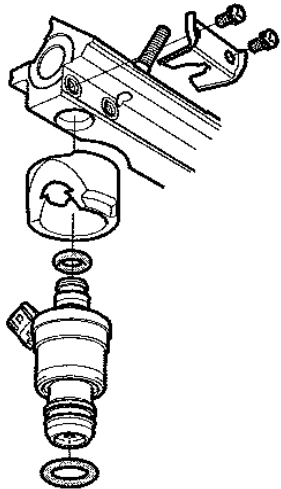
## Fuel Tank

- Composite with aluminum liner
  - Pressure relief device
  - In-tank solenoid valve
- @3000 psi: 7.2 GGE  
@3600 psi: 8.0 GGE

(GGE = gasoline gallons equivalent)

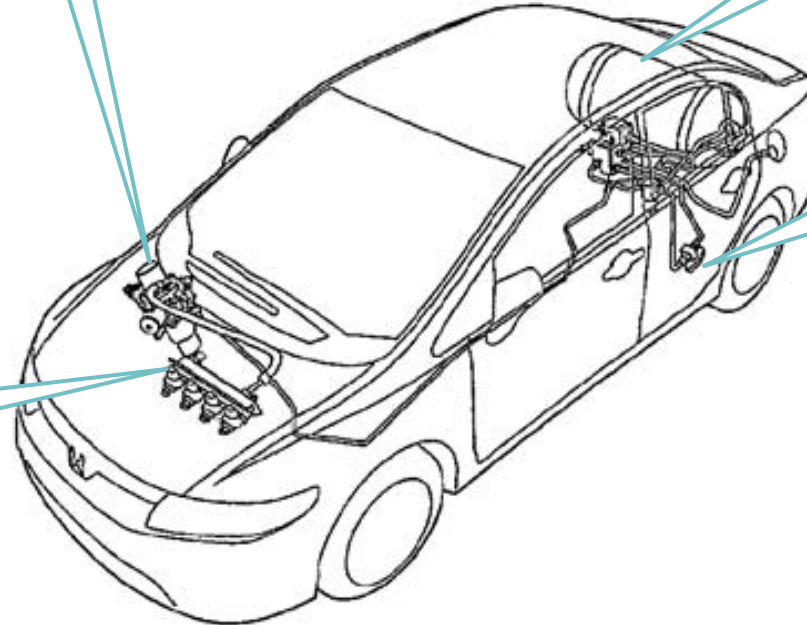
## Injectors

Dedicated gaseous  
fuel injectors



## Engine Valve/Seat

Changed materials, designed to  
reduce wear and be compatible  
with CNG, a non-lubricating fuel.



## Manual shut-off valve

### Other Key Components

- Tank pressure sensor
- Tank temp sensor
- Rail pressure sensor
- Fuel temp sensor
- Fuel shut-off solenoid valve
- Fuel filters
- Receptacle

### Reference:

HONDA CIVIC 2006-2010 Service Manual, GX Supplement

**HONDA**  
The Power of Dreams

Dedicated components for a practical, safe, and durable system

# 2006 -2012 Civic GX Technology: Engine and Exhaust

## i-VTEC CNG Engine 1.8l

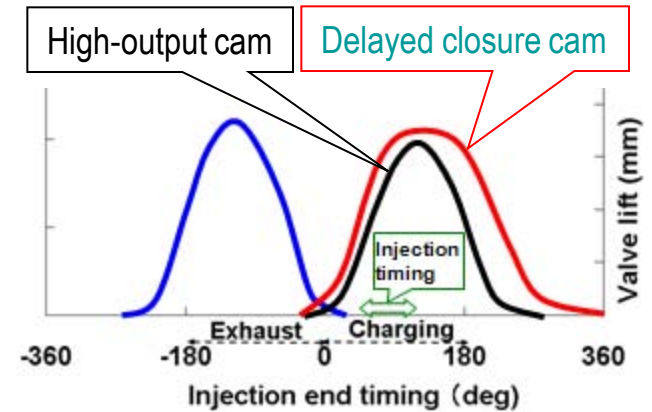


CR 12.5:1

### Inlet Valve Delay Closure

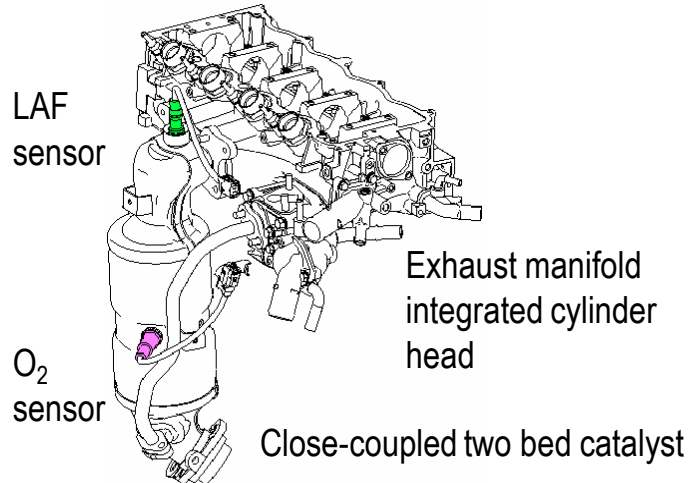
- Reduced pumping loss
- Reduced mechanical loss
- Improved thermal efficiency

→ Improved HWY FE 15%



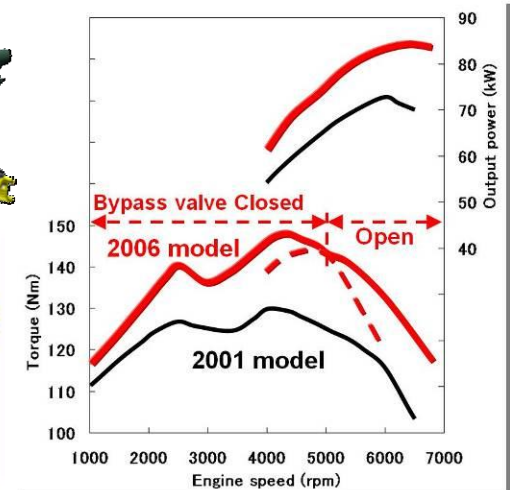
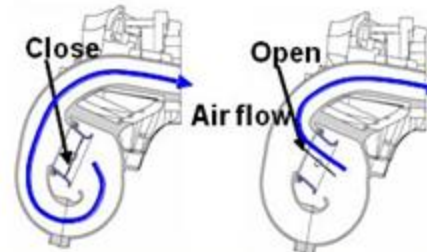
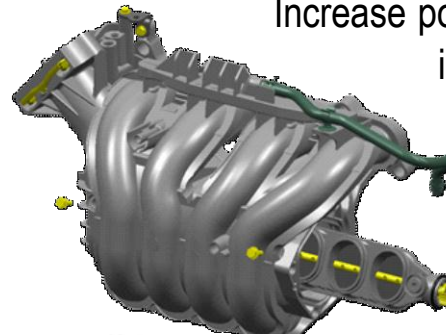
### Closed-Coupled Catalyst

Quick light-off → Complies with AT-PZEV



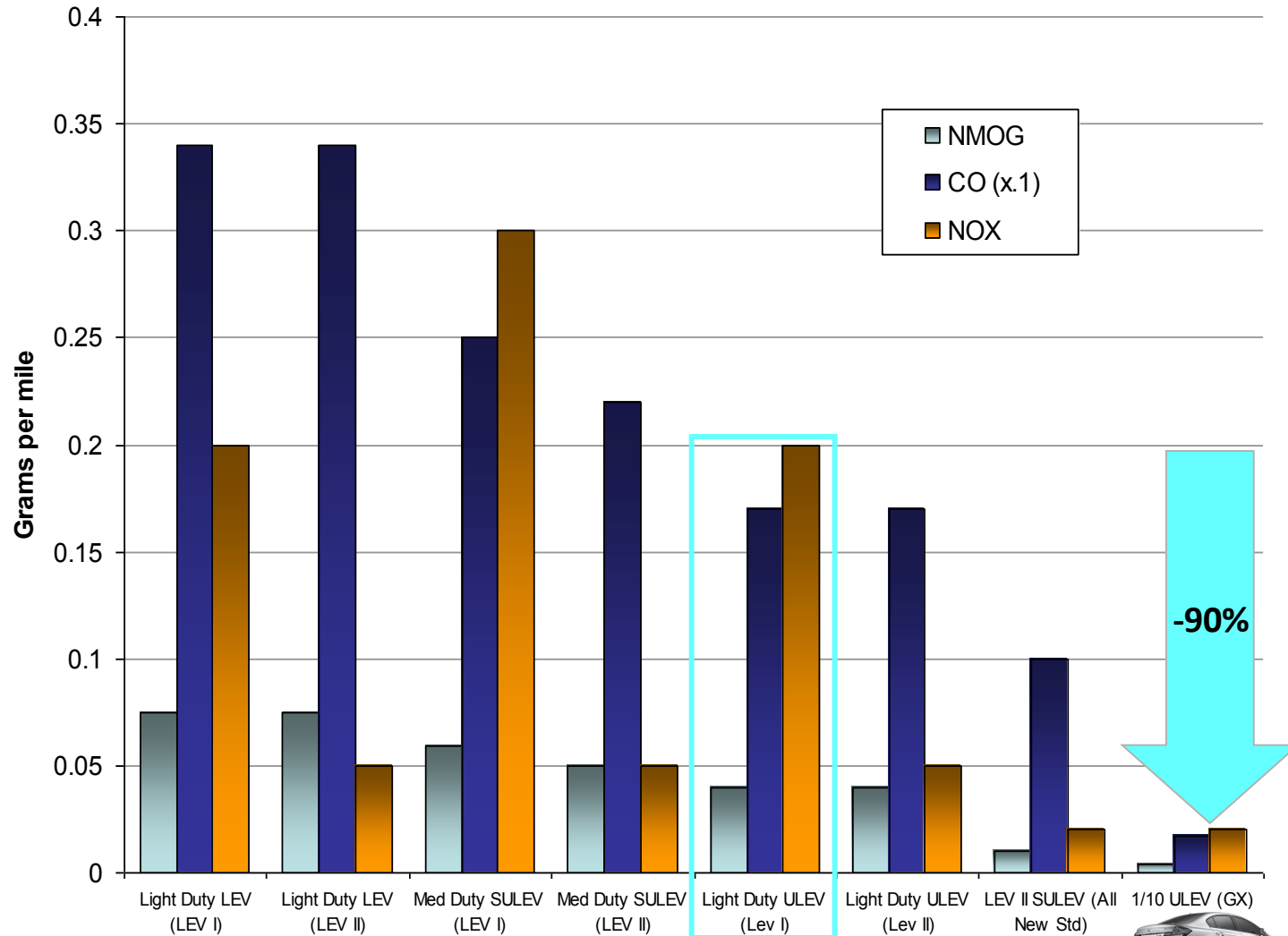
### Variable-Length Air Intake Manifold

Increase power by 7%. Combined with 8% increased displacement → 15%

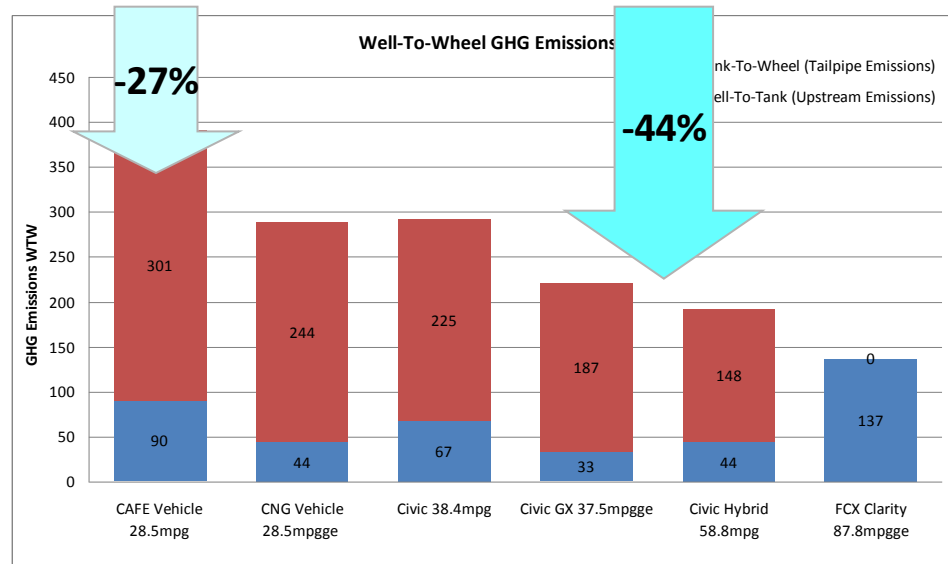


Specific design improved fuel economy, increased power, and achieved AT-PZEV

# Emission Standards Comparison



# Natural Gas Vehicles – GHG Reductions



**391**

**288**

**292**

**220**

**192**

**137**

Using CA Greet Model:  
Civic GX is a 44% GHG Reduction from the Average US Gasoline Car

# Honda Civic Natural Gas - Range

---

Tank Capacity is 8 GGE

Nominal Range is  $8 \times 38 = 304$  miles (this would run the car out of fuel.)

Real World Range is  $7.8 \times 30 = 234$  miles

Overnight, home refueling (Phill)

Fast refueling at public stations (3 to 5 minutes)

Comparisons:

3X “100 mile BEV”

1X Honda Fuel Cell “Clarity”

75% of Gasoline Car



# Fleet Sales & Marketing





## FILL YOUR TANK *without* EMPTYING YOUR POCKETS.

Only two things you really need to know about the 2013 Civic Natural Gas: It's the cleanest internal-combustion passenger vehicle<sup>1</sup>, and CNG prices are almost half that of regular gas<sup>2</sup>. The fact that it now comes standard with Pandora<sup>®</sup> compatibility<sup>3</sup>, SMS text message function<sup>4</sup> and a rearview camera simply turns an intelligent decision into an insanely obvious one. Learn more at [civcnaturalgas.honda.com](http://civcnaturalgas.honda.com).

CIVIC



insert dealer information



## DON'T JUST SAY IT WITH YOUR BUMPER, SAY IT WITH YOUR WHOLE CAR.

The Natural Gas-powered Civic is the cleanest internal-combustion vehicle on the planet. New for 2012, the Civic features an available Honda Satellite-Linked Navigation System™ with FM Traffic and customizable I-MID Interface. Also, because natural gas is domestically sourced, the cost of driving a Natural Gas Civic is much more predictable. The Natural Gas-powered Civic, only from Honda. To each their own.

[civcnaturalgas.honda.com](http://civcnaturalgas.honda.com)

CIVIC



insert dealer information

CIVIC Natural Gas with available navigation shown. \*New York, NY, only. CARS-11000 and SUV certification as of October 2011. \*\*The U.S. Department of Energy's Alternative Fuel Vehicle Report, July 2011. \*\*EPA's 2011 Fuel Economy Guide. CNG prices are almost half that of regular gas. \*\*As of 10/1/11. Prices may vary. ©2011 American Honda Motor Co., Inc.

Civic Natural Gas with available navigation shown. EPA 31-2, 31-2, CARB AT20V and CARB certification as of September 2011. \*\*The Honda Satellite-Linked Navigation System™ is available in the United States, Canada and Puerto Rico. FM Traffic service only available in the United States, except Alaska. Please see your Honda dealer for details. ©2011 American Honda Motor Co., Inc.

# Honda Civic GX Fleet Applications

World's Cleanest Taxi Cab!



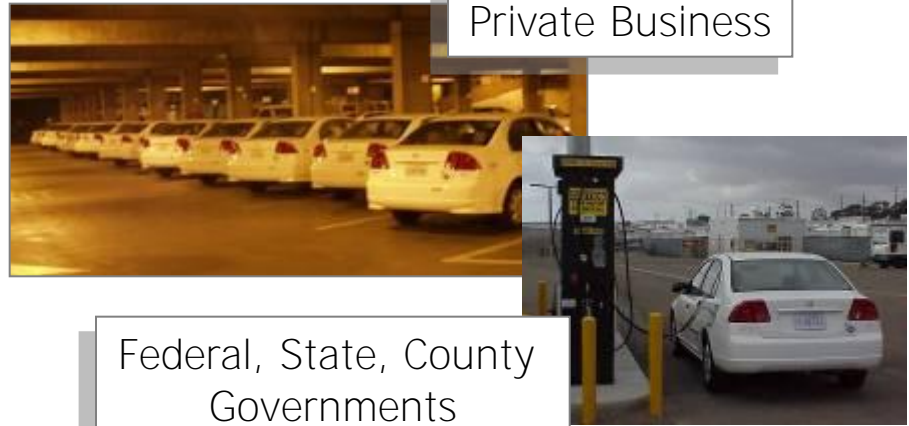
Parking Enforcement



Community Patrol



Private Business



Federal, State, County Governments



# Retail Consumer Market

# Examples Incentives

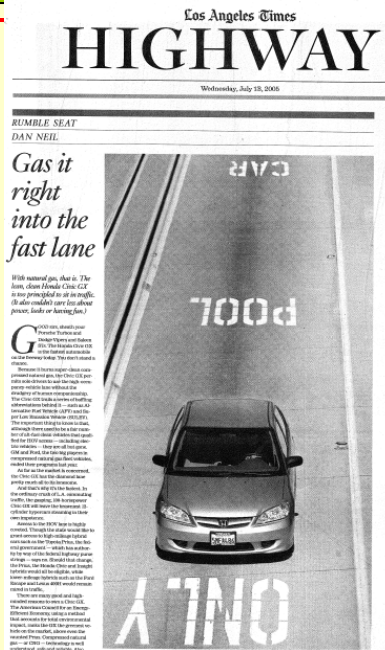
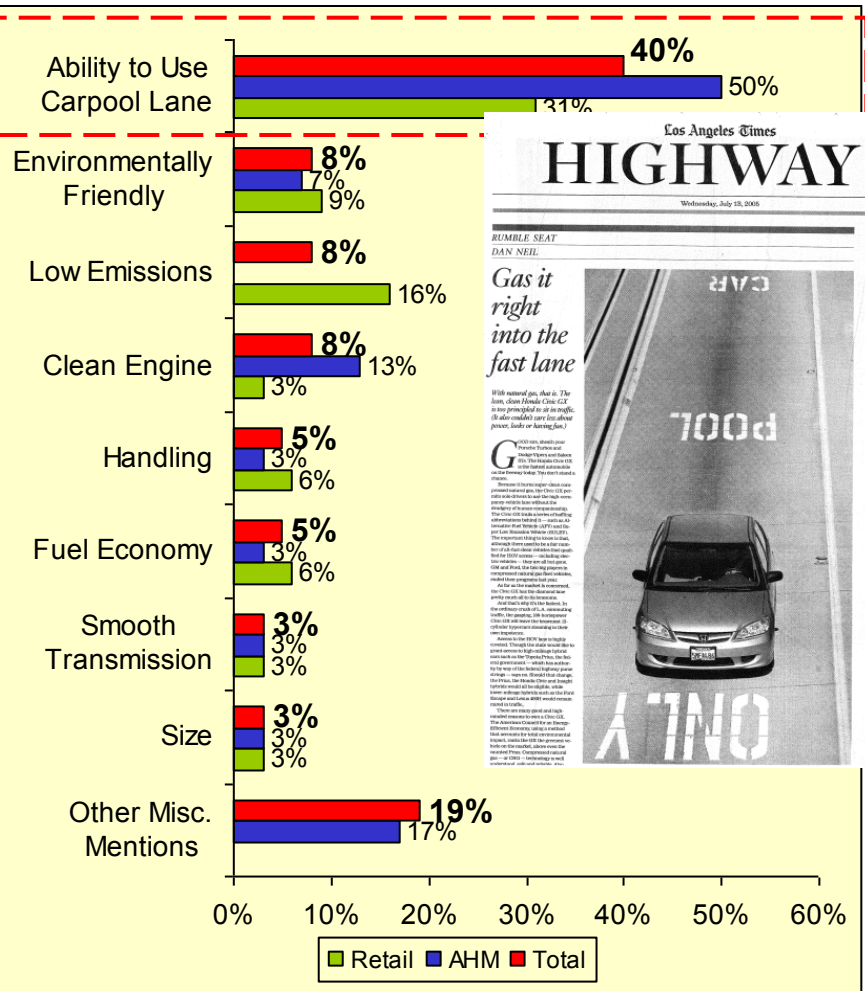
---

- Financial Incentives
  - State Incentives – Vary
  - Local municipal and/or air district Buy downs
    - Up to \$3,000 rebate
- Incentives beyond money
  - Environmental stewardship
  - Reduce dependence on oil
  - Free/Preferred Parking
  - HOV lane access for single occupant

# Customer Benefit: Carpool Access

- Top benefit for CNG customers is carpool lane access.
- Currently no limit for CNG vehicles in CA.

## Top Likes of Civic Natural Gas



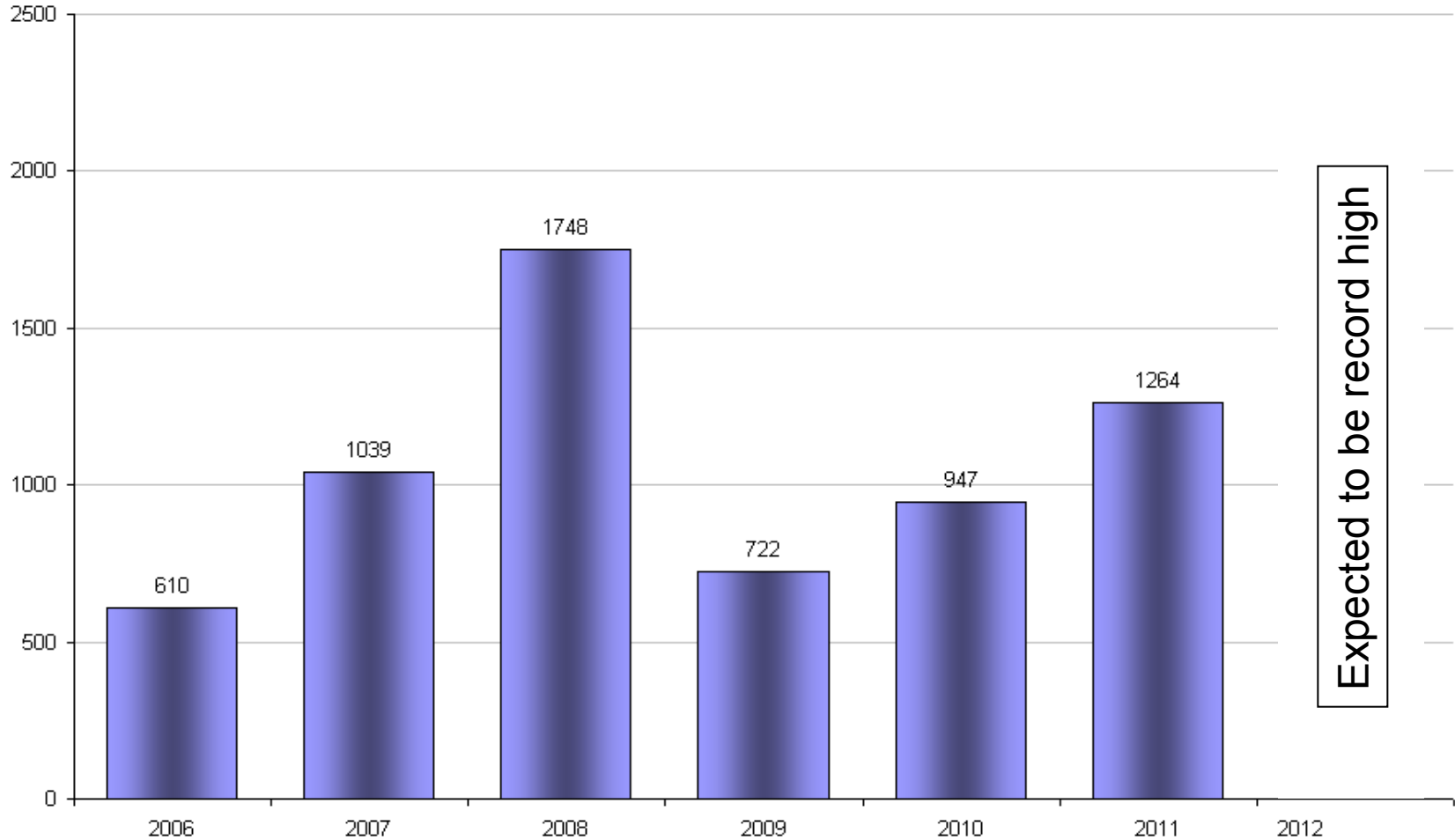
HOV Sticker	Detail
	SULEV exhaust ILEV evap  No limit
	SULEV hybrid or alt fuel <b>AND</b> 45 mpg HWY. Reached 85,000 limit.
<b>Single-occupant use of HOV lanes by alternative fuel vehicles that qualify as Inherently Low Emission Vehicles (ILEVs) and Super Ultra Low Emission Vehicles (SULEVs). EV and CNG vehicles qualify.</b>	

**HONDA**

HOV access for CNG vehicles until January 1, 2015.

# Civic Natural Gas Sales Trend

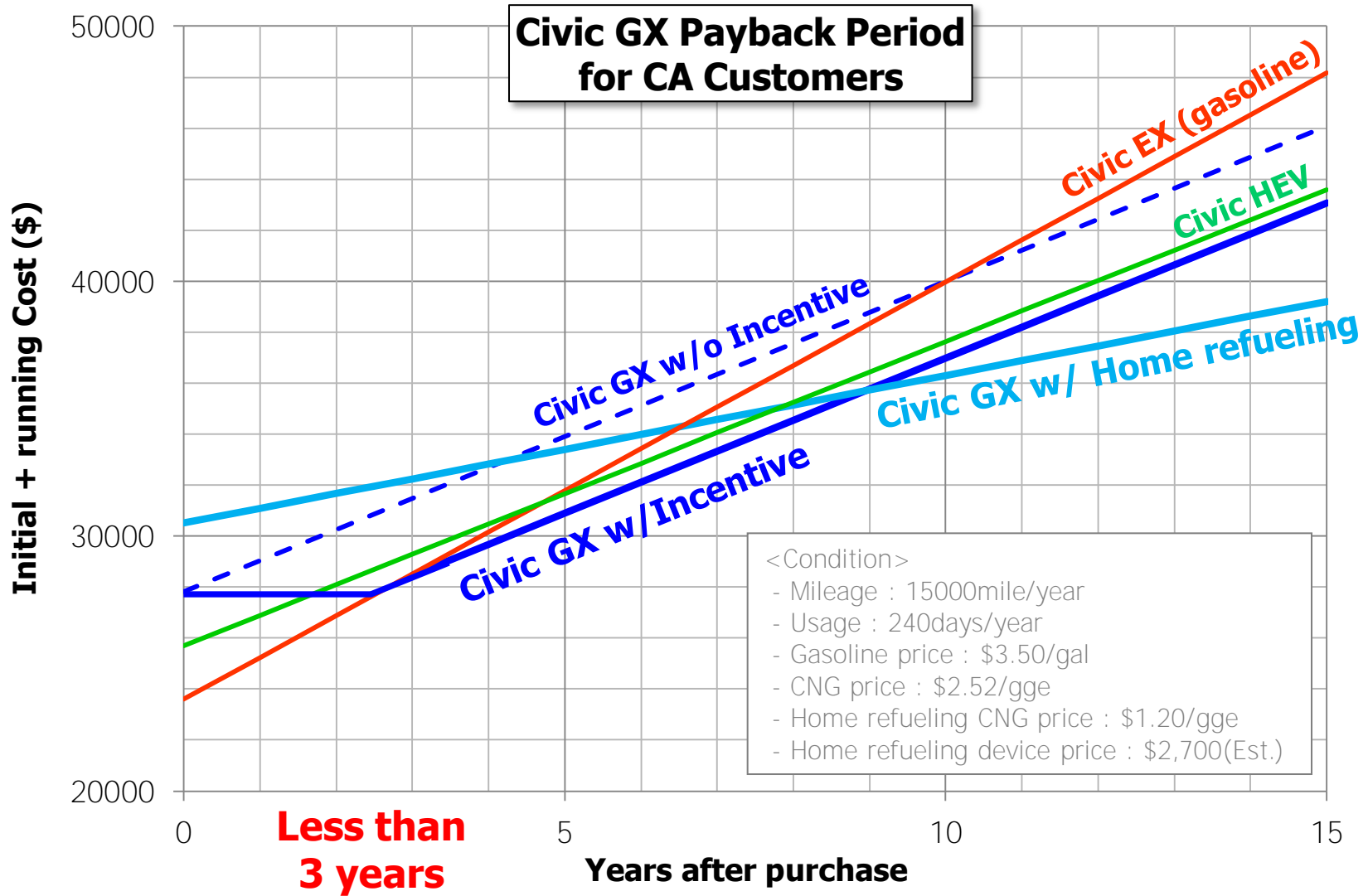
Civic CNG Deliveries - CY







# Cost Evaluation with assumption of 15K mile/year usage

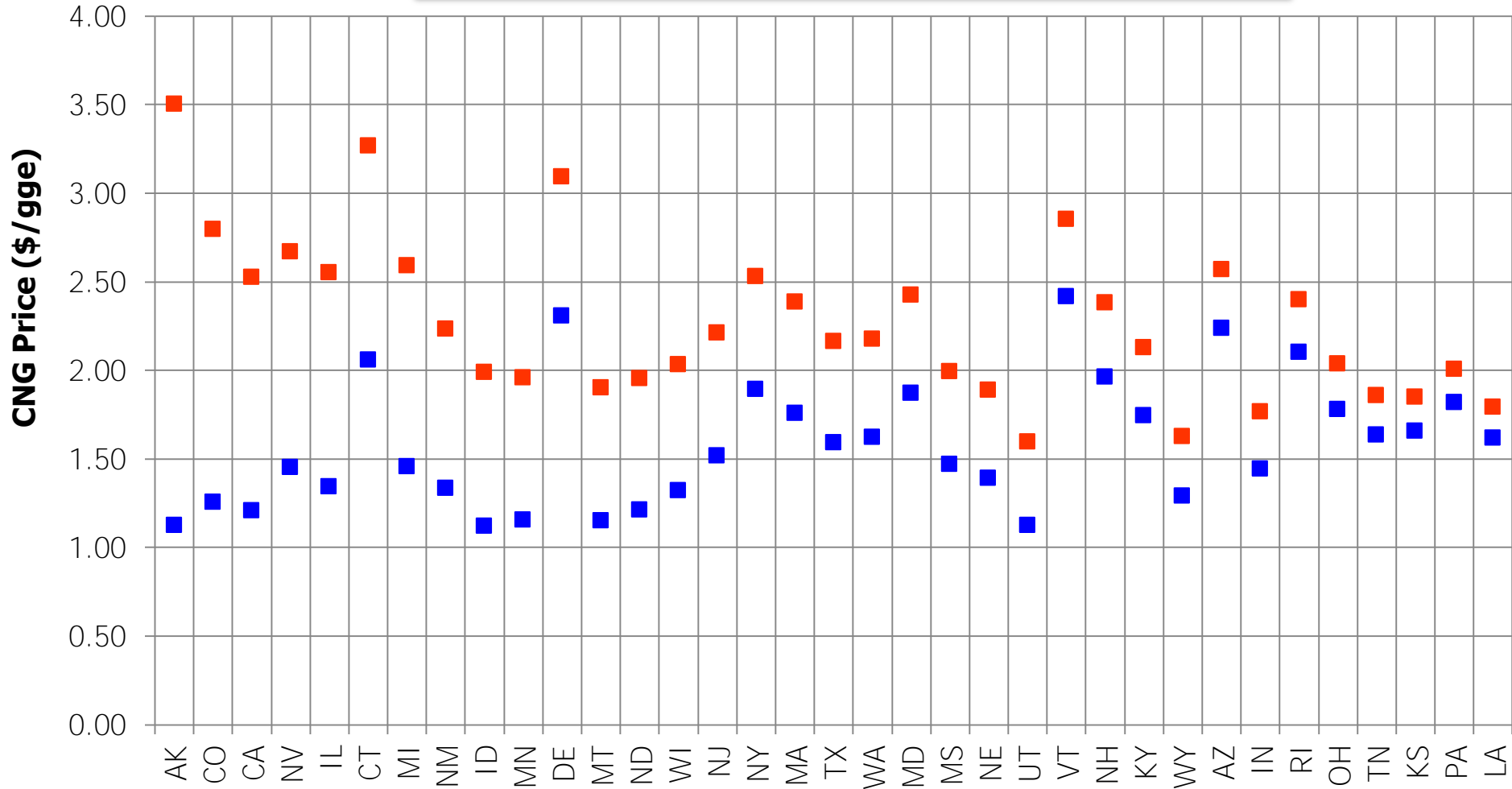


Price increase of CNG vehicle could be recouped by less than 3 years.  
(not include home refueling equipment)



# CNG Price Gap (Public Station vs. Residential)

**CNG Price Gap between Station and Residential**



CNG price gap between station and residential varies among states



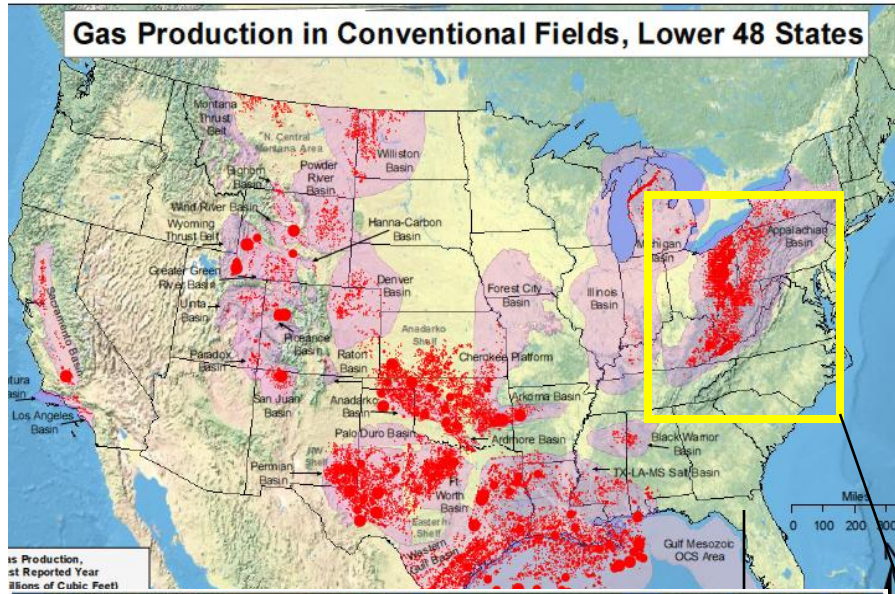
# CNG Infrastructure / Fuel Quality

# Partnership Experience with Home Refueling equipment company

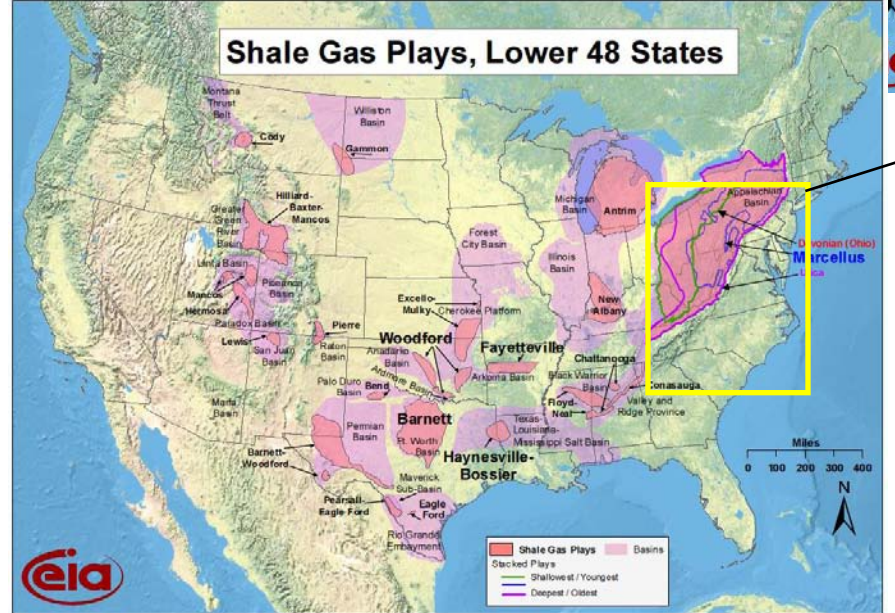
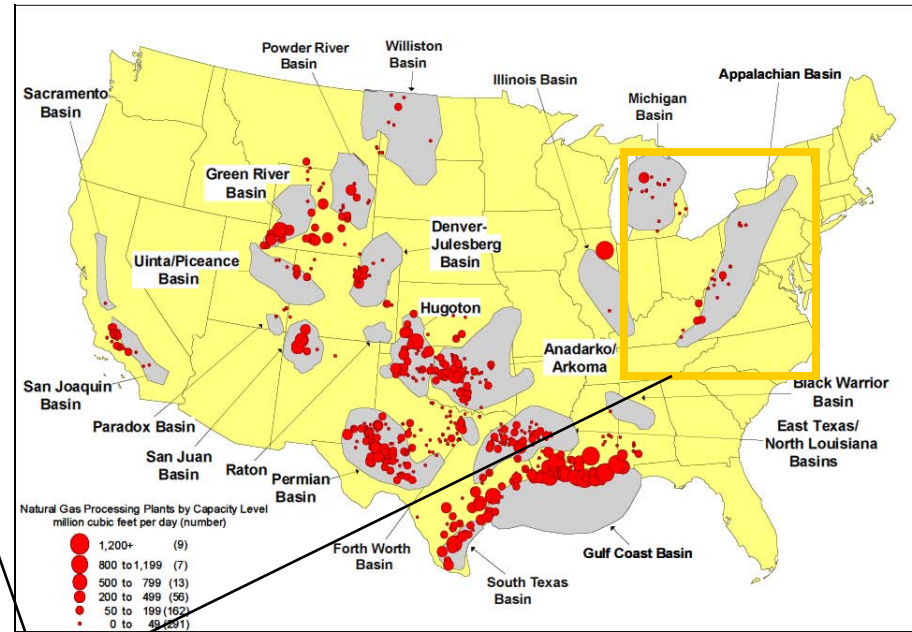
---

- NGV buyers .....
  - are more receptive if they understand fueling options
  - want convenient and cost-effective refueling
  - synchronized vehicle & refueling unit delivery
- Fuel Quality (delivered to home) is critical
  - It is necessary to develop fuel quality standard (moisture).

# Natural Gas Fuel Production Vs. Processing Capacity



## Natural Gas Processing Plant Concentration (2004)



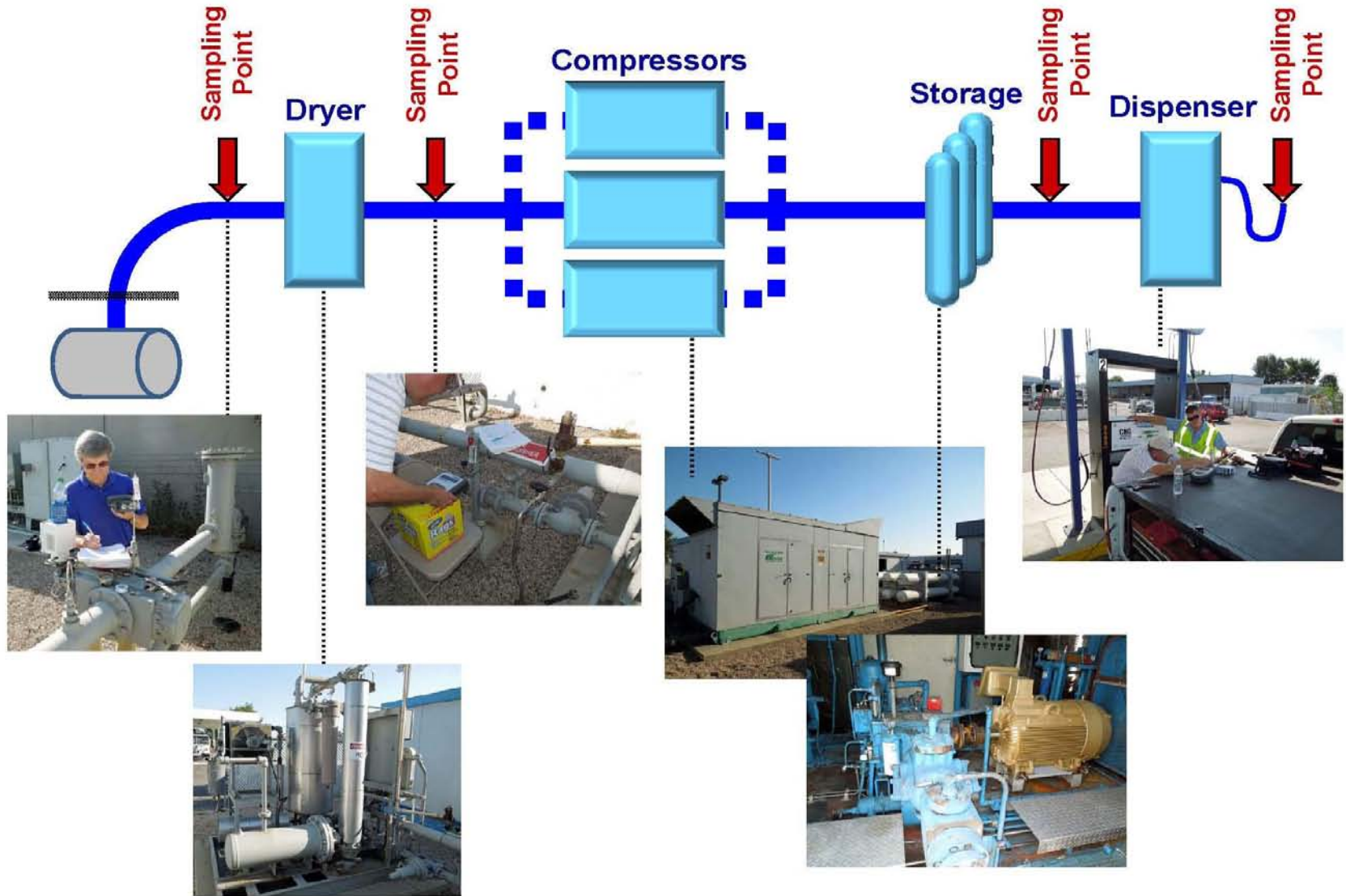
### Concern Point for Highlighted Area:

- **Large amount of Natural Gas production and low amount of processing capability.**
- **Fuel can be distributed to LDC (local distribution companies) as unprocessed (Wet) fuel.**
- **Increased Shale Gas production (Wet Fuel)**





# Typical Station Layout & Sampling Points

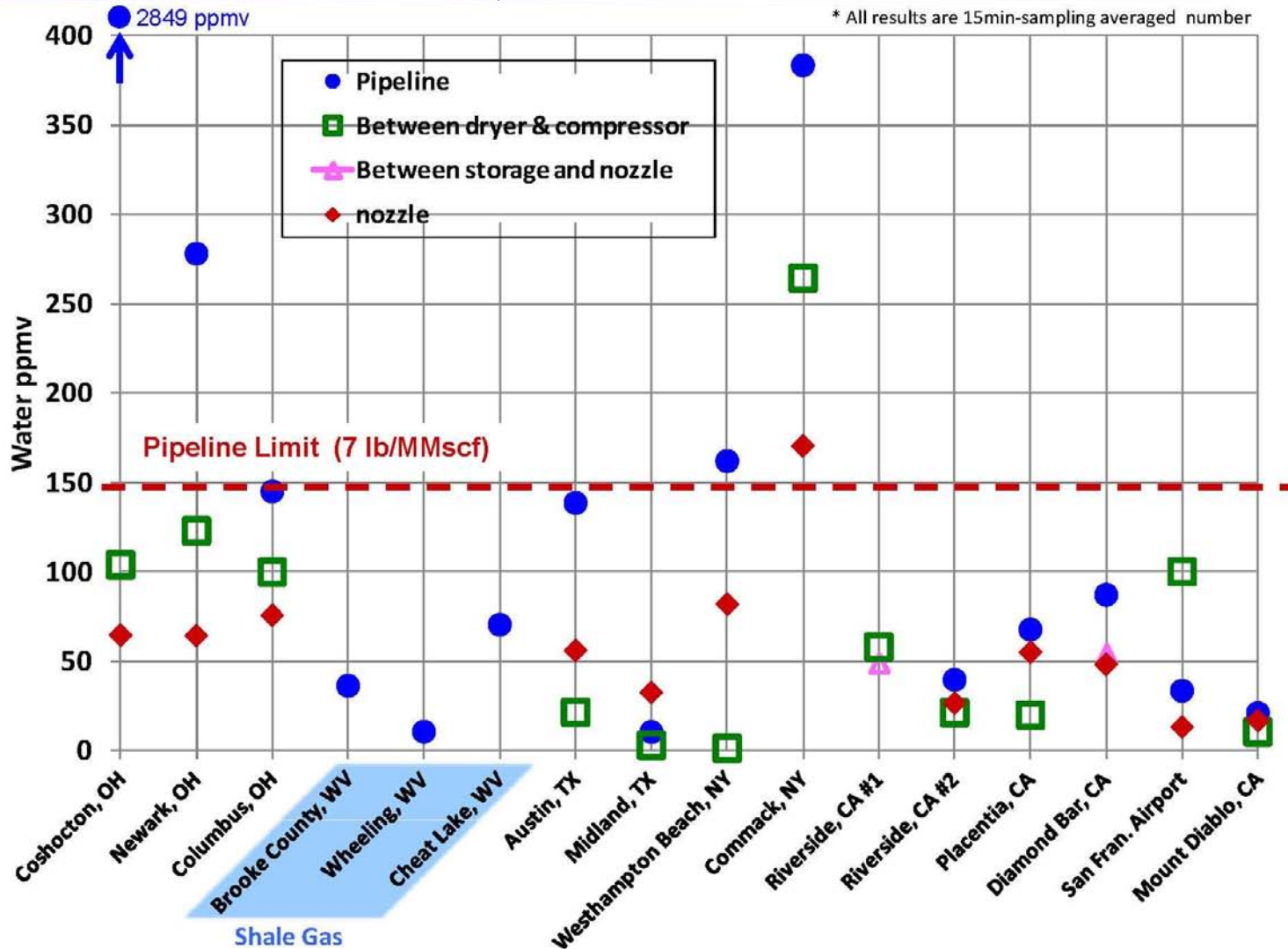


**Sampled were taken in above points of public injection stations. (to check for moisture content)**

# Overall Results

Phil's maximum dryer capability : 855 ppmV

4

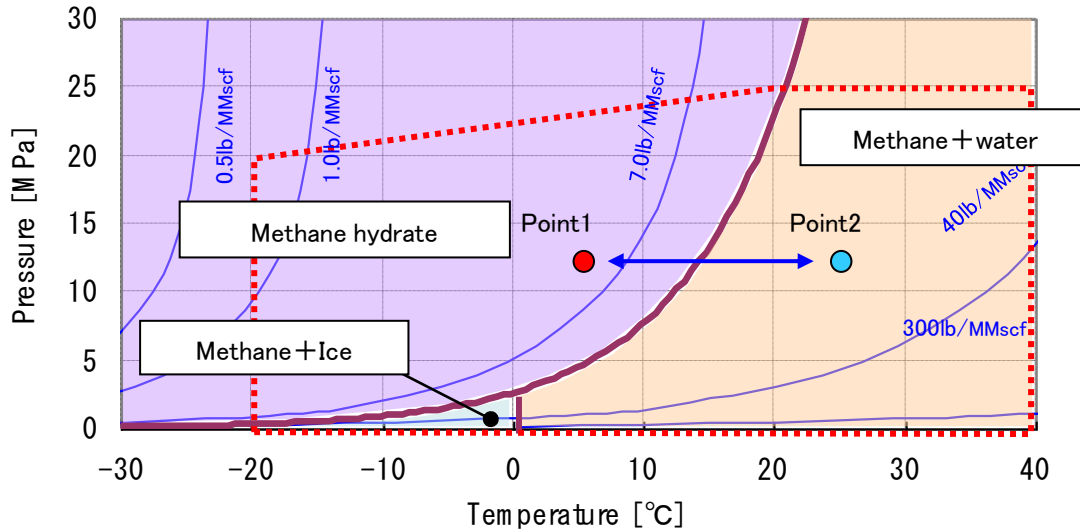


Concern with gas in Ohio & NY is high moisture content. (Gas in Ohio contains moisture that exceed the Phil Dry Layer capability) Some areas has Shale gas with low moisture content.

# Moisture problem

## Methane hydrate Generation

— Dew point line (each moisture level)  
 [Red dashed box] CNG operation zone



With fuel containing 10lb/MMscf moisture, methane and water co-exist at point 2 and methane hydrate is generated at point 1.

Solenoid get stuck due to methane hydrate generation.

Water in a fuel tank suggests that fuel with excess amount of moisture, above CNG fuel standard or dryer capacity of home refueling equipment, is delivered

300~450lb (Estimated) > 40.0lb > 7.0lb/MMscf  
 (Delivered gas) (Home refueling Equipment dryer capacity) (CNG fuel standard)

# 2012 Civic CNG Owner's Manual

---

- Fuel Quality and Honda Refueling

- In order to insure that your Civic Natural Gas vehicle receives CNG fuel with quality equal to or above the NFPA-52 and SAE J1616 fuel standards, Honda only recommends that your vehicle be refueled at public commercial-grade CNG refueling station. Public stations offer an approximately five minutes refueling time, and the assurance of natural gas quality meeting NFPA and SAE standards.
- Public refueling stations use commercial quality filtering and drying equipment that helps to assure your vehicle will only be refueled with automotive grade CNG, meeting the NFPA and SAE standards. Due to the nature of home natural gas supplies from gas companies, even with filtering and drying equipment, it is possible to introduce moisture into your vehicle's CNG tank and fueling system, possibly resulting in damage to the system. Moisture damage can require inconvenient and costly repairs.
- **Due to the wide variation of natural gas quality for home use, Honda does not recommend the use of home refueling at this time.** If you choose to use a home refueling device, you should consult with the equipment manufacturer and the local natural gas quality of the natural gas at the location the refueling equipment will be installed. They may recommend additional filtering and drying equipment, and a schedule for maintaining this equipment to insure delivery of natural gas that meets the NFPA and SAE standards of fuel quality. It is important to understand the quality of fuel not just when it is evaluated, but the range of quality, particularly moisture content, from the natural gas provider.



# Conclusion

---

- Natural Gas is very good transportation fuel from energy security (energy diversity).
- Due to limited refueling infrastructure, Civic Natural Gas Sedan's sales are limited. But sales have increased in the past a couple of years because of low fuel cost, incentives (both monetary and non-monetary)
  - HOV lane access is regarded as the most attractive. This incentive should be maintained unless it hurts the value of HOV lane.
- Infrastructure availability is critical for further expansion of this kind of alternative fuel vehicle. Government leadership to develop its network is desired.
- Honda's effort to address the limited fueling infrastructure; home refueling equipment, is hindered by the fuel quality. Maintaining fuel quality at delivered site (equivalent to or above NFPA-52 or SAE J1616) is desired.
  - It would be possible that moisture in delivered natural gas is higher than before due to fracking activity.



# Contact

Ichiro Sakai

[ichiro\\_sakai@ahm.honda.com](mailto:ichiro_sakai@ahm.honda.com)

202-661-4400 (Tel)