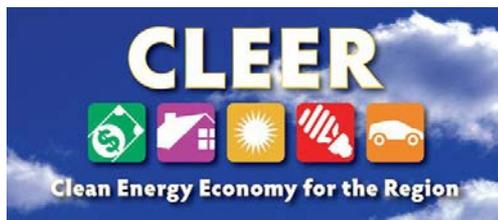




Compressed Natural Gas: Benefits for Vehicle Fleets



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3-PART MESSAGE

STRATEGY/TECHNOLOGY

IMPLEMENTATION

LESS CAR



EFFICIENT CAR



CLEAN FUEL



Don't drive if you can help it:

Walking, Biking, Transit, Carpooling, telecommuting.

If you drive, drive something efficient:

efficient vehicles, LRR tires, maintenance strategies, fleet management, lifecycle-cost-purchasing

Fuel diversity in the vehicle fleet:

- Plug-in passenger cars
- CNG light duty trucks
- CNG/LNG heavy duty
- Biofuel substitution

- Building/Land Codes
- Regional Planning Effort
- Safe Routes to School
- Education/Outreach

- Fleet Efficiency Policy
- Fleet Manager Workshop
- Technical support to local governments
- Case study: Eagle Cty 30%

- Western Slope CNG Coll.
- DoE Electric Vehicle planning grant
- RFTA: CNG buses
- CMC/FluxFarm biobutanol



Today's presentation:

- The high costs of imported oil
- CNG: stable fuel prices over time
- CNG vehicle safety
- Vehicle options
- Return on Investment



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Why Alt Fuels?

Oil imports are a risk to U.S. economic security

We are not out of oil, just out of cheap oil.
Extraction is becoming increasingly complex and costly:



The old days



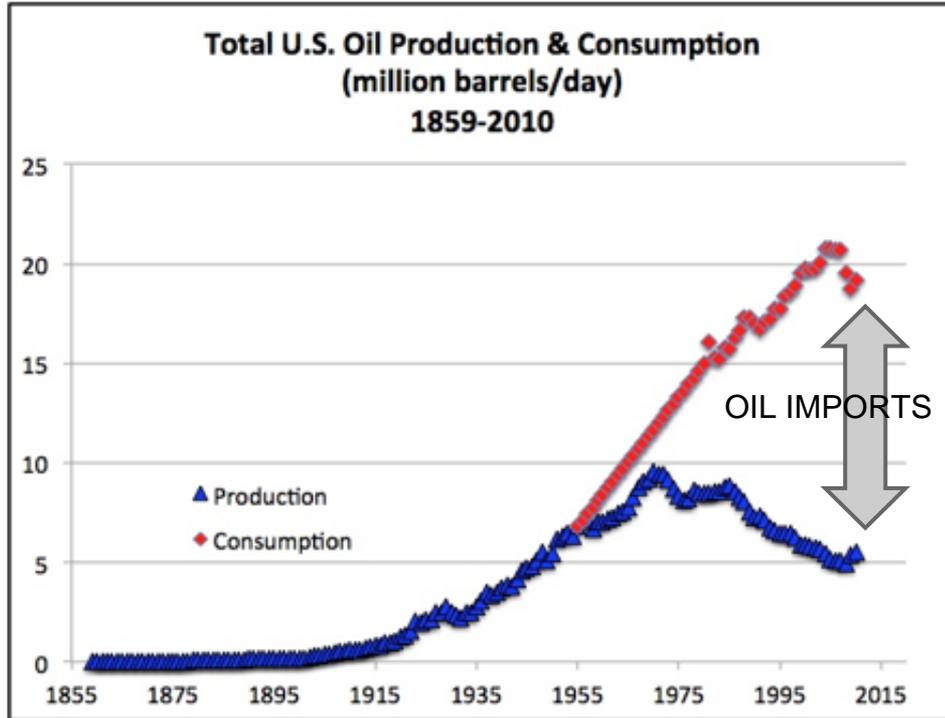
Today, on land



Today, offshore

New oil discoveries, but U.S. still uses too much

U.S. has 2% of global reserves, consumes 20% of global production



Blue = Production rising somewhat (Bakken, etc.)

Red = Consumption falling somewhat (recession)

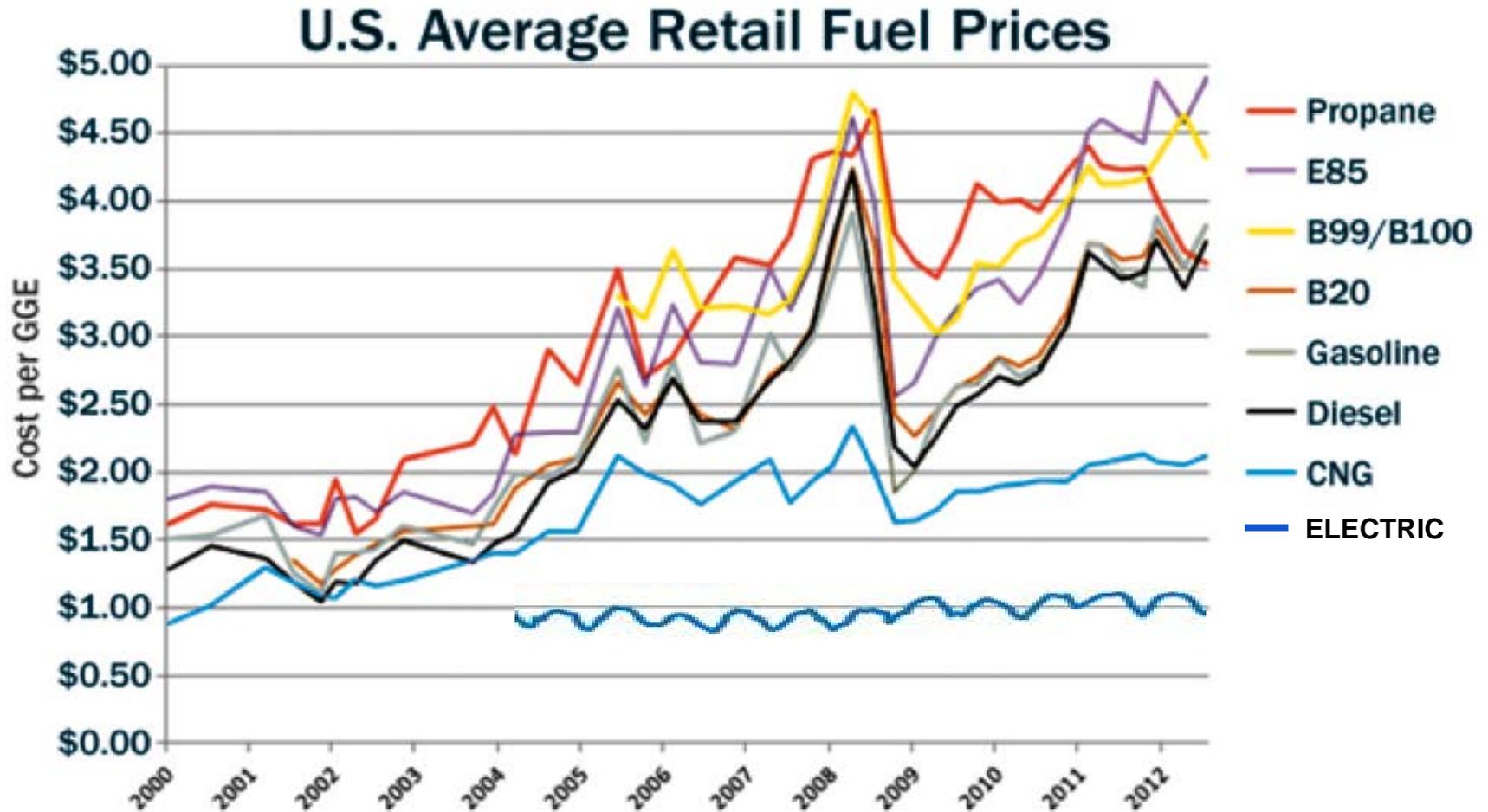
Annual Regional Spending on Gas/Diesel, 2011

Garfield County: \$110 million (\$50M foreign oil)

Mesa County: \$280 million (\$120M foreign oil)



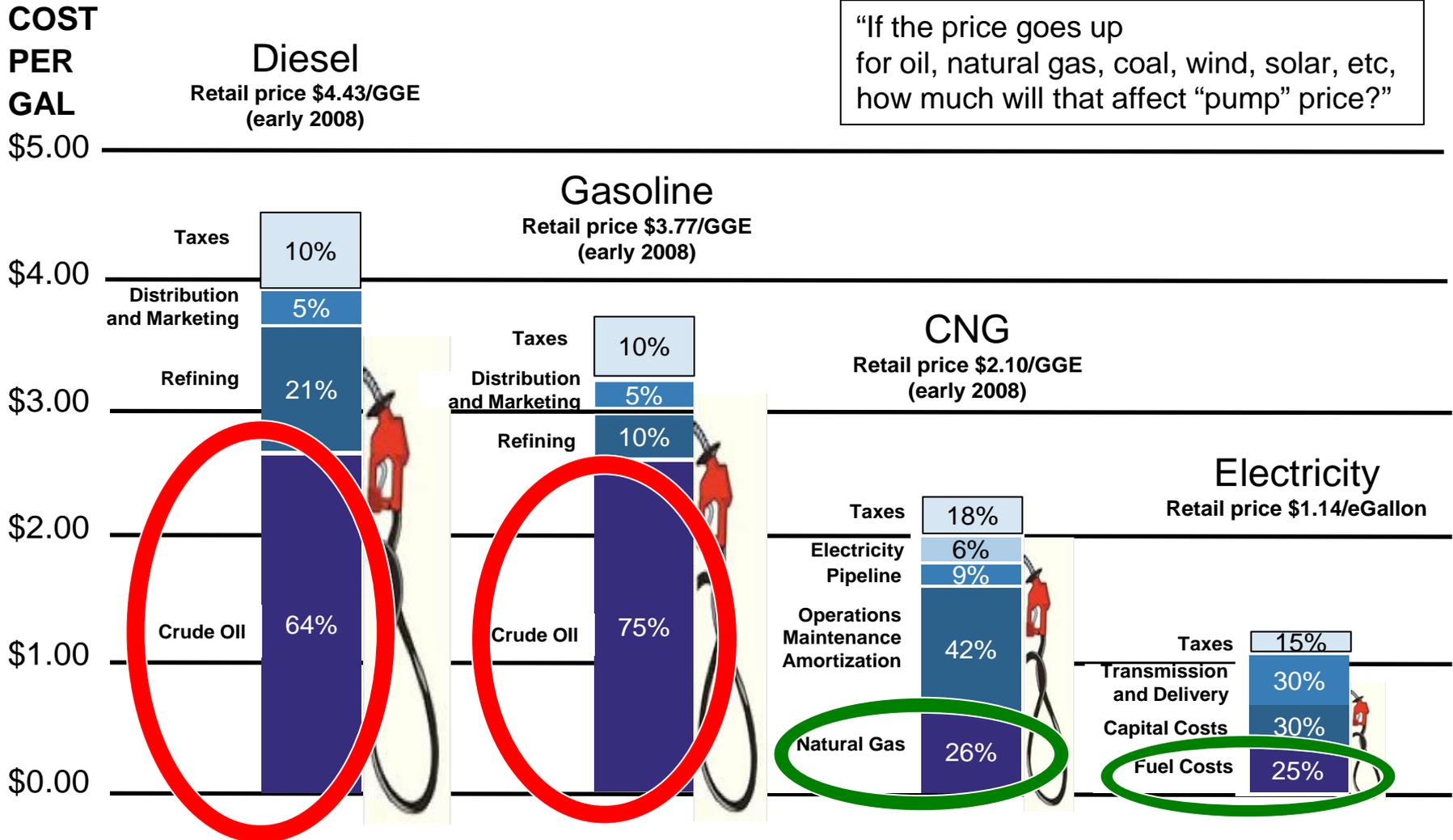
CNG and Electricity have advantages: Lower price, lower volatility, made in U.S.A.



Source: U.S. Energy Information Administration, with electric data added by Mike Ogburn.

“Pump price” of certain alternative fuels are less subject to changes in market prices for energy

“If the price goes up for oil, natural gas, coal, wind, solar, etc, how much will that affect “pump” price?”



Are CNG Vehicles Safe? Yes!

FMVSS regulations include strict alt-fuel requirements.

CNG tank testing for FMVSS 304 typically includes

- Pressure cycling test (13,000 cycles)
- Burst Pressure Testing (2.25x service pressure, ~8000 psi)
- Bonfire Testing (to ensure proper relief valve operation)



See a video of abuse tests at http://www.youtube.com/watch?v=_46pyBNNzFs
Or search for CNG Auto Sales - CNG Safety

Gasoline is dangerous – what about CNG?

Real-world proof of proper tank performance in a crash:

CNG Civic, rear end crash →
CNG Tank in trunk survived, no leakage
Driver walked away.



← **Strobe lights caused a wiring fire**
CNG Tank survived the resulting fire
No leakage, no rupture, no explosion.

CNG Vehicle hit by Gasoline Vehicle →
Gasoline vehicle exploded, burning both cars
CNG tank did not burst during the resulting fire
Safety relief valve vented all fuel, as designed.





Gov. Hickenlooper's CNG initiative with Detroit

Colorado, Oklahoma lead CNG state-level pledge

On Nov. 9, 2011, Gov. Hickenlooper signed an MOU with Oklahoma Gov. Mary Fallin pledging to use CNG vehicles in their states' fleets. Eleven other governors have also signed and committed to increased CNG vehicle usage. Several governors traveled to Detroit to deliver the MOU to the Big 3 automakers.



Memorandum of Understanding

This Memorandum of Understanding (MOU) describes a coordinated effort between the undersigned States (States) to attract automobile manufacturers in the U.S. to develop a functional and affordable original equipment manufacturer (OEM) fleet natural gas vehicle (NGV) that will also meet public demand. The States recognize the benefits and unique attributes of clean burning natural gas and understand the significant opportunity compressed natural gas (CNG) presents to save State and taxpayer dollars by encouraging an energy future that utilizes domestic energy resources to fuel our nation's transportation needs. Through the joint solicitation of a Multi-State Request for Proposal (Joint-RFP) that aggregates annual State fleet vehicle procurements, the States will endeavor to provide a demand base sufficient to support the design, manufacture, and sale of functional and affordable OEM NGVs by automotive manufacturers in the United States.

In anticipation of soliciting a Joint-RFP, the States will endeavor to coordinate with local agencies, municipalities, and companies to determine the number of NGVs each State can commit to purchase and the required specifications necessary to meet fleet needs. The Joint-RFP shall require that the ultimate cost of an OEM NGV should be comparably priced to an equivalent gasoline powered model and that warranty and reliability concerns are not compromised. Simultaneously, the States understand the need for continued development and expansion of CNG fueling infrastructure and should endeavor to encourage private investment, predicated on demonstrating an anticipated increase in State NGVs, to meet growing demand.

Pursuant to the terms of the Joint-RFP, to be executed at a later date, the States intend, where practical, to transition new fleet vehicle acquisitions, in committed volumes, to a resulting OEM NGV. Such future acquisitions should, when economically feasible, rely on traditional distribution channels that incorporate local businesses in procurement processes. In continued recognition of the benefits of CNG, the States should also endeavor to pursue fleet vehicle conversions to CNG, where economically compelling, based on a life-cycle cost analysis. The States will also reach out to fellow Governors to determine broader interest and participation in the principles and process outlined in this MOU.

This MOU embodies the principle understandings of the States but shall not create any legal relationship, rights, duties, or obligations binding or enforceable at law or in equity. Notwithstanding the foregoing, each State shall in good faith endeavor to reach a mutually agreeable and economically beneficial Joint-RFP, as contemplated herein. This MOU does not create additional state power, enhance existing state power, or interfere with federal authority or law. This MOU shall continue to demonstrate the States' understanding until rescission of the Joint-RFP, or until otherwise discontinued by either State.

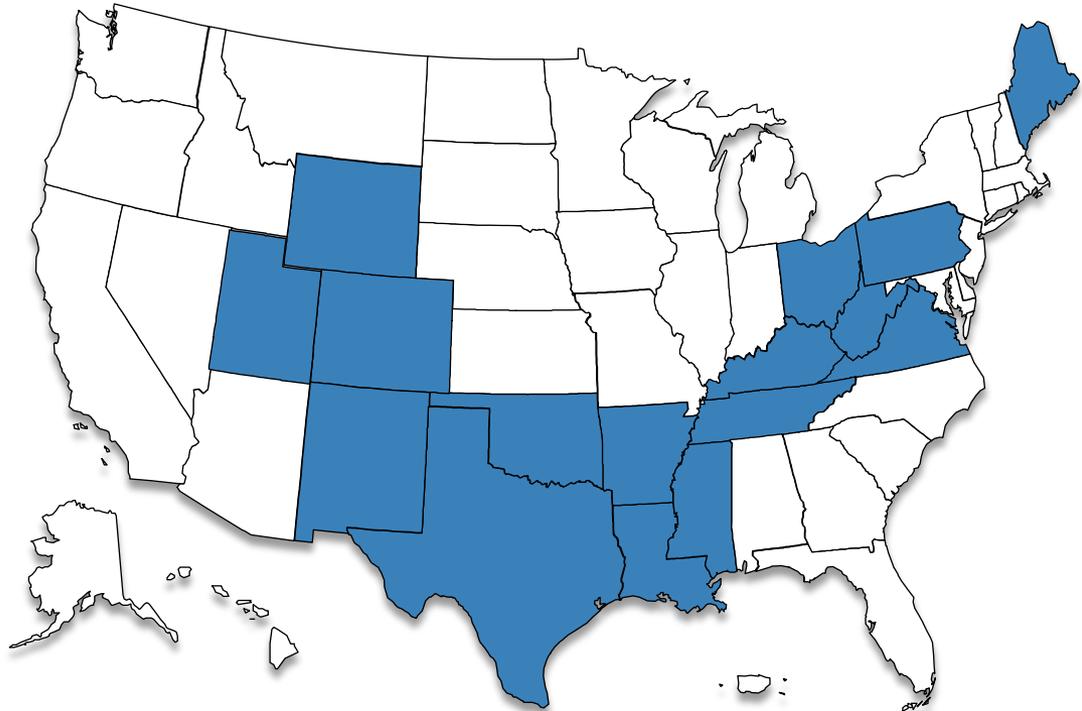
Set forth by:

State of Oklahoma


Mary Fallin, Governor

State of Colorado


John Hickenlooper, Governor



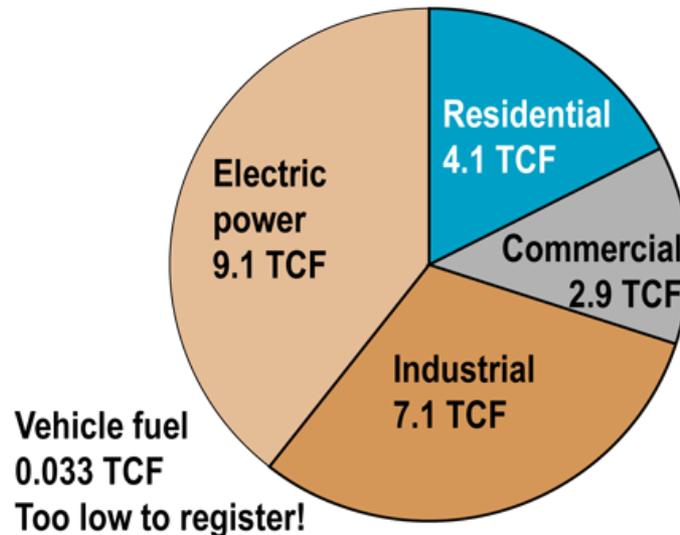
Will a switch to CNG increase demand for natural gas drilling and hydraulic fracturing?





Will a switch to CNG increase demand for natural gas drilling and hydraulic fracturing?

We'd need 88 times more CNG vehicles on the road just to match use by the commercial sector, or 275 times more vehicles to top use by the electric power sector.



2012 natural gas consumption:
23.4 trillion CF
Source: U.S. EIA

- RFTA RFP seeks to select suppliers that use drilling “best practices”
- BioGas fuel sources are being developed in Europe and the U.S.



Compressed Natural Gas

Heavy Duty horsepower, torque as good as diesel



Horsepower and torque match diesel specs

Zero torque loss up to 12,000 feet*

Zero horsepower loss until 8,700 feet*

(*Cummins ISL-G specs vary by HP rating)

Maintenance is different

Periodic tank inspection.

No diesel particulate filters or exhaust fluid.

Spark plugs may require changing at 45,000

miles, fuel filters require periodic draining.

New in 2013:

Cummins Westport ISX12-G

heavy truck engine

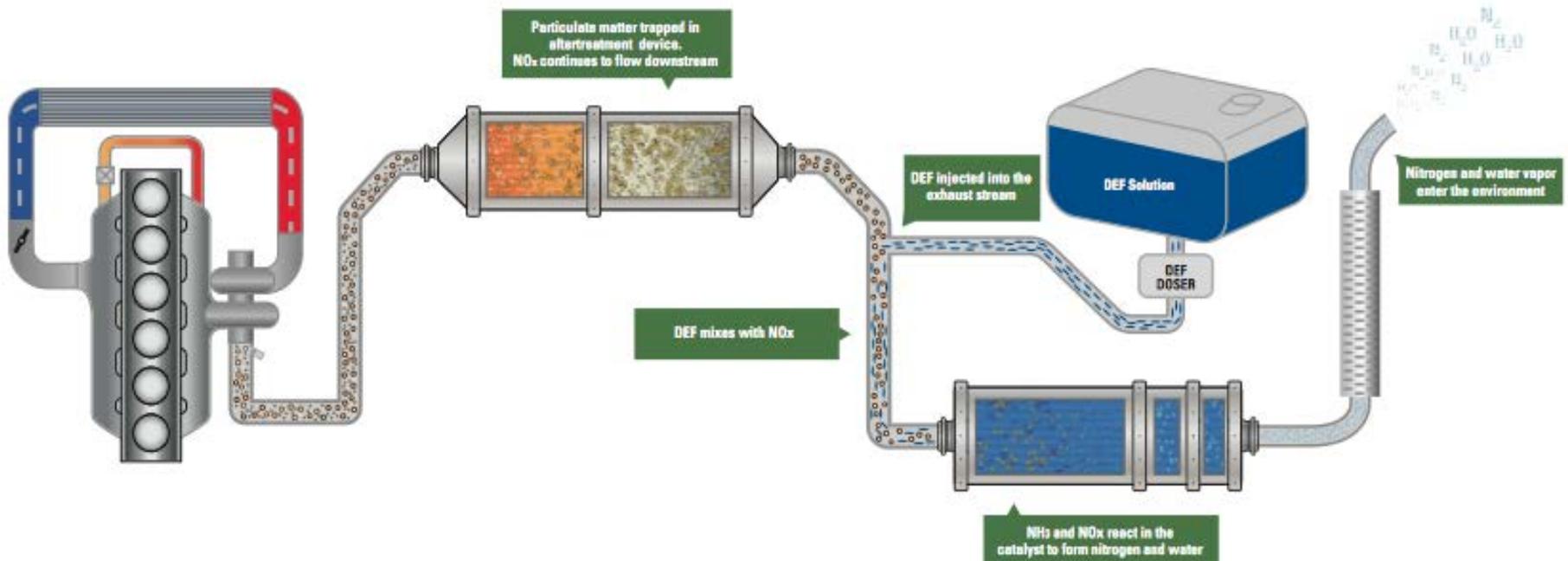
400HP - 1,450 lb-ft,

CNG or LNG natural gas



CNG is simple, while Diesels have complex systems to meet EPA 2010 emission standards

- Then: 1990's diesels had little or no exhaust aftertreatment
- Now: 2010 diesels have DPF filter + SCR catalyst





Compressed Natural Gas

Factory-equipped CNG vehicles are here



Dedicated-CNG light duty

Vehicle availability

Light duty car and van availability very limited.
No pickups are available as CNG-only

CNG-only

No gasoline backup. Range is typically about 40% less than gasoline vehicle.

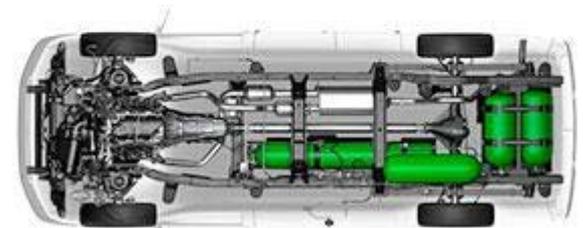
Cargo capacity may be less

Depends on placement of CNG tanks

- Honda tank fills 80% of trunk
- Optional GMC van tank is placed in cargo area

Horsepower nearly the same.

Maintenance is similar.



UFP Four-tank system

Compressed Natural Gas



Factory-equipped CNG vehicles are here



Bi-Fuel Gasoline-CNG vehicles

Vehicle availability

Pickups truck options are improving.

Varies by manufacturer.

Car & van options are limited: after-market only.



Horsepower nearly the same

Slight horsepower drop vs gasoline.

Typically less than 10% loss, only at peak power.

Maintenance is similar

Only the fuel system changes. Periodic tank inspection necessary. Cleaner burning fuel means cleaner oil, less wear



Reduced cargo capacity

Depends on placement of CNG tanks. CNG takes up to 4x more space per "gallon" stored.



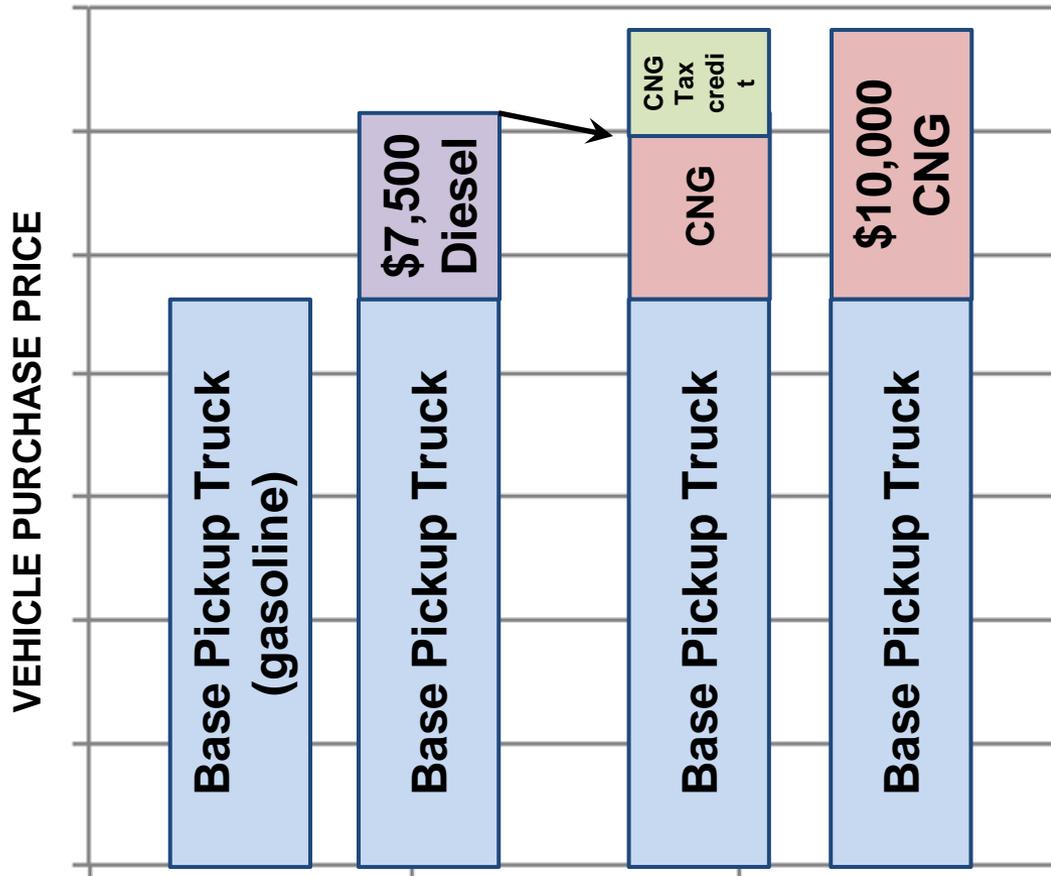


CNG Pickups – Return on Investment

CNG bi-fuel option cost is very competitive vs diesel engines



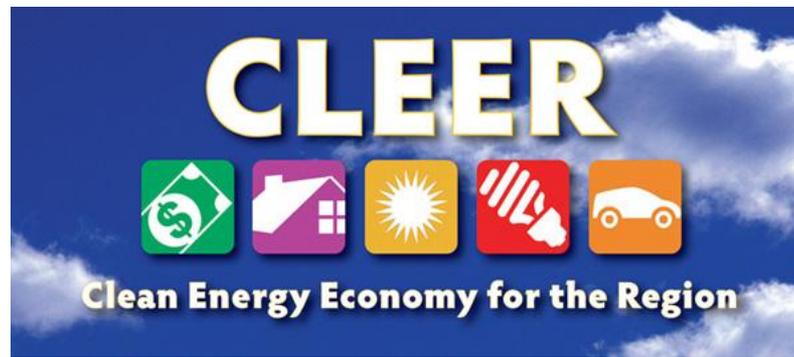
Tax credits make CNG vehicles **equal or less than diesel to buy**



Private Sector Companies:
CNG vehicle cost...
vs Diesel: NO INCREASED COST!
Ongoing savings \$400-\$600 per yr
vs gasoline: payback at 50k-70k mi
Ongoing savings \$900-\$1300 per yr

Tax Free Organizations:
CNG vehicle cost...
vs Diesel: payback at 40k-70k mi
Ongoing savings \$400-\$600 per yr
vs gasoline: payback at 80k-105k mi
Ongoing savings \$900-\$1300 per yr

CO State Tax Credit is 35% on CNG option in tax year 2013 up to \$6,000, 25% credit in 2014-2018
Note: miles-to-payback and savings calculations are based on Mesa/Garfield fuel prices as of August 2013.



Sign up with Refuel Colorado

Contact CLEER for
a *free* fleet payback analysis



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Rifle Shell















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BACKUP SLIDES

Facility considerations for gaseous fuels

Building upgrades may be required

- CNG is lighter than air. LNG can puddle, then evaporate. Ventilation required. NFPA 52 governs natural gas vehicles in buildings.
- Propane is heavier than air. Ventilation and attention to drains is required. NFPA 58 governs propane vehicles in buildings.
- The fleet maintenance building should be evaluated by an engineering firm. Costs could be low, or high... it depends!



Ventilation: Five air changes per hour

Methane or hydrocarbon sensors:

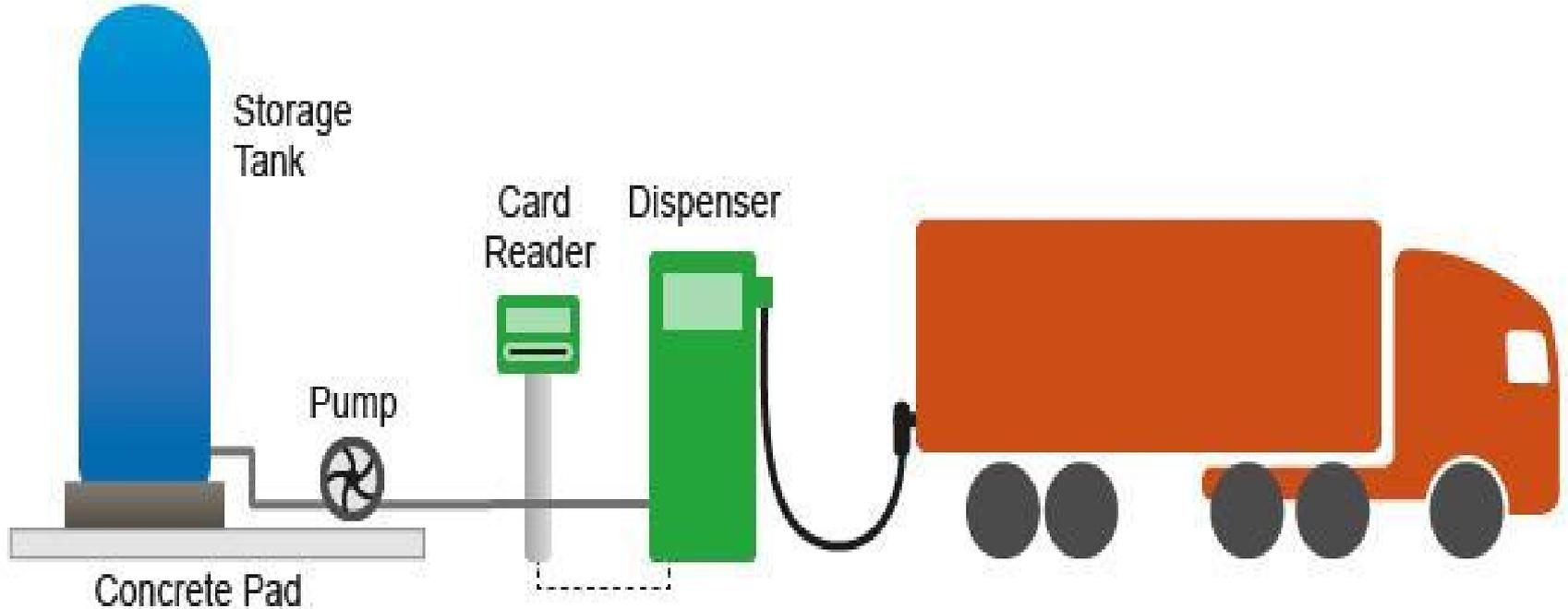
If CNG or propane are detected, ventilation increases or garage doors open

Electrical systems: Special conduit, lighting and motors may be required near ceiling, or near floors.

Heating systems: No open flames. Closed combustion only.

Fueling facilities

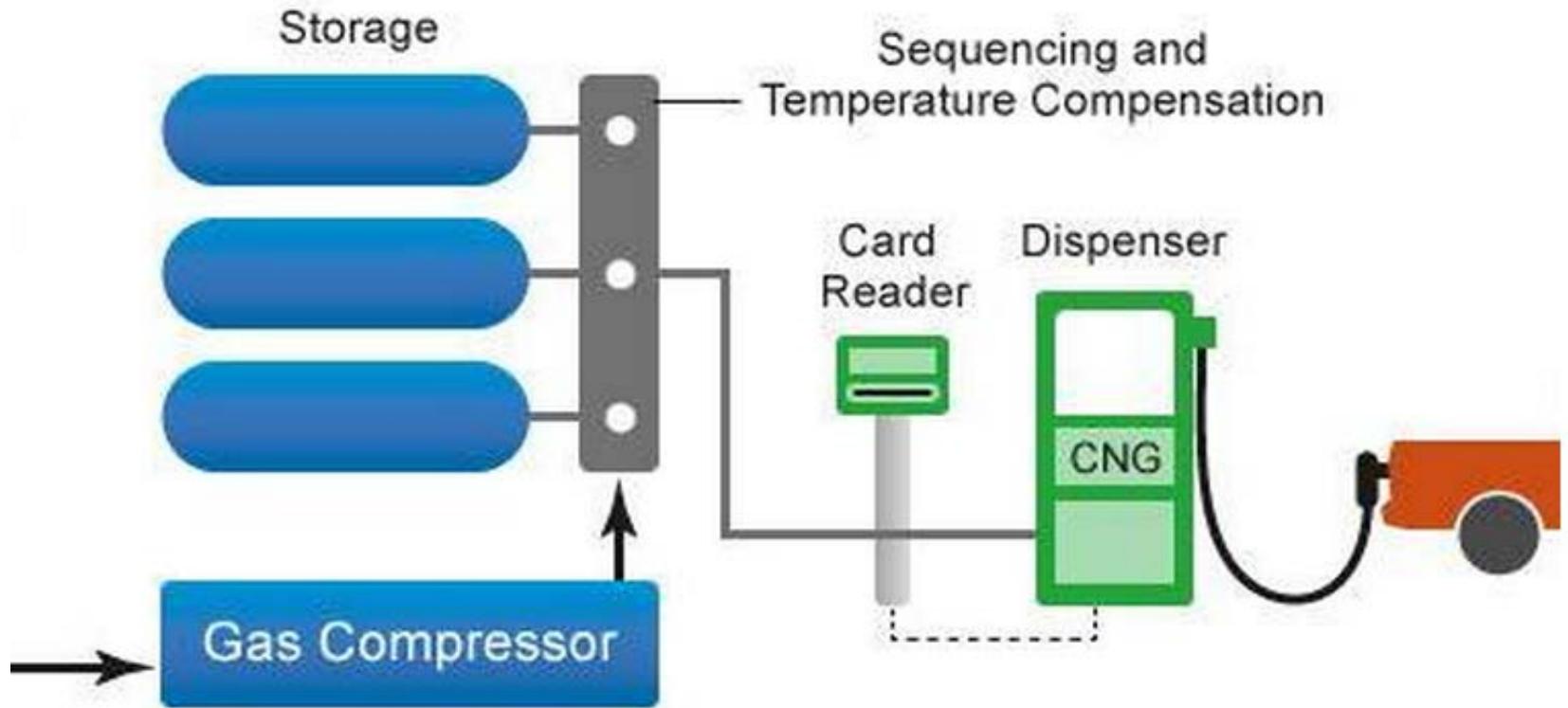
LNG station: heavy duty vehicles only
Low pressure, but very cold: -260 degrees F



Fueling facilities

Fast Fill CNG station

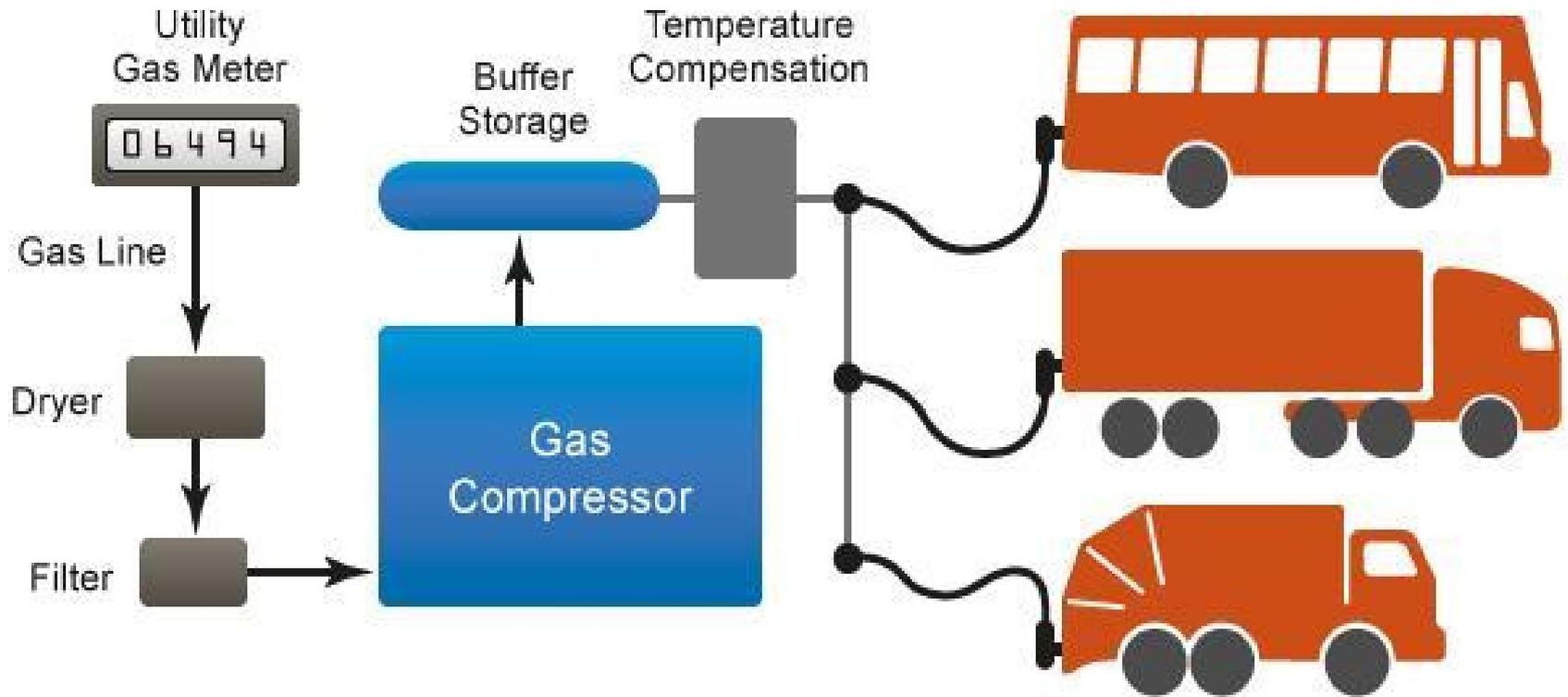
24/7 credit card station is preferred



Fueling facilities

Time Fill CNG Station

Typically not available to the public



Fueling facilities

CNG home fueling, time fill

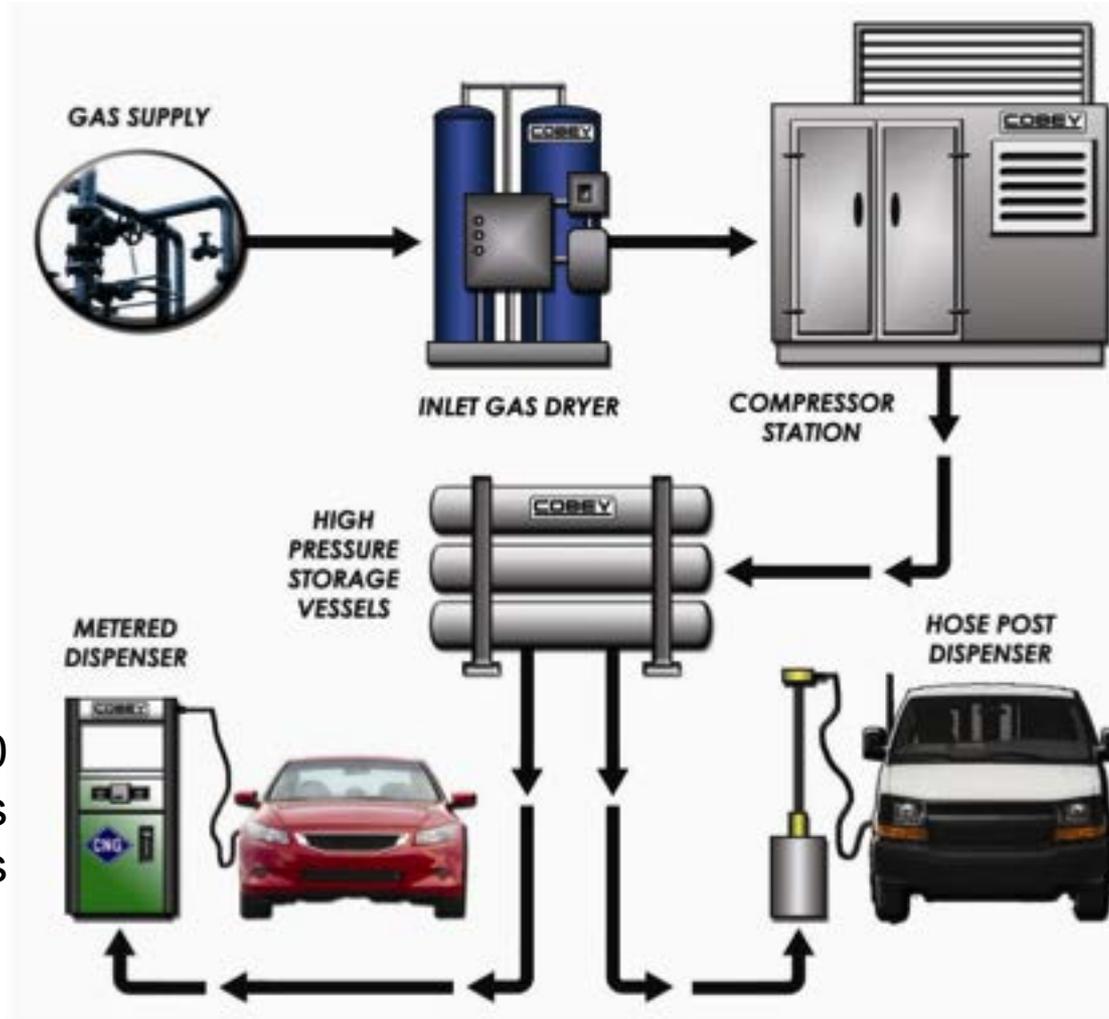
Costly at present; new appliances being designed



Fueling facilities

Fast + Time-Fill CNG Station

City of Grand Junction does this. Fast fill open to the public 24/7.



Fills in 10 minutes or less

Fills overnight



Fueling facilities

CNG station cost examples

(Pricing that follows is for discussion only.)

Fueling system prices vary:

- Specifics of a fueling site greatly affect pricing.
- Pressure available from the gas utility greatly affects compressor capacity and fill speed.
- Demand pricing of the electric utility affects operational cost. Lots of electricity is used to compress natural gas from the feeder pipe into CNG storage tanks and vehicles.

Fueling facilities

Fuel Maker FMQ: Overnight CNG fill



1 or 2 hoses

0.5 to 4.0 gallons per hour

10-hour filling period = 5 to 40 GGE of CNG

Price varies by fill rate, **\$10,000 to \$40,000**

(gas dryer not included)



Fueling facilities

Time-Fill CNG

Cost

\$5,000 per single-hose post

\$1,000 for second hose on post

Plus

\$300,000 compressor
for 20 gal/hr.

10-hour filling period
= 200 GGE of CNG

\$650,000 compressor
for 100 gal/hr.

10-hour filling period
= 1,000 GGE of CNG





Fueling facilities

Fast-Fill CNG costs

Station price varies. One example: \$1,150,000

Storage vessels (+ hydraulic intensifier) give very fast first-fills

10 hour period = 1,900 GGE of CNG



Large vehicle example:

60 gallons in 6.5 minutes

Second 60 gal in 8.5 minutes

Five 60-gallon fills per hour

Pickup example:

20 gallons in 2.5 minutes

Second 20 gal in 2.5 minutes

Fourteen 20-gallon fills / hour

(Reality will probably be a blend of these two examples)

Fueling facilities

RFTA CNG “Direct Fill” for 22 buses



- Minimal storage with 3 large compressors: \$2.5 million
 - Can fill a 150-gallon bus tank in about 15 minutes.
- Unique large-fleet solution. Not ordinarily required.



Which CNG fueling scenario seems better?

Option 1: Buy a small time-fill system, **\$40,000**

- Becomes obsolete as your fleet grows, or if fast-fill becomes available
- Lets a fleet try CNG by themselves, but investment value may be lost.

Option 2: Buy a time fill system, locate it behind locked gates

- Three fleets buy separate 10-vehicle time-fill stations for **\$350,000** each.
- Combined, they can fill **600 gallons in 10 hours** overnight.
- Closed to the public.

Option 3: 3 fleets pool funds to buy a **\$1.1 million** fast-fill

- Central location can fill **1,900 gallons in 10 hours**.
- **Spare capacity is available to the public.**
- Offer 24/7 credit card access.



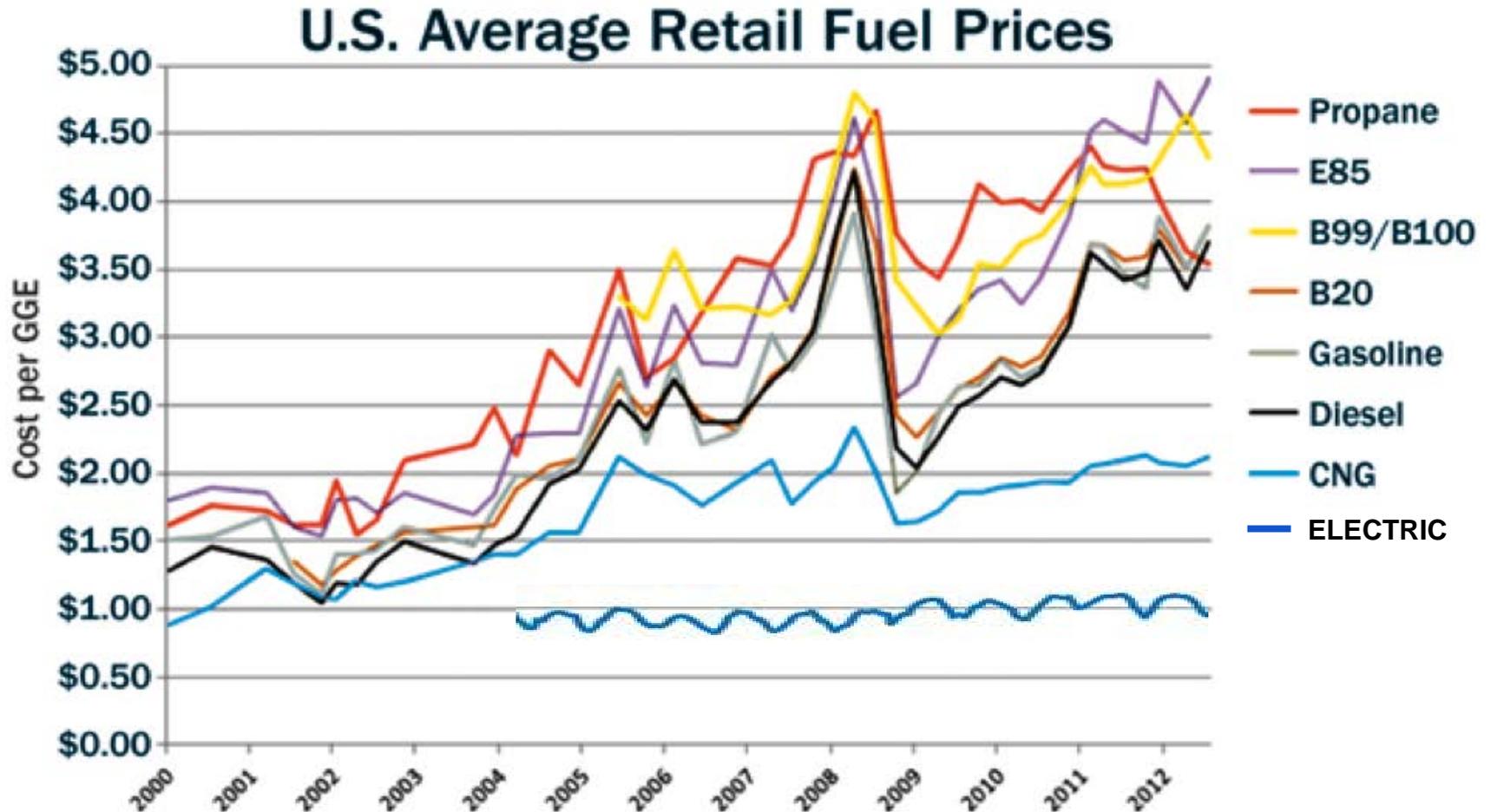
Part 1. Vehicles and Fuels

Alt-Fuels Overview

Cost comparisons



CNG and electricity have advantages: Lower price, lower volatility



Source: U.S. Energy Information Administration, with electric data added by Mike Ogburn.



National Average Price Between September 28 and October 12, 2012

Fuel	Price
Biodiesel (B20)	\$4.18/gallon
Biodiesel (B99-B100)	\$4.39/gallon
Electricity	\$0.11/kWh* \$1.14/eGallon**
Ethanol (E85)	\$3.47/gallon
Natural Gas (CNG)	\$2.12/GGE
Propane	\$2.56/gallon
Gasoline	\$3.82/gallon
Diesel	\$4.13/gallon

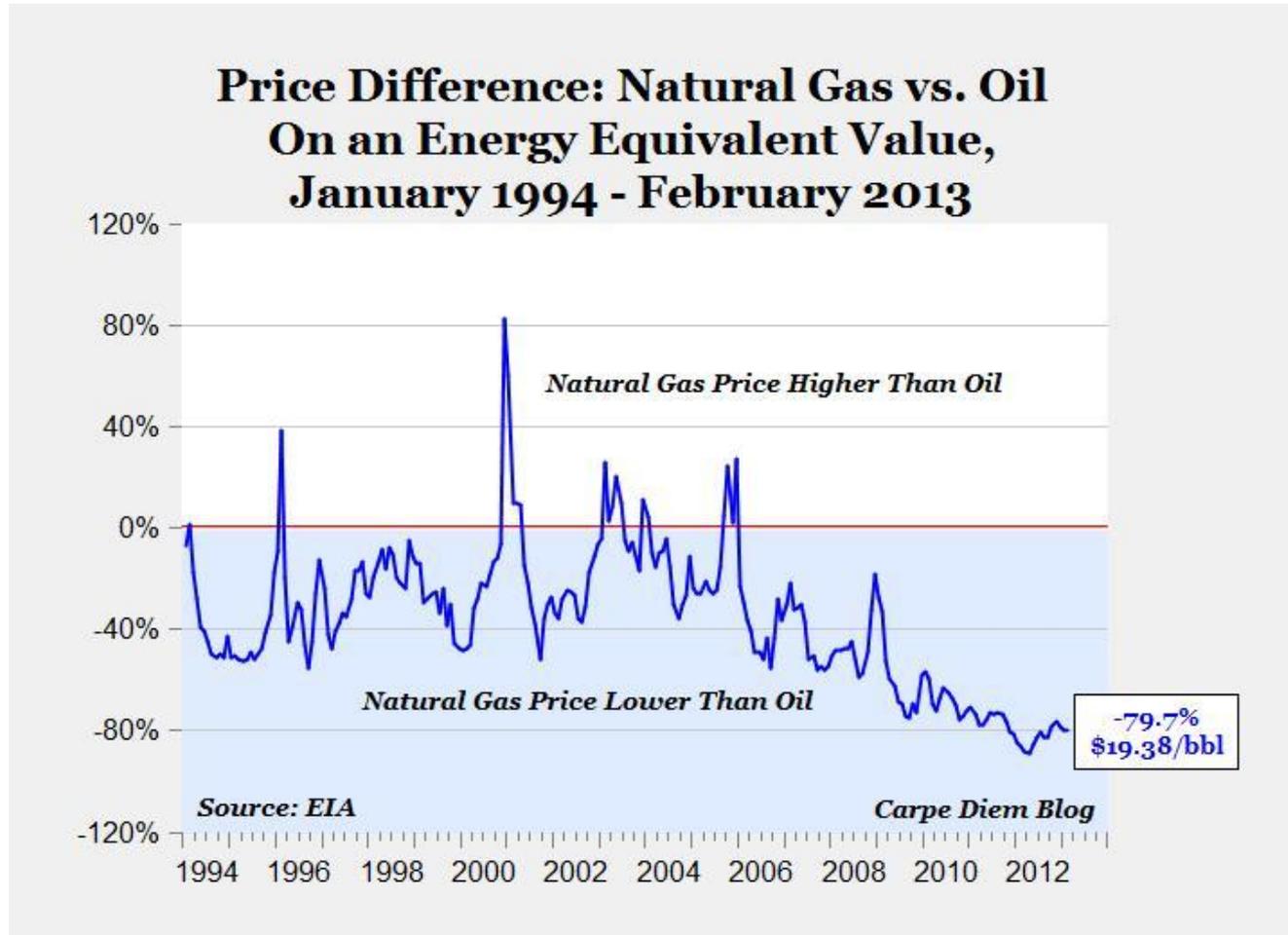
Source: Fuel price form Alternative Fuel Price Report 2012 (PDF) <http://www.afdc.energy.gov/fuels/prices.html>, via Ford Motor Company

* Average price per kilowatt hour in 2012 from U.S. EIA.

** eGallon is a concept that conveys a price for a "GGE" equivalent for electricity that is more recognizable than kWh
<http://energy.gov/articles/egallon-how-much-cheaper-it-drive-electricity>



Natural gas costs 80% less per unit of energy than crude oil

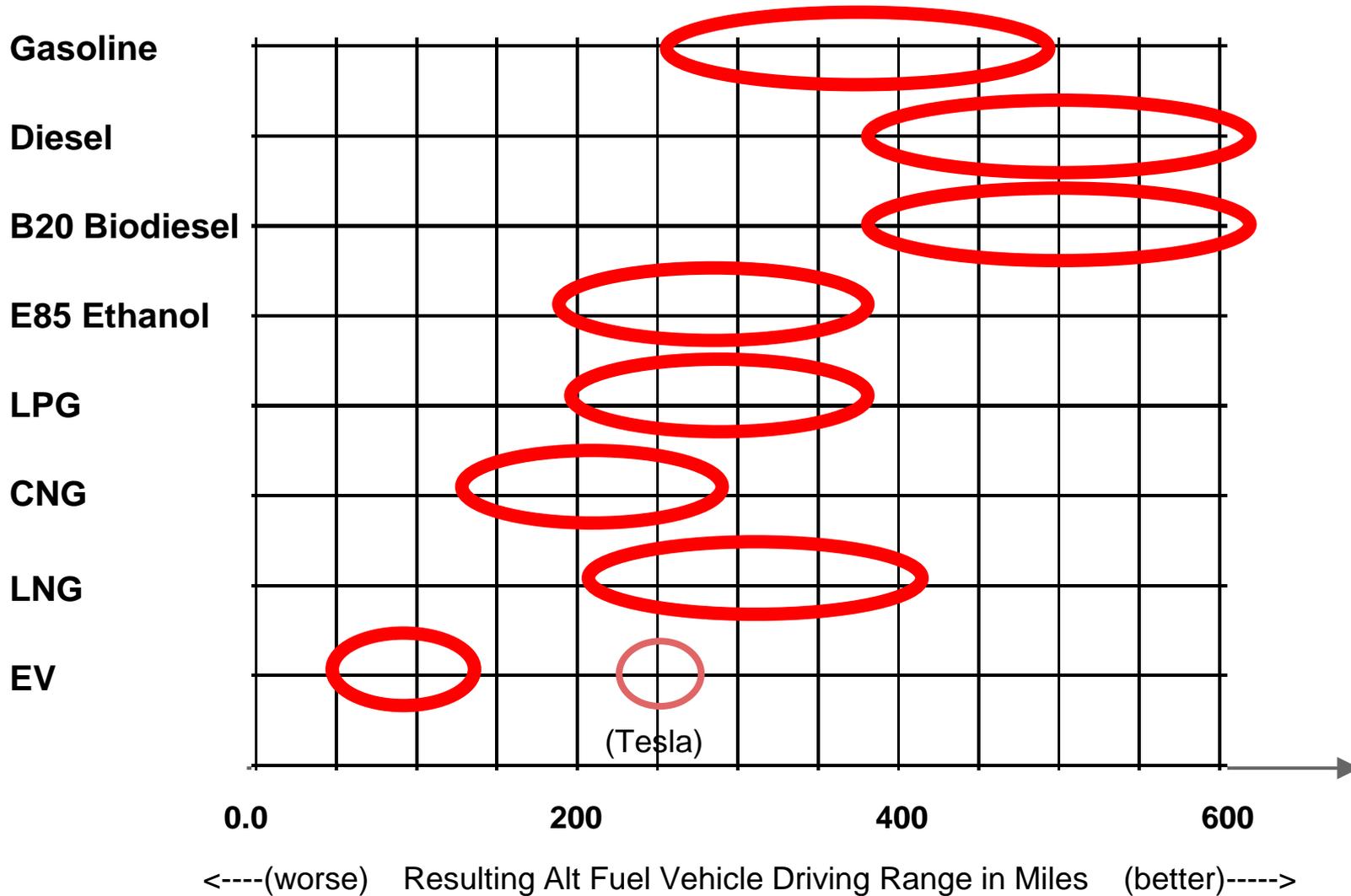


<http://www.aei-ideas.org/2013/03/natural-gas-is-80-cheaper-than-oil-on-an-energy-equivalent-basis-and-can-save-commercial-truck-fleets-a-bundle/>



What fleet owners and managers want to know: Driving range of Alt Fuel Vehicles.

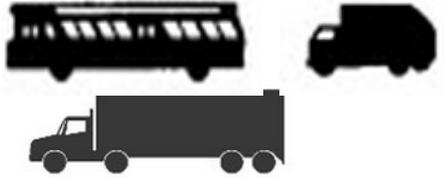
Given the amount of energy I was able to fit on my vehicle, how far can I go?



Alt Fuels most likely to succeed in each vehicle class:

Based on a combination of vehicle availability, energy density, efficiency, cost savings

Note: this is a subjective analysis meant to simplify a complex market. Fleet needs may vary.

<p>Class 1- 0 to 6,000 pounds</p> 	<p>Plug-in Hybrid or Electric Passenger Vehicles</p>	<p>-Gallons per year are low, so savings is low for CNG, LPG, etc. -Many plug-in options in this class</p>
<p>Class 2- 6,001 to 10,000 pounds Class 3- 10,001 to 14,000 pounds</p> 	<p>CNG or LPG, bi-fuel Pickup trucks & work vans</p>	<p>-no plug-in options in this class -bi-fuel CNG or LPG options available -good payback if annual VMT is high</p>
<p>Class 4- 14,001 to 16,000 pounds Class 5- 16,001 to 19,500 pounds Class 6- 19,501 to 26,000 pounds</p> 	<p>CNG or LPG Medium duty trucks School and shuttle buses</p> <p>Electric Medium duty truck/van</p>	<p>-good payback if annual VMT is high -vehicle can be designed for tanks -CNG or LPG medium duty engines exist</p> <p>-Good if fleet VMT matches driving range -Low fuel/maint costs; fast charging options</p>
<p>Class 7- 26,001 to 33,000 pounds</p> 	<p>CNG Short haul trucks, Refuse trucks, Transit buses</p>	<p>-Natural gas heavy duty engines exist -Good payback if annual VMT is high -Vehicle design can fit CNG tanks</p>
<p>Class 8- >33,000 pounds</p> 	<p>LNG Long-haul trucks</p>	<p>-Fuel usage too high for CNG -Natural gas heavy duty engines exist -LNG required due to high fuel usage</p>