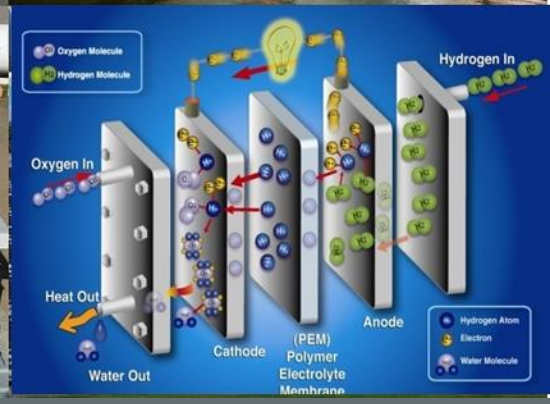
Natural Gas Opportunities and Applications for Sustainable Transportation

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







Alternative Natural Gas Applications Workshop

Alexandria, VA

October 8, 2014

Reuben Sarkar

U.S. Department of Energy

Deputy Assistant Secretary

Sustainable Transportation

EERE Areas of Focus

Sustainable
TRANSPORTATION

Renewable
ELECTRICITY GENERATION

Energy Saving
HOMES, BUILDINGS, & MANUFACTURING

“All of the Above” for Sustainable Transportation

Sustainable TRANSPORTATION

- Improving Efficiency
- Diversifying Fuel Sources
- Domestic & Renewable

Hydrogen and Fuel Cells

Vehicles

Bioenergy

National Energy Goals & Climate Action Plan

50% oil imports

17% GHG emissions

by 2020

Natural Gas for Sustainable Transportation

- Current Status
- Opportunities
- Challenges
- Accomplishments
- Conclusion

Natural Gas is an Abundant Domestic Source

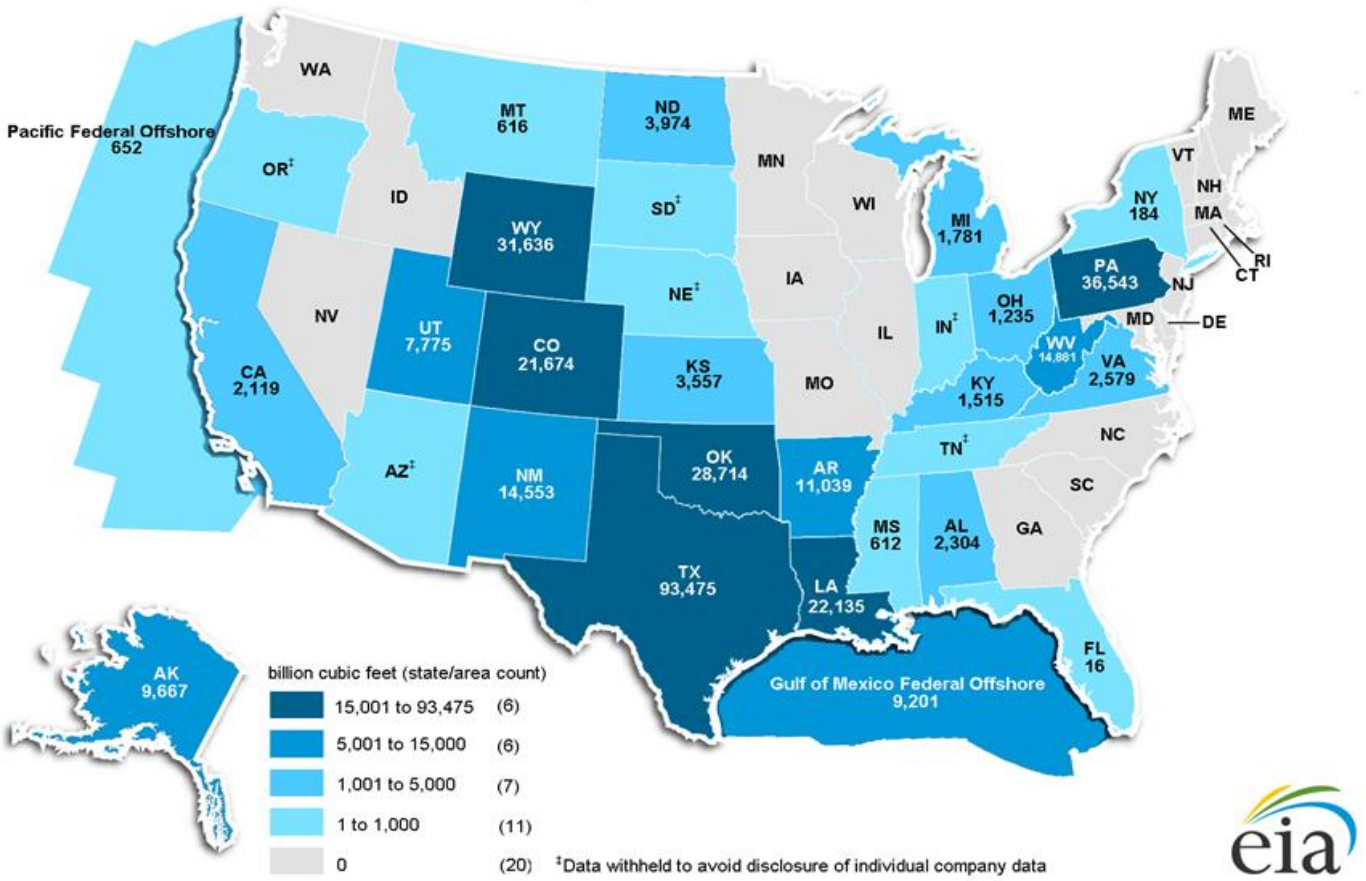
452

TCF (trillion cubic feet) proven NG reserves*

~2,700

trillion ft³ of total technical and economic potential

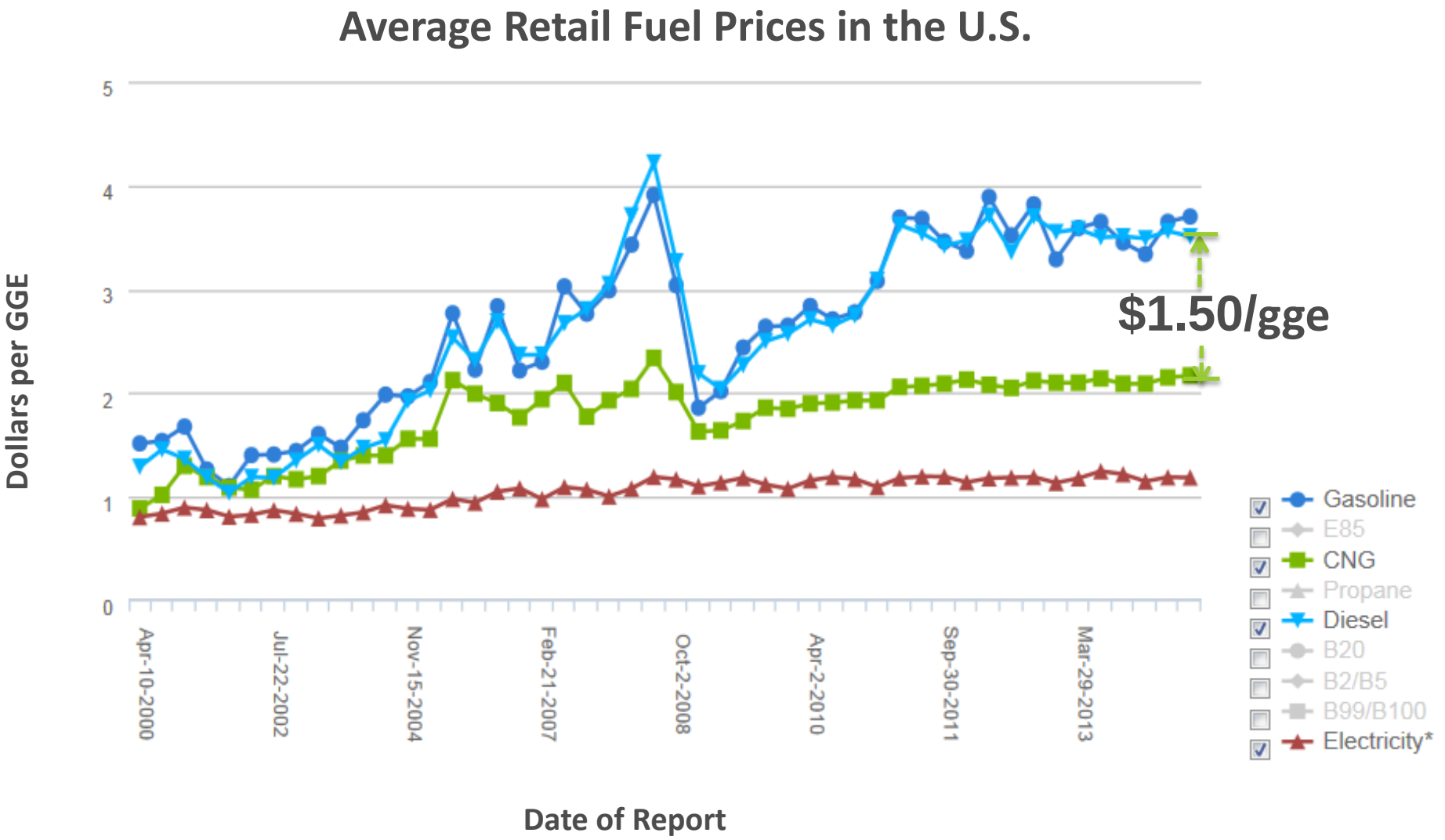
Proved Natural Gas (NG) Reserves by State*



U.S. EIA, Annual Survey of Domestic Oil and Gas Reserves. Released on April 2014.

*323 TCF for wet NG and 129 TCF for shale NG

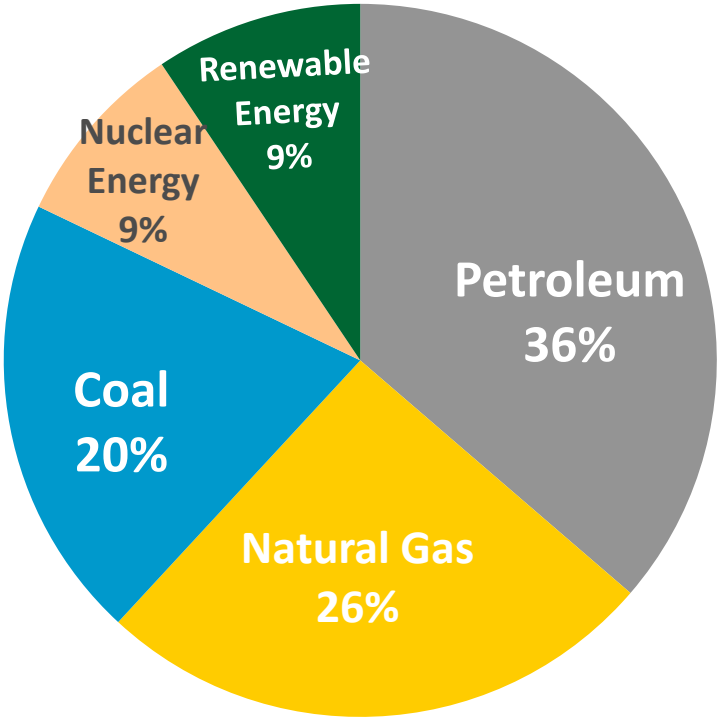
….with a price advantage over gasoline…

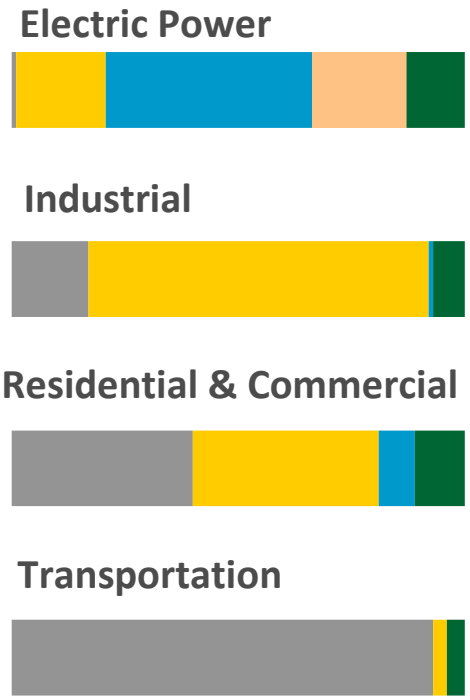


Source: Clean Cities Alternative Fuel Price Reports http://www.afdc.energy.gov/fuels/prices.html

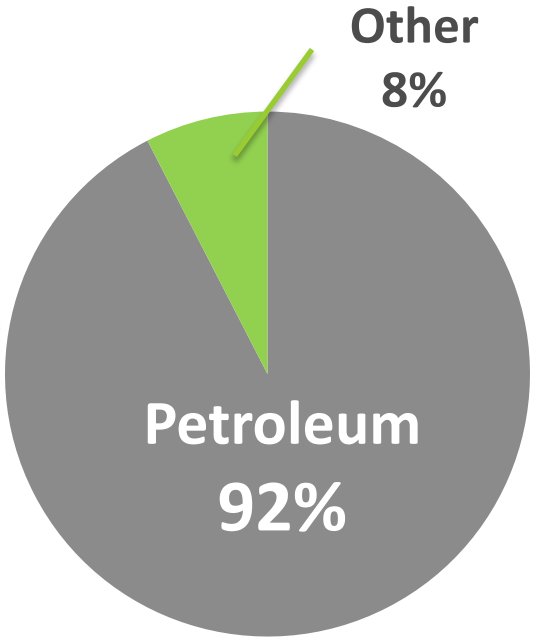
…and with an untapped potential for the transportation sector

U.S. Energy Consumption by Sector





3% of total energy consumed in the transportation sector is **natural gas****



Total U.S. Energy Consumption = 97 Quadrillion Btu/year*

*Energy Information Administration, Annual Energy Review 2011, Table 1.3

**U.S. EIA 2013 Annual Energy Review http://www.eia.gov/totalenergy/data/annual/#consumption

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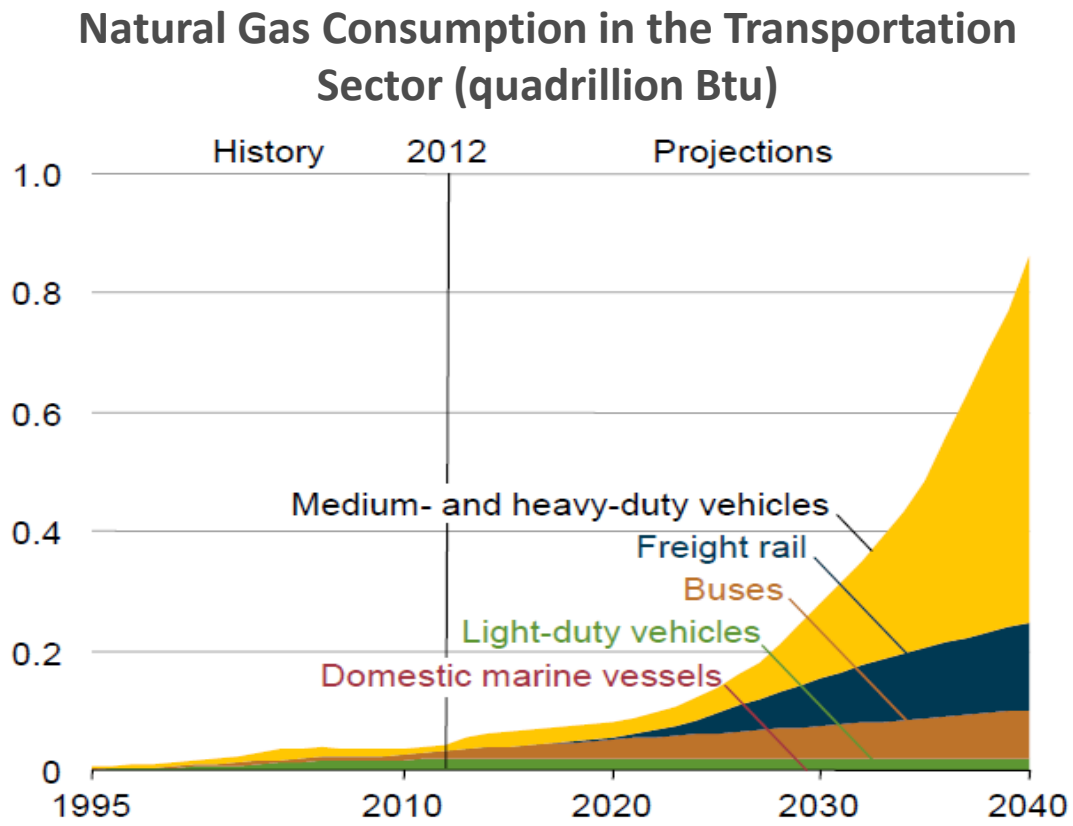
Expected Growth and Opportunities in Heavy Duty Segment

Transportation – Fastest Growing Sector for NG Consumption

From 40 Bcf in 2012 to 850 Bcf in 2040

Heavy duty trucks - fastest growing segment



Source: EIA, Annual Energy Outlook 2014

Possible Pathways for Natural Gas Use in Transportation

1. Direct Fuel

Compressed and Liquefied Natural Gas

Fuels

Trucks

Buses

Natural Gas Light Duty Vehicles (NGV)

2. Source to produce alternative fuels

NG — Produces → Electricity — Fuels → BEV

NG — Produces → H_2 — Fuels → H_2 FCV

NG — Produces → Liquid Fuels — Fuels → ICE

Reduced GHG Emissions from Vehicle Portfolio Using NG

NGV

Can result in

~10% ↓

in GHG emissions*

H_2 FCV

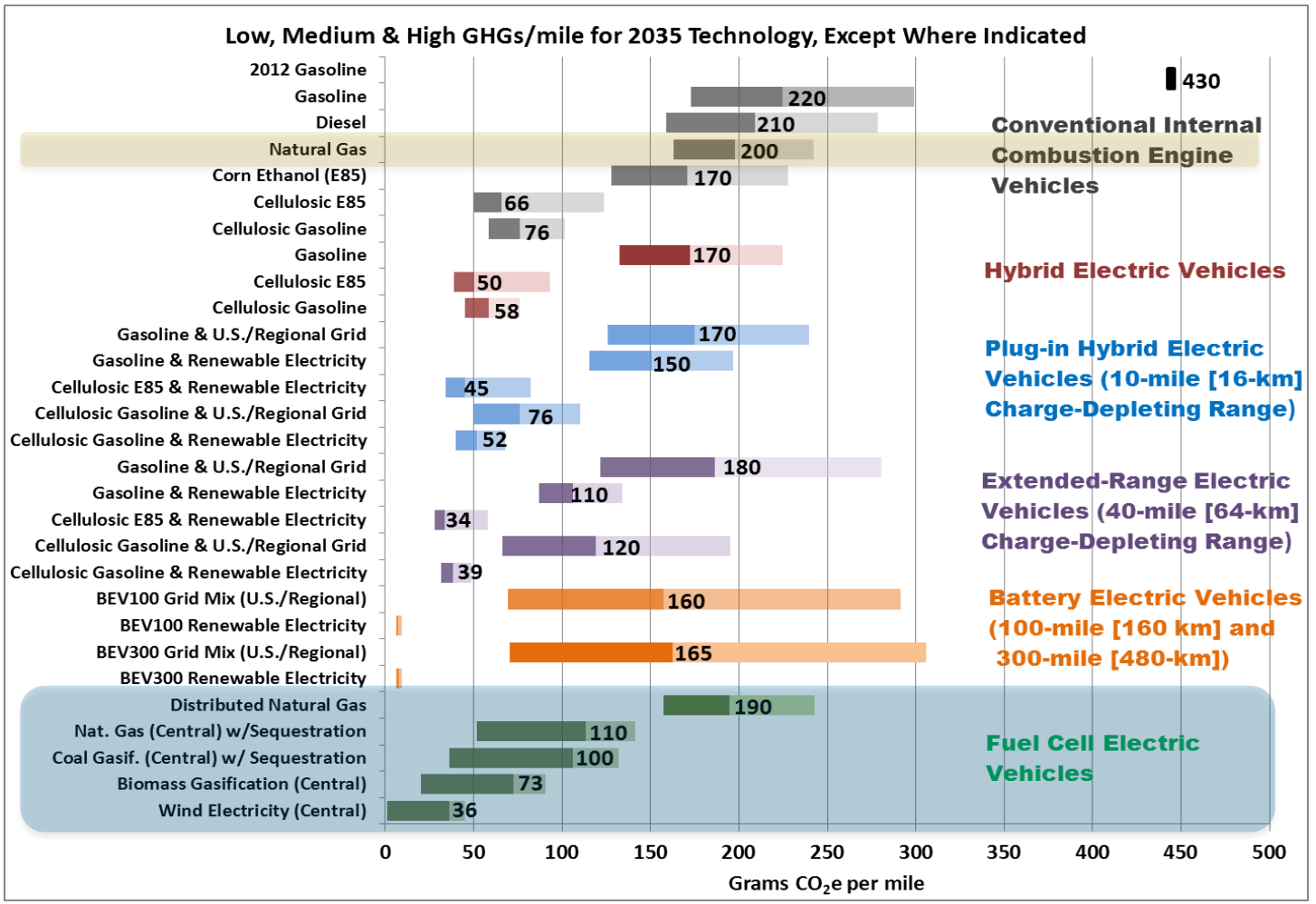
With distributed NG is the source of H_2 can result in

>50% ↓

in GHG emissions**

Well-to-Wheels Greenhouse Gases Emissions for 2035 Mid-Size Car

(Grams of CO2-equivalent per mile)



Low/medium/high: sensitivity to uncertainties associated with projected fuel economy of vehicles and selected attributes of fuels pathways, e.g., electricity credit for biofuels, electric generation mix, etc.

Source: http://hydrogen.energy.gov/pdfs/13005_well_to_wheels_ghg_oil_ldvs.pdf

* Compared to 2035 gasoline ICE with NG R&D
** Compared to 2012 gasoline ICE

Largest AFV petroleum reductions come from CNG Vehicles

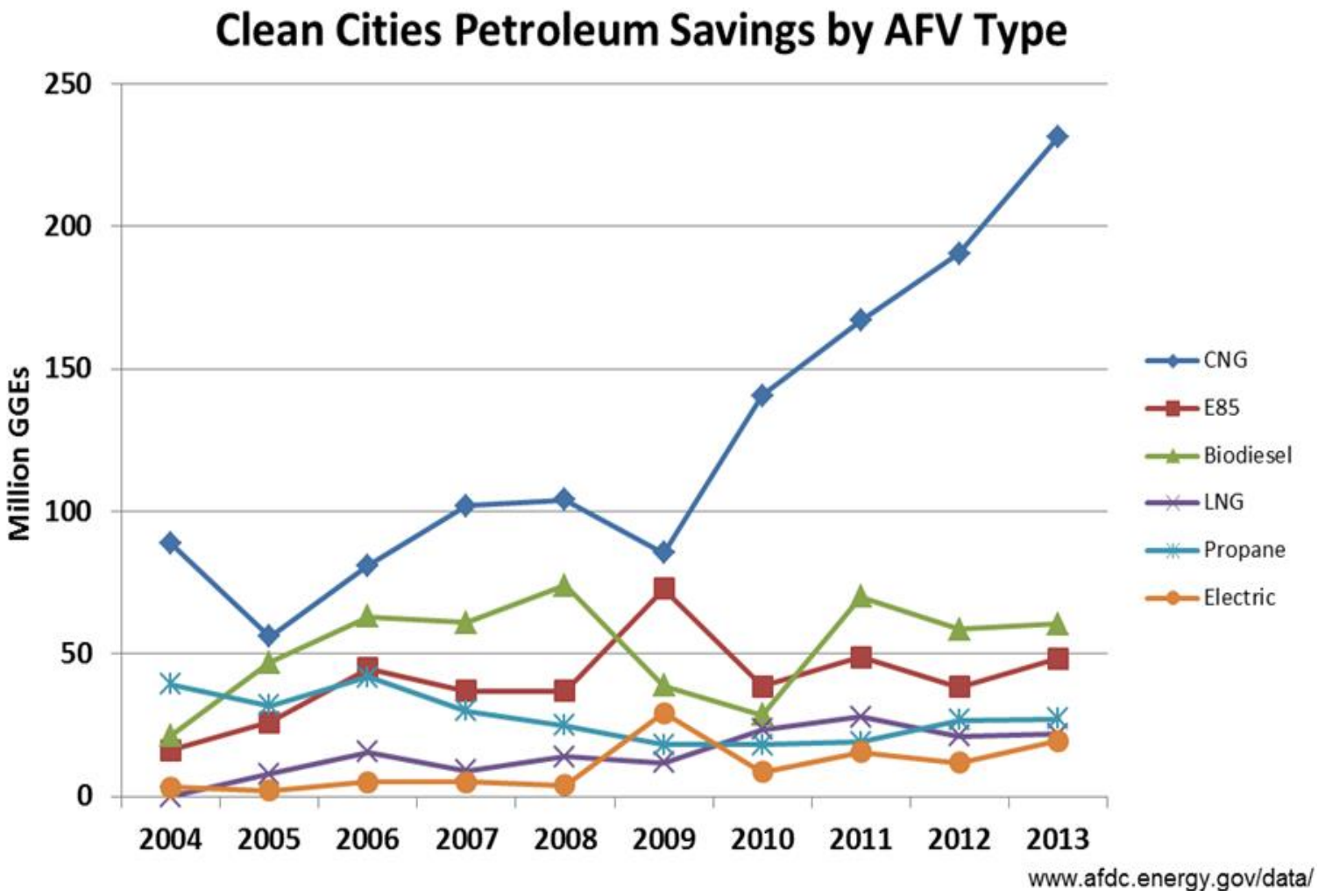
Clean Cities
U. S. Department of Energy

>50%

petroleum reductions coming from NGVs

~230M

GGE saved with NGVs



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Infrastructure

~750 CNG and **~65** LNG public stations for

~10 public H_2 stations for

VS.

150,000 Gasoline stations

http://www.afdc.energy.gov/fuels/natural_gas_locations.html
http://maps.nrel.gov/transatlas

On-Board Storage

Natural Gas and Gasoline Vehicle Performance Comparison

2014 Honda Civic	Natural Gas	Gasoline
Fuel Capacity (gge)	8.03	13.2
Volume of tank (gal)	~30	~13.2
EPA rated range (miles)	250	410
MSRP	$26,640	$18,390

Price Difference: ~$8,000

- Space
- Driving Range
- Cost

Honda Civic – Natural Gas

Adapted from NPC Future Transportation Fuel Study, NG Subcommittee, 2012

Engine Efficiency of Natural Gas ICEs

- Efficiency penalty of **20%** compared to diesel engines
- Efficiency improvements should focus on lean combustion
  - **Ignition Technologies**
  - **Fuel Injection Technologies**
- Near-term target is less than **5%** efficiency penalty compared to diesel engines
  - Longer-term is parity

*Overall Efficiency value in the long term

Source: Memorandum for the Secretary, EERE Planned activities in NG as a transportation fuel in FY16

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Clean Cities Awards are Enabling NGVs Deployments

- **$300M Clean Cities ARRA Awards**
  - **20 awards**
  - **36 states**
  - Enabled deployment of **>150** CNG and LNG stations

> 3,600 

- **$11M Clean Cities Alternative Fuel Implementation Awards**
  - **20 awards**
  - **30 states + DC**
  - Helped communities establish action plans, implement sustainable policies, address barriers, and develop incentives

- **$4.5M Current FOA for Alternative Fuel Vehicles**
  - Demonstration and Enhanced Driver Experience Projects
  - Training for First Responders, Public Safety Officials, and Critical Service Providers
  - Emergency Response and Preparedness Operations

ARPA-E Projects in NG are Helping Address Unique Challenges

CHANGING WHAT'S POSSIBLE

MOVE Program

Methane Opportunities for Vehicular Energy

The **Advanced Research Projects Agency-Energy (ARPA-E)** advances high-potential, high-impact energy technologies that are too early for private-sector investment.

ARPA-E's MOVE Program is aimed to find cost effective ways to power light duty vehicles with America's abundant natural gas resources.

Objectives

- **Reduced payback for**
- **Conformable tanks with energy density- CNG**
- **Convenient, low-cost at-home refueling**

Source: MOVE Program Objectives

Vehicle Technology Forums & User Groups for NGVs

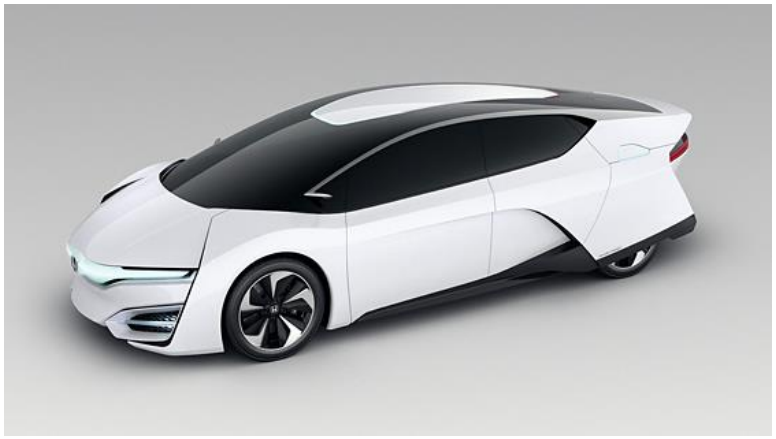
- **Natural Gas Transit and School Bus Users Group**
  - Transit agencies, school bus fleets, and government agencies come together to receive technical assistance and share information about using natural gas

- **Natural Gas Vehicle Technology Forum**
  - Supports development and deployment of commercially competitive natural gas engines, vehicles, and infrastructure.
  - Stakeholders include equipment manufacturers, national laboratories, government agencies, vehicle fleets, and industry groups.

NGVTF
Natural Gas Vehicle Technology Forum

Fuel Cell Cars are Here

FCEVs on display at North American auto shows.



Honda Fuel Cell Electric Vehicle

Toyota Fuel Cell Electric Vehicle

Hyundai's first mass-produced Tucson Fuel Cell SUVs arrive in Southern California
May 20, 2014

Lease includes H_2 and **maintenance**.

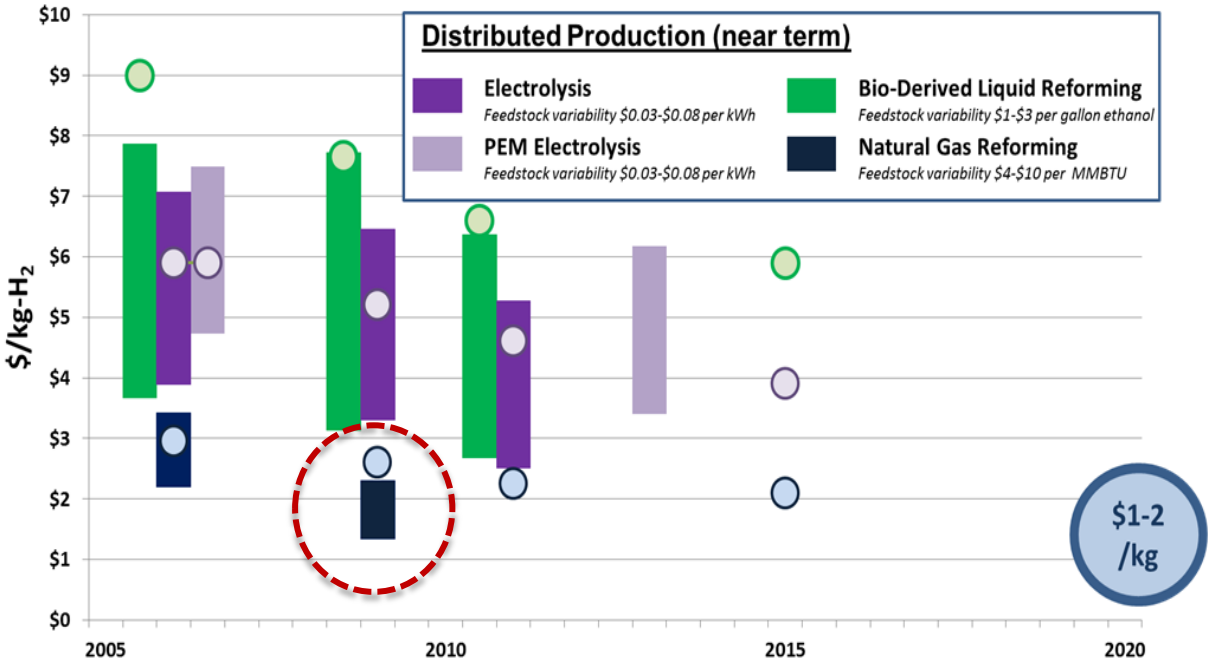
H_2 from NG can be Competitive with Gasoline

H_2 from NG using Steam Methane Reforming (SMR)

1. Can make H_2 competitive with **gasoline** at high volumes

2. Must be produced at **< $4/gge** by 2020*

Cost of H_2 from Distributed Production by Selected Technologies



Source: Program Record #10001, www.hydrogen.energy.gov/program_records.html.

*Including delivery and dispensing at the pump

Public-Private Partnership to Overcome H_2 Infrastructure Challenges

H_2USA

Mission: To promote the commercial introduction and widespread adoption of FCEVs across America through creation of a public-private partnership to overcome the hurdle of establishing hydrogen infrastructure.

Fuel Cell &
Hydrogen Energy
Association

Mercedes-Benz

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Conclusion

- **Abundant domestic NG resources** present an opportunity to reduce our dependence on foreign oil for transportation sector.
- **NG could be a potential bridge** for other alternative fuel vehicles such as FCEVs fueled by H_2 from NG.
- **Synergies between H_2 and NG** offer opportunity to leverage technology so that common challenges are addressed in parallel.

Thank you