Low Cost Alcohol Fuels—the Most Cost Effective Pathway to Reducing Light-Duty Vehicle Emissions, GHG Emissions, and Petroleum Use

Presented at

America's Future Natural Gas Economy: Promoting the Next Energy Breakthrough

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Hudson Institute

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Low Cost Alcohol Fuels *Agenda*

1. *Introduction*
2. *Opportunity*
3. *Benefits*
4. *Summary*

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Fuel Freedom Foundation is working to reduce the cost of driving existing cars and trucks by opening the market to cheaper fuel choices at the pump

- Non-partisan initiative dedicated to reducing the cost of driving for the U.S. consumer
- Initiate changes necessary for gasoline, diesel, natural gas, ethanol, methanol, and electricity to compete on equal footing
  - Overcome the regulatory, commercial, and practical barriers that impede innovation in fuel production, consumption , and true market competition
- Focusing on Light-duty vehicles
  - Light-duty vehicle sector largest fuel user
  - Sector fuel and vehicle price sensitive—need consumer value proposition for alternatives to gain market share

Liquid fuels produced from natural gas can provide consumer savings and meet environmental and energy policy goals

- NG liquids are a more affordable pathway to increase alternative fuel market share in the transportation sector
- Lower cost NG liquids are feasible due to advanced drilling technologies coupled with existing NG to liquid technologies--no breakthrough needed
- NG liquids will provide
  - Potential for reduced criteria and toxic emissions
  - Slightly lower GHG emissions with existing technologies (much lower with advanced vehicle technologies)
  - Significant petroleum displacement
- Concentrate on current ethanol FFV fleet and conversions for the legacy fleet
  - 21 million FFVs on road but little E85 used
  - Cars can be converted to run on ethanol and gasoline
  - Liquid fuels like ethanol can scale quickly to meet vehicle needs
- Choices at the pump will usher an era of economic growth fueled by innovation in the transportation sector

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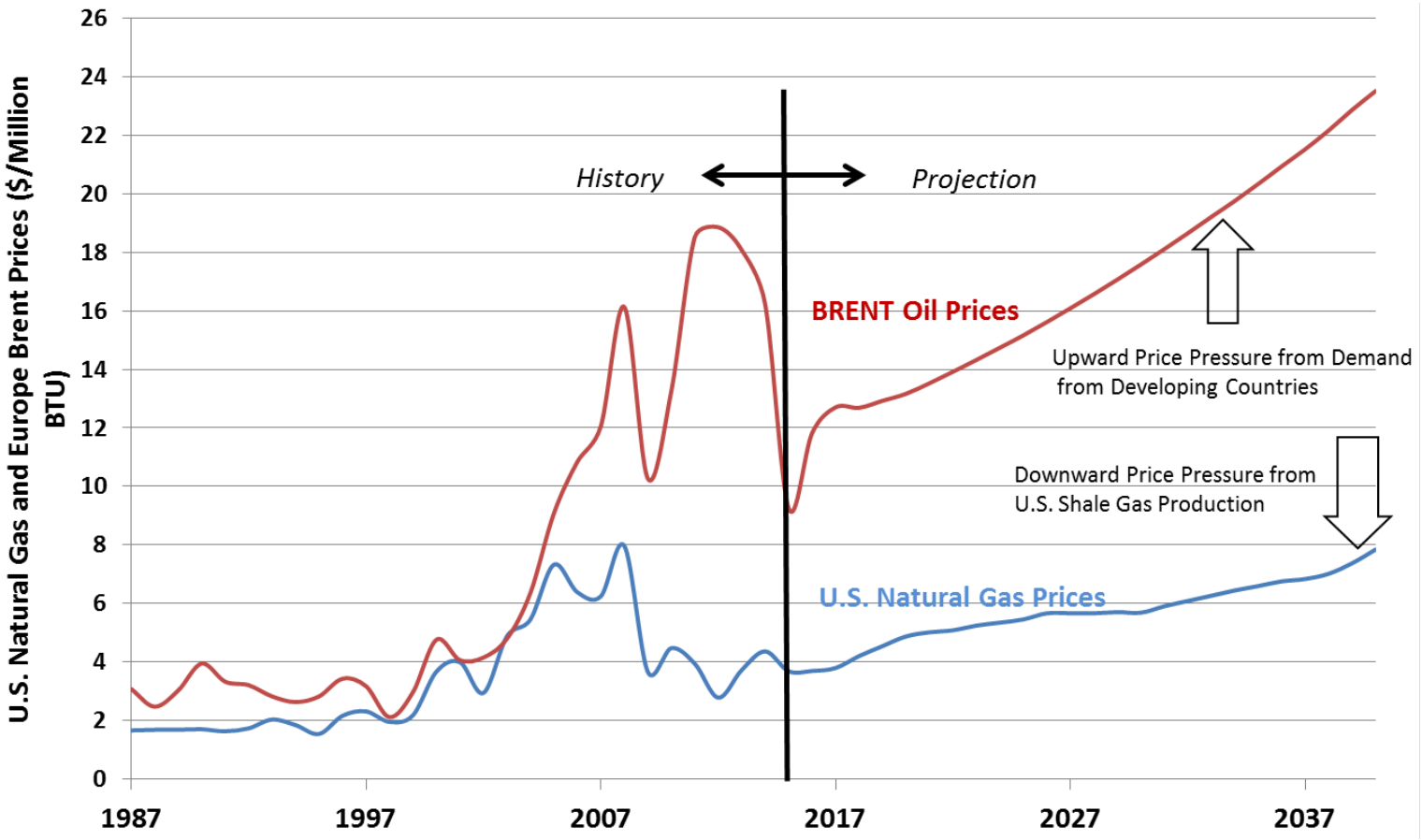
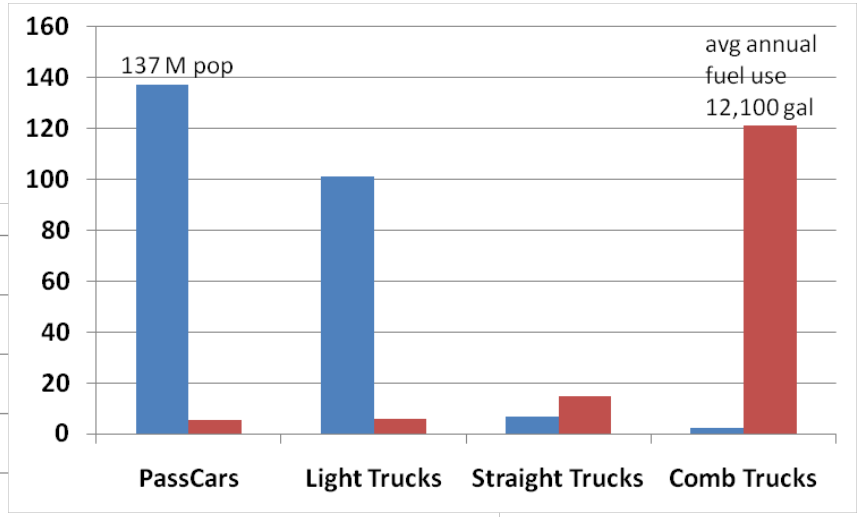
Increasing North America Supply of Natural Gas Widens Price Difference with Petroleum

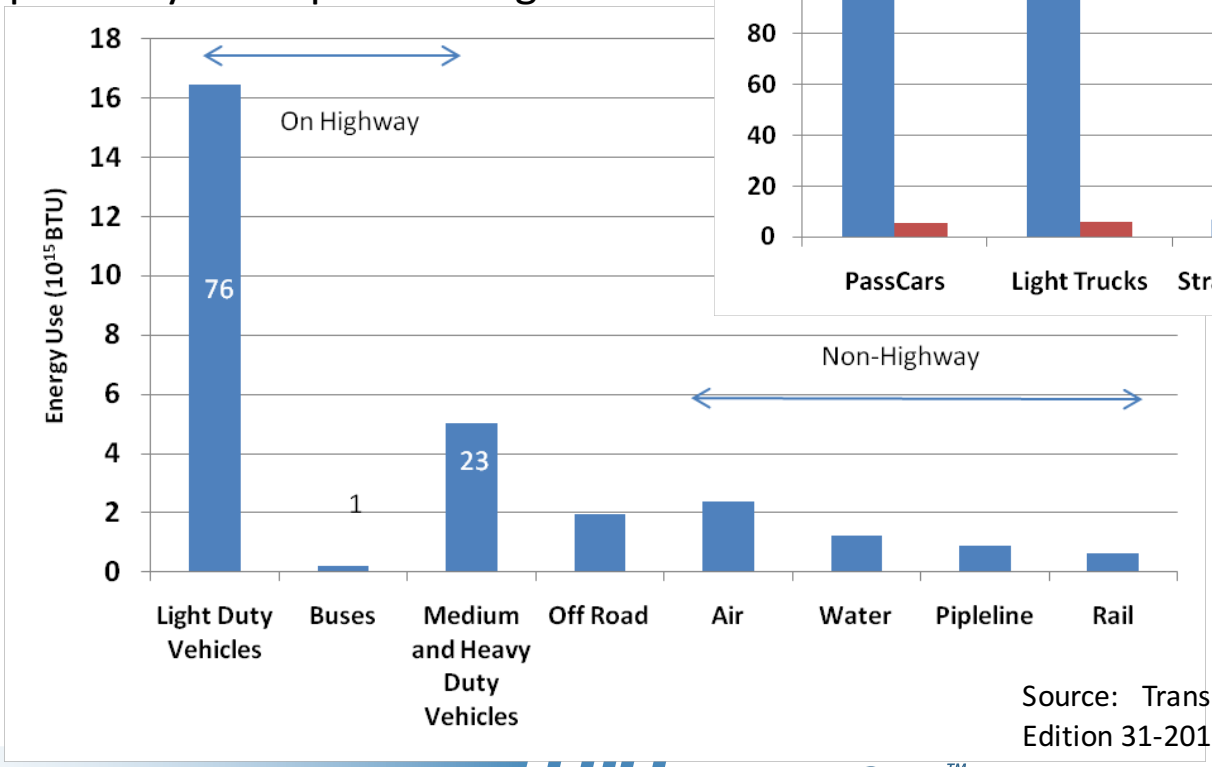


Source: EIA Energy Outlook 2015

LDVs use little fuel compared to HDVs but LDV fleet uses 3 times the energy compared to the on-road HDV fleet

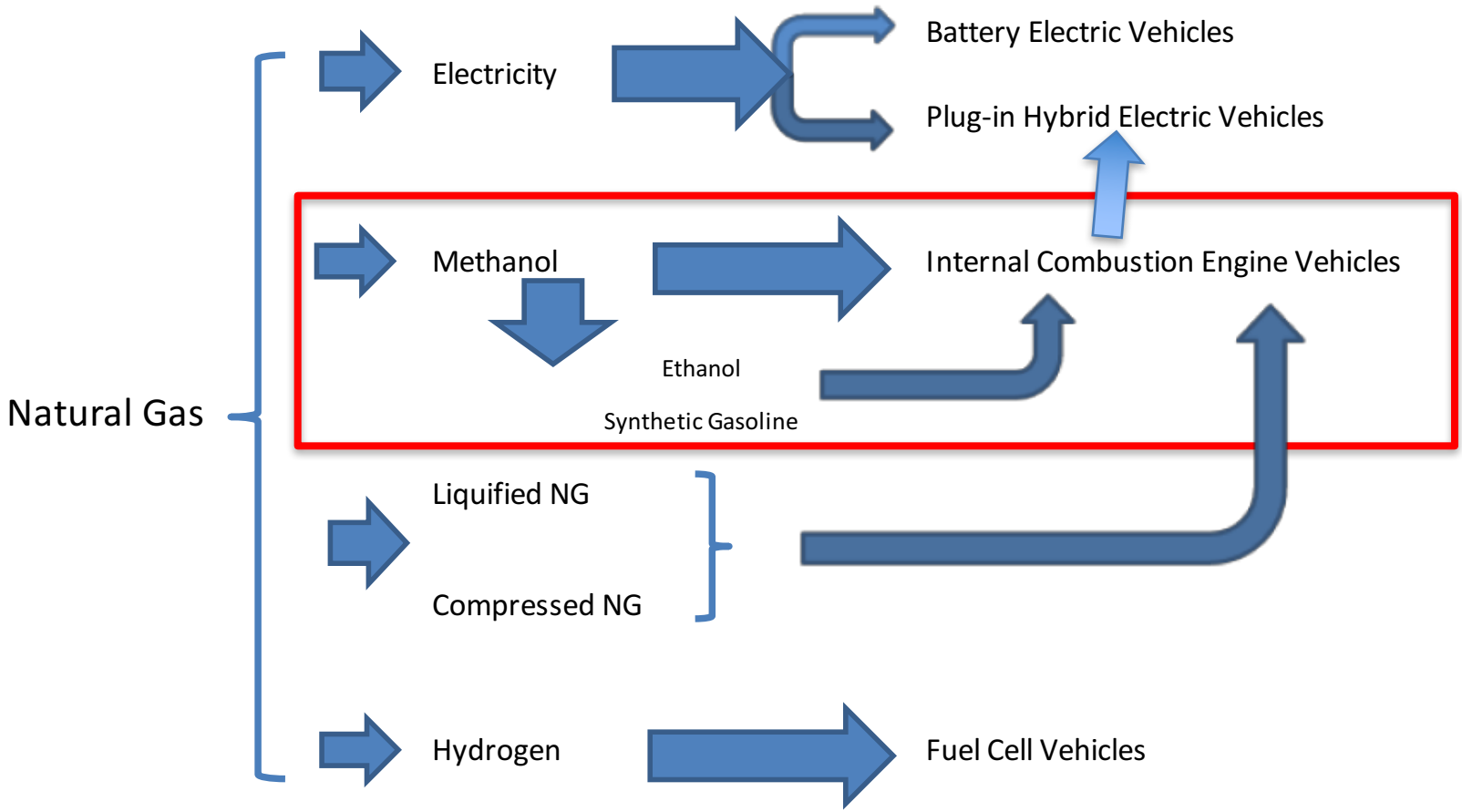
- LDV low fuel use is a challenge for alternative fueled vehicles
- NG derived liquids provide opportunity to displace LDV gasoline





Source: Transportation Energy Data Book: Edition 31-2012

Liquid derived Natural Gas Pathways minimize vehicle and infrastructure costs



Various fuels could be introduced into the retail fuels market

- Ethanol as E85 (E51-E83 as specified in ASTM D5798-13a)
  - Large population of FFVs
  - OEMs continue to produce new FFV models; dedicated models for high efficiency ICEs
  - Small fueling infrastructure in place (about 3,000 pubic and private stations)
  - Limited retail success
- Mid level ethanol gasoline blends
  - E15 approved for 2002 vehicles
  - E30 suggested for increased octane needed for high efficiency ICEs
- Methanol as M85 (ASTM D5797 being revised)
  - No certified dedicate or FFVs
  - No infrastructure or approved dispensing equipment
  - Possible evaporative emissions issue at M10 (or GEM 10-20)

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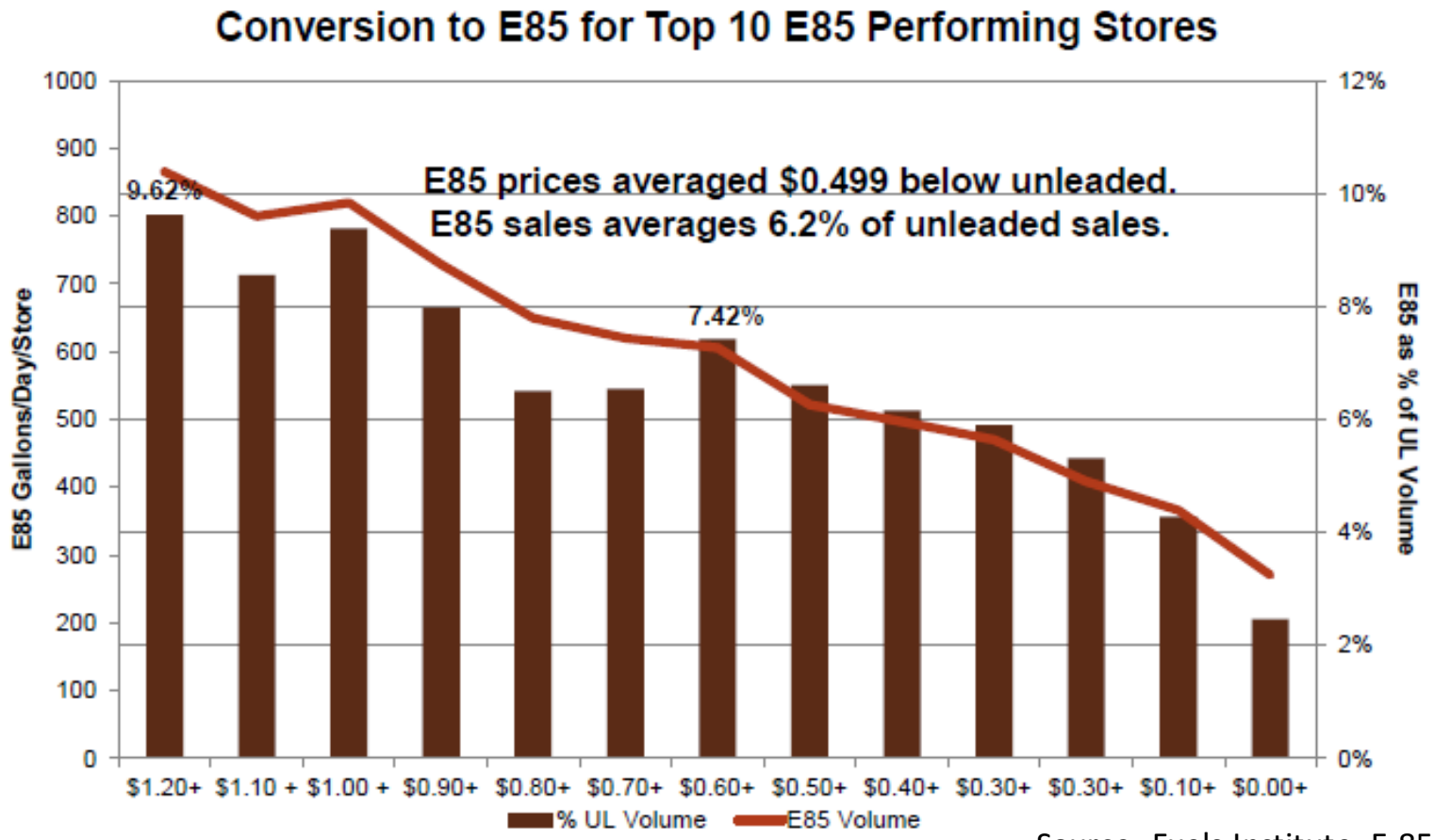
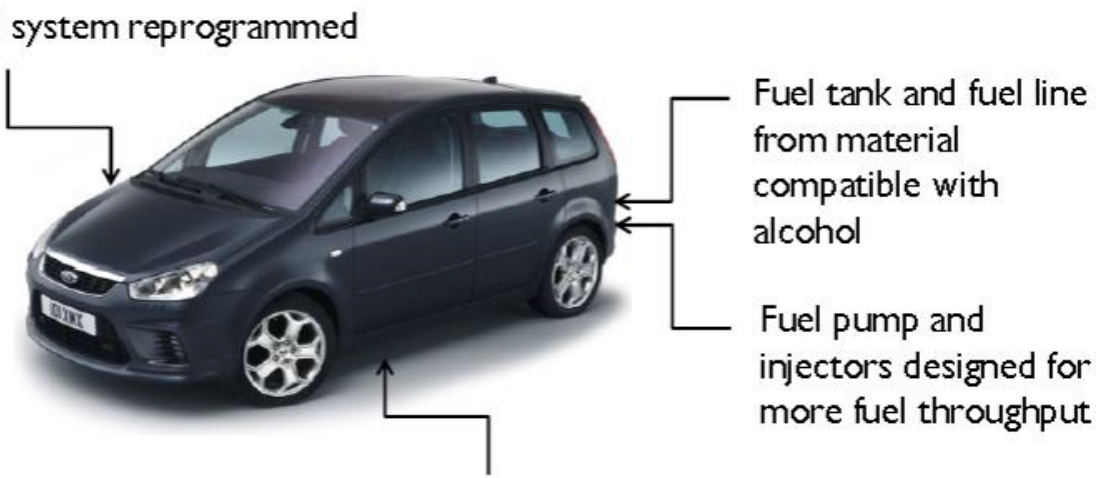
Consumers mostly motivated by lower pump prices

Fuel retailers are successfully marketing E85 today in several markets if competitively priced



Source: Fuels Institute, E-85 A Market Performance Analysis Forecast

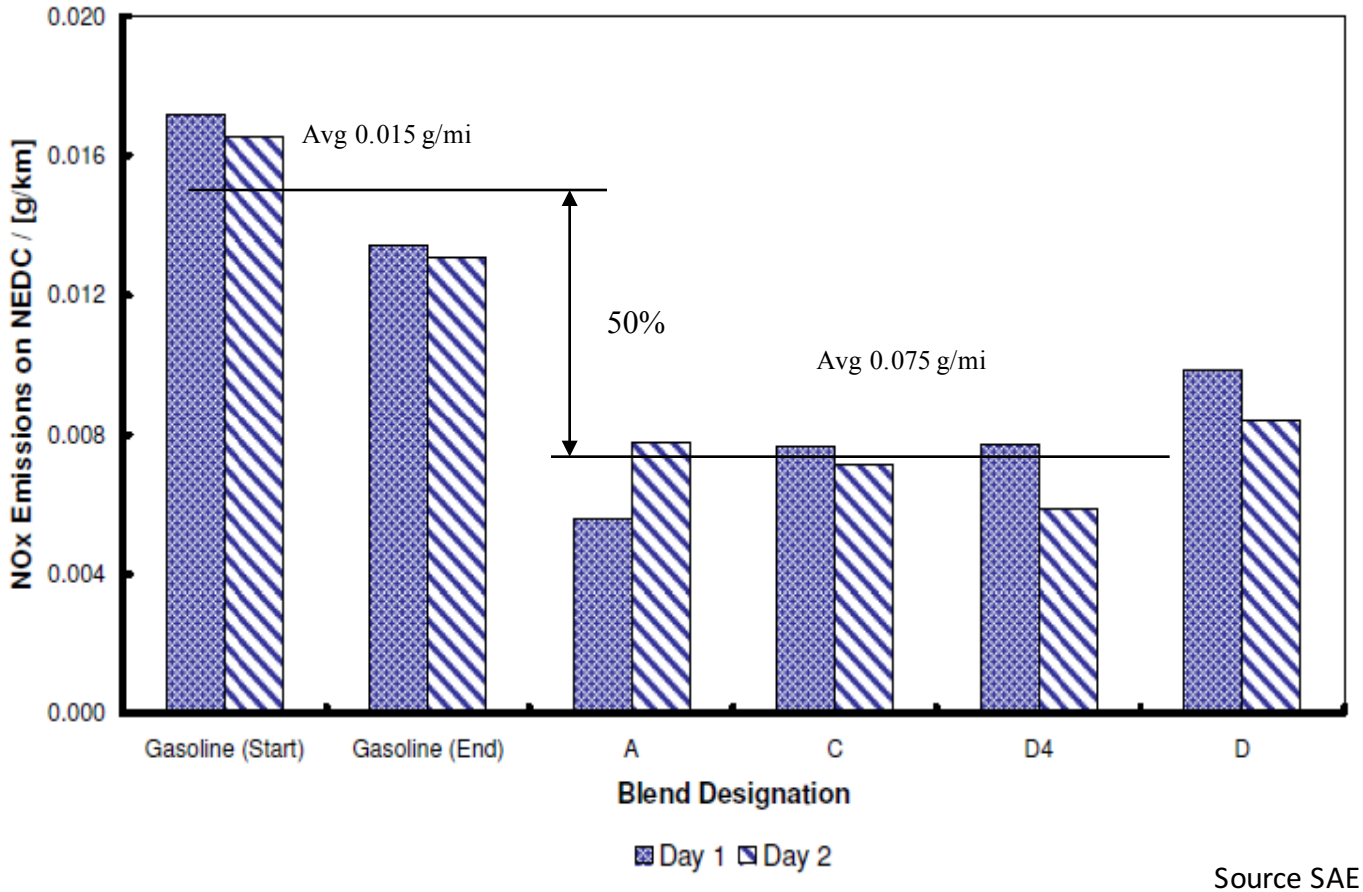
Existing Fleet of FFVs and Potentially Larger Population with Vehicle Conversions



Total incremental production cost ~$100

FFV FLEXIBLE FUEL VEHICLE

Limited Emissions Testing has shown benefits of alcohol blends in existing FFVs

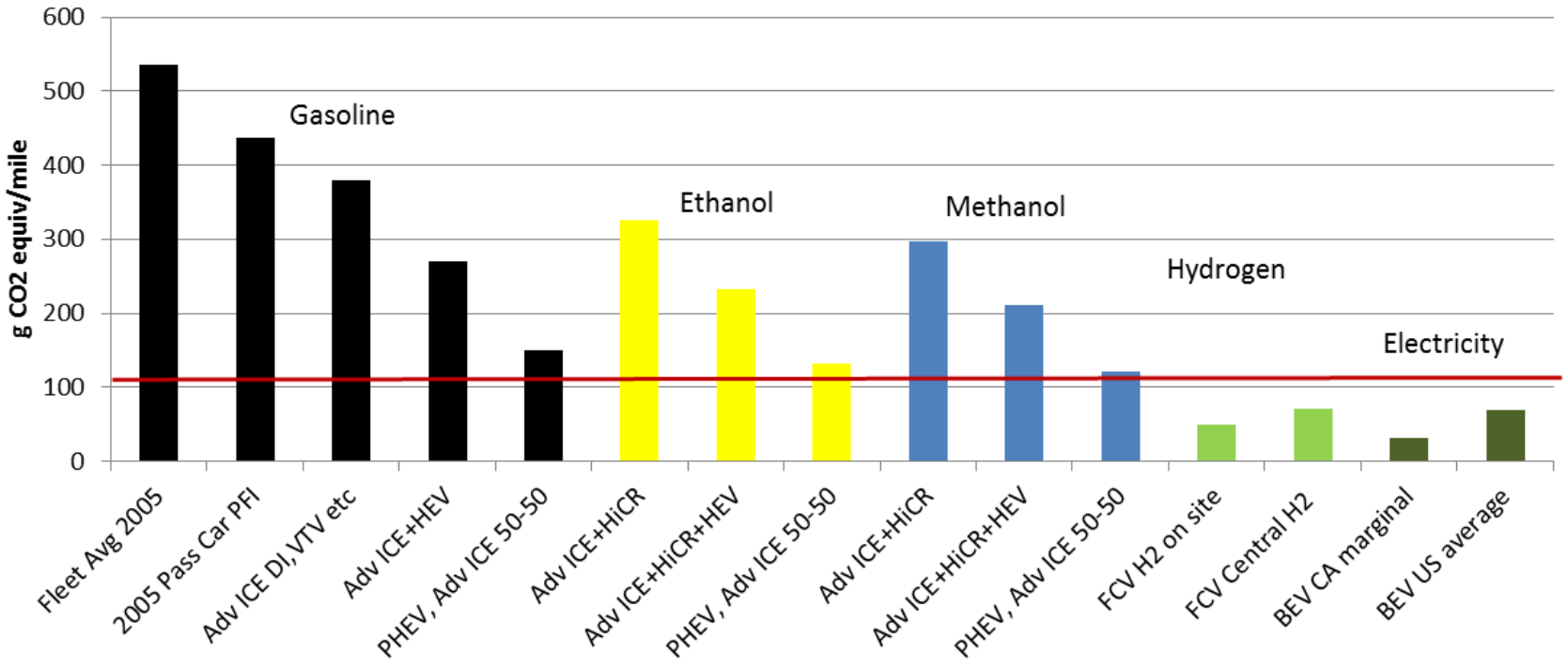


Source SAE 2012-01-1279

Ethanol and methanol use in FFVs and converted legacy vehicles reduces petroleum consumption and provides air quality improvement and GHG emission reductions

- Criteria Emissions-- NOx and therefore secondary PM reduction especially with legacy fleet
- Toxic Emissions--less benzene but increased in aldehydes (meets standards) with alcohols
- GHG emissions for alcohol pathways
  - Natural gas to methanol slight to no benefit depending on methane emissions associated with natural gas production
  - Natural gas to ethanol slight worse than methanol
  - Renewable feedstocks provide much greater benefits for either ethanol or methanol (comparable to cellulosic ethanol)
- Petroleum displacement—depends on blend
  - M56<E85<CNG~BEVs~H2FCV
- Alternatives could **enable** higher efficiency ICE technologies
  - Increased compression ratio along with boosted, downsized, DI technologies
  - Additional improvements with heavy EGR and reforming

Advanced ICE coupled with electrification provides nearly 80% GHG reduction with gasoline, ethanol, and methanol fuels



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Natural gas derived alcohol fuels have potential to provide large near term societal benefits and a pathway to sustainable renewable fuels

- Natural gas supply in U.S. opens opportunity to introduce less expensive natural gas derived fuels like ethanol and methanol
- Current U.S. fleet of FFVs coupled with conversions creates demand to justify production
- "E85" availability provides high octane fuel **enabling** higher efficiency ICEs
- Alcohol fuels provide tailpipe emission benefits with existing fleet and new vehicles
- Alcohol fuels will enable more efficient newer vehicles—lowering GHG impact—at potentially lower costs than alternatives

Thank you for your attention

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