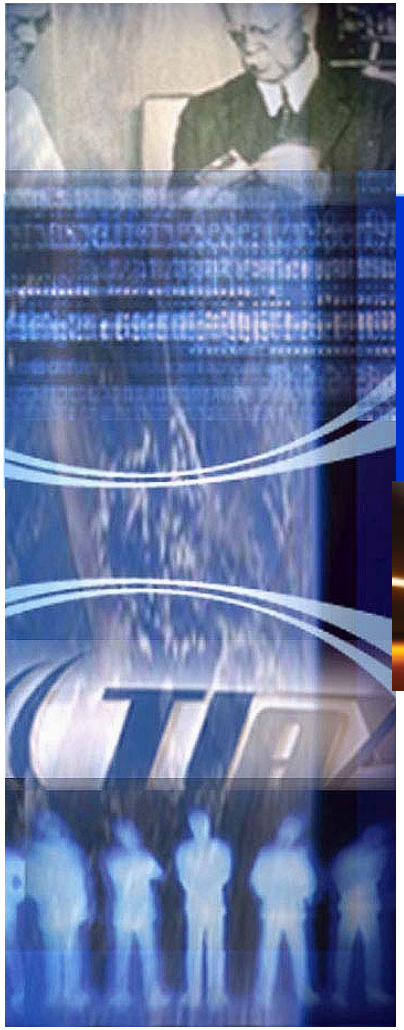

Powered by Innovation since 1886

The California Experience: 30 Years of Alternative Fuels in 20 Minutes or Less

Presentation Number P12-6407

Presented at

No Silver Bullets: Alternative Fuels in the Transportation Sector

TRB Workshop

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Agenda

1. Reducing Petroleum…*the 1980's*
2. Reducing Smog…*1990's*
3. Global Warming, Petroleum Dependency, and the Environment…*the 2000's*
4. Outlook

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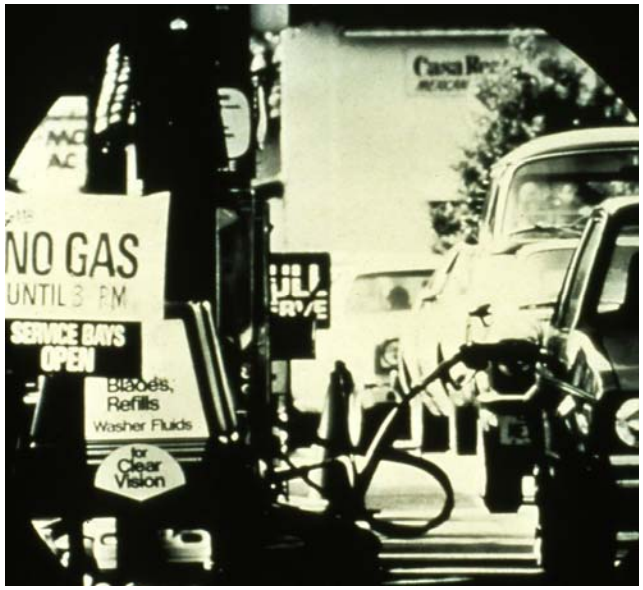
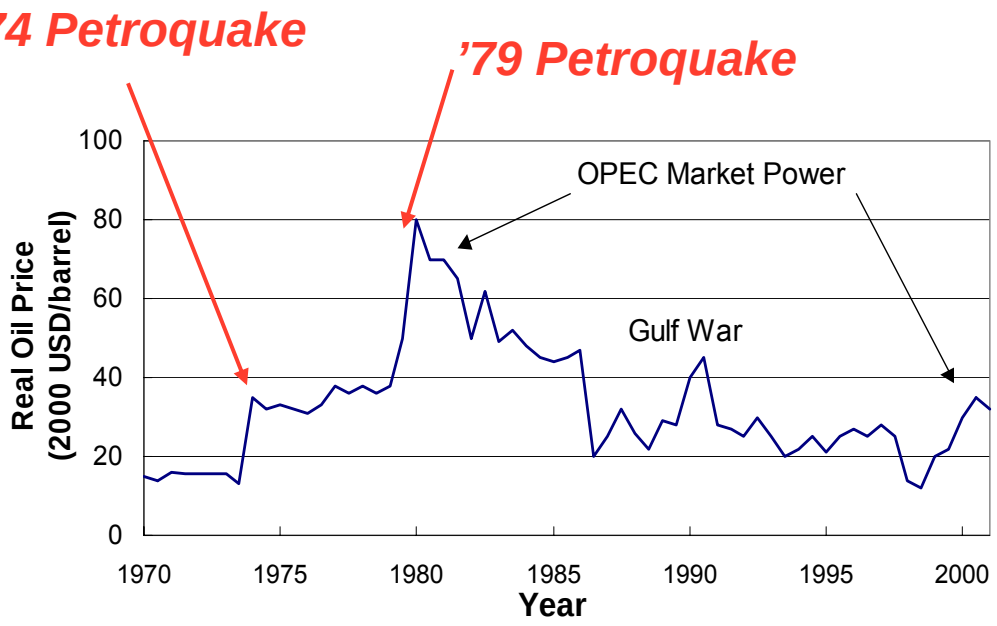
Petroquakes of the 1970's Motivated Interest in Alternative Fuels

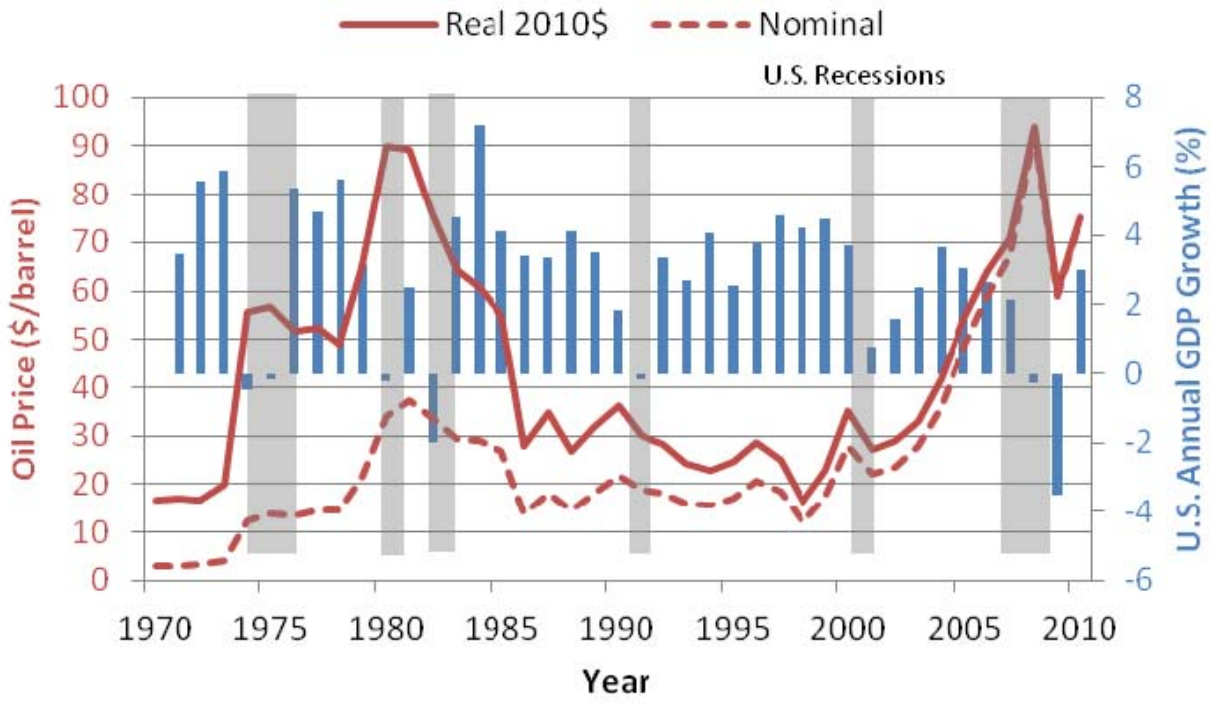




Source: National Energy Policy, May 2001, Figure 2-7
for West Texas Intermediate Crude Spot Price

Economic Growth

- Inexpensive energy has fueled our economy through economic efficiency, growth, and international competition
- Each oil crisis has been followed by a U.S. economic recession and increase in energy trade deficit



Oil Prices in the 1980's Remained High but Declined from the All Time High in 1980.

- High oil prices resulted in reduced demand for petroleum in the first part of the 1980's. Reduced demand brought about oil price collapse in 1986 and relatively stable prices for the rest of the decade
- The petroquakes of the 70's set the stage for alternative fuels throughout the world
  - Brazil – ethanol
  - Germany – methanol
  - Italy – natural gas
  - New Zealand - methanol, then natural gas
  - Canada – LPG and natural gas
  - The Netherlands – LPG

California Response

- California aggressively investigated alternative fuels for transportation and stationary applications
  - Philosophy was to displace entire barrel of oil
  - Investigated low level alcohol blends for light-duty vehicles
  - Converted light duty vehicles to dedicated ethanol and methanol
  - Worked with Ford and VW to provide "factory built" light-duty vehicles
  - Worked with initially GM/DDA (DDC) and MAN to develop and demonstrate methanol heavy-duty transit buses

First Dedicated Ethanol and Methanol Fleets in California

- 1981 VW Rabbits Dedicated Light-duty Vehicles
  - First vehicles built on assembly line
    - 20 Methanol
    - 19 Ethanol

- 1981(40)-1983(500) Ford Escorts Dedicated Light-duty Vehicles

Early Ethanol and Methanol Demonstrations in State Owned Fleets

- Fueling done at fleet location or at few stations located on major highways
- From early VW, Escort, and heavy-duty experience California selected methanol primarily based on costs
- Dedicated VW and Escorts fleets a technical success but public relation (emotional) failure
  - Too few methanol fueling stations
  - Fear of running out of fuel was a serious problem

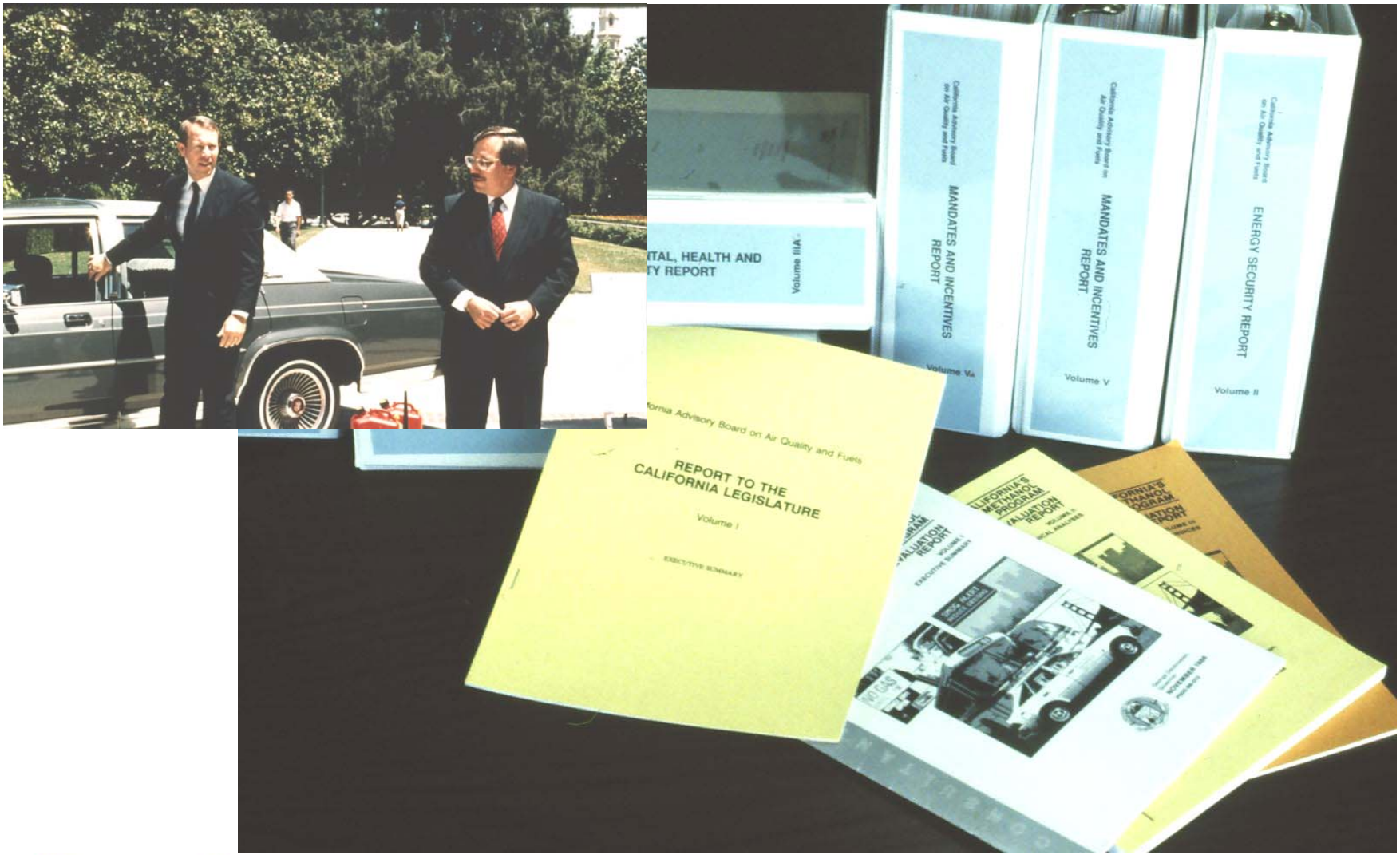
Flexible Fuel Vehicle (FFV) Technology

- FFVs can use gasoline or methanol or any combination
- Solved the fueling station "PR" problem with fleet users
- Still need a convenient fueling infrastructure for methanol to be used

Los Angeles Air Quality the Worst in the U.S.

- With collapse of oil prices in mid 80's , air quality was emphasized as a major benefit of alternative fuels
- South Coast Air Quality Management District (SCAQMD), California Air Resources Board (ARB), and CEC worked together to promote the use of alternative fuels

Proposed AB 234 Mandated FFVs for All Light-Duty Cars Sold in California



CEC Methanol Bus Demonstration Project

- Worked with GM/DDA and MAN to provided methanol buses to Golden Gate Transit
- Buses placed in revenue service from 1984-1988

- Fuel facility included M100 fueling dispenser and 12,000 gal UGST

CEC Heavy-Duty Methanol Truck Demonstration

DDC Truck Demonstration Sites 6V-92TA, 6L-71TA Methanol Technologies

Penske—GSF and FedEX

City of Los Angeles

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Major Milestones in California's Alternative Fuel History

- AB234 recommendations in 1990
  - Continue to implement methanol in light-duty vehicles
  - No "show stoppers"—methanol use provides
    - Emission benefits; methanol less reactive than gasoline
    - Possible air quality strategy to reduce ozone
    - FFVs provide a technology platform for widespread use in market place
  - Reformulated gasoline shows promise of lower exhaust emissions from light-duty vehicles and should continued to be monitored
- California worked with the Ford and other auto makers to get CAFE credits for alternative fueled vehicles, including FFVs
  - Alternative Motors Fuel Act (AMFA) of 1988 established credits
  - Credits for vehicles not fuel use starting in model year 1993
- California Air Resources Board (ARB) developed low emissions regulations (LEV) which set very low vehicle emissions standards along with gasoline and alternative fuel standards
- ARB also adopted a fuel infrastructure requirement the so called "fuel trigger"

Methanol Fueling Station Infrastructure

- Earlier fleet adopters used fueling stations built on their facilities
- CEC expanded infrastructure working through independent retailers
- CEC worked with all major oil companies and work agreement that each oil company install a limited number of methanol dispensers at their stations throughout California
- Number of stations reached some 60 retail stations located throughout Northern and Southern California

Lots of Debate on Methanol as a Replacement for Gasoline and Diesel

Oil Companies Introduced Reformulated Gasoline in California

METHANOL—
A proven alternative fuel. It can do a lot for gasoline without affecting fuel systems or pollution control devices.

The effectiveness of methanol as an automobile fuel has been tested by a number of organizations and laboratories. Blends tested ranged from 2% methanol to 100% methanol.

Extensive research by ARCO Petroleum Products Company's Fuels Research Center has shown that blending gasoline with 5% methanol and 5% tertiary-butyl alcohol produces a fuel that is in all ways comparable to conventional gasoline. This new fuel composition was awarded an EPA waiver in November 1981; and the ARCO Chemical product, OXINOL® octane enhancer, is now being used by blenders and refiners extensively.

Studies on OXINOL octane enhancer included numerous fleet tests, consumer market tests, and long-term durability tests on vehicles that used OXINOL blending component for up to 80,000 miles of day-to-day driving. No discernible differences were found between the performance of the cars using the OXINOL blend and those using conventional gasoline.

A wealth of data has proven that the use of recommended levels of OXINOL blending component has no adverse effect on fuel systems or pollution control devices.

Evidence of the widespread consumer acceptance of this product? As of August of this year, over 6 million barrels of gasoline with OXINOL octane enhancer have been delivered to 2,000 service stations via 20 terminals.

A very convincing amount of scientific data confirms that when properly blended, methanol-based components like OXINOL octane enhancer are the most viable gasoline extenders available today.

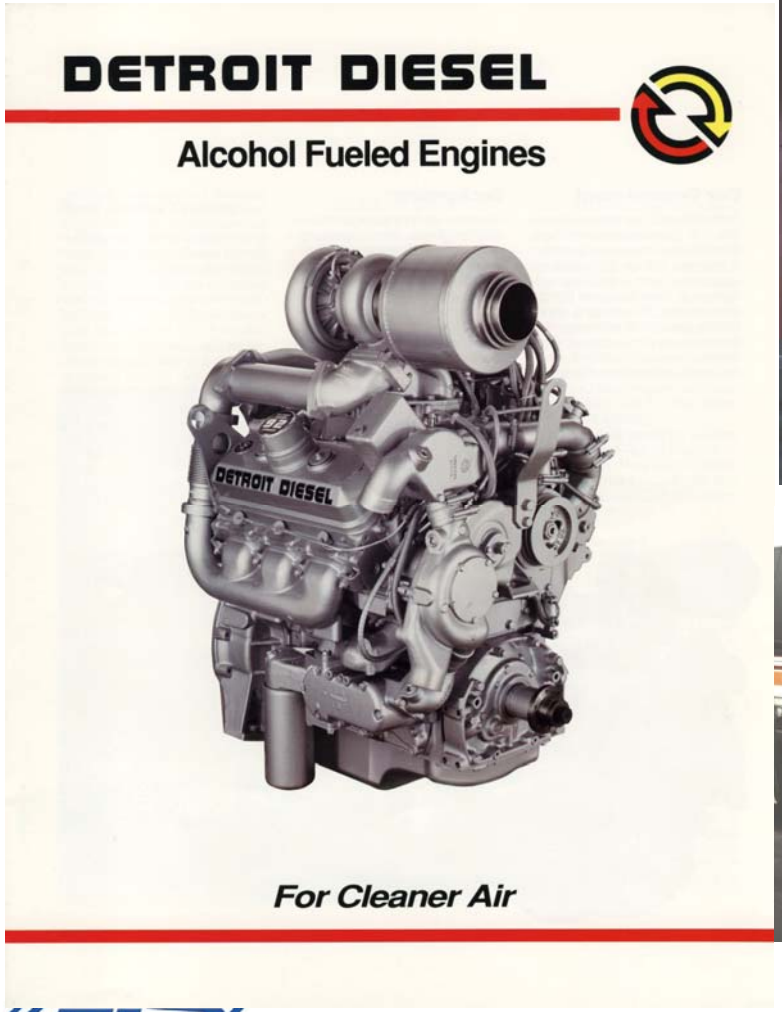
For more information, contact Oxygenated Fuels, ARCO Chemical Company, 1500 Market Street, Philadelphia, PA 19101. Call Ed Guetens, 215/557-2161, or George Yogis, 215/557-2255.

ARCO Chemical Company

U.S. Alternative Fuel Policies

- Clean Air Act Amendments of 1990
  - Debate on reformulate gasoline and alternative fuels
  - Reformulate gasoline required in areas classified as severe and serious ozone non-attainment areas
- The Energy Policy Act of 1992 — Emphasized the use of AFVs as a petroleum conservation measure
  - Provide tax credits for alternative fueled vehicles
  - Fleet requirements for government, fuel providers, and private fleets
  - Ultimately only government fleets and fuel provider mandates adopted
  - Only required fleets purchase vehicles not use alternative fuels

DDC Commercialized Alcohol Engine and Los Angeles MTA Purchased and Operated 333 M100 Buses in Downtown Los Angeles in 1991



FFVs Offered for Sale in California by Auto Makers Starting in 1992

- 1992 GM sold 1200 Chevrolet Luminas
- In 1993 3,300 FFVs sold
  - Ford Taurus, GM Lumina, and Chrysler Dodge Spirit/Plymouth Acclaim

Methanol Economics in California

- CEC established Methanol Fuel Reserve to provide methanol to fleet and retail stations
  - –Pool supplies from various producers
  - –Develop pricing for M85 and M100 fuel markets (compared initially to chemical market)
  - –Prior to reformulated gasoline using MTBE methanol priced from $0.35 to $0.65
- Methanol too expensive to compete at world oil prices of $20 per barrel

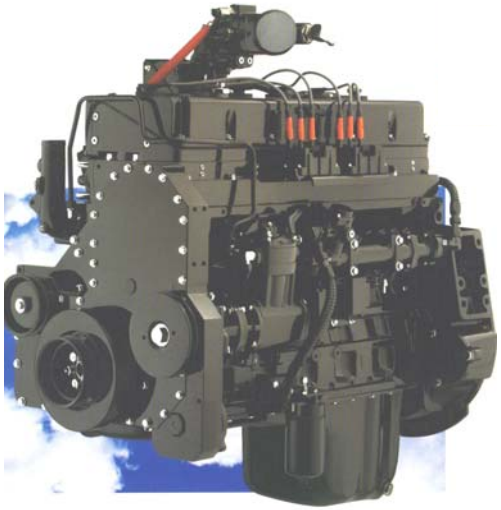
Application	Methanol Price 1995 ($/gal)	Equivalent Price 1995 ($/gge or ggd)	Nominal Gasoline or Diesel Price 1995 ($/gal)
Light-Duty Vehicles	0.50	1.58	1.08 to 1.15
Transit Buses	0.40	1.22	0.82

Fuel Competition Also a Major Factor

- Cummins introduced natural gas transit buses also meeting low NOx, PM in the early 1990's
  - U.S. government subsidies capital cost of facilities and buses
  - Lower equivalent compressed natural gas prices made CNG buses cheaper than diesel
- Demand for methanol increased dramatically as MTBE production increased to meet RFG requirements in 1993
  - $0.48 per gallon in Jan 1993 and increased to $1.70 per gallon in January 1995
  - Price spike lasted until about November 1995
  - Availability was also a problem especially for large volume users
- RFG and advanced emissions technology achieved extremely low light-duty vehicle exhaust emissions

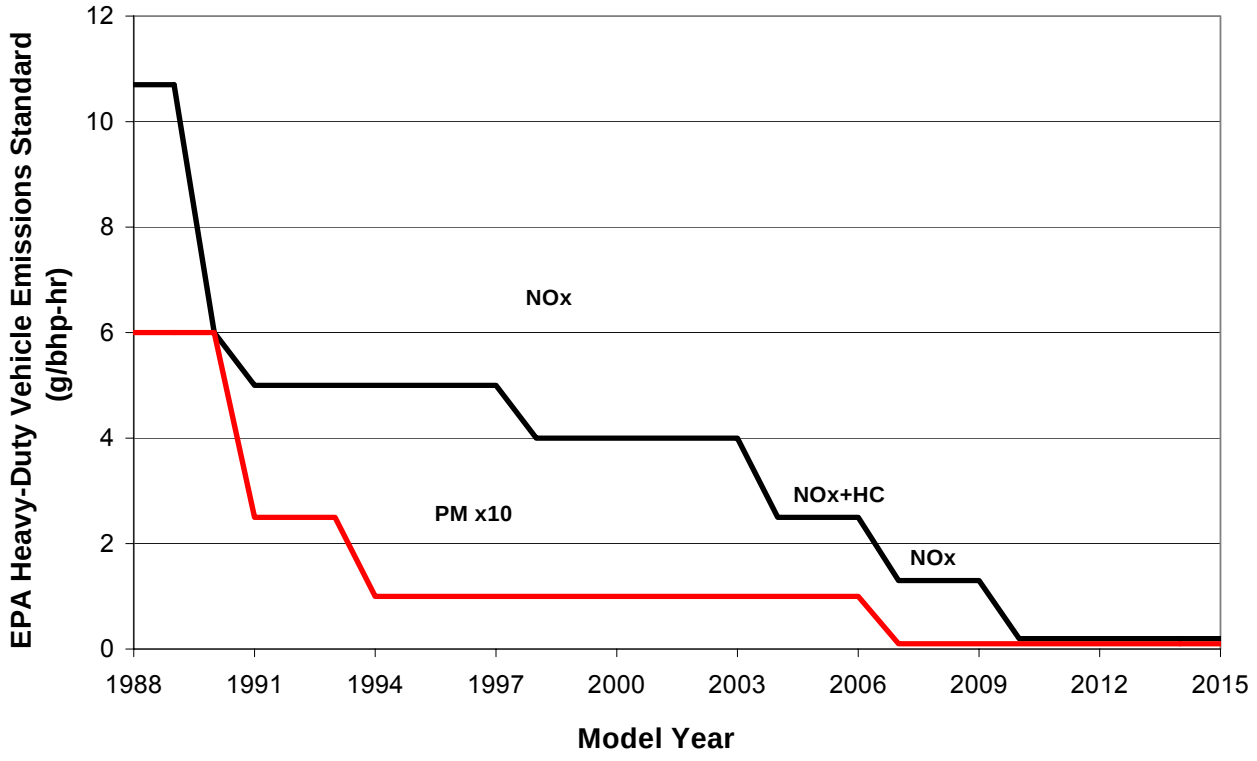
Clean Fuel Race Won By RFG and Natural Gas

- Ford discontinued sale of methanol FFVs in 1996. New Taurus model only ethanol compatible
- Cummins and DDC focused attention on natural gas engines for transit (CNG) and trucking (CNG and LNG) applications
  - Cummins L-10 and C8.3L
  - DDC Series 50G
  - 6V-92TA alcohol engines discontinued



ARB Classification of Diesel Exhaust as a Carcinogen

- Alternative fuels provided both NOx and PM reductions
- Moyer program developed to monetize NOx benefits and also provide PM benefits



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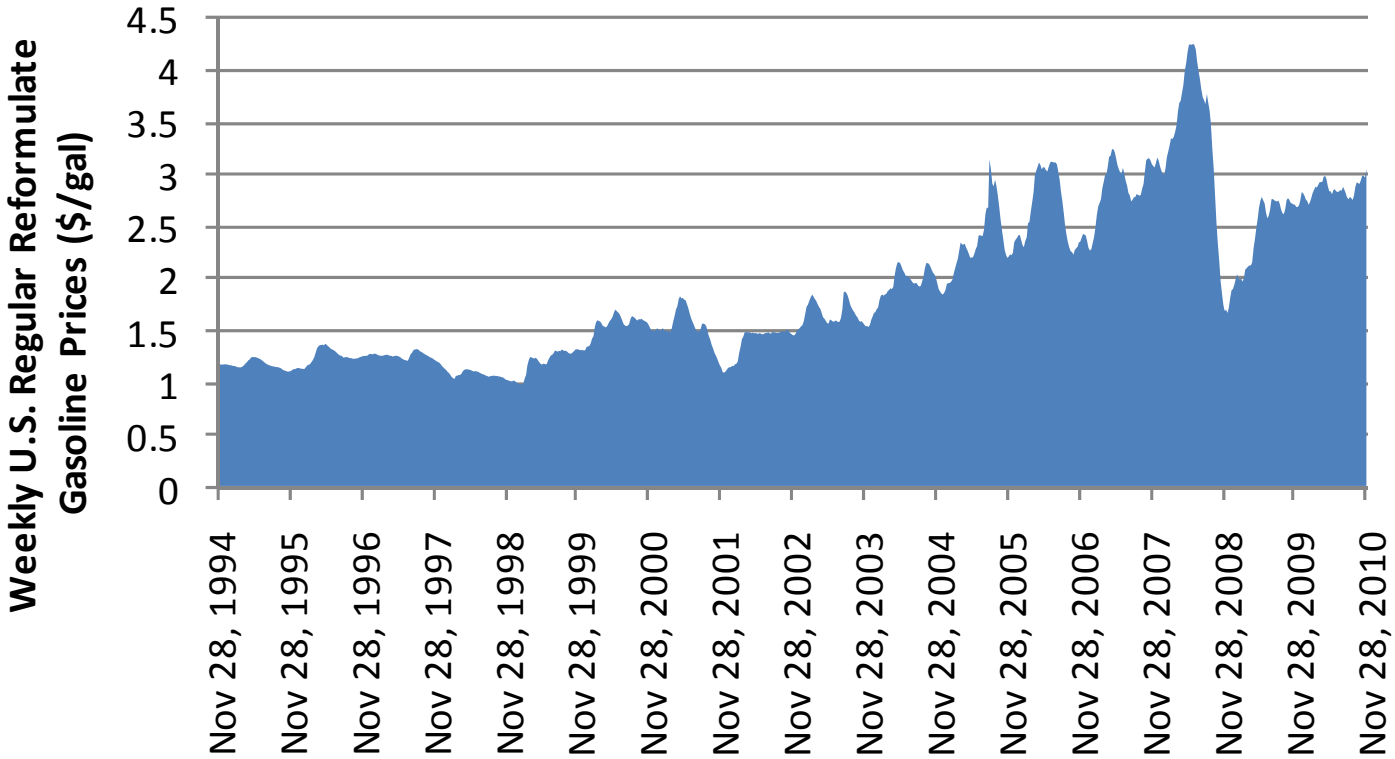
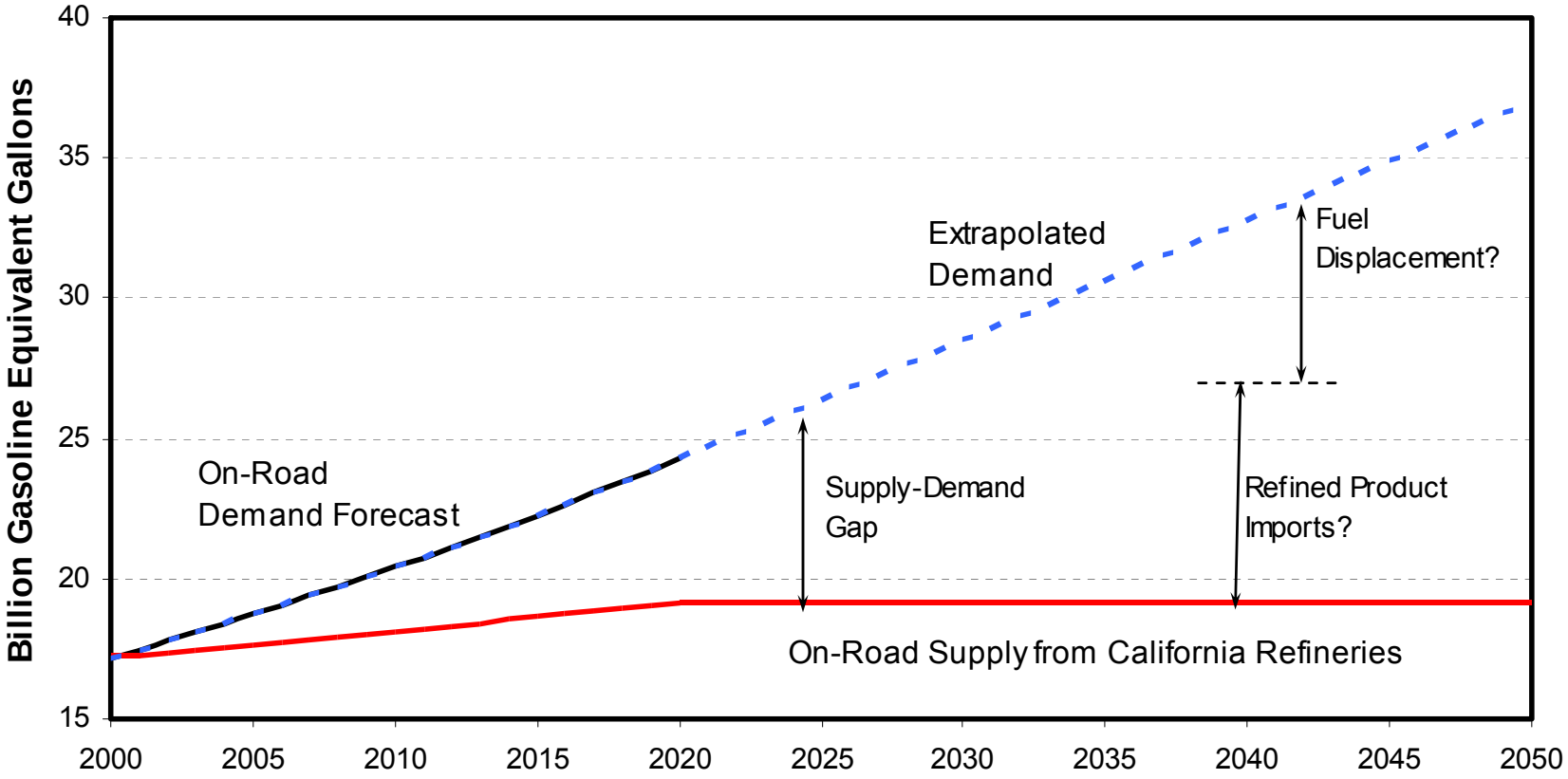
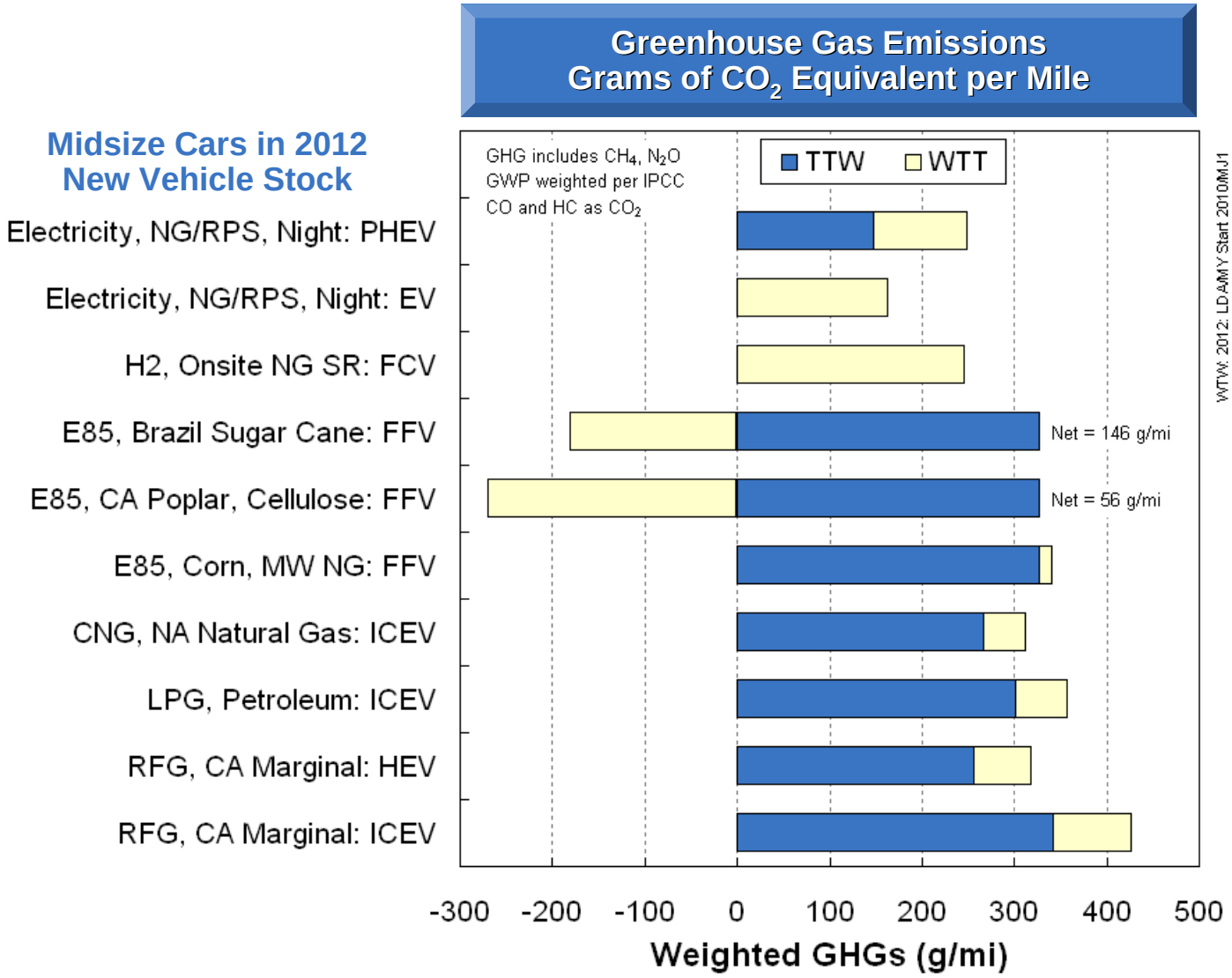
Gasoline Price Volatility increase dramatically in the 2000's



Business as usual demand forecasts in California and the US were unsustainable



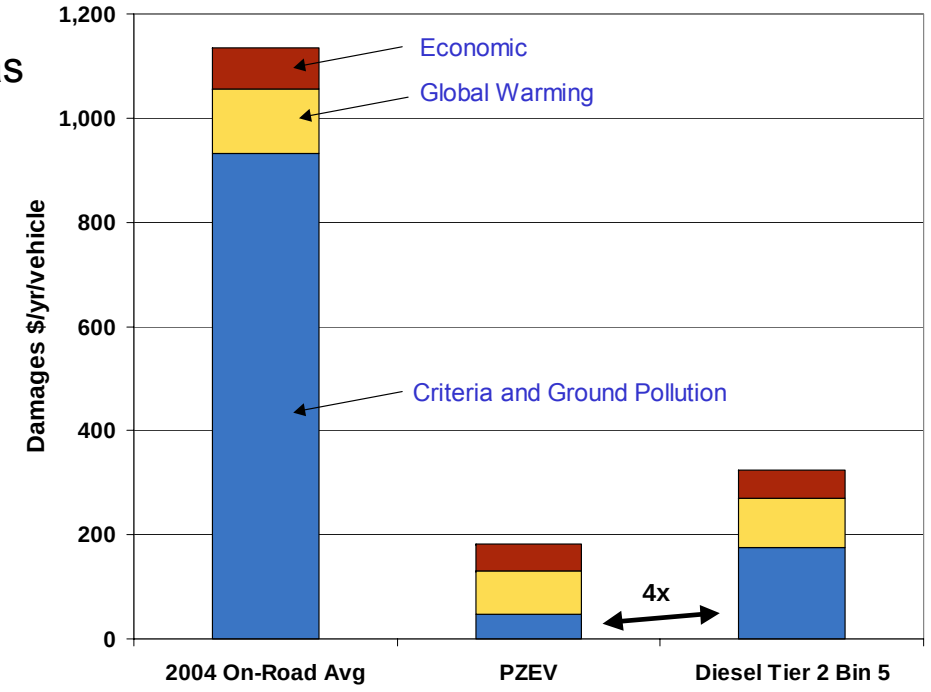
Alternative fuels and advanced vehicle technologies shown to reduce GHG



CEC and ARB Petroleum Dependency Study (AB2076)

- Evaluated the impacts of conventional and alternative fuel technologies
  - User economics
  - Cost of damages for criteria pollutants, greenhouse gases, and water pollution
  - Economic costs of petroleum dependency
  - Full Fuel Cycle Analysis
- Global Warming as important as criteria and energy impacts

Pollutant	LDV PZEV Gasoline g/mi
NO_x	0.024
CO	0.4
NMOG	0.024
Exhaust PM	0.002



California Legislation Driving Future Fuels and Technology

- 2000--AB 2076 Established petroleum reduction goals
  - Reduce petroleum consumption to 15% below 2003 level
  - Introduce non petroleum fuels at 20% by 2020 and 30% by 2030
- 2002--AB 1493 Established GHG emission standards for LD vehicles
  - Advanced engine and vehicle technologies
  - Alternative fueled vehicle technologies
- 2005--AB 1007 Requires development of alternative fuels plan
  - How to achieve goals adopted in AB2076
- 2006--AB 32 Directs ARB to set cap on greenhouse gas emissions
  - Considers all sectors of California Economy—transportation, electric generation, industry, and residential
- 2007 AB118—authorizes the CEC to develop and deploy alternative and renewable fuels and advanced transportation technologies to help meet the state's goals for reducing greenhouse gas emissions and petroleum dependence in the transportation sector.

California and Federal Legislation Driving Future Fuels and Technology

- 2010 Low Carbon Fuel Standard, LCFS
  - Reduce carbon intensity of California's transportation fuels by at least 10% by 2020
  - LCFS applies to all refiners, blenders, producers or importers of transportation fuels in California
  - Determined on "full fuel cycle" basis
  - CEC shall incorporate LCFS draft compliance schedule into the State Alternative Fuels Plan per AB1007
- 2011+ California and Federal fuel economy and GHG regulations for LD and HDVs
  - LDVs up to MY 2016 and MY2017-2025
  - ARB LEV III and ZEV programs
  - HDV MY2017 up to 23% reduction in GHG depending on vocation

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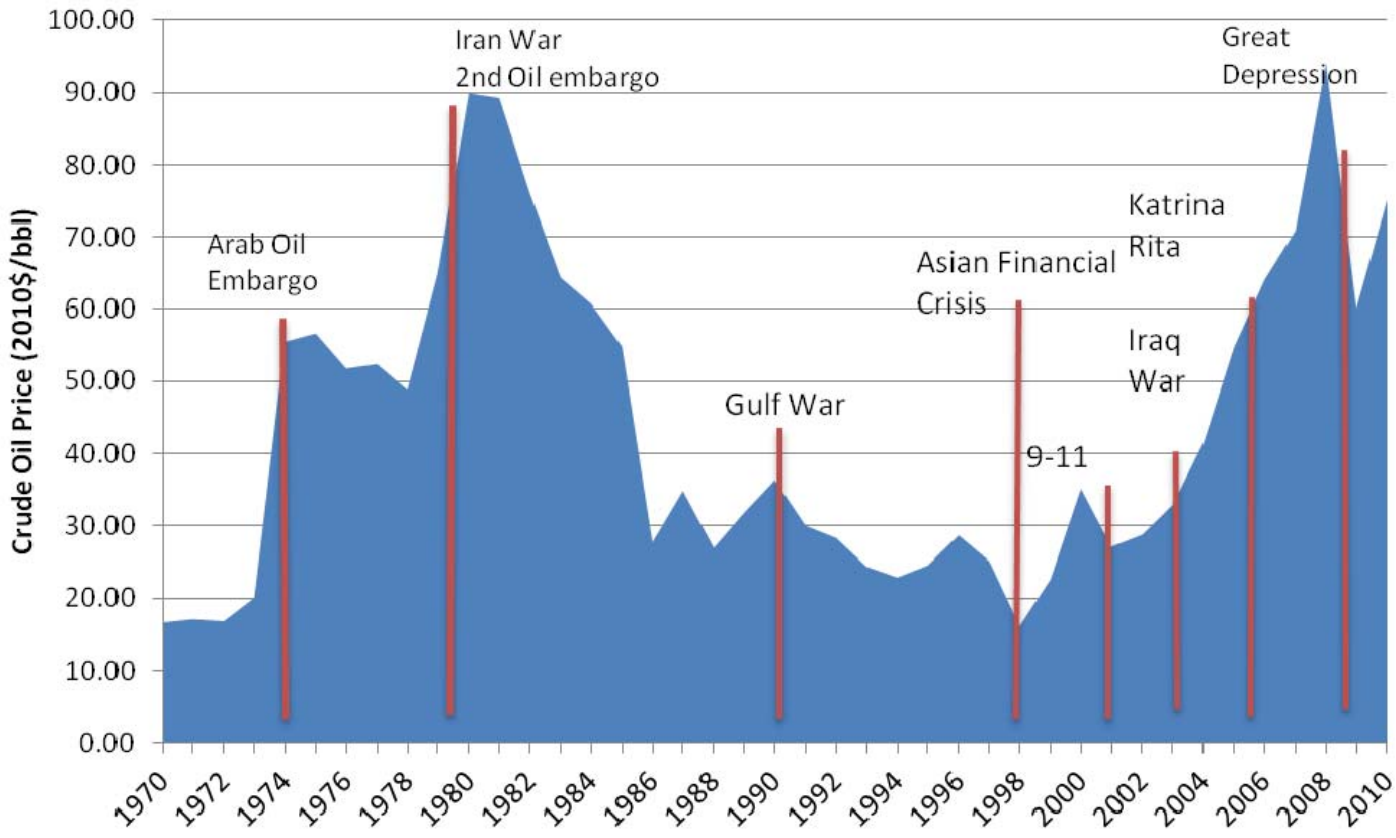
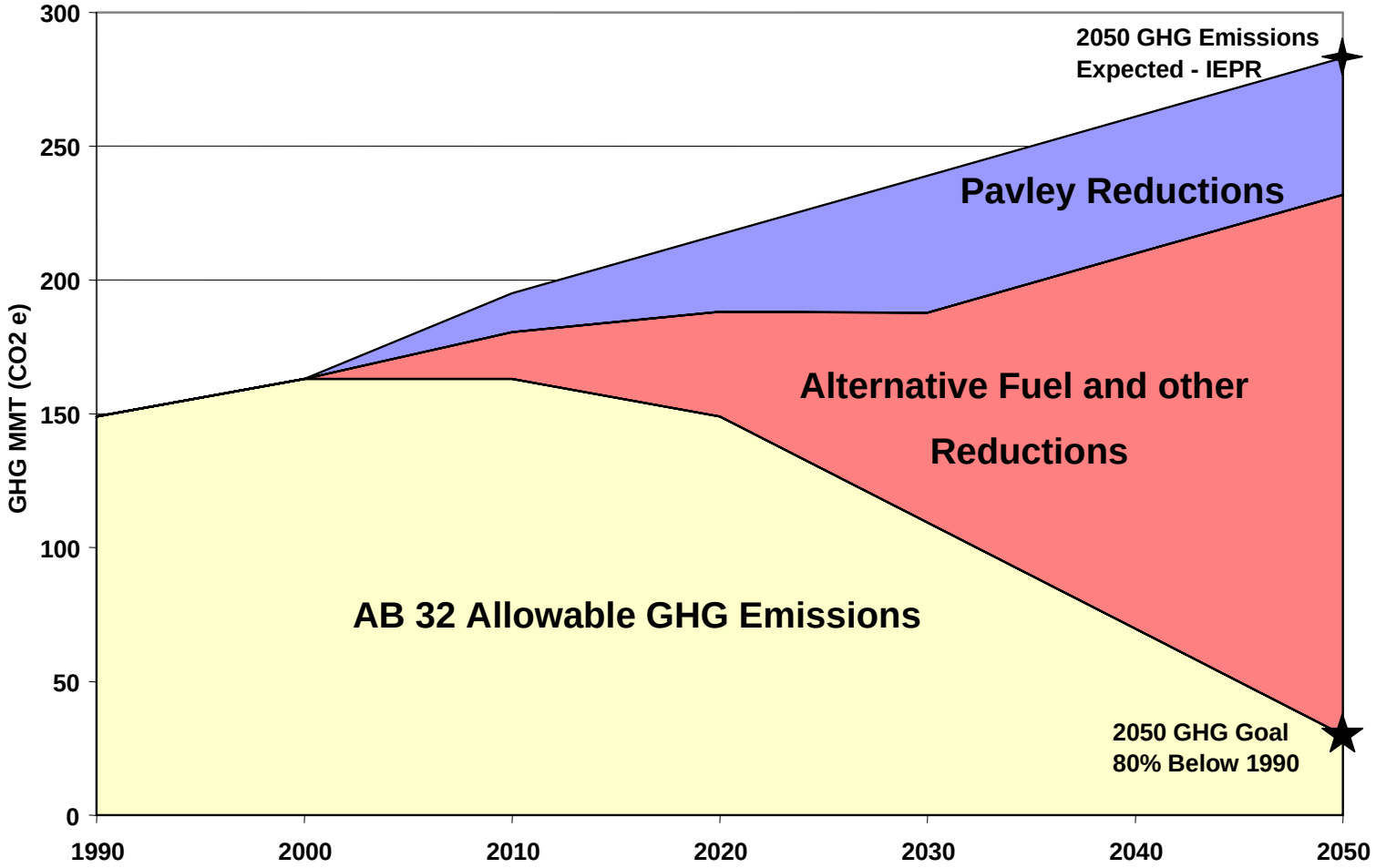
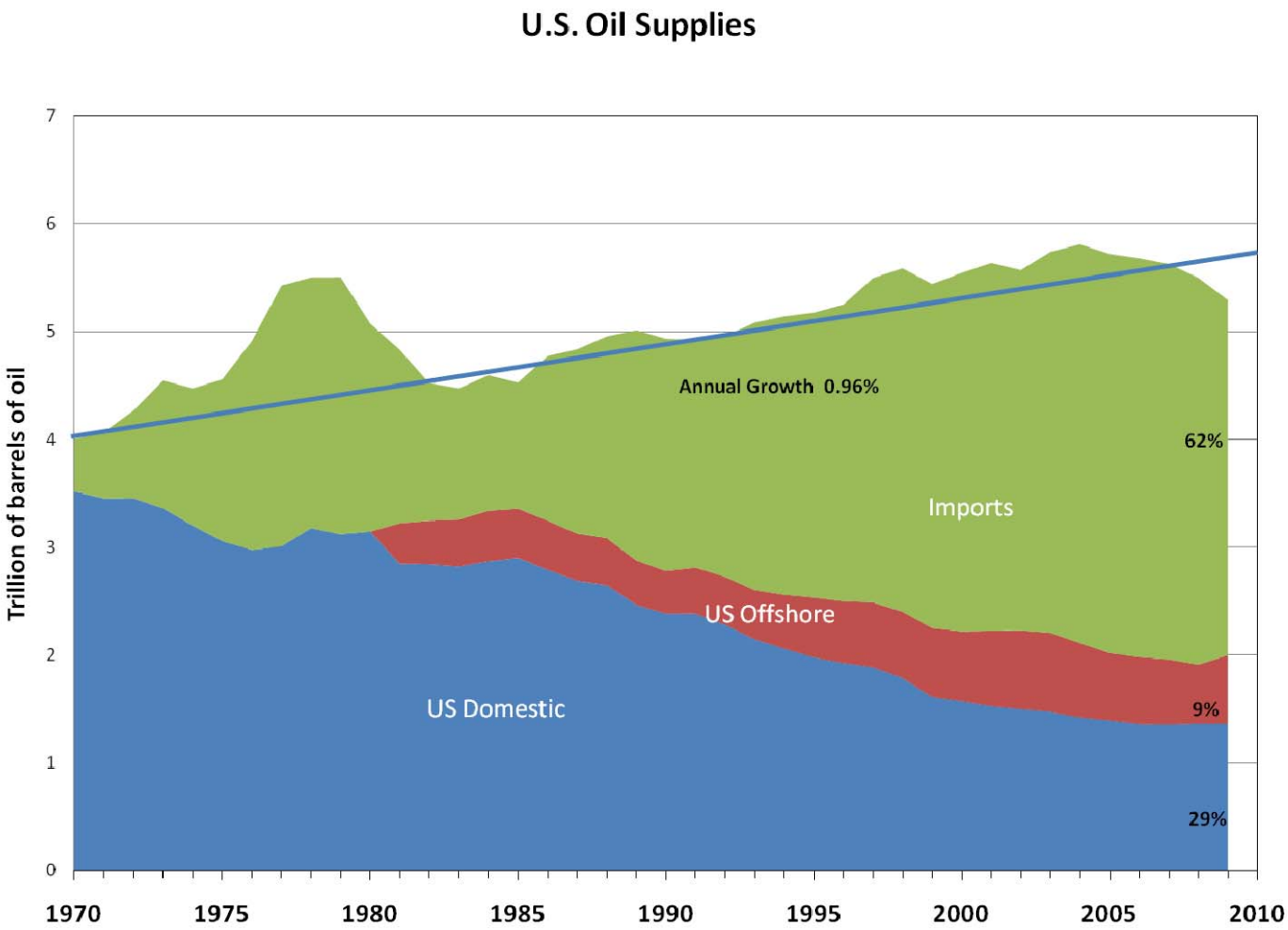
World oil prices may accelerate penetration of advanced technologies

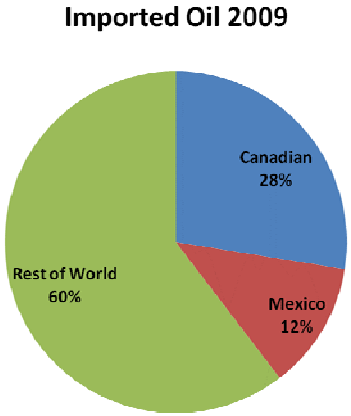


Allocated fairshare GHG emissions from on and off road applications (excludes planes, trains, and ships)



Alternative Fuels and Policies to date have had little impact on imports

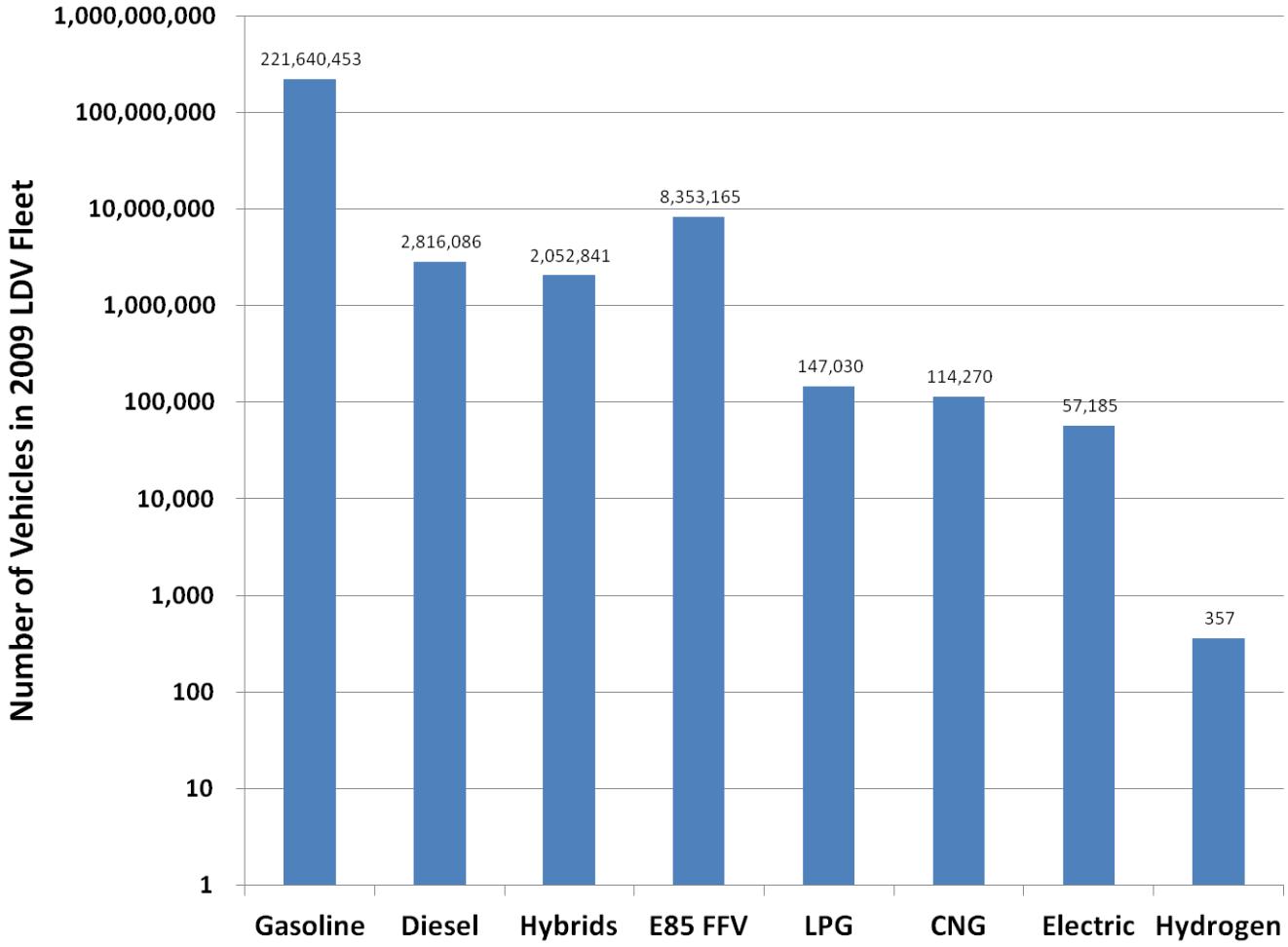




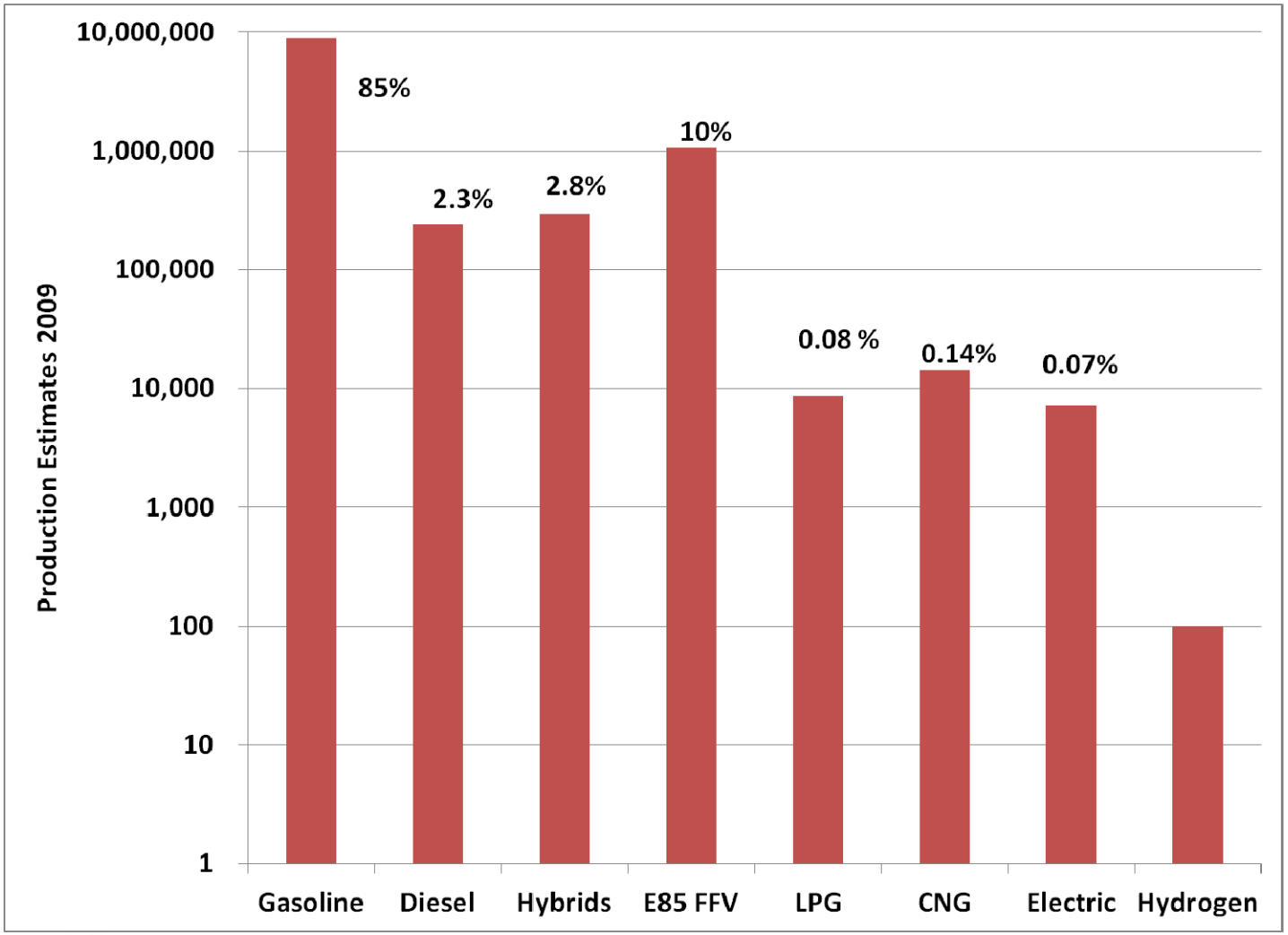
Fill and Go Alternative Fuel Strategies have been most successful

Alternative Fuel	2007 (thousand gge)	2008 (thousand gge)	2009 (thousand gge)
Liquefied petroleum gas	152,360	147,784	129,631
Compressed natural gas	178,585	189,358	199,513
Liquefied natural gas	24,594	25,554	25,652
E85	54,091	62,464	71,213
Electricity	5,037	5,050	4,956
Hydrogen	66	117	140
Biodiesel	367,764	324,329	325,102
Ethanol in gasoline	4,694,304	6,442,781	7,343,133

Advanced technology and alternative fuel vehicles populations still very low

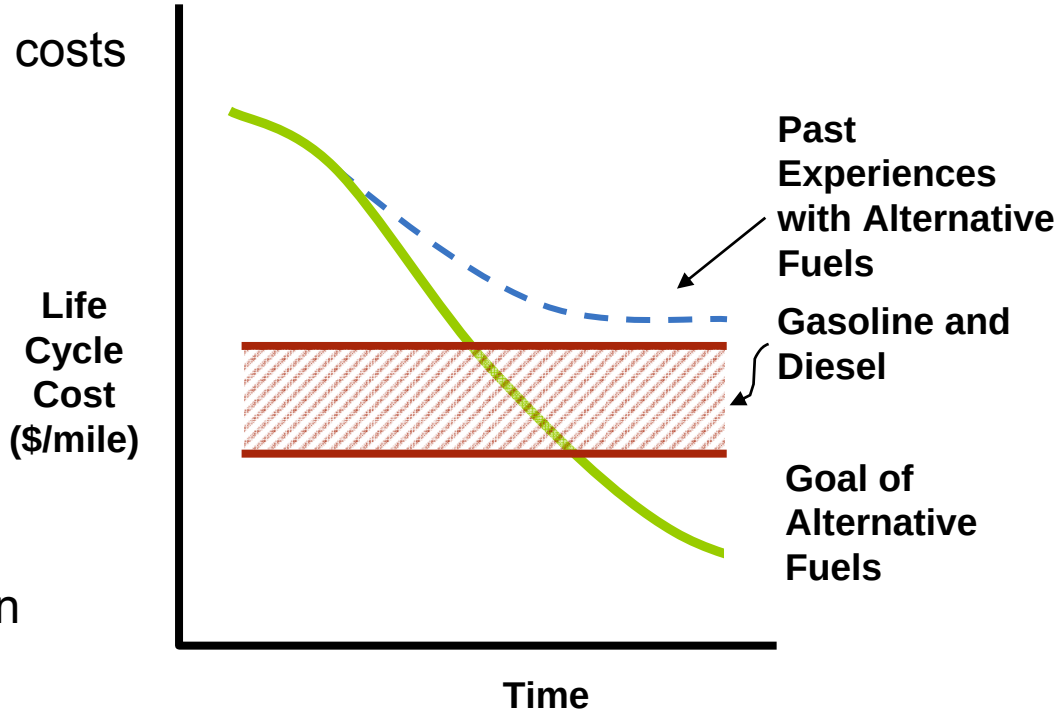


New LD vehicle sales also very small especially since fleet turn over 10+ years



Alternatives have to compete with conventional fuels and this has not been easy so far

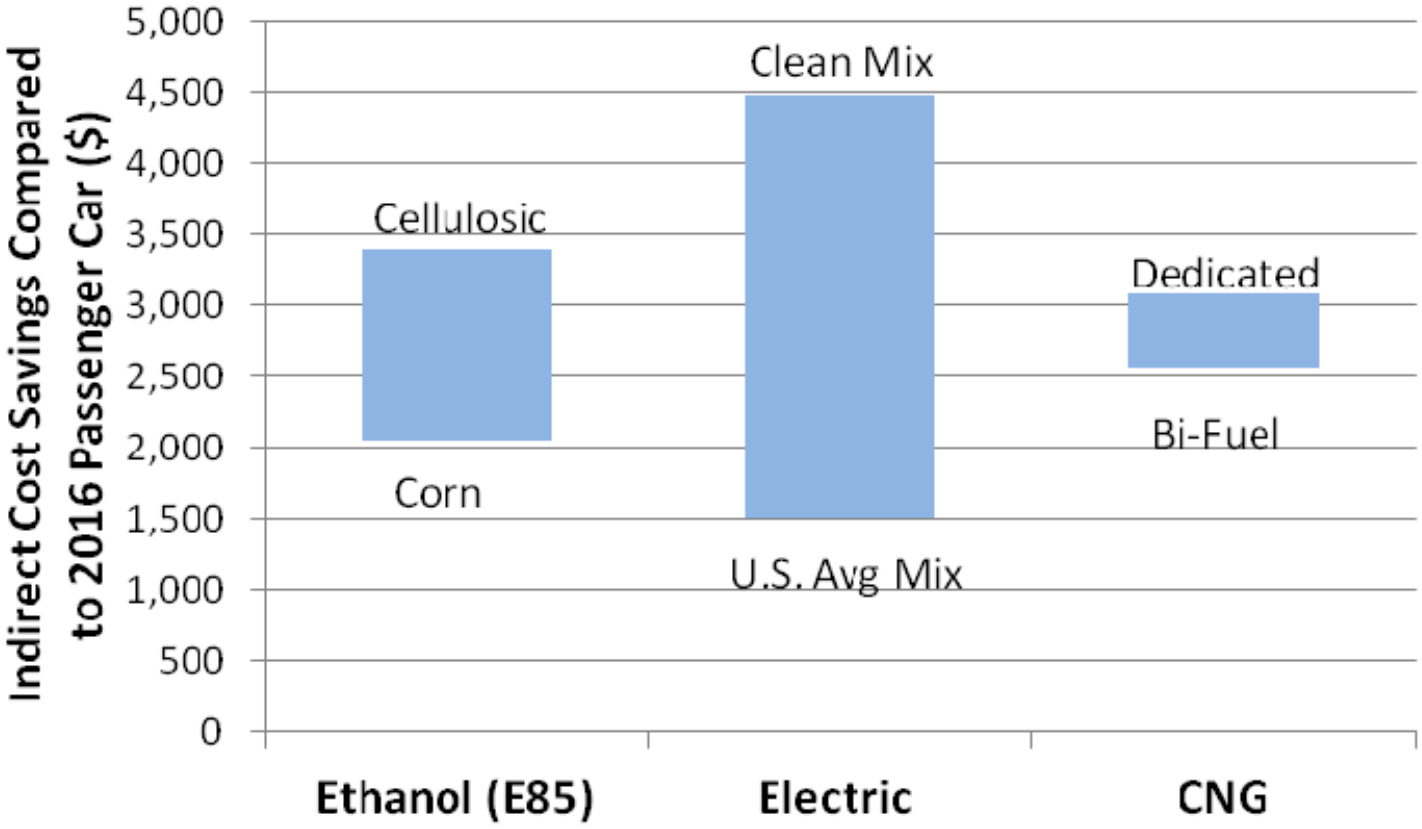
- User economics
  - Higher first costs
  - Lower fuel costs
  - Potentially lower lifecycle costs
- Vehicle attributes
  - Range
  - Performance
  - Space
  - Safety
  - Image
- Fueling infrastructure
  - Convenience and location
- Incentives
  - Financial, HOV, others



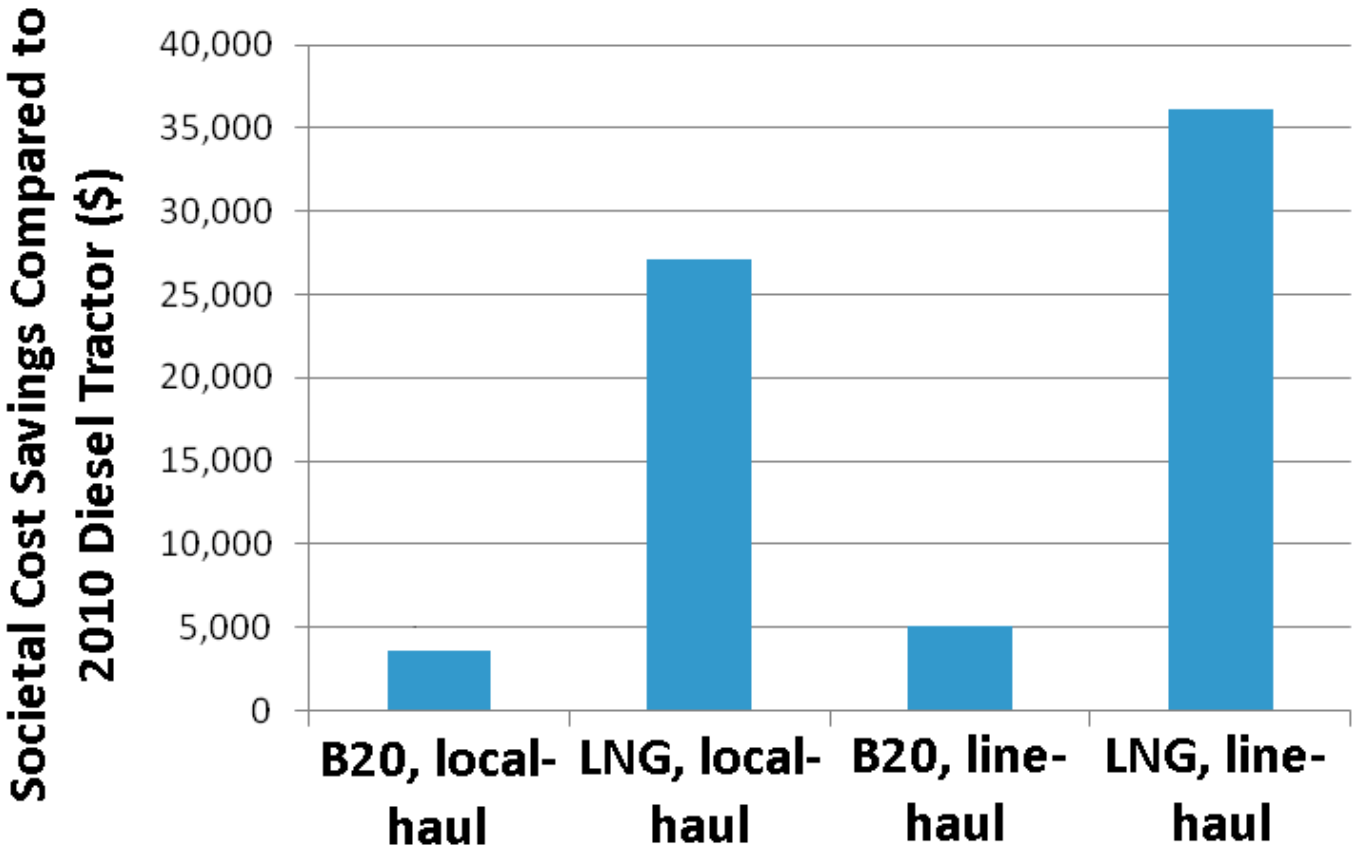
Regulations and policies have helped move alternative fuels and technologies into the market place

- Low level blend market most successful alternative fuel strategy
  - Values blend components at or greater than gasoline or diesel on a volume basis; alternative fuels do not have to complete on energy basis
  - Difficult to market as neat fuel on volume basis
- FFV CAFE incentives very successful at vehicle production (failure at decreasing gasoline use and increasing use of alternative fuels; need complimentary fuel sales requirements)
- Vehicle incentives have helped move advanced technologies into the market
  - HEV, PHEV, and BEV state and Federal tax credits
  - Moyer, Prop 1b and others based on societal benefits
- Infrastructure incentives have also been helpful
- Success of fleet rules depends on how rules structured
  - EPACT required only AFV not fuel use
  - SCAQMD 1190 rules required cleanest technologies and fuels (NGV)

Societal Costs of LDV alternative fuel options



Societal costs of HDV alternative fuel options



Alternative fuels and advanced technologies have to provide a value proposition to the consumer

- Have to have compelling case for saving money
  - Short payback or immediate savings
- Little or no compromises on vehicle attributes
- Convenient and accessible fueling infrastructure
- Incentives helpful early on but not sustainable
- Vehicle mandates/requirements (fleet rules) must integrate both vehicles and fuels

Thank You For Your Attention

Contact Michael D. Jackson
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