



California Alternative Fuels Plan



Presented at



**National NGV Conference-Summit
October 15, 2007**

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Full Fuel Cycle Analysis

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Closing Comments

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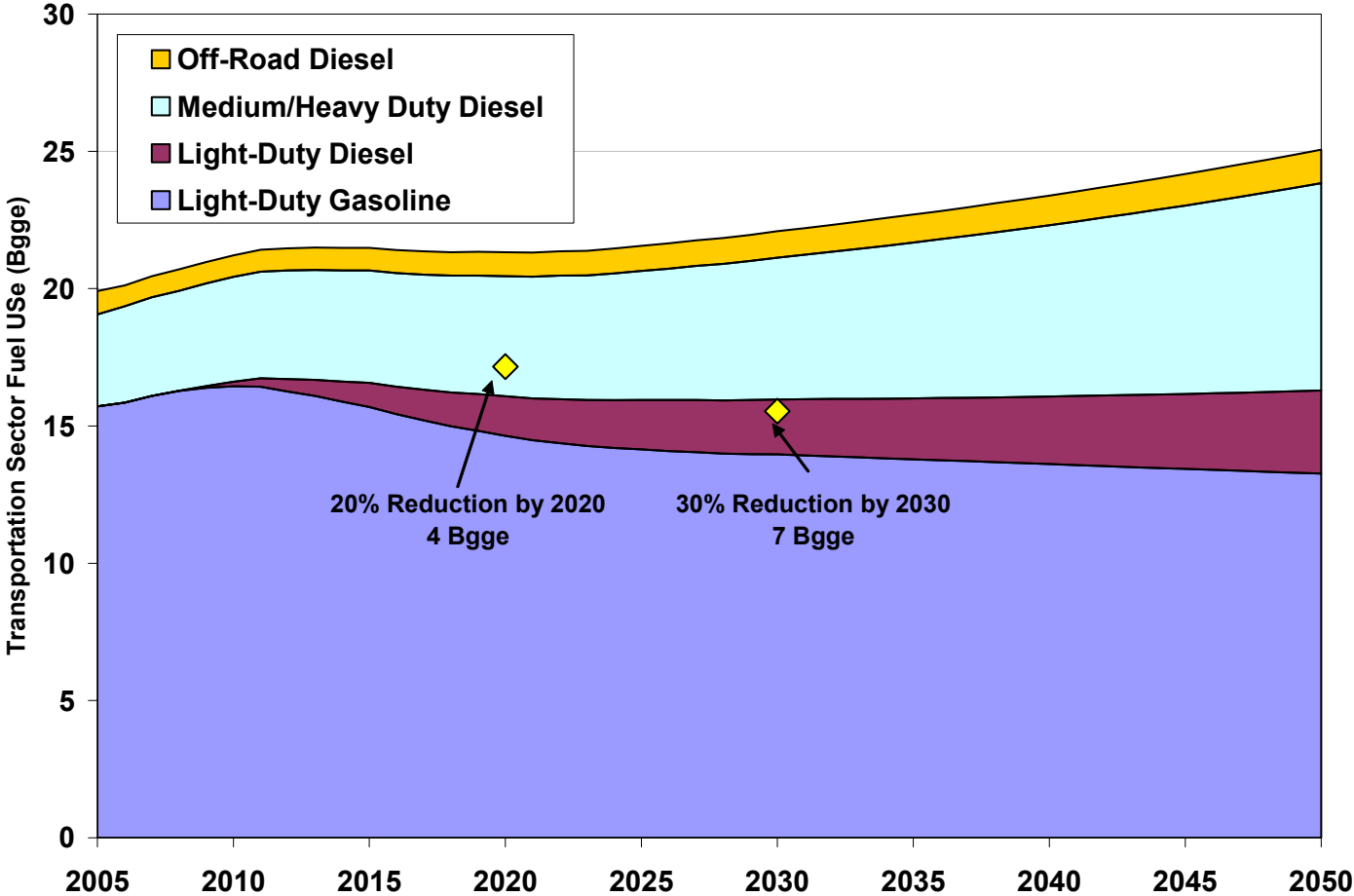
In Assembly Bill 1007 (Pavley) the California Legislature stated:

- The production, marketing, distribution, and use of petroleum fuels causes significant degradation of public health and environmental quality
- Clean alternative fuels have the potential to considerably reduce these impacts and are important strategies to attain air and water quality goals
- Research, development, and commercialization of alternative fuels have the potential to strengthen California's economy by providing job growth and helping to reduce the state's vulnerability to petroleum price volatility
- CEC and ARB recommended in their report to legislature—"Reducing California's Petroleum Dependency"—that the state adopt a goal of 20% nonpetroleum fuel use in 2020 and 30% by 2030

CEC-ARB Petroleum Dependency Study (AB2076) also suggested:

- Reducing petroleum demand by 15% below 2003 level by 2020 (reduce to 15.3 billion gge or a reduction of 2.7 billion gge)

Demand for gasoline and diesel for on and off road applications



California's Climate Change Policy Goals

- The California Global Warming Solutions Act of 2006 (AB32) + EO S-03-05
 - Transportation “fairshare” reductions
 - 1990 estimated GHG emissions 149 million metric tons (MMT) CO₂ e
 - 2000 estimated GHG emissions 163 MMT CO₂ e
 - Transportation reduction goals
 - 2010 reduce to 2000 level; reduction of 32 MMT CO₂ e
 - 2020 reduce to 1990 level; reduction of 68 MMT CO₂ e
- Governors Executive Order S-03-05
 - 2050 reduce 80% below 1990 level: reduction of 253 MMT CO₂ e from transportation using fairshare principle

Other California Climate Change Vehicle and Fuel Standards

- California Regulations to Control Greenhouse Gas Emissions from Motor Vehicles (AB1493, Pavley)
 - 34% reduction in CO₂ e in PC/LDT1 by 2016
 - 25% reduction in CO₂ e in LDT2 by 2016
 - Reduces GHG emissions by 28.9 million metric tons (MMT) in 2020 and 51.2 MMT in 2030
 - Includes both advanced ICE and alternative fuels technologies
- Low Carbon Fuel Standard, LCFS (Governor's Executive Order S-01-07)
 - 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

ARB has started the LCFS rule making process

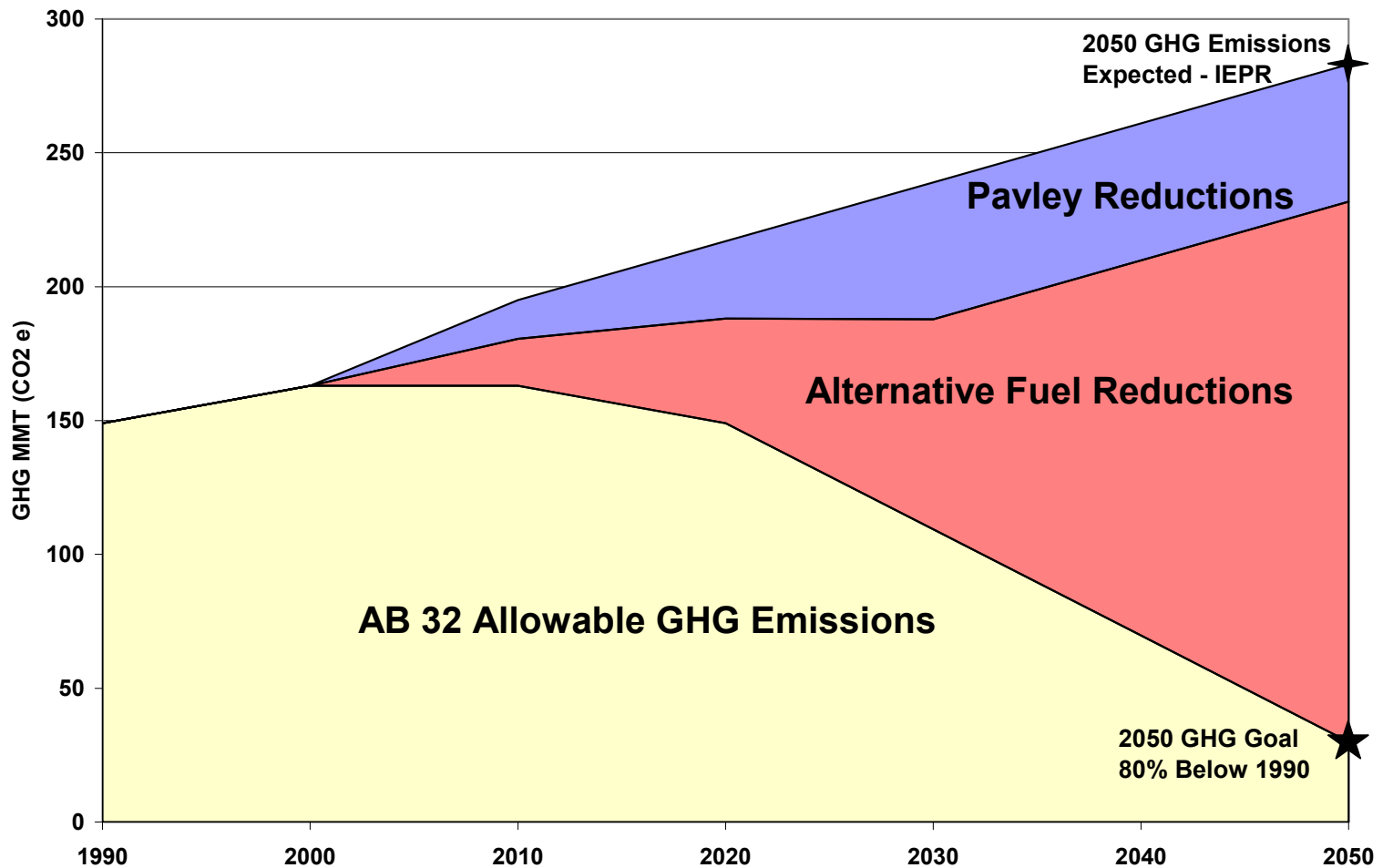
Global Warming Intensity

- Total effect on climate change
- Greenhouse gas emissions (CO₂, N₂O, black carbon, etc.)
- Other effects due to land use change
- Some effects are uncertain and variable (more research is needed!)
- Unit is grams of carbon dioxide equivalent per mega-joule of energy in the fuel (**gCO₂e/MJ**)

Adjusted for inherent drivetrain differences

- Gasoline = 1.0 by definition
- CNG = 0.67
- Electricity = 0.20
- Hydrogen (FC) = 0.48

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



Bioenergy Action Plan requires percentage of biofuels used be produced in state

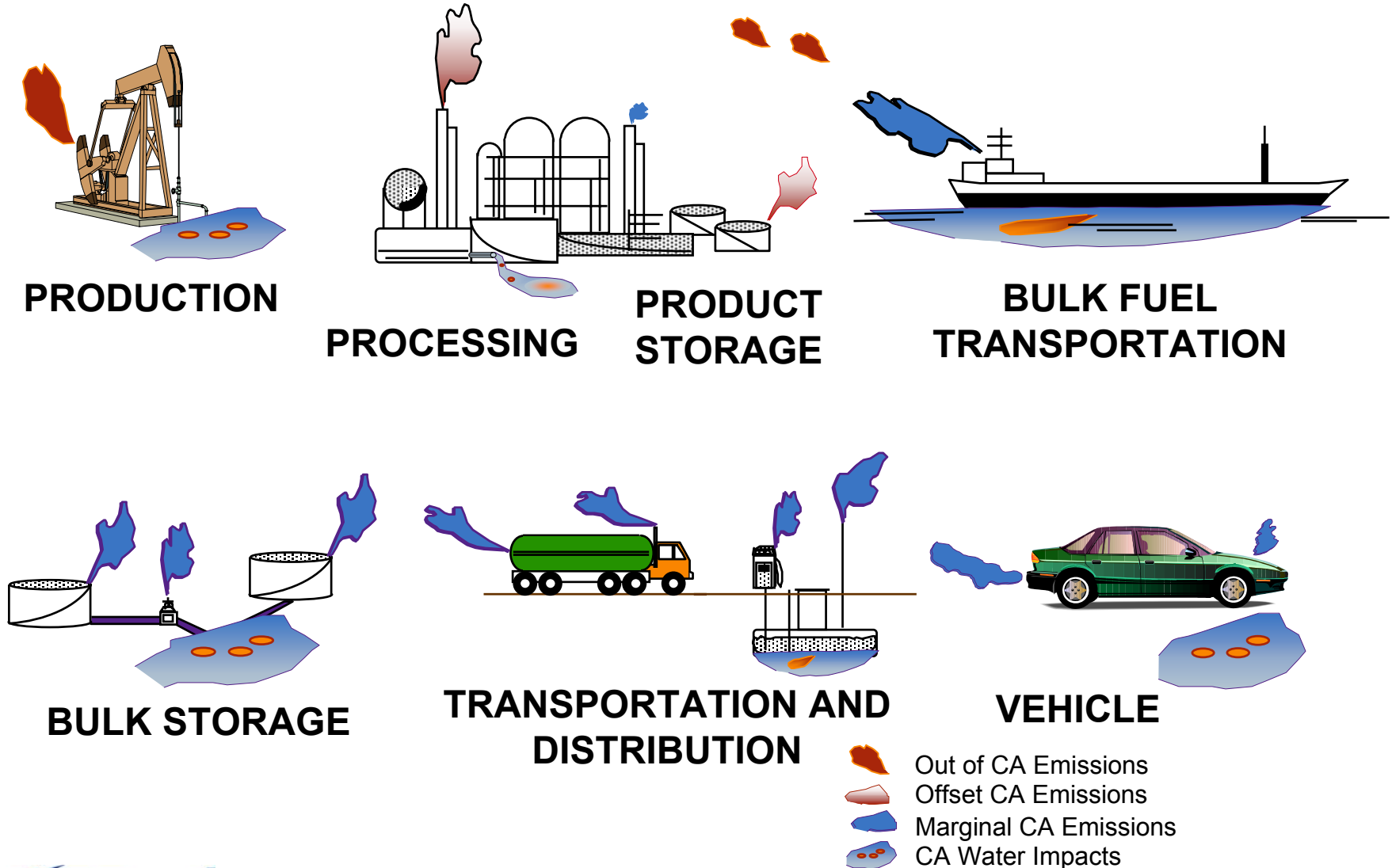
- Bioenergy Action Plan (Executive Order S-06-06, April 25, 2006)
 - State shall produce a minimum of
 - 20% of its biofuels within California by 2010
 - 40% by 2020
 - 75% by 2050
 - For biomass for electricity, the state must meet a 20% target within the established state goals for renewable generation for 2010 and 2020

AB 1007 requires CEC, in cooperation with ARB and other state agencies, to develop and adopt a state plan to increase the use of alternative transportation fuels

- One component of the plan is a **full fuel cycle assessment** of alternative transportation fuels considering emissions of:
 - Criteria air pollutants
 - Air toxics
 - Greenhouse gases
 - Water pollutants
 - Other substances that are known to damage human health
- “Alternative fuel” means a nonpetroleum fuel, such as electricity, ethanol, biodiesel, hydrogen, methanol, or natural gas
- The plan shall set goals for 2012, 2017, and 2022 (CEC and ARB added 2030 and 2050)

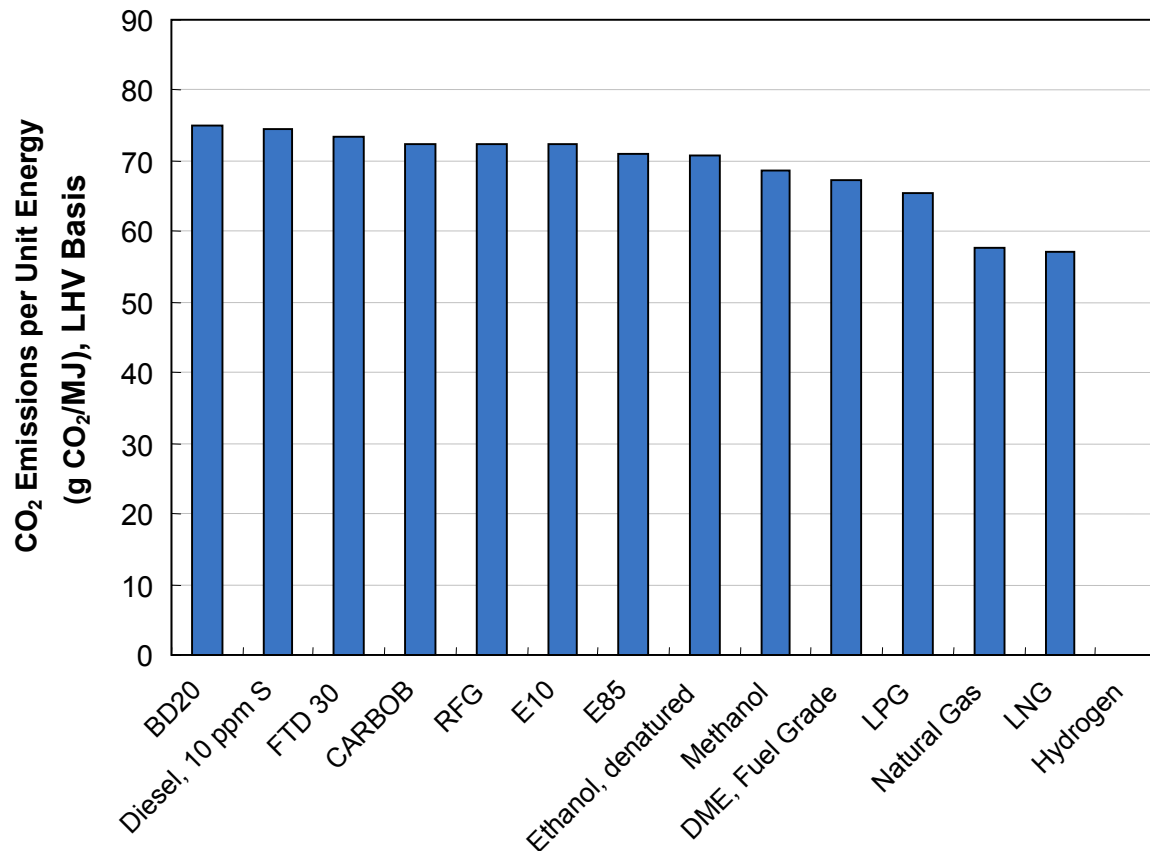
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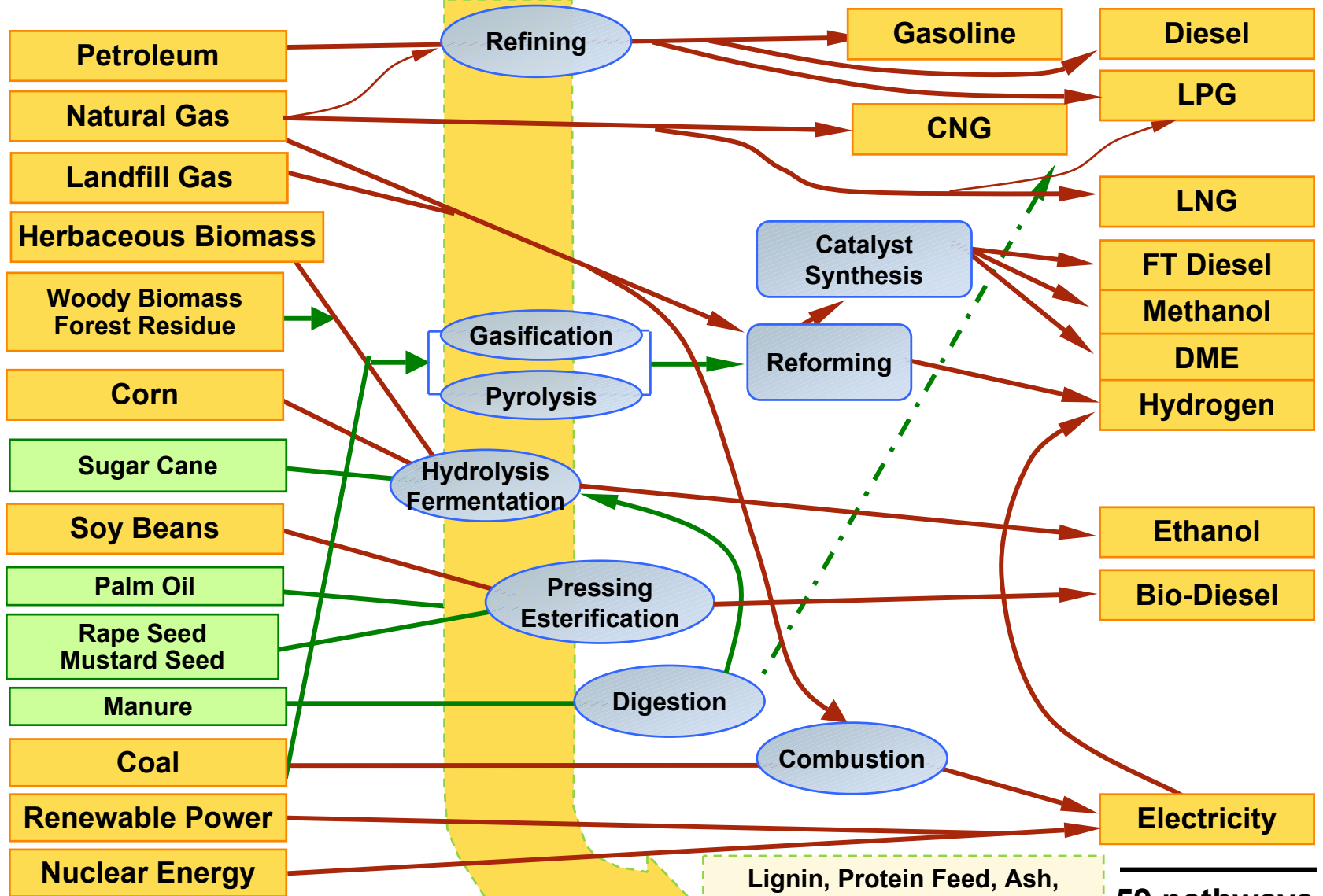
Number of emission events throughout fuel cycle



Alternative fuels have lower carbon content in fuel relative to heating value and result in lower CO₂ emissions

- Need to account for fuel cycle and vehicle energy use in comparing CO₂ emissions





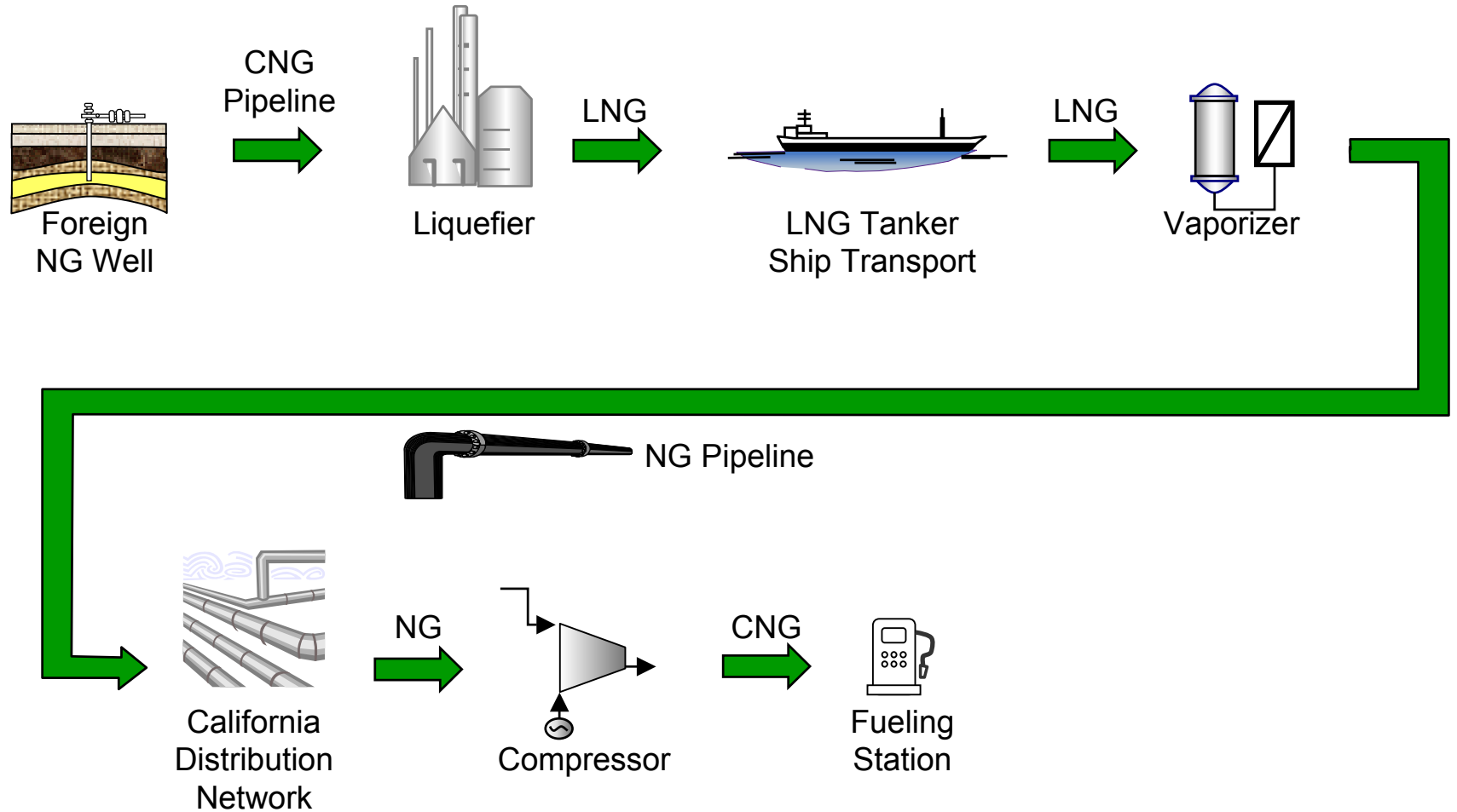
Lignin, Protein Feed, Ash,
Silica, Metals, Edible oils, Pet.
Coke, Waste Heat

59 pathways

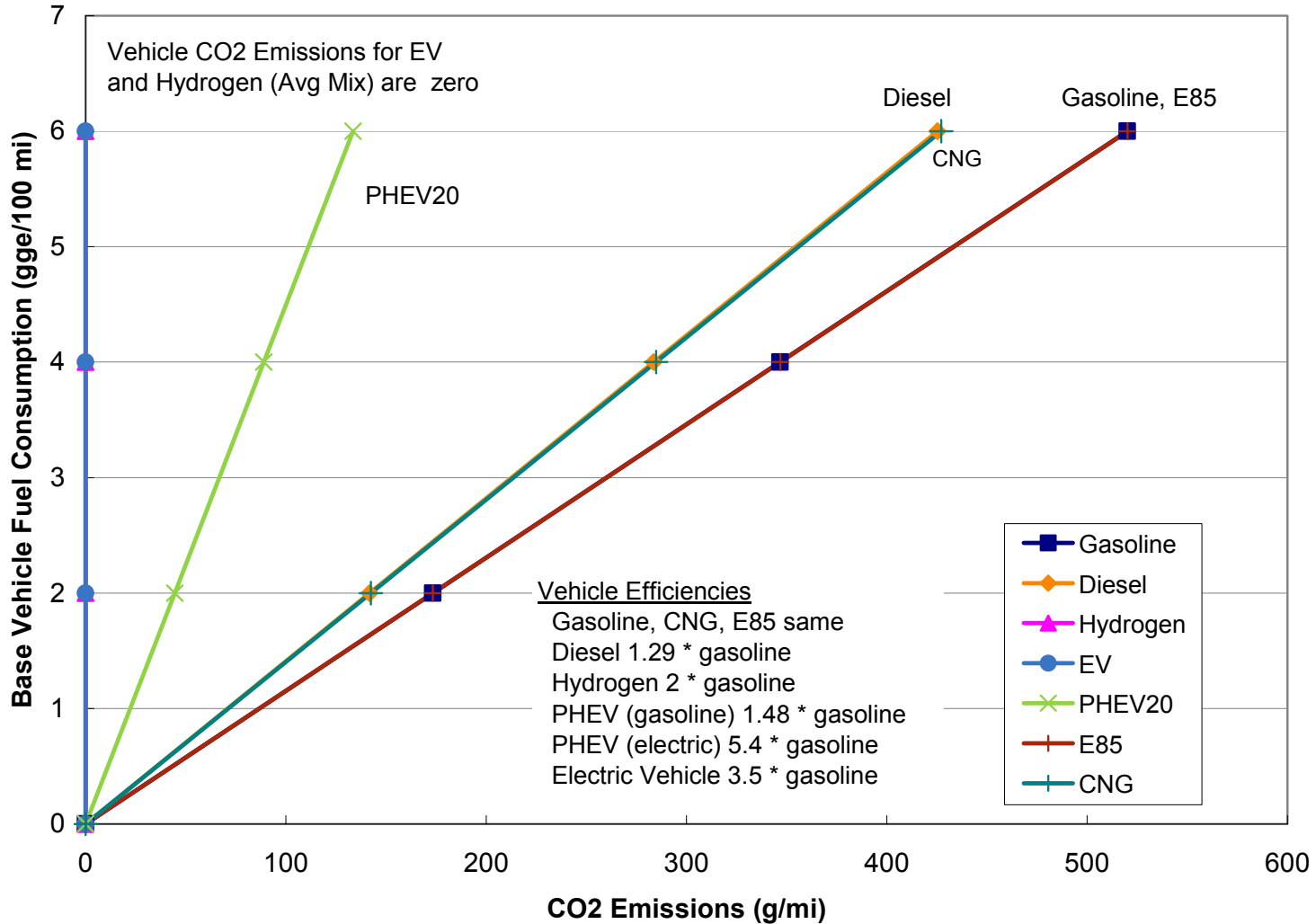


Existing GREET pathway
New pathway

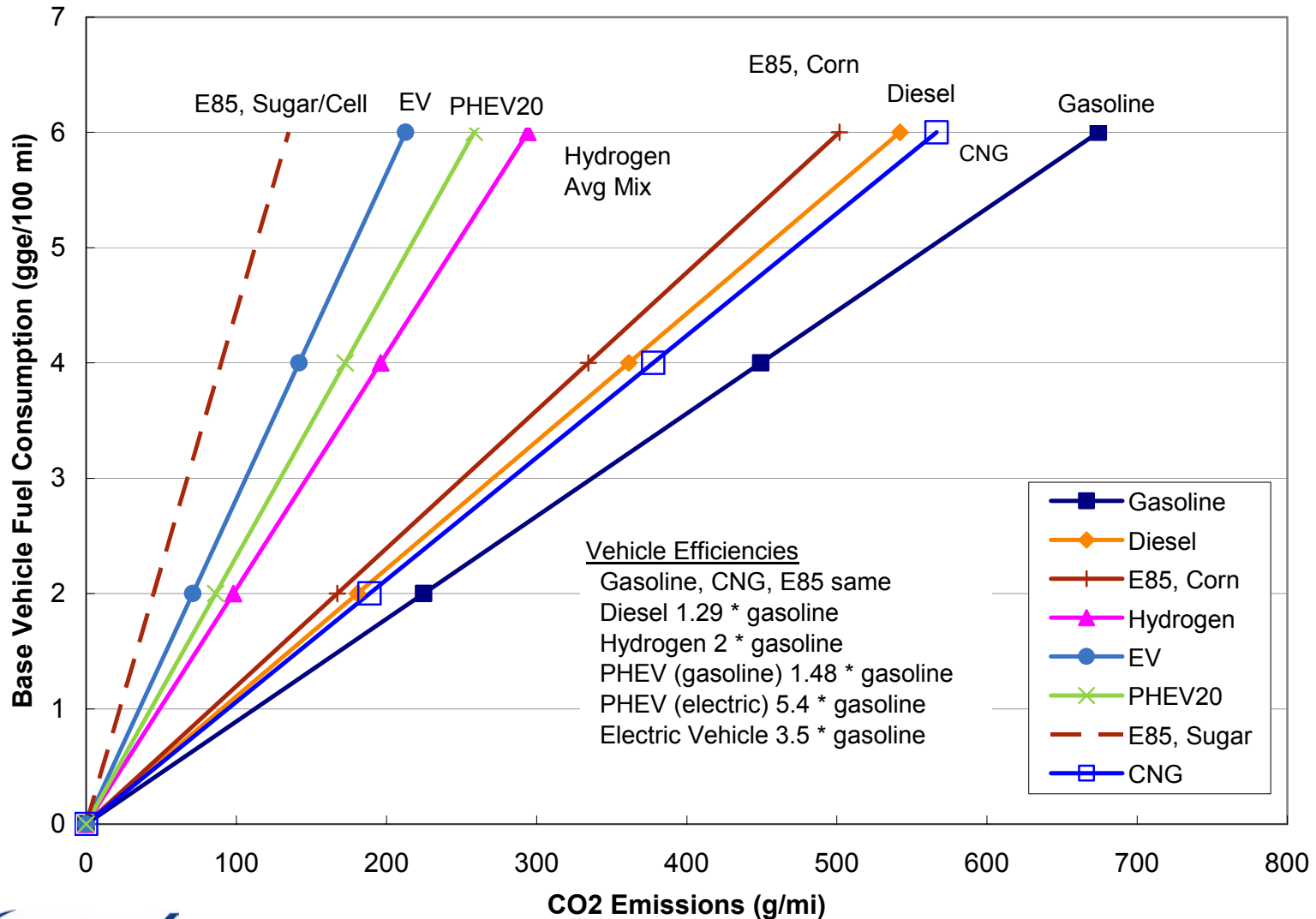
Imported LNG from Remote Natural Gas to CNG



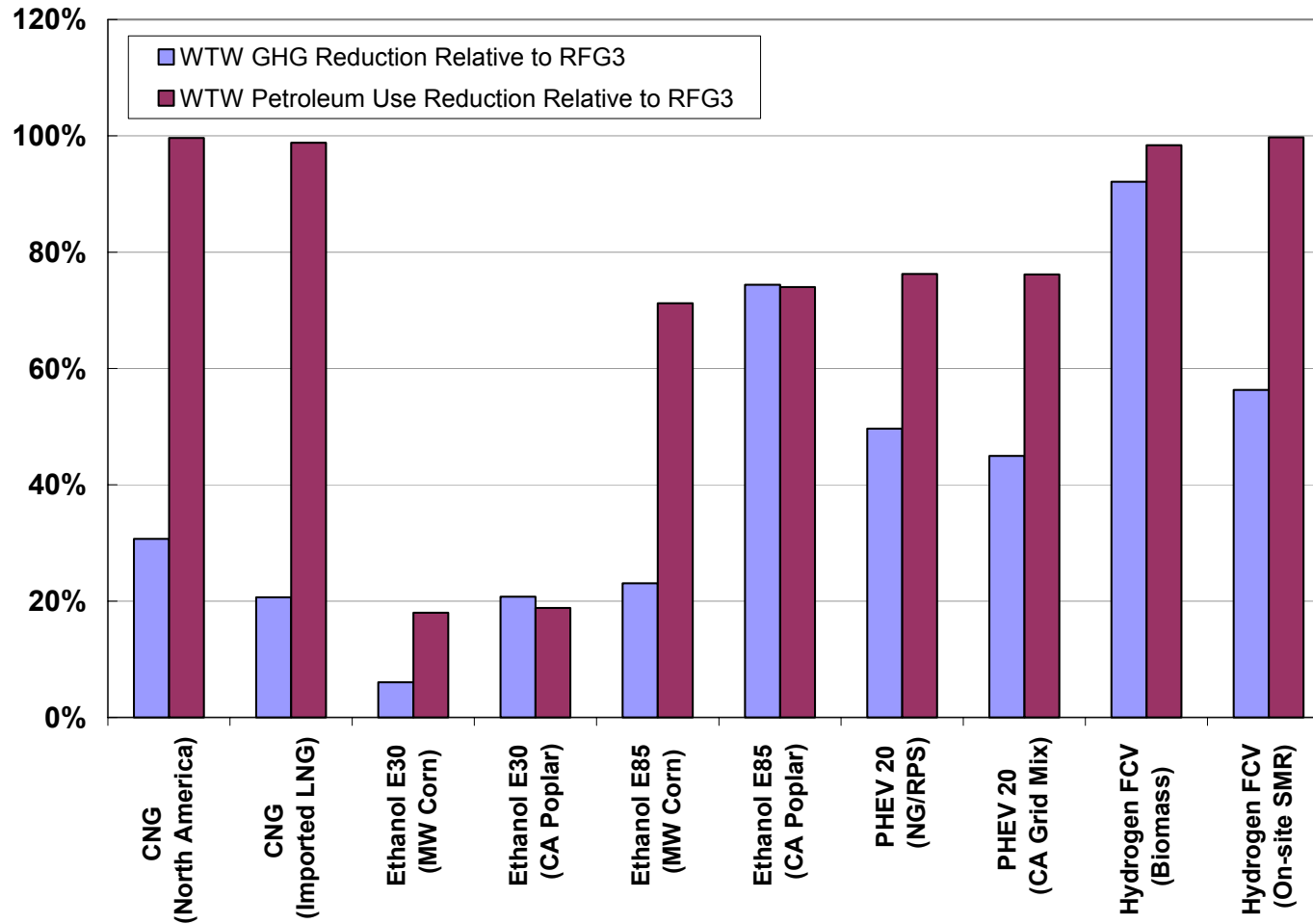
Vehicle CO₂ Emissions vs. Fuel Consumption (equiv gasoline gals/100mi)



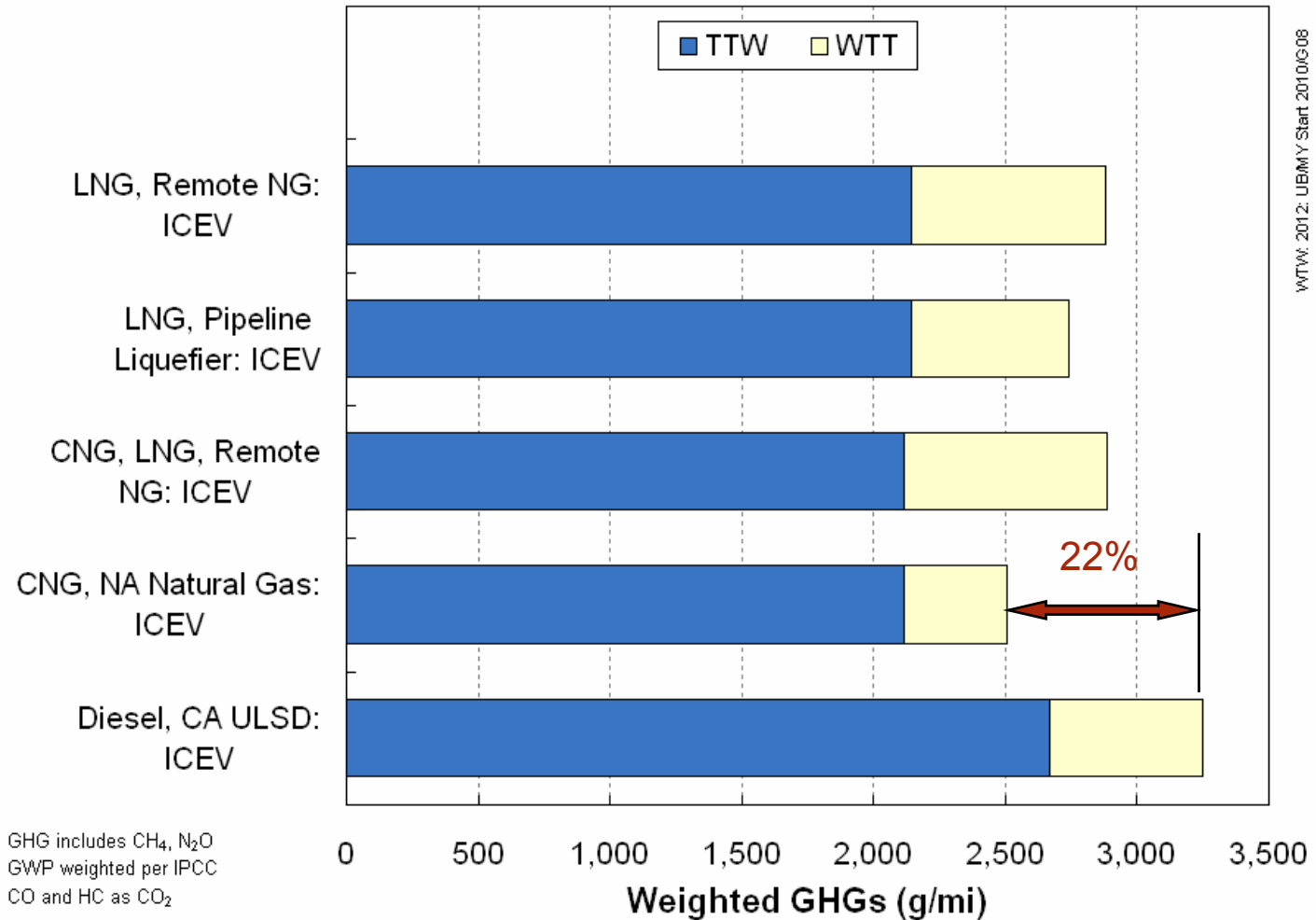
Total CO₂ Emissions vs. Fuel Consumption (equiv gasoline gals/100mi)



GHG and petroleum reduction for light duty vehicles

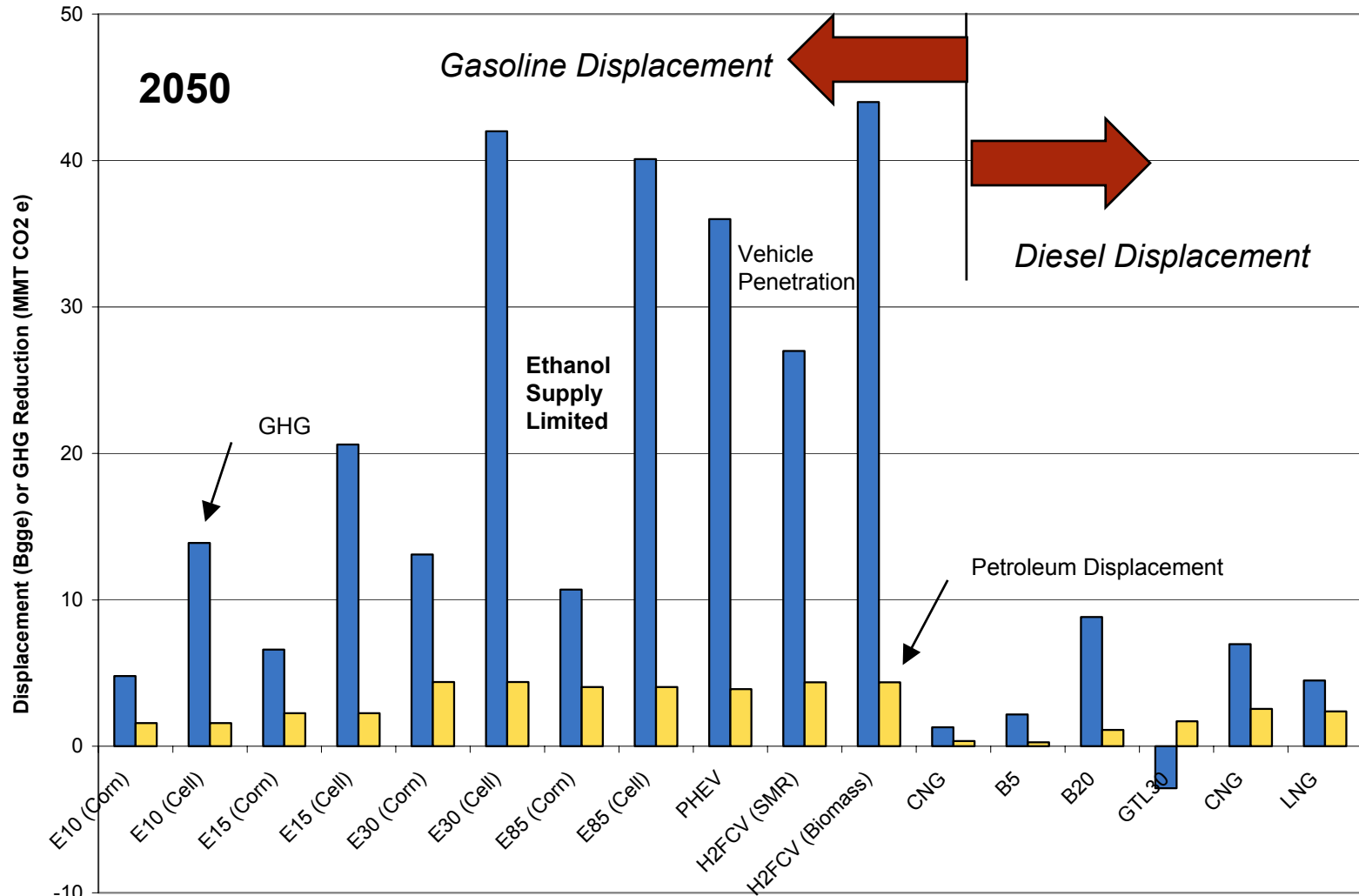


Comparison of WTW GHG Emission for Transit Buses



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Gasoline strategies have higher overall leverage than diesel strategies



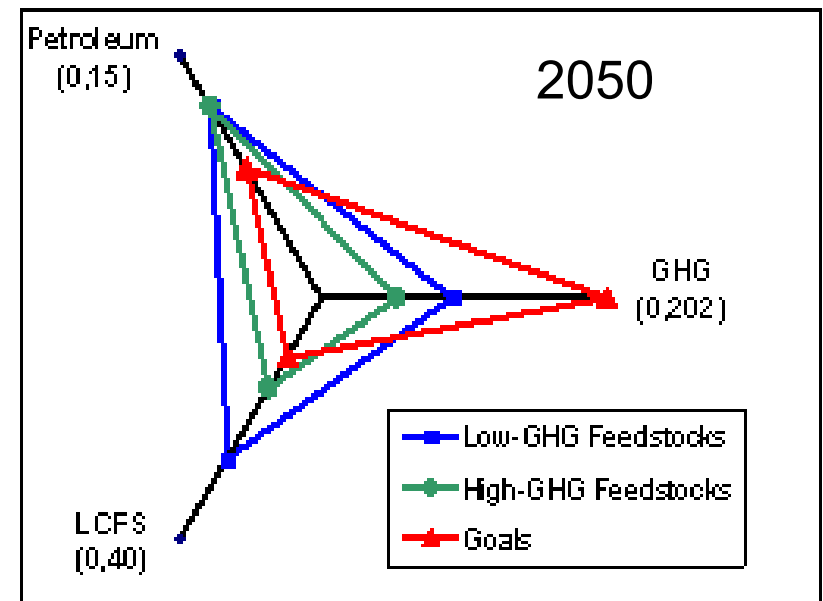
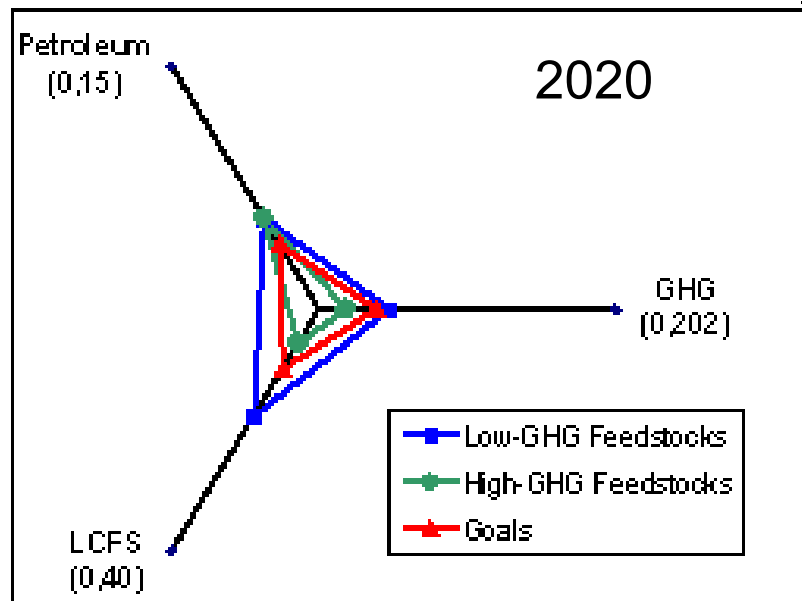
Combination of strategies need to meet policy goals

- Efficiency
- Biofuels
 - Blends: ethanol, biodiesel, biomethane, and others
 - Neat fuel use
- Alternative fuel technologies
 - Natural gas and propane
 - Electric drive technologies
 - PHEVs
 - Hydrogen Fuel Cells
- Land Use and VMT (vehicle miles travel) reduction

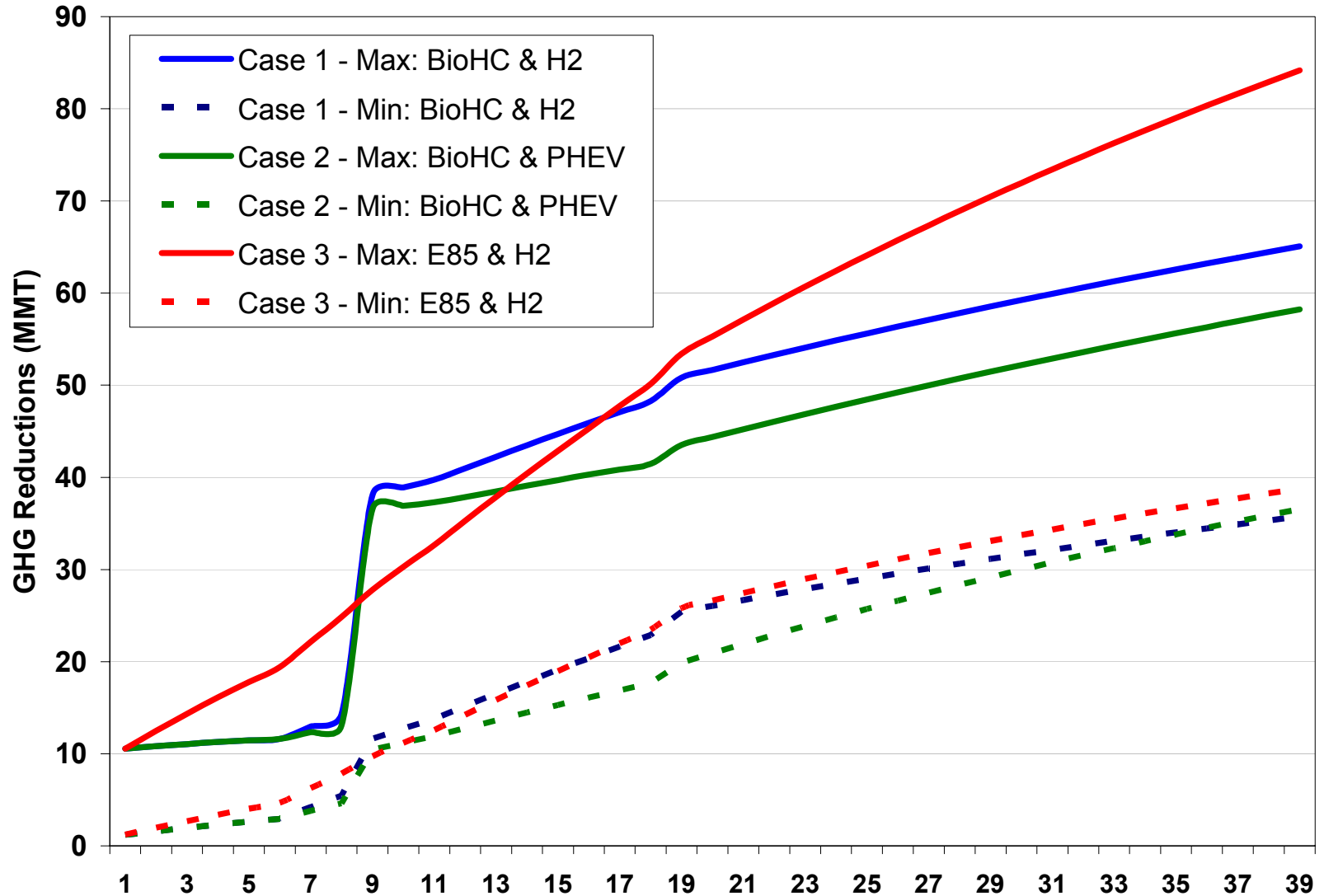
Biohydrocarbon Fuel Cell Strategy

Year	Petroleum Displacement (Bgge)		GHG Reduction ¹ (MMT)		LCFS (% Carbon Intensity)	
	Goal	Scenario	Goal	Scenario	Goal	Scenario
2012		1.8		4 - 14		1.1 - 5.3
2020	4	4.6	39	16 - 36	10	4.7 - 13.0
2030	6	9.0		38 - 70		10.4 - 23.4
2050		13.6	202	56 - 111		15.8 - 34.9

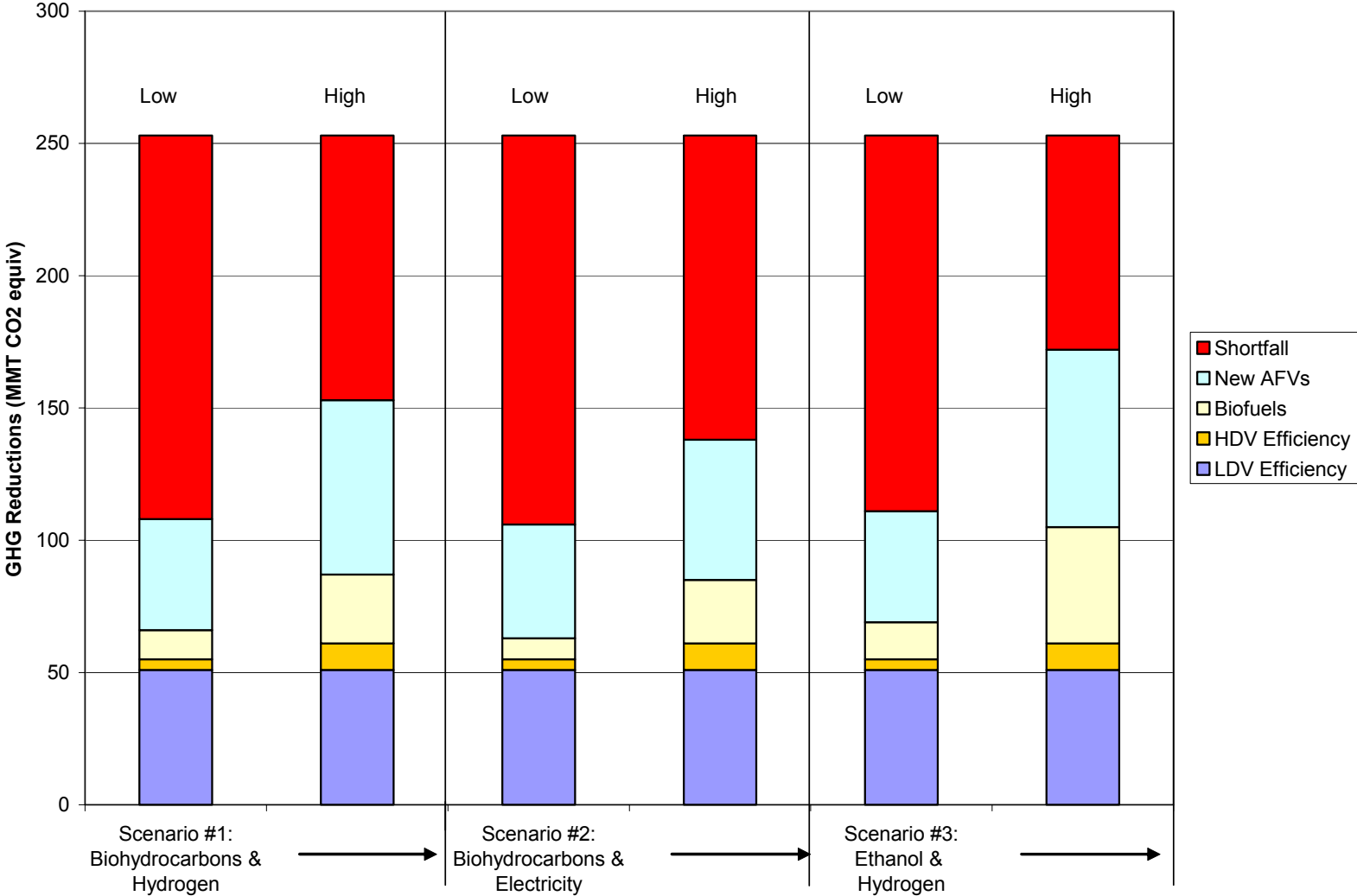
¹. AB 32 and EO less Pavley



Comparison of GHG reduction for biofuels and electric drive scenarios



Possible GHG reductions in 2050 compared to goal



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Combination strategy is needed to come close to achieving all policy goals

- Alternative fuels plan needs to include
 - Gasoline and diesel biofuels blend strategies
 - Introduction of new alternative fueled vehicles for light duty vehicles
 - Use of natural gas, propane, and electric drive technologies in cost effective market segments
 - Continued use of diesel and gasoline fuels in light and heavy duty applications but at much lower demand (improved efficiency)
- Biofuels
 - Up to 6 billion gallons of biofuels blended in gasoline or used as combination of E10 and E85 (3 billion gallons from in-state production)
 - Up to 276 million gallons of biodiesel blended in ULSD (B5 to B20)
- New alternative light duty vehicles
 - E85 FFVs (competes with ethanol blends)
 - PHEVs and FCVs (many many tradeoffs; one winner or both?)

Combination strategy is needed to come close to achieving all policy goals (continued)

- High fuel use markets will require support to maintain product and low cost products
 - Higher cost technologies but fuel savings for generally lower life cycle costs
 - Need to keep OEMs in market to effectively capture market
 - OEMs will need support to develop new products with the latest technology
 - Conversely will have to provide incentives to offset higher costs of conversions
- Need to get low GHG systems into market as fast as possible
 - Blends easiest
 - All other strategies require roll out of new vehicles (and in case of alternative fuels new infrastructure)

Thank you for your Attention

