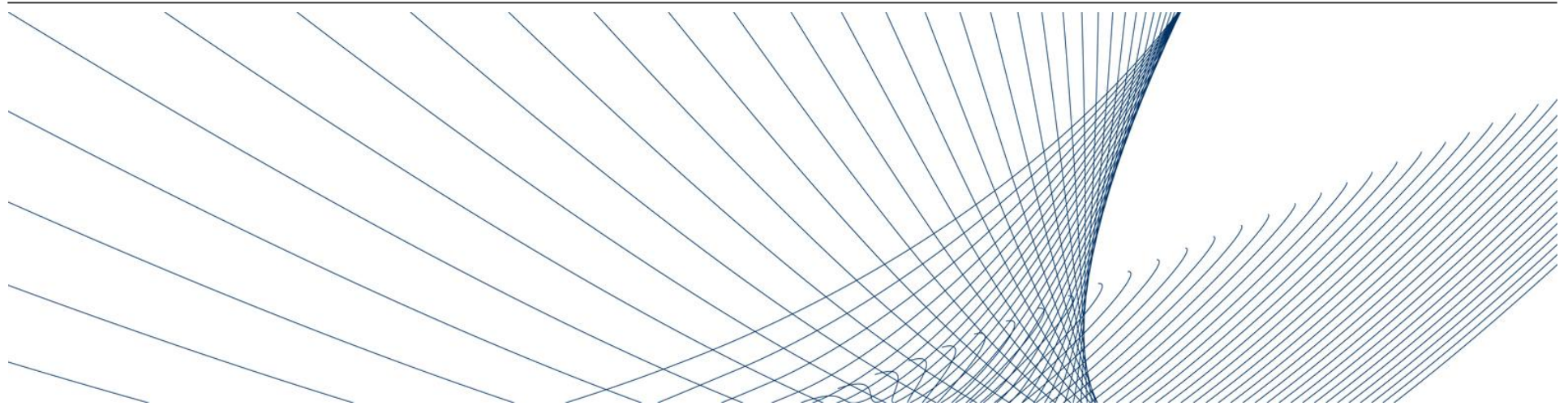


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Future Directions in Engines and Fuels

Department of Energy DEER Conference

Presented by Stuart Johnson, Engineering and Environmental Office

September 28, 2010

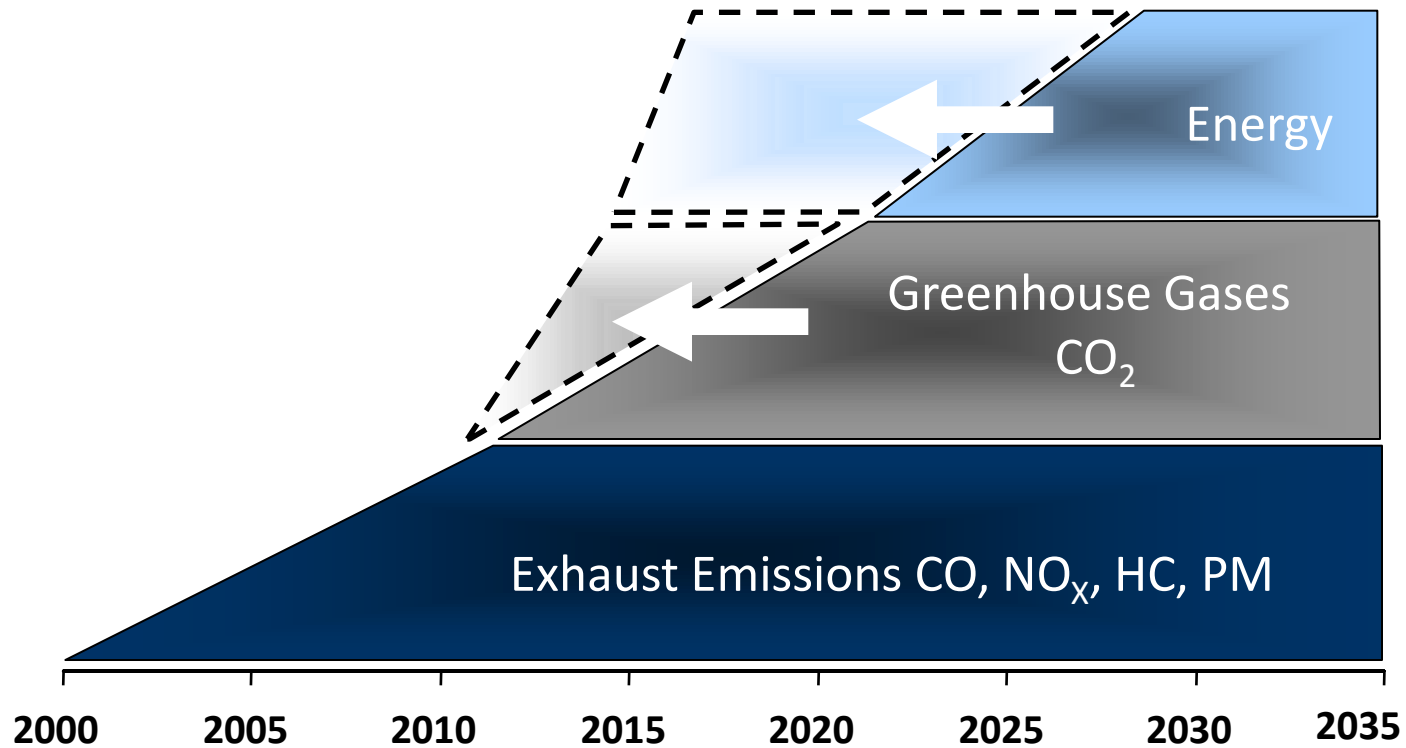
Future Direction in Engines and Fuels

Agenda

- **Introduction**
- **Industry Challenges**
- **Engine Technologies**
 - **Diesel**
 - **Gasoline**
 - **Fuels**
 - **Hybrids**
- **Conclusions**

Future Direction in Engines and Fuels

Introductory Slide



Future Direction in Engines and Fuels

Mobility Industry Challenges – Criteria Emissions

- **Agencies (EPA, CARB) expected to significantly lower emission standards**
 - **California: LEV III**
 - **SULEV (Tier 2, Bin 2) fleet average**
 - **Reduces HC, CO NOx, PM levels**
 - **Zero evaporative emissions**
 - **Lower full useful life off-cycle standards (SFTP)**
 - **EPA expected to set a similar regulation**
 - **Tier 3**
 - **Future advanced combustion engines expect to comply**
 - **Both diesel and gasoline concepts**
 - **LEV III, Tier 3 could be the last set of traditional emission standards**

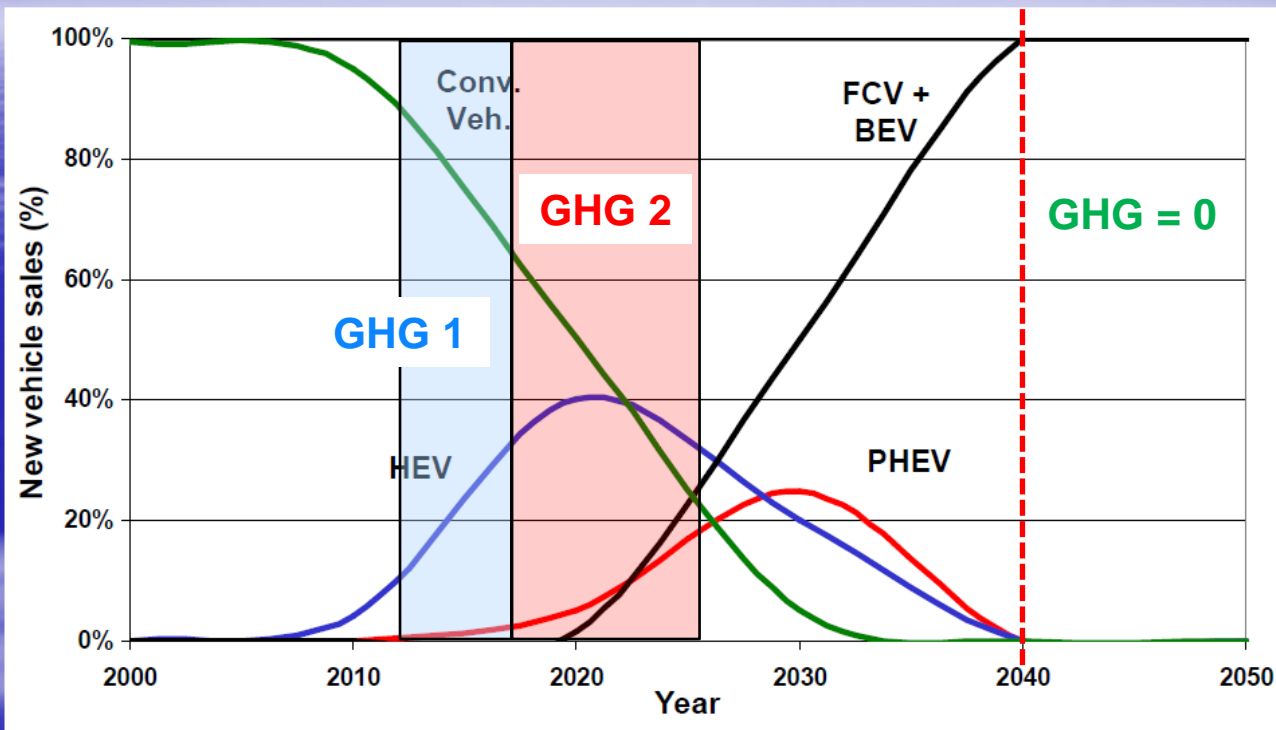
- **Future regulatory focus has shifted away from criteria pollutants towards energy issues (policy, security, climate change)**

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Mobility industry Challenges – CARB GHG Scenario

Path to 2050

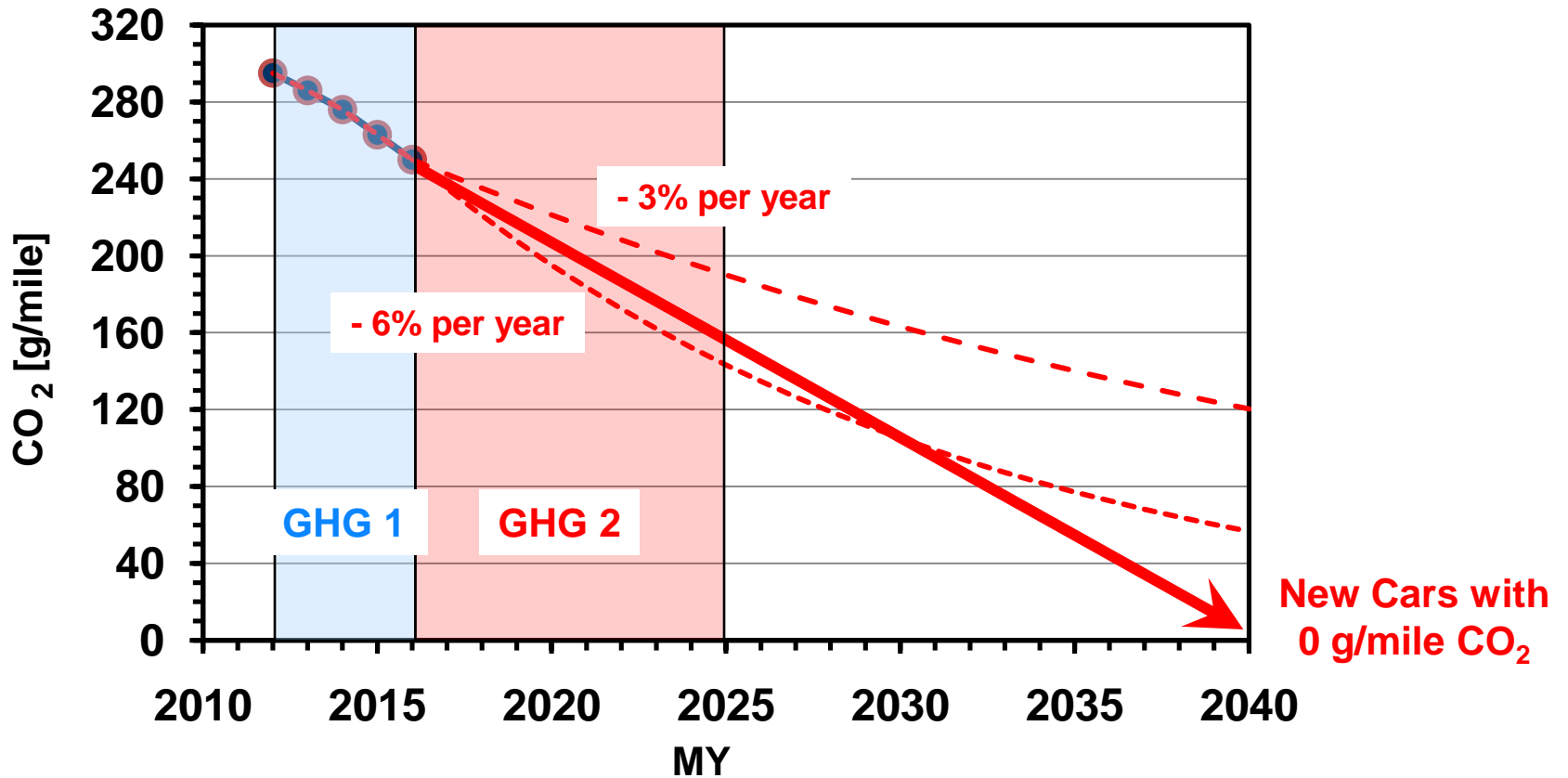
New Passenger Vehicle Sales (Auto only) – Scenario 2



ZEV sales reach 100% by 2040, but on-road fleet is still mixed:
ZEVs are 87% of on-road fleet in 2050

Future Direction in Engines and Fuels

Mobility Industry Challenges – Potential California GHG CO₂ Targets



New Direction in Engines and Fuels

Industry Mobility Challenges – NGO Press Campaign

NRDC Supports 60 mpg Fuel Efficiency Standard by 2025

WASHINGTON (September 2, 2010) -- The Consumer Federation of America released a report today recommending the Obama administration establish a 60 miles-per-gallon fuel efficiency standard for cars by 2025. (...)

The following is a statement from NRDC's Transportation Director Roland Hwang:

“CFA’s analysis clearly shows that raising fuel efficiency standards to 60 miles per gallon is good for consumers’ pocketbooks. Making cars and trucks go farther on a gallon is the cleanest, cheapest and fastest way to meet our energy needs and will help break the country’s addiction to oil.

Without stronger standards, American automakers could fall behind in the global race for the clean car market, putting even more manufacturing jobs at risk. Achieving 60 mpg by 2025 can be done using and improving technologies that already exist, such as hybrid electric cars and electric vehicles. We have learned from cell phones, microwaves, and computers that higher volumes can lead to dramatic improvement in innovation and driving down costs. Raising standards to 60 mpg is good for consumers, good for the environment and good for jobs.”

The Natural Resources Defense Council is a national, nonprofit organization of scientists, lawyers and environmental specialists dedicated to protecting public health and the environment. Founded in 1970, NRDC has **1.3 million members** and online activists, served from offices in New York, Washington, Chicago, Los Angeles, San Francisco and Beijing.

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Focus on Efficiency/GHG – Engine/Fuel Technology

- **Advanced combustion concepts will focus on efficiency**
 - **Significant CO2 reductions are still possible**
 - **Diesel and GDI (Gasoline Direct Injection)**
 - **Downsized displacement**
 - **Fewer cylinders**
 - **Optimized charging**
 - **Reduced friction**
 - **Improved fuel Injection**
 - **Variable valve timing**
 - **Variable valve lift**
- **Low carbon fuels will also play an important role**
 - **Liquid fuels make the most sense for a light-duty vehicle**
 - **Energy density, range**
 - **Increased use of ethanol and biodiesel is certain**



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Hybridization

- **Significant electrification of the light-duty fleet inevitable**
 - **100% hybridization possible**
 - **Hybrid focus will be directed at GHG reduction, not criteria pollutant reduction**
 - **Appropriate hybrids will be developed for different markets**
 - **Brand image**
 - **Customers needs/expectations**
 - **Hybrids will cover the entire range**
 - **Stop/Start**
 - **Micro hybrids**
 - **Mild**
 - **Full**
 - **Plug-in**
 - **Three VW Group hybrids announced**
 - **2011 Touareg**
 - **2012 Audi Q5**
 - **2013 Jetta**

Future Direction in Engines and Fuels

Conclusions

- **Criteria pollutants essentially zero after LEV III, Tier 3 finalized and phased-in**
- **Future focus in on CO2 reduction, energy security**
- **Still significant CO2 reduction possible from combustion engines**
- **Liquid biofuels will play an important role in the light-duty section**
- **Electrification of the light-duty fleet inevitable with a wide range of hybrid configurations**
- **Government policy can greatly influence the introduction of hybrid concepts and the use of biofuels (treatment in future GHG regulations, for example)**

Future Direction in Engines and Fuels

Volkswagen Powertrain and Fuel Strategy

