

Diesel Engine Emissions Reduction 2006

Diesel Technology – Challenges & Opportunities for North America

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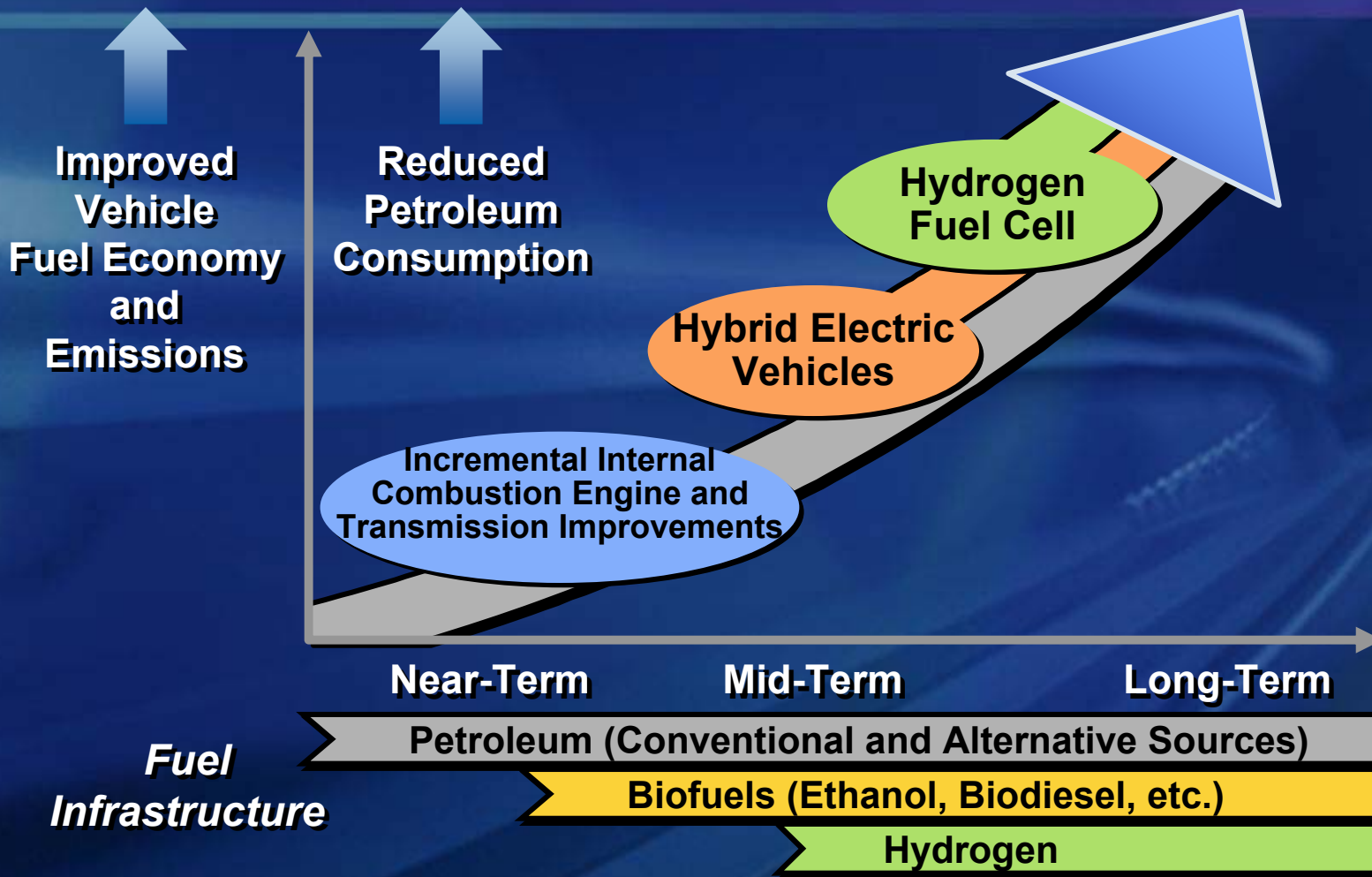
GM's Diesel Portfolio

Market Perspective

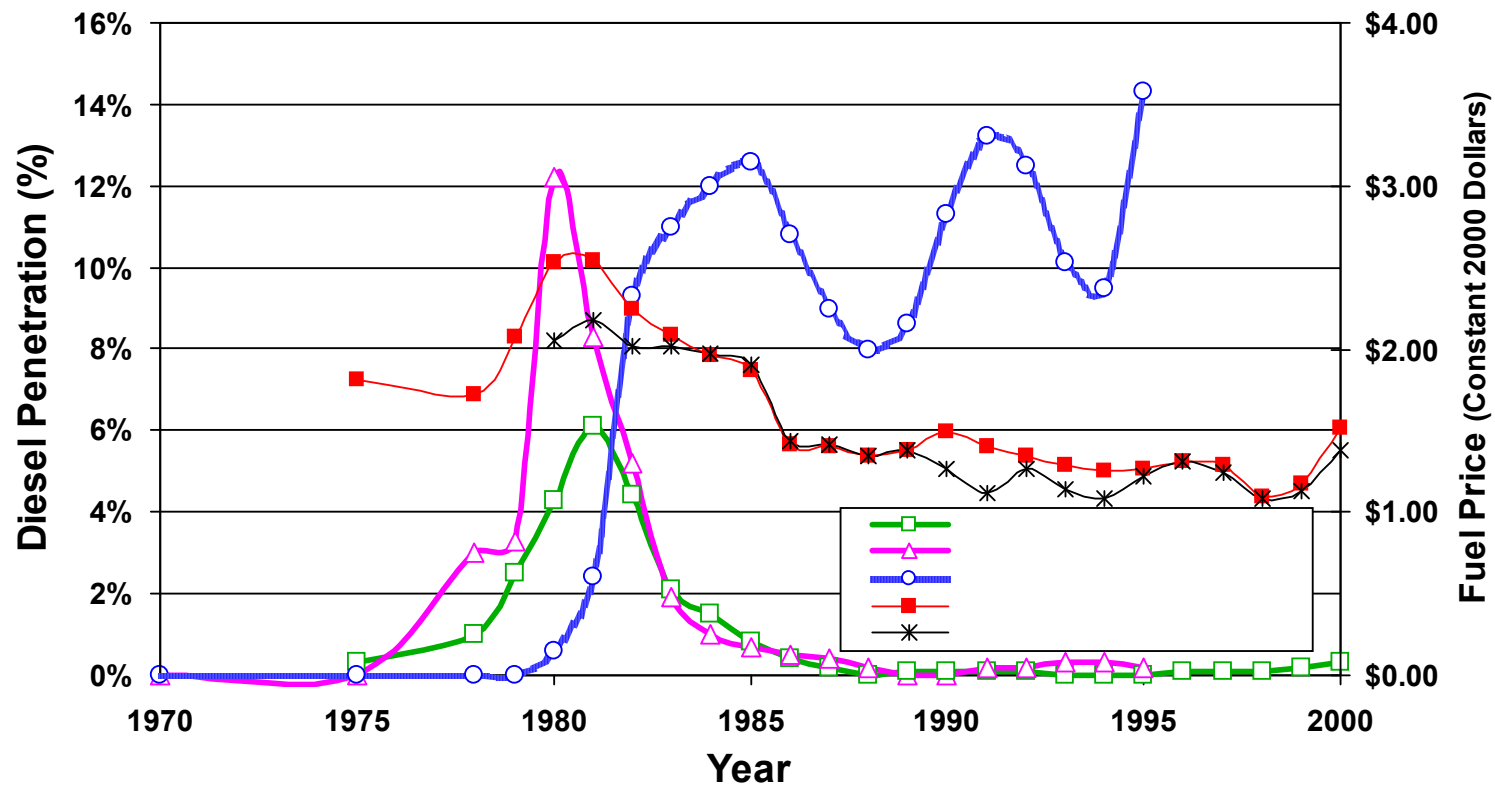
- GM is committed to developing global diesel solutions
- Diesel powertrains satisfy unique vehicle requirements
 - Utility & large vehicles
 - Diminishing returns when applied to smaller U.S. vehicles
- Significant technological challenges exist for long term light duty North American presence
 - NO_x aftertreatment & fuel limitations
- GM is developing technologies to address these challenges



Advanced Propulsion Technology Strategy



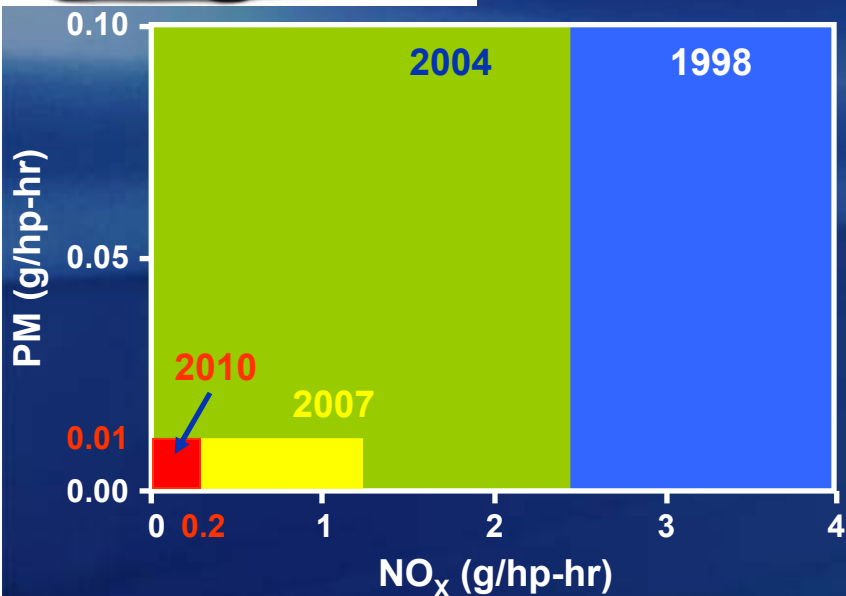
Passenger Car Diesels Disappear, HD Truck Diesels Continue



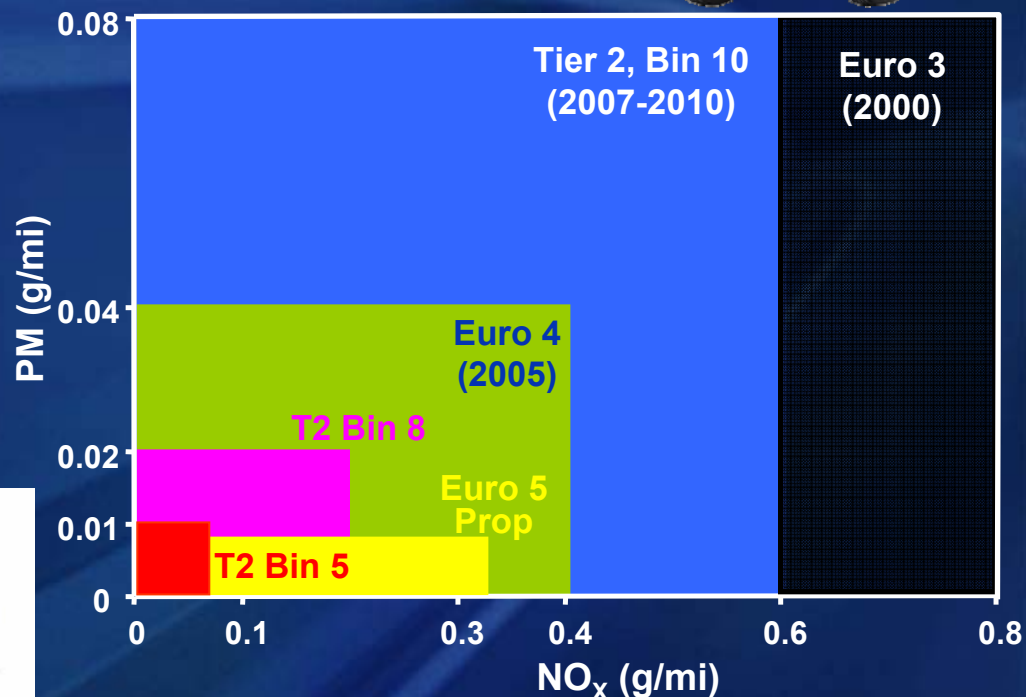
- Diesels experienced explosive growth in the early 1980's driven by fuel economics and availability, and new diesel entries
- Passenger car and Class 1 truck diesel sales fall off quickly as diesel fuel price advantage disappears, overall fuel costs drop, and fuel rationing ceases
- Class 2 truck diesel sales continue even as diesel and gas prices equalize

Emission Overview

U.S. Heavy Duty Emission Standards



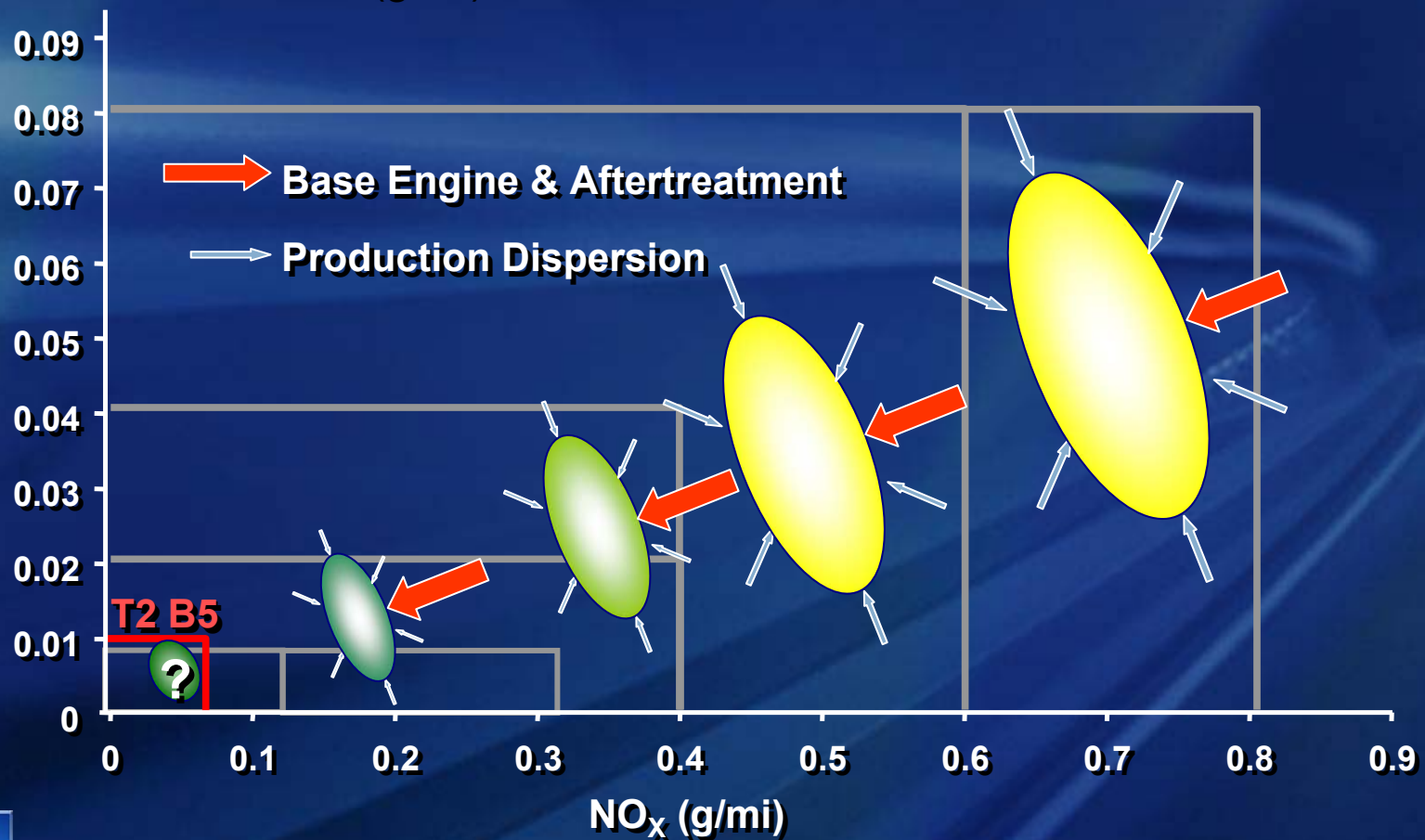
U.S. Light Duty Emission Standards



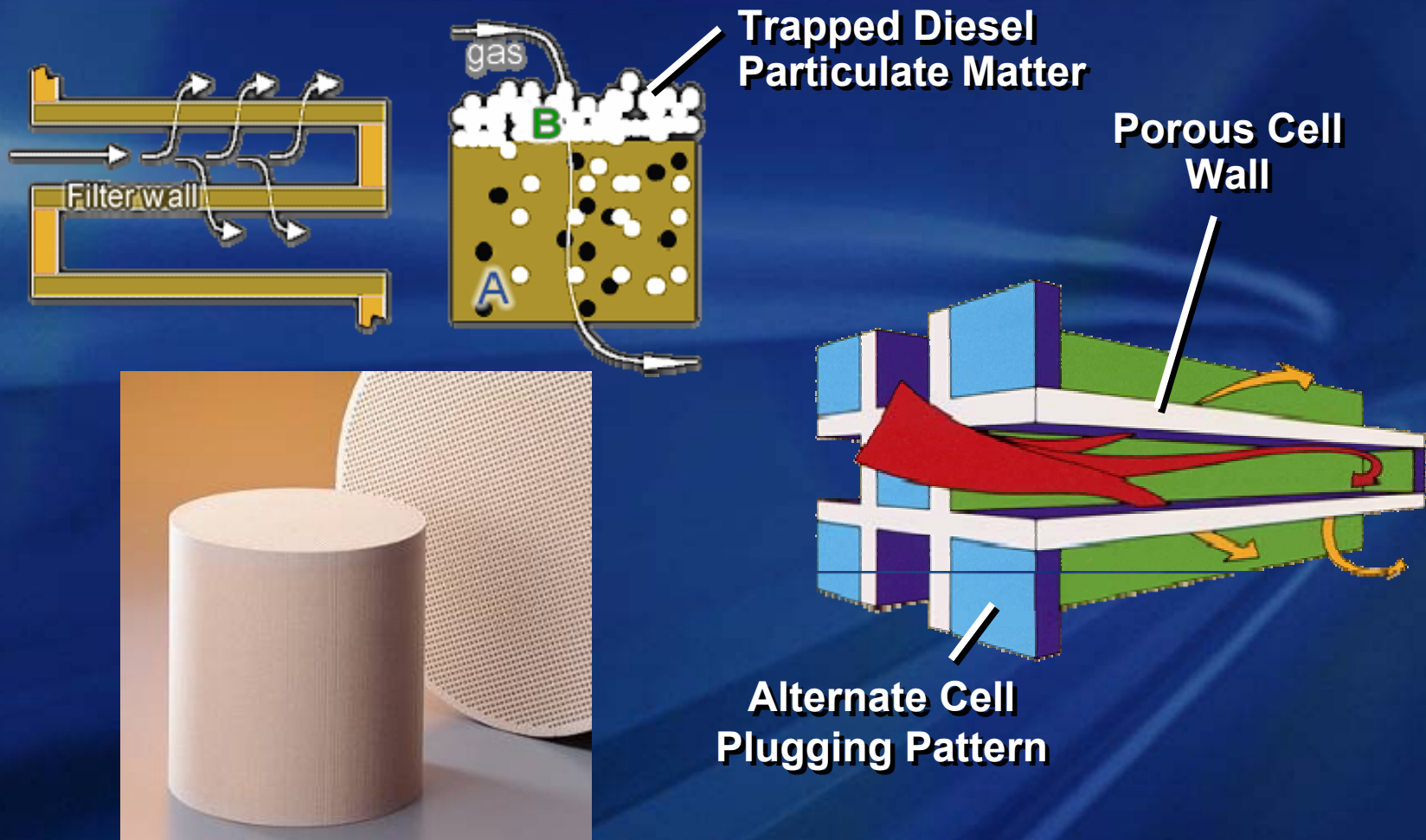
Tier 2 Bin 5 and Production Dispersion

Lower Emission Standards Require Less Variation

Particulate Matter (g/mi)



Diesel Particulate Filter (DPF) Function

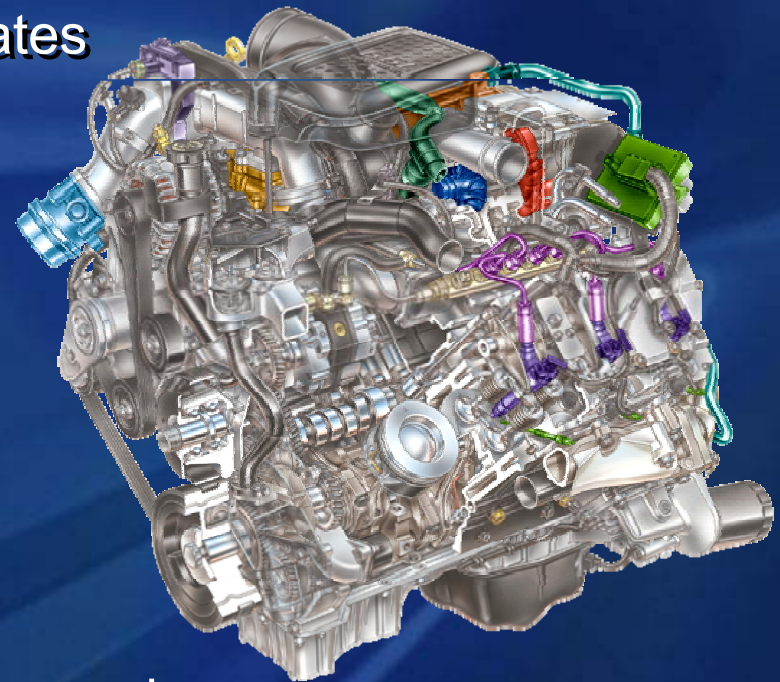


2007 Duramax 6.6L V8 LMM Engine

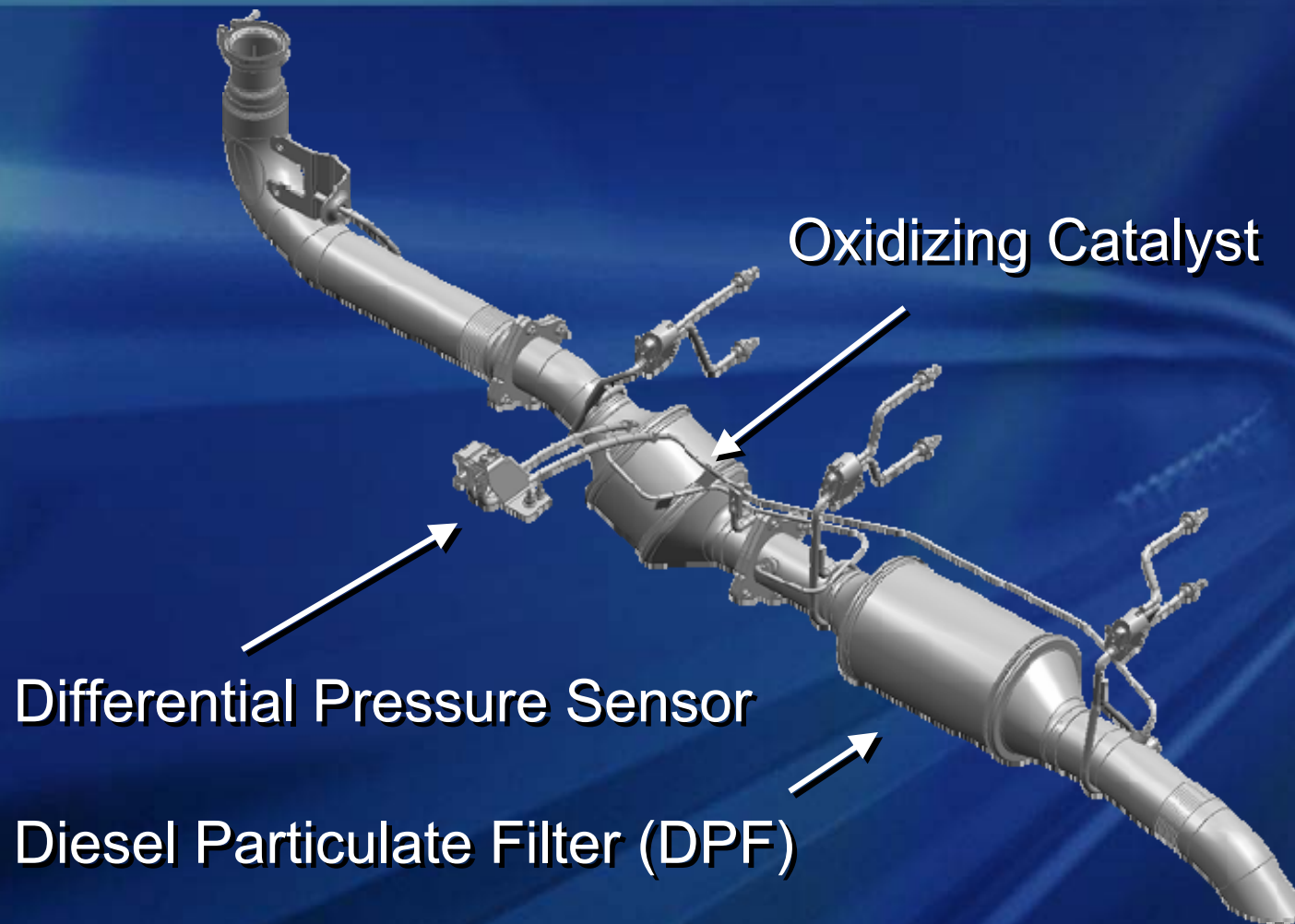
Base Engine Modifications for Emissions

Major changes include:

- Structural improvements
- High pressure fuel system updates
- Intake throttle
- Higher capacity EGR cooler
- Revised cooler circuitry
- Extensive engine software and calibration changes
- Diesel Particulate Filter (DPF)
- Post injection to support DPF regeneration
- Updated internal turbocharger upgrades

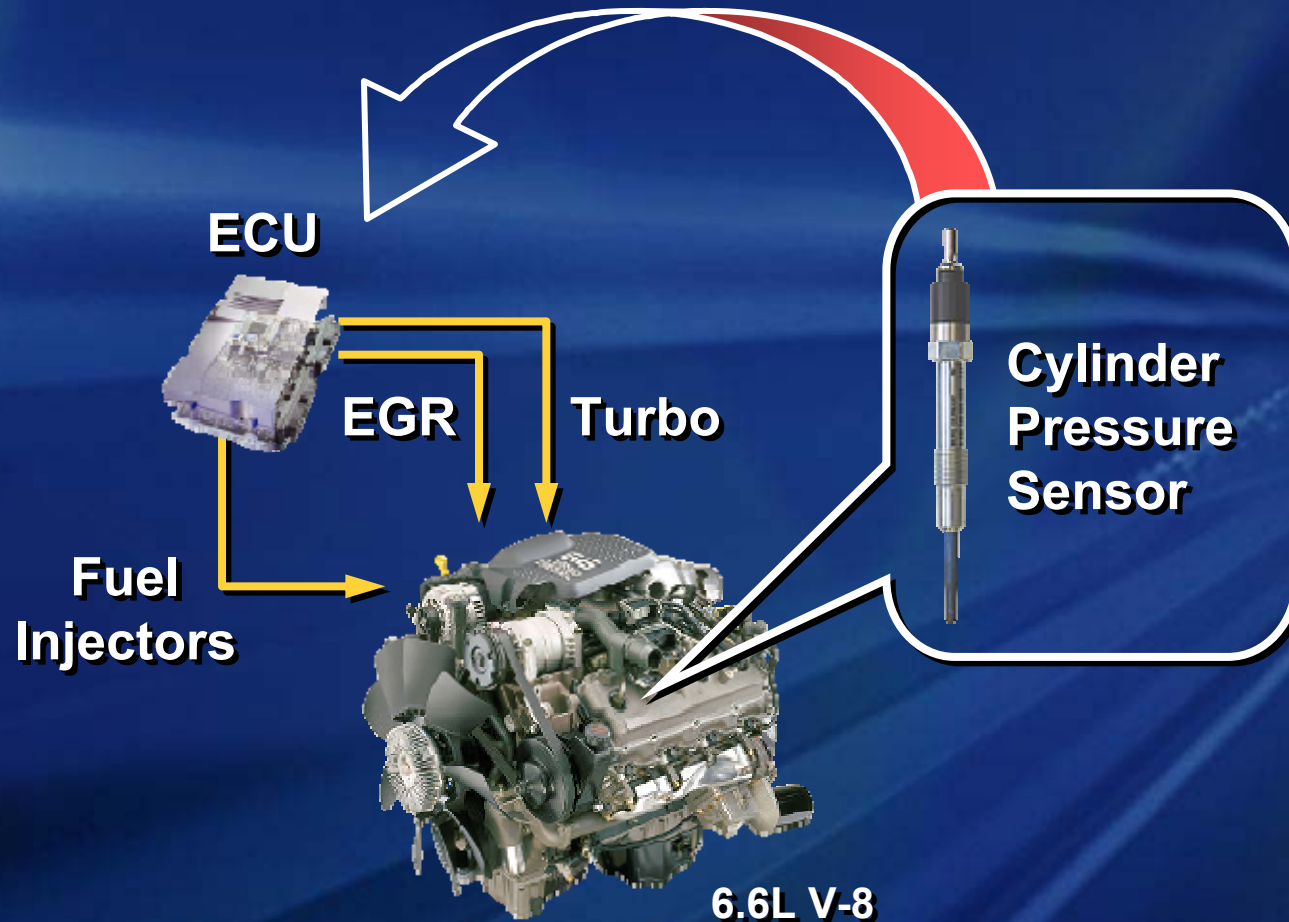


2007 Exhaust Aftertreatment System



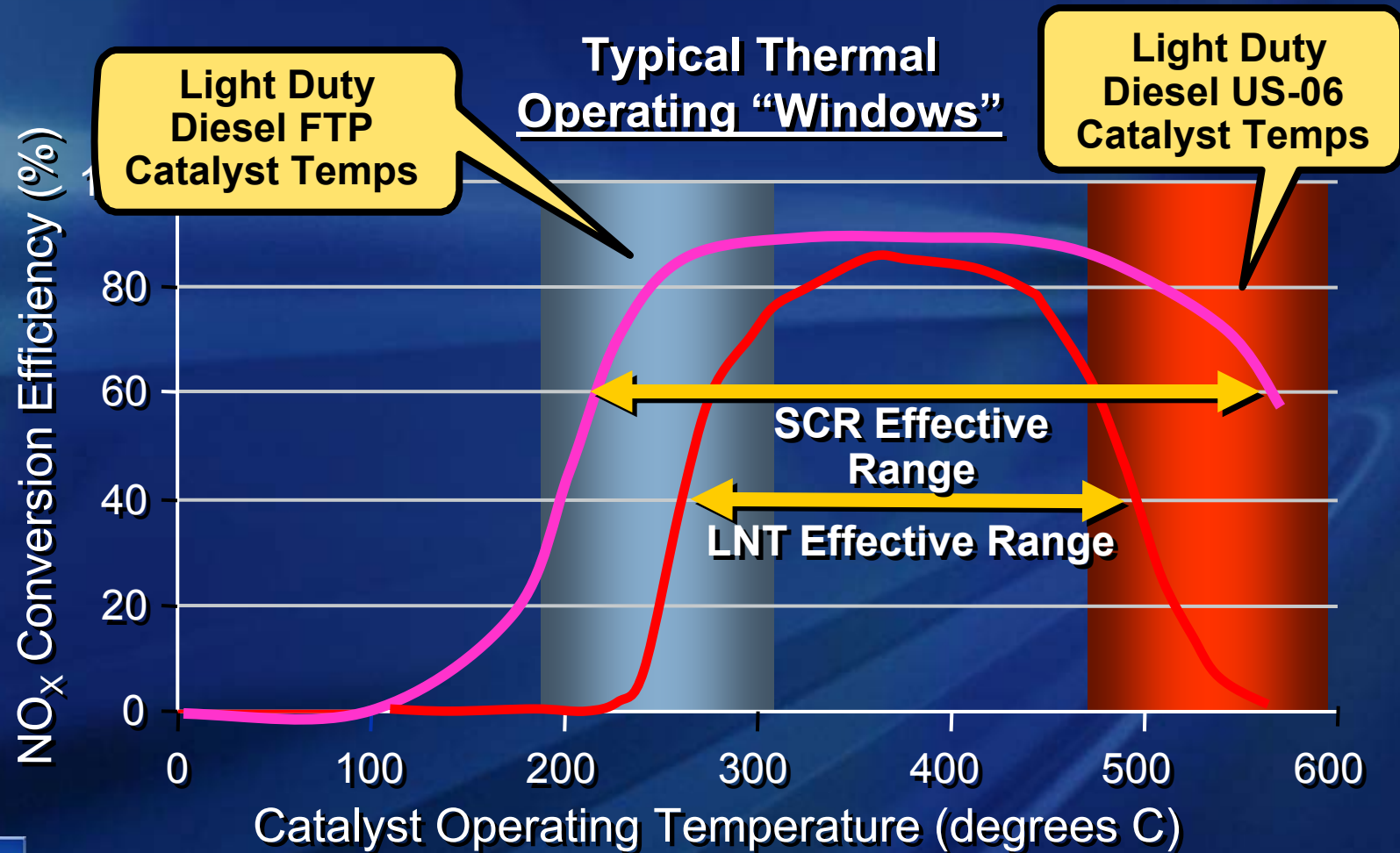
Engine-out Emissions Technologies

Closed Loop Diesel Combustion Control



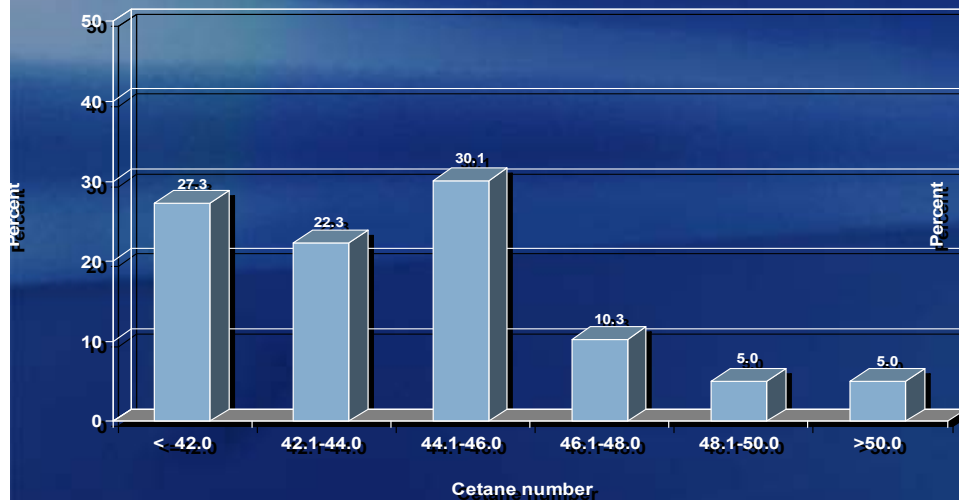
NO_x Aftertreatment Systems

Balancing the requirements of FTP with US-06



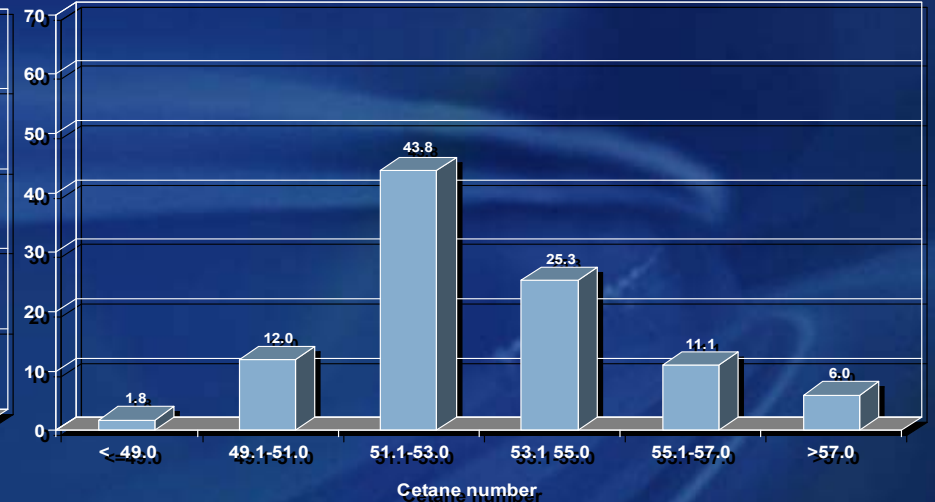
Other Challenges – Fuel Properties

North America versus European Cetane



North American Cetane

2005 AAM Winter & Summer Diesel Fuel Surveys

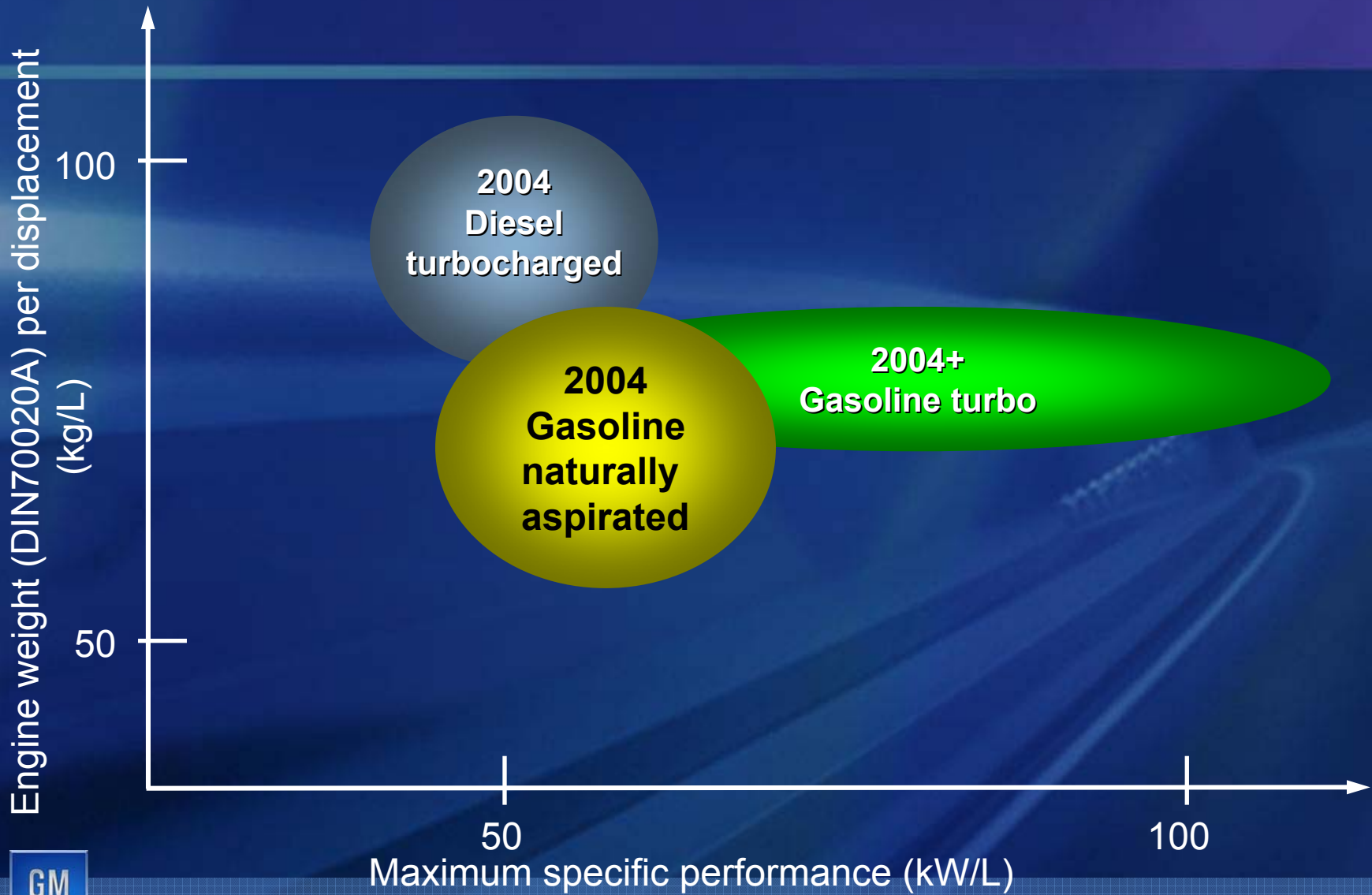


European Cetane

2005 SGS Summer Diesel Fuel Survey

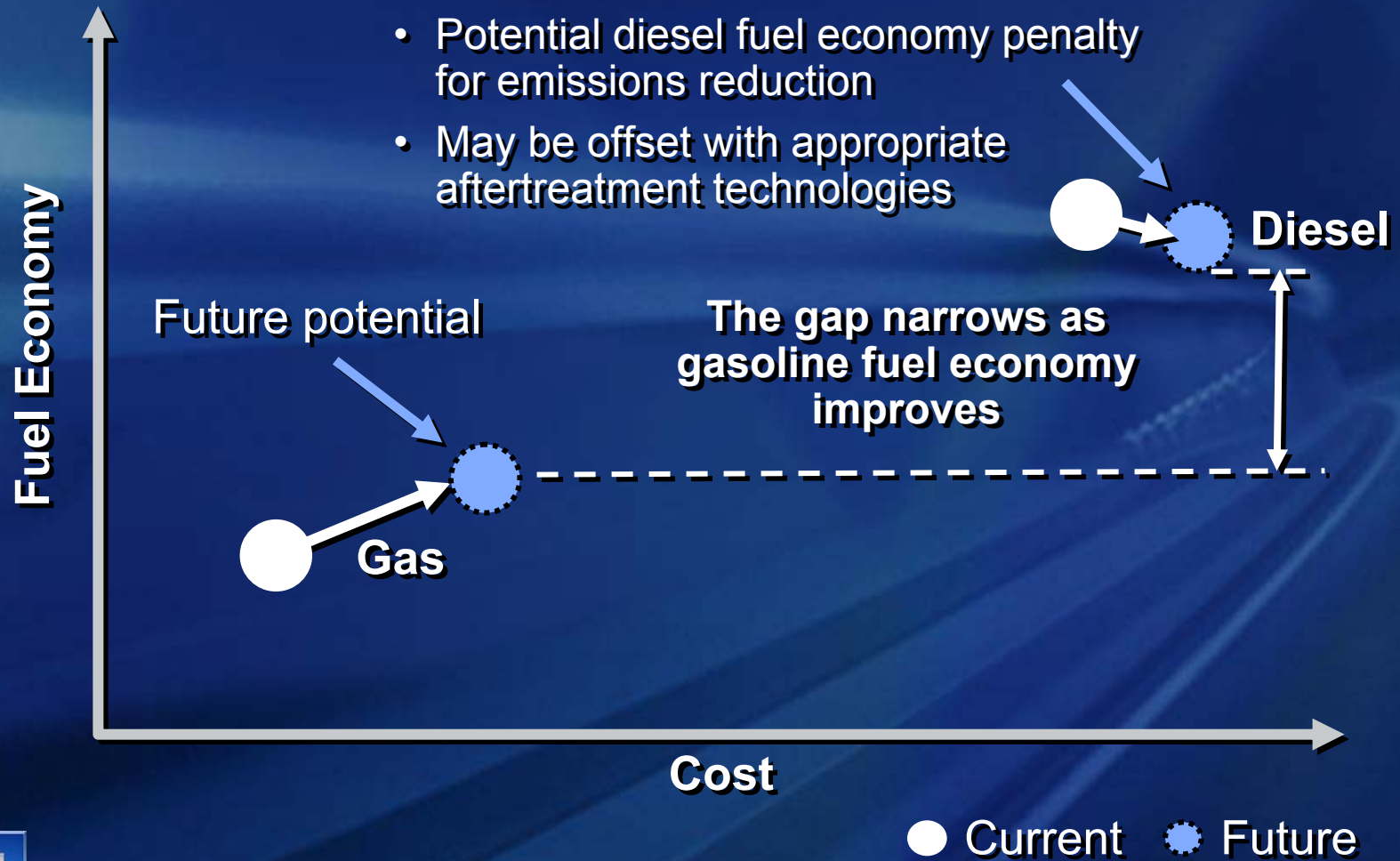


Engine Weight

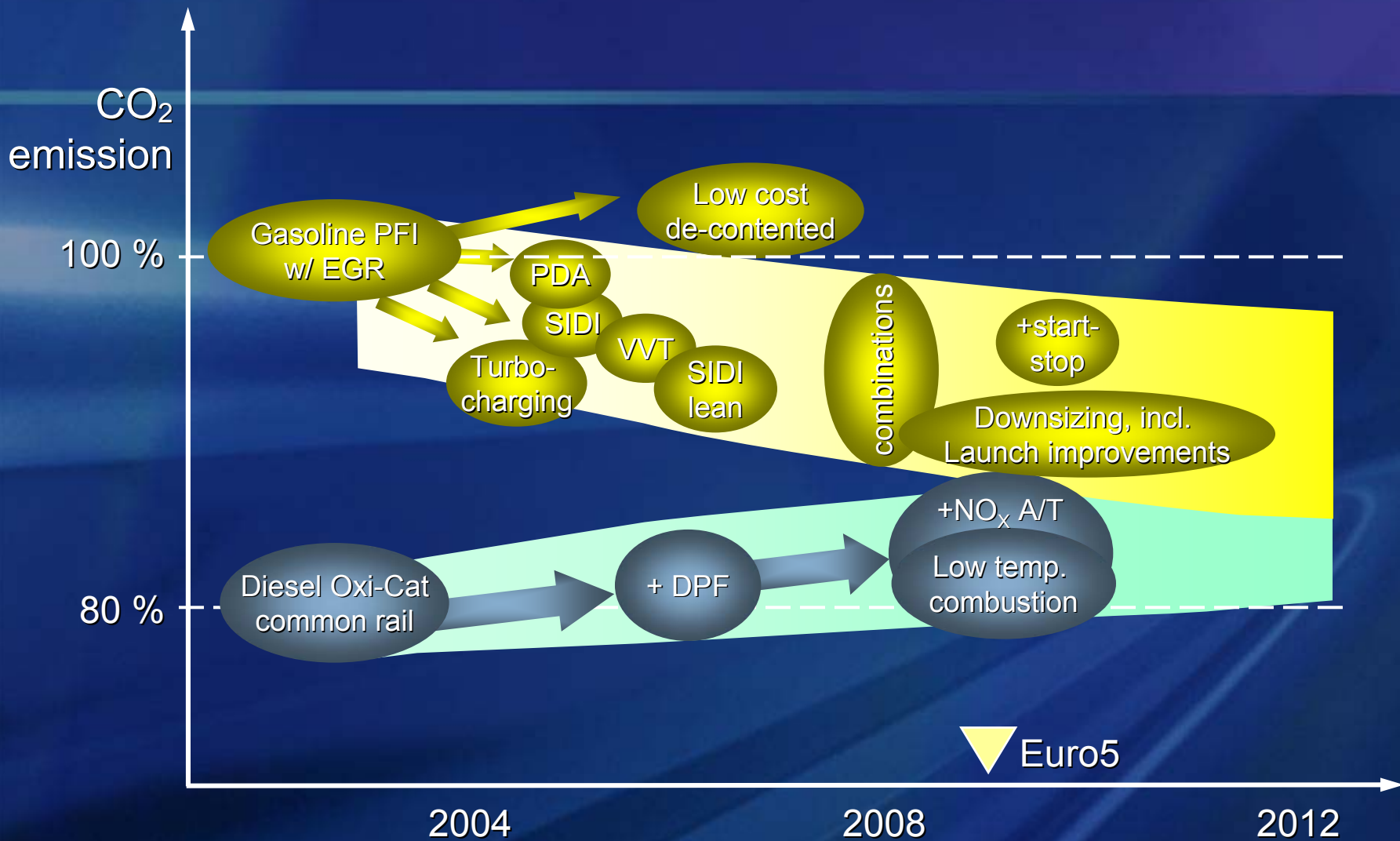


Internal Combustion Engines

Diesel versus Gasoline & U.S. Emissions Challenge

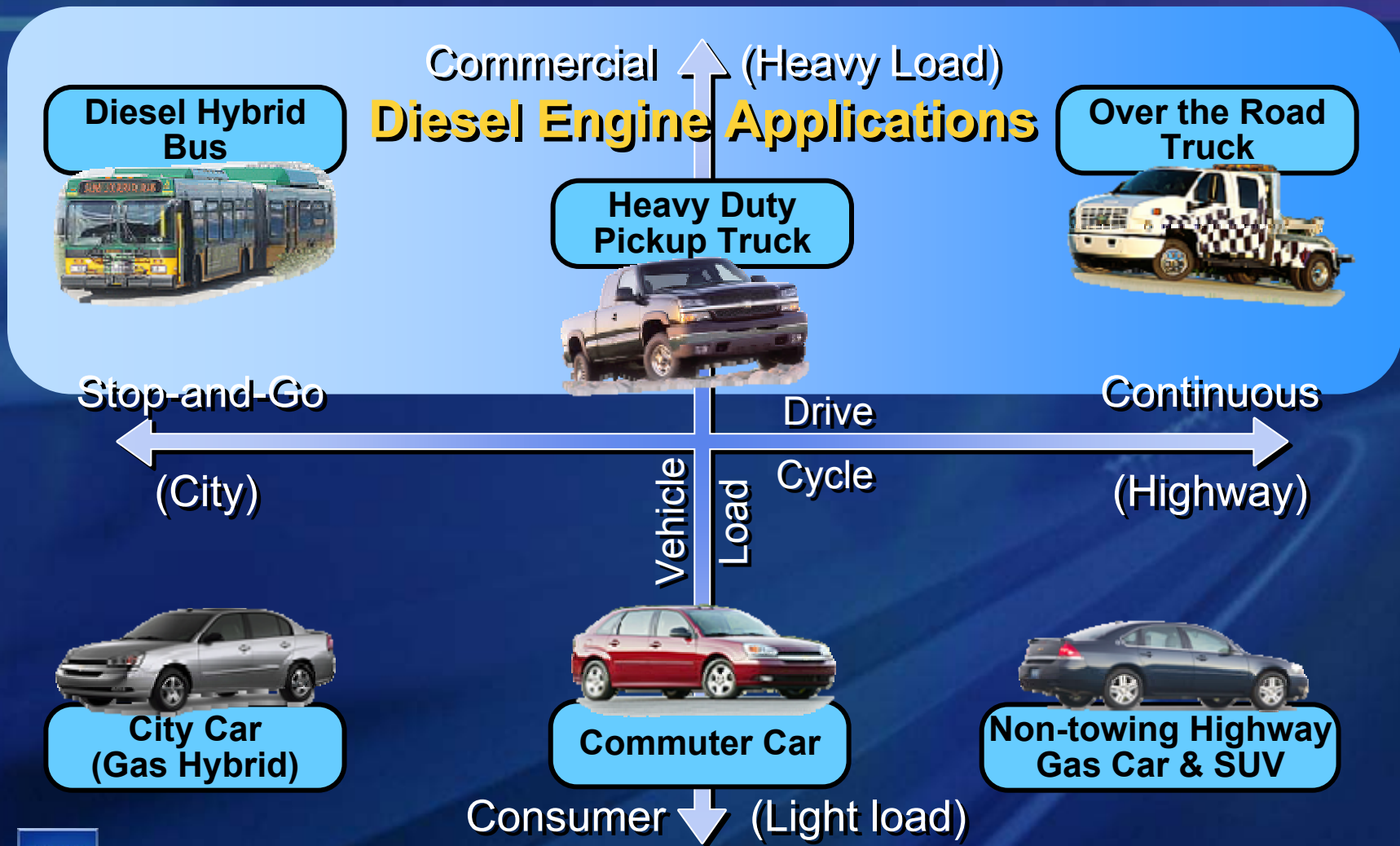


CO₂ Emissions Reduction Technologies



Assumptions: C -segment vehicle; Constant Performance Index (PI)
 (PI = Time 0-100 km/h + Time 60-100 km/h + Time 80-120 km/h + Time for 1 km at Vmax)

Propulsion Application Map



Why Use Diesels?

- Improve vehicle performance with lower displacement engine
 - “Fun-to-drive” high torque powertrain solution
- Achieve benefit of tax incentives in European markets
- Satisfy fuel economy improvement objectives
 - Positive influence on CO₂ & CAFE
 - Real world fuel economy improvement – a robust solution
 - Fuel economy advantage is greater under high load
- Heavy duty towing & hauling
 - Improved utility & towing capabilities
 - Increased durability



GM

Where to Use Diesels?

- European light duty vehicles (near 50%)
- Asia-Pacific
 - Korea, India and potentially China are growing markets
 - Strong diesel bias in Korean SUV market (over 90% diesel)
- U.S. market, with its larger vehicles, could benefit from new diesel technologies
- Growing large truck diesel market share demonstrates U.S. consumer acceptance of diesel engines
- North American light vehicles
 - First introduced diesel engines in larger vehicles
 - Consumer recovery of additional financial investment
 - Utility applications (towing & hauling)



Technology Options

Advanced Propulsion Solutions

- Portfolio approach is required for advanced powertrain strategies
 - Market, vehicle, & customer requirements influence powertrain usage
- Diesel engines are critical to GM's global product portfolio
- Emission regulations, fuel price, fuel taxation, taxation based on engine displacement, and fuel consumption largely dictate markets where diesels are popular today



Summary

- Diesel technological advancements over past 15 years have radically changed public perception of diesels
- Must retain fuel economy advantages while meeting new emissions standards
- Diesel must overcome cost disadvantages







WESTERN EUROPE Ricardo Forecast Diesel Passenger Car Sales & Market Penetration to 2006

