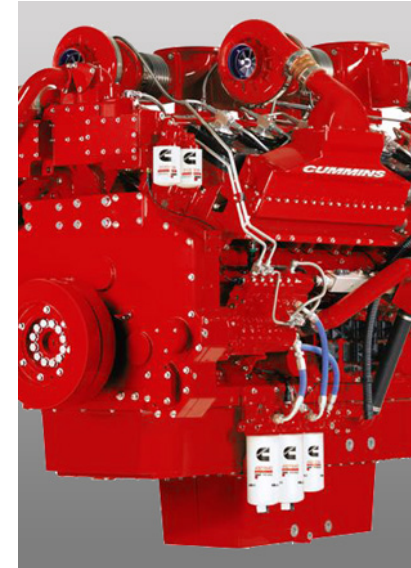
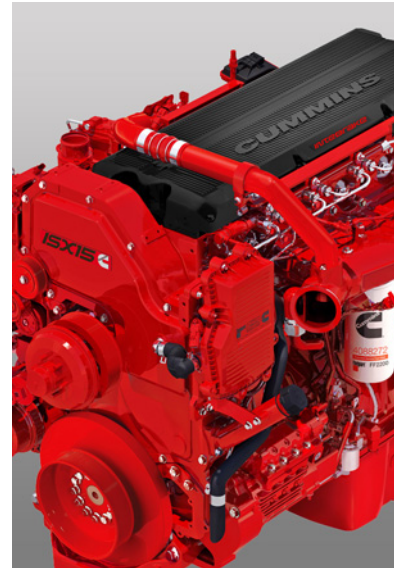
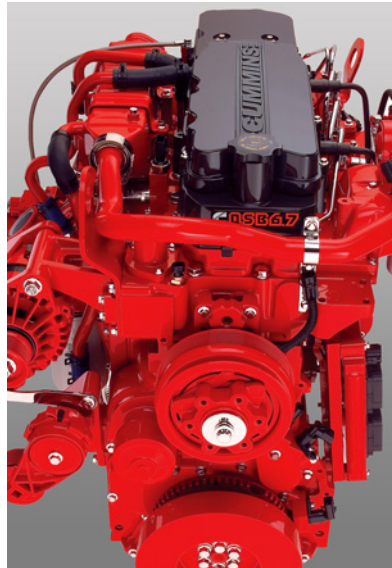
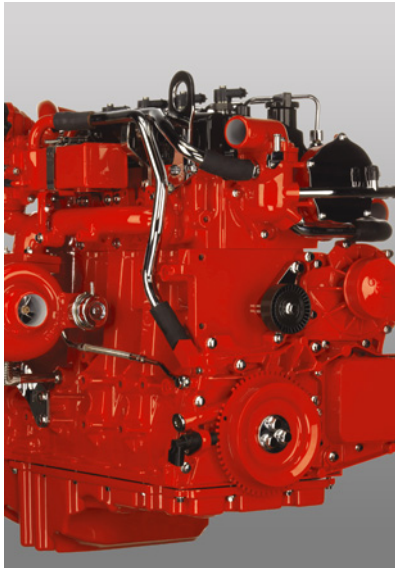


# The Next ICE Age

Michael Ruth

Director – Advanced Systems Engineering

Cummins Inc.



# The more things change, the more they stay the same.

1913



**Detroit Electric**  
\$2,600  
60 miles

1/3 range



4X cost



**Model T**  
\$650  
180 miles



EV range

ICE vehicle range



2012



**Nissan Leaf**  
\$36,500  
73 miles  
\$600/yr  
230 g/mi CO<sub>2</sub>

1/4 range



3X purchase cost

1/3 annual fuel cost

31% Lower CO<sub>2</sub>/mile



**Nissan Versa**  
\$12,500  
345 miles  
\$1750-\$2050/yr  
335 g/mi CO<sub>2</sub>



# Cummins Inc.

Diversified Global Power Leader – Four Complementary Businesses



Engines



Power  
Generation



Components



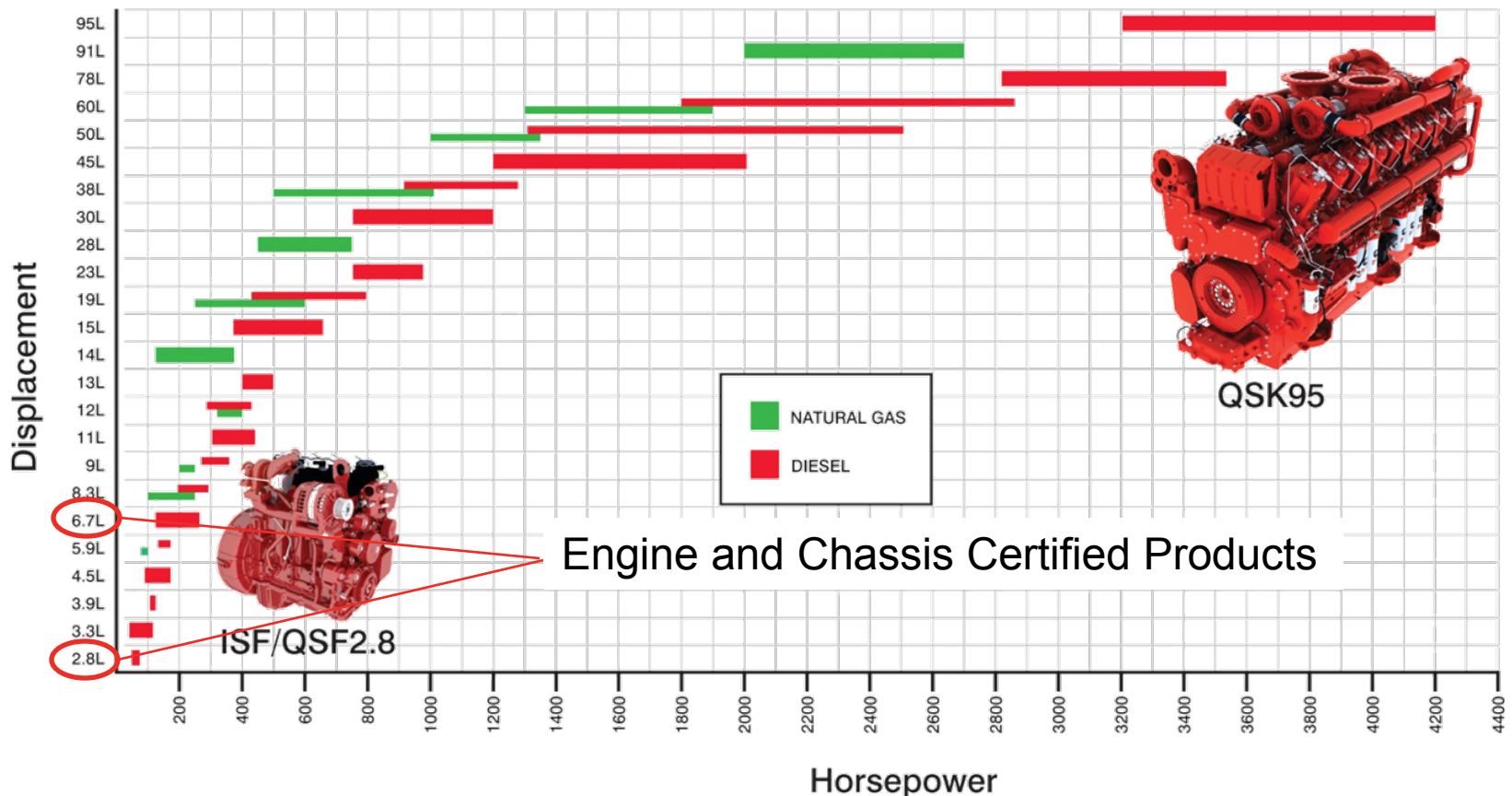
Distribution

- World's largest independent diesel engine manufacturer
- Will produce over 1M diesel and natural gas engines in 2012
- Over 60% of sales outside the U.S.
- Approximately 44,000 employees worldwide

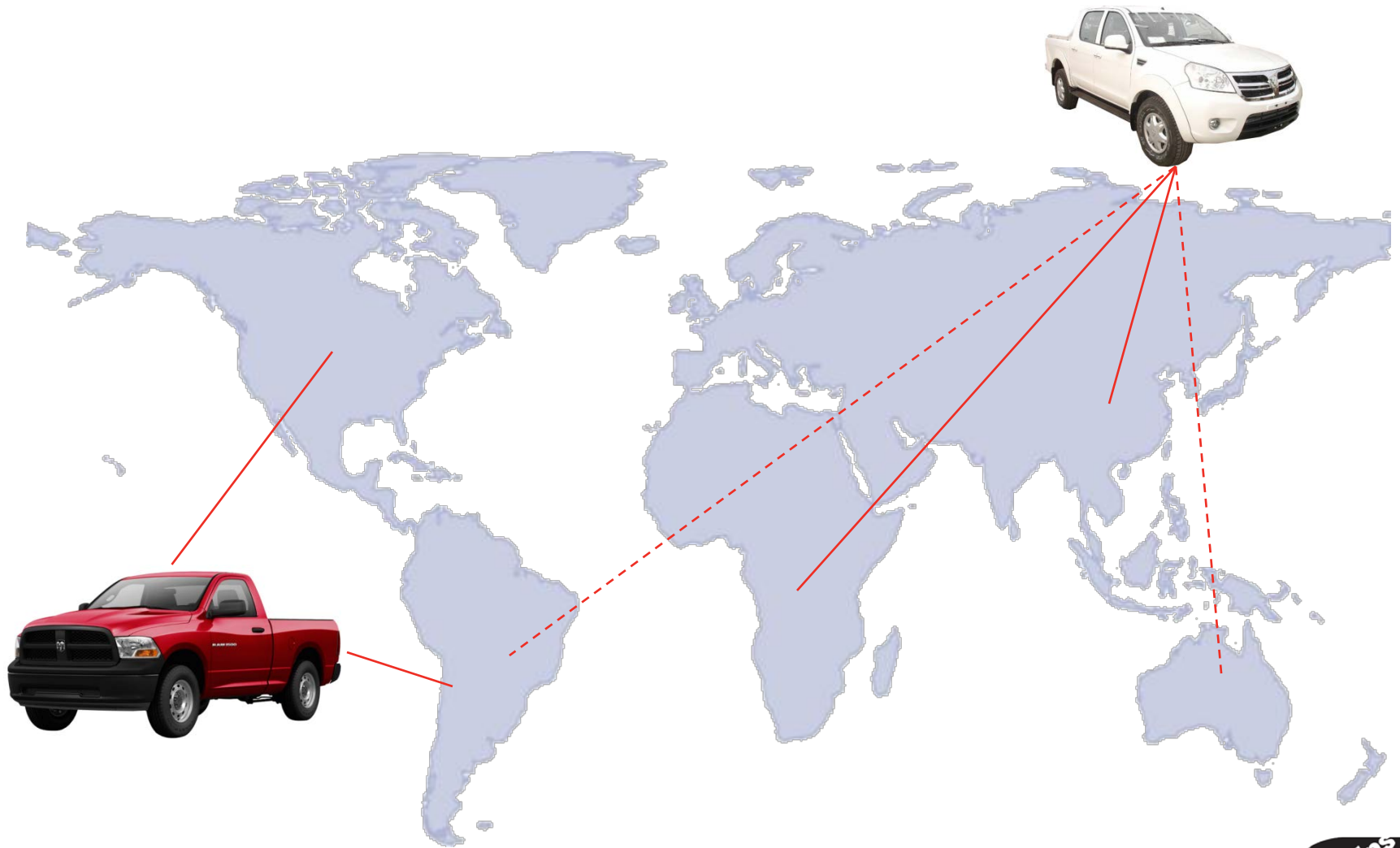


# Broad Product Range

- A major expansion of the range since the late 1990s, with twice the number of engine platforms covering 49 to 4200 horsepower



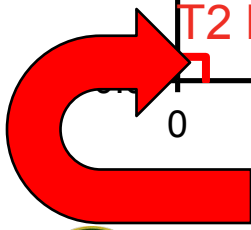
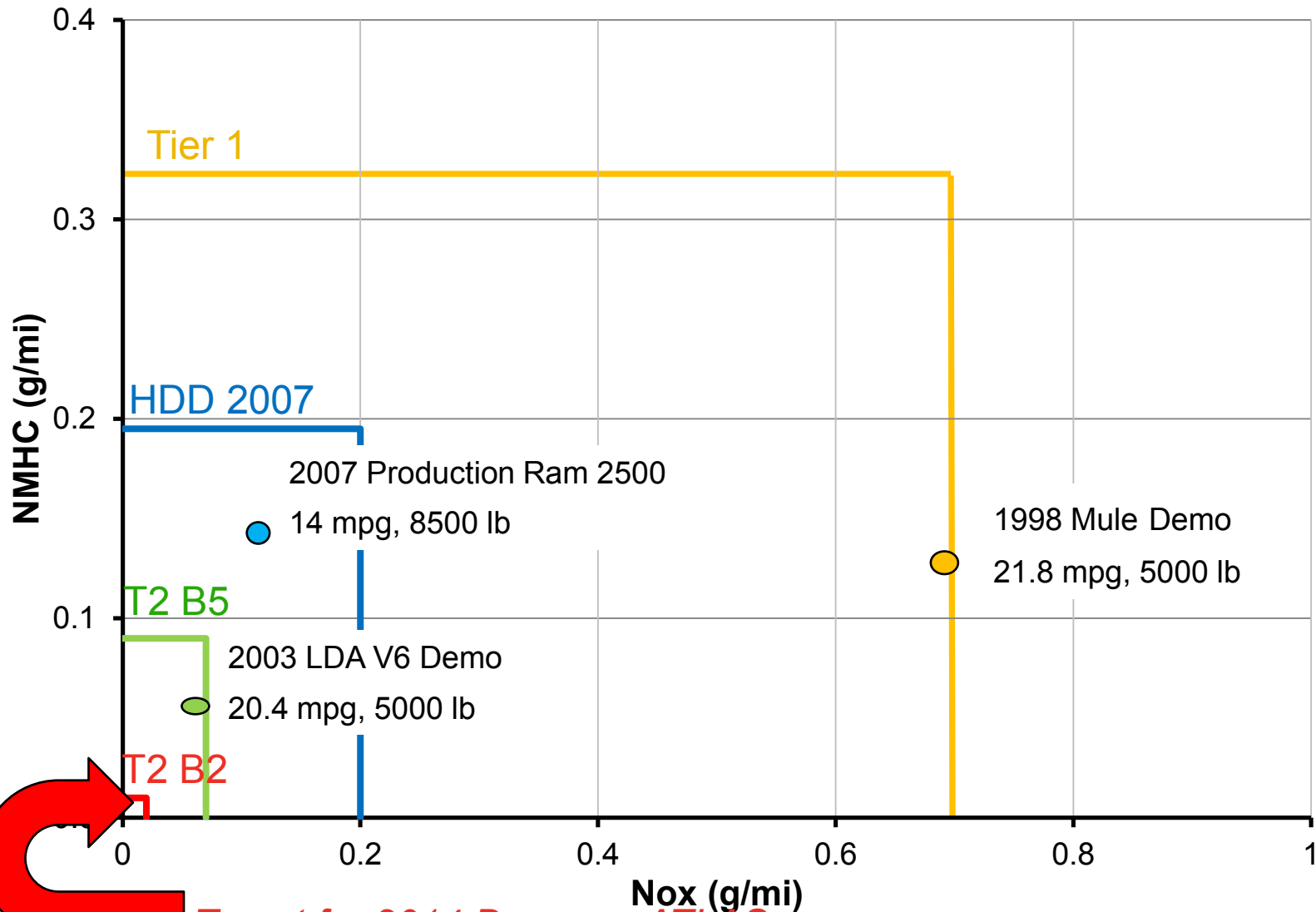
# Cummins Chassis Certified Products



U.S. DEPARTMENT OF  
**ENERGY**

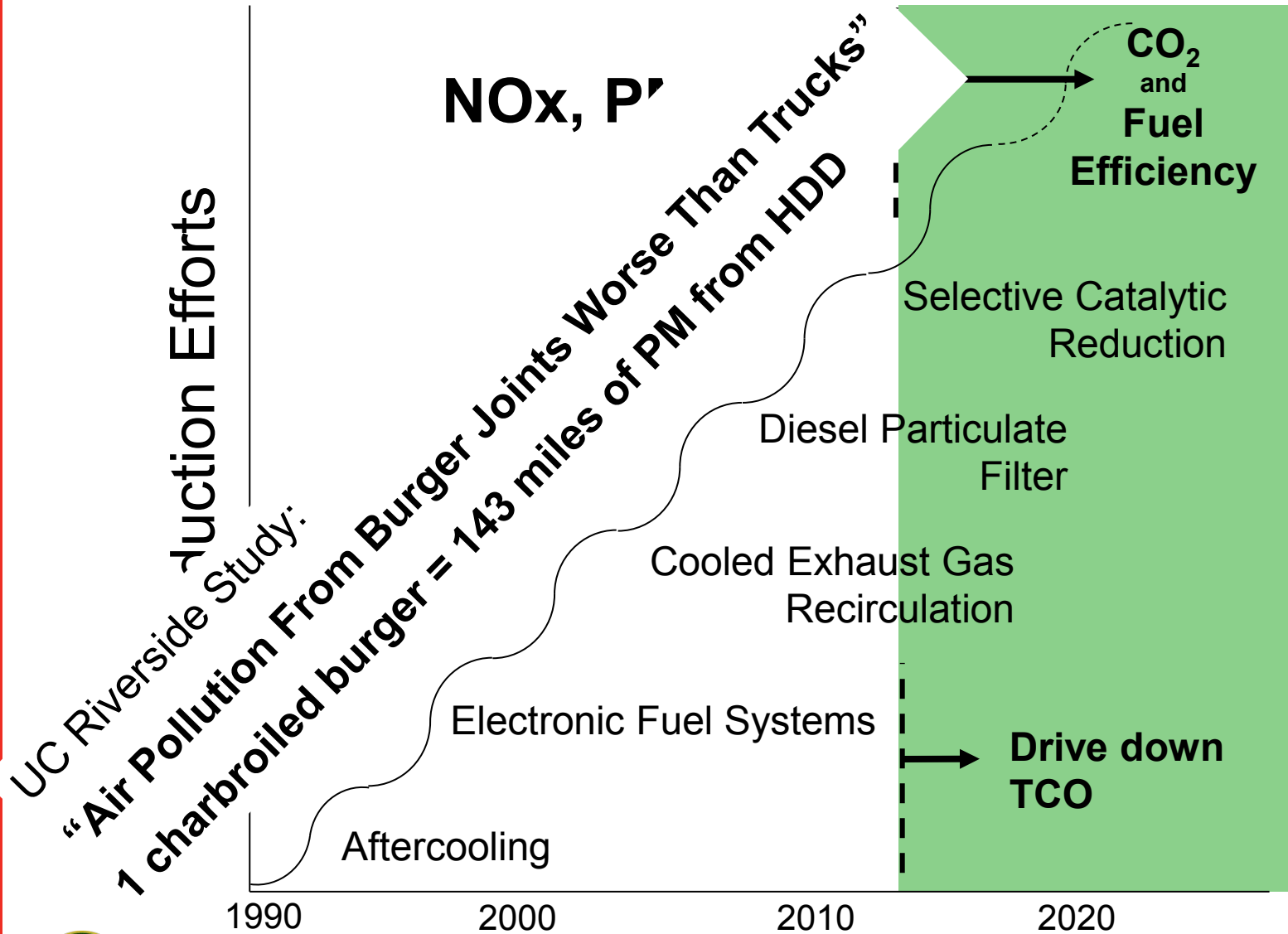


# Light Duty Emissions Efforts at Cummins



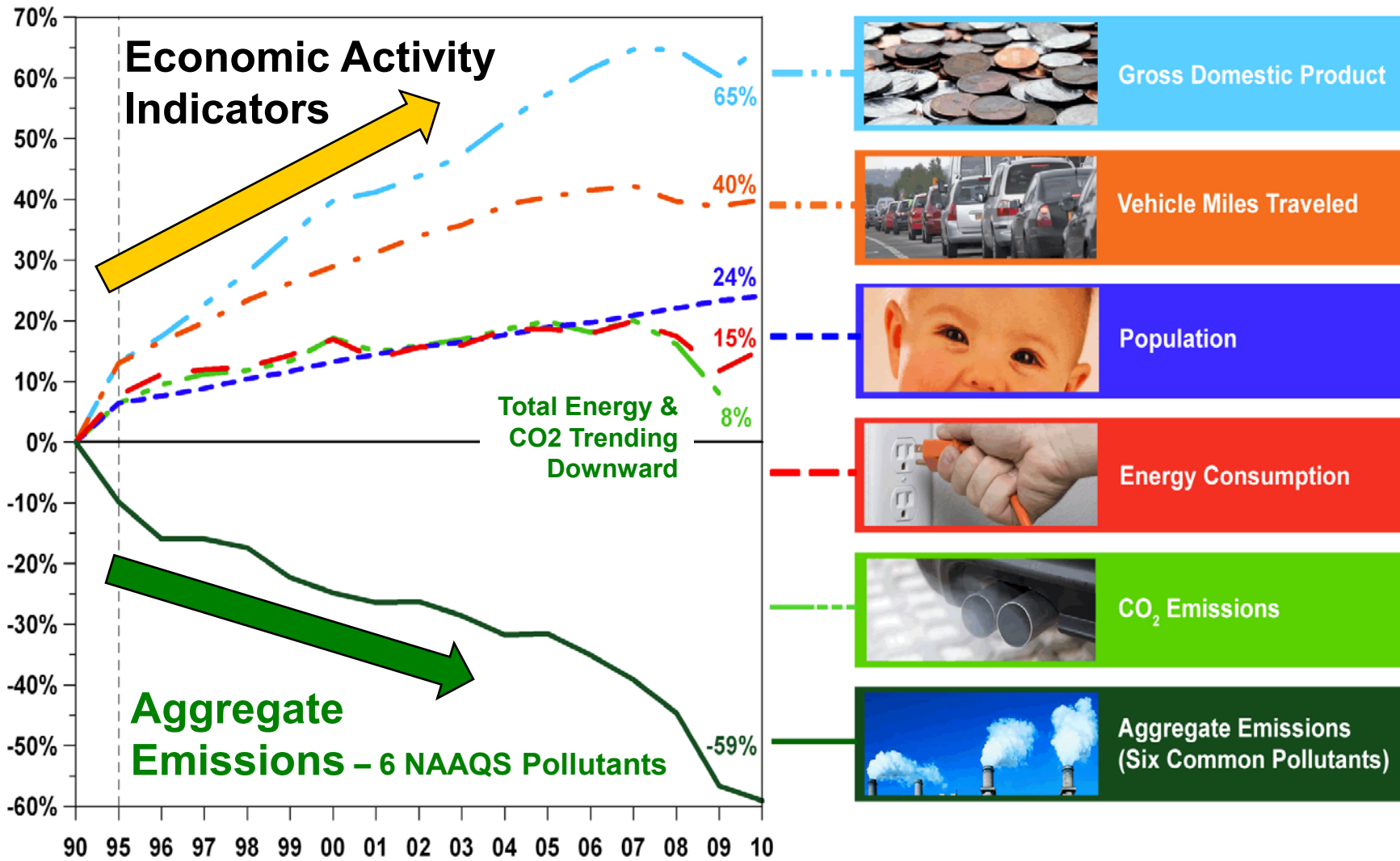
*Target for 2014 Demo on ATLAS program*

# Current Development Focus on Cost and CO<sub>2</sub>



# Sustained Progress Indeed ...

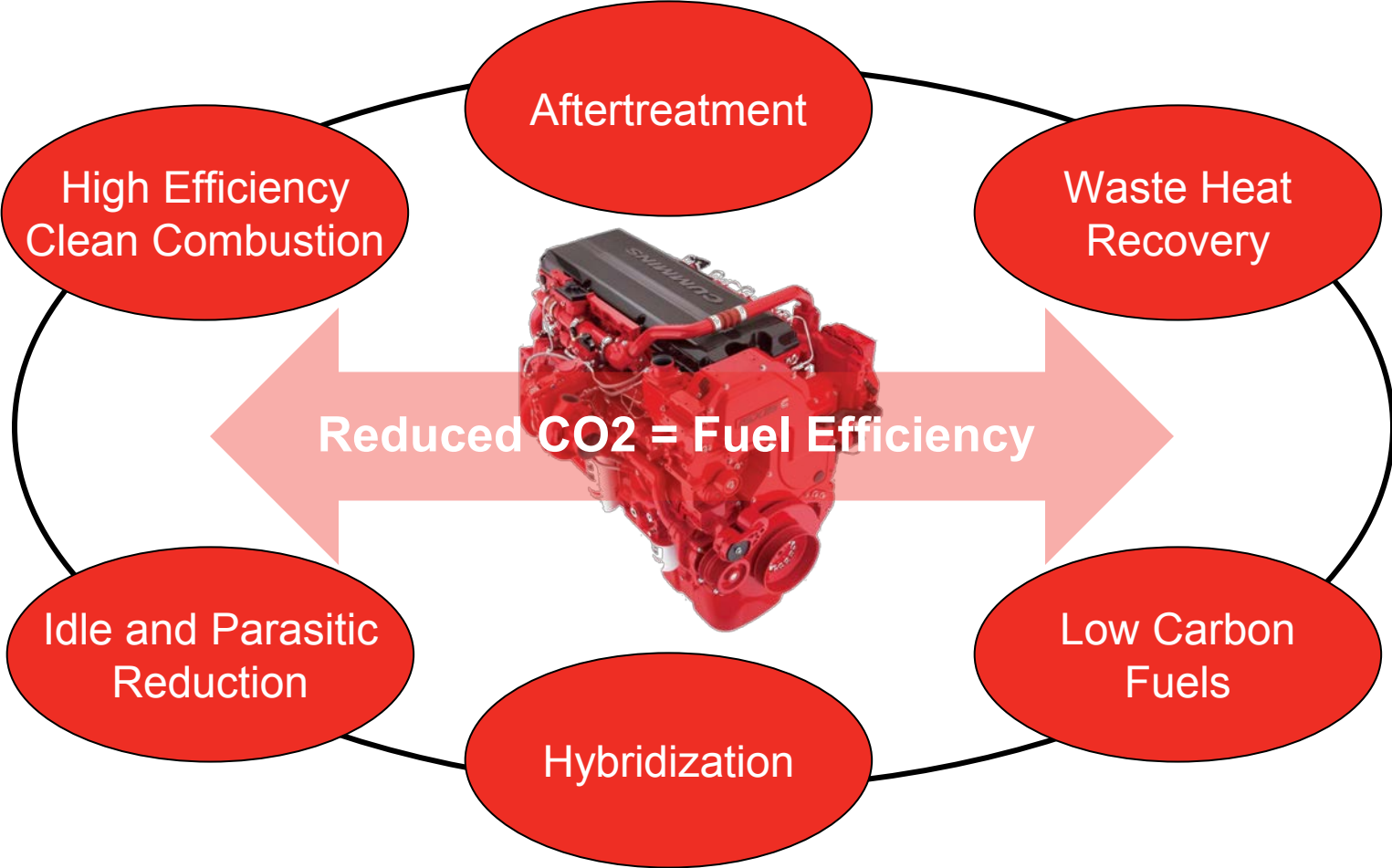
Emission Standards



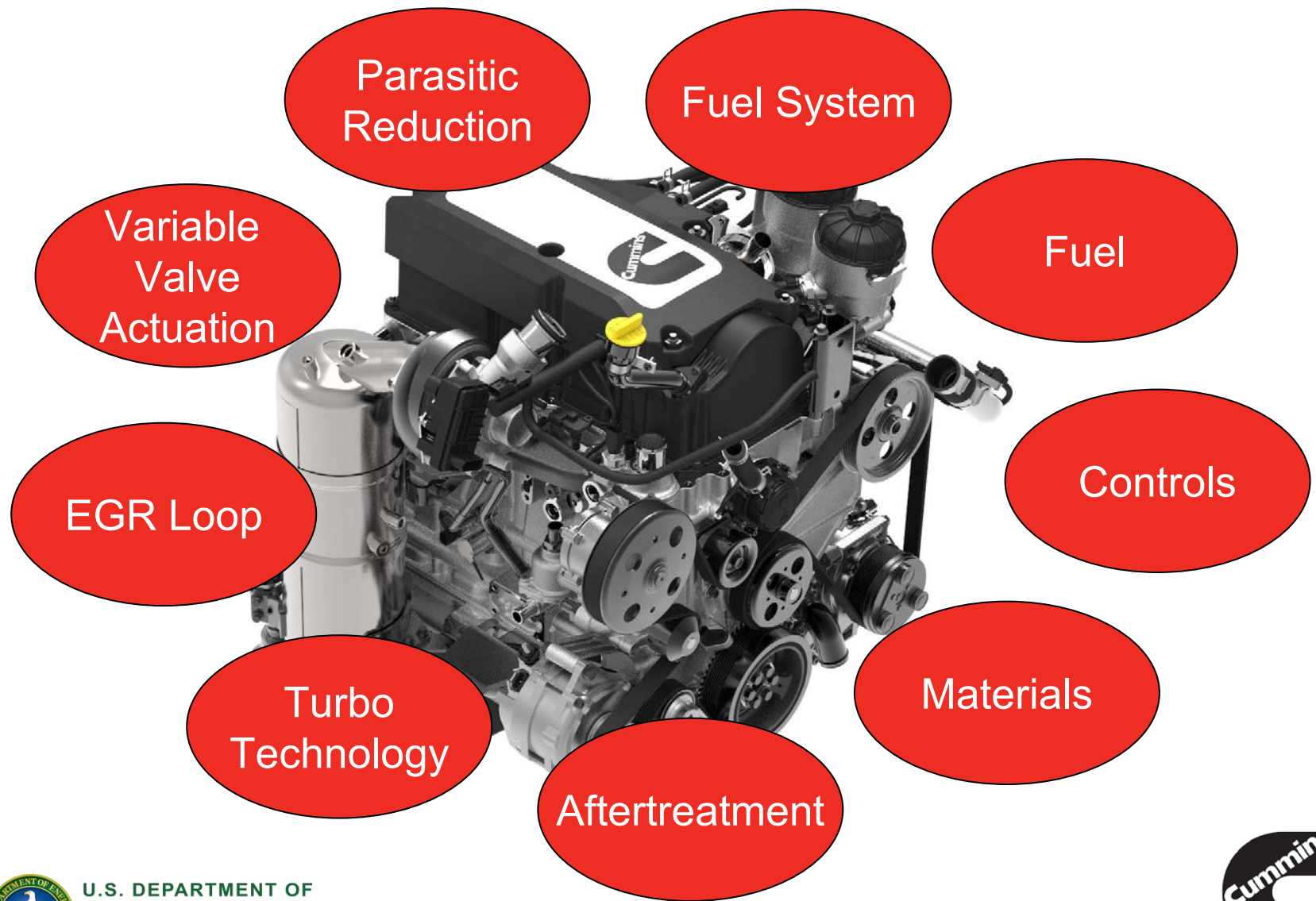
Source "Our Nation's Air – Status and Trends through 2010"  
EPA-454/R-12-001 - February 2012



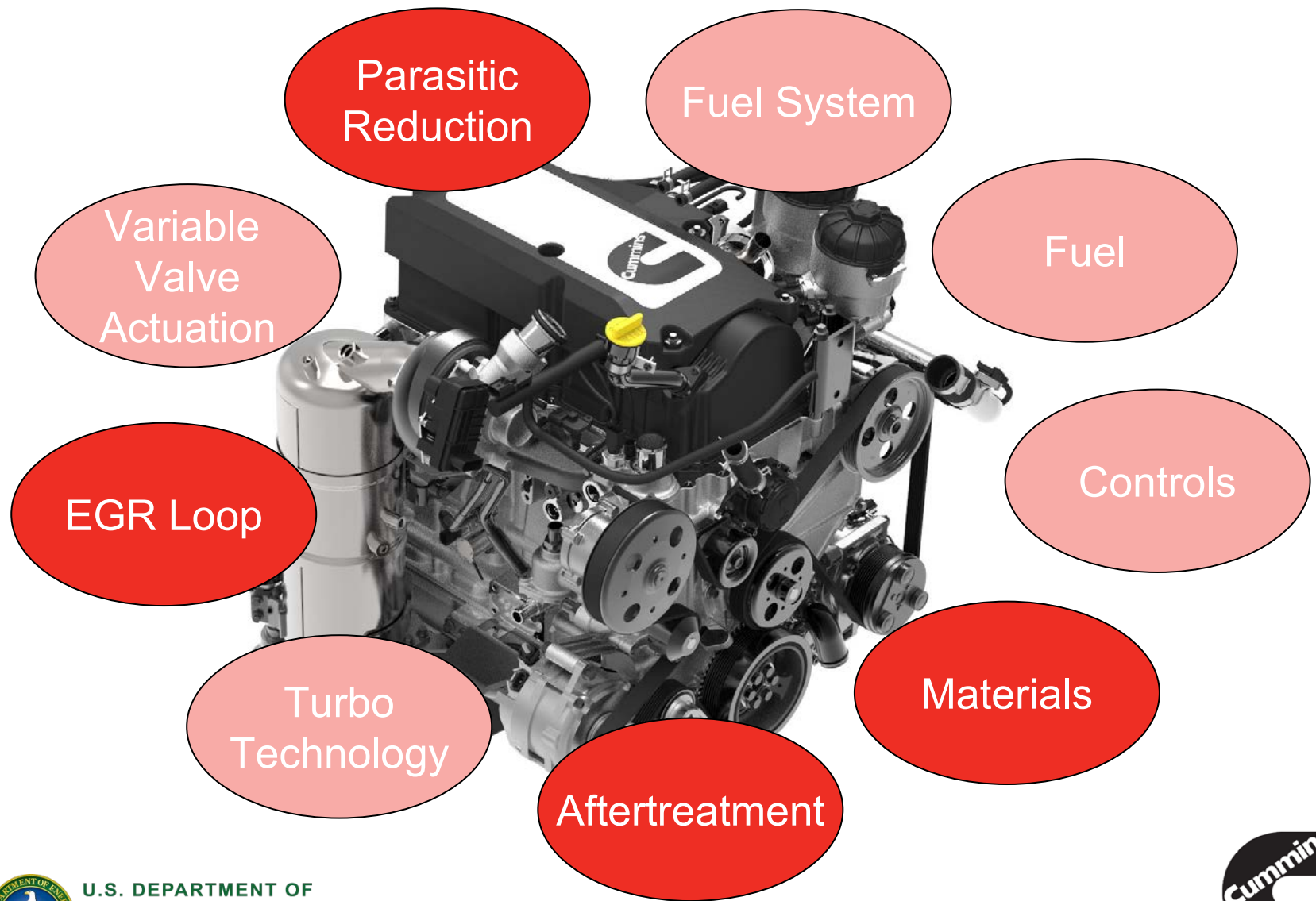
# Focus Areas for All Engine Applications



# Chassis Certified Engine Technology Levers

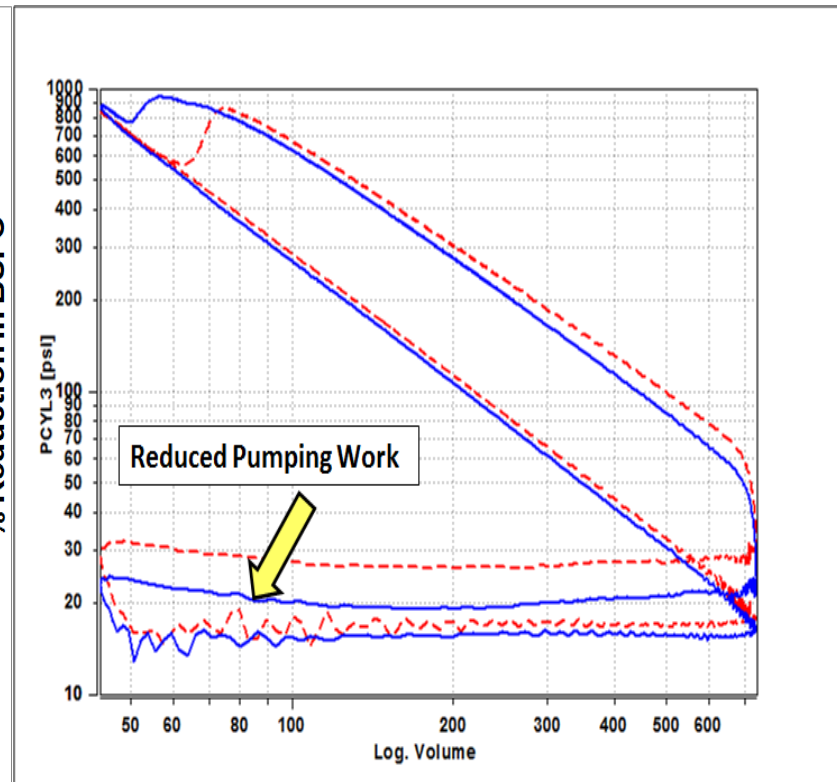
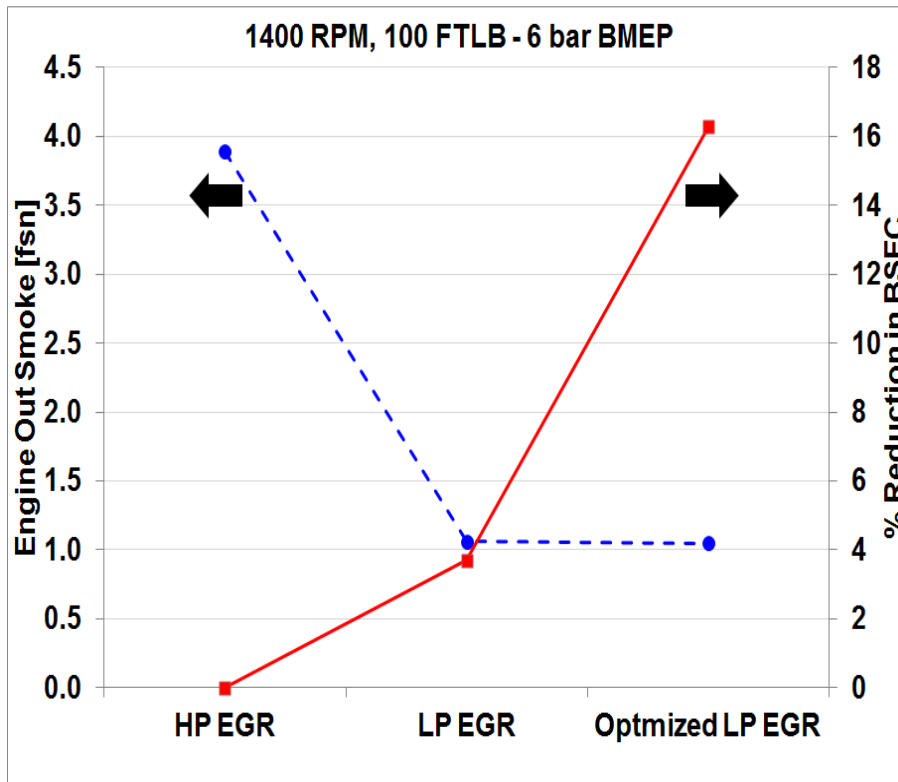


# Chassis Certified Engine Technology Levers



# Air Handling Optimization

Reduce emissions while maintaining the fuel economy advantage of diesel

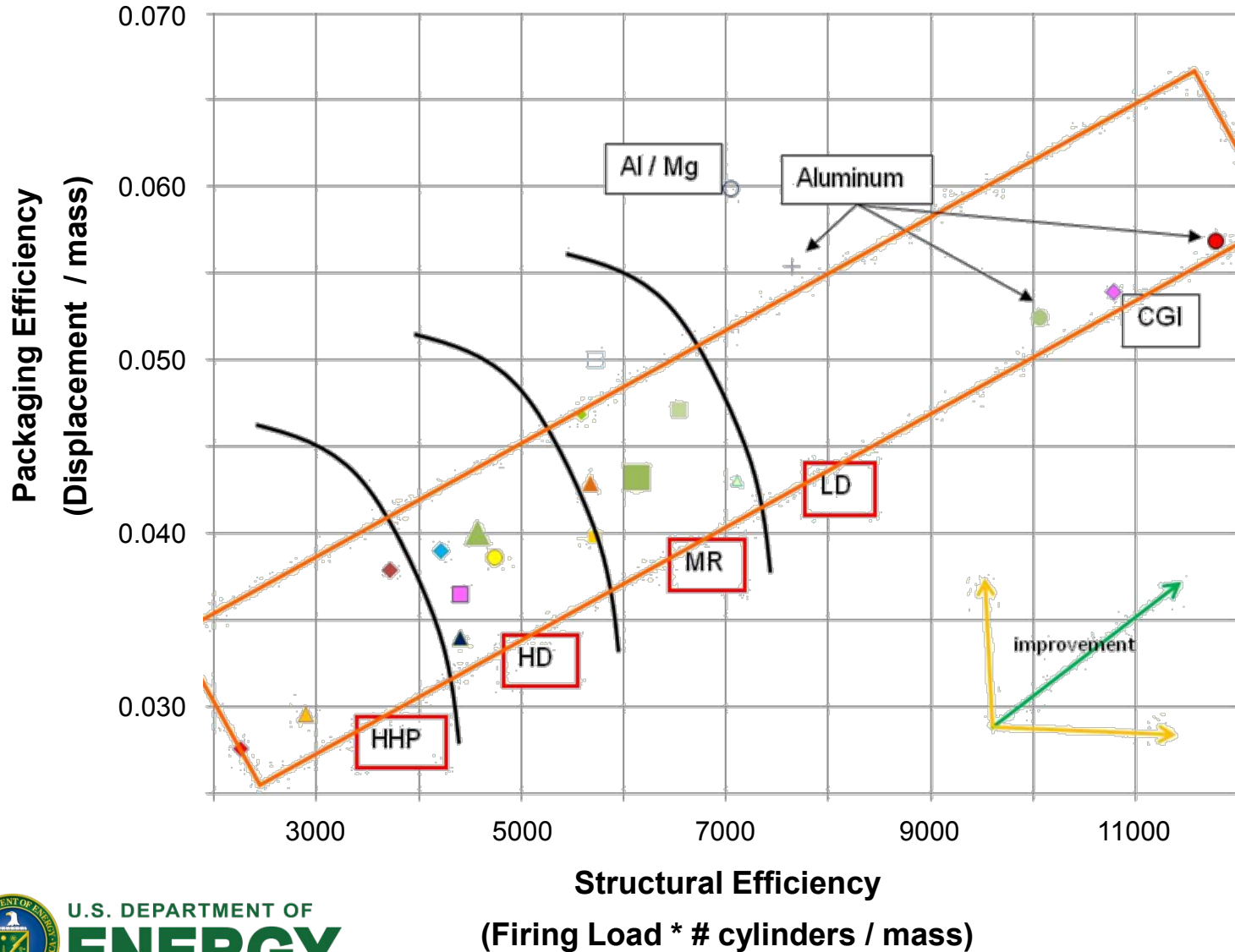


# Lube Oil

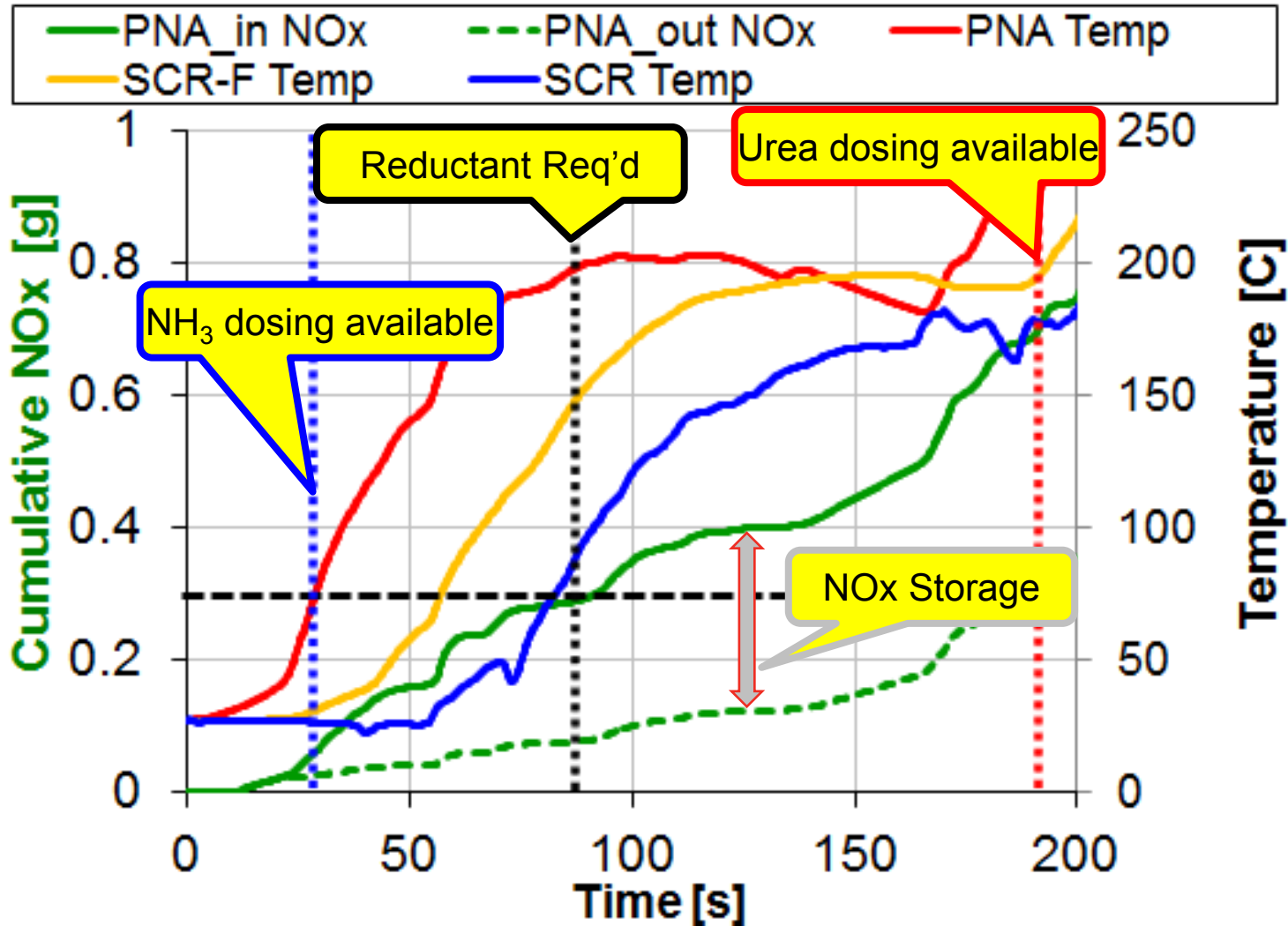
- Engine design changes to take advantage of low viscosity lube oil
  - Bearing materials and journal sizing to maintain high durability at high film pressures
- 5500 lb full sized pick-up truck

	Base 15W40	10W30	5W30	5W30 Low V	
Fuel Economy LA-4	24.6	24.6	25.0	25.9	MPG
Fuel Economy HWFET	29.6	30.0	30.0	30.4	MPG

# Base Engine Design Technology



# Direct NH<sub>3</sub> Delivery and Storage Catalysts



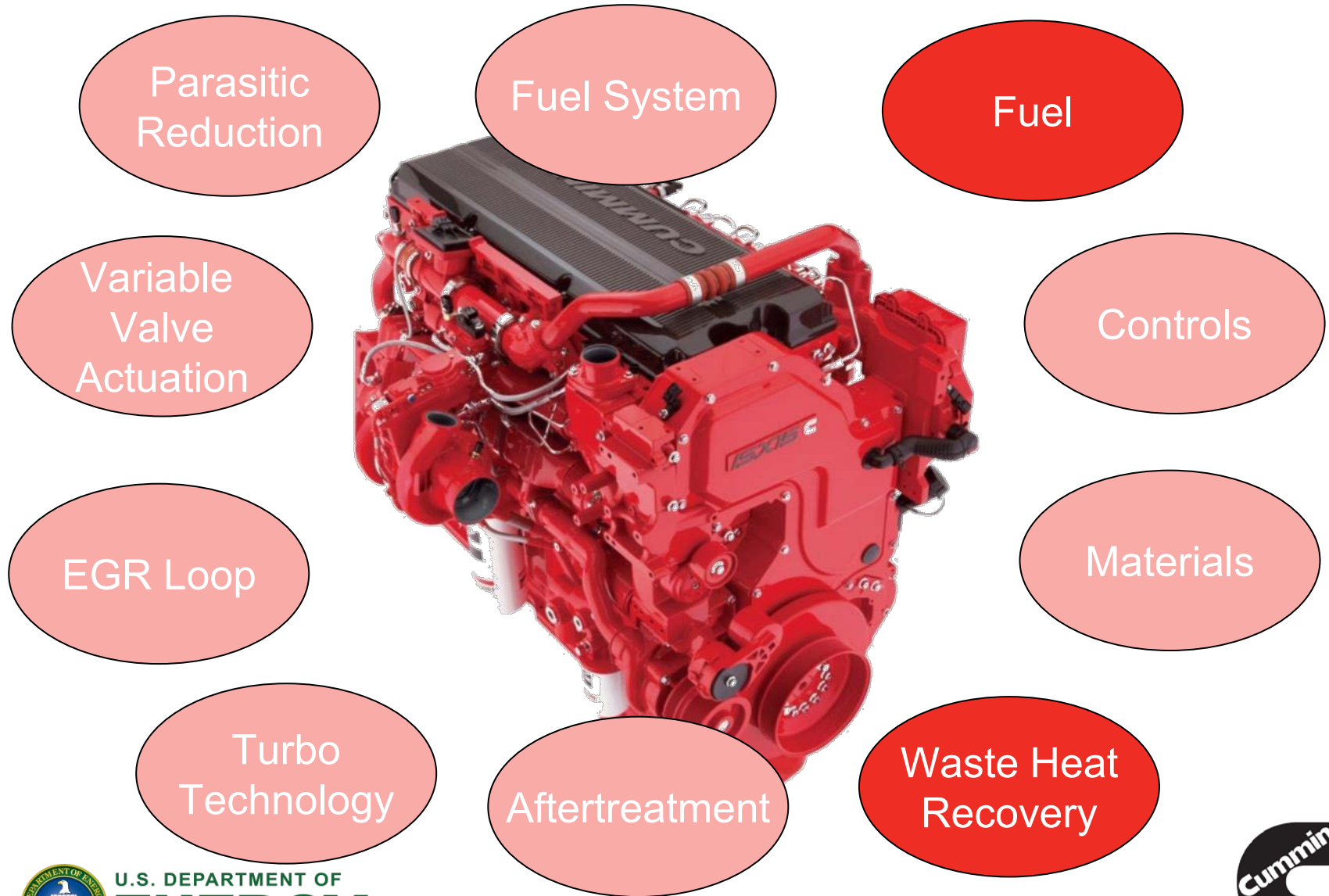
Aftertreatment

# Heavy Duty Engine Technology Levers



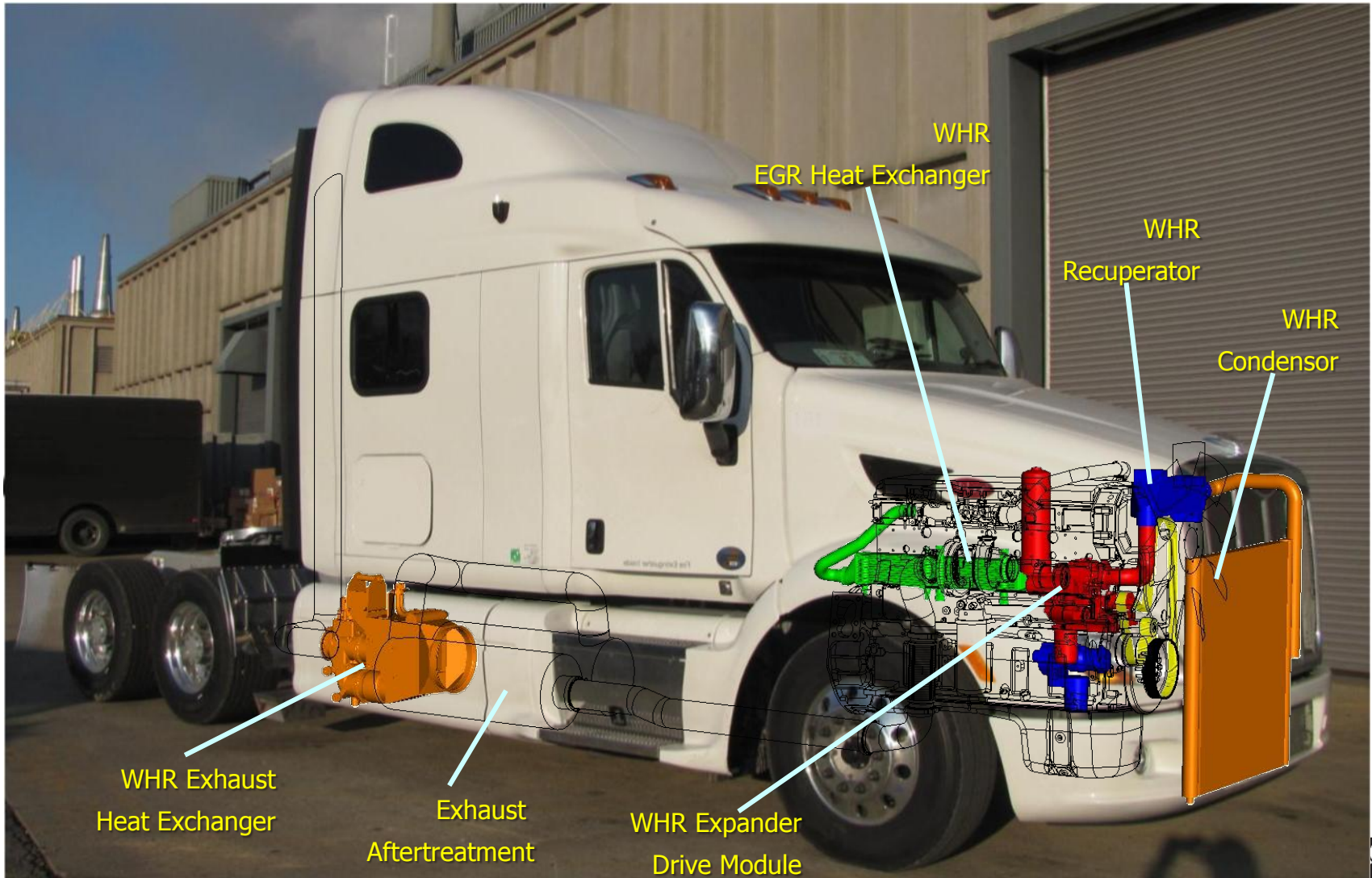


# Heavy Duty Engine Technology Levers



# SuperTruck – WHR System

Waste Heat Recovery

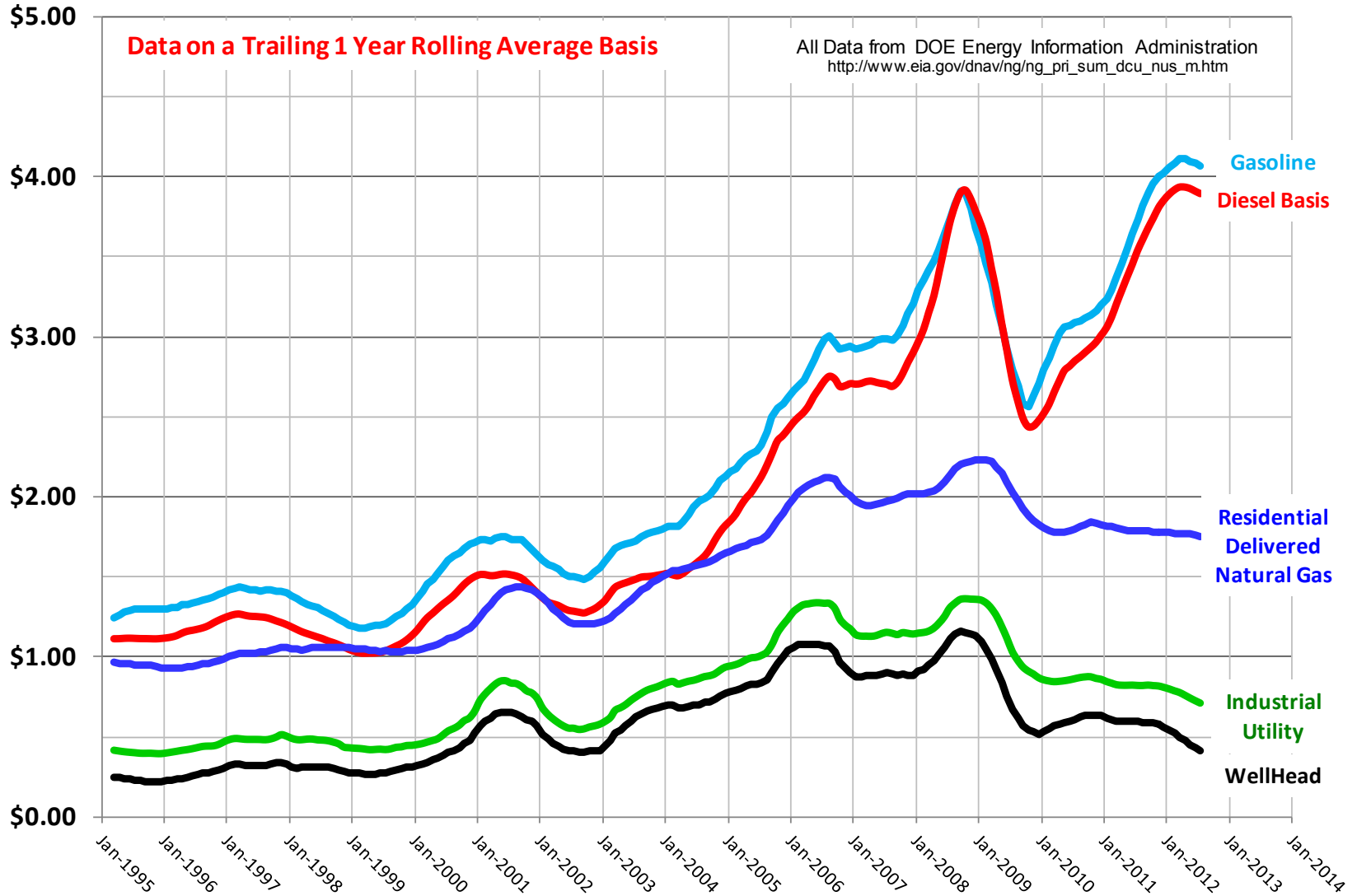


U.S. DEPARTMENT OF  
**ENERGY**



# Energy Prices Drive the Market

## U.S. Fuel Prices - \$/Gallon Diesel Equivalent Energy



# Summary

- The Internal Combustion Engine has a future for personal and commercial transportation.
  - Energy costs and operational cost will drive technology choices
  - Light duty diesel has an opportunity to compete as CAFE/GHG regulations will drive the need for more technology on today's engines
  - Diesel will be capable of matching gasoline emission rates
  - New design techniques will put LD diesels on equal weight measures as gasoline
  - Low Carbon Fuels are important to the future ICE