



Advanced Engine Technology

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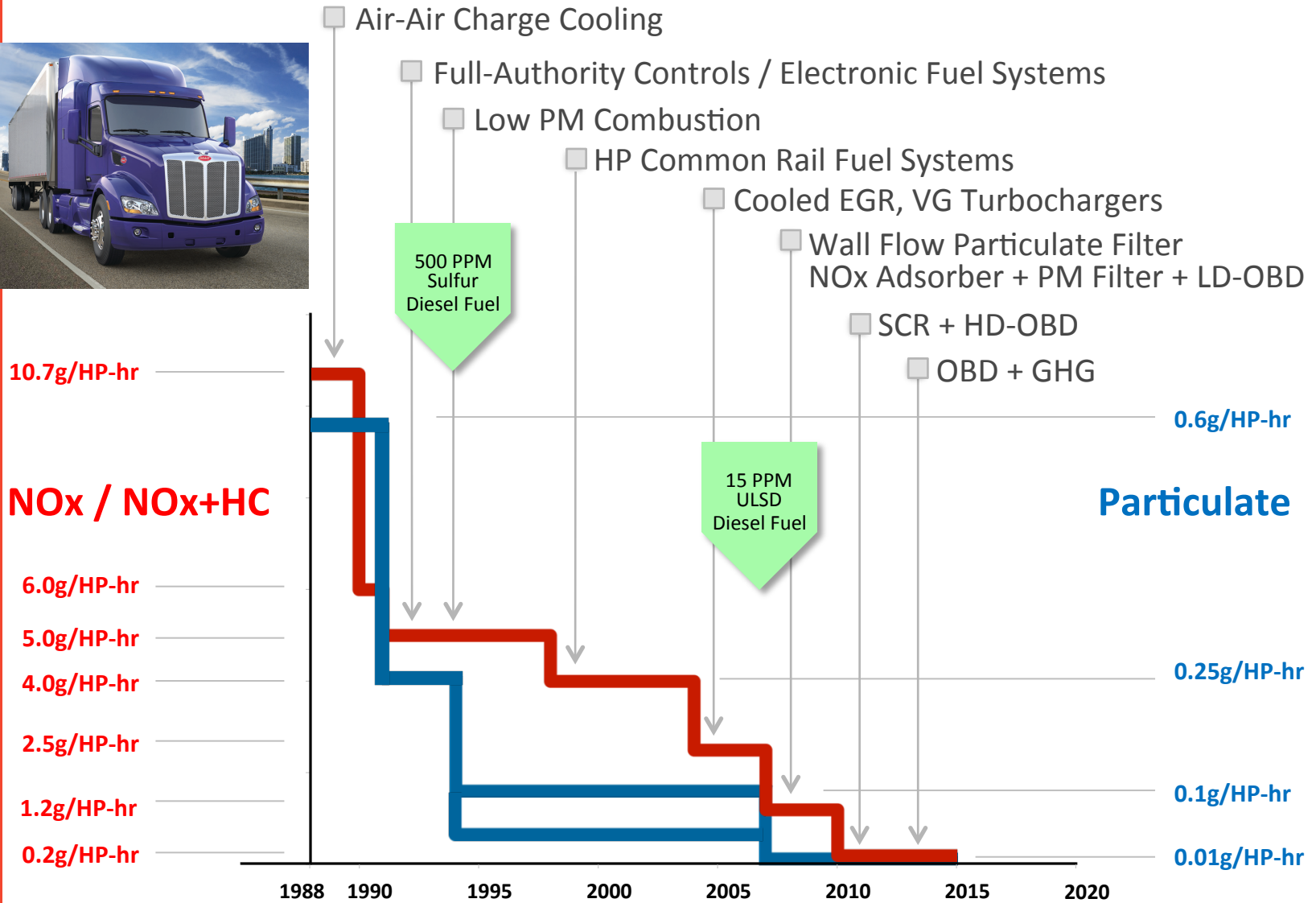
ICCT Workshop
October 22, 2013



Agenda

- Background: Engine development
- Future engine development to reduce CO2
- Regulation and GHG reduction

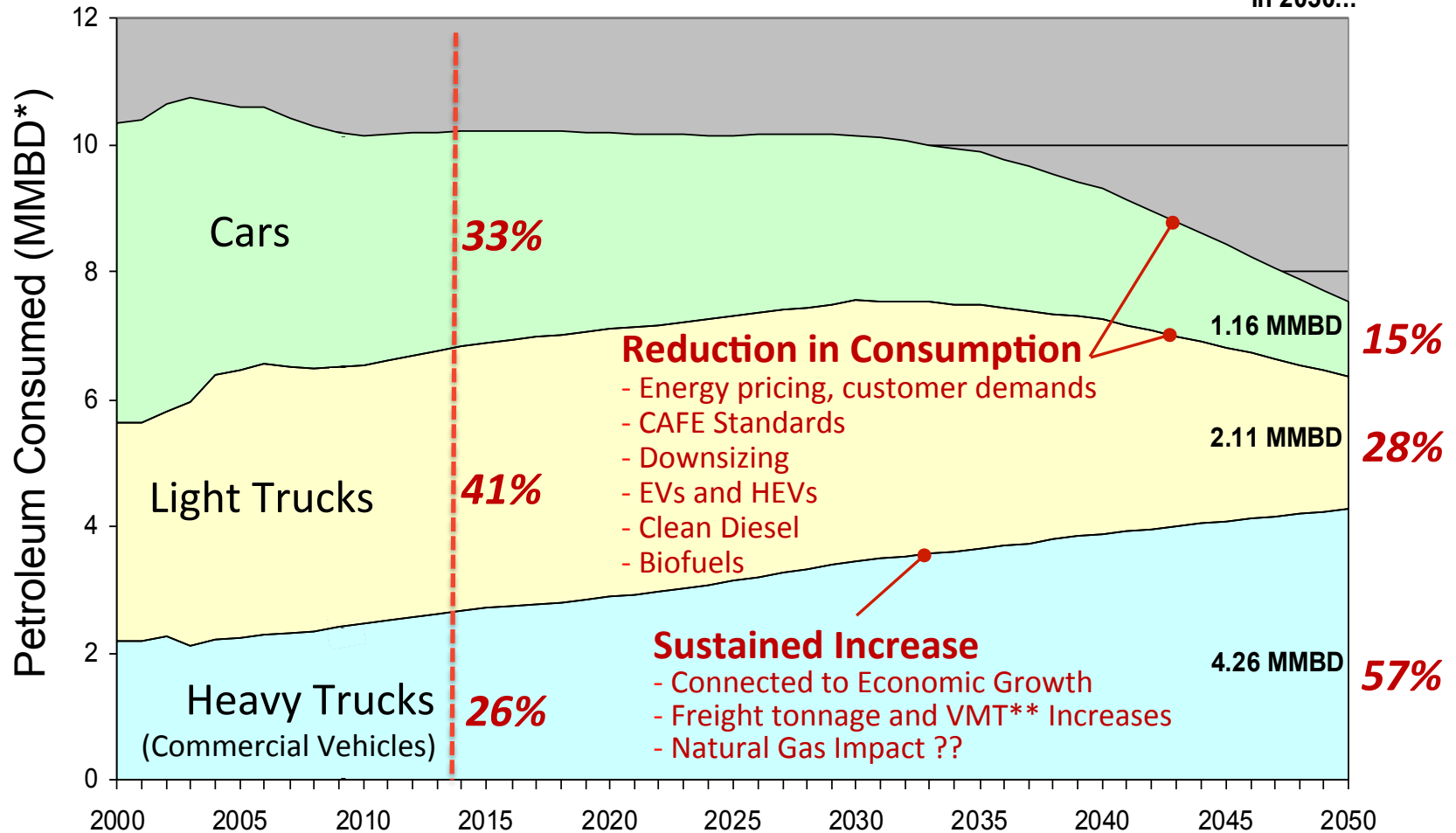
The Road to Clean Diesel – US On-Highway



Oil consumption projections in the U.S. transportation sector by vehicle type

28% of US Energy is Consumed by the Transportation Sector.....

in 2050...

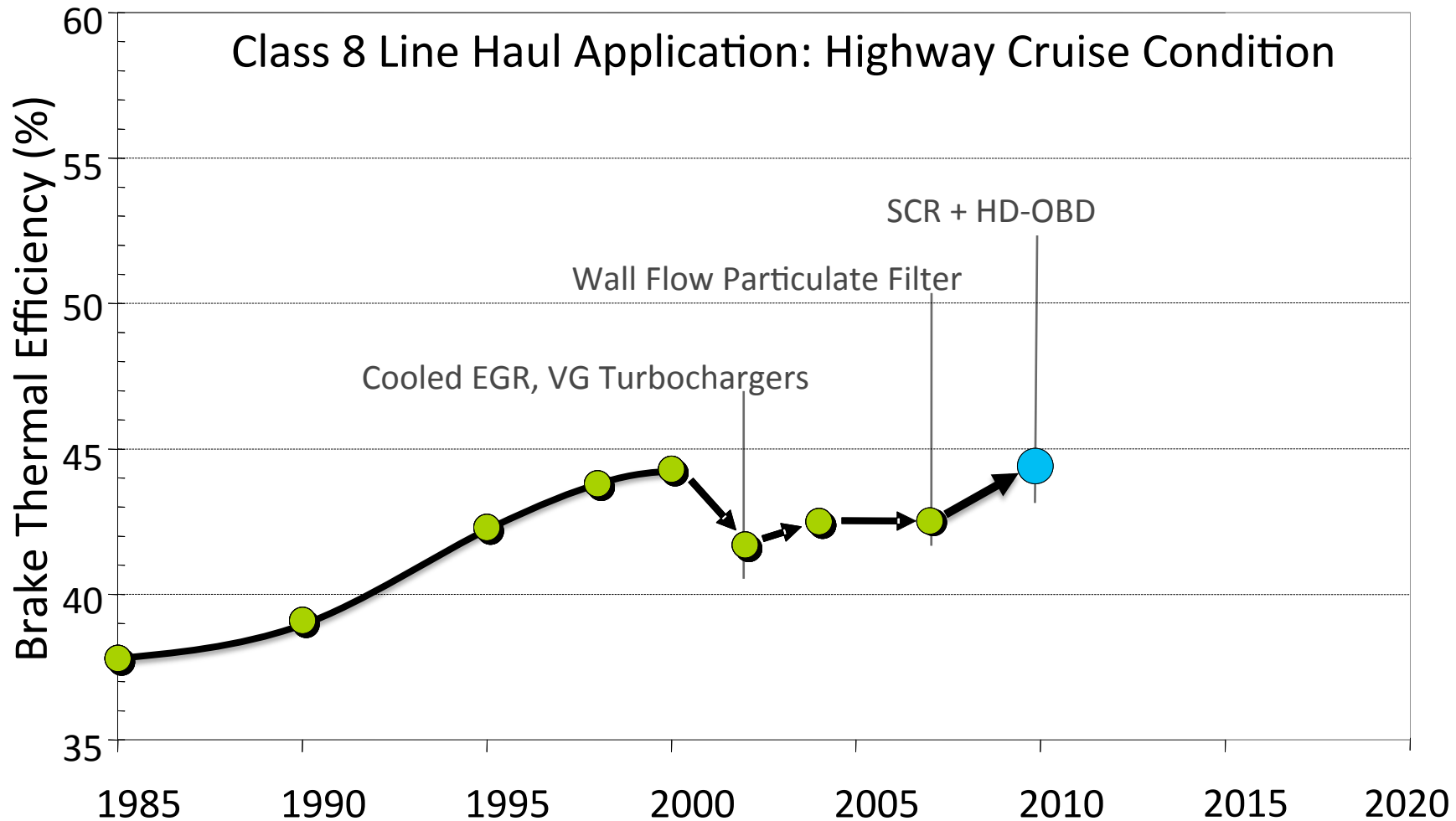


*MMBD – Million Barrels Per Day
 **VMT – Vehicle Miles Traveled

U.S. Department of Energy, Energy Information Administration. 2009b. Annual Energy Outlook 2009. Report No. DOE/EIADOE/EIA-0383(2009). Washington, D.C. March 2009.



Evolution of HD Diesel Engine Efficiency



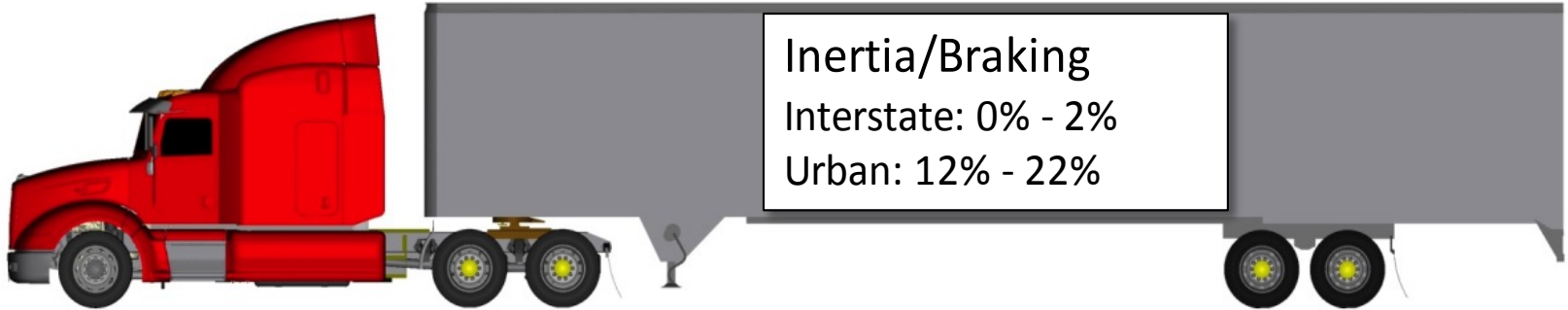
Brake Thermal Efficiency (BTE) - the engine output divided by the fuel energy input

Vehicle Energy Analysis



Engine Losses
Interstate: 56% - 59%
Urban: 58% - 61%

Aerodynamic Losses
Interstate: 16% - 25%
Urban: 3% - 11%



Inertia/Braking
Interstate: 0% - 2%
Urban: 12% - 22%

Auxiliary Loads
Interstate: 1% - 4%
Urban: 7% - 10%

Drive Train
Interstate: 2% - 6%
Urban: 5% - 9%

Rolling Resistance
Interstate: 12% - 17%
Urban: 4% - 14%

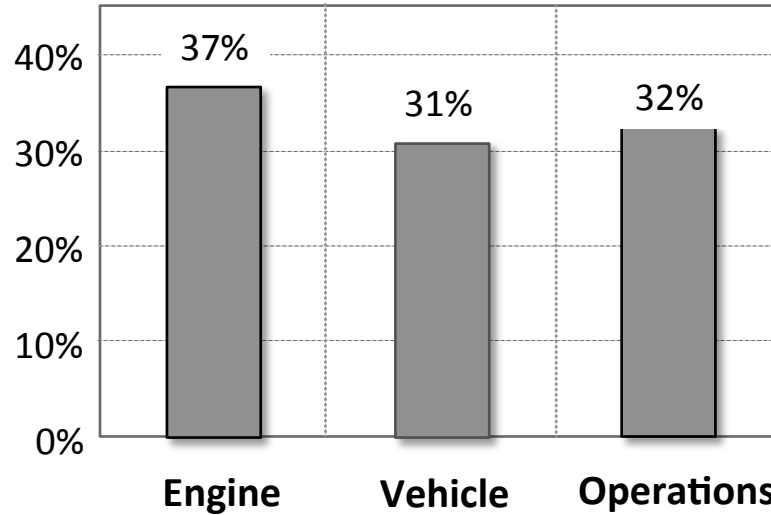


Opportunities for Improvement



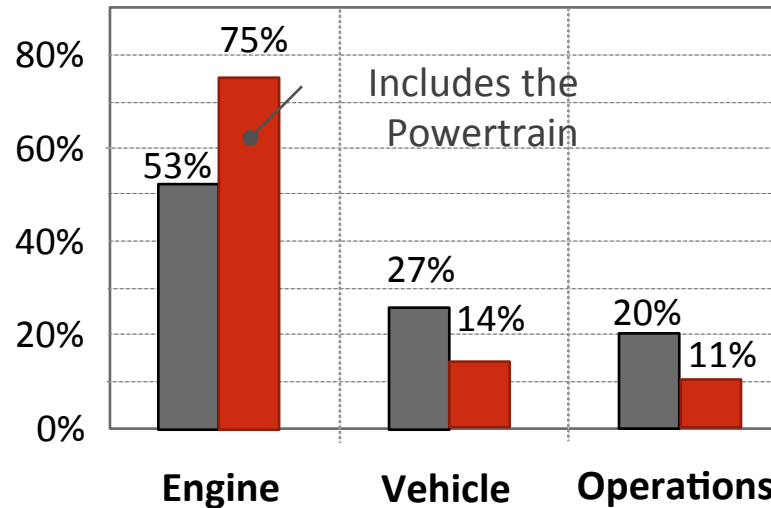
Line-Haul

(Inter-state Routes)



Vocational

(P&D, Bus, Refuse, Pick-up)



■ Conventional Powertrain

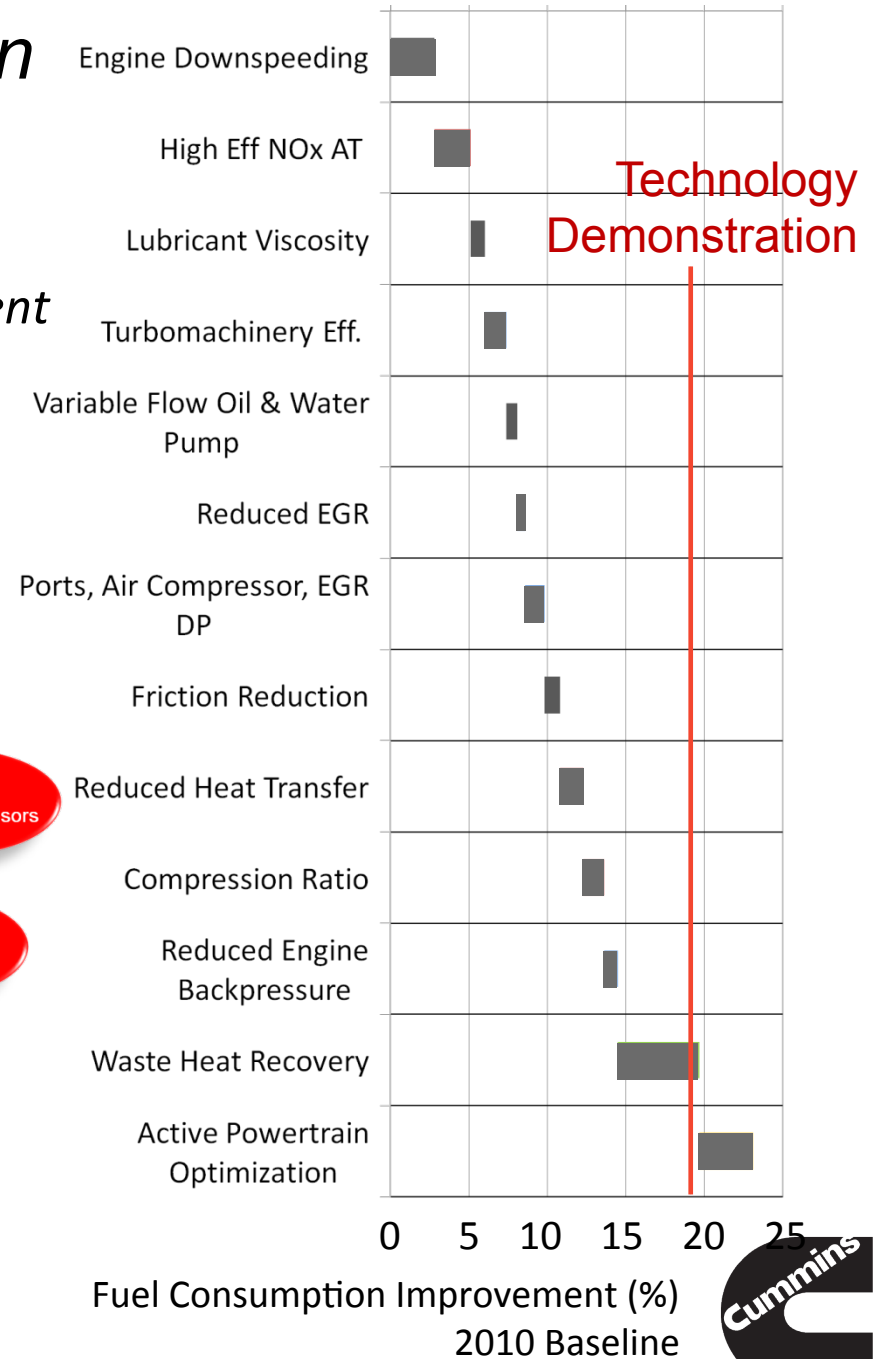
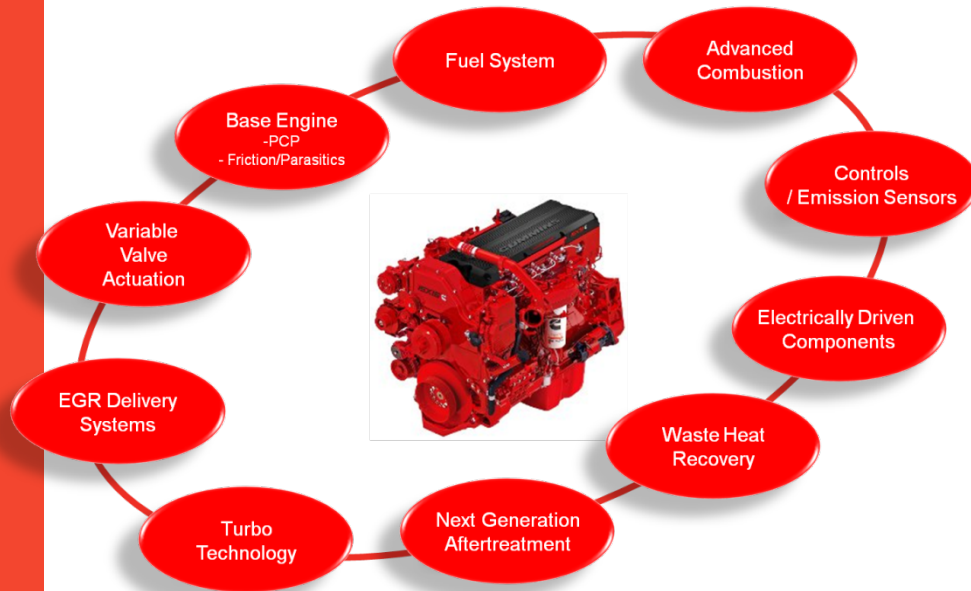
■ Hybrid Powertrain



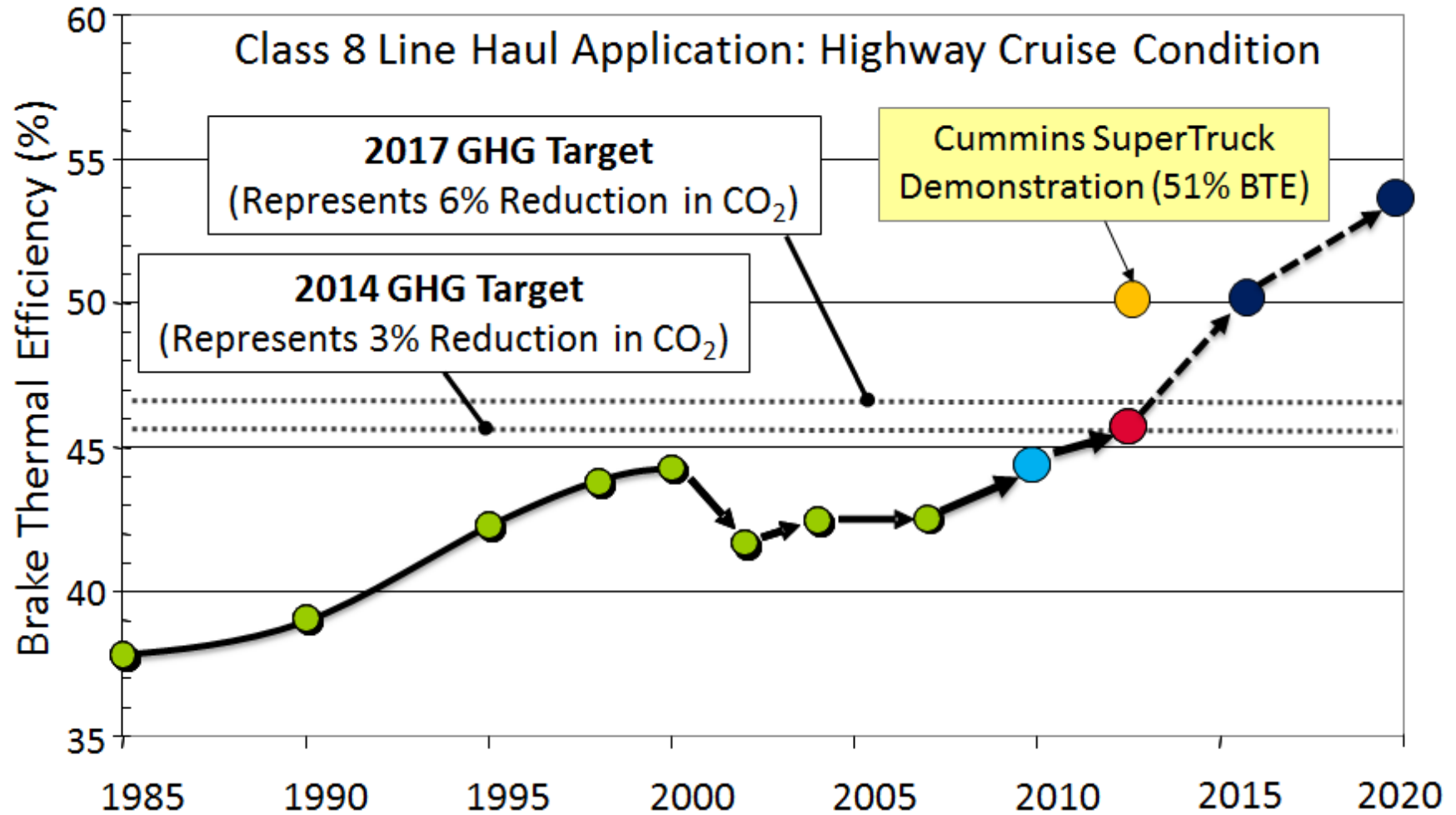
SuperTruck Demonstration

Line-haul

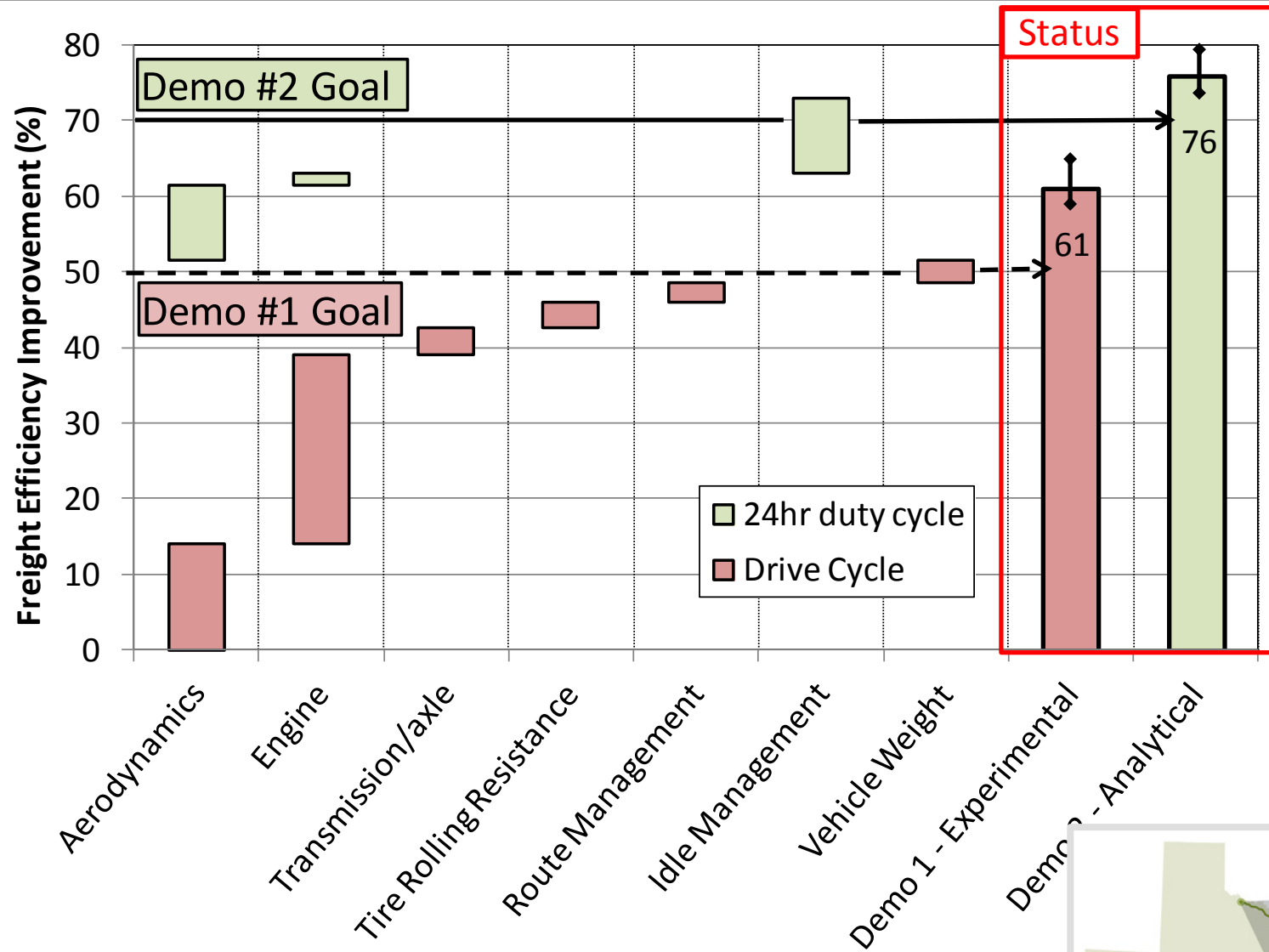
SuperTruck : Industry and US Department of Energy Co-sponsored Program to Improve Engine Efficiency and Vehicle Freight Efficiency



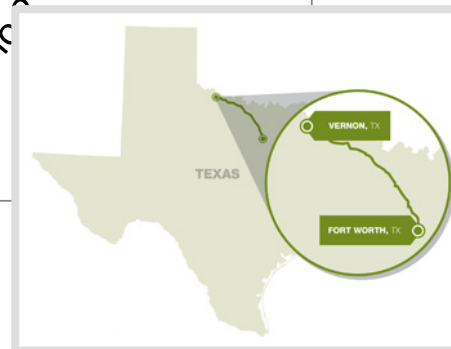
Technology Demonstration



Vehicle Demonstration of Freight Efficiency Improvement



Approximately 19% reduction in Engine Fuel Consumption



Controlling GHGs – A Systems Approach



Fuels

- Reduced carbon intensity
- Bio Diesel, CNG, LNG

Engines / Power Trains

- Advanced Engines and Aftertreatment
- Waste Heat Recovery
- Integrated Power Trains
- Hybrids / Automated Transmissions

Tractor / Trailer

- Aerodynamics
- Tires / Rolling Resistance
- Idling Technologies

Fleets / Operators

- Incentives for low GHG vehicles
- Logistics, Driver training & aids

Highways / Infrastructure

- Highway Construction / Congestion
- Speed limits
- GVW



US EPA Phase 1 GHG: Engine **AND** Vehicle Regulation



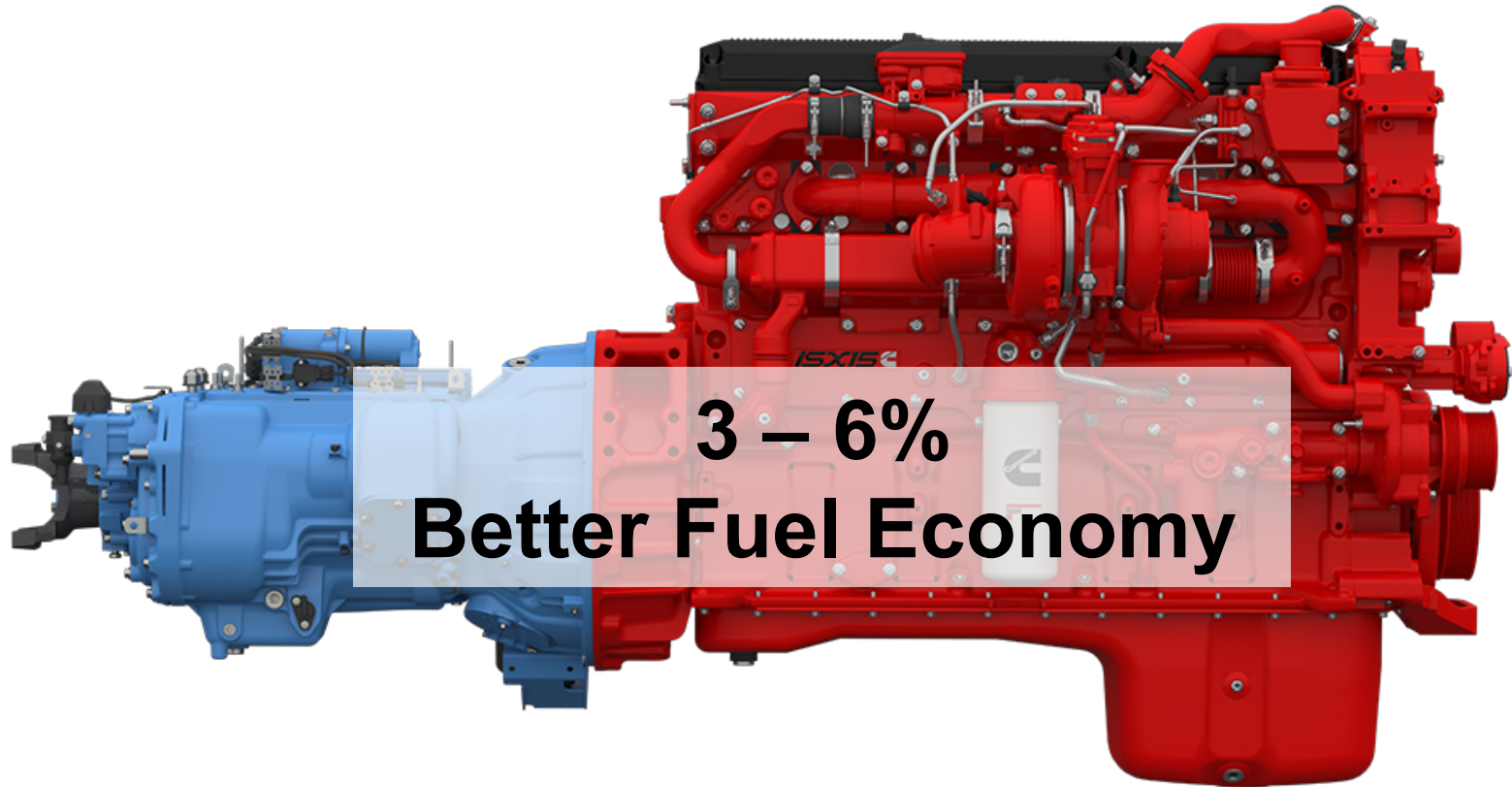
US EPA Phase 1 GHG: Engine AND Vehicle Regulation

- Drives technology directly at all levels
- Regulatory simplicity (feasibility)
- Fidelity
- Enforceability
- Assurance of intended environmental benefit across applications and in use
 - CO₂ and criteria pollutants



ISX15 SmartTorque2

Eaton Fuller Advantage Automated Transmission

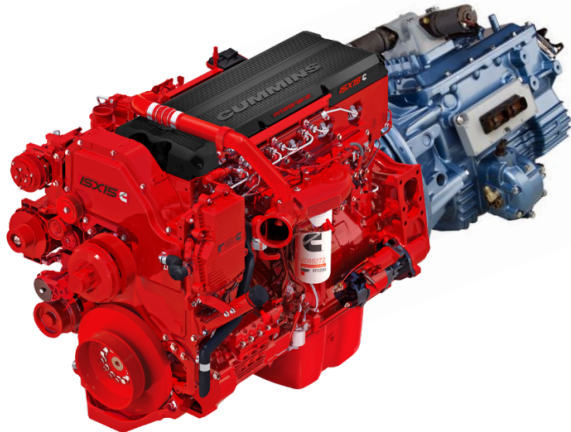


Powering Business Worldwide

Proposal for EPA Phase 2 GHG Rule: Engine/Powertrain **AND** Vehicle Regulation



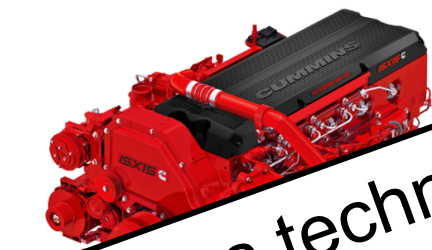
OR



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Proposal for EPA Phase 2 GHG Rule: Engine/Powertrain **AND** Vehicle Regulation



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- Regulatory simplicity (feasibility)

- Fidelity

- Enforceability

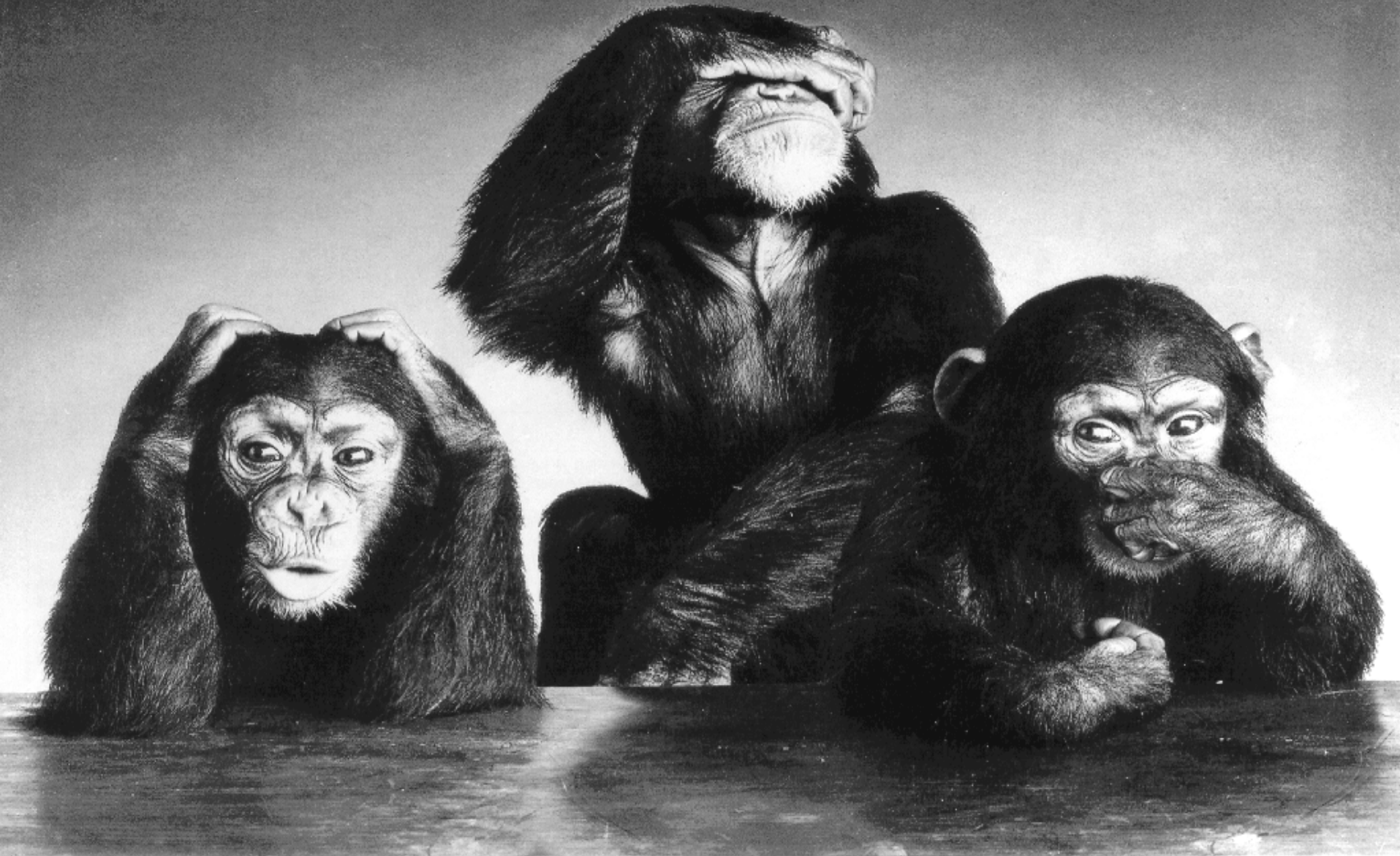
- Assurance of intended environmental benefit across applications and in use
 - CO₂ and criteria pollutants



Summary

- Engine regulation has been successful in reducing real world criteria emissions
- Future engine technology development will be focused on CO2 reduction
 - New engine & powertrain technology has the potential to make significant reductions in CO2 emissions
- Regulatory framework and approach can play an important role
 - Engine/powertrain program AND vehicle program can help efficiently drive technology development to reduce emissions

Thank you!



Hear no diesel. See no diesel. Smell no diesel.