Advanced Engine Technology

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Agenda

- Background: Engine development
- Future engine development to reduce CO2
- Regulation and GHG reduction
The Road to Clean Diesel – US On-Highway

- Air-Air Charge Cooling
- Full-Authority Controls / Electronic Fuel Systems
- Low PM Combustion
- HP Common Rail Fuel Systems
- Cooled EGR, VG Turbochargers
- Wall Flow Particulate Filter
- NOx Adsorber + PM Filter + LD-OBD
- SCR + HD-OBD
- OBD + GHG
- 500 PPM Sulfur Diesel Fuel
- 15 PPM ULSD Diesel Fuel

10.7g/HP-hr
6.0g/HP-hr
5.0g/HP-hr
4.0g/HP-hr
2.5g/HP-hr
1.2g/HP-hr
0.2g/HP-hr


Particulate

0.6g/HP-hr
0.25g/HP-hr
0.1g/HP-hr
0.01g/HP-hr
Oil consumption projections in the U.S. transportation sector by vehicle type

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

- Reduction in Consumption
  - Energy pricing, customer demands
  - CAFE Standards
  - Downsizing
  - EVs and HEVs
  - Clean Diesel
  - Biofuels

- Sustained Increase
  - Connected to Economic Growth
  - Freight tonnage and VMT** Increases
  - Natural Gas Impact ??

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

Evolution of HD Diesel Engine Efficiency

Class 8 Line Haul Application: Highway Cruise Condition

Brake Thermal Efficiency (%)

- Cooled EGR, VG Turbochargers
- Wall Flow Particulate Filter
- SCR + HD-OBD

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%

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

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

- **Drive Train**
  - Interstate: 2% - 6%
  - Urban: 5% - 9%
Opportunities for Improvement

Line-Haul

(Inter-state Routes)

Vocational

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

Includes the Powertrain

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

Class 8 Line Haul Application: Highway Cruise Condition

- **2017 GHG Target**
  (Represents 6% Reduction in CO₂)
- **Cummins SuperTruck Demonstration (51% BTE)**

- **2014 GHG Target**
  (Represents 3% Reduction in CO₂)

Brake Thermal Efficiency (%) vs. Years:

The graph shows the improvement in brake thermal efficiency over time, with the Cummins SuperTruck demonstration achieving a 51% BTE, which represents a significant reduction in GHG emissions.
Vehicle Demonstration of Freight Efficiency Improvement

Freight Efficiency Improvement (%)

- Demo #2 Goal
- Demo #1 Goal

24hr duty cycle
Drive Cycle

- Standard Deviation: 3%

- 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
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- Drives technology directly at all levels
- Regulatory simplicity (feasibility)
- Fidelity
- Enforceability
- Assurance of intended environmental benefit across applications and in use
  - $\text{CO}_2$ and criteria pollutants
ISX15 SmartTorque2
Eaton Fuller Advantage Automated Transmission

3 – 6% Better Fuel Economy
Proposal for EPA Phase 2 GHG Rule: Engine/Powertrain **AND** Vehicle Regulation

**OR**
Proposal for EPA Phase 2 GHG Rule: Engine/Powertrain 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
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.