

# The Role of Higher Performing Lubricants in Reducing Emissions and Improving Efficiency

EPA Mobile Sources Review Subcommittee

Scott Halley, May 31, 2017

# Agenda



- Introducing Lubrizol
- Lubricants 101
- The Role of Higher Performing Lubricants (i.e., Why Higher Performing Lubricants Matter)
  - Heavy-Duty Vehicles
  - Light-Duty
- Facilitating the use of Higher Performing Lubricants
  - New vehicle certification
  - Throughout useful life



# Introducing Lubrizol

# Introducing Lubrizol



- **US-based, global leader in lubricants and additives**

- Headquartered in Wickliffe, Ohio
- 5,100 US employees serving customers in >100 countries, with more than 8,300 global employees

- **Market-driven, problem-solving technology**

- More than 3,000 patents
- Innovative solutions to customers' toughest challenges

- **Owned by Berkshire Hathaway Inc.**

- 2016: revenues \$222 billion, net income \$24 billion



Driven by high performance chemistry and a high performance team



# Lubrizol chemistries optimize performance and durability while reducing environmental impact



## Lubrizol Additive Product Areas



### Driveline

- Commercial vehicles
- Passenger car
- Off-highway applications
  - Agriculture
  - Construction
  - Forestry
  - Mining



### Engine Oils

- Heavy-duty engines
- Large engines
  - Marine diesel
  - Stationary natural gas
- Passenger car engines
  - Small engines
  - Motorcycles
- Power tools and recreational vehicles



### Fuels

- Biofuel
- Diesel
- Gasoline
- Marine



### Industrial

- Emulsifiers for explosives
- Grease
- Hydraulic fluids
- Industrial gear oils
- Metalworking fluids
- Oilfield

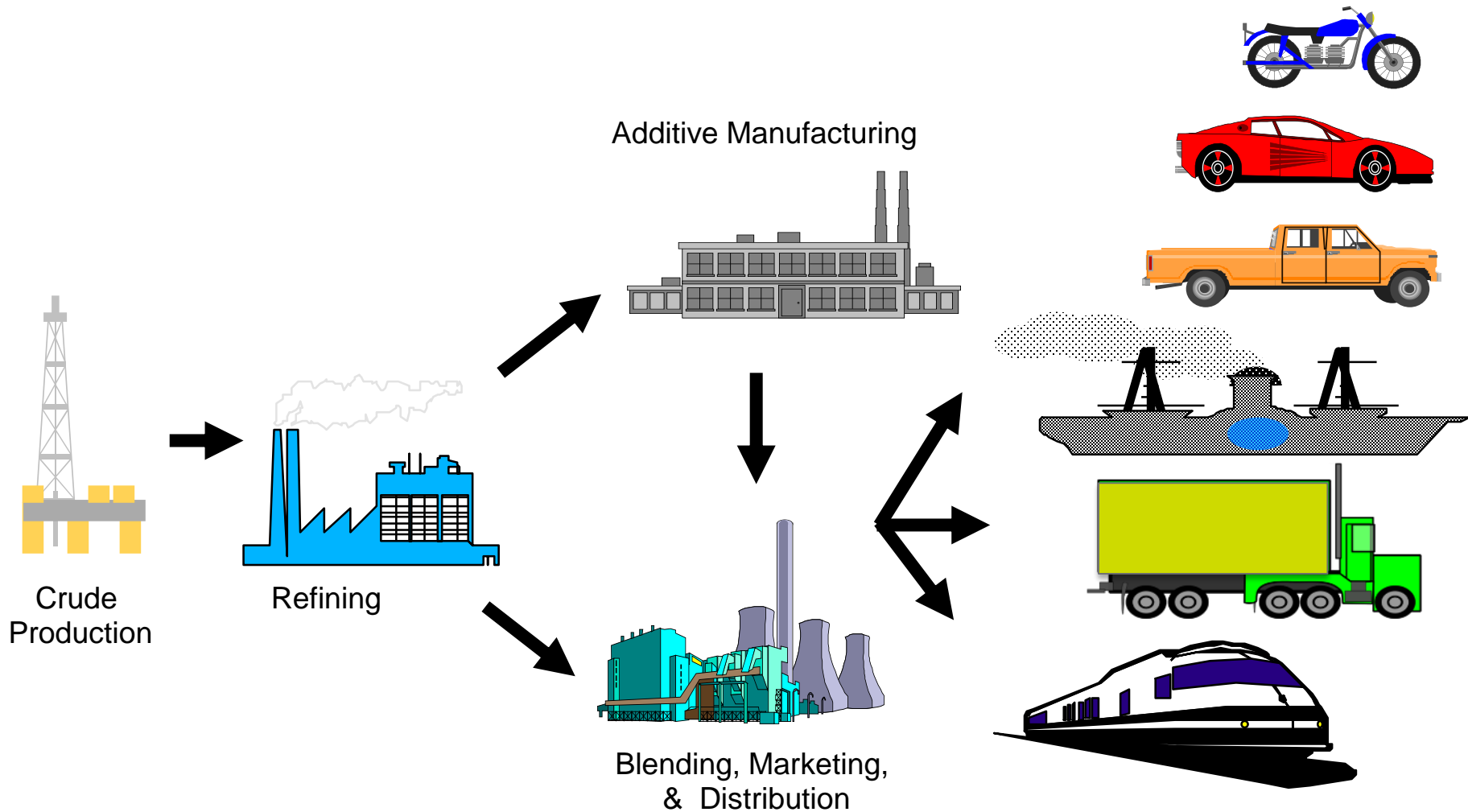


# Lubricants 101

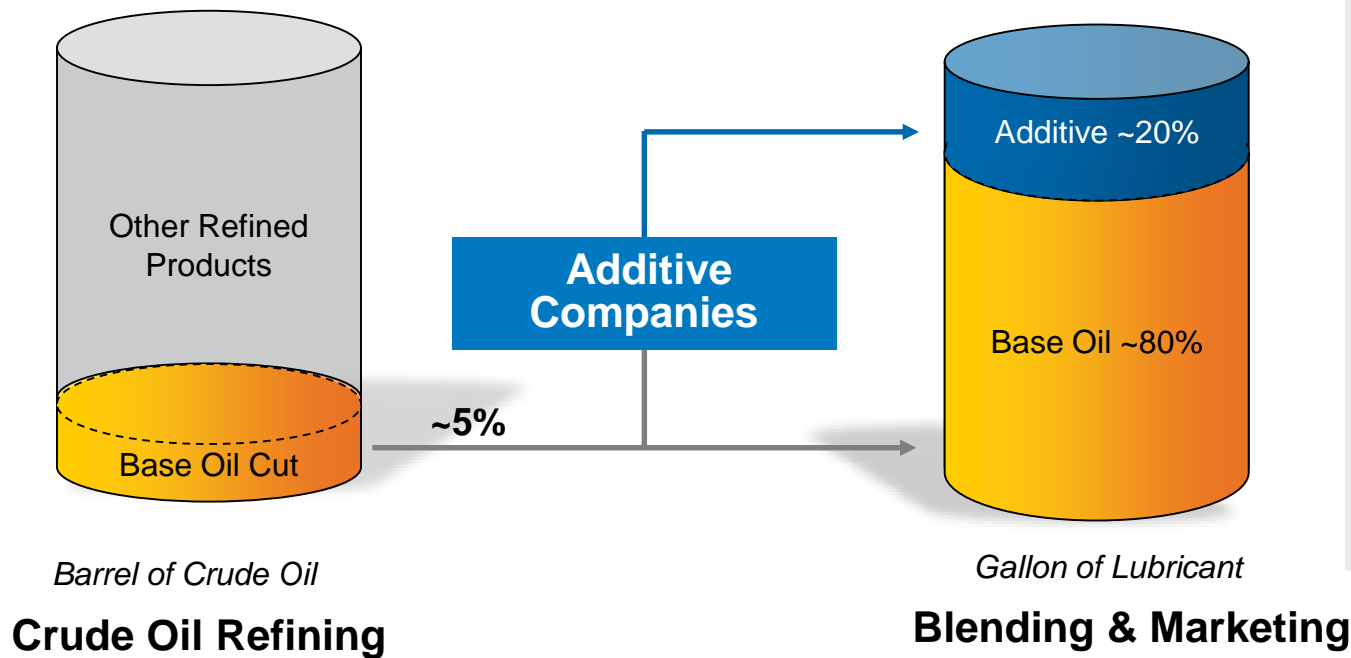
# From Dinosaurs to Finished Lubricants



SUCCESS  
TOGETHER



# Lubricants and additives provide improved performance in a variety of ways



- Antifoams
- Pour Point Depressants
- Corrosion Inhibitors
- Friction Modifiers
- Antioxidants
- Antiwear Agents
- Detergents
- Viscosity Modifiers (VM)
- Dispersants
- Others



# Four reasons why Higher Performing Lubricants will matter more in the future



## 1 Vehicle sales growth

## 2 Improving efficiency

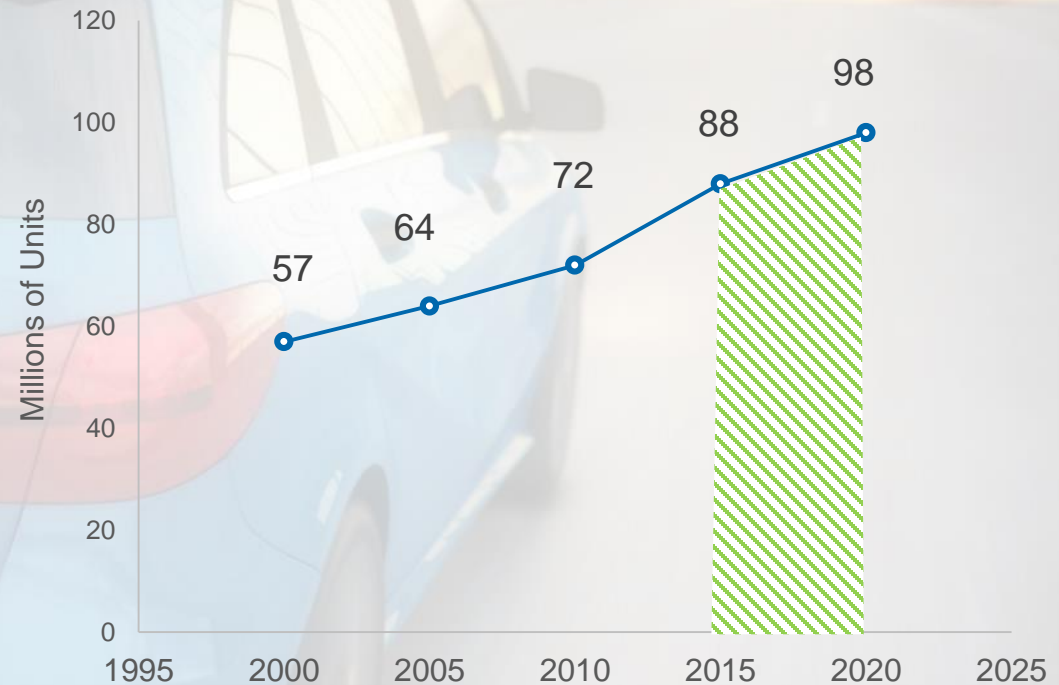
## 3 Powertrain enablement

## 4 Lower viscosity oils

- Worldwide vehicle fleet will double by 2030
- Asian markets are leading growth
- From 2000-2020, Chinese car market projected to grow 35X

## Annual worldwide vehicle sales

(Light, medium and heavy duty vehicles)



Sources : IHS AutoInsight, McKinsey, KPMG, Lubrizol  
[www.greencarreports.com](http://www.greencarreports.com); [www.Wikipedia.com](http://www.Wikipedia.com)

Demand grows for high performance lubricants and engineered solutions



# Increased efficiency and lower emissions are major emerging trends worldwide



1 Vehicle sales growth

2 Improving efficiency

3 Powertrain enablement

4 Lower viscosity oils

HD Segment follows

- New regulations are leading to efficiency improvements in hardware and lubricants
- All major markets are strengthening their emissions-related regulations
  - China: China 6a (2020) and 6b (2023)
  - India: BS VI (2021)
  - US: Tier 3 being phased in
  - EU: RDE<sup>a</sup> and WLTP<sup>b</sup> test cycle and procedure
- Additional CO<sub>2</sub> targets are also approaching:
  - EU: 95 g/km<sup>c</sup> by 2021
  - China: Phase III fuel economy legislation
  - US: 54.5 mpg in the US expected by 2025

This will lead to greater use of lighter viscosity, lower SAPS lubricants

Notes 1. RDE is an acronym for Real world Driving Efficiency, a test cycle for emissions performance which is conducted on the road  
2. WLTP is an acronym for Worldwide harmonized Light vehicle Test Procedure which is expected to replace the New European Drive Cycle (NEDC) in the EU  
3. Current limit based on the NEDC test cycle and this may be changed once the WLTP test cycle is adopted

# More sophisticated powertrains will require more sophisticated lubricants



1 Vehicle sales growth

2 Improving efficiency

3 Powertrain enablement

4 Lower viscosity oils

OEM

Oil

Additive

- Future engine and transmission systems will be optimized to deliver more power, more efficiently
  - Higher power density, smaller engines
  - Downspeeding of engines
  - Increasing the number of gears
  - Shift to automatic transmissions
  - Continued use of diesel particulate filters
  - Introduction of gasoline particulate filters
  - Greater use of SCR systems on light duty diesel vehicles
  - Light weighting and many other options

Operating conditions will more severe—and hardware will be more sophisticated

# These trends will require Higher Performing Lubricants (HPLs)



1 Vehicle sales growth

2 Improving efficiency

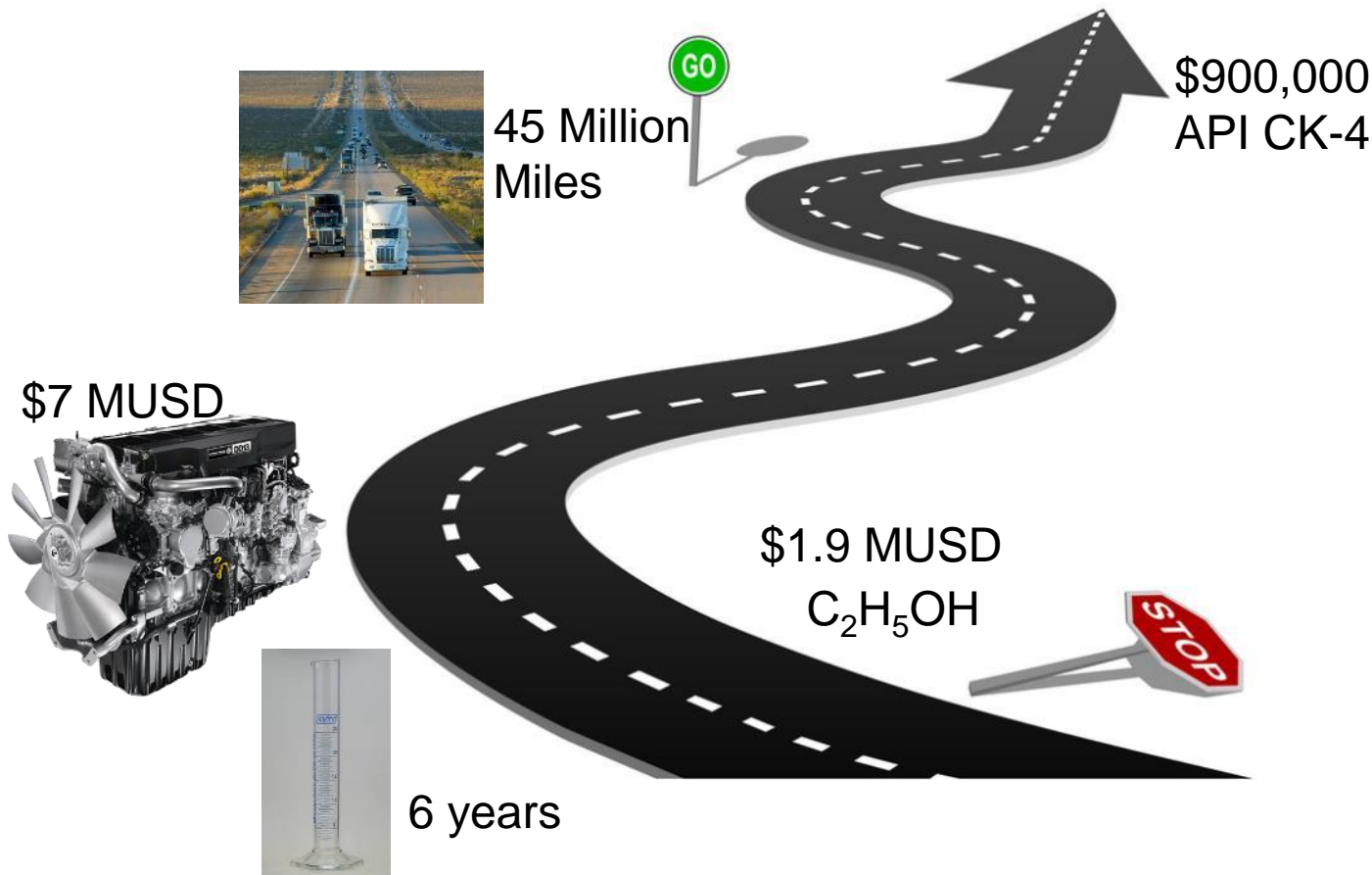
3 Powertrain enablement

4 Lower viscosity oils

- New specifications and OEM requirements mean that future HPLs will deliver:
  - Lighter viscosity grades
  - Lower HTHS viscosity levels
  - More fuel economy overall
  - Fuel economy durability over the life of the drain
  - Uncompromised durability
- Lubricants further enable the durable operation of new engines and hardware

A new frontier of lubricants is on the way

# Creating new lubricants requires extensive testing and resources—and takes years of planning

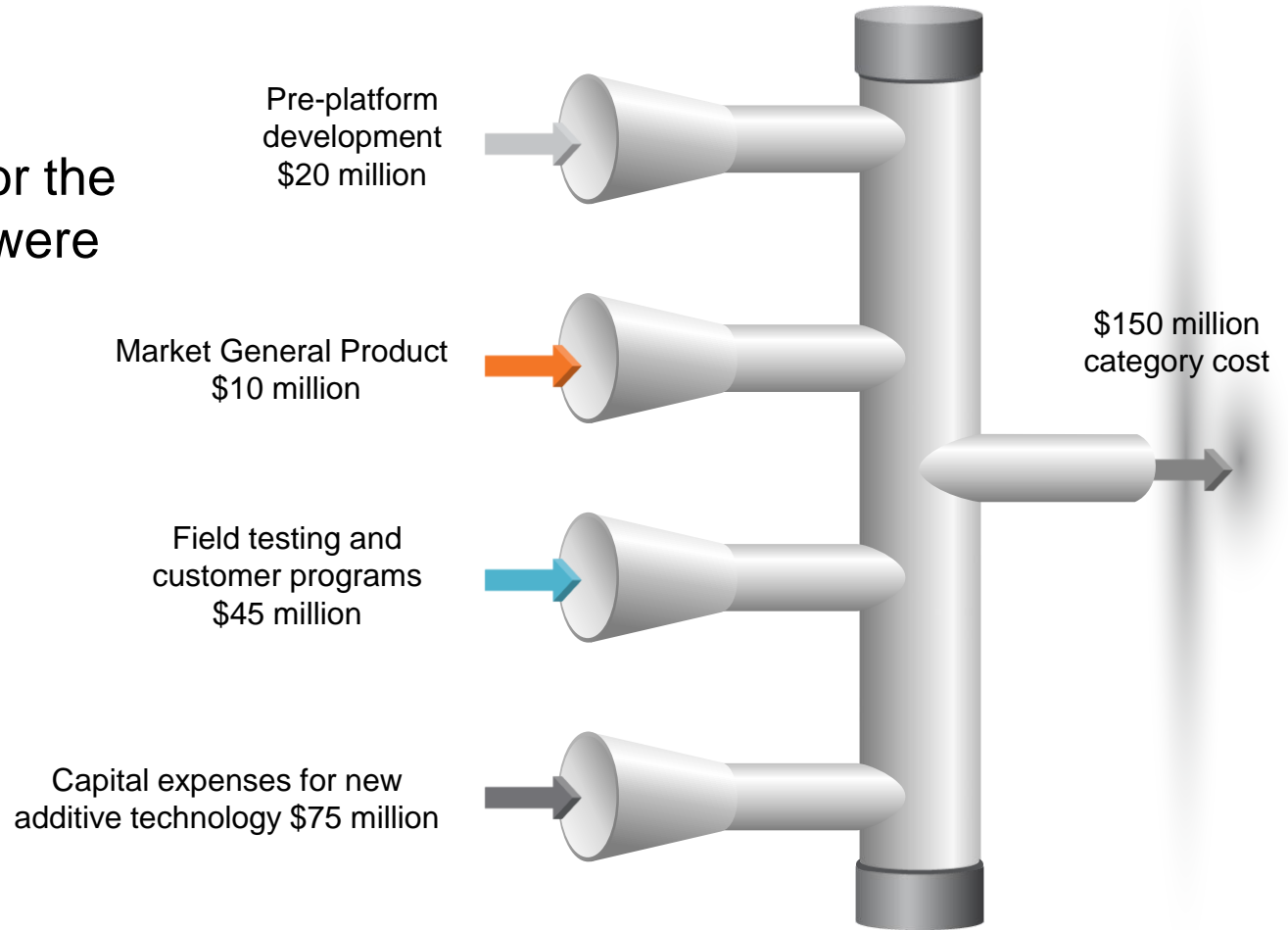


Success requires open discussion and coordination among regulators, OEMs, oil companies, and lubricant industry

# Developing a new industry performance standard is a particularly resource-intensive activity



Example:  
Lubrizol's Category  
Development costs for the  
CK-4/FA-4 standard were  
~\$150M



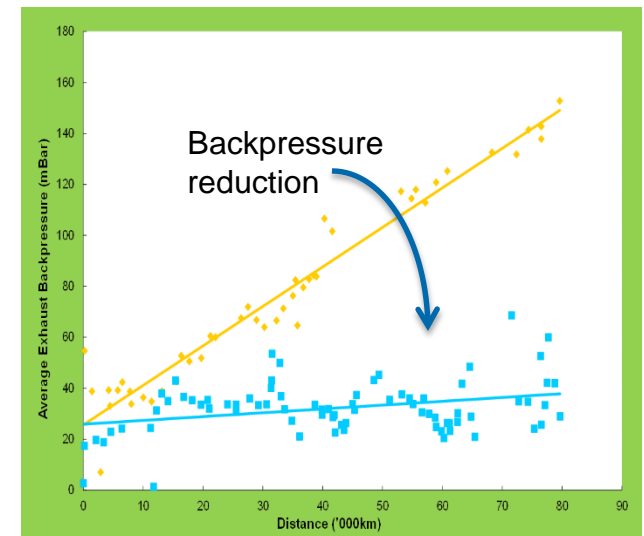
These investments require coordination and cooperation



# The Role of Higher Performance Lubricants (HPLs) Heavy Duty Diesel Engine Oil

# Case Study: How lubricants extend the life of diesel aftertreatment devices

- Certain additive chemistries, when consumed by the engine, can cause deposits in DPFs and other aftertreatment devices
- These deposits can:
  - Restrict exhaust flow
  - Increase exhaust back pressure on the engine
  - Reduce fuel economy
  - Shorten the useful life of the after treatment device
- A new formulation architecture was developed that reduced these deposits, lowered exhaust back pressure, and extended useful life of emission reduction hardware

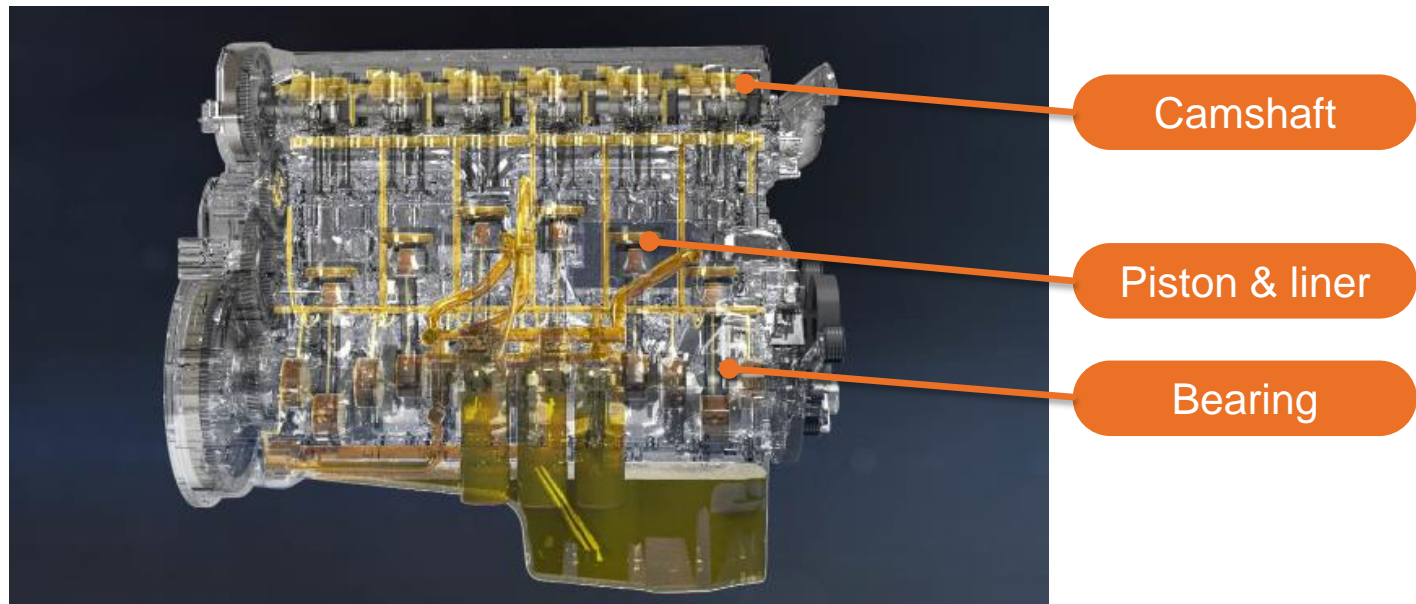




# Newer lubricants improve fuel economy by lowering “High Temperature High Shear” (HTHS)



- Traditional viscosity grades represented gravimetric flow of a fluid
- HTHS better represents the fluid viscometric properties in engine environments (e.g., the piston ring to cylinder interface)

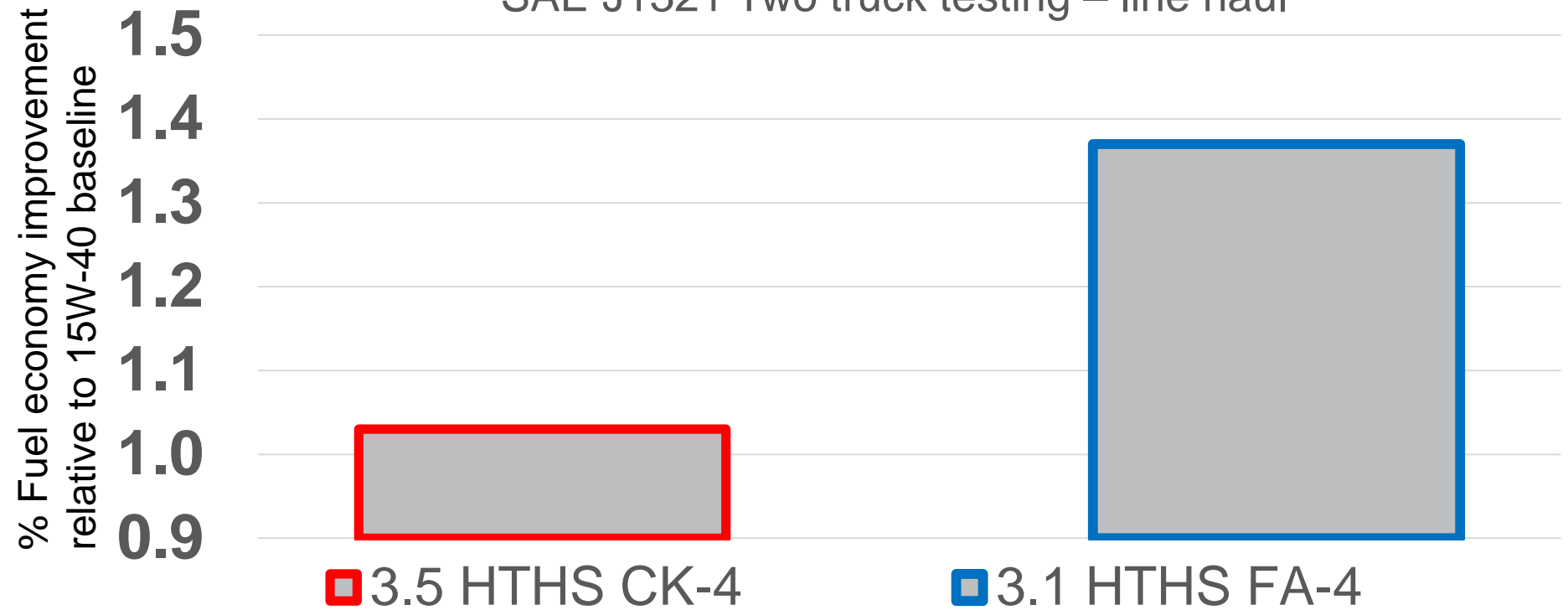


HTHS is a strong predictor of the fuel economy benefits of a lubricant

# Fuel Economy – The importance of HTHS



SAE J1321 Two truck testing – line haul

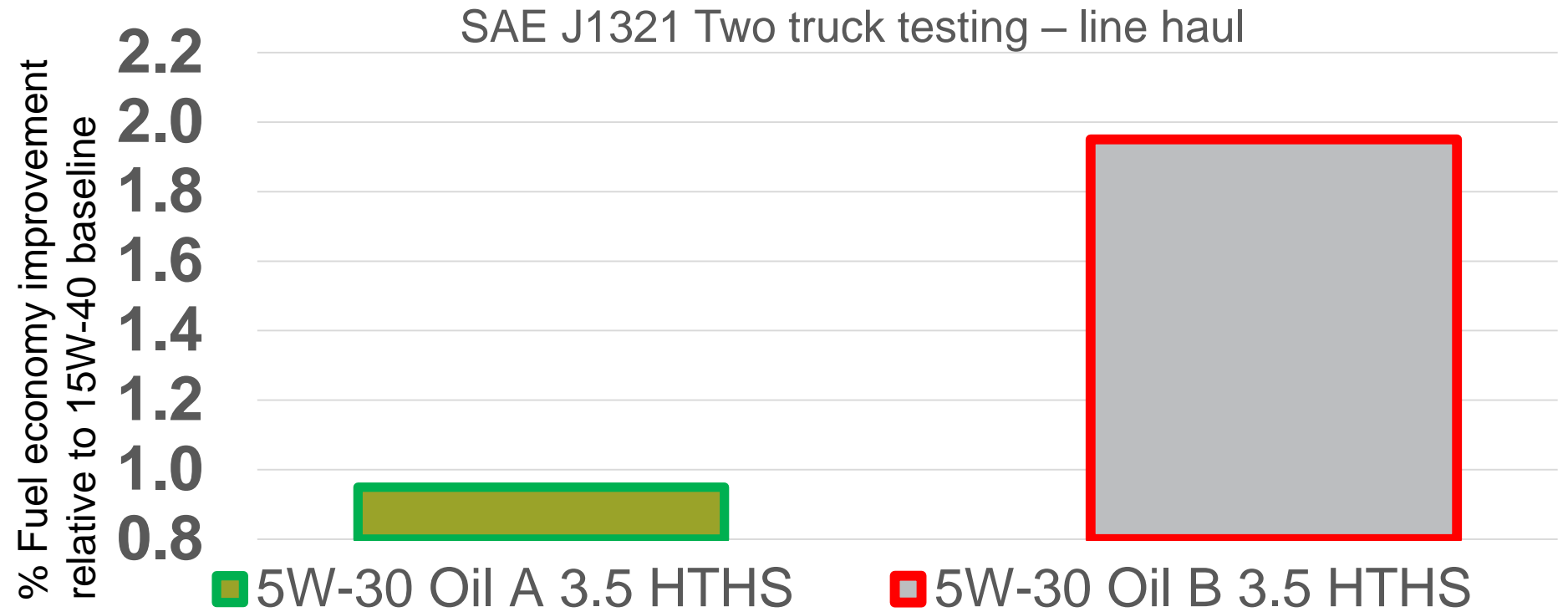


Fuel Economy Improvement for lower HTHS oils noted in SAE J1321 class 8 truck testing

\* %FE better than 15W-40 baseline Oil in J1321 2-Truck Testing at Independent Lab



# Fuel Economy – The importance of formulation



Same viscosity, same HTHS, yet different fuel economy performance

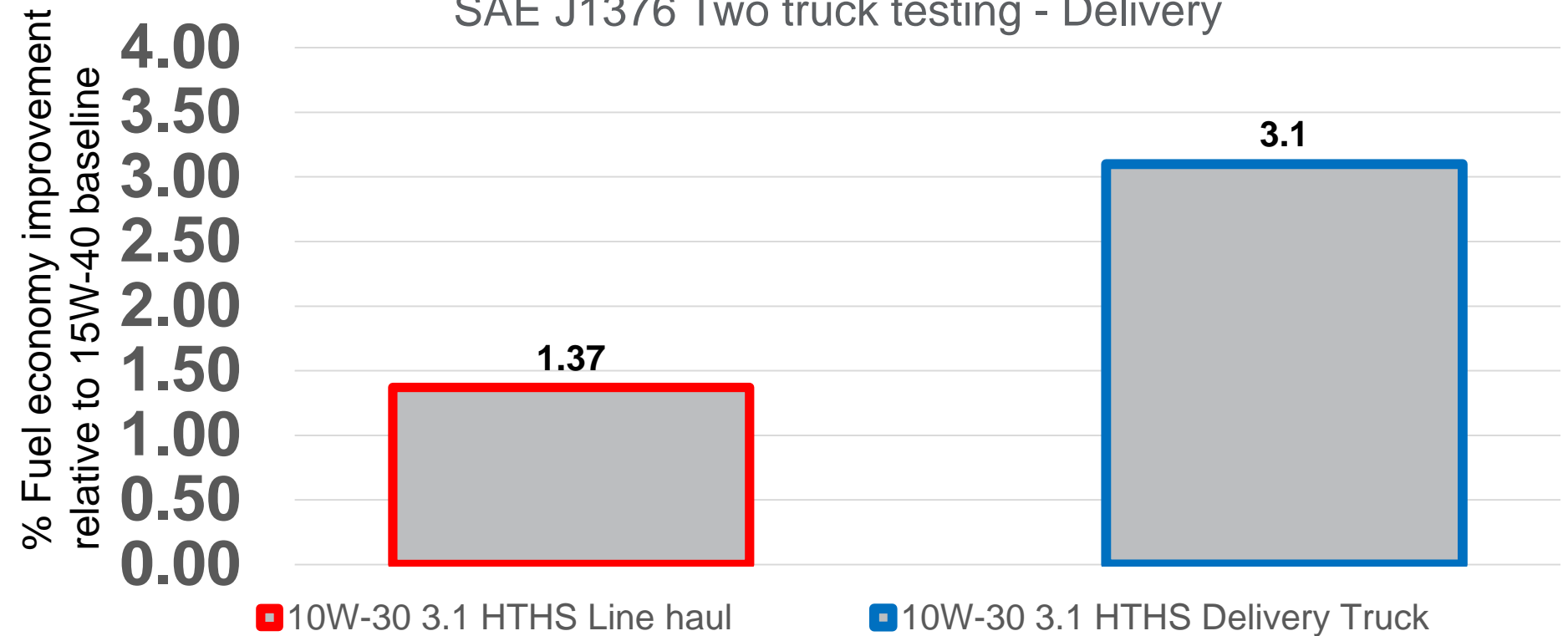
\* %FE better than 15W-40 baseline Oil in J1321 2-Truck Testing at Independent Lab



# Fuel Economy – The importance of duty cycle



SAE J1376 Two truck testing - Delivery



Fuel Economy Improvements are greater in Class 6 trucks on a delivery cycle

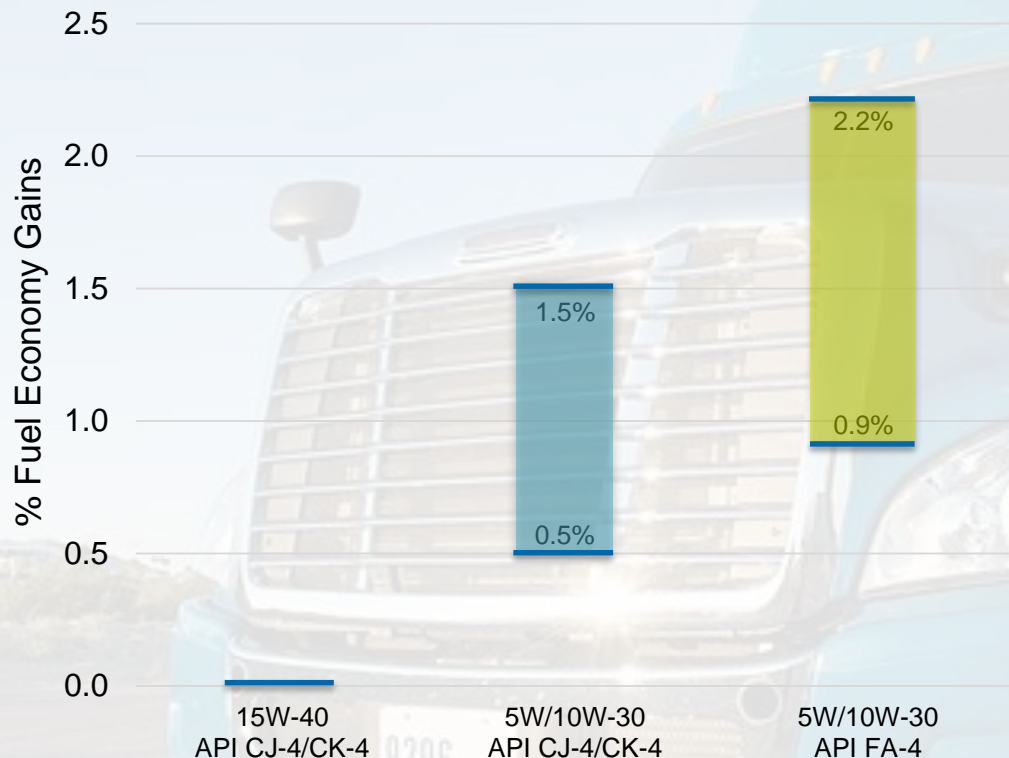
\* %FE better than 15W-40 baseline Oil in J1321/J1376 2-Truck Testing at Independent Lab



# The Benefits of Fuel Efficient Lubricants



## The expected savings when moving from SAE 15W-40 to lower viscosity lubricants should be significant



“ Class 8 over-the-road fleets can realistically expect fuel savings in the range of 0.5% to 1.5% by switching from 15W-40 to 5W/10W-30 engine oil, either CJ-4 or CK-4.

The savings from switching to the fuel-efficient FA-4 variant, available after December 2016, can be expected to add a further 0.4–0.7% of increased fuel efficiency. ”



“This is one of the rare instances where an efficiency technology can be implemented across the entire fleet very quickly, does not require an upfront investment and does not require any changes in operating or maintenance practices following implementation”

Source: Trucking Efficiency Confidence Report: Low-Viscosity Lubricants



# Durability cannot be compromised



SUCCESS  
TOGETHER

Main Bearing - Upper



Main Bearing - Lower



Piston 6 - Thrust



Piston 6 - Anti-Thrust



TEST MILEAGE:  
**511,836**

Piston 6 - Crown



Piston 6 - Undercrown



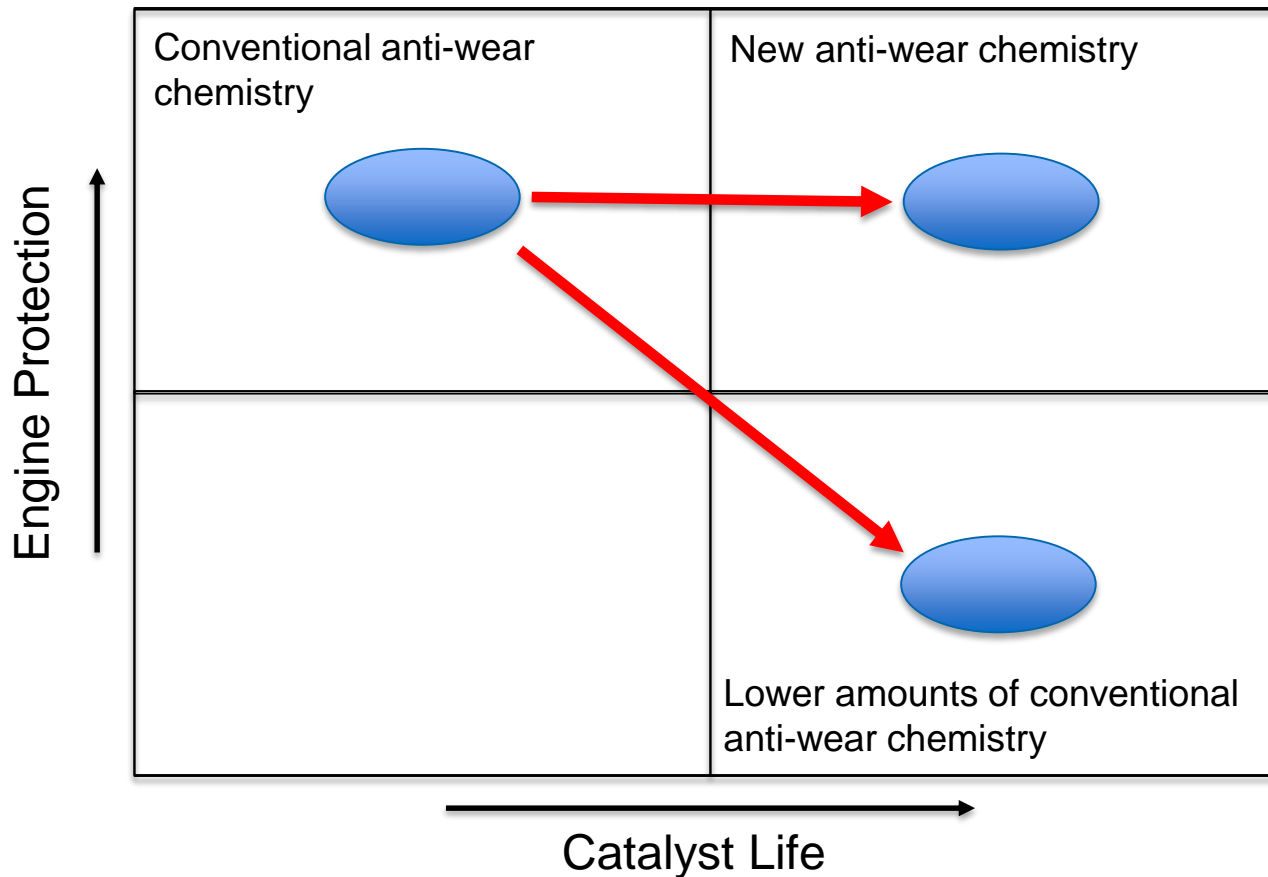
API FA-4 oils protect the engine well

**Lubrizol**



# The Role of Higher Performance Lubricants (HPLs) Passenger Car Motor Oil

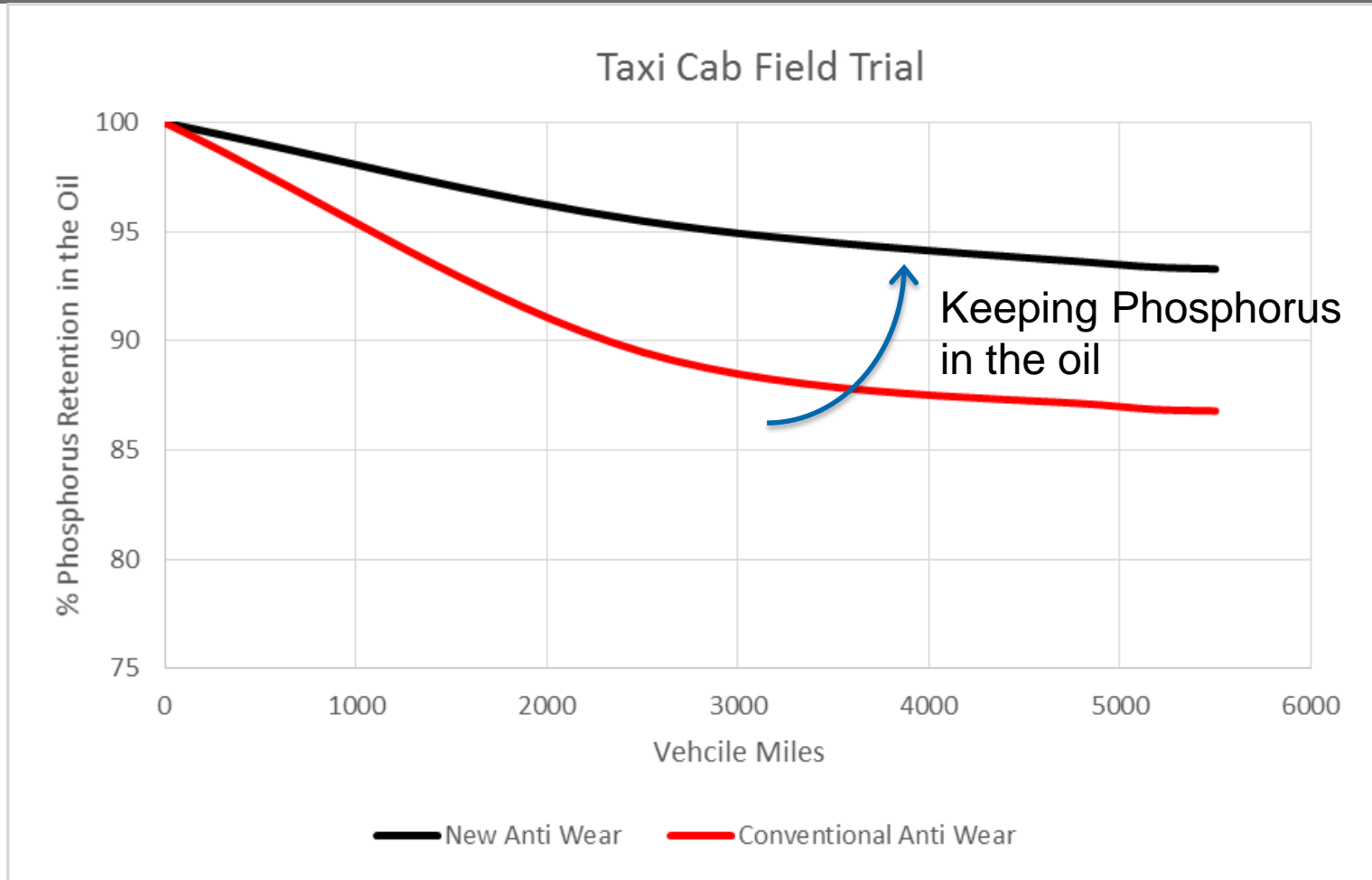
# Case Study: Extending the life of three way catalysts



A new generation of higher performing lubricants will protect three-way catalysts



# Case Study: New formulations are extending the life of three way catalysts



Keeping anti-wear additives in the oil protects the engine and extends TWC life



# Like HDVs, future LDV engines will use sophisticated strategies to meet upcoming FE/GHG requirements



- Turbo Charging
- Direct Gas Injection (GDI)
- Engine downsizing
- Stop-Start
- Cylinder Deactivation
- Variable Valve Timing
- Electrification
- Lightweighting



Like HDVs, future LD engines will operate in severe operating conditions

# GDI engines will produce its own challenges

## Gasoline Direct Injection Engines will be in 62% of new cars in 2022\*

Multiple issues need to be addressed:

- Low Speed Pre-Ignition (LSPI)
- Timing Chain Wear
- Intake Valve Deposits
- Turbocharger Coking

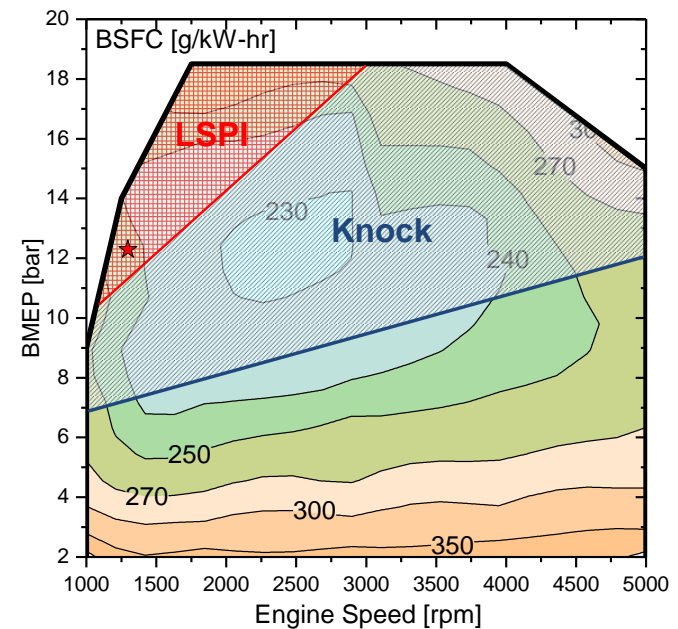


\*Projection from IHS

# Case Study: Reducing LSPI leads to reduced CO<sub>2</sub>



- Low Speed Pre-Ignition (LSPI) - uncontrolled combustion events that can occur in Turbocharged, Gasoline Direct Injection (TGDI) engines
- Multiple studies have shown that both engine oils and fuels have an impact on LSPI propensity and severity
- To quantify an engine oil's LSPI performance, several engine tests have been developed (GF-6, dexos1™, proprietary)
- New formulation architectures are being developed which will reduce the propensity for LSPI





# Encouraging the use of higher performing lubricants

# Encouraging the use of HPLs



- Higher performing lubricants are a cost-effective way to reduce emissions, increase efficiency, and protect advanced engines and other hardware throughout their useful life
- Because lubricants require regular service, strategies to encourage higher performing lubricants at every oil change will pay dividends for the life of the vehicle
- Precedents are being established today which could lay the foundation for more lubricant customization in the future

# Frequent oil/filter changes create many opportunities to use HPLs and maximize GHG/fuel savings throughout vehicle's useful life



## Heavy Duty Diesel Example

Engine Overhaul  
1,000,000 - 1,500,000 miles



Gear Oil Replaced  
500,000 miles



Tires replaced  
DPF cleaning  
100,000 - 300,000 miles



Oil and filter replace  
20,000 - 30,000 miles



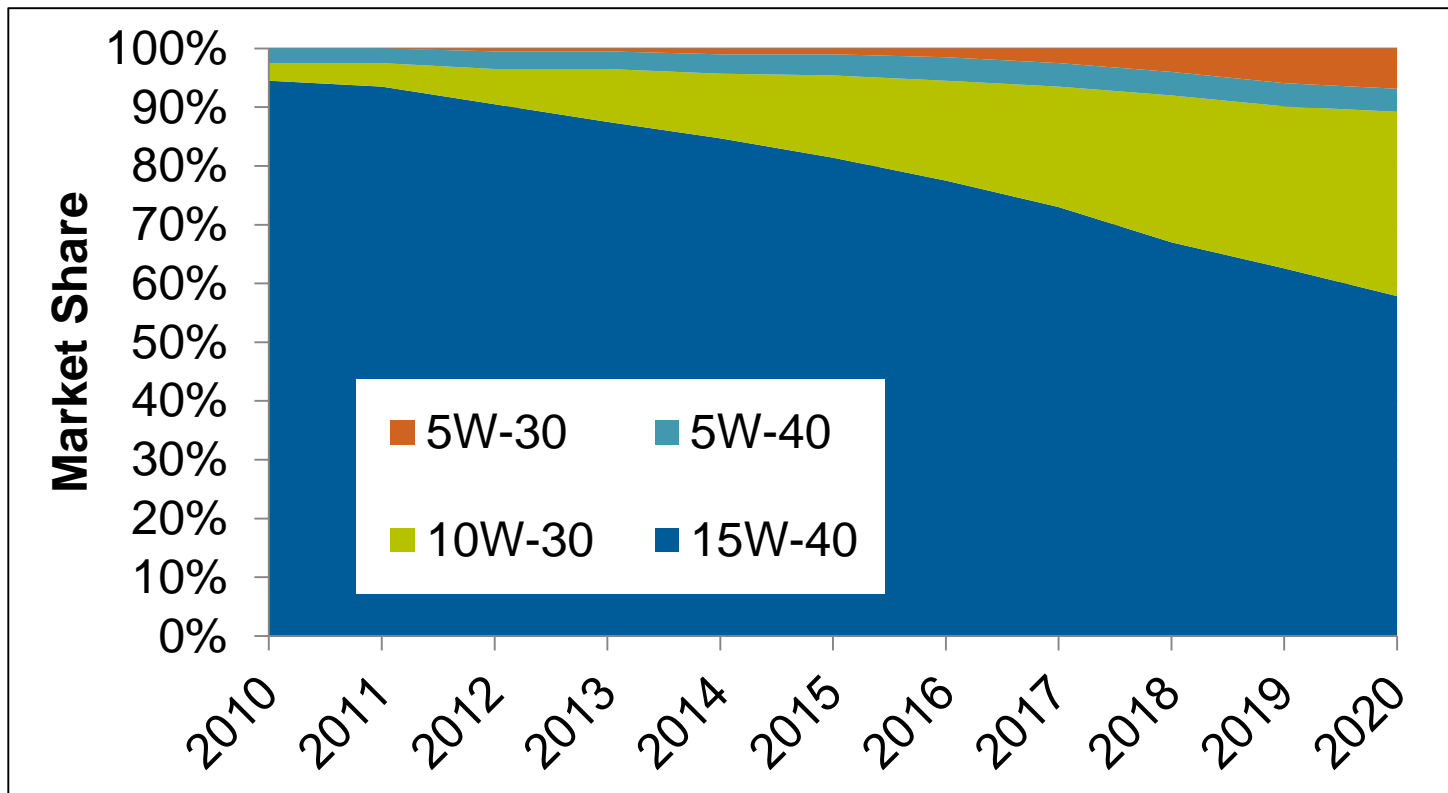
DEF tank filling  
3,000 - 6,000 miles



Lubricant and oil point-of-sale transactions create frequent opportunities to  
Ensure consumers and fleets use the right oil for the right vehicle



# The market is not taking full advantage of the emissions potential of available HPLs



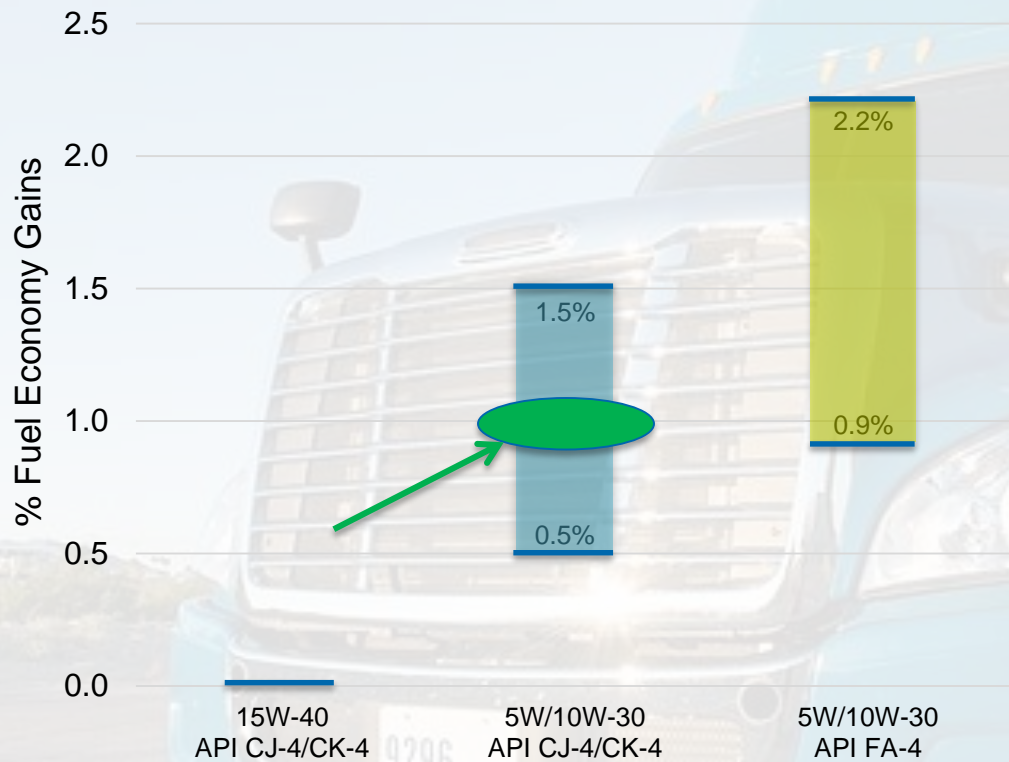
10W-30 oils have been recommended for most engines since 2006 but the service fill market has been slow to respond

Source : Lubrizol





# Moving from 15W-30 to 5/10W-30 improves fuel economy



“ Class 8 over-the-road fleets can realistically expect fuel savings in the range of 0.5% to 1.5% by switching from 15W-40 to 5W/10W-30 engine oil, either CJ-4 or CK-4.

The savings from switching to the fuel-efficient FA-4 variant, available after December 2016, can be expected to add a further 0.4–0.7% of increased fuel efficiency. ”

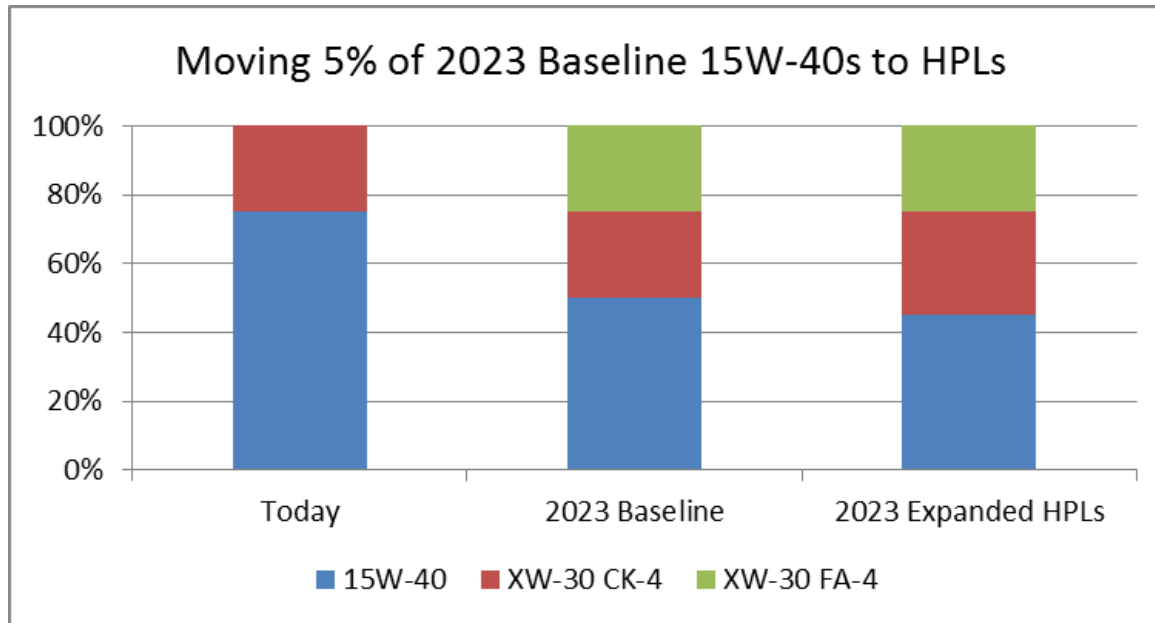


Encouraging the use of HPLs can have a significant impact on GHG

Source: Trucking Efficiency Confidence Report: Low-Viscosity Lubricants



# Expanding the use of HPLs can make a sizeable contribution toward GHG reduction



## Assumptions

- 3.5MM Class 8 trucks
- 6.25 mpg
- 125,000 mi/yr
- 1% FE savings
- Shift 5% of market from 15W-40 to XW-30 over 7 years, linear

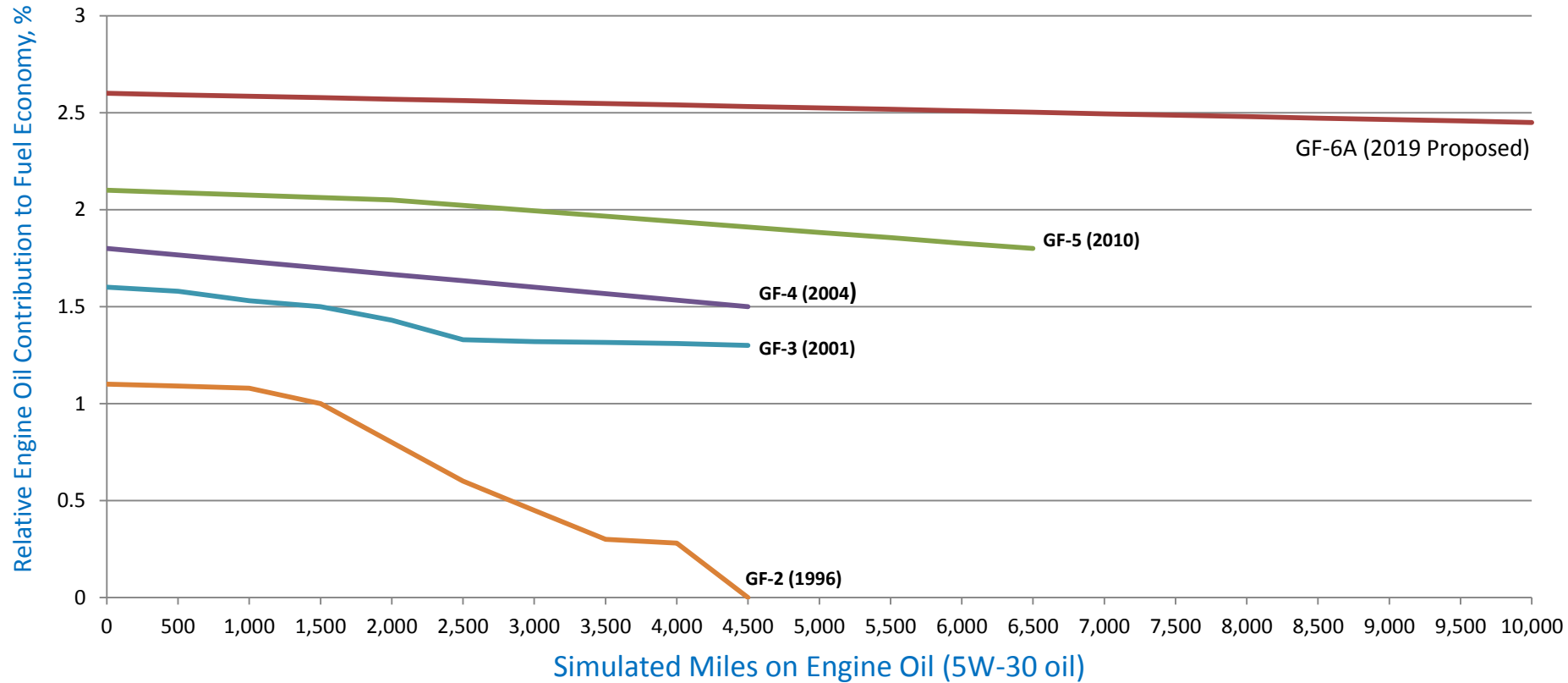
## Savings

- 121 MM gallons fuel
- 1.23 MM MT CO2

Market projection based on <http://www.pc-11explained.com/chevron-view.html>



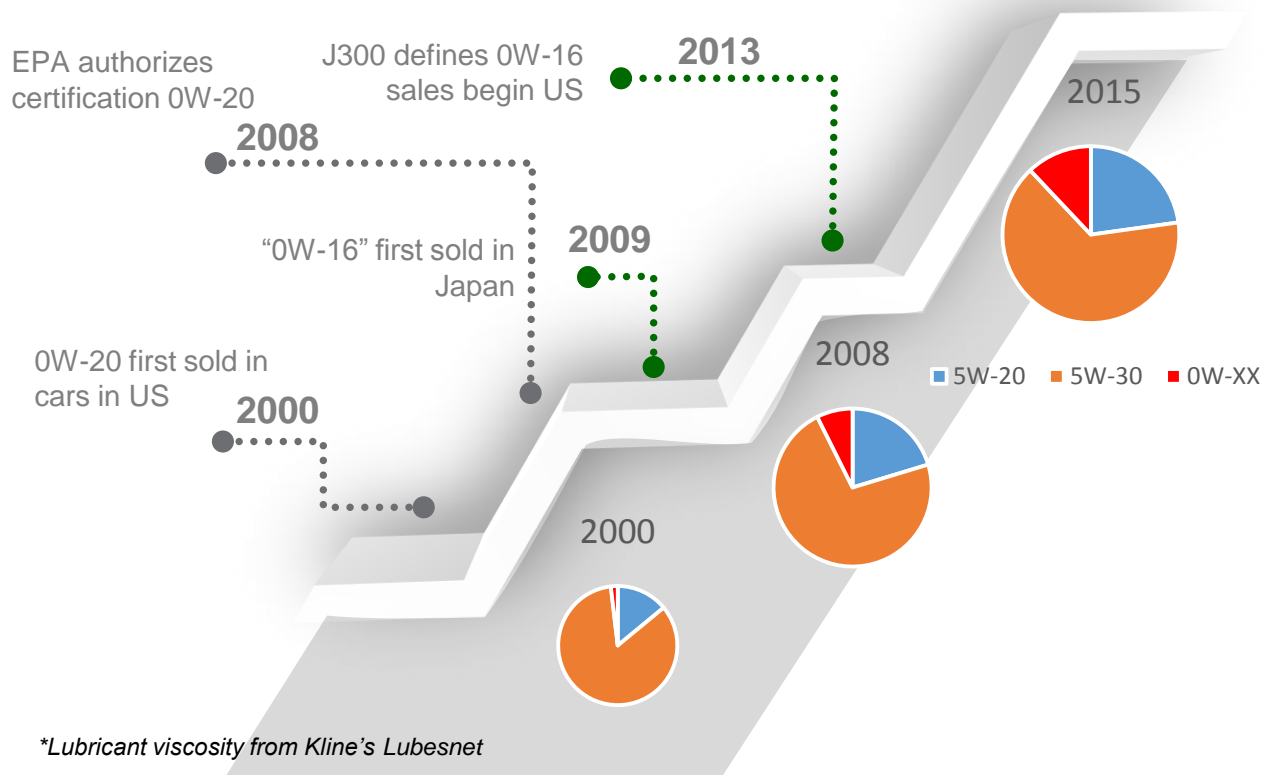
# Improved lubricant specifications benefit the entire passenger car vehicle fleet



Improved specifications benefit older cars as well



# A Chicken and Egg quandary exists with the development and acceptance of HPLs



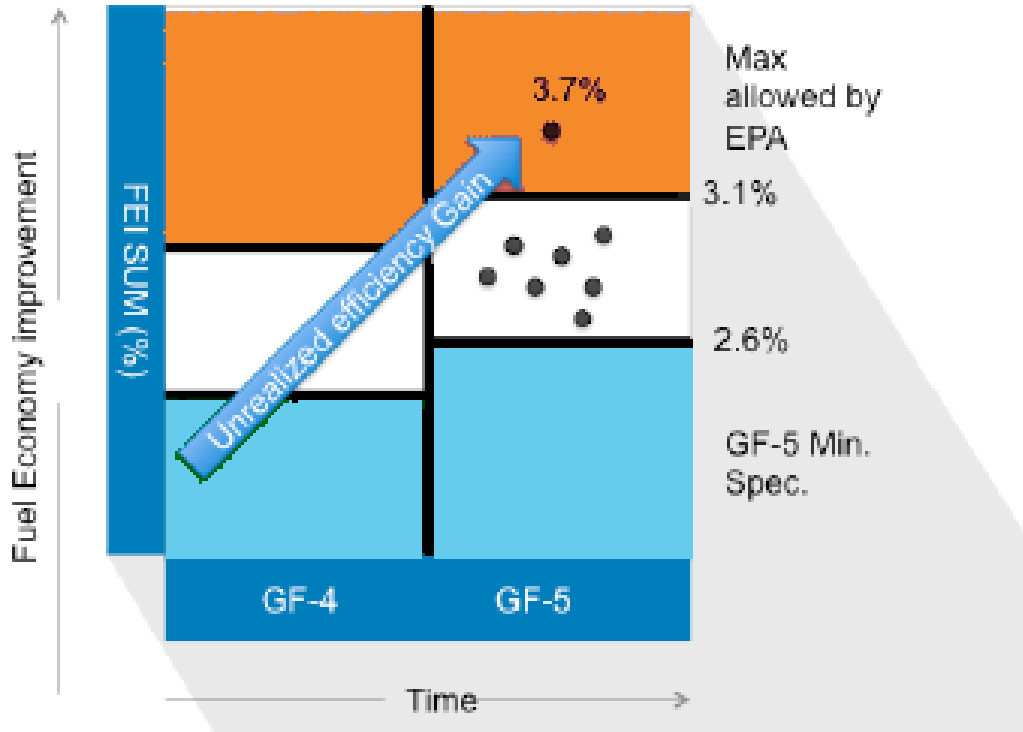
- 0W-20: **8 years** between product launch and EPA certification testing
- 0W-16: **4 years** for SAE J300 grade definition. EPA certification? 0W-8's **10+ years?**

New lubricant formulations need faster routes to market

# Further CO<sub>2</sub> reduction is possible by moving beyond the basic industry specification



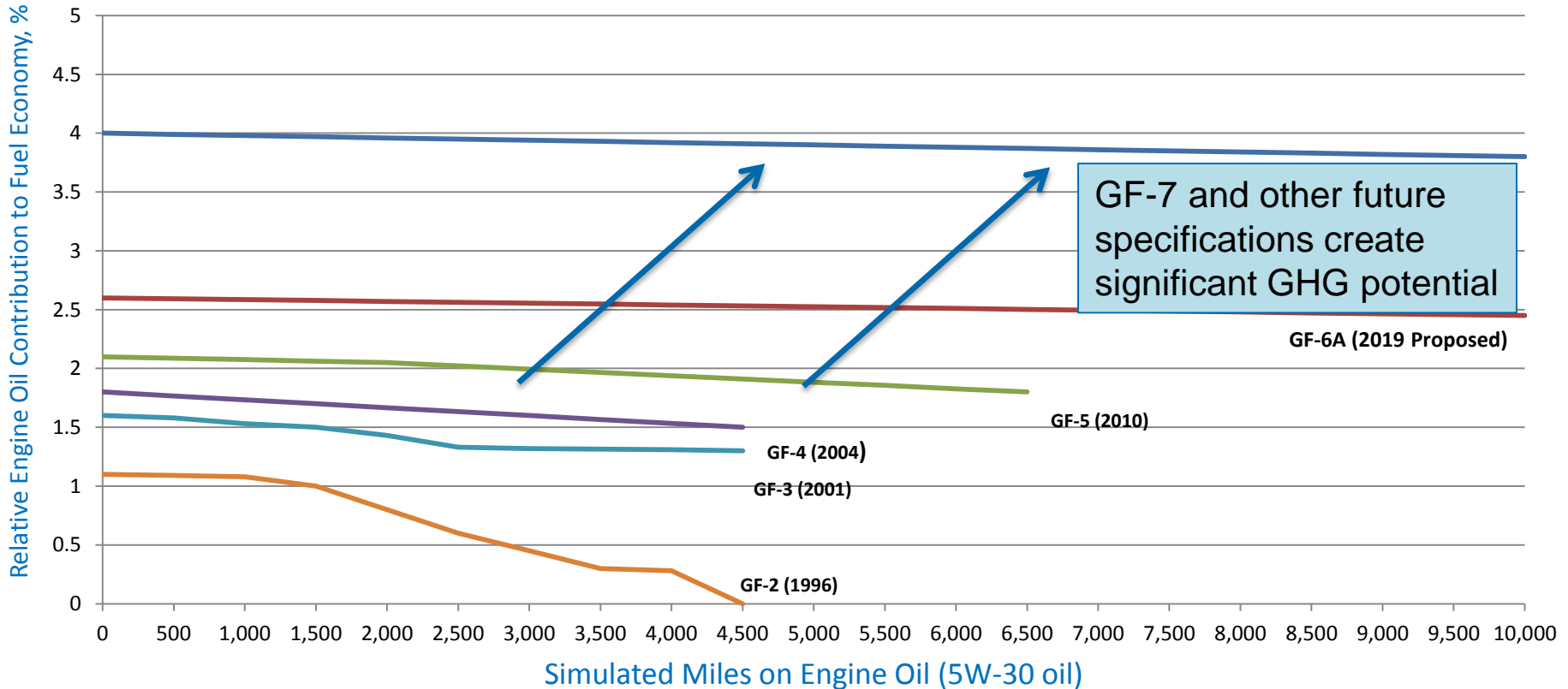
## 0W-20 Case Study



- Currently, vehicle certification procedures limit lubricant options and lead to unrealized efficiency potential
- As OEMs move towards more stringent GHG requirements by 2025, additional lubricant flexibility will enhance the GHG potential of future lubricant adoption
- By 2025 GF-6 and even GF-7 are likely to be in place

The current approach can restrict usage of HPLs in certification—and therefore, throughout useful life

# Future HPLs can play a significant GHG role by 2025



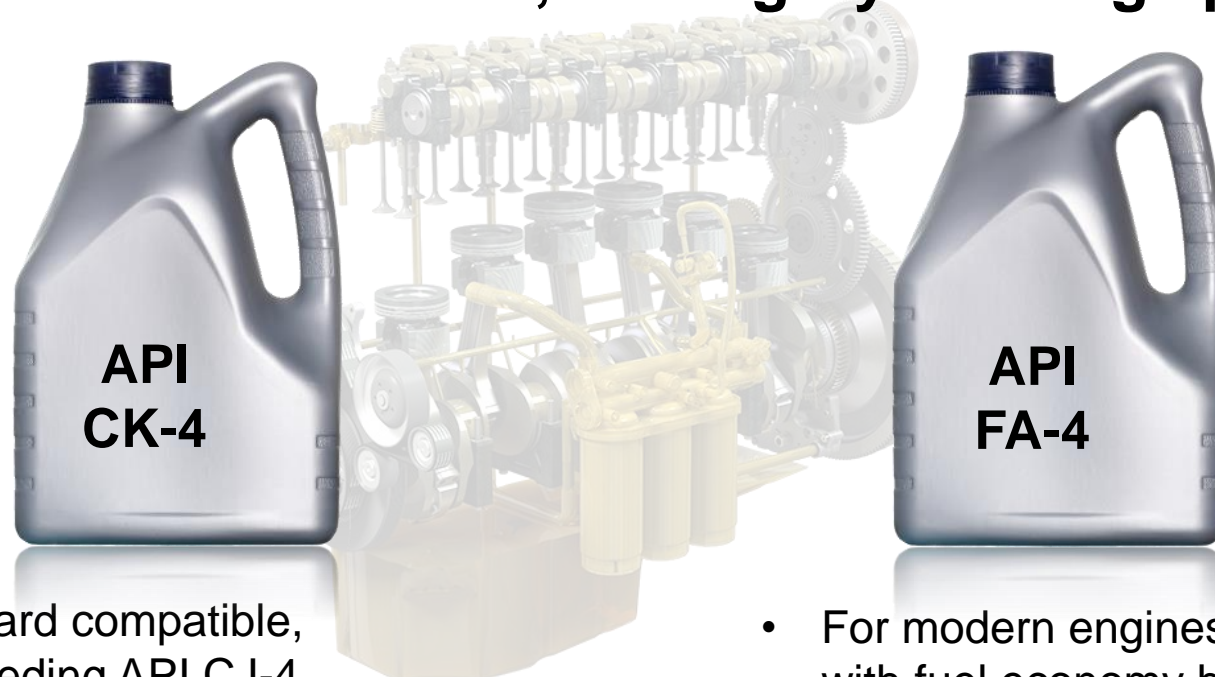
Back serviceable Engine Oil upgrades benefit older cars as well



# The precedent is being set for tailored lubricants



## For the first time ever, a category is being split



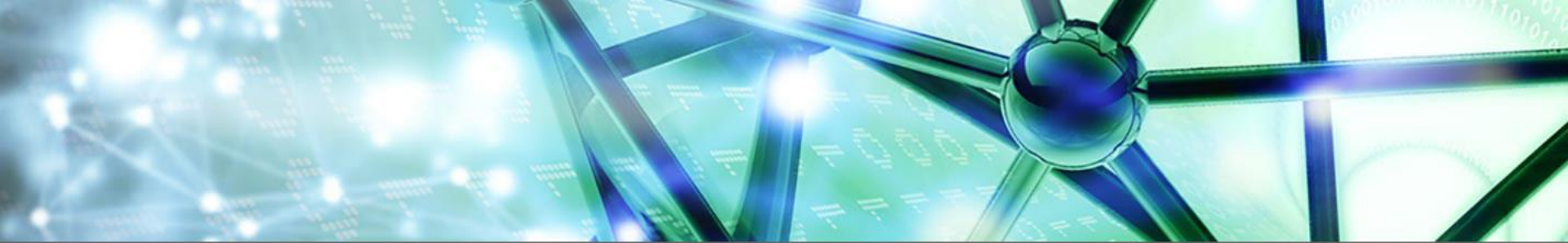
- Backward compatible, superseding API CJ-4
- 15W-40, 5W-40, 10W-30, 5W-30
- HTHS viscosity of 3.5 cP or above

- For modern engines, with fuel economy benefits
- 10W-30, 5W-30
- HTHS viscosity of 2.9 - 3.2 cP

A future may exist with engine-specific lubricant requirements

- Lubricants have always contributed to emission control and GHG reductions
- As new engine and combustion strategies are developed to meet new emission standards, the lubricant industry will respond with higher-performing lubricants
- Maximizing the GHG benefits of higher-performing lubricants will require HPL use in vehicle certification and throughout useful life—and perhaps even customized lubricant usage in the future
- **Programs to educate and encourage consumers and fleets to use HPLs will help ensure their use and are worth pursuing**





## Working together, achieving great things

When your company and ours combine energies, great things can happen. You bring ideas, challenges and opportunities. We'll bring powerful additive and market expertise, unmatched testing capabilities, integrated global supply and an independent approach to help you differentiate and succeed.