Engine Lubricants : Trends and Challenges

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Performance you can rely on.

Infineum

Global Concerns leading to Global Regulations

Environmental Concerns

GHG : Global Warming

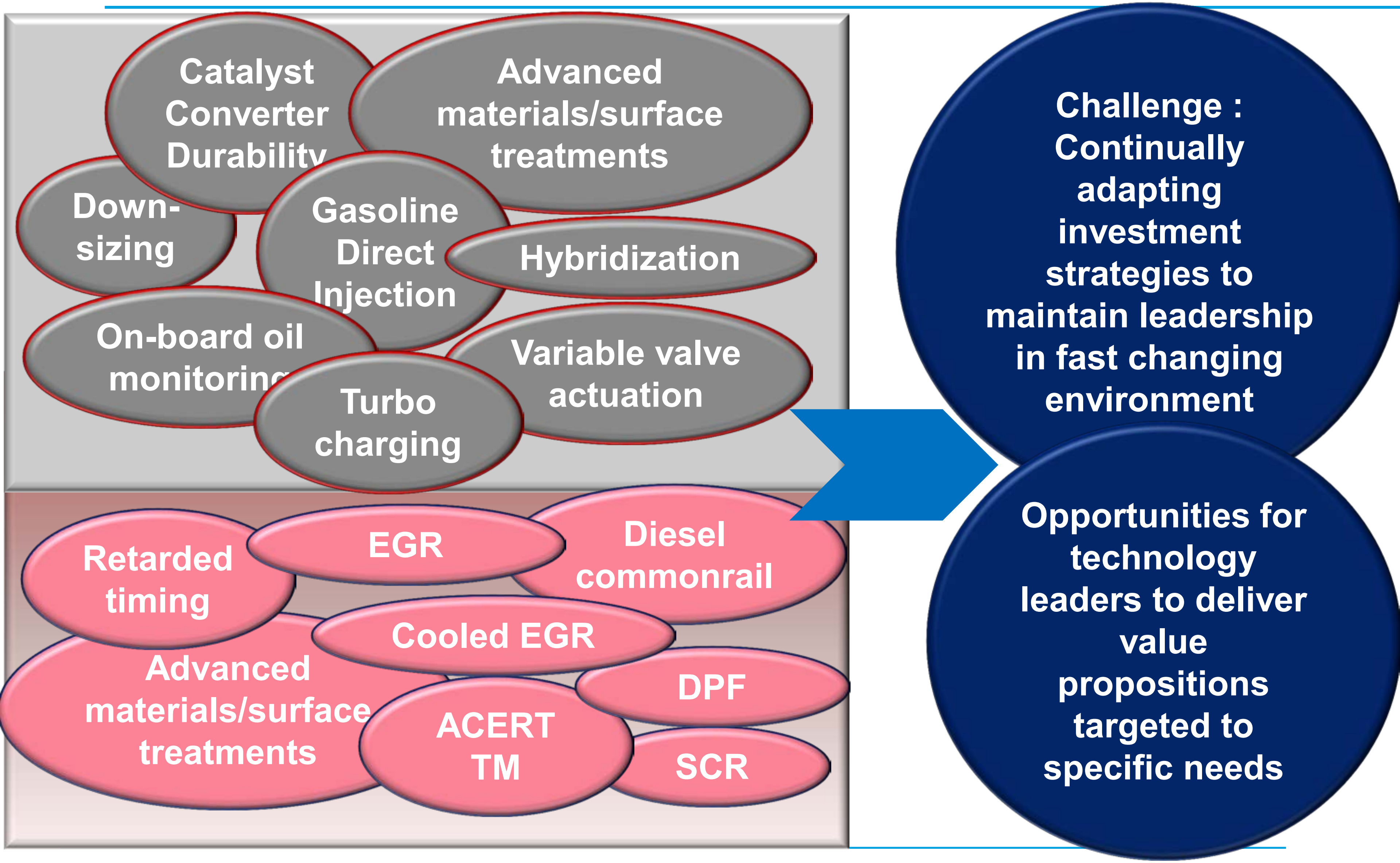
Depletion of Natural Resources

Security of Energy Supply

→

Emissions and Fuel Efficiency regulations

Rapid evolution of engine technologies → Challenges and opportunities for lubricant industry



Today's Presentation

Emissions

- Light Duty Vehicles
- Heavy Duty Vehicles

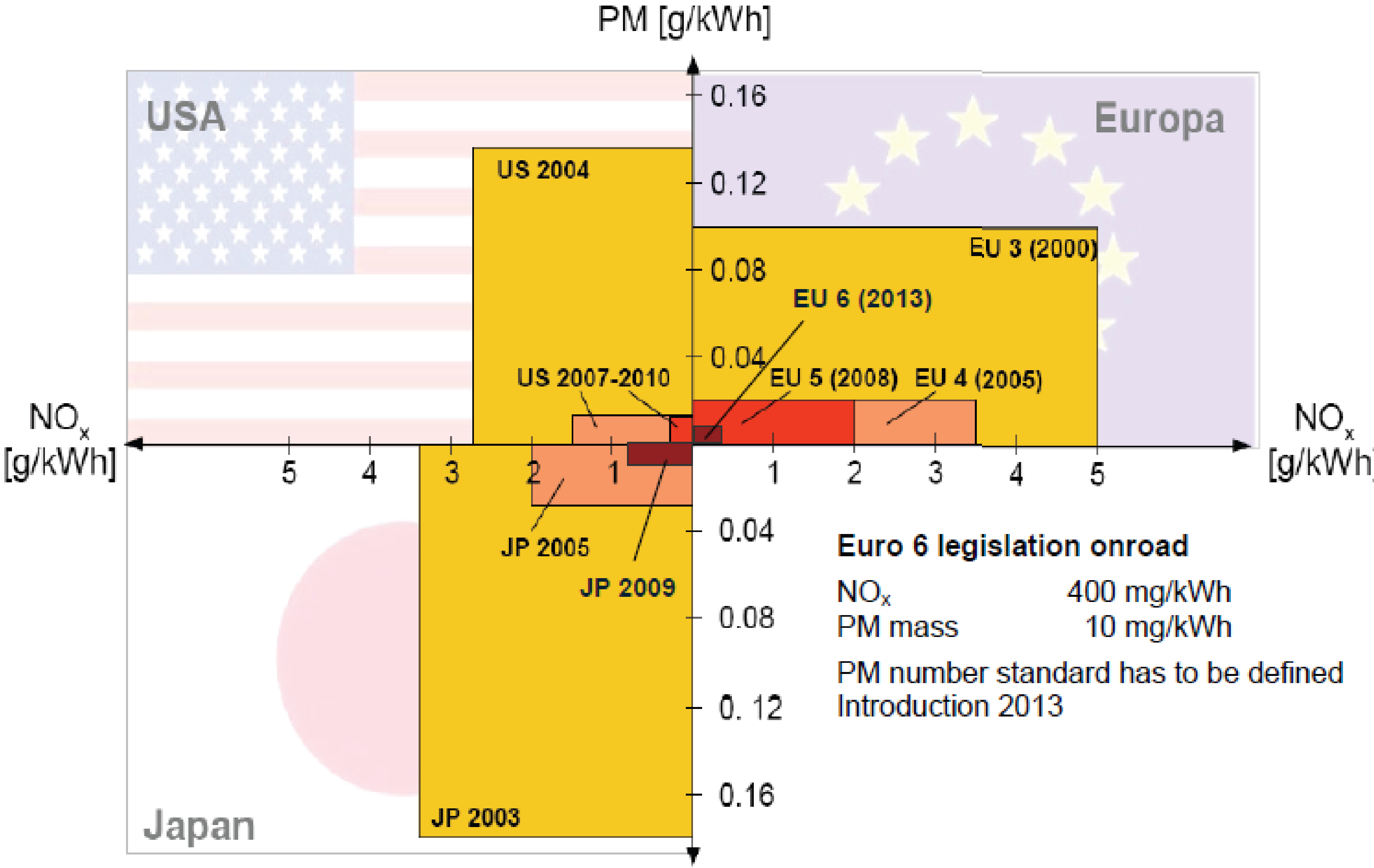
Fuel Economy

- Light Duty Vehicles
- Heavy Duty Vehicles

Emissions : Heavy Duty Vehicles

Performance you can rely on.

Evolution of Emission Legislations



Euro 6 legislation onroad

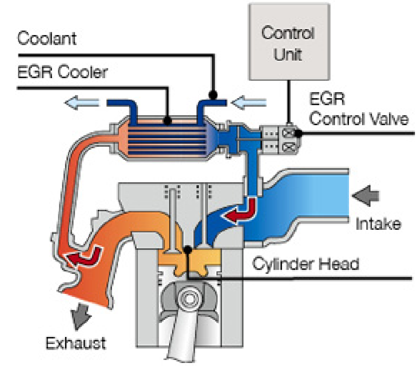
NO_x	400 mg/kWh
PM mass	10 mg/kWh

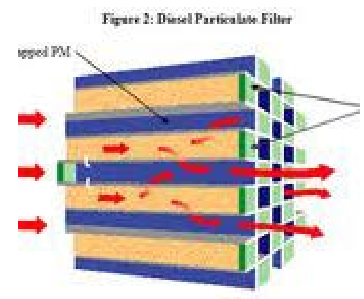
PM number standard has to be defined
Introduction 2013

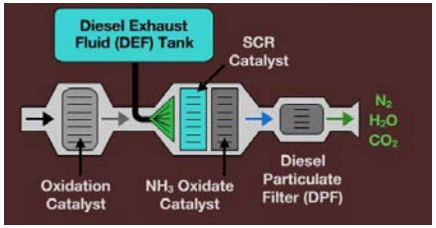
Emission Control Strategies

- **Approaches vary with OEMs but involve some combination of**
  - Exhaust Gas Recirculation (EGR) – without or with external cooling
  - Diesel Particulate Filter (DPF)
  - Selective Catalyst Reduction (SCR)
  - Other proprietary systems

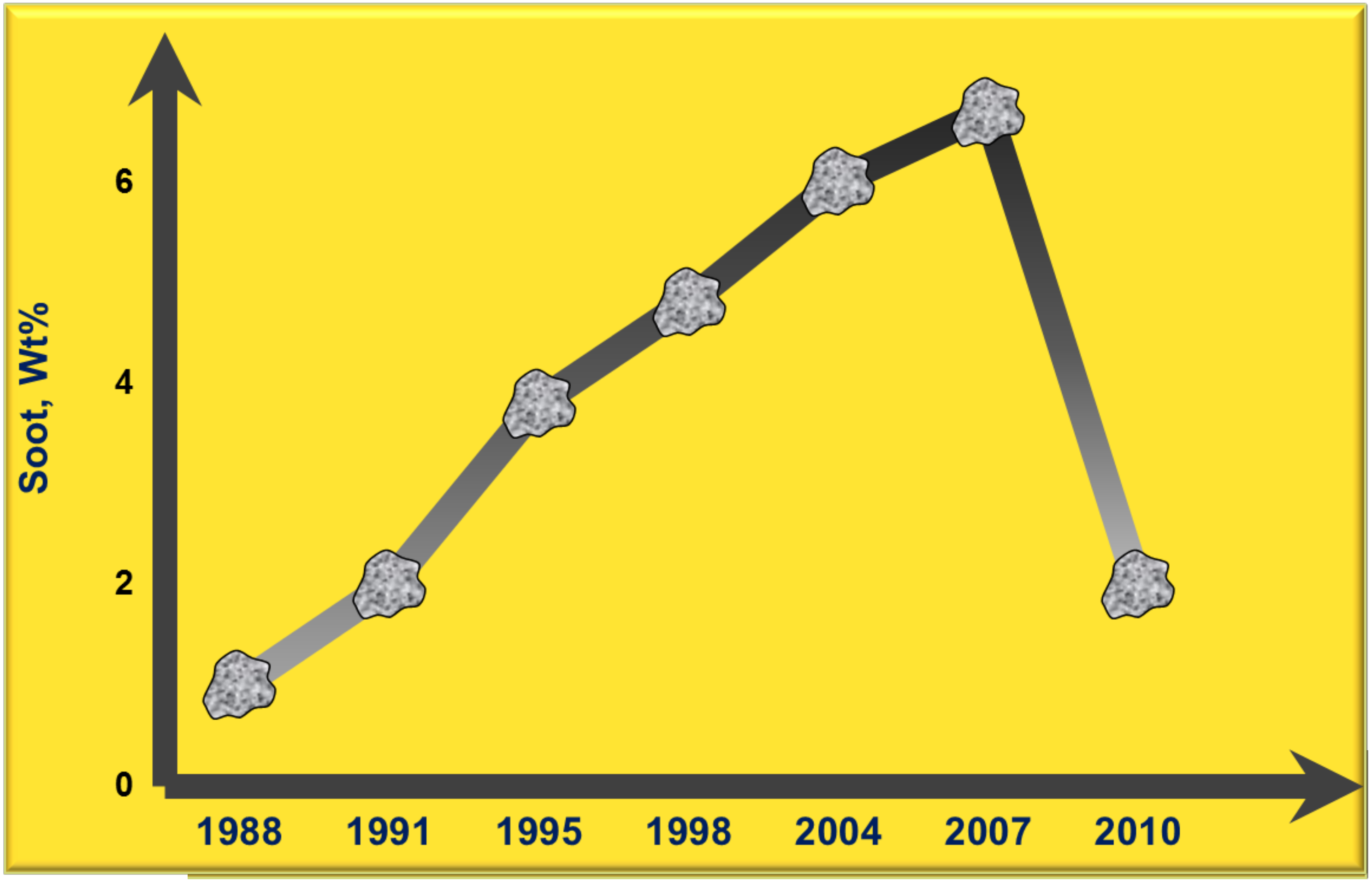
- **Different approaches lead to different lubricant needs**





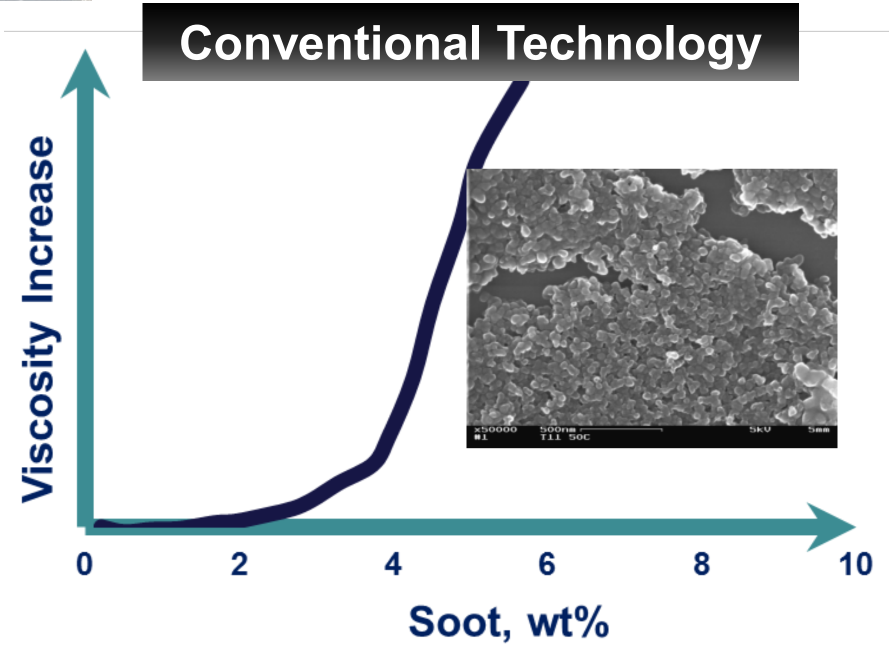


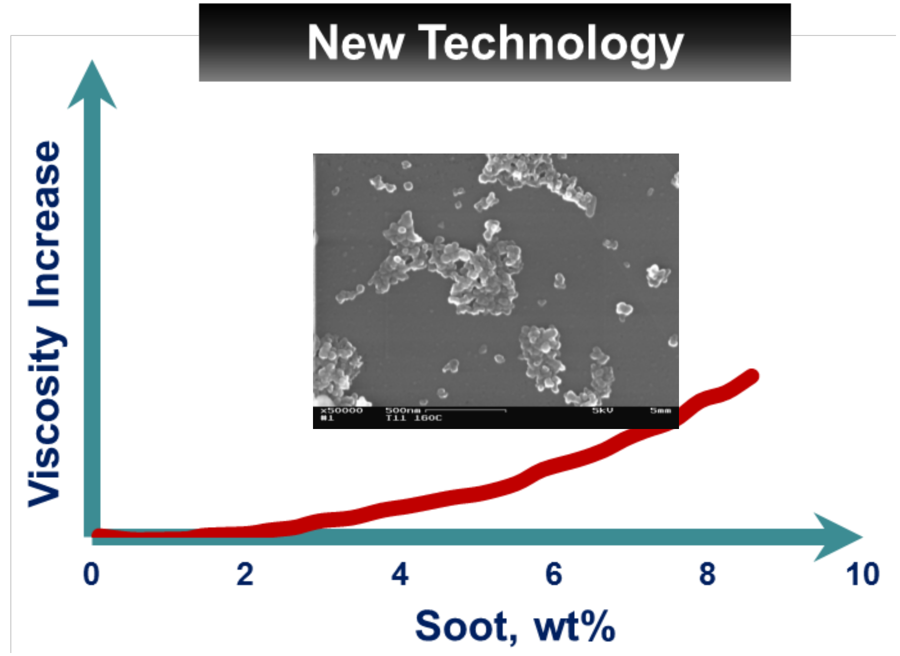
Lubricant Soot Loading



Retarded Timing	*EGR*	*Cooled EGR*	*SCR / Reduced EGR*

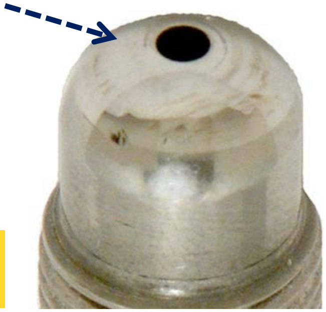
Increasing soot loading required significant advances in additive technology





Excessive wear

Low wear

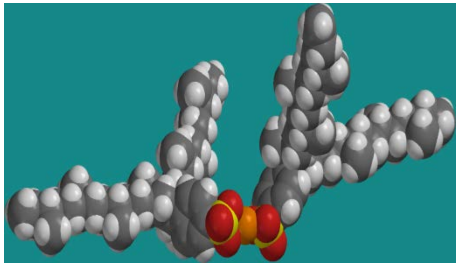
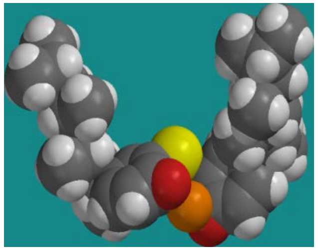
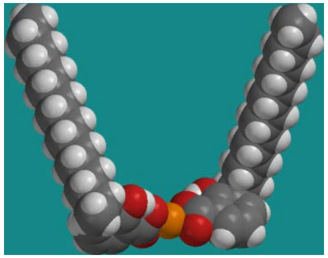


Cummins ISM

After-Treatment Compatibility

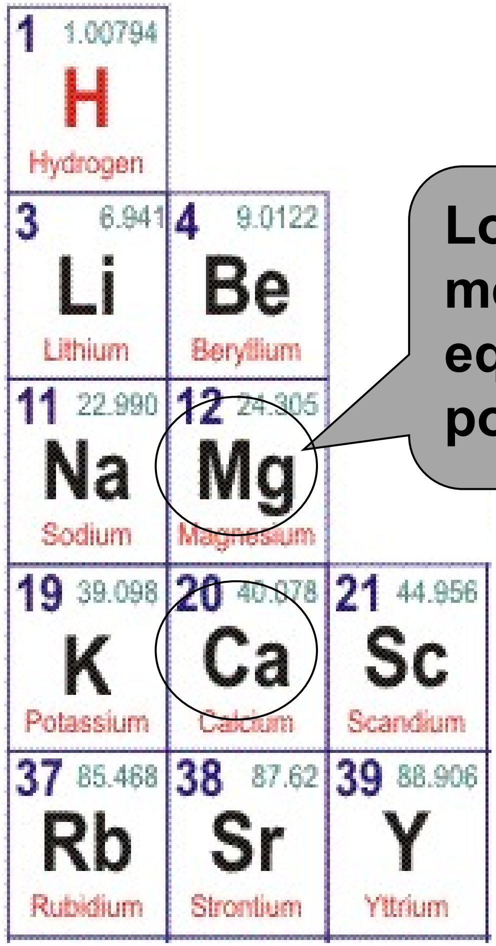
- SCR/DPF systems are used in modern engines to reduce PM and NOx in the exhaust
- Efficiency and life of these systems can be compromised by presence of certain lubricant additive emissions in exhaust gases
- Leads to restrictions on permissible amounts of phosphorus, sulfur and metal containing additives in the oil
- Choice of detergent chemistry becomes critical

Role of Detergent Type

	Sulphonates	Phenates	Salicylates
			
Piston Cleanliness			
Top	No	Yes	Yes
Bottom	Yes	No	Yes
TBN Durability	Yes	No	Yes
Rust Control	Yes	No	Yes
Antioxidancy	No	Yes	Yes
Sulphur - Free	No	No	Yes

Well-rounded performance and zero sulfur

Role of Detergent Metal



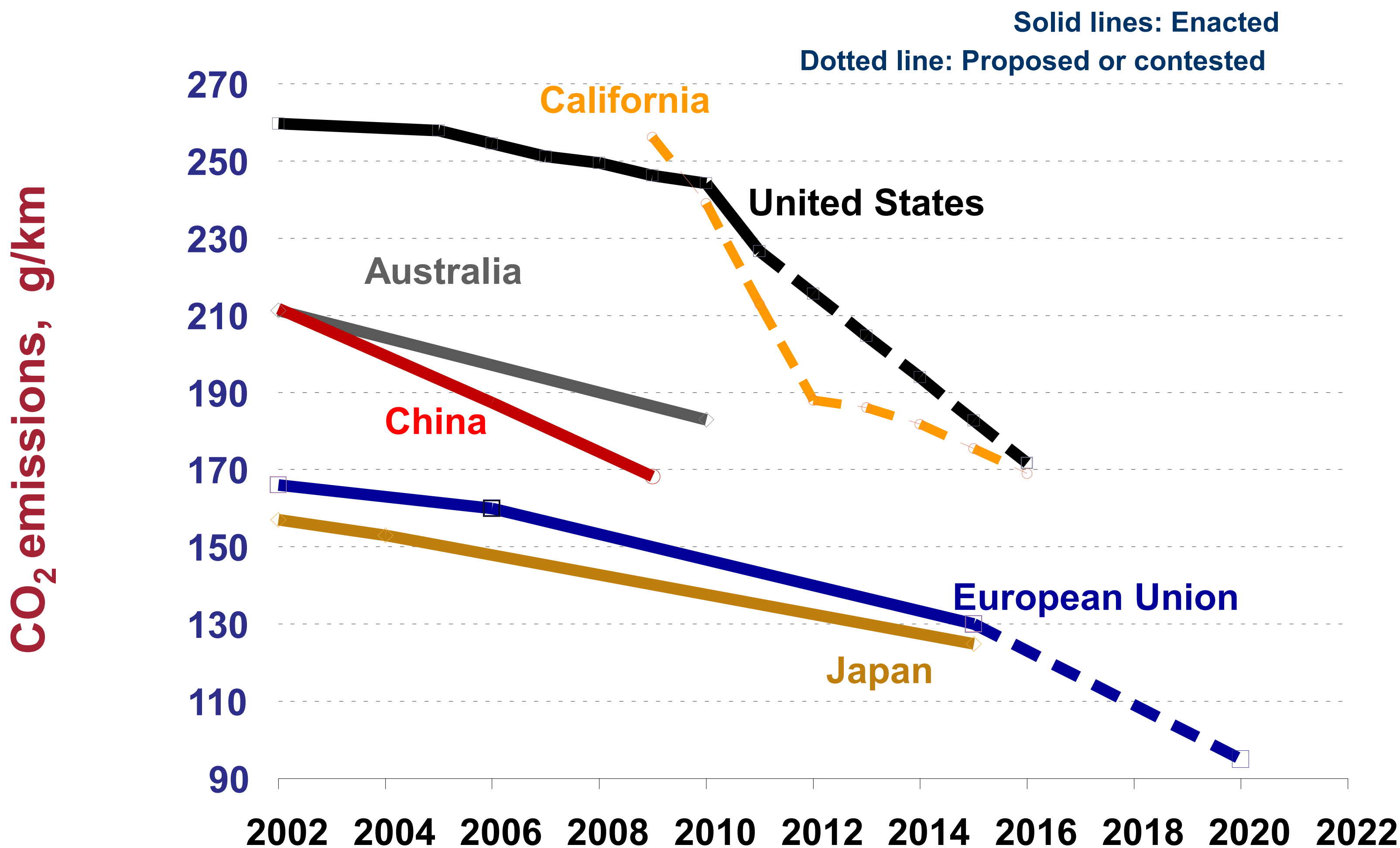
Lower atomic weight means 36% less SASH at equal acid neutralization power

Next Frontier

Non-metallic technologies for piston cleanliness and acid neutralization

Fuel Economy

Tough GHG regulations are coming into effect in all major markets

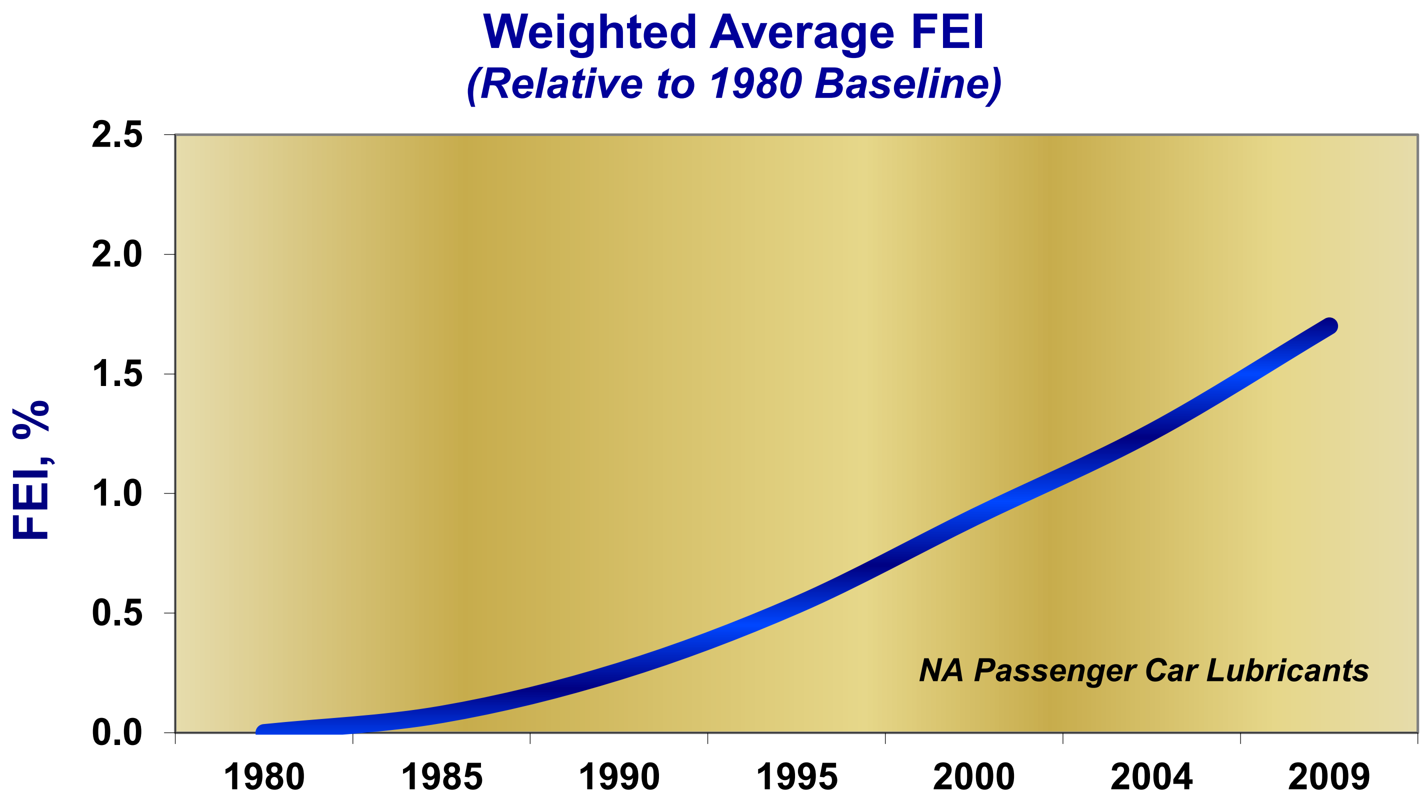


Source: Passenger Vehicle Greenhouse Gas and Fuel Economy Standards: A Global Update CCI May 2009 Update

Lubricants have important role to play

- OEMs are looking at all aspects of hardware design and operation for energy efficiencies
- Majority of fuel efficiency improvements will undoubtedly come from hardware changes
- Nevertheless lubricants also have an important role to play
- North American experience illustrates the importance of lubricant contribution to fuel efficiency

Lubricants have important role to play

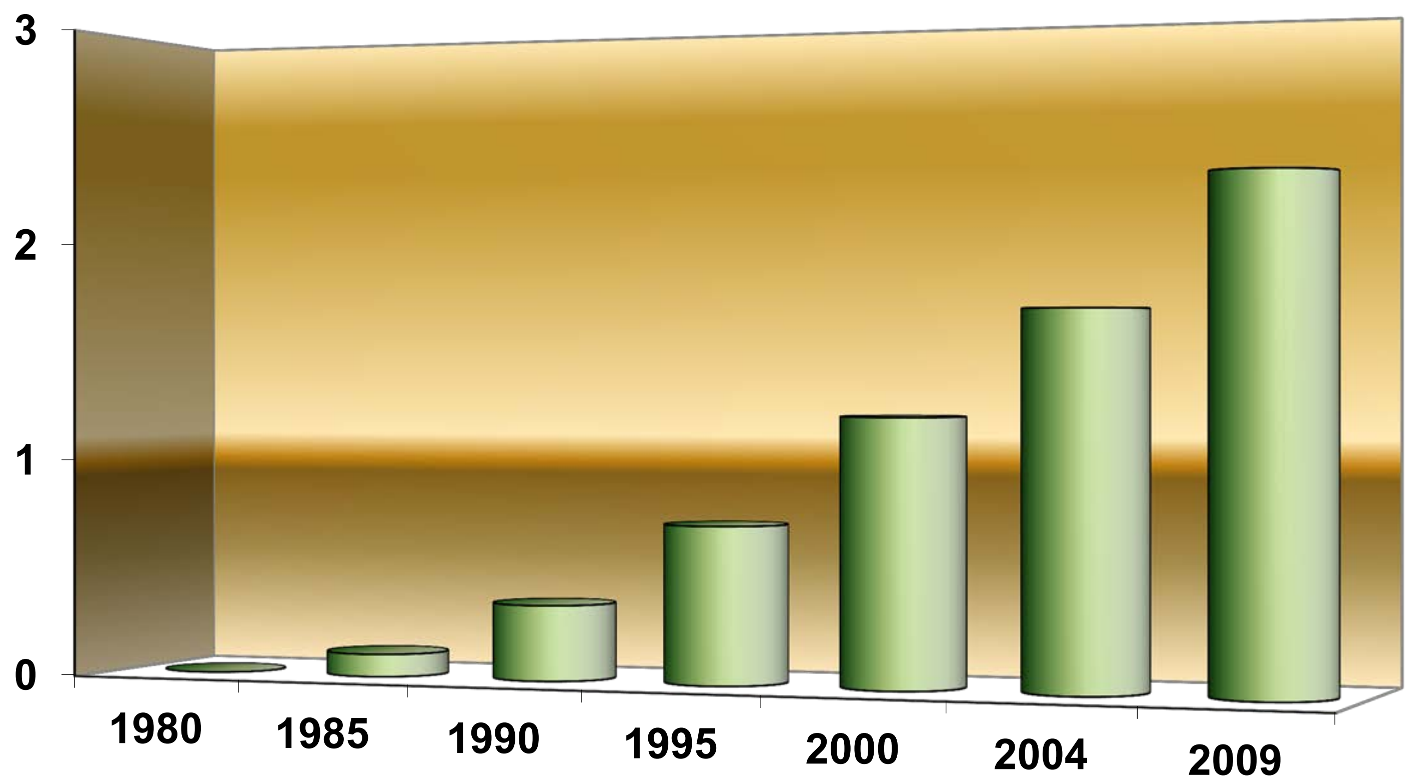


Steady increase in FE performance over last 3 decades!

Fuel Savings

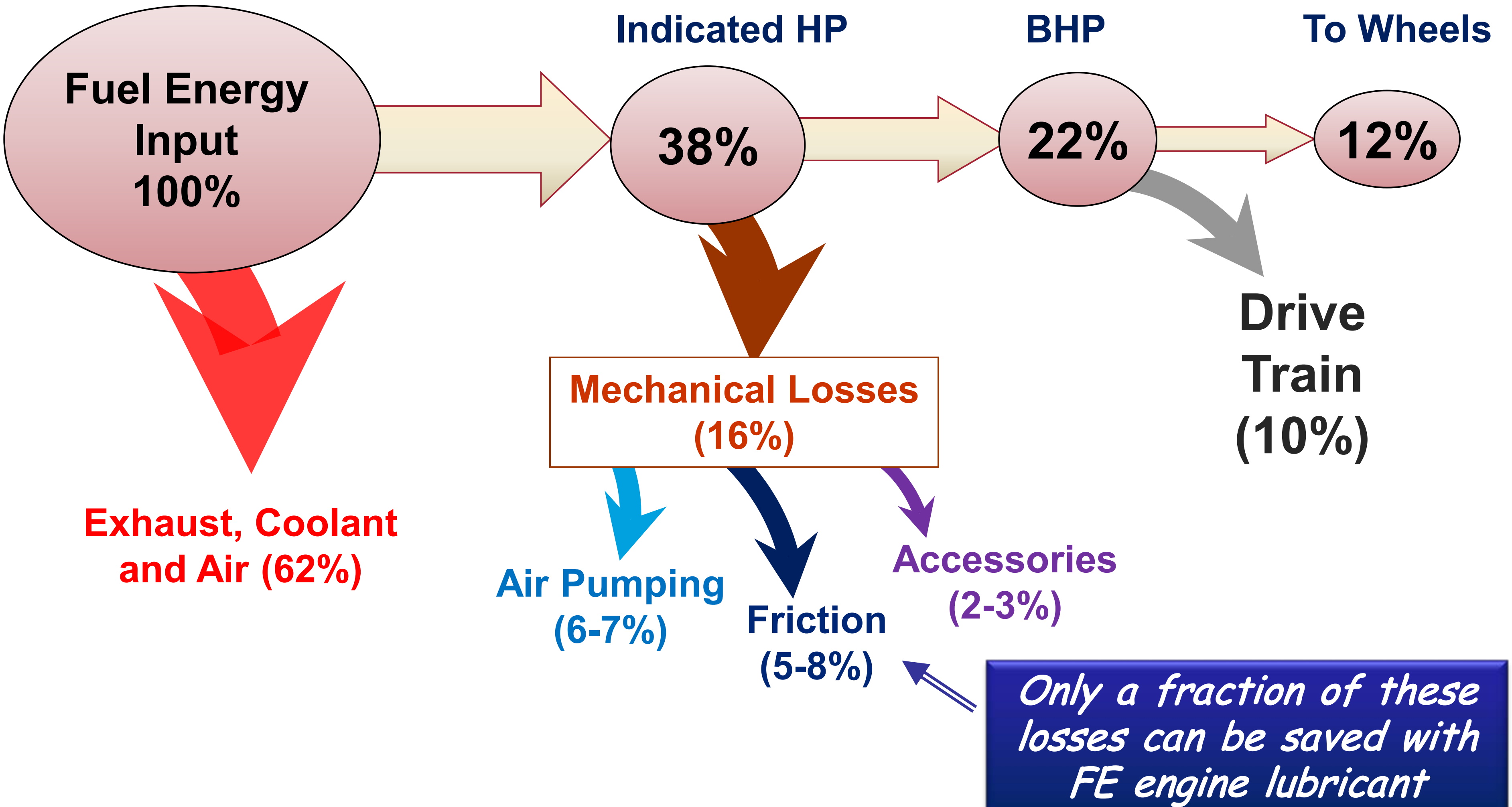
NA PCMO Lubricants

Billion gallons per year



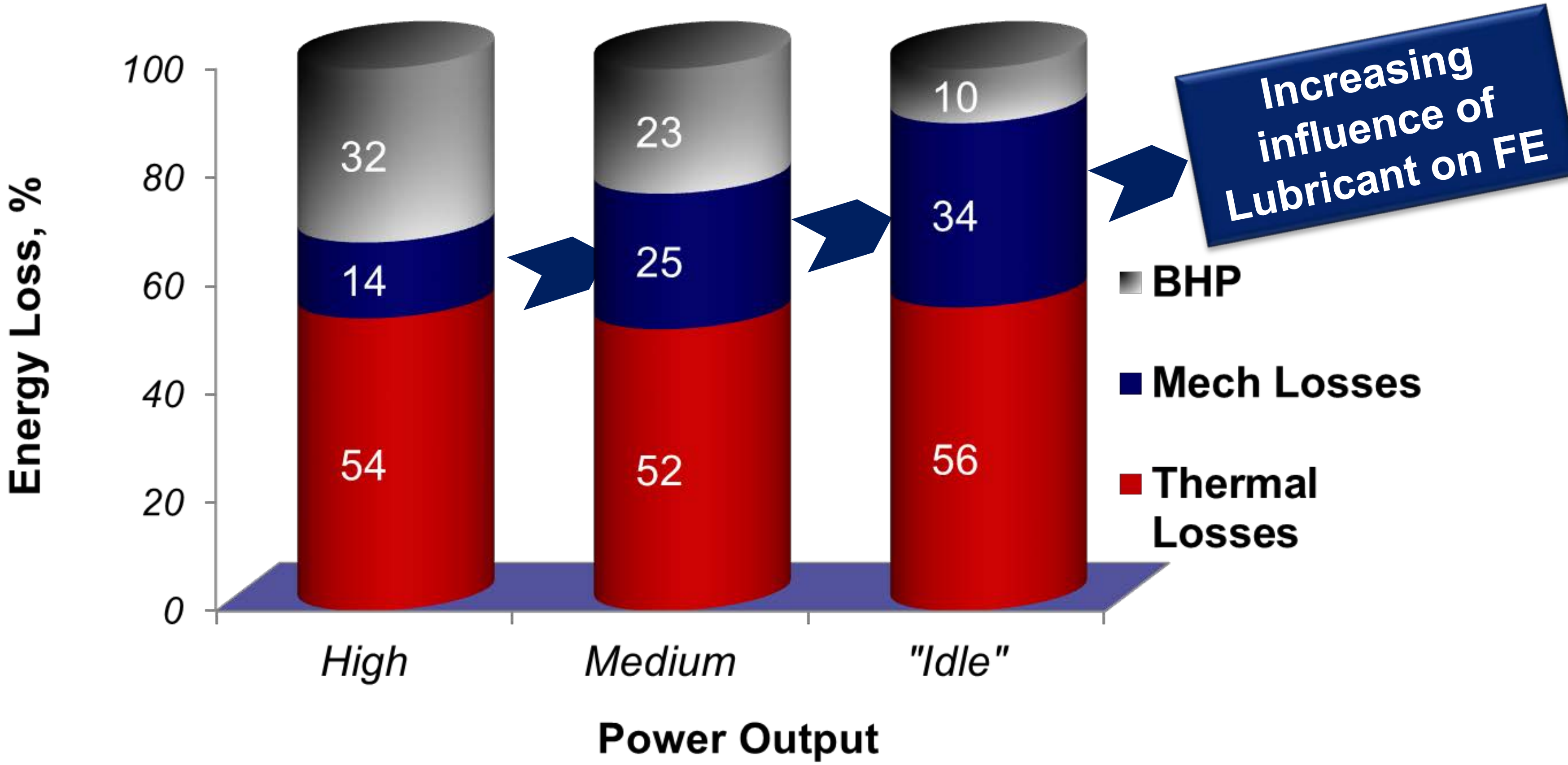
Performance you can rely on.

Typical energy distribution in a vehicle

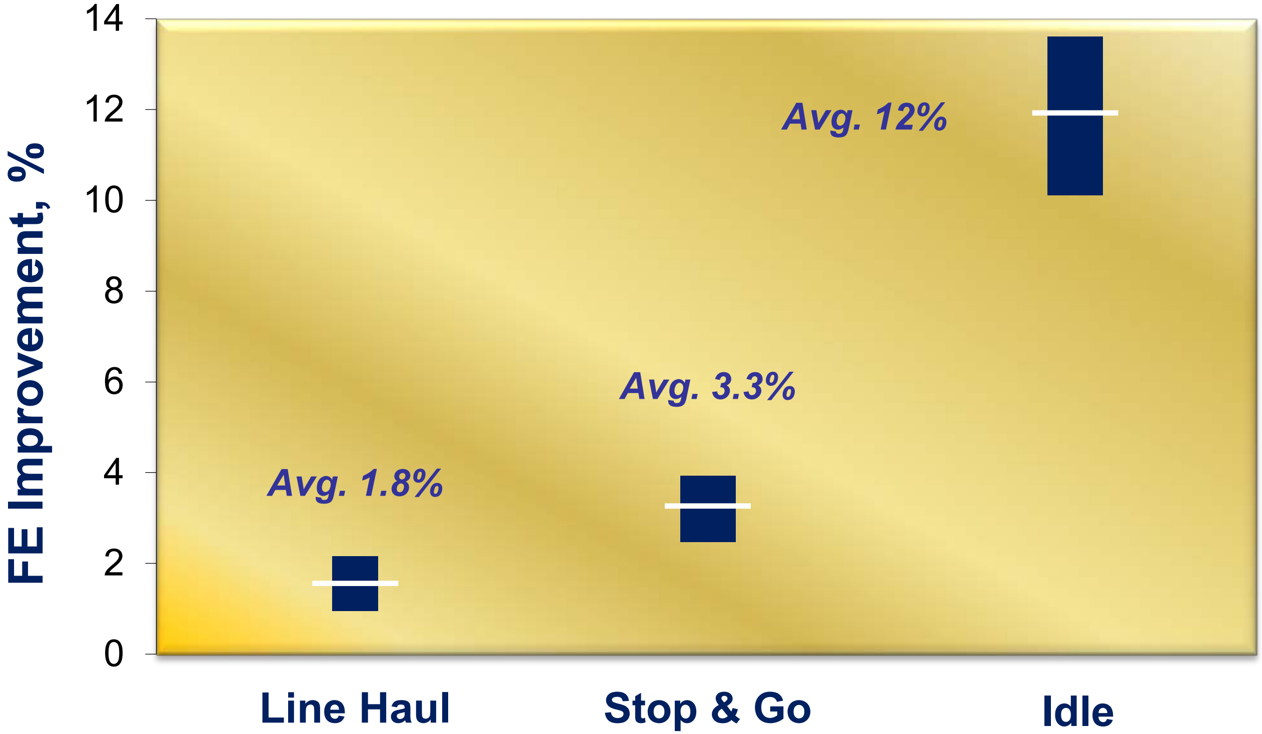


Majority of the data taken from "Pinkus and Wilcox, The Role of Tribology in Energy Conservation, Lubrication Engineering, 34 (11), pp 599-610"

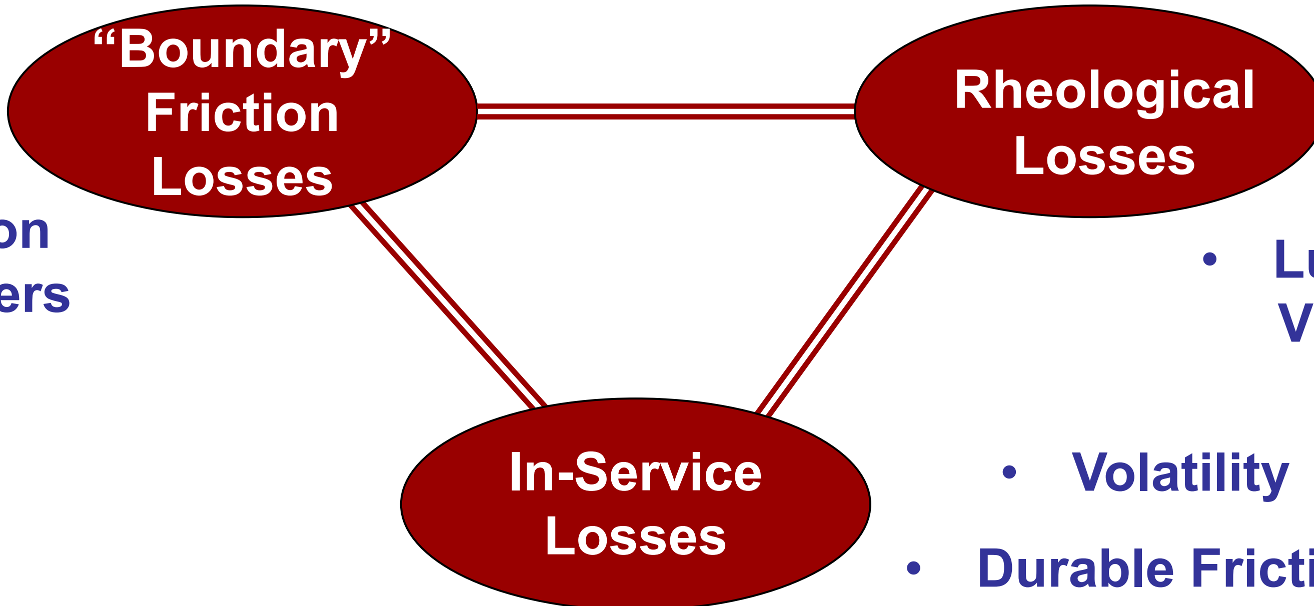
Energy Distribution varies with Drive Cycle



On-Road FE Results - Drive Cycle Effect



Fuel Economy triangle



- Friction Modifiers

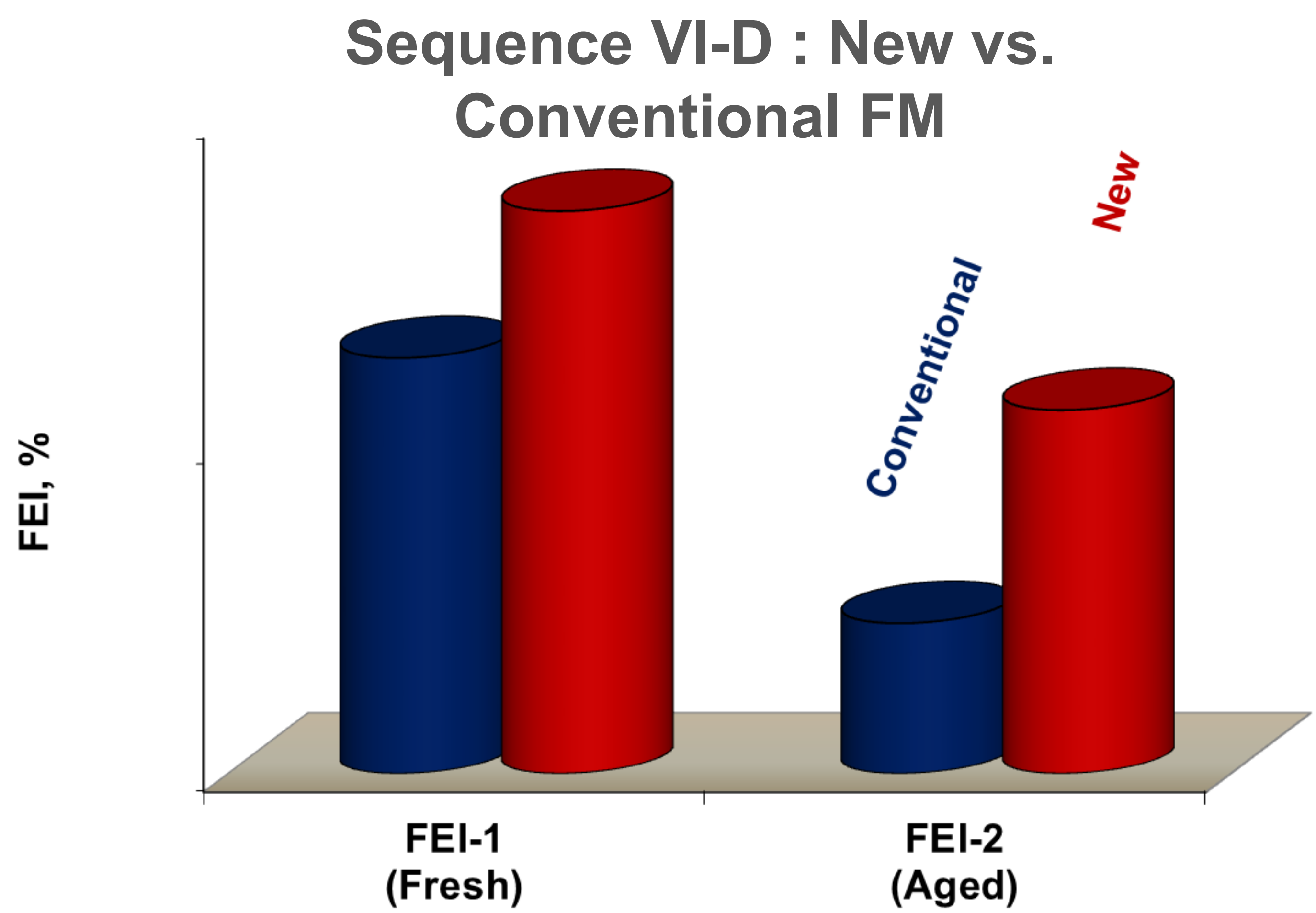
- Lubricant Viscosity

- Volatility
- Durable Friction Modifiers

Boundary friction losses

- **Friction modifier is the main additive lever to reducing boundary friction losses**
- **However, increasing use of low friction engines has reduced the effectiveness of conventional friction modifiers**
- **In addition, the ILSAC quality lubricants are required to demonstrate FE performance not only in the fresh state but upon ageing as well**
- **Today's friction modifiers must**
  - be effective in reducing friction in boundary as well as mixed lubrication regimes
  - retain their effectiveness even after ageing

Advances in FM technology offer clear advantage in ILSAC FE Protocol



Rheological Losses

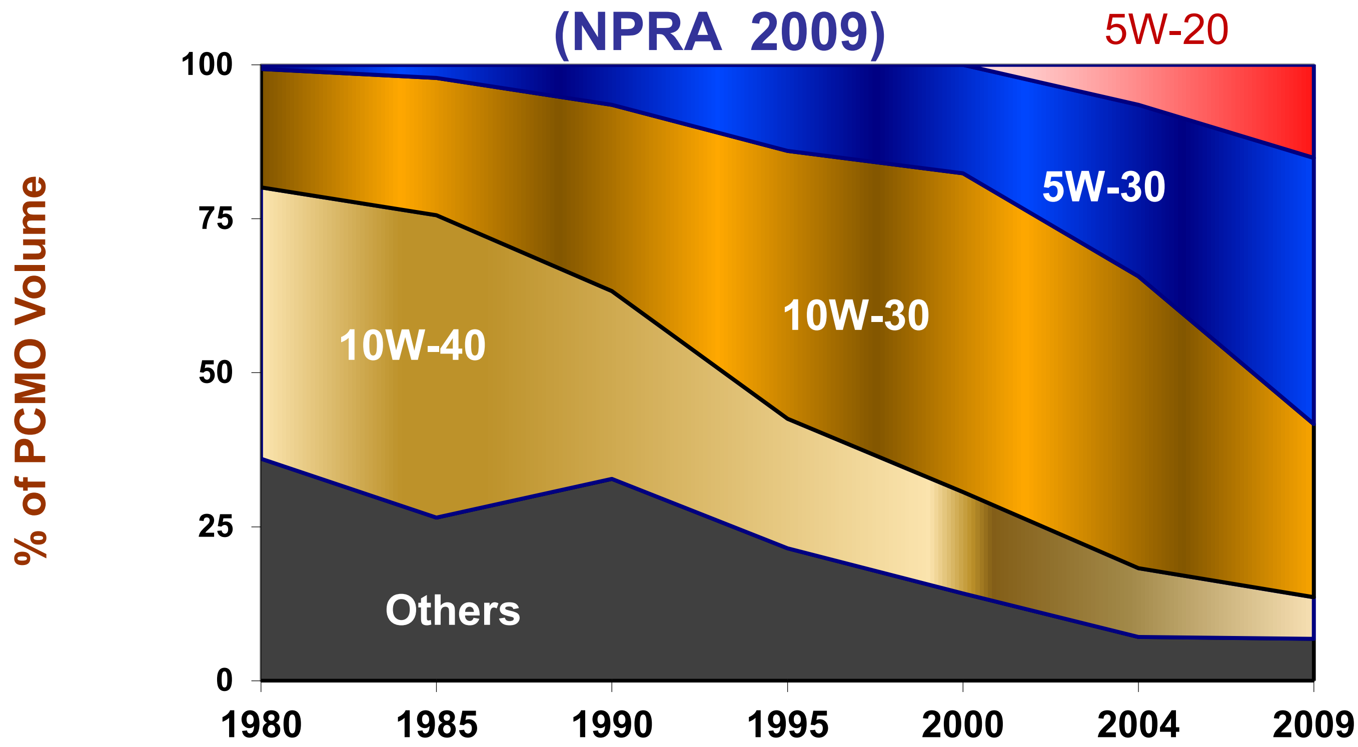
- **Lubricant viscosity is the key factor in controlling energy losses in hydrodynamic and mixed lubrication regimes**
  - Bearings, oil pump, piston assembly

- **Combined energy losses in these components are estimates to be 3-4%**

- **NA and Japan have been at the forefront in capturing these energy credits by transitioning to low viscosity lubricants**

Sustained march to lighter viscosity grades

Evolution of PCMO Grades in North America

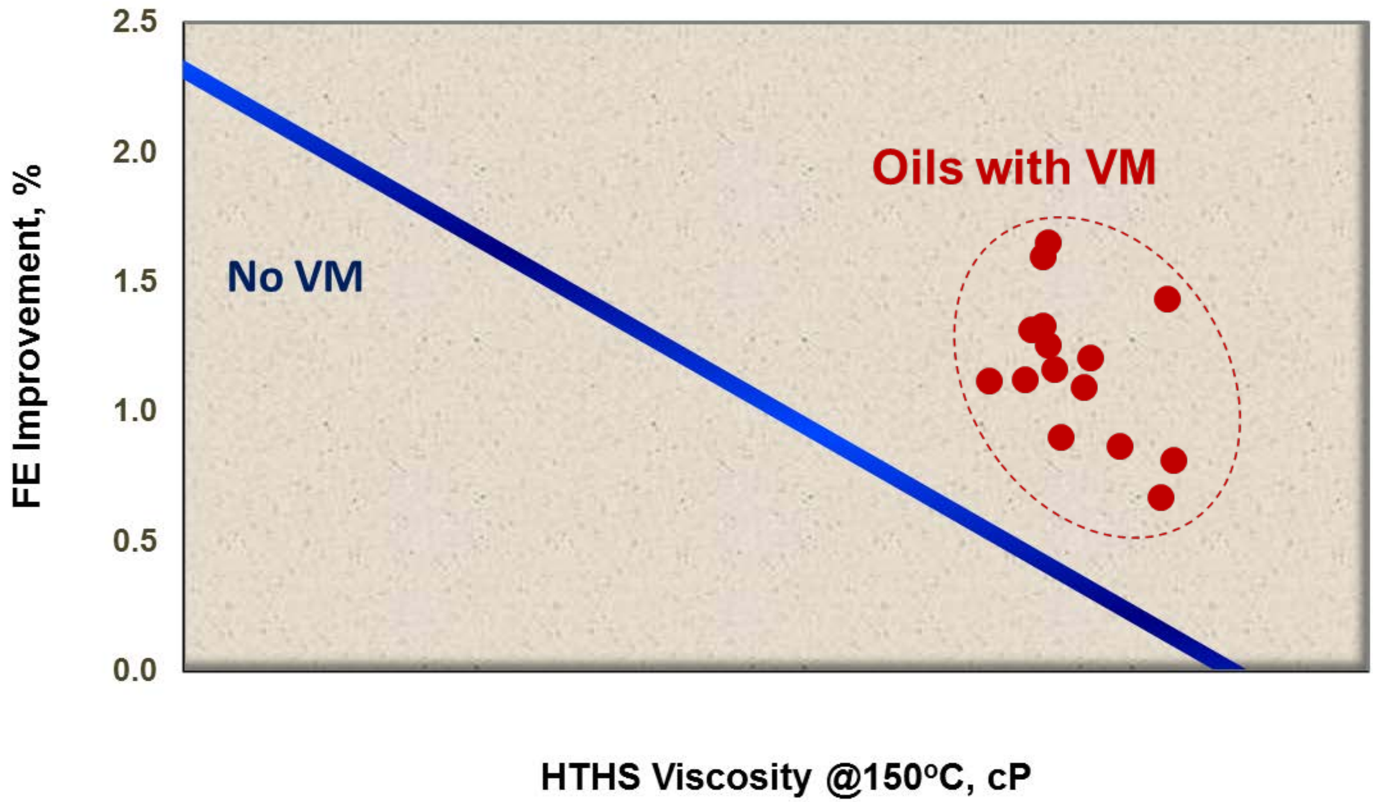


Which viscosity is relevant to FE?

- **HTHS viscosity is widely seen as the most critical lubricant property for fuel economy**

Lower HTHS ➔ Higher FE

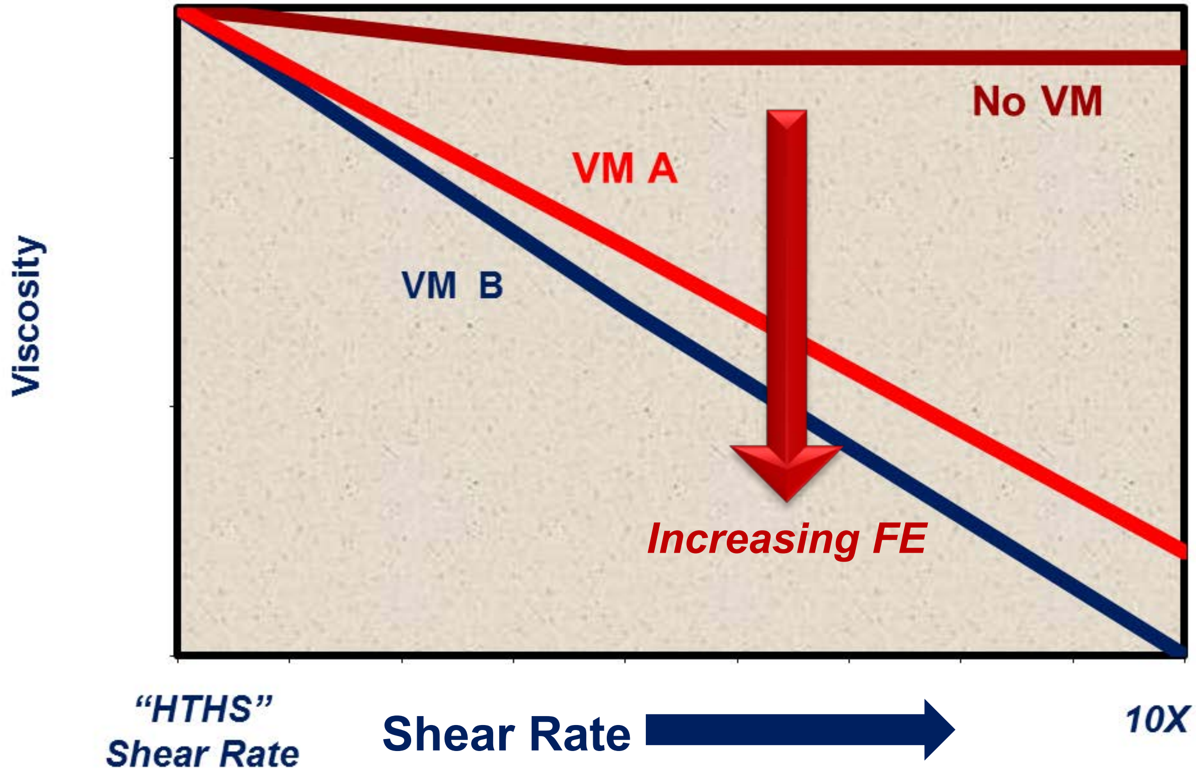
However, HTHS may not be serving us well



Much higher FE for oils with VM

Different FE performance for different VMs

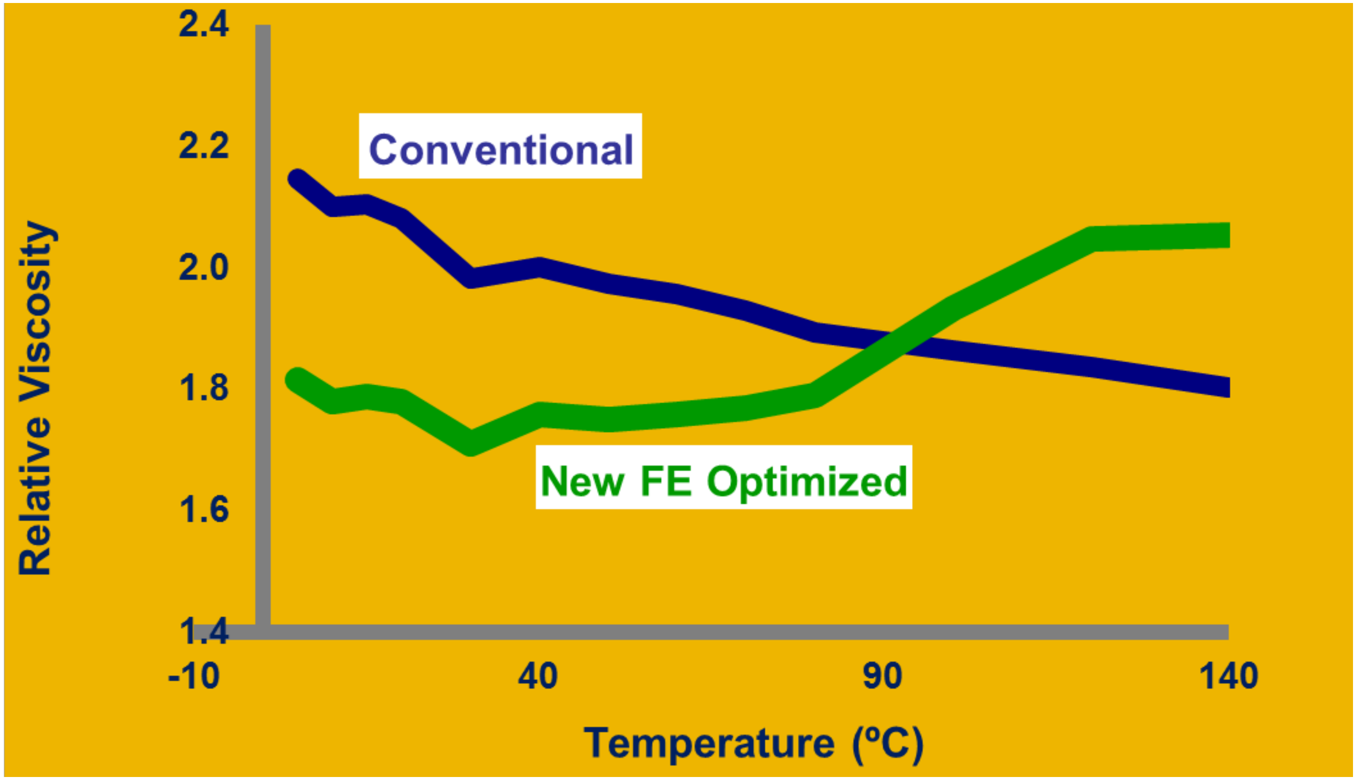
Viscosity at ultra high shear rates may be more Important than HTHS



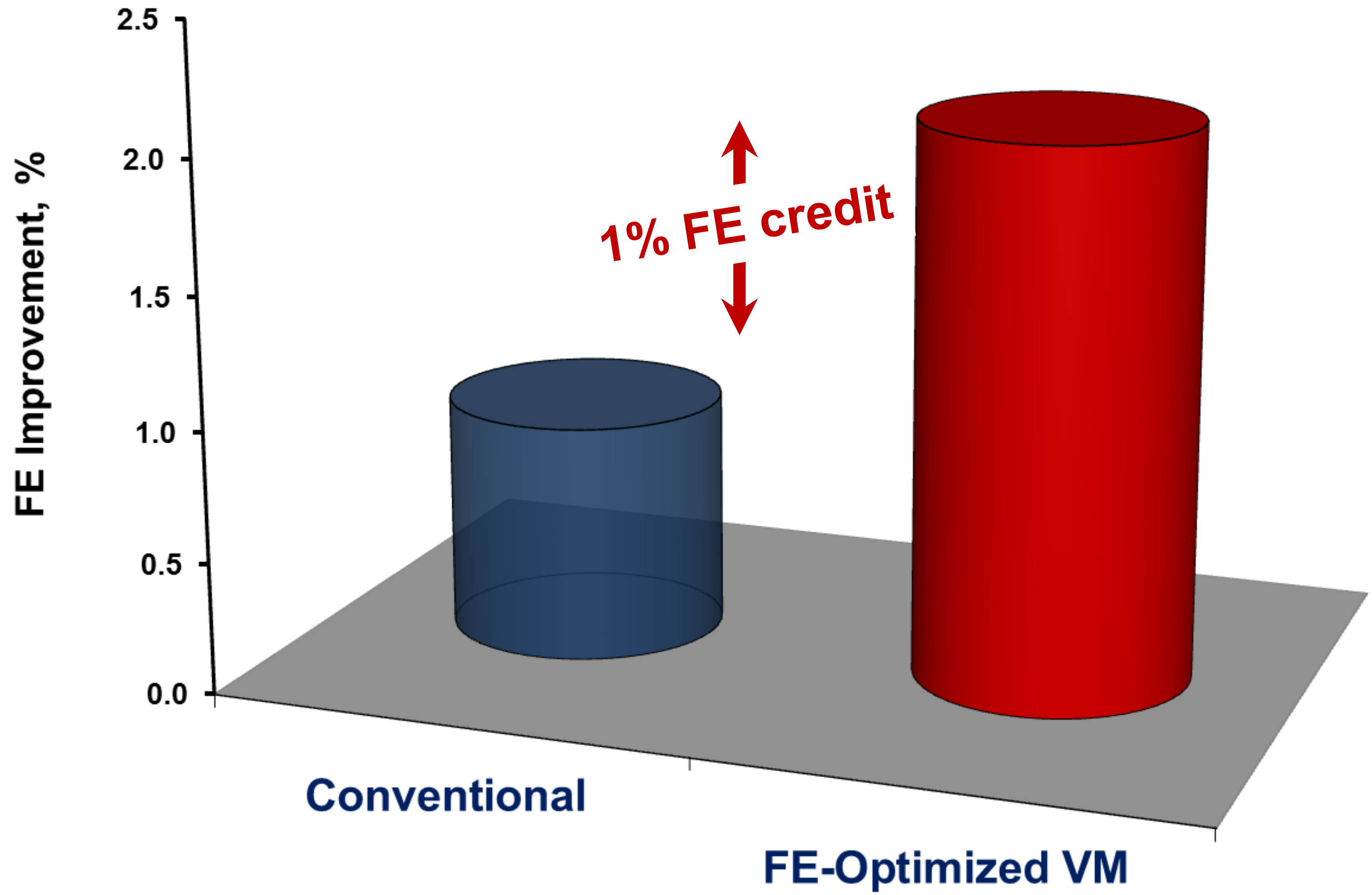
Opportunity to design "FE Optimized" VM by maximizing shear thinning at very high shear rates !

VM Optimized for "Cold Start"

- European NEDC and Japan JC-08 test procedures involve significant "Cold Start" segments
- Recent advances in VM technology have made it possible to minimize lubricant viscosity under the cold start conditions



FE-Optimized VM offers significant advantage in NEDC testing



Summary

Summary and Conclusions

- **Environmental and energy supply concerns are major drivers of change for the transportation industry**
- **Engine manufacturers respond to these concerns with new hardware technologies, resulting in rapidly evolving performance challenges for the lubricant industry**
- **Performance challenges provide opportunities to create value for lubricant developers, lubricant marketers and OEMs**
- **High technology solutions require high investments**
- **Early collaboration is essential for optimum deployment of these investments**