



# Lubrication Needs for Next Generation Gasoline Passenger Car Engine Technology

V Simpósio de Lubrificantes, Aditivos e Fluidos

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Ravi Tallamraju



# Passenger Car Motor Oil Global Market Engine Oil Market Drivers

The engine oil market undergoes constant change as a result of three factors:



Changing emissions legislation



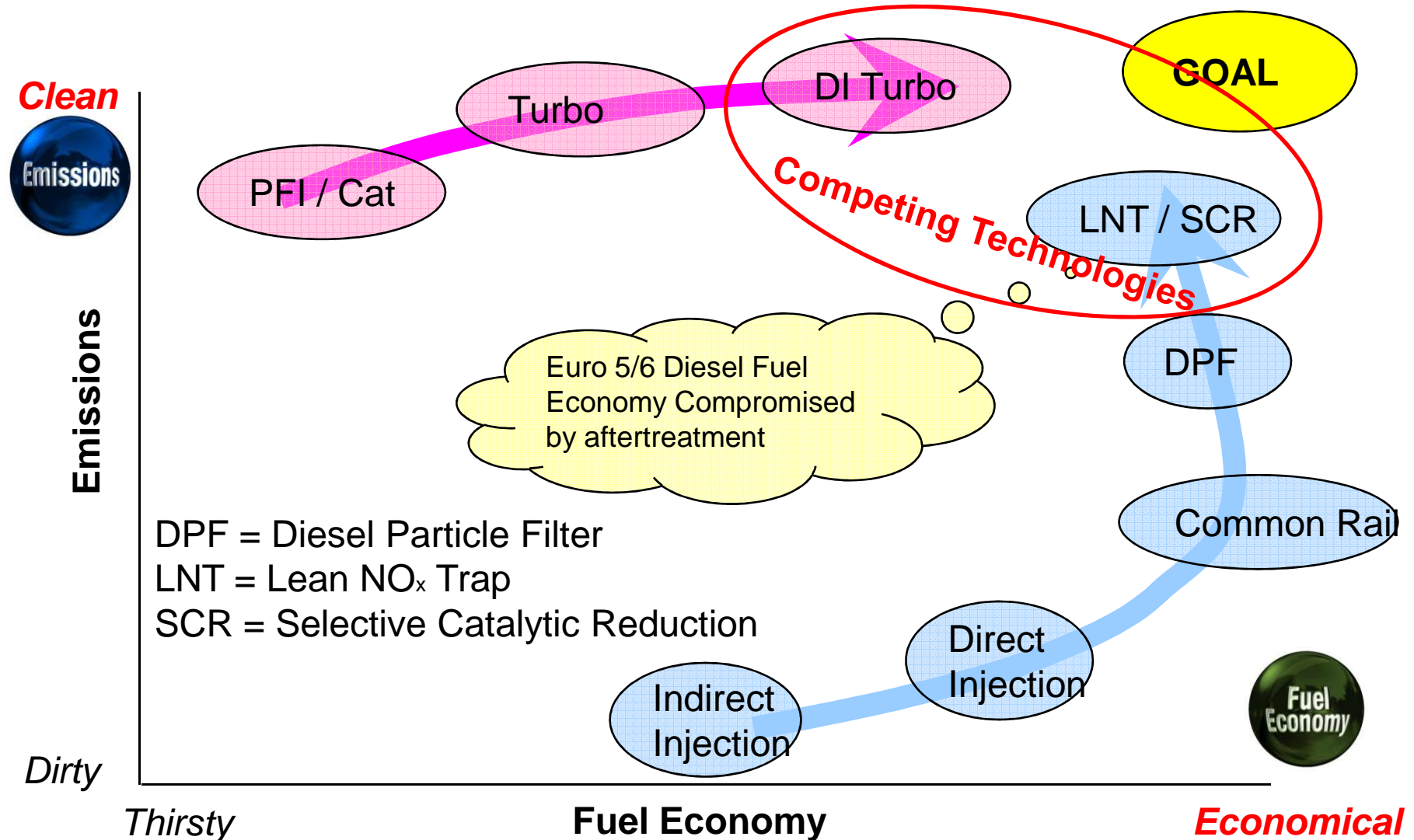
Increased fuel economy requirements



Durability under severe operating conditions

**Diesel vs. Gasoline**

head-to-head on fuel economy and emissions

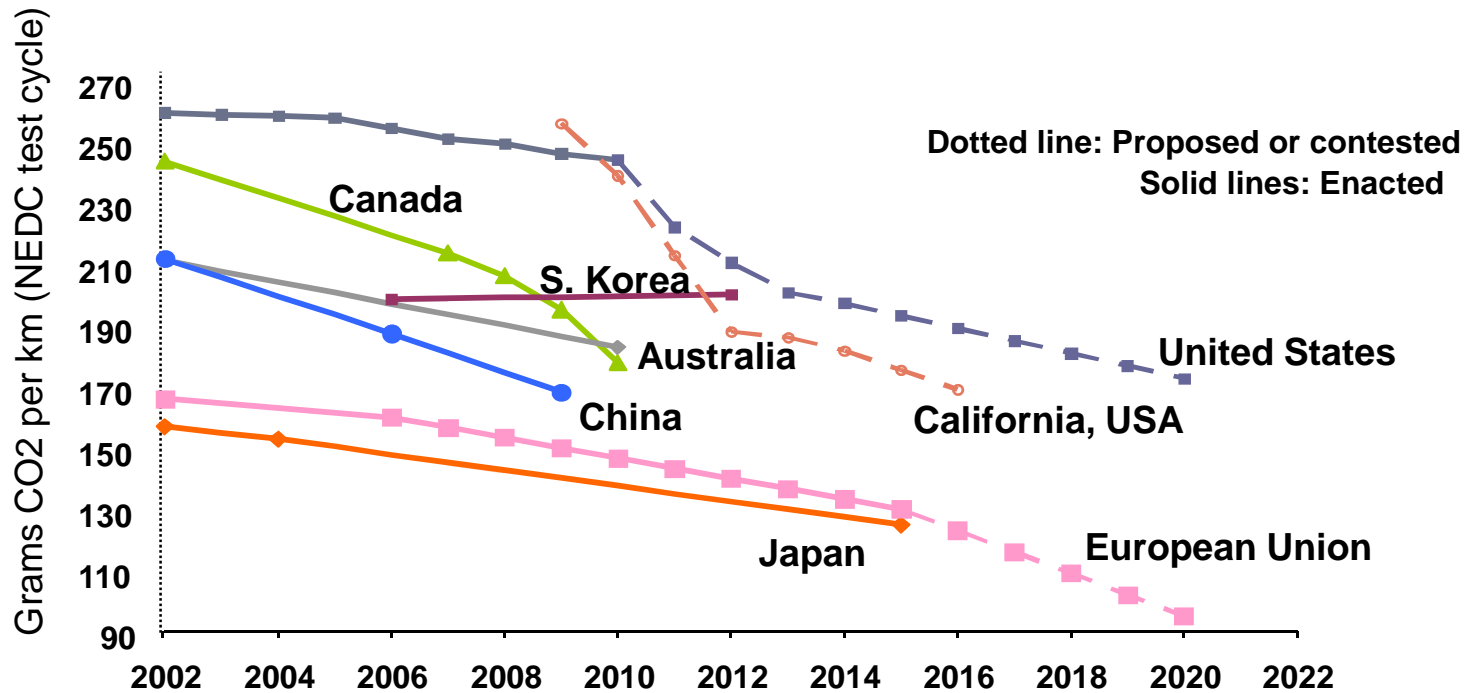


# Passenger Car Motor Oil Global Market Legislation Focused on Reducing CO<sub>2</sub> Emissions



- Many countries implementing regulations to limit CO<sub>2</sub>

Actual and Projected GHG Emissions for New Passenger Vehicles



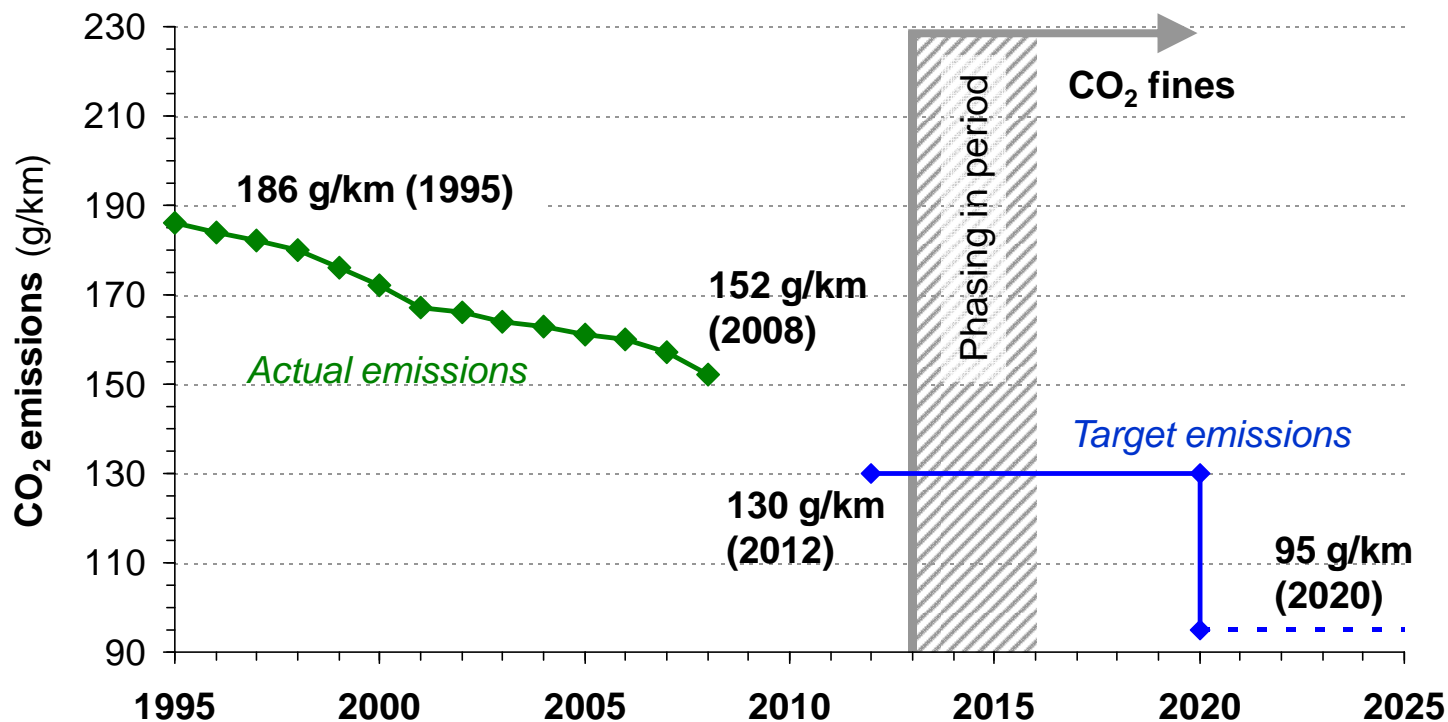
Source: Passenger Car Vehicle Greenhouse Gas and Fuel Economy Standards: A Global Update, January 2009.



# Passenger Car Motor Oil Global Market

## Example: EU CO2 Passenger Car Legislation

- EU average new car CO<sub>2</sub> emissions and proposed targets



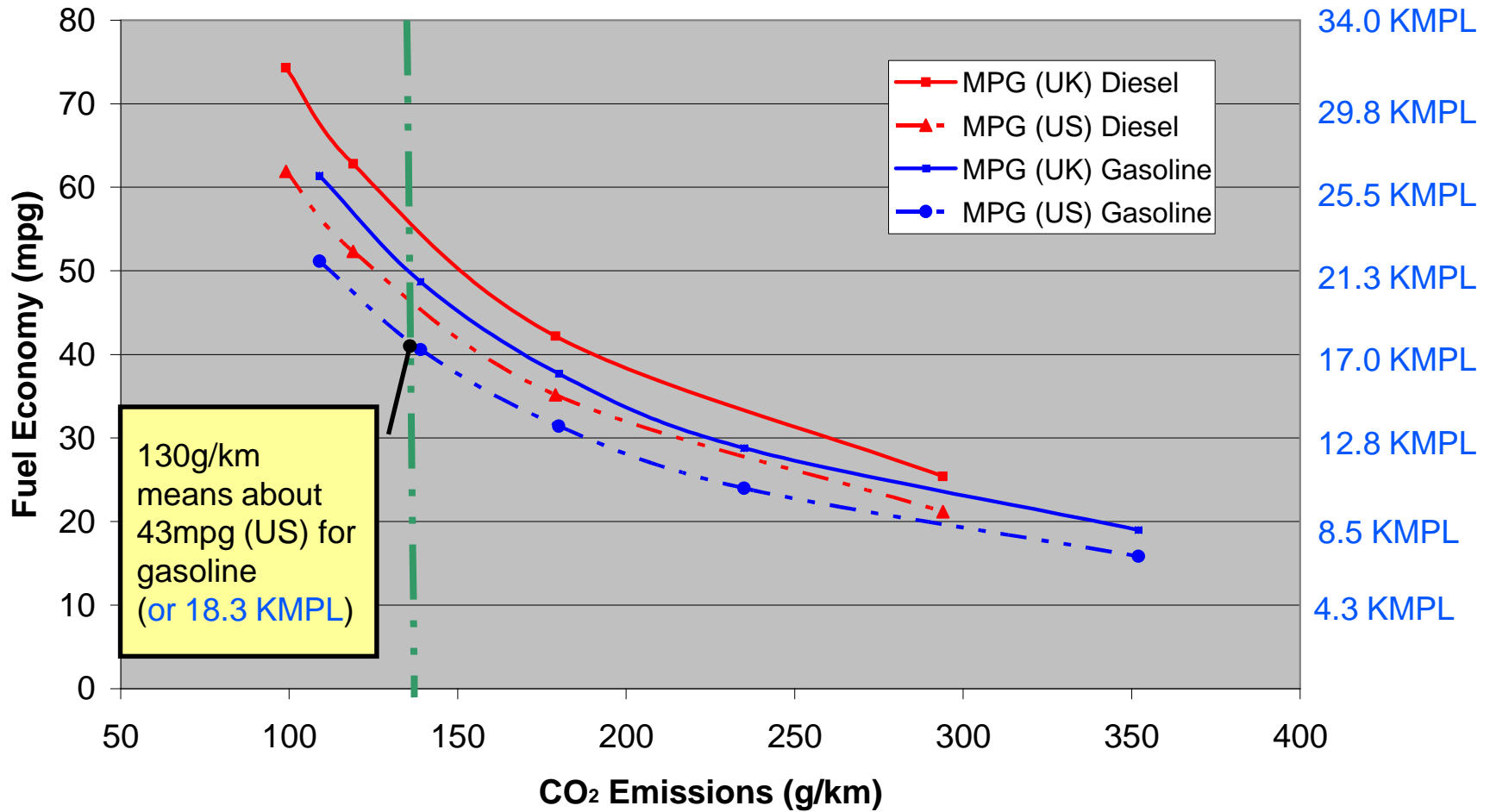
CO <sub>2</sub> fines	
1 <sup>st</sup> g/km	€5
2 <sup>nd</sup> g/km	€15
3 <sup>rd</sup> g/km	€25
4+ g/km	€95/g

per g CO<sub>2</sub> above emissions limits

Based on 2008 sales, the fines payable in 2015 would be over €29 billion



# FE-Emissions Link

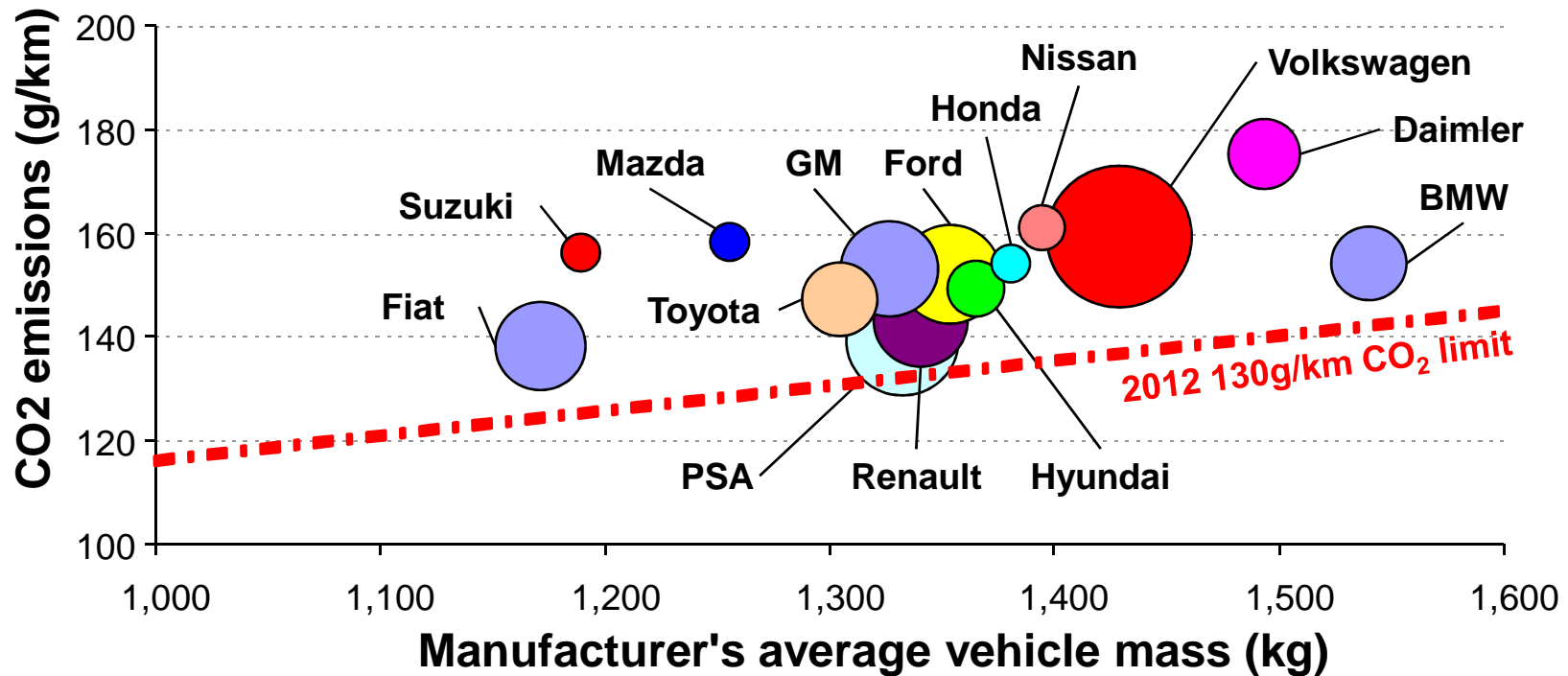


# Passenger Car Motor Oil Global Market

## Example: EU CO<sub>2</sub> Passenger Car Legislation



- OEM positions in 2008 compared to 2012 CO<sub>2</sub> target
- Bubble size indicate relative volume of vehicle production



Each OEM may identify different ways to reduce CO<sub>2</sub> emissions





## Passenger Car Vehicle Hardware Changes

- The introduction of more sophisticated hardware will provide significant challenges for engine lubricants

<b>Gasoline</b>	<b>Euro 3 2000</b>	<b>Euro 4 2005</b>	<b>Euro 5 2009</b>	<b>Euro 6 2014</b>
<b>Engine design</b>	PFI	PFI + GDI	T-GDI	T-GDI
<b>Aftertreatment</b>	TWC	TWC	TWC	TWC +GPF

<b>HD Diesel</b>	<b>Euro 3 2000</b>	<b>Euro 4 2005</b>	<b>Euro 5 2009</b>	<b>Euro 6 2014</b>
<b>Engine design</b>	IDI + DI	DI	DI	DI
<b>Aftertreatment</b>	EGR	EGR +SCR	EGR + SCR	EGR +DPF +SCR

Source : Lubrizol

**KEY**

**Engine design types**

- PFI** Port fuel injection gasoline
- GDI** Direct injection gasoline
- T-GDI** Turbo charged GDI
- IDI** Indirect injection diesel
- DI** Direct injection diesel

**Aftertreatment system types**

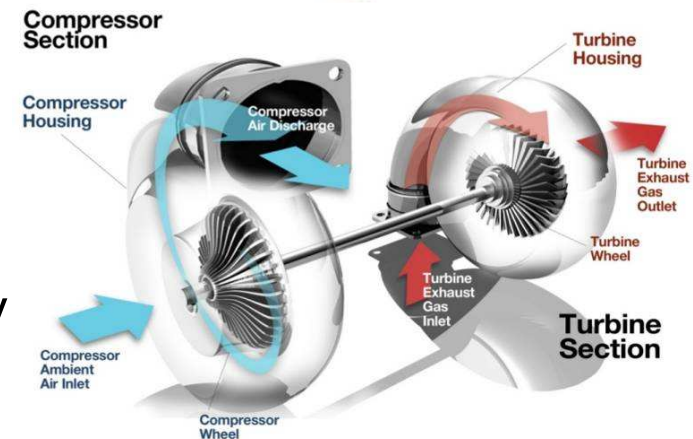
- TWC** Three-way catalyst
- GPF** Gasoline particular filter
- EGR** Exhaust gas recirculation
- DPF** Diesel particulate filter
- SCR** Selective catalytic reduction



# Passenger Car Motor Oil Global Market Engine Design Changes

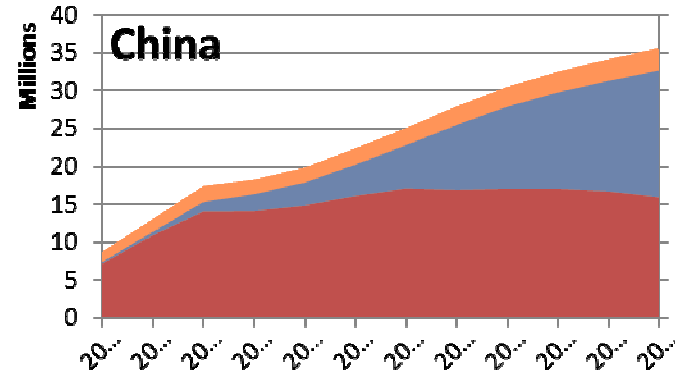
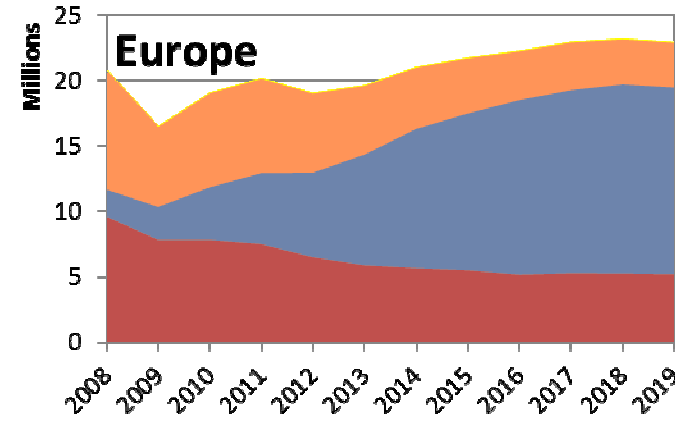
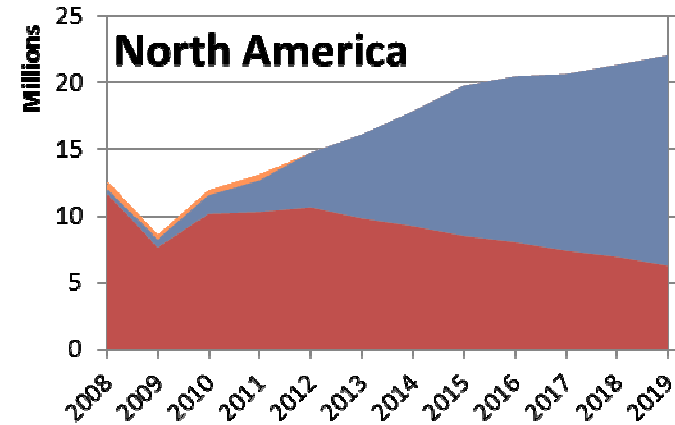
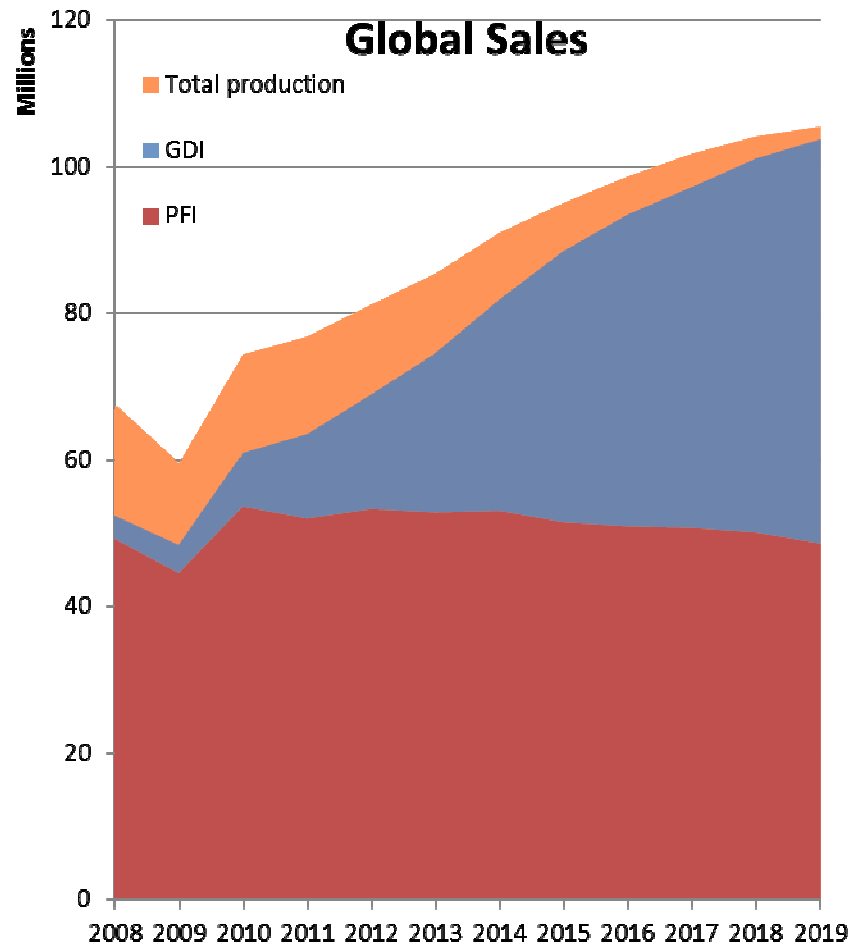


- Gasoline direct injection (**GDI**)
  - Involves injection of the gasoline directly into the combustion chamber, rather than into the intake port
  - Gives power and efficiency benefits
  
- Adding a turbocharger (**T-GDI**)
  - Gives the engine designer the ability to provide the right amount of air for optimum combustion
  - Further increases power and efficiency



T-GDI engines are compact with high power output

# GDI-New Sales Projections



Source: IHS Global insight

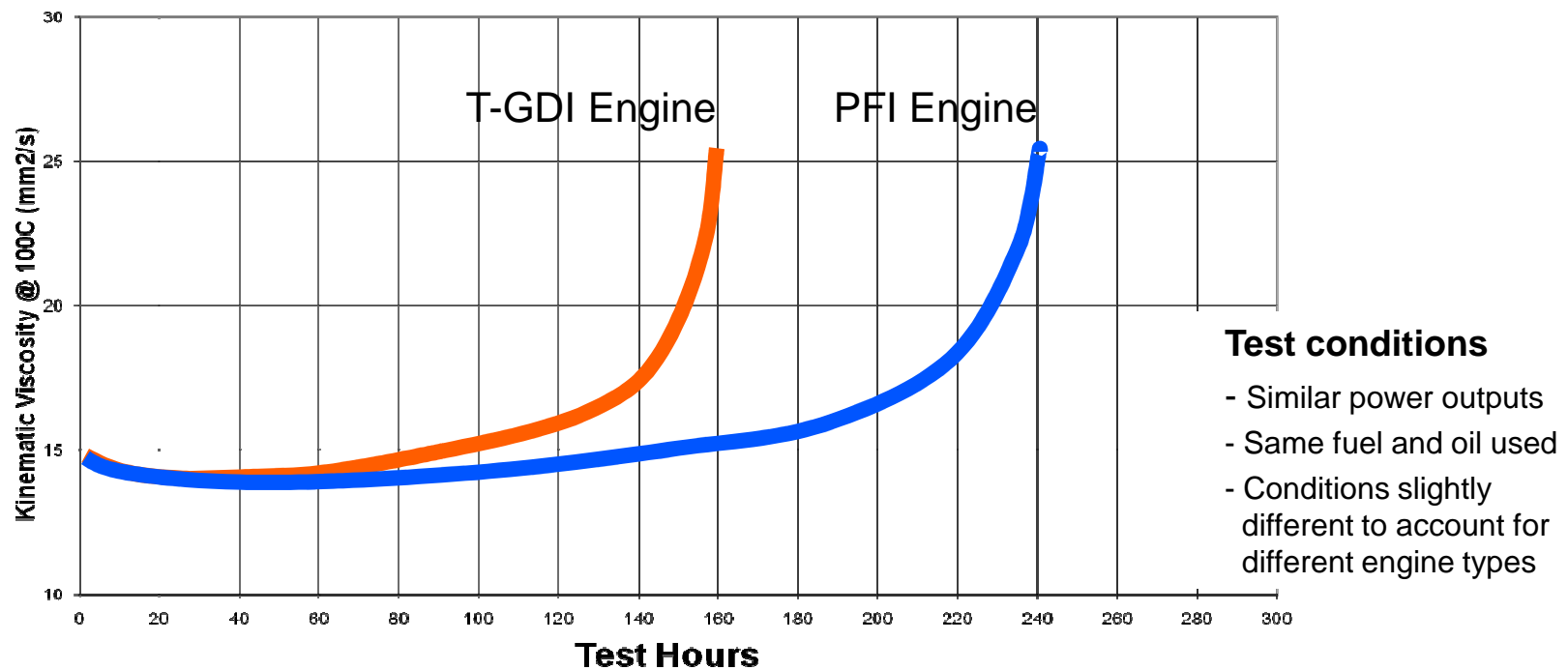
# Passenger Car Motor Oil Global Market

## T-GDI: Performance Challenges for Engine Oils



- Increased power density

Comparison of Engine Oil Viscosity Increase in PFI and T-GDI



T-GDI engines run hotter and harder, leading to increased oxidation

# Passenger Car Motor Oil Global Market T-GDI: Performance Challenges for Engine Oils



- Turbocharging
  - Turbocharging increases the severity on the lubricant
  - A critically hot area for the oil is the turbocharger bearing
  - Accelerated oxidation rates can lead to a rapid degradation of the oil, causing deposits in the turbocharger and other areas



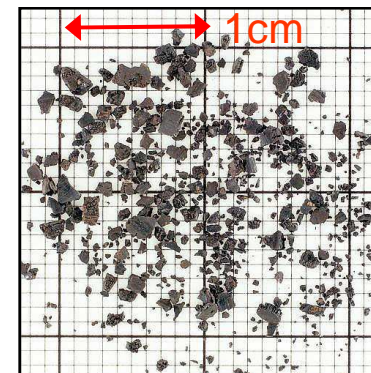
**Turbo bearing seizure**



**Turbo shaft failure**



**Oil pickup blockage**



**Pickup deposits (solvent washed)**

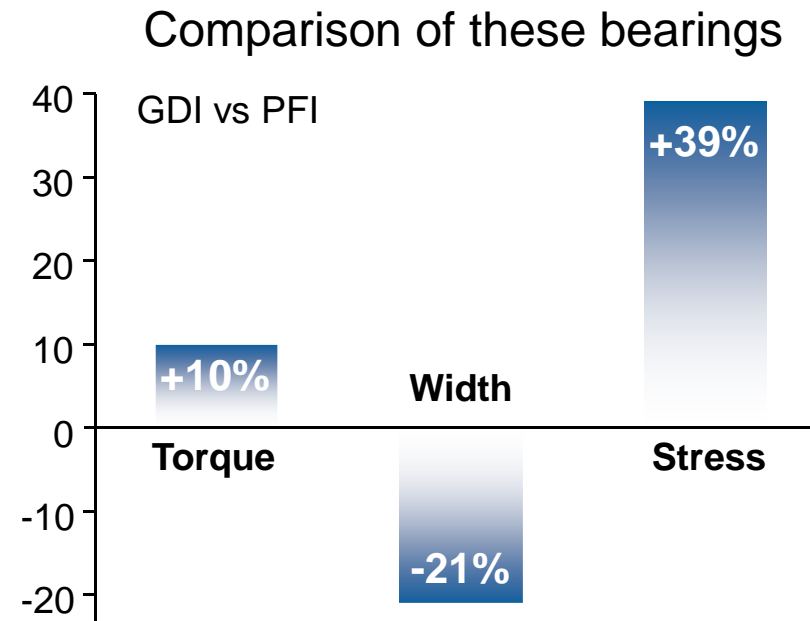
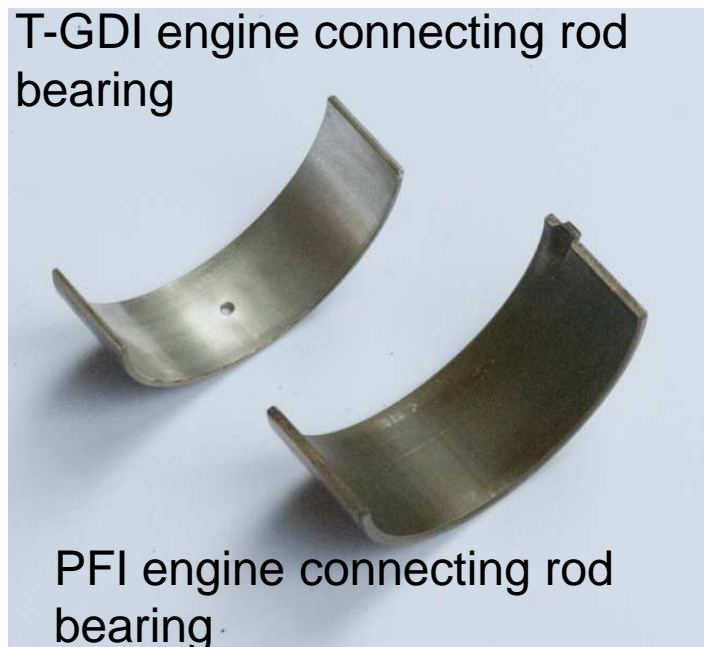
**Turbocharging leads to increased oxidation and oil degradation**



# Passenger Car Motor Oil Global Market

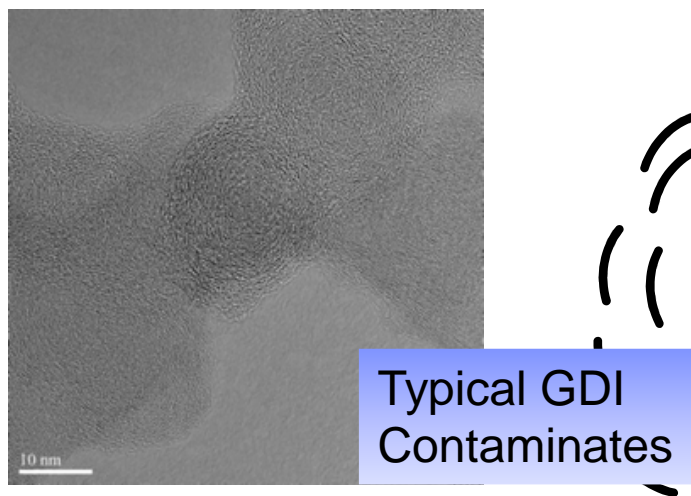
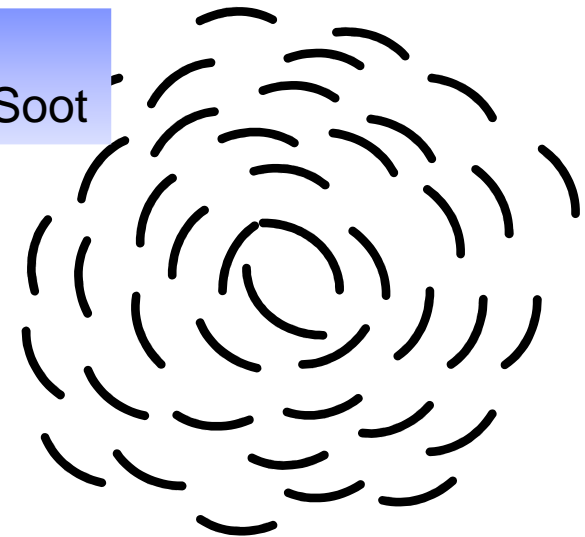
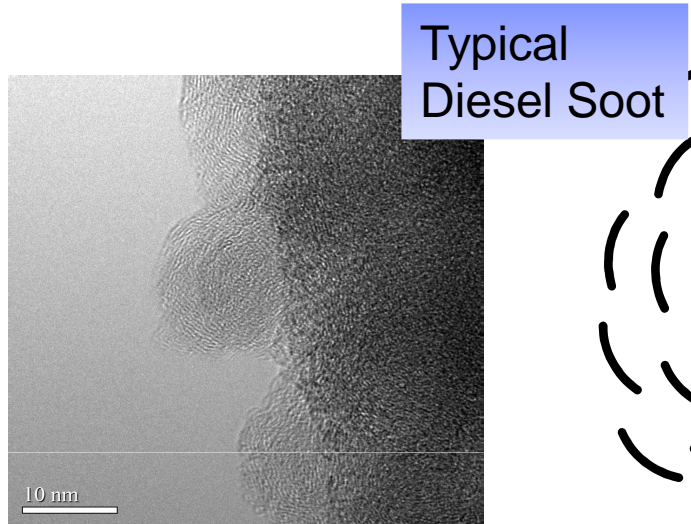
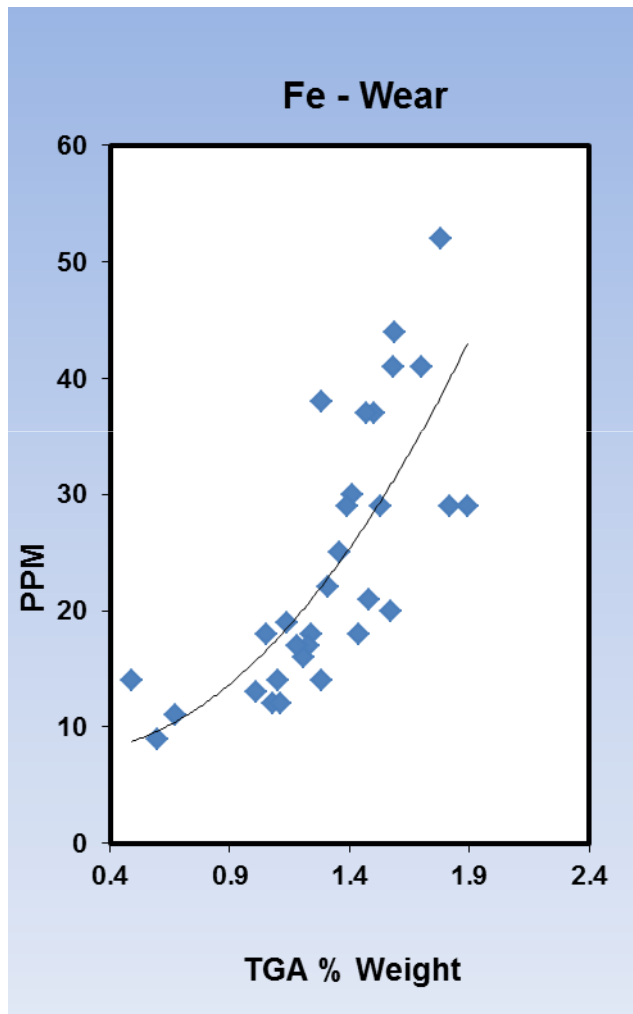
## T-GDI : Performance Challenges for Engine Oils

- Downsizing
  - More torque from a downsized engine means higher loads on smaller bearings – a challenge to the lubricant film strength



Downsizing leads to the need for increased wear protection

# TEM - Visual Comparison of Lubricant Drains: Diesel soot vs. GDI contaminates

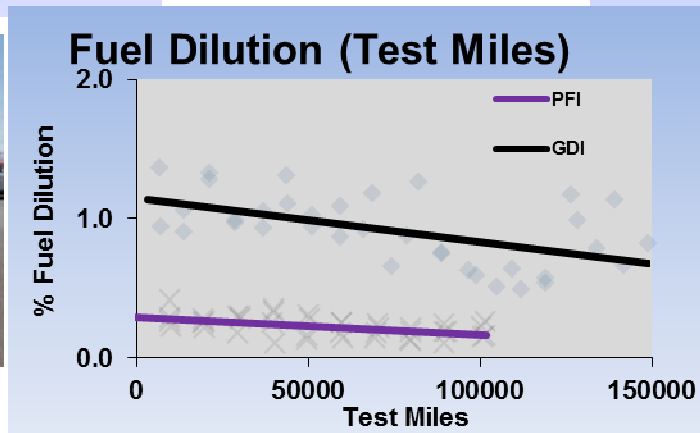
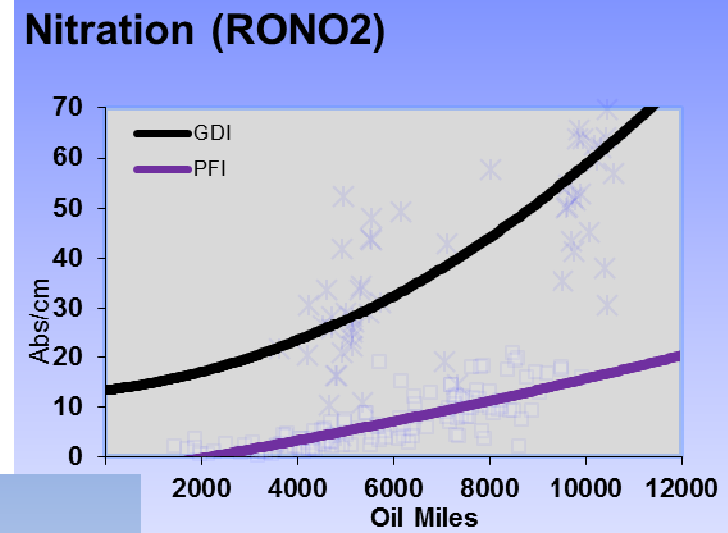
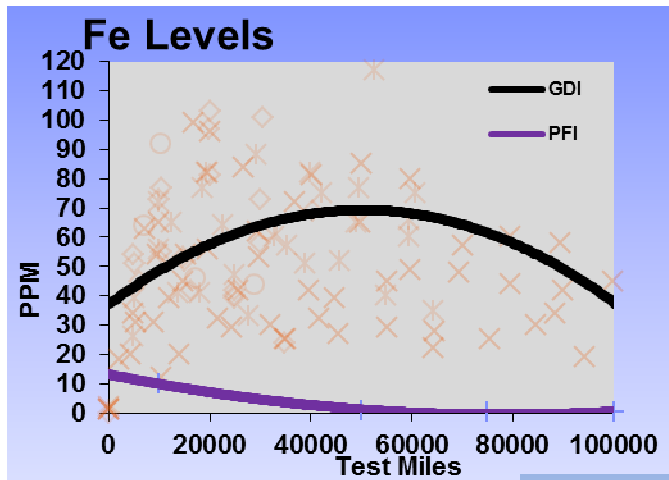


**GDI engines create increasingly severe environment for wear**



# Field Testing Summary

GDI engines create an increasingly severe environment for lubricant  
 Lubrizol has globally accumulated over 3 million miles on our lubricant formulations in GDI powered vehicles



**GDI engines create increasingly severe environment for lubricant**



# The Changing Market : Vehicle Hardware Changes

## Vehicle hardware change

## Impact on lubricant technology

Indirect injection



**Direct injection**



Greater deposit protection and soot handling

Non-turbocharged



**Turbo charging**



Greater protection against thermal degradation

Basic or no aftertreatment



**Advanced after-treatment**



Requirement for after-treatment compatibility

Changes in hardware lead to higher quality lubricant technology

# Fuel Economy Improvement drivers for Brazil



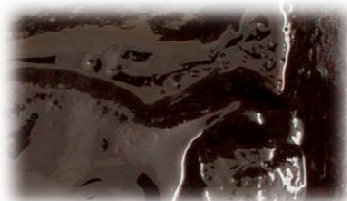
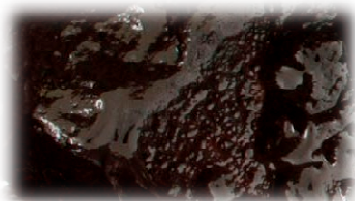
- New legislation for energy efficiency improvement standards for Brazil\*

Fuel	Current Average Fuel Economy*, KMPL	Proposed Average Fuel Economy target (for 2017)*, KMPL
Gasoline	14.0	17.26
Ethanol	9.71	11.96

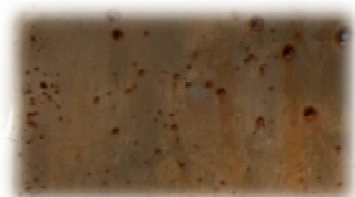
- New tax incentives\* introduced for improvements in fuel economy for Brazil
  - **15.46%** improvement in fuel economy (2017) → up to **1%** IPI tax credit
  - **18.84%** improvement in fuel economy (2017) → up to **2%** IPI tax credit
- Incentives & new standards can influence changes in technology towards GDI engines for Brazil
- GDI engine models already introduced/ being introduced to Brazil & are expected to grow
  - Examples : VW Passat ; Peugeot 3008 ; Hyundai/ others ?

\* Source : INOVAR-AUTO energy efficiency rules – October 2012

## GDI Sludge Concern with Low Quality Lubricants/ Fuels



**Low tier oil:** High temperature oxidation drives viscosity increase and sludge deposits



**High tier oil:** No significant sludge deposits

### Issues of concern for Brazil & other emerging markets

Impact of lubricant quality – misapplication of lubricant?

Impact of ethanol / other bio-fuels?

Impact of severe operating conditions?

Impact of “stop & go” city operation; fuel dilution?

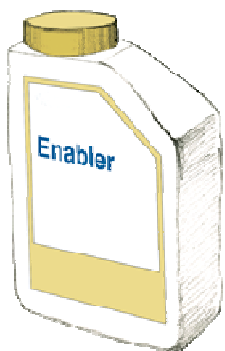
Impact of drain interval ?

**“Higher Performance” lubricants are required for new GDI Engines**

## Passenger Car Motor Oil Global Market Improving Fuel Efficiency

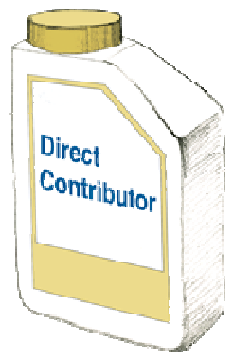


- Engine oils both **enable** and **directly contribute** to improving fuel efficiency



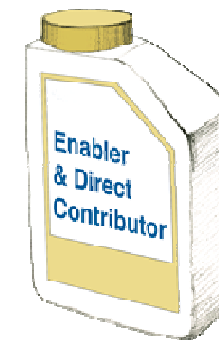
### Enabler

- Providing high performance robustness that allows changes to engine design technology without impacting fuel economy



### Direct Contributor

- Formulated to maximise fuel economy: e.g. choice of viscosity grade, friction modifier selection and use, viscosity at high temperature high shear (HTHS), base oil viscosity index



The roles are interlinked

## Summary

- Legislation focused on reducing CO<sub>2</sub> (GHG) **Emissions** and improving **Fuel Economy** → significant penalties for non-compliance
  - Primary drivers for move to GDI/ T-GDI technologies for new gasoline cars worldwide
- New GDI/ T-GDI engine technologies require high performance lubricants
  - Much higher power densities → higher thermal and oxidative stress
  - Lighter viscosity grade for fuel economy → Increased need for wear protection
  - Turbo charger protection needs → higher thermal and oxidative stress
  - Higher level of abrasive contaminants → better wear protection needs
  - After treatment devices → elemental limits on lubricants
- Need to upgrade the lubricant quality significantly to address **Durability** concerns with:
  - Higher overall performance needs
  - Lighter viscosity grades (0W-xx / 5W-xx)
  - Higher quality base oils ( Group II and Group III )
  - New additive technology



***Lubrizol***



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