Environment Friendly Fuels & Lubricants: Indian Trends

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- ✓ Demand & Growth Projections
- ✓ Emission Norms
- ✓ Fuel Quality Up-gradation
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  - ❑ Fuel Efficient Engine Lubricants
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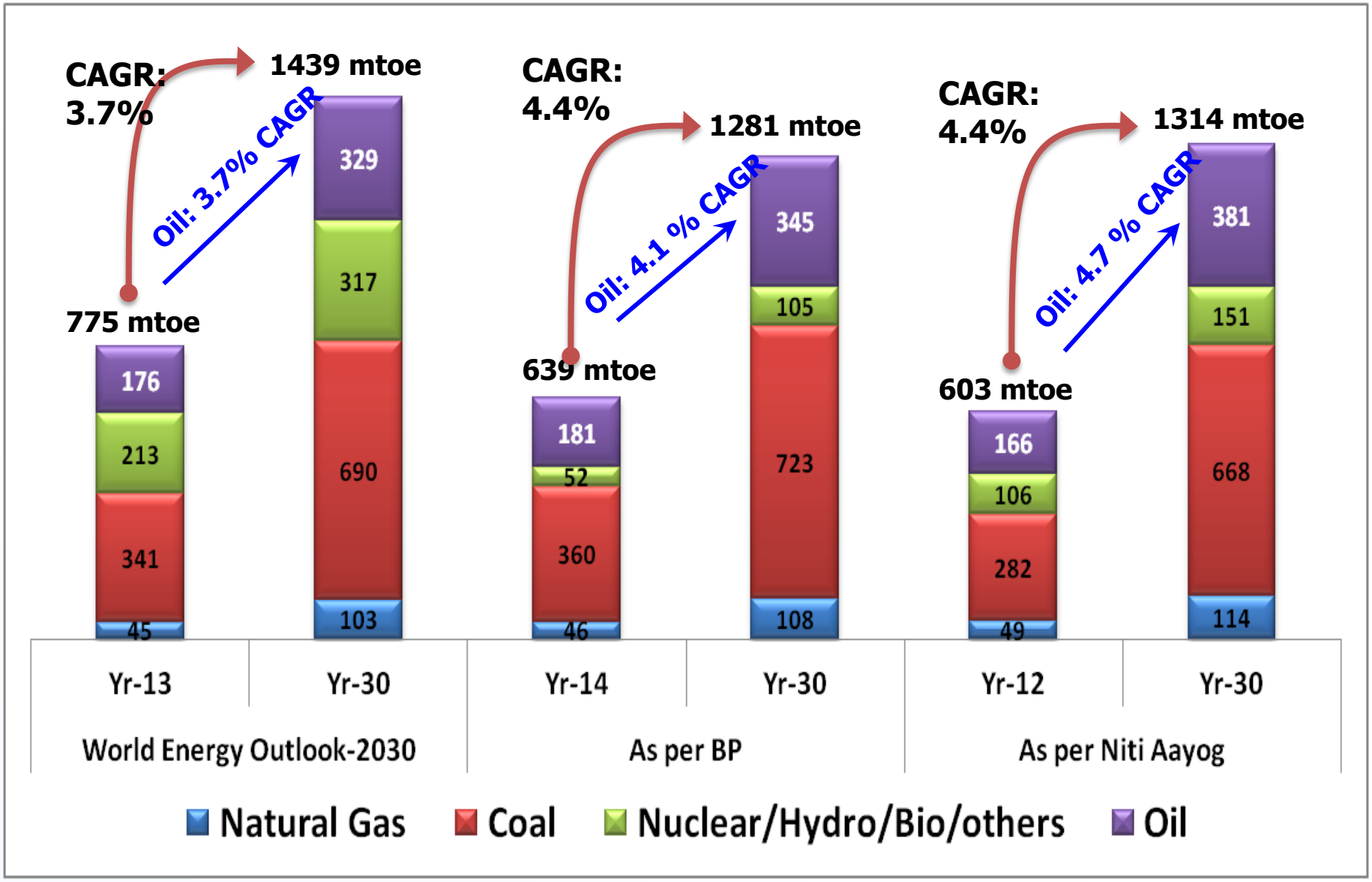
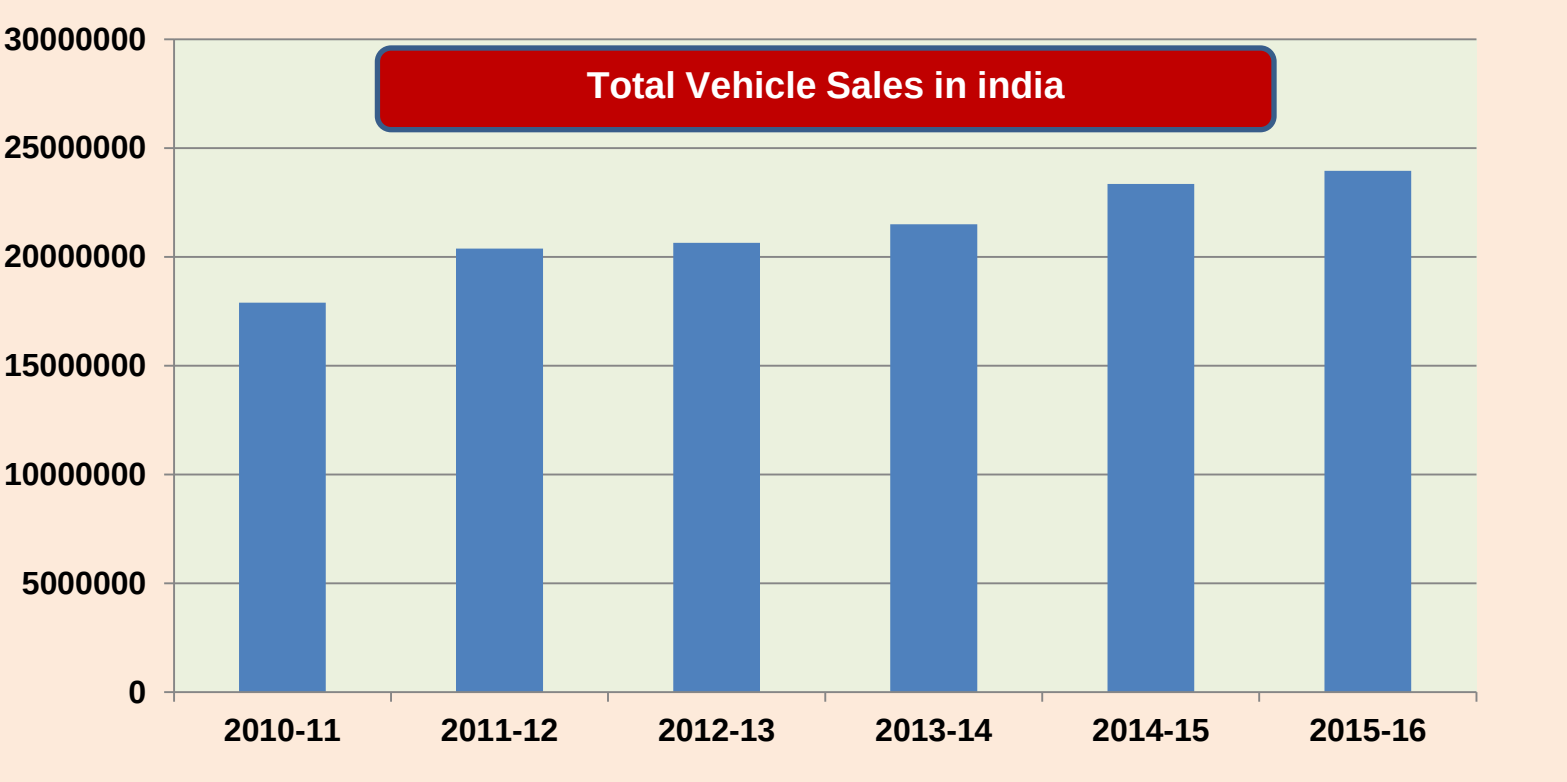
Primary Energy Demand-2030



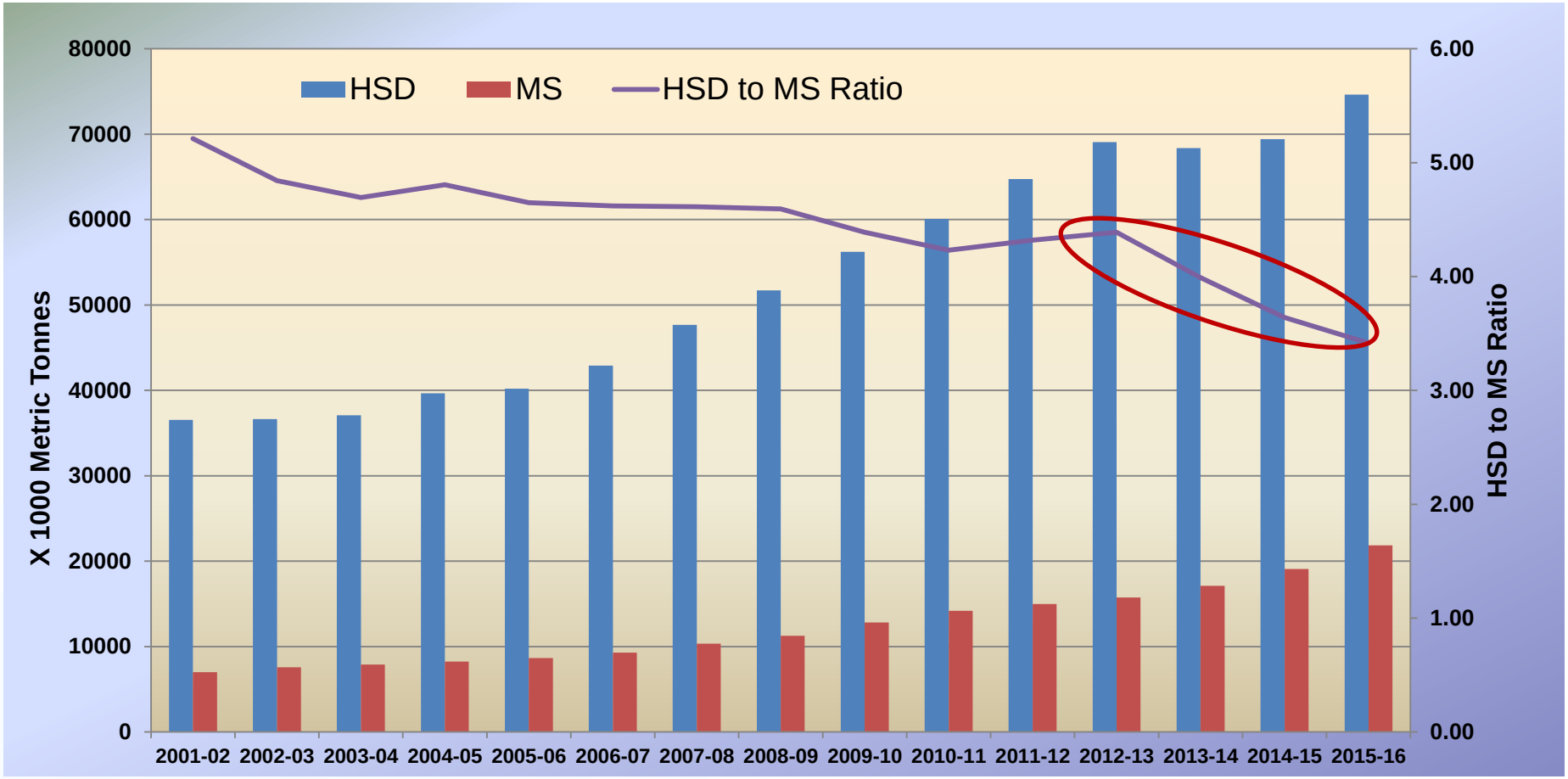
Growth of Indian Automobile Industry



Source: SIAM, Booz & Company

- ✓24 million vehicles produced in 2015-16 of which
- ✓Share of two wheelers, passenger vehicles, three wheelers and commercial vehicles were 78%, 15%, 3% and 4% respectively
- ✓Automotive Mission Plan 2016 envisages a 3.5 – 4 times growth from current levels by 2026
- ✓Contribution of 7% towards GDP

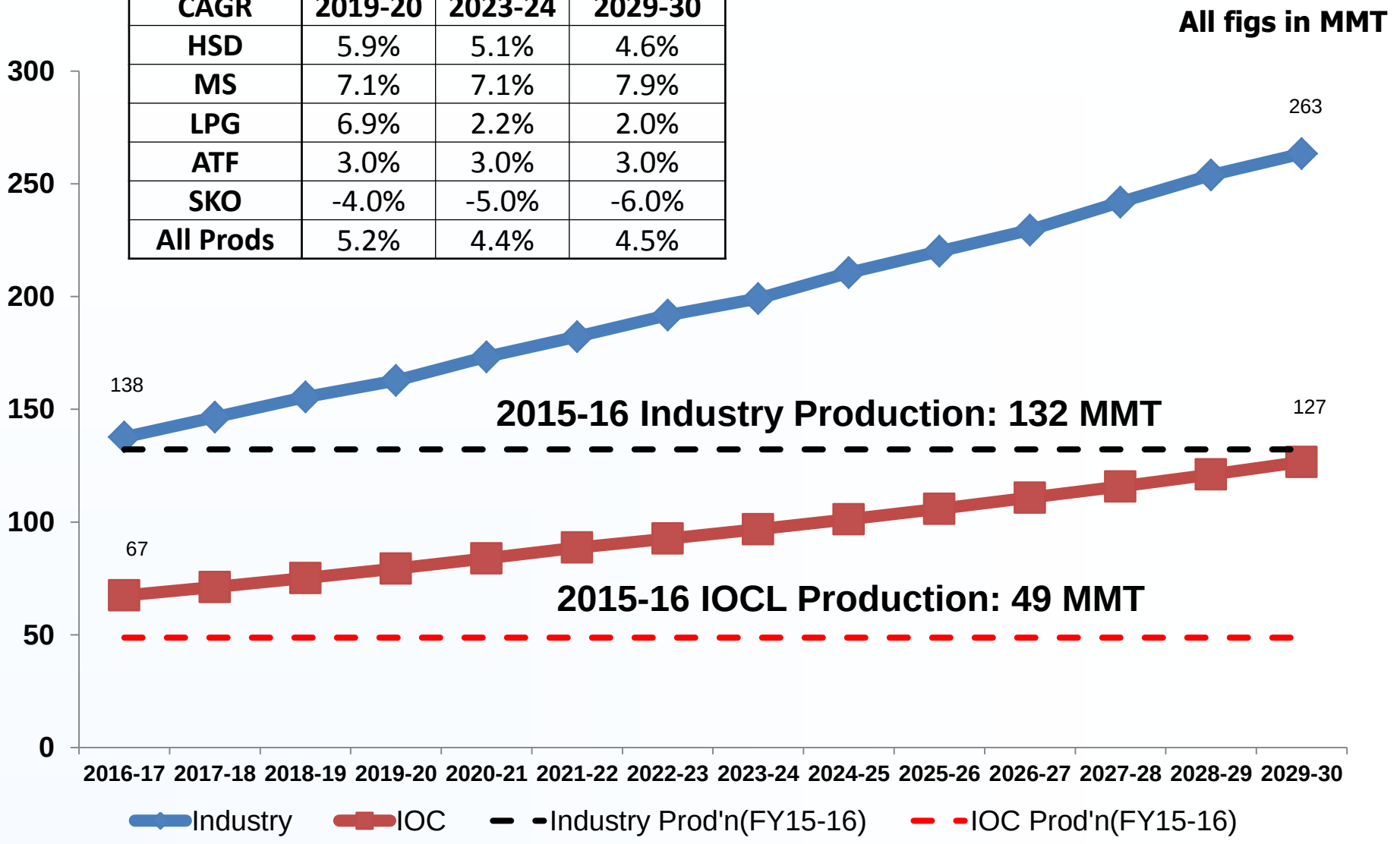
Consumption Trends - India



- **India witnessing a robust gasoline demand**
- **Relatively flat Diesel trajectory being observed for past 4 years**
- **Downward trend in Diesel to Gasoline consumption ratio**

Fuel Matrix: Demand Supply Gap (HSD/MS/LPG/ATF/SKO)

CAGR	2019-20	2023-24	2029-30
HSD	5.9%	5.1%	4.6%
MS	7.1%	7.1%	7.9%
LPG	6.9%	2.2%	2.0%
ATF	3.0%	3.0%	3.0%
SKO	-4.0%	-5.0%	-6.0%
All Prods	5.2%	4.4%	4.5%



Demand projections as per MD data & Production figs as per IOCL/ Industry Data

Chronology of Indian Gasoline Specs.

Fuel Characteristics	India 2000	BS-II 2002	BS –III 2005	BS IV 2010 NCR 2017	BS VI 2020
Density Kg/m3 @15ºC	710-770	710-770	720-775	720-775	720-775
Sulphur Content, ppm	1000	500	150	50	10
RON	88/93	88/93	91/95	91/95	91/95
Motor Octane Number	84 (AKI)	84 (AKI)	81/85	81/85	81/85
RVP, kpa	-	35-60 (35-67)	60(67)	60	67
Olefin Content, %vol	-	-	21	21	21 (18)
Aromatic Content, %vol	-	-	42	35	35
Lead Content, g/l	0.013	0.013	0.005	0.005	0.005
Benzene % vol	3/5	3	1	1	1
Final boiling point deg C	215	215	215	210	210

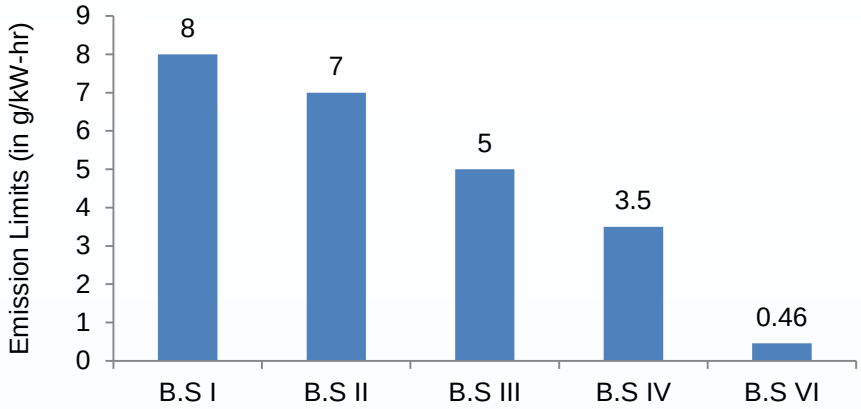
Chronology of Indian Diesel Specs.

Major parameters:	India 2000	BS-II 2002	BS –III 2005	BS IV 2010 NCR 2017	BS VI 2020
Density, kg/m^3	820-860	820-860	820-845	820-845	845 max
Cetane Number, min	48	48	51	51	51
Sulphur,ppm, max	2500	500	350	50	10
Kinematic Viscosity,cst	2.0-5.0	2.0-5.0	2.0-4.5	2.0-4.5	2.0-4.5
PAH, % mass	-	-	11 (max)	11 (max)	8 (max)
Distillation recovery					
85%	350°C	350°C			
95%	-	-	360°C	360°C	360°C

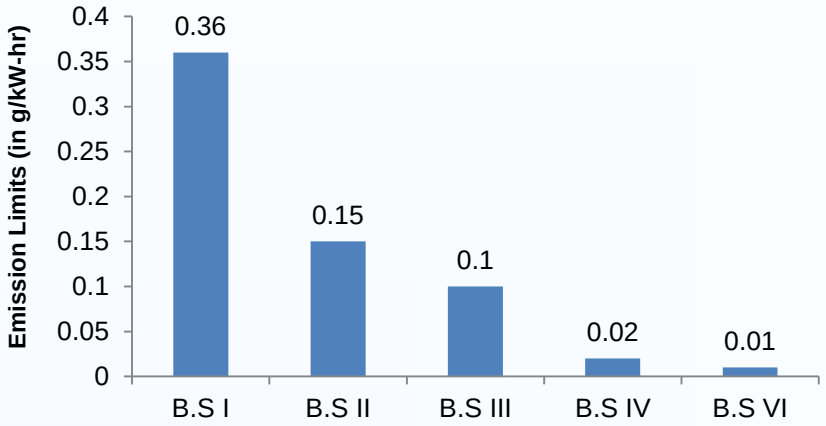
Emission Norms in India

Heavy duty Vehicles

Trends in NOx norms



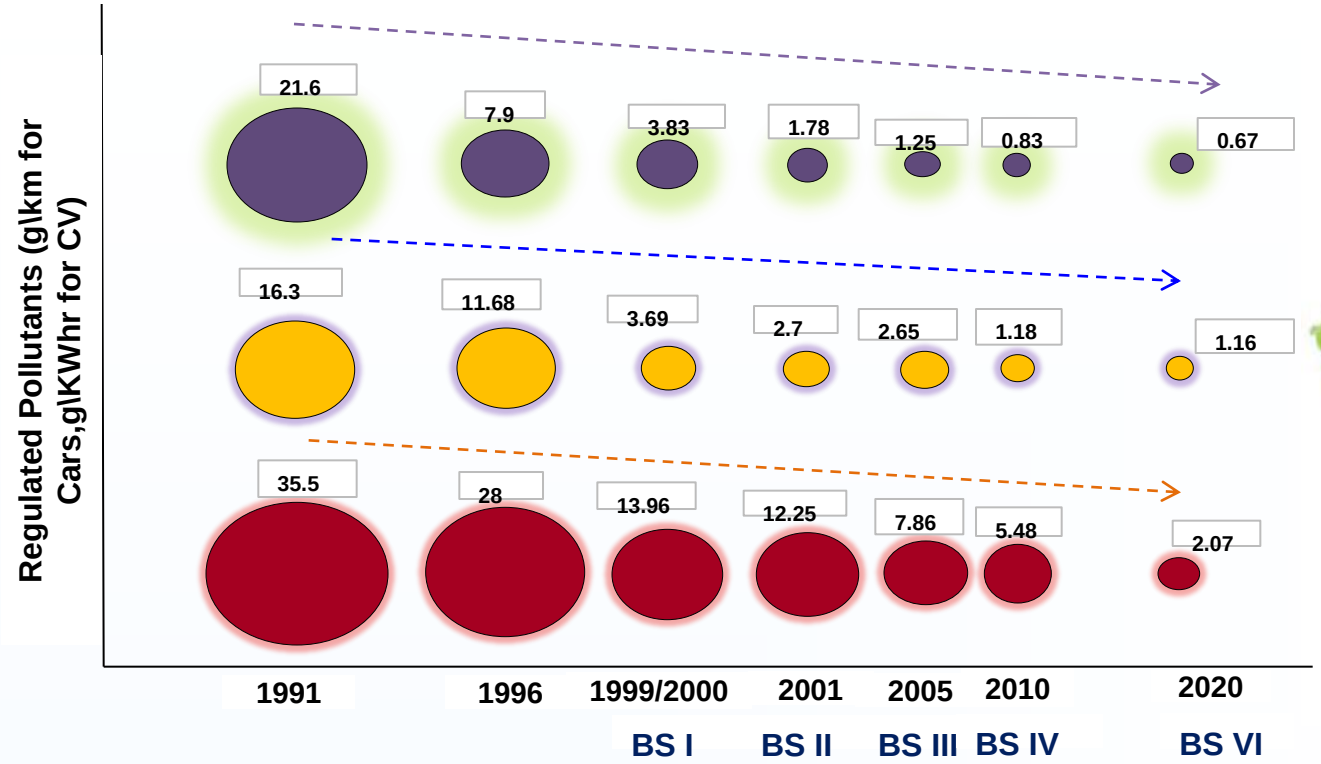
Trends in Particulate Matter Reductions

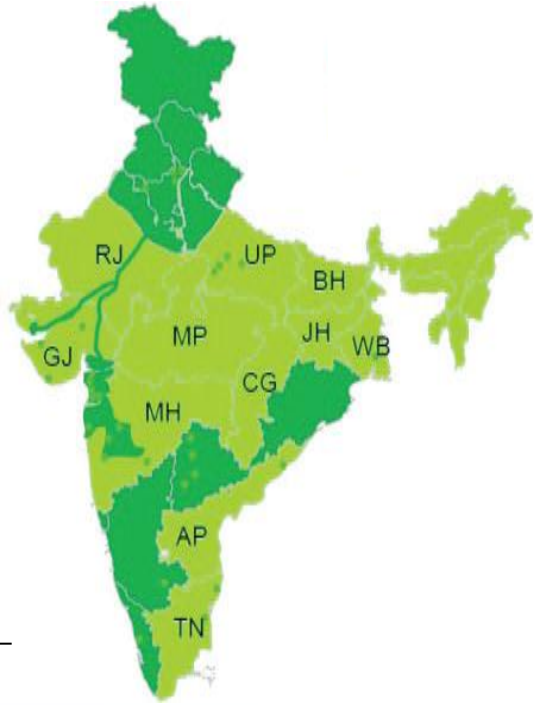


Light Duty Vehicles & 2/3 wheelers

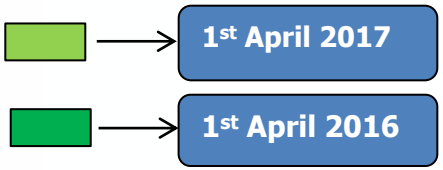
- **BS VI PN concentration for LDVs and HDVs : 6x10^11 p/km**
- **Particle size from 23 nm to be sampled during the testing**

Changing Landscape





BS IV Fuel availability in India

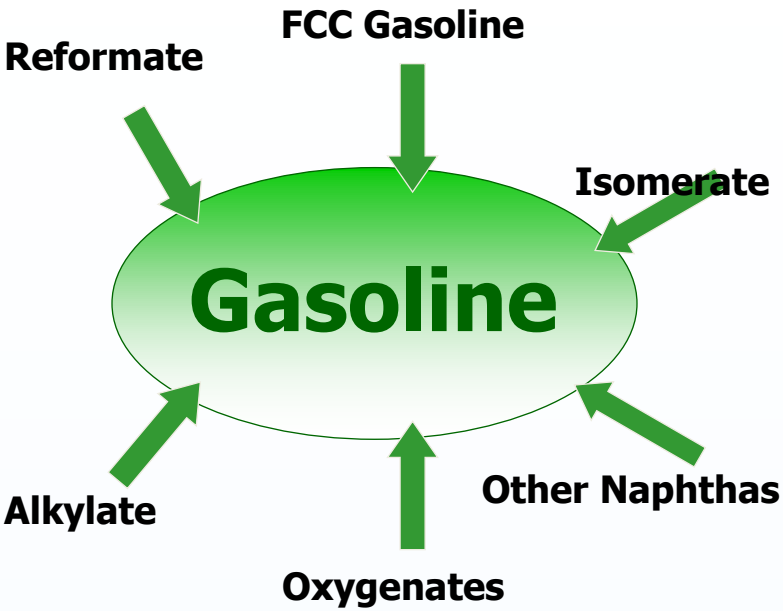


Cars/Light Duty -Diesel	Cars- Gasoline	Commercial Vehicle
95.7% reduction till BS 4 96.5% reduction till BS 6	92.8% reduction till BS 4 92.9% reduction till BS 6	92.8% reduction till BS 4 92.9% reduction till BS 6

Source: SIAM

A collective investment of Rs 80K Cr from BS III to VI (Rs 30 K Cr alone from BS IV –VI) quality up-gradation by OMCs

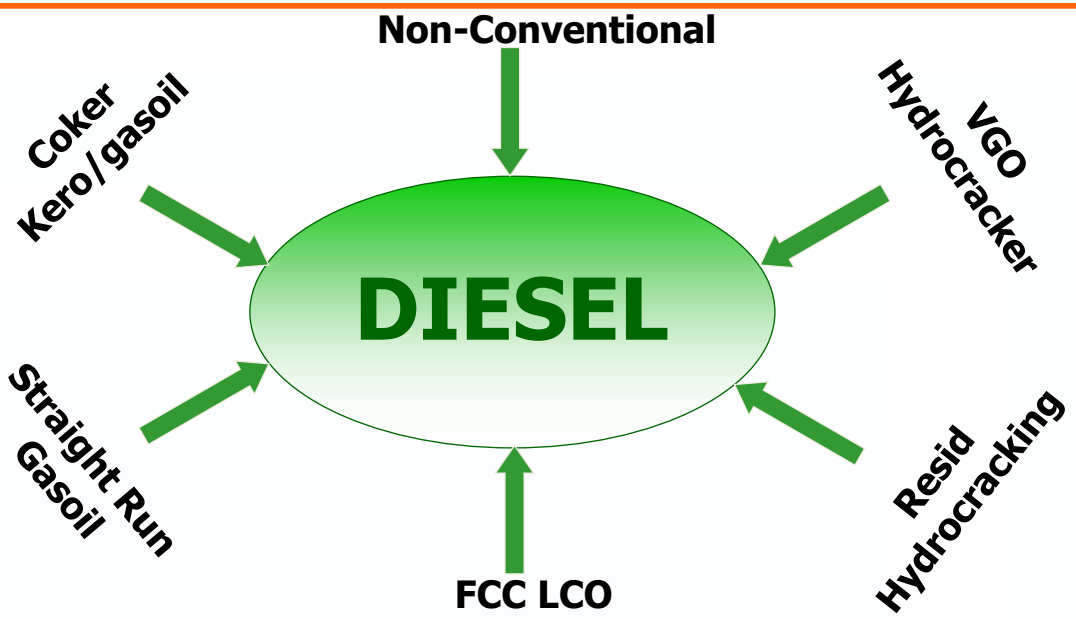
Typical Gasoline Pool



- Gasoline pool constituent varies depending on availability of process/streams
- Each process producing gasoline blending component is important to meet final specifications:
  - Aromatics within limit
  - Olefins within limit
  - Sulfur within limit
  - Desired Octane

Process	Pros	Cons
Catalytic Reforming	• High octane (RON 98-104) • Low RVP • Low sulfur • No olefins	• High aromatics (>70%) and benzene (3-5%)
FCC	• Moderate octane (RON 89-93)	• High sulfur (> 300 ppm) • High olefins (>25%)
Isomerization	• Better octane than LSR (RON 80-93) • Low sulfur, olefins and aromatics	• Higher investment for increasing octane • High RVP (>70 kPa)
Alkylation	• Good octane (90-98) • Low RVP • No olefins and aromatics	• Environmental concerns

Typical Diesel Pool



S No	Process Unit	HSD Component	Characteristics
1	Fludised Catalytic Cracking	TCO	Low Cetane, High Sulphur
2	Crude distillation	SRGO	Crude Specific
3	Hydro Cracking	Gas Oil	High Cetane, Low Sulphur
4	Delayed Coking & Visbreaking	Kero/Gas Oil	Low Cetane, High Sulphur

Refining Technology: IOC's Basket

Commercialized / Demonstrated

- **INDMAX**
- Naphtha isomerization **(Zeosom)**
- DHDT **(indeDiesel)**
- FGH **(indeHex)**
- **indDiesel^{Ren}**
- INDAdept^{G}
- LPG Deasphalting
- Catalysts

Under commercialization

- **Octamax**
- **Removal of sulfur & diolefins (indSelectG)**
- **ATF Hydrotreating (indJet)**
- **IndDSK**
- **IndDSN**
- **IndCoker^{AT}**

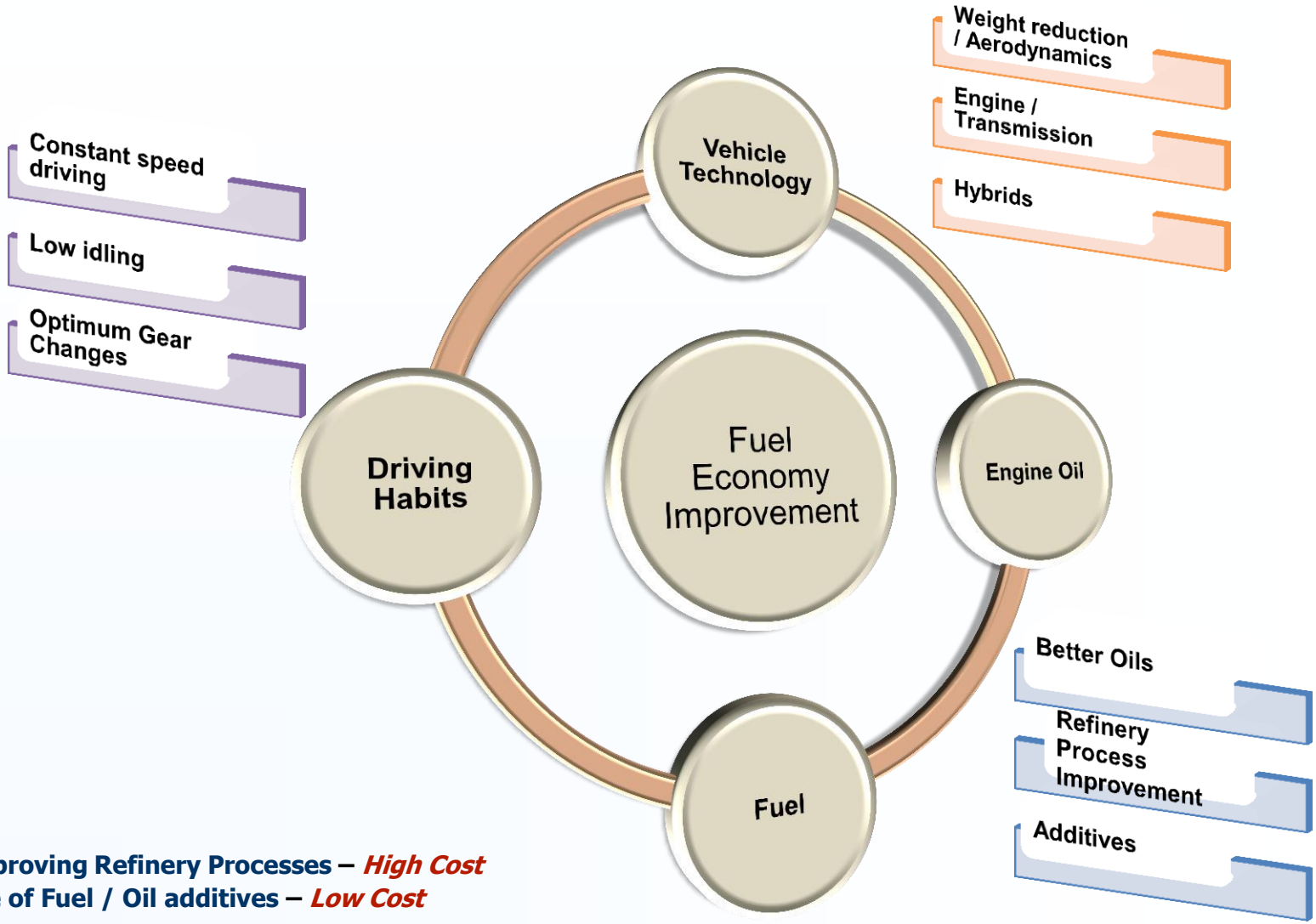
Ready for commercialization

- **INDALIN**
- **INDALIN-Plus**

Under development

- **indPet**
- **indResid^{H}**
- **IndErupt**
- **Membrane Deasphalting**
- **Propane Dehydrogenation**
- **Superior Resid Conversion**
- **CNT production**

Fuel Economy Improvement & Emissions Reduction - Options



Improving Refinery Processes – *High Cost*
Use of Fuel / Oil additives – *Low Cost*

Indian Fuel Economy Legislation

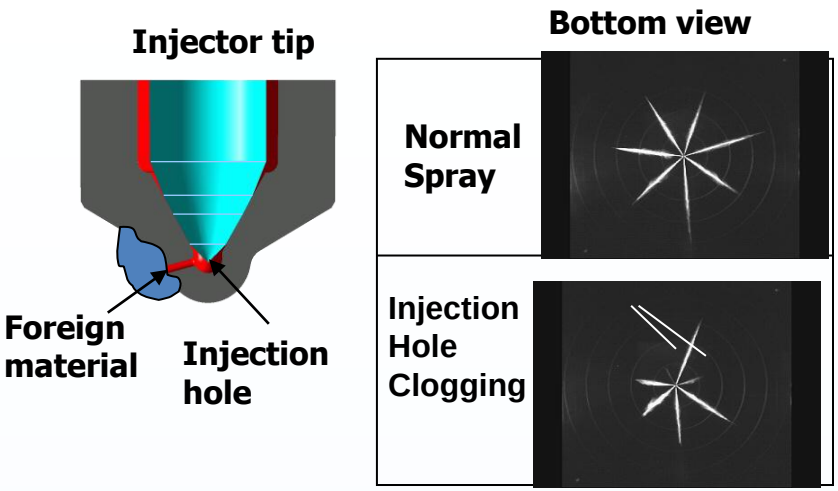
- ✓Notification of Min. of Power, The Gazette of India, Jan 30th, 2014
- ✓*Average Consumption figures of 2009-2010 as base line*
  - ❑*Covers MS,HSD,LPG & CNG*
  - ❑*Applies to - Vehicles GVW< 3500 KG*
    - *Seats 9 max including driver*
- ✓Average CO_2 targets 130 gms/Kms in 2017 and 113 gms/kms by 2022
- ✓*Compliance Started from April 1st 2017*
- ✓Fuel Economy norms for heavy duty/commercial vehicles issued recently by BEE, Ministry of Power
  - •*Limits on constant speed fuel consumption for vehicles with GVW >12 tonnes*
  - • *Compliance from 1st April 2018 covering diesel vehicles of M3 and N3 category*

Fuel Additives

- **Additive is a fine chemical which modifies the characteristic of Refined Petroleum Fractions**
- **Additives Provide economical and easy means**
  - of Improving Performance
  - Controlling quality during production, distribution, and while the product is in use
  - Impart Properties which are not present in the base fuel
  - Extend the life of the machine and expands the range of application

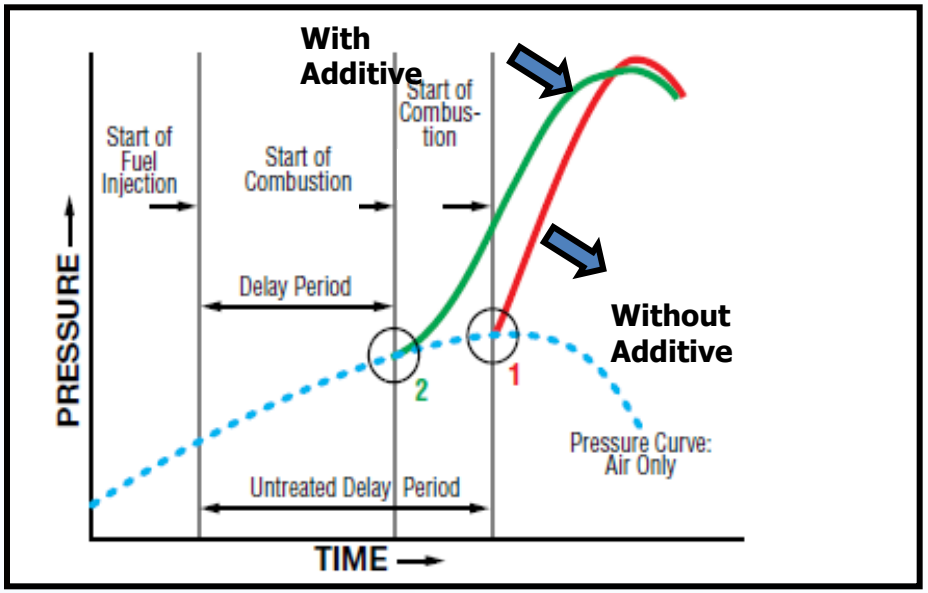
Detergent & Dispersant	Keep the engine clean and sludge in suspension
Antioxidant	Prevents formation of sludge & deposits, slows down the rate of oxidation of the hydrocarbon
Corrosion Inhibitor	Prevents corrosion /rust on ferrous and non ferrous surfaces
Foam Inhibitor	Minimizes foam formation
Lubricity Additive	Improves lubricity and reduces wear
Cetane / Octane Improver	Improves combustion ability

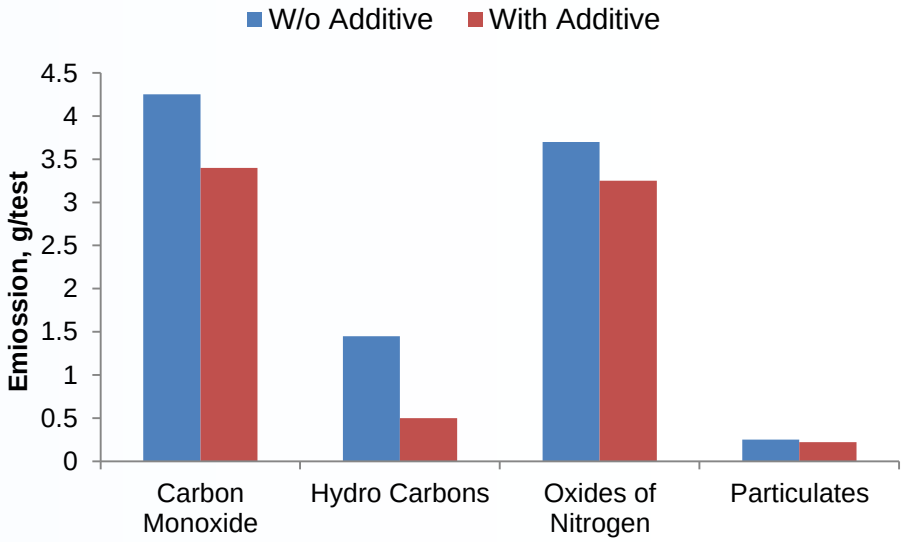
Diesel MFAs



Heavily Scored Injector Pintle with Untreated Fuel

Clean Injector Pintle with additive treated Fuel





Source: Lubrizol

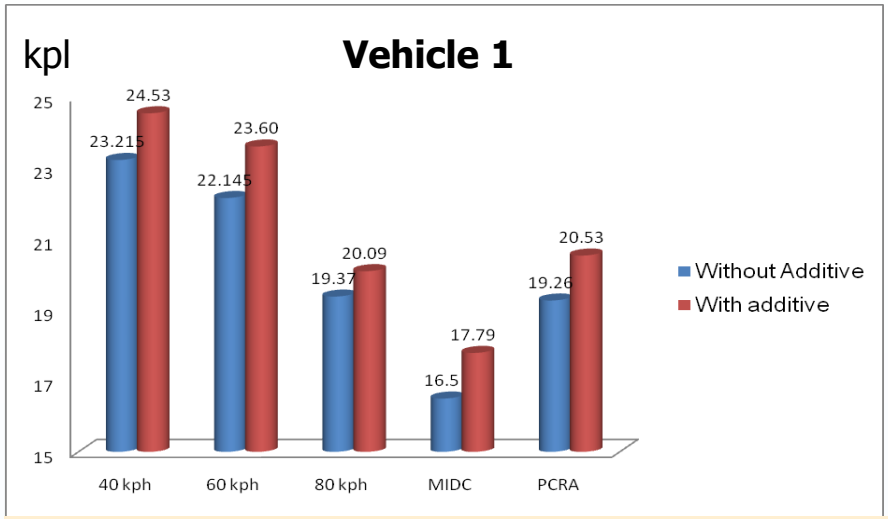
Gasoline MFAs

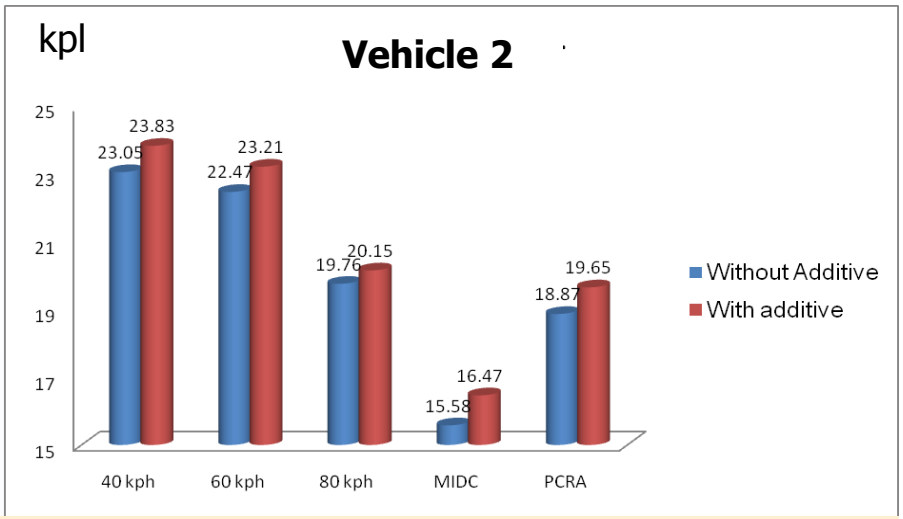
Heavily Scored Inlet Valve with Untreated Fuel

Clean Inlet Valve with additive treated Fuel

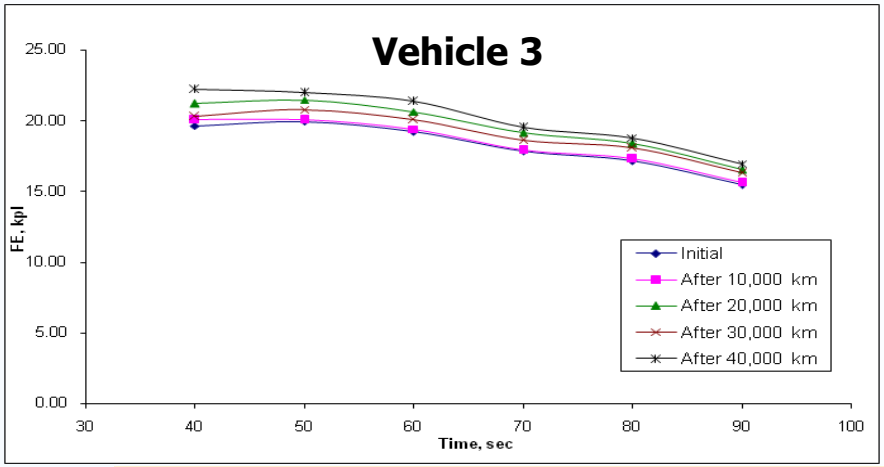
PRODUCT	Treat Level ppm	IVD, mg	CCD, mg	REMARKS
Base Fuel	-	152.7	3421	-
Base Fuel + MFA-1	250	34.0	4300	Good IVD control but higher CCD deposits
Base Fuel + MFA-2	600	7.42	2217	Excellent in IVD & CCD control
Base Fuel + MFA-3	250	2.85	3250	Excellent in IVD & CCD Control

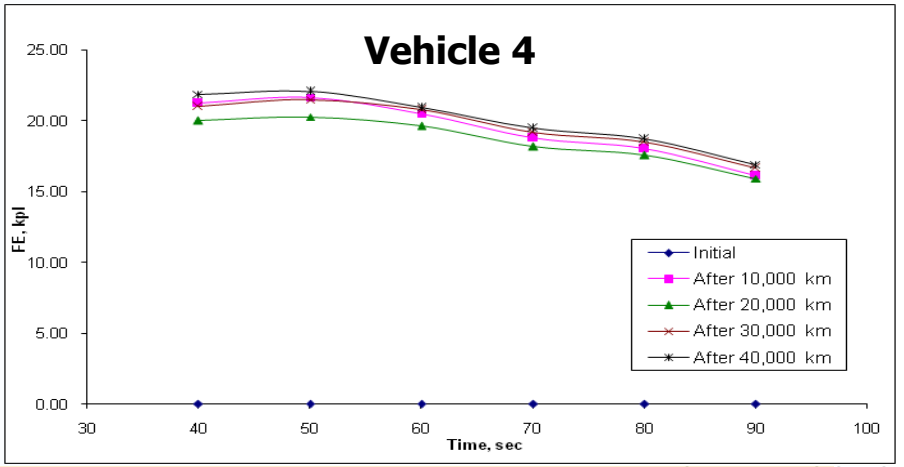
Impact of MFA on Fuel Economy





Both Driving cycle and Constant fuel economy improves by Gasoline MFA





Source: IOC R&D

The effect of MFAs is sustainable

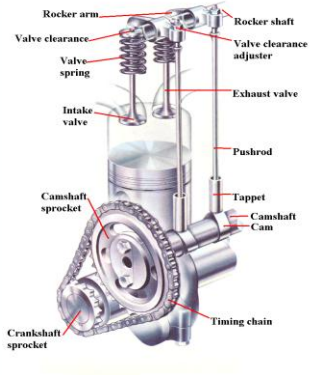
Lubricant Factors Affecting Fuel Economy

Piston & Bearings

- Predominantly operate Hydrodynamic regime
- Reduction of viscous drag from lubricant minimizes friction, leading to fuel economy

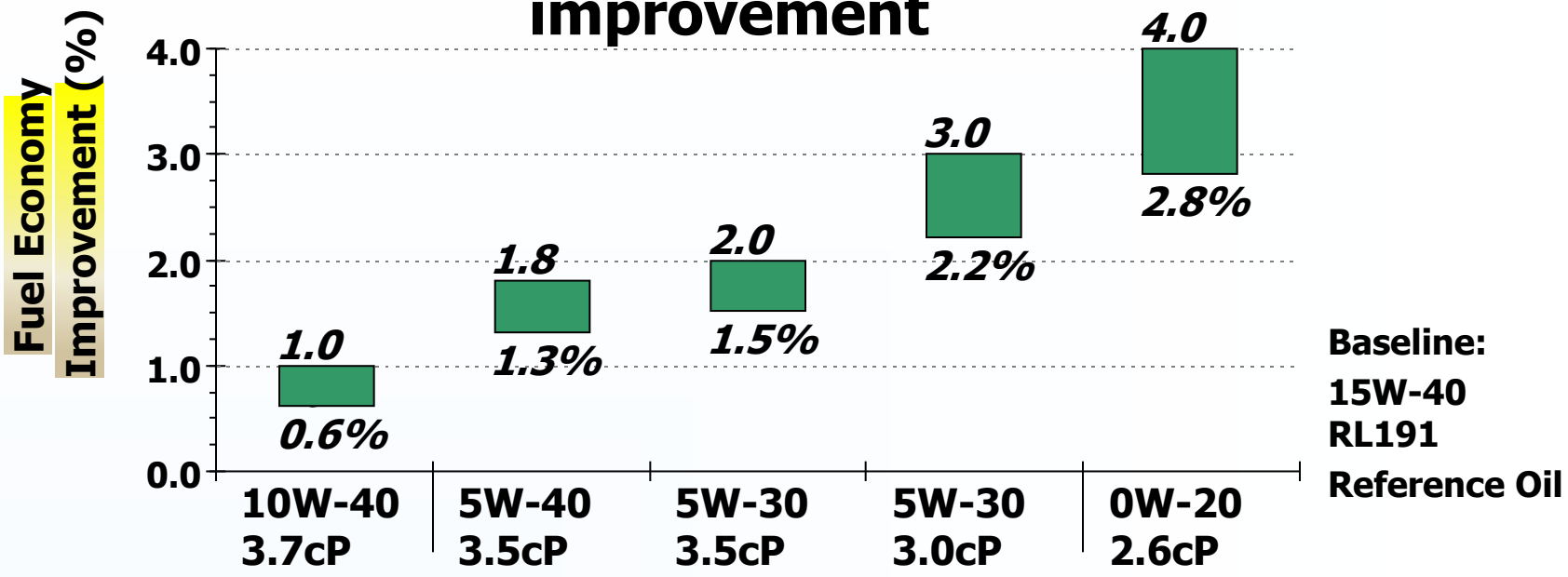
Valve Train

- Operates in mixed or boundary regimes
- A good friction modifier in the lubricant formulation may reduce boundary friction leading to fuel economy



Effect of Viscosity

Typical ranges for M111E fuel economy improvement

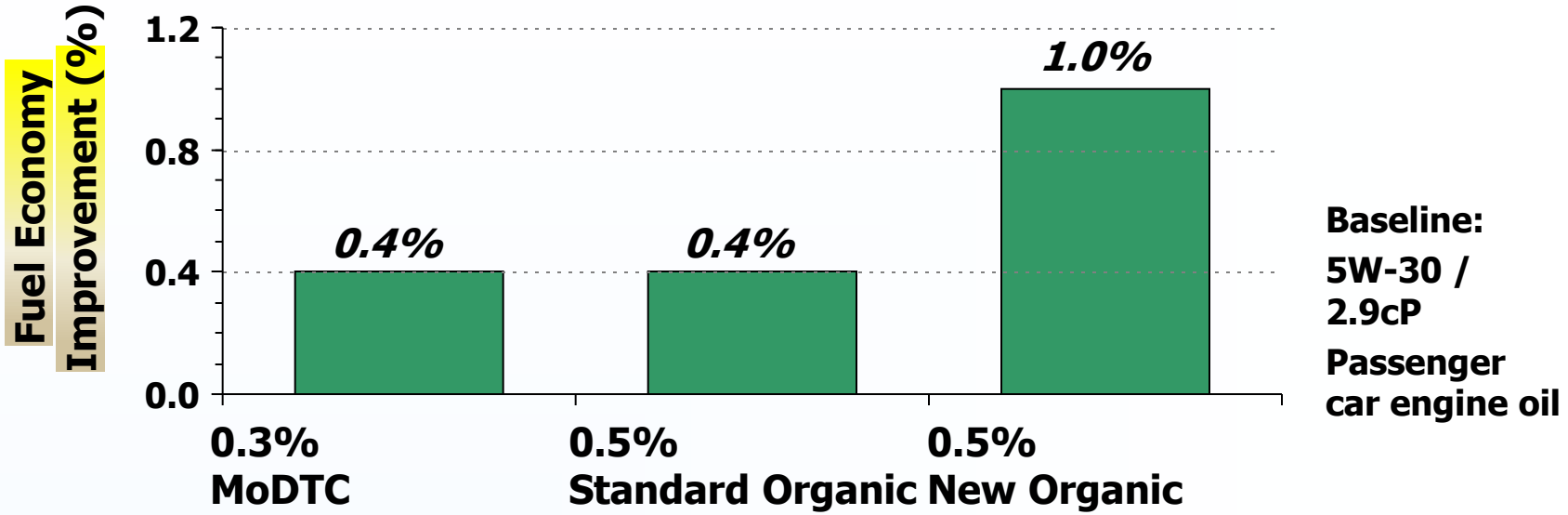


- Viscometrics can affect the level of fuel economy improvement
- Viscometrics are affected by many factors, including high temperature-high shear viscosity (HTHS), kinematic viscosity, shear stability, cold crank viscosity, base oil viscosity index

Source : Lubrizol

Effect of Friction Modifiers

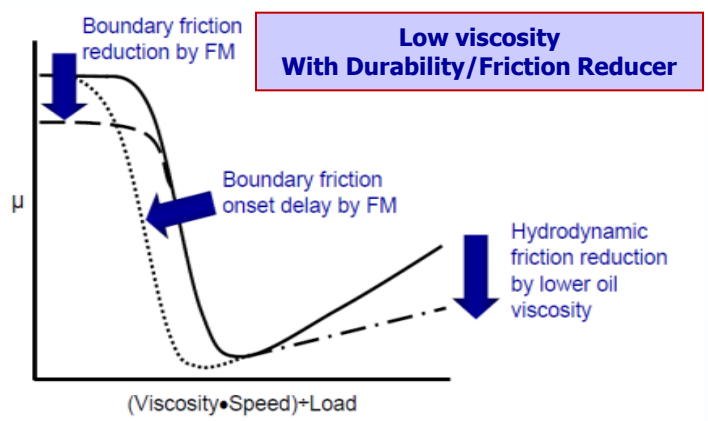
Fuel economy improvement by friction modifier type

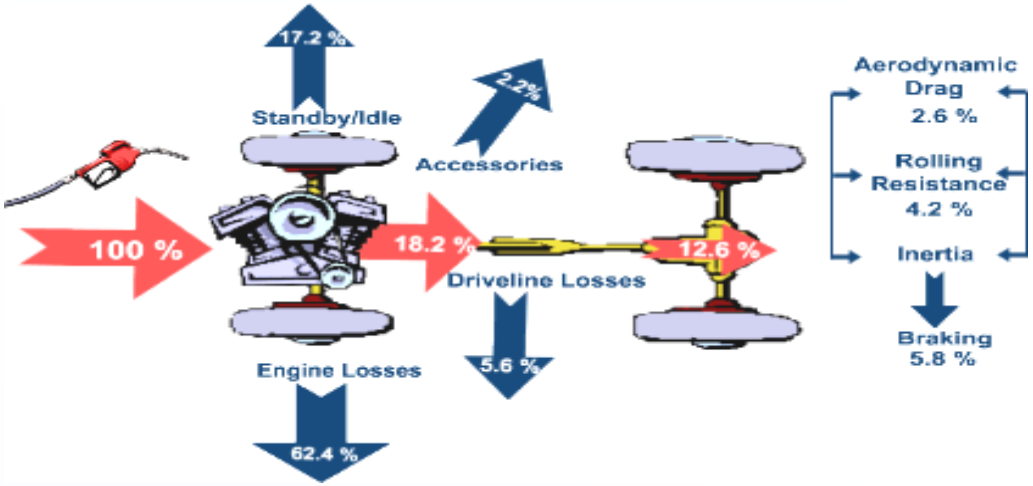


Note : MoDTC is an acronym for molybdenum dithiocarbamate

- Many components affect fuel economy
- Getting the balance of components right is critical to fuel economy
- Friction modifiers do not all perform the same and must be tailored to the rest of the formulation for optimum results

Fuel Efficient Passenger Car Diesel Engine Oil



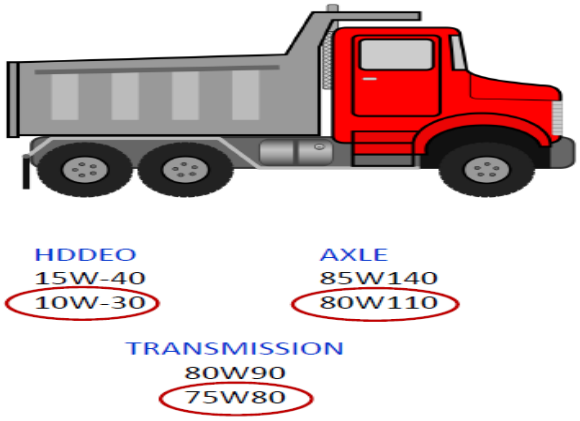


Engine Oils	Fuel Economy (kpl)	% improvement w.r.t 15W40	% improvement w.r.t 5W40
SAE 15W40*	18.85		
A5 / B5 5W40 (Industry Ref.)	19.45	+3.19%	
Candidate A5 / B5 5W30 w/o FM	19.81	+5.08%	+1.83%
Candidate A5 / B5 5W30 with FM	19.95	+5.86%	+2.58%

Composite Fuel Economy Benefits in Commercial Vehicles

- ✓**Lower Viscosity Grades**
  - **Engine Oil: API CI_4 + 10W-30**
  - **MTF: Dedicated 75W-80**
  - **Axle Oil: Dedicated 80W-110**
- ✓**Huge Benefits to Fleet Operators in Commercial vehicle sector**

Data Generated at IOC R&D 90 KW, BS III/ BSIV, Water cooled, Turbocharged DI Diesel Engine



Test	Type	% Imp. (Engine + Trans. + Axle Oil)*
DBDC Cycle	Cold	4.12
DBDC Cycle	Hot	4.65

Automotive Oils	Viscosity grade	ODI
Engine Oil	CI4 Plus 10W-30	1.5 Lac kms
Transmission oil	75W-80	2.4 Lac kms
Axle Oil	80W-110	2.0 Lac kms

Added Long Drain Potential

Expected Cost benefits to customer	Details	Existing grade	FE grade
	No of vehicles	4000	4000
	Average km/lt	3.5	3.62
	ODI	1 lacs	2 lacs
	Annual cost saving due to fuel only	--	1.3 crore

3.5-4.7 % improvement in FE in OEM fleet*

***Reference Oils : CI4 Plus 15W-40, Transmission oil 80W-90 & Axle Oil 85W-140**

Recap.....

- Fossil fuels to continue as major primary energy source
- Changing product slate – Declining HSD:MS consumption ratio
- Increasing environmental concern
  - ➢ Stringent fuel specifications
- BS VI fuel quality needs major changes and investments in the refineries
- Fuel Economy is going to impact the future technological choices
- R&D interventions would continue in:
  - ✓ Improved energy efficiency (EII) through:
    - ✓ Refinery technologies
    - ✓ Fuel Additives
    - ✓ Energy efficient lubricants

Thank You

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