ADVANCED MOTOR FUELS & LUBRICANTS IN INDIA

IndianOil R&D
The Power of Possibilities

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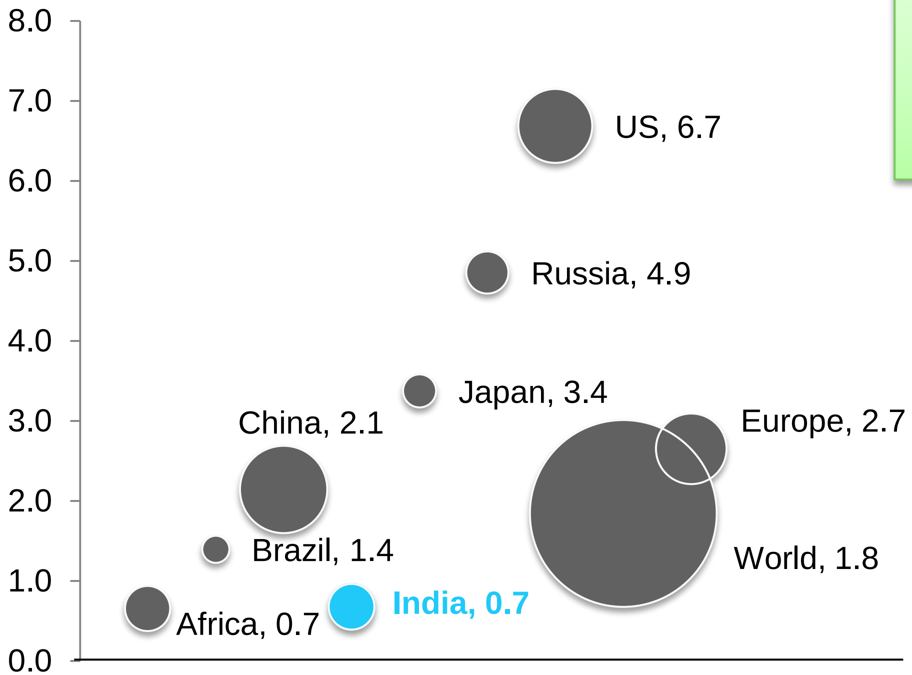
IndianOil R&D The Power of Possibilities

INDIA: Energy Overview

- 3rd Largest Energy Consumer
- 3rd largest oil consumer & oil importer in the world
- 2nd Largest Coal Consumer, 3rd Biggest Producer

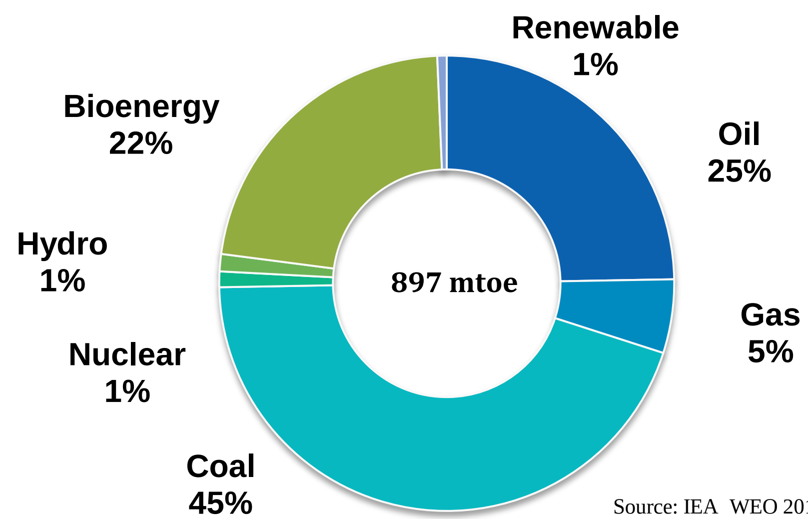
Energy Demand Per Capita (toe/person)



Size of the bubble represents energy demand in 2016

*: IEA WEO 2017, BP Stats 2017, UN Population Data

India's Energy Mix - 2016



Source: IEA WEO 2017

CAGR (2006-2016): 5.7% vs. World Avg of 1.7%
Primary Energy Demand: Doubled from 441 mtoe in 2000 to 897 mtoe in 2016

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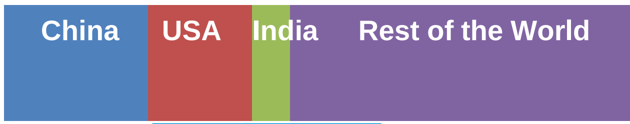
Road Ahead..

2016

India: 3rd largest energy consumer, 6.2% share

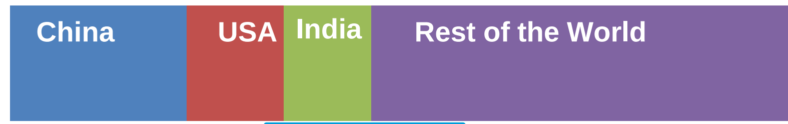


India 2016: 897 Mtoe

World: 13,760 mtoe

2040

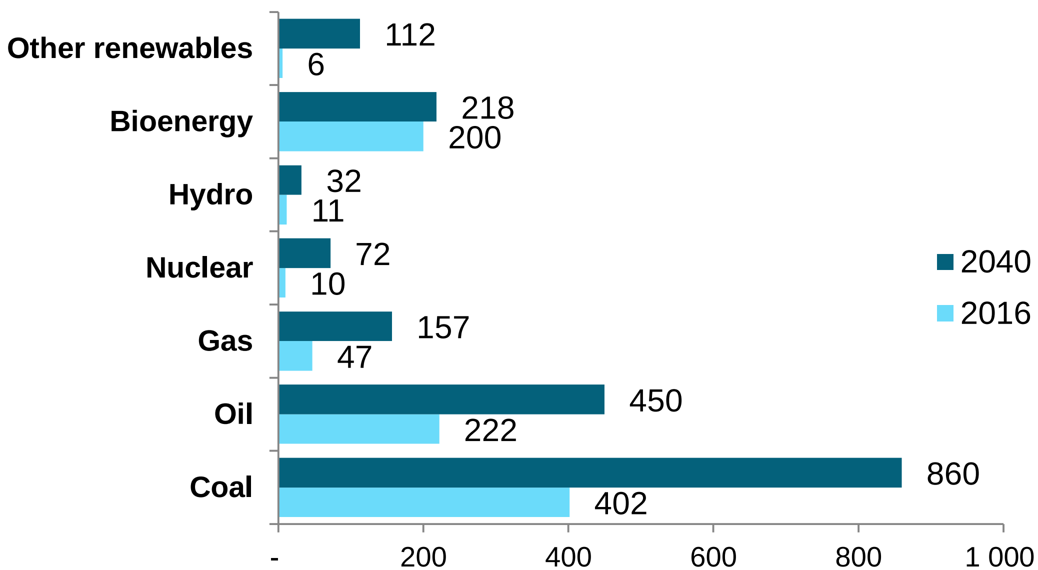
India's Share in global energy demand almost doubles to 11%



India 2040: 1901 Mtoe

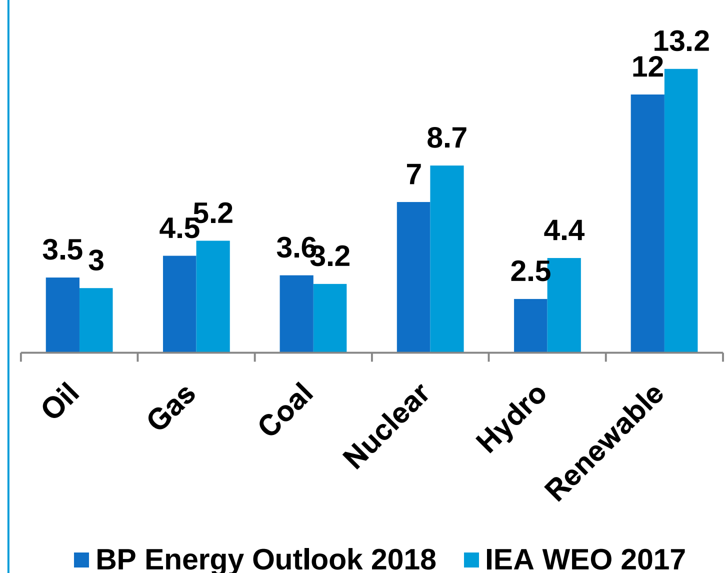
World: 17,866 mtoe

India- Energy Mix (Mtoe)



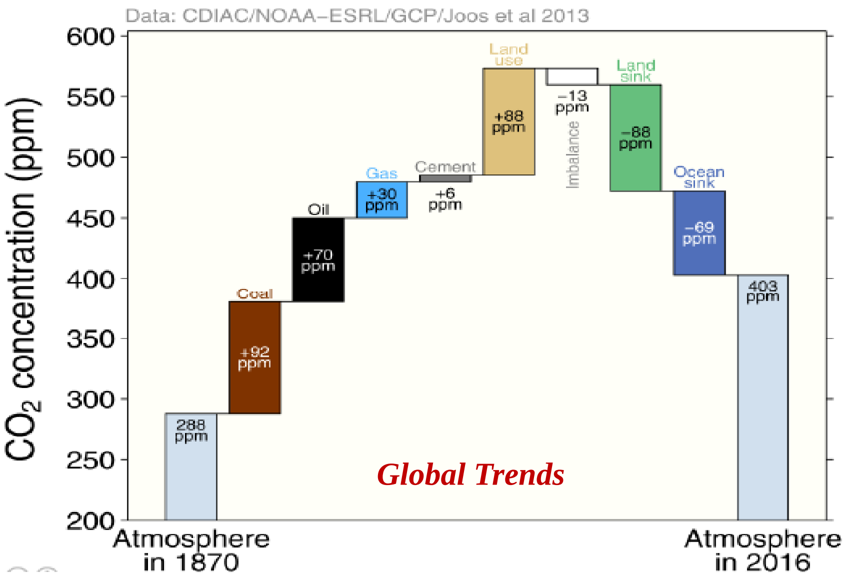
IEA WEO 2017, New Policy Scenario

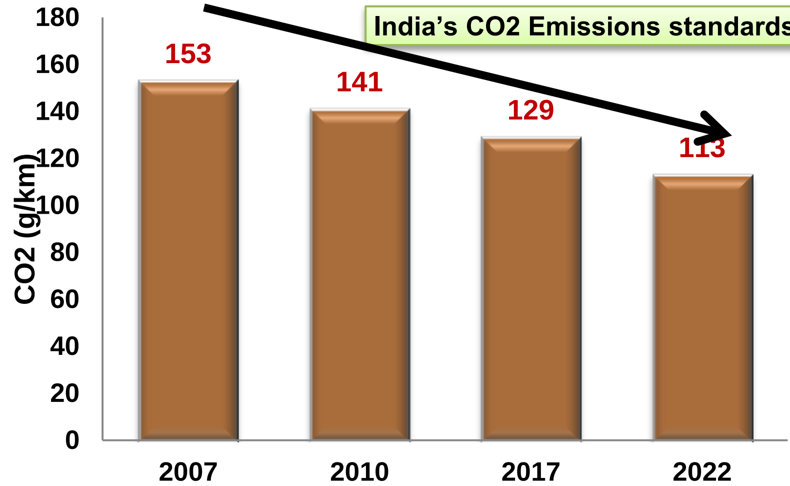
Growth of Fuel Type CAGR (%) 2016-40

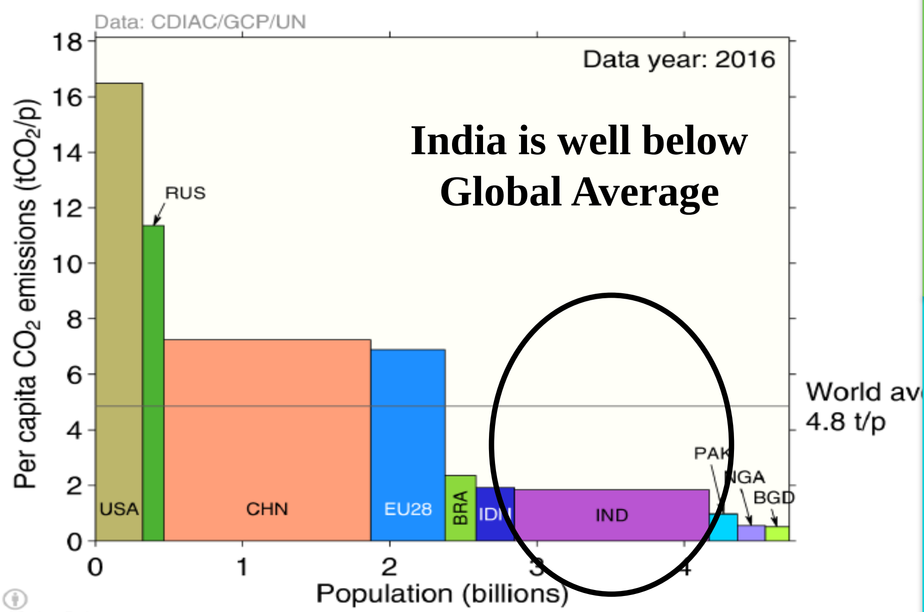


Source: BP Energy Outlook 2018, IEA World Energy Outlook, 2017

CO2 Emissions and FE Norms





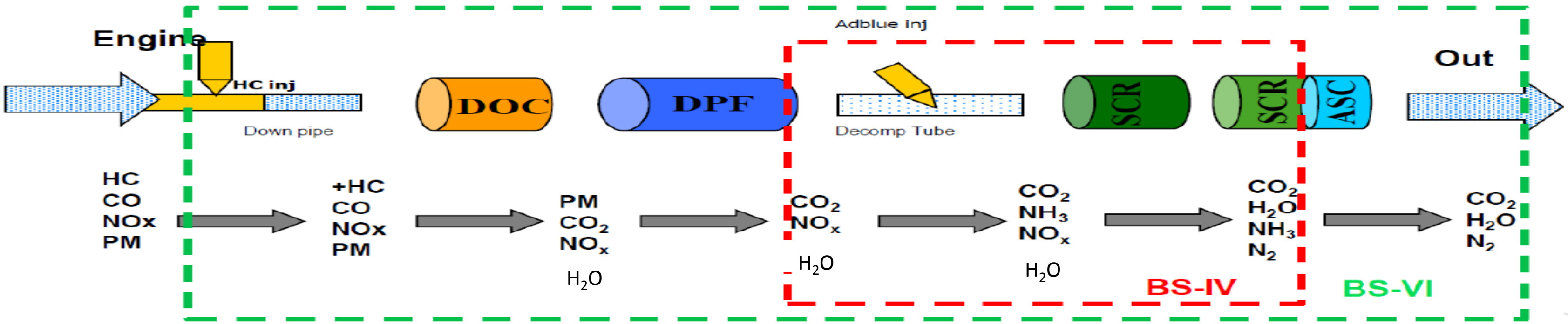


Source: Global Carbon Budget 2017

- ✓ Notification dated Jan 30th, 2014 for **Light Duty Vehicles**
- ✓ *Average Consumption figures of 2009-2010 as base line*
  - ❑ *Covers MS,HSD,LPG & CNG*
  - ❑ *Applies to - Vehicles GVW< 3500 KG / 9 seater (max)*
- ✓ Average CO_2 targets 129 gm/Km in 2017 and 113 gm/km by 2022 - Compliance Started from April 1st 2017

- ✓ Draft notification for Fuel Economy norms for **Heavy duty/commercial vehicles** issued recently by BEE
  - *Limits on constant speed fuel consumption for vehicles with GVW >12 tonnes*
  - *Compliance was proposed from 1st April 2018 covering diesel vehicles of M3 & N3 category - under discussions*

Fuels & Lubricants : Enablers for FE & BS VI Compliance



Fuel Sulphur & Low SAPS Engine Oil is Very Important

Increased emissions | Increased cost and size of after treatment system | **Fuel economy penalty**

Blocks NOx storage sites (NOx traps), increases sulphate particles (DOC, CRT, SCR, cDPF) and desensitization decreases catalytic conversion (DeNox traps, SCR)

Sulphur

After-treatment System

Sulphated Ash

Ash blockage (DPF,CRT)

Raised backpressure on engine and fuel economy penalty cost to manufacture

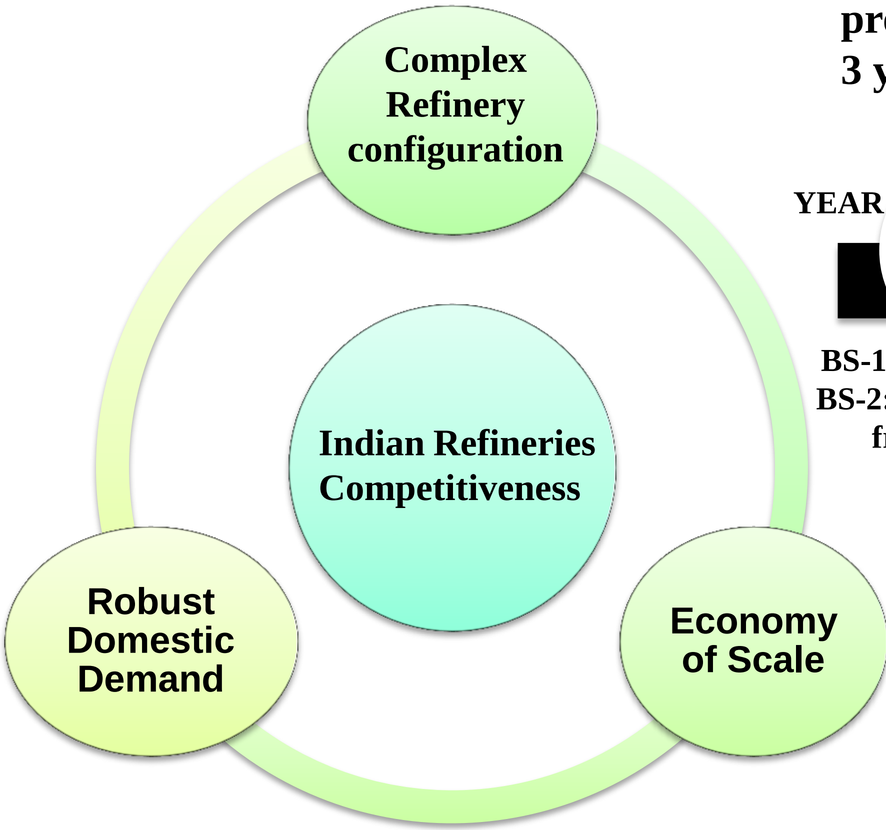
Phosphorus

Deactivation of catalyst

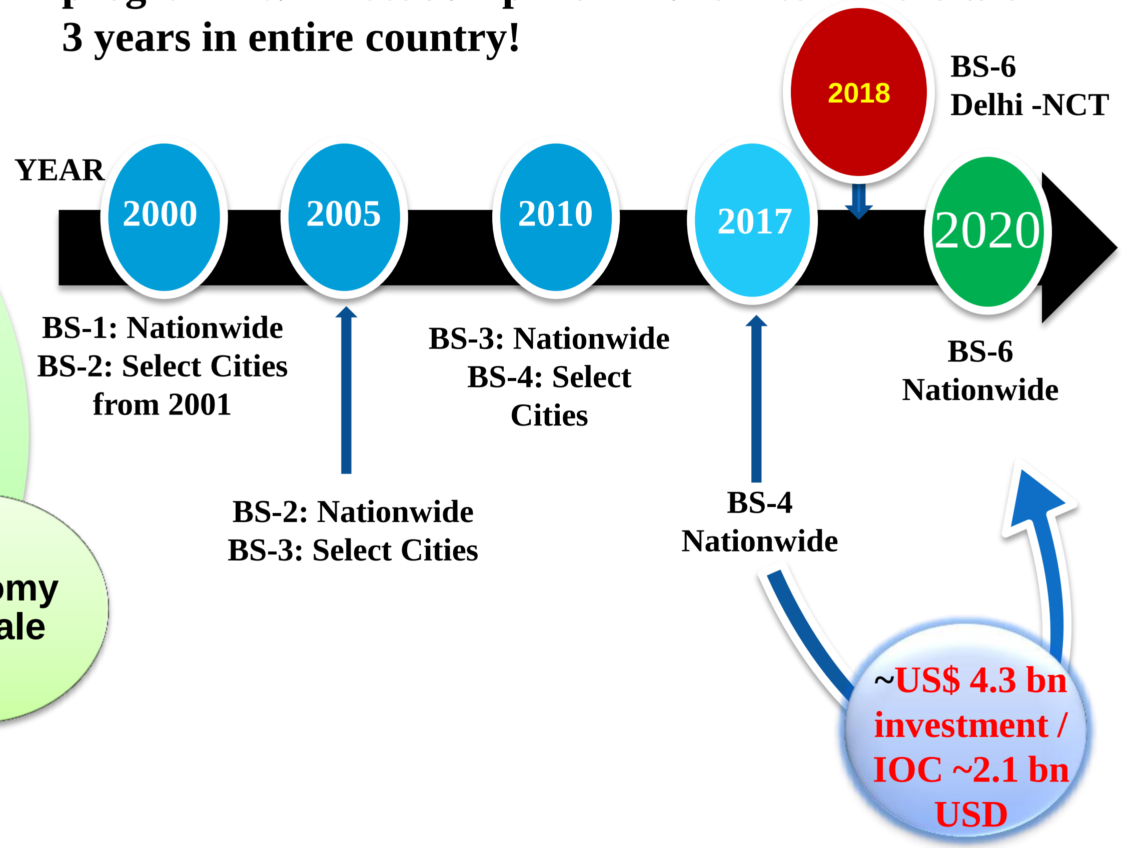
Increased emissions

Source: www.dieselnet.com

Complex Refinery Configuration



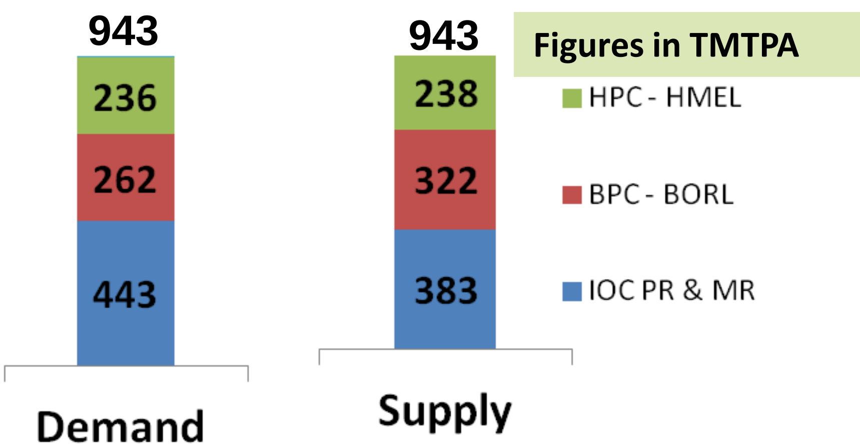
One of most Ambitious Fuel Quality Upgradation programme. Direct Jump from Euro-4 to Euro-6 within 3 years in entire country!



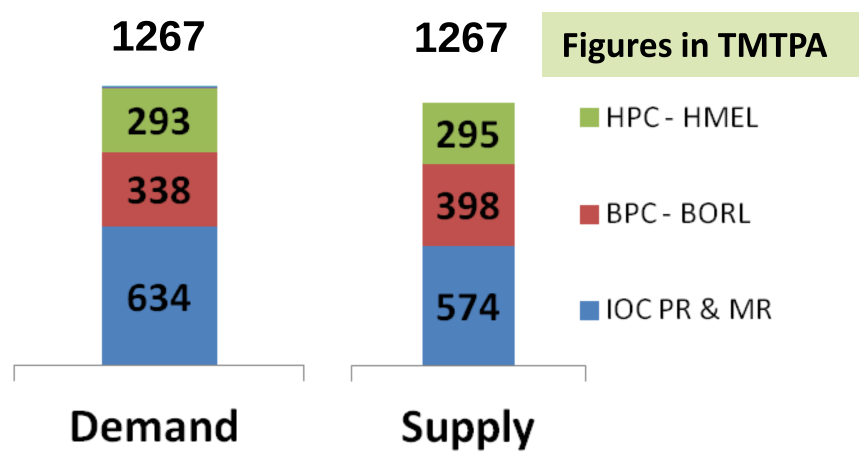
- ✓ **Building complex integrated refineries capable for producing high performance fuels and create flexibility to provide fuels for world market.**
- ✓ **Indian refineries capable to process opportunity crudes (Heavy & High TAN).**
- ✓ **Higher secondary capacity to help in processing cheaper intermediate stocks**

Advancement of BS-VI Fuels in Delhi NCT

MS Projections in NCT for 2018-19



HSD Projections in NCT for 2018-19



BS VI Challenges

- **For supplying 100% BS-VI fuels w.e.f 1.4.2020, facilities to be made ready by Sep'2019 – i.e. 3.5 years time. – Needs upgradation**
- **Space constraints in refineries for add-on infrastructure – requires dismantling of existing facilities to create space for new facilities.**
- **Revamp in existing units requires longer shutdown days – affects unit operation & product availability.**
- **Increases Refinery Opex in view of addl. Power/Utility/Catalyst/ Chemicals, manpower and repair/maintenance cost.**
- **No return on Investment.** For margin improvement, Refiners opt for opportunity crudes. The capacity of existing secondary and treating units becomes inadequate leading to investment.

- **Pan Industry investment of Rs 30, 000 crores for implementation of BS VI projects**
- **Rs 18,000 crores & Rs. 12,000 crores to upgrade Gasoline & Diesel technologies**

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

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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/m³	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

BS VI fuel in BS IV Vehicles

	Vehicle Make and Model	% change in emission with BS VI fuel compared to BS IV fuel					
		CO	HC	NOx	HC+NOx	PM	CO_2
Gasoline	1200 cc PC HB (BS III) – (1,50,000 kms) - MIDC	↓	↓	↓	NA	NA	↔
Gasoline	1200 cc PC HB (BS IV) – (500 kms) - MIDC	↔	↓	↓	NA	NA	↓
Gasoline	150 cc 2W 4T (BS III) – (16,000 kms) - IDC	↔	NA	NA	↔	NA	↓
Diesel	4 L LCV (BS IV) (20,000 kms) - DBDC	↓	↓	↔	NA	↓	↔
Diesel	4 L LCV (BS III) (1,41,400 kms) - DBDC	↑	↑	↔	NA	↓	↔
Diesel	1400 cc PC Sedan (BS IV) (17,000 kms) - MIDC	↓	↓	↓	NA	↓	↔
Diesel	HD 6 L Engine (BS IV) - (New Engine) - ETC	↓	↓	↓	NA	↓	↔

Source: IOC R&D Generated data

Role of MFAs in Fuels

Gasoline MFA

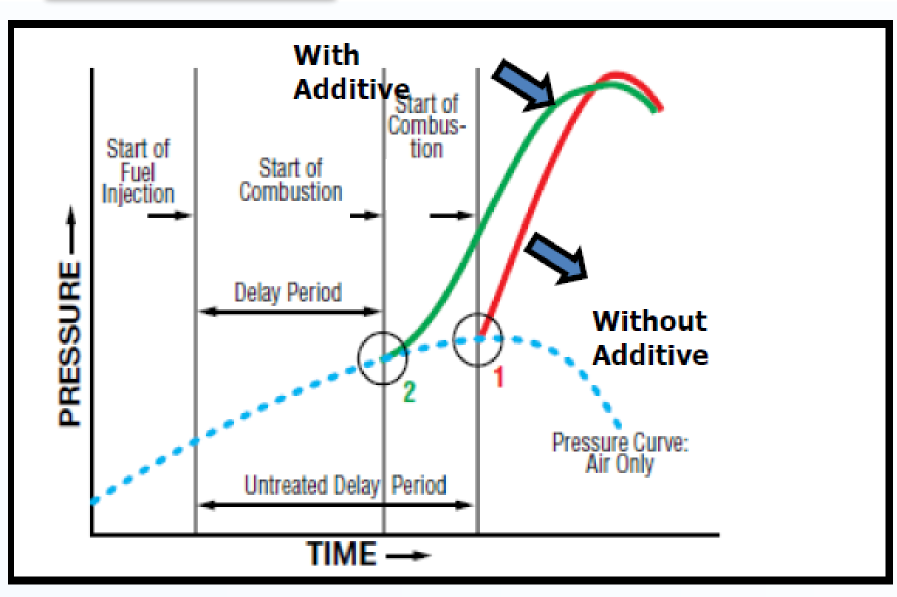
Gasoline without MFAs

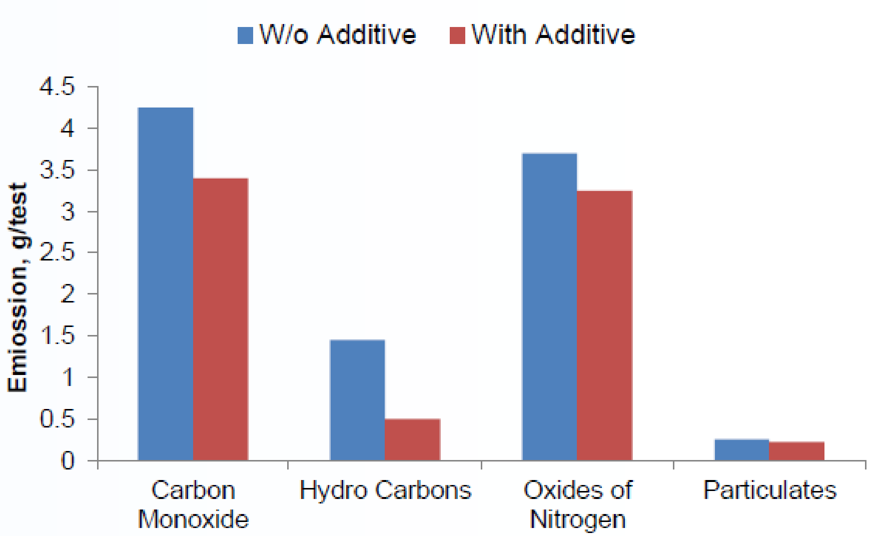
Gasoline with MFA

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

MBM 111 Engine Tests at IOC R&D

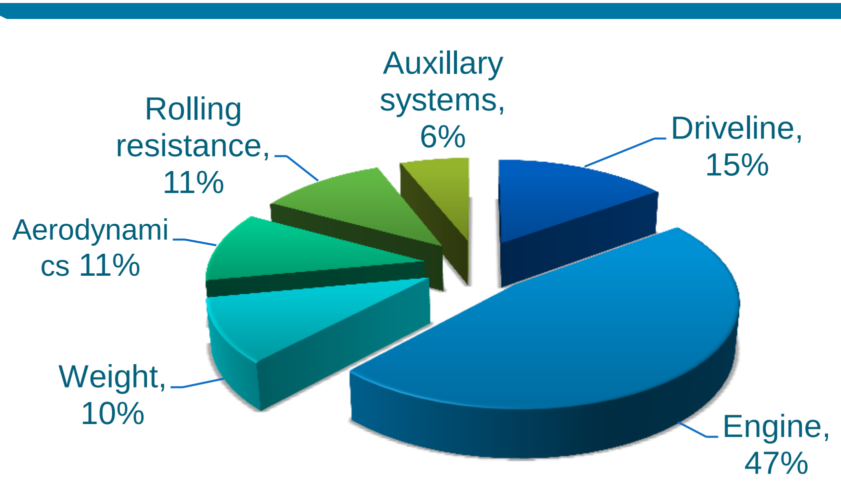
Diesel MFA



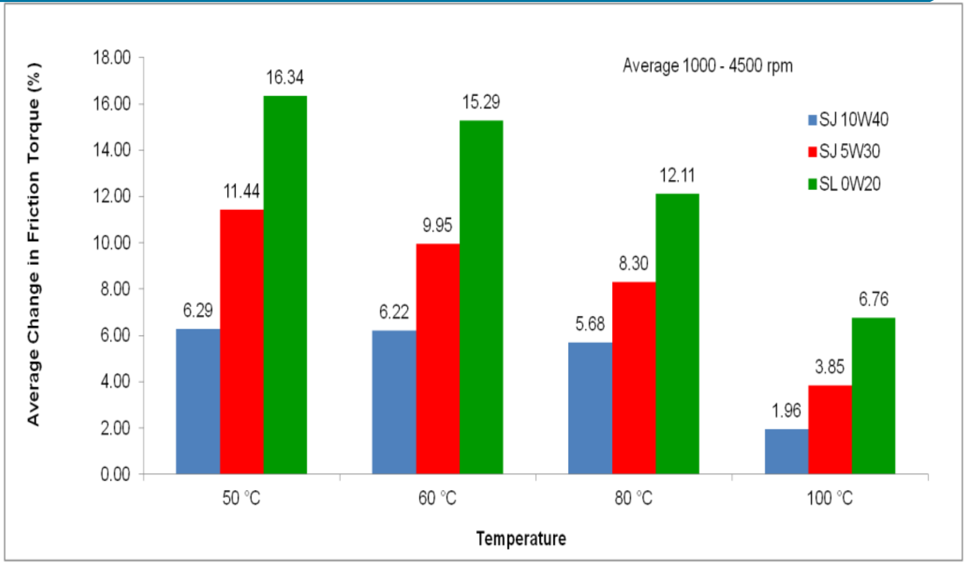


Source: Lubrizol

Fuel Efficiency through Engine Oils



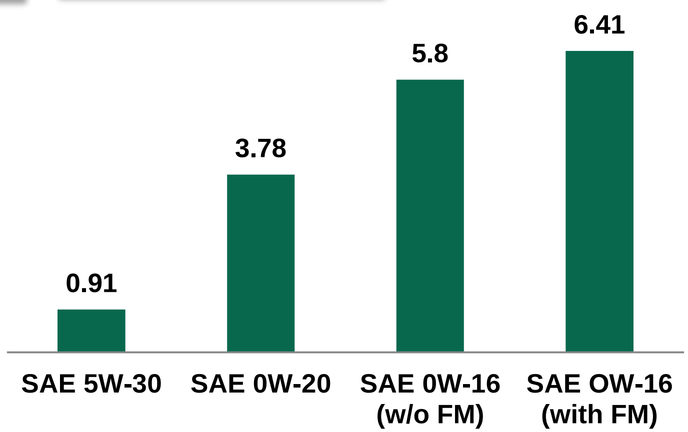
Source: ZF, CTI Innovative Automotive Conference, 2010



Friction Torque Reduction - Motored Torque Test [SAE 15W-40 reference]

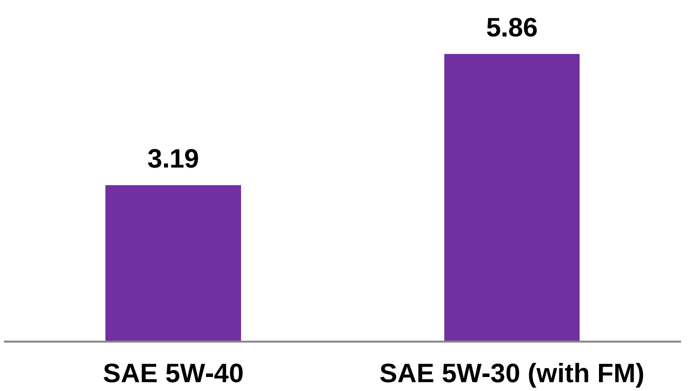
Gasoline

FE % age benefits – Baseline SAE 10W-30



Diesel

***FE %age benefits - Baseline SAE 15W-40**

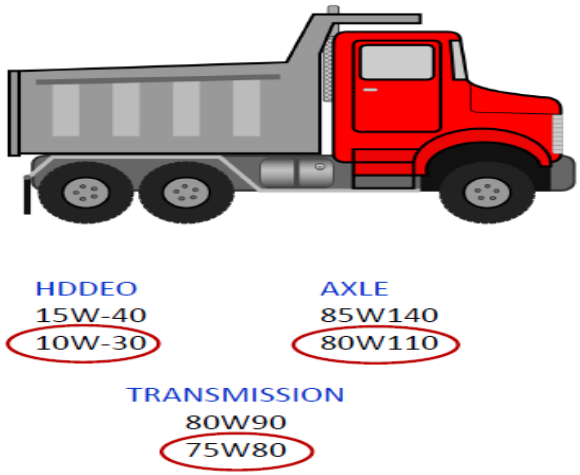


Source: SAE Paper no: 2017-01-2349 – IOC R&D

Composite Fuel Economy Benefits in Commercial Vehicles

- ✓ Lower Viscosity Grades
  - Engine Oil: API CI_4 + 10W-
  - 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



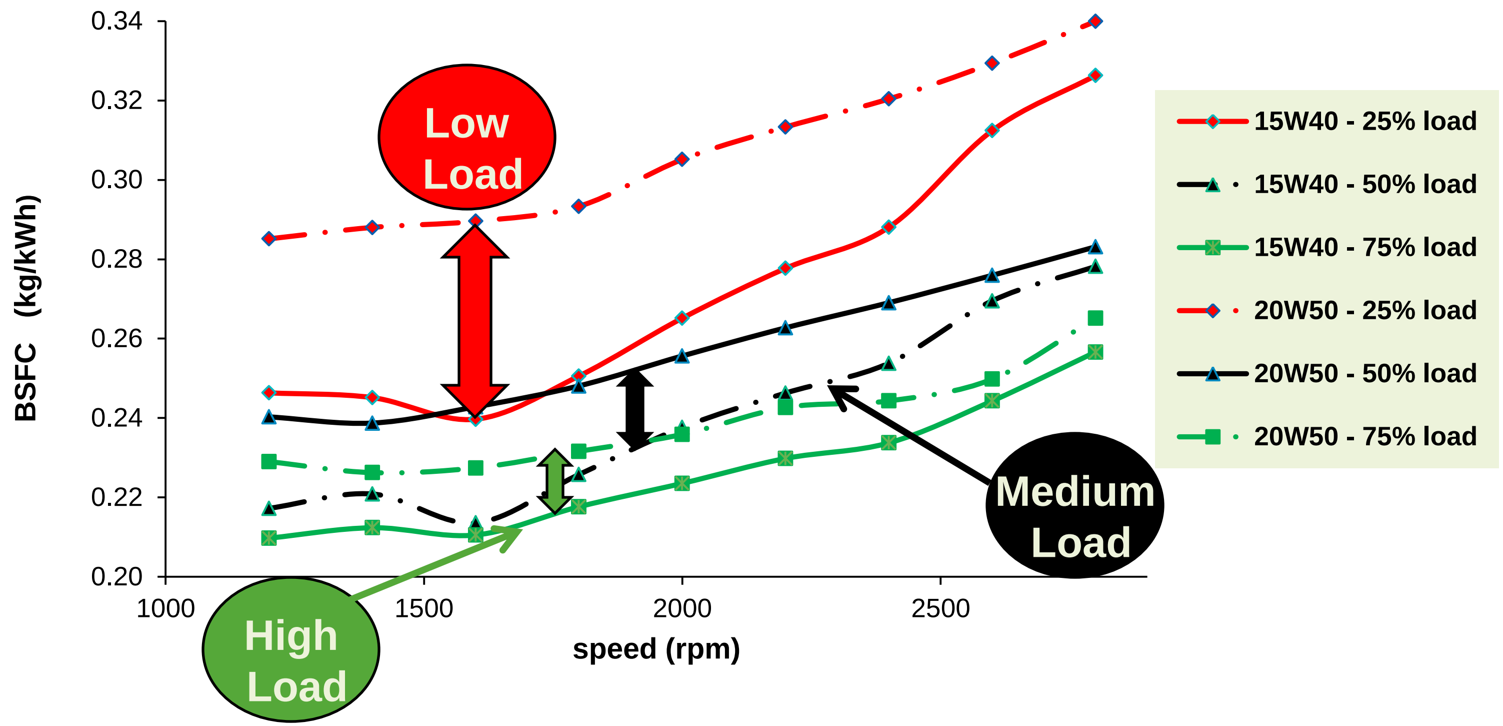
Test	Type	% Imp. (Engine + Trans. + Axle Oil)*
DBDC Cycle	Cold	4.12
DBDC Cycle	Hot	4.65

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

3.5-4.7 % improvement in FE in OEM fleet*

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

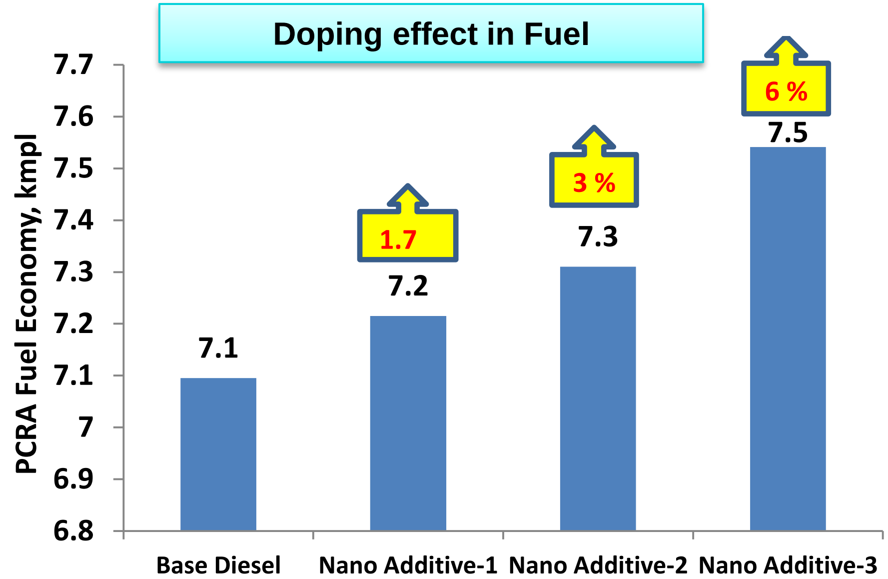
Low viscometric NGEOs



- Study compares BSFC (brake specific fuel consumption) while employing Servo 20W-50 & 15W-40 in a **commercial heavy duty gas engine**.
- Gain in BSFC for **lower viscosmetric oil is found to be more prominent at lower load**
- **Avg. % improvement in BSFC by employing 15W 40 : approx. 7%.**

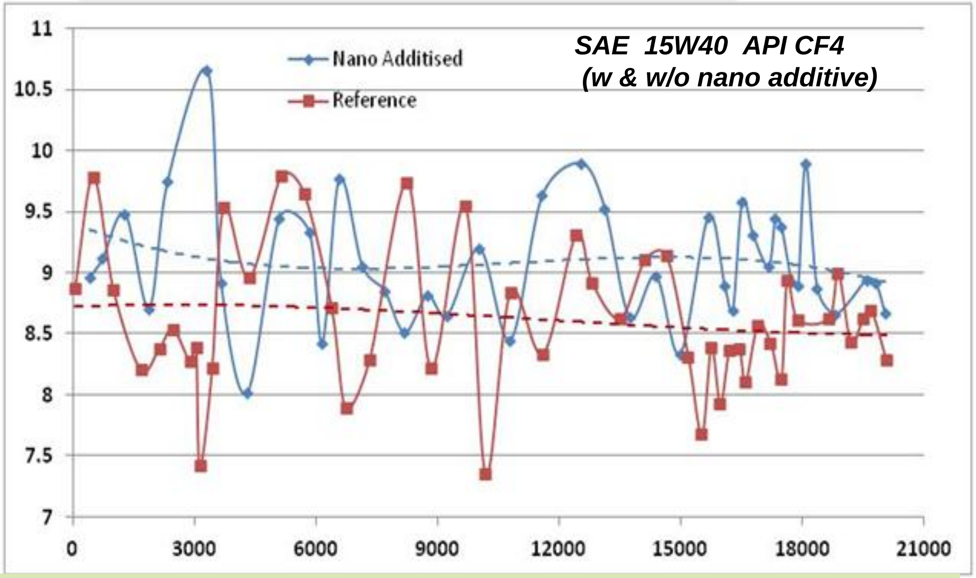
Source: SAE technical paper 2015-01-2041 – IOC (R&D)

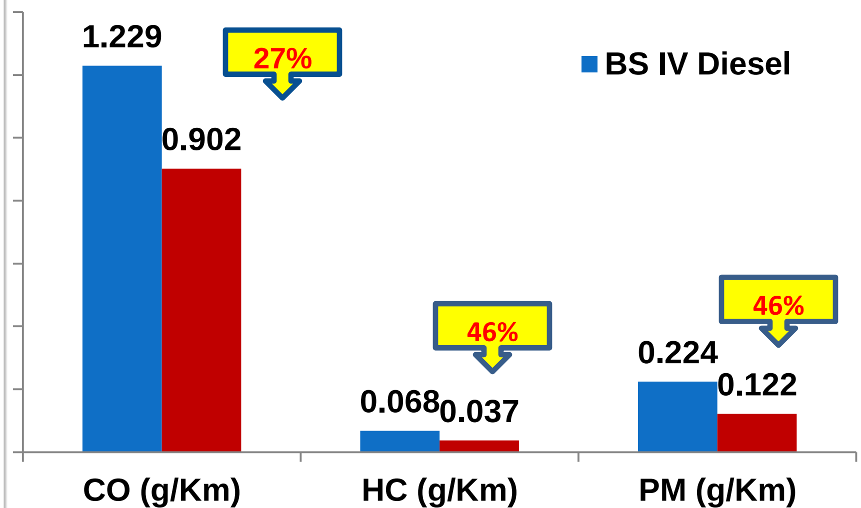
Nano Interventions in Mobility



Fuel Economy of BS III LCV as per PCRA method

Doping effect in Engine Oil





Emission Results over DBDC

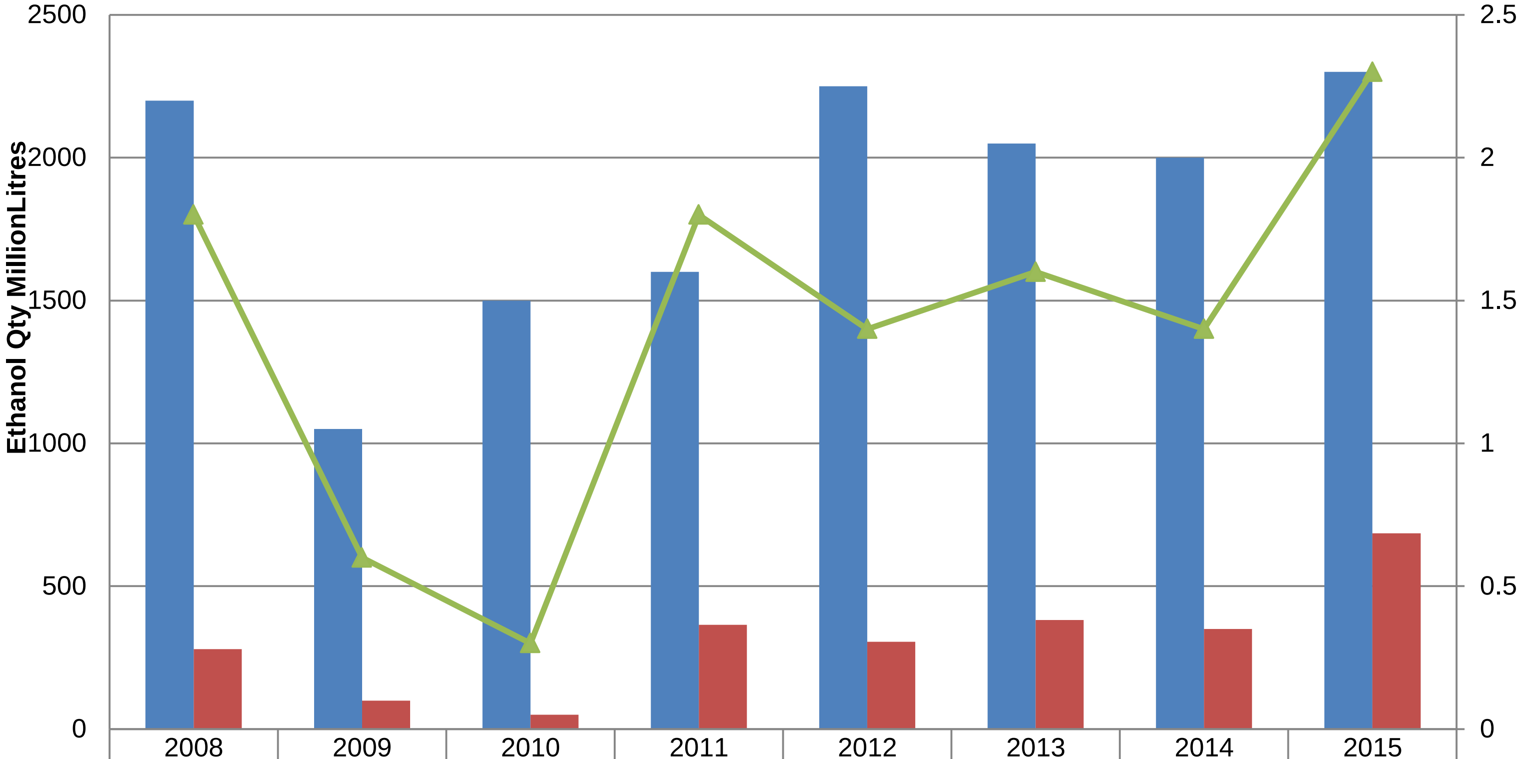
Significant improvement (~3%) in fuel consumption observed

National Bio-fuel Policy-2018

- **Wide scope of Bio-fuel categories**
  - ✓ First Generation (1G) bio-ethanol & biodiesel – New raw materials *(sugar-beet, sweet sorghum, corn, damaged grains etc.)*
  - ✓ Advanced Bio-fuels (high GHG reductions)
    - Lignocelluosic biomass (2G ethanol) – Abundant availability in India
    - Non-food crops (3 G Biofuels) – Algae based ,
    - Industrial waste & residue streams – CO/CO2 to fuels
    - Drop-in Fuels from biomass , MSW, plastics & industrial waste ,
    - Bio-CNG from food waste, biomass, MSW & sewage water etc
    - Biomass to methanol
    - UCO to Biodiesel
- **Special emphasis on R&D on Bio-fuels**
  - ✓ VGF Scheme , Deferential pricing
  - ✓ Inclusion of Biojet & Biogas/BioCNG
- **Industry working Group working on following agenda**
  - ✓ R&D Bio-fuel Activities to be taken up on priority and timelines
  - ✓ Requirement of Govt. interventions in policy framework
  - ✓ Institutional frame work and Modus Operandi through common platform for all R&D's in bio-fuels

Ethanol Supply and Demand Status

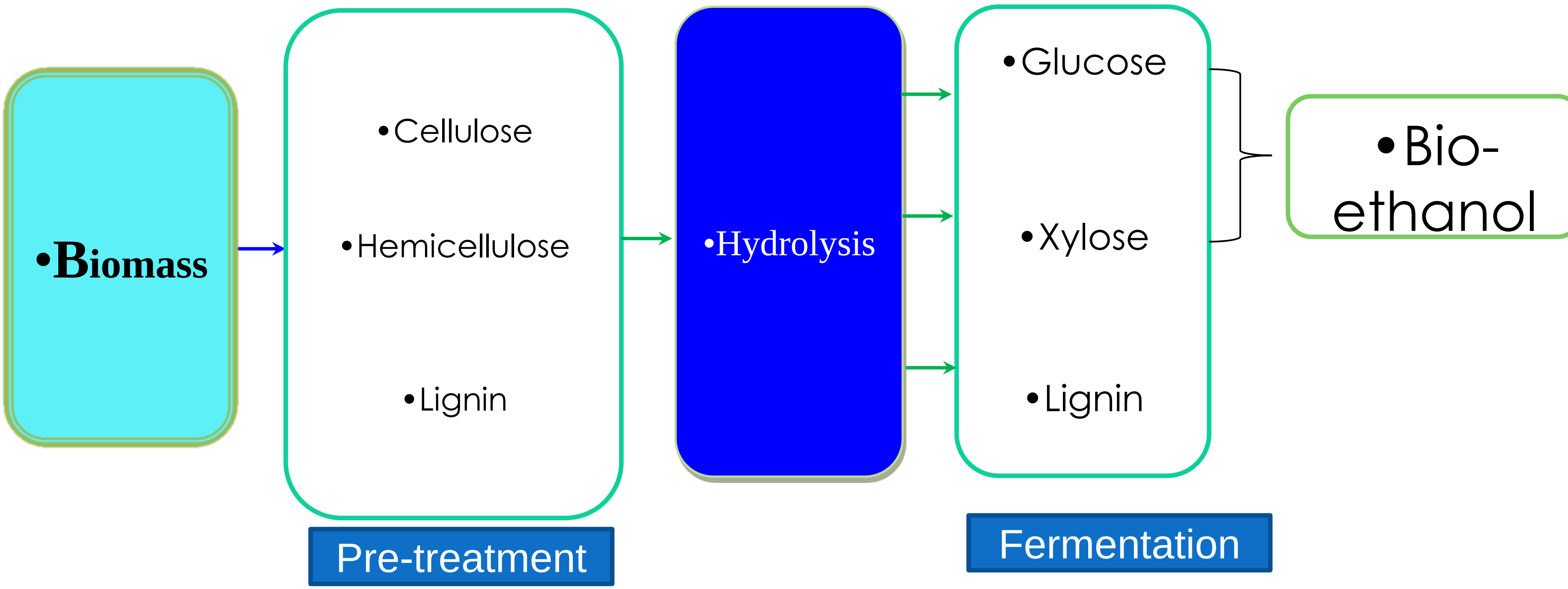
Total Ethanol Production, Fuel Ethanol Consumption and Blending



	2008	2009	2010	2011	2012	2013	2014	2015
production	2200	1050	1500	1600	2250	2050	2000	2300
Consumption as Fuel	280	100	50	365	305	382	350	685
Ethanol blend rate (%)	1.8	0.6	0.3	1.8	1.4	1.6	1.4	2.3

10% Bio-ethanol allowed in India but only 5% is the likely achievement in 2018-19
376 crore litres (~3.76 billion litres) ethanol required in FY 18-19 to meet 10% EBP target

2nd Generation Ethanol



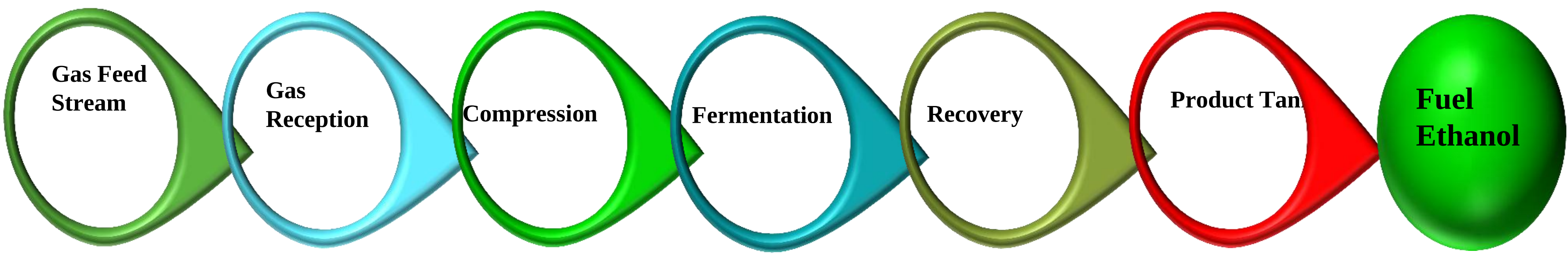
- ***Twelve 2-G ethanol plants being setup by OMCs at various locations***
- ***Indigenization efforts required to establish financial sustainability***

Ref. Off-Gases to Ethanol

• $H_2+CO+CO_2$

• PSA Tail Gas from Refinery / Hydrogen Generation Unit (HGU)

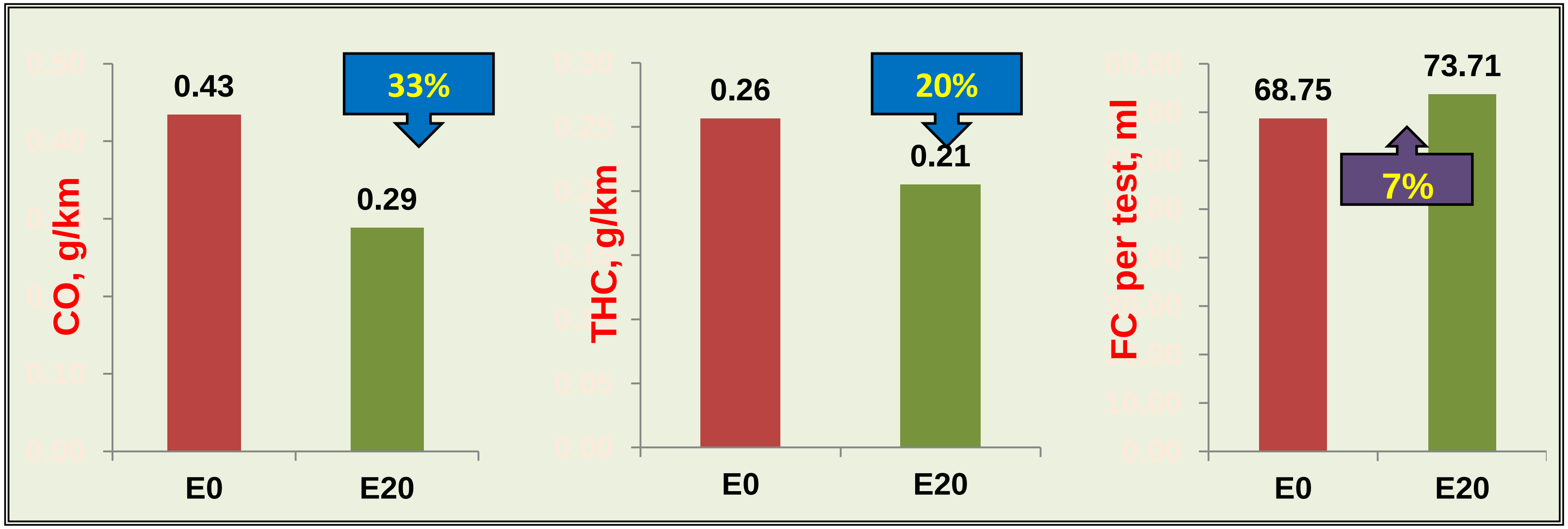
➢ IOC and Lanzatech under agreement to setup World's 1st Demo plant: 33,000 t/annum



IOCL will act as a Global Licensing Partner of M/s Lanzatech for all future plants

Ethanol- Gasoline Blends

Studies on a 150 cc BS III motorcycle with E20 blend



Emissions

Fuel Consumption

10% ethanol blended gasoline evaluation on a fleet of vehicles

- Fuel economy decreased by about 2% (on an average basis) with E10 compared to normal gasoline.
- Decrease in CO & HC emissions were around 15% and 10% respectively
- No significant trend in NOx emissions.

Material Compatibility – E20 blends

ARAI, IIP and IOC R&D conducted studies on E20 blends

- 8 metals tested: no significant change in weight & corrosion rate observed with E20.
- 3 elastomers (SBR, HNBR and Poly-chloroprene) showed better performance, in most properties with E20.
- NBR/PVC and Epichlorohydrin performed inferior as compared to Gasoline.
- Plastics like Acetal, PBT and PA12 behaved similar to Gasoline.
- Performance of one polymer (PA66) was negative with E20

Life Expectancy and Replacement Cost

Name of the Elastomer / Plastic	Fuel system components	% reduction in life expectancy compared to E0 *	Cost of replacement of parts (Rs) **	
			4-Ws/vehicle	2-Ws/vehicle
NBR/PVC Blend	gaskets, O-rings, sleeves, pipes & caps	18	2741	1456
Epichlorohydrin	seals, hoses, gaskets, O-rings & diaphragm	12		
Polyamide-66 (PA 66)	Carburettor, fuel vapour canister	21		

* Values deduced from material compatibility studies with respect to E0 gasoline

** Based on the price list provided by representative 4-wheeler and 2-Wheeler OEMs. The numbers does not include the labour cost.

Methanol as Transport fuel

- China uses M15, M85 & up to M100 as fuel whereas countries like Israel are using M15.
- Europe uses blends of 3-5% Methanol in gasoline.

Fuels	Specific Energy, MJ/kg
Methanol	20-23
Gasoline	46-47
NG	50-52
Coal (Anthracite)	26-27
Ethanol	27-30

Specific energy content of methanol is less than half compared to NG & Gasoline

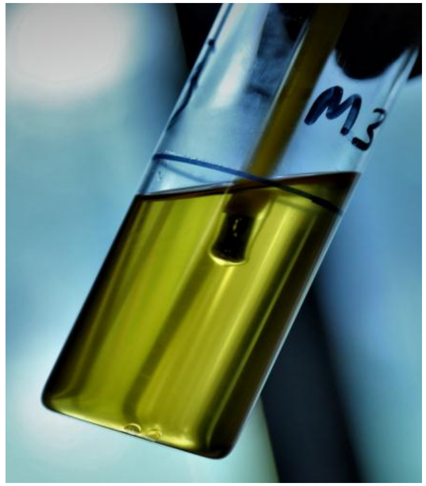
Methanol Requirement for 15% Blend in Gasoline

Indian gasoline consumption : **23 MMTPA for 2016-2017** (Source : PPAC)

Methanol requirement for M15: **3.45 MMTPA (~10000 TPD)**

Methanol-gasoline blends- Phase separation at Low temperature

Gasoline as such at $-10^{0}C$ (moisture –80 ppm) –No Phase separation



M3 at $-10^{0}C$ (moisture-150ppm Phase separation

M 5 at $-10^{0}C$ (moisture- 150ppm
----Phase separation

M15 at $-10^{0}C$ (Moisture-- 600 PPM) --Phase separation

M15 blend+3%CS at $-10^{0}C$ Moisture-- 1200 PPM) - No Phase separation

- **In case of water or moisture being present in methanol gasoline blend this decrease miscibility at low temperature.**
- **In order to overcome this challenge a suitable co-solvent needs to be applied in the right dosage (<u>up to 20% of the actual methanol content).</u>**

Ref.: ACEA Position Paper on Methanol as a Gasoline Blending Component - OCTOBER 2015

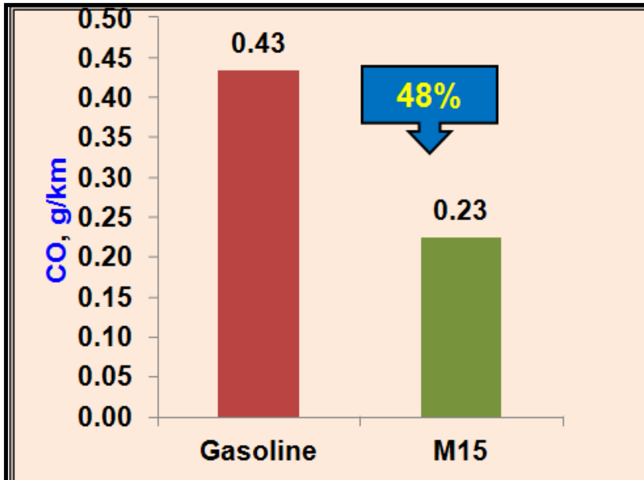
RVP Study: M15 blend with BS IV and BS VI Gasoline

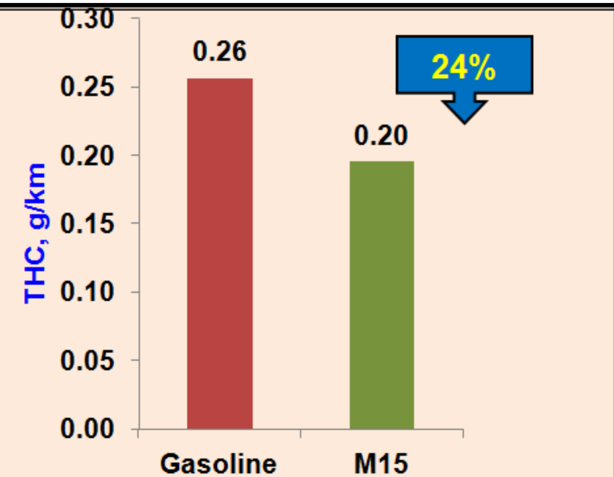
Key Findings

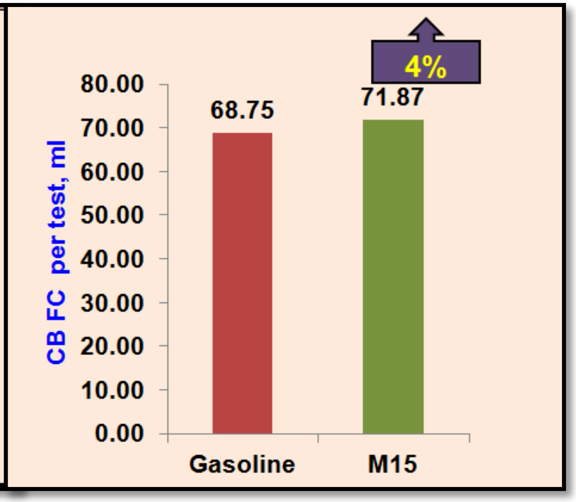
- Irrespective of gasoline grade, methanol blending raise RVP by 20-24 units
- Addition of suitable co-solvent in M15 blends bring RVP closer to acceptable range
- Reduction depends on the RVP of base gasoline and its M15 blend
- Co-solvent essential to enhance the water tolerance and phase stability at low temperature.
- Reduction in RVP of M15 blend by cosolvent is an added advantage

Performance Evaluation of M15 blends

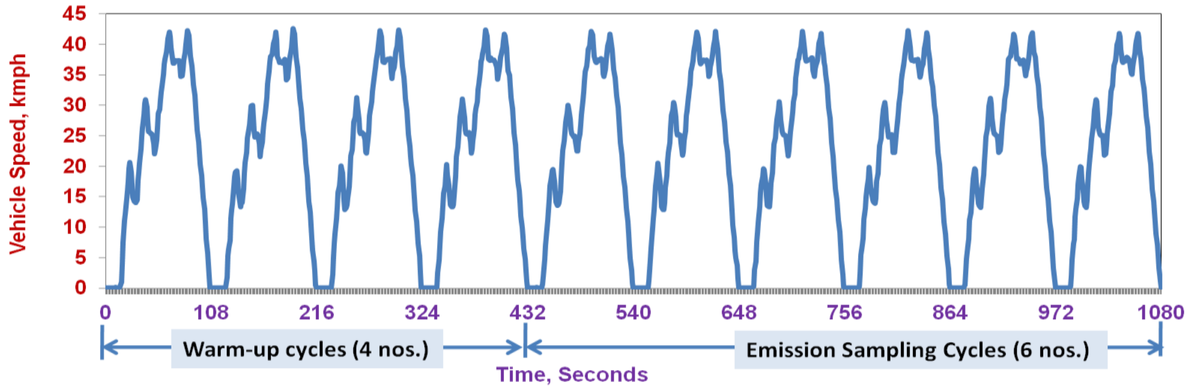
Performance and Emissions (IDC)







CO decreases by 48%; THC decreases by 24%; NOx is comparable;
Fuel Consumption increases by ~4%



Indian Driving Cycle (IDC)

Test Vehicle

BS-III, 150 cc motorcycle (carbureted)

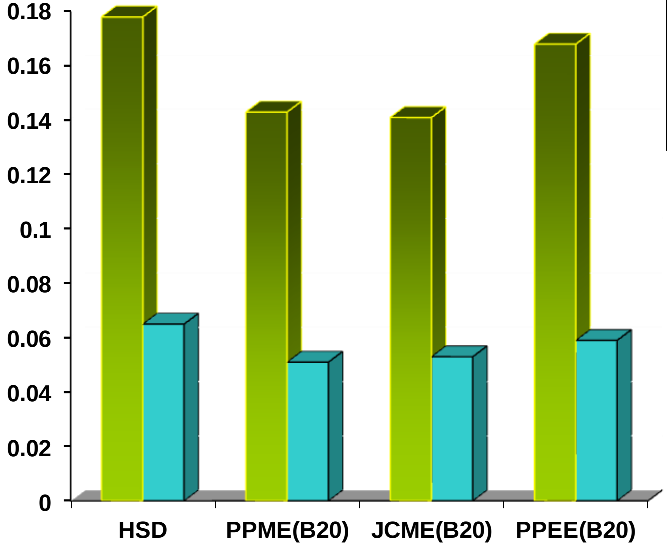
Co-processing Vegetable Oil in Refinery

- Vegetable oils contain typically about 100 – 800 ppm of metals (P, Na, K, Ca, Mg, Fe, Cu etc.)
  - For co-processing, metal level kept below 5 ppm level to avoid catalyst deactivation
- Degumming & de-metallation of oil : Process developed & optimized to reduce metal content below 5 ppm
- Long duration experiments (1.5 years) conducted for Co Processing with 10% Jatropha oil at typical DHDT conditions/ catalyst
- Commercial trial done in CPCL Refinery

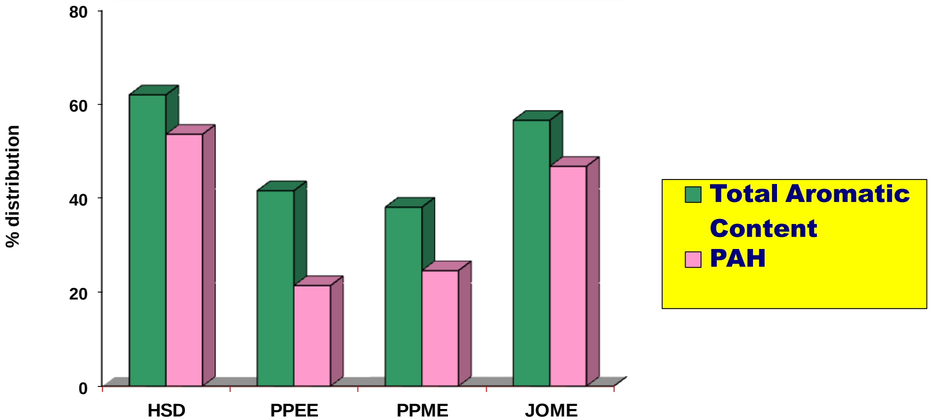
- Advantages of Co-processing in Refinery
  - ✓ Utilizes existing refining infrastructure
  - ✓ No need for disposal of raw Glycerol
  - ✓ Cetane Improvement of 2-3 units

Biodiesel Emission & Performance Study

Climatic chamber testing at Indian Oil R&D



- **HSD** : High Speed Diesel
- **PPME**: Pongamia Pinnnata Methyl Ester
- **JCME**: Jatropha Curcas Methyl Ester
- **PPEE**: Pongamia Pinnata Ethyl Ester



Lower PAH content with Biodiesel indicate lesser carcinogenicity of Particulates

LNG as Automotive Fuel

LNG: Excellent fuel for Heavy duty applications

LNG Import Infrastructure to grow 3 folds

LNG Terminals	Capacity (MMTPA)
Operational	26.7
Under Construction	21.5
Proposed	32.0

LNG Bus Flagged off by Hon'ble Minister, MOP&NG

- **IOC pioneered LNG as Automotive Fuel in collaboration with TATA Motors**
  - **Trial run of 1st LNG Fuelled Truck concluded successfully during 2015-16**
  - **LNG fuelled buses developed by Tata Motors under trial with IOC's LNG dispensing solution**
  - **LNG Fuelling Stations at strategic locations – need of hour**

Bio-CNG

Sustainable Alternative Towards Affordable Transportation (SATAT) – Launched 1st Oct'18

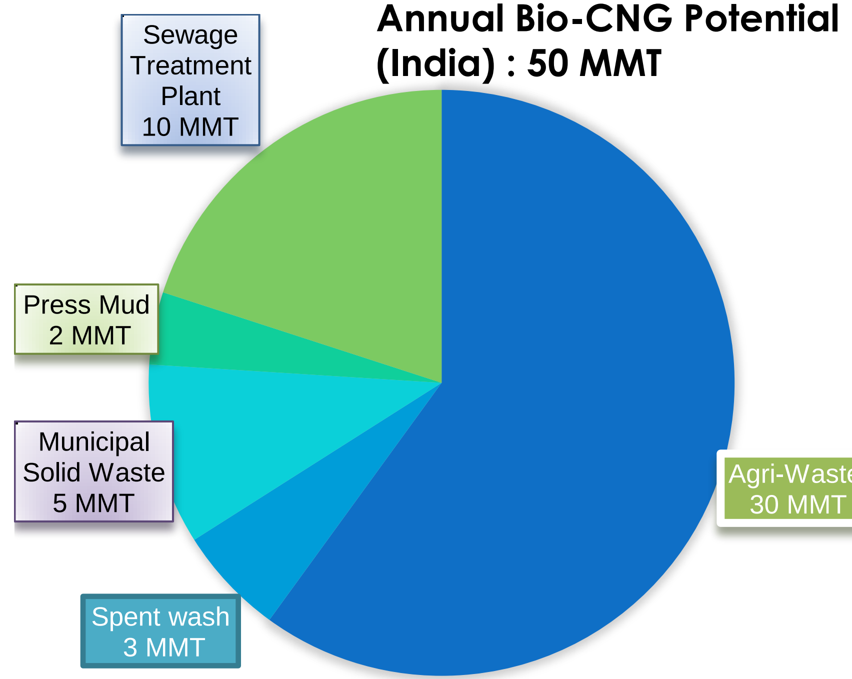
Key Features

- 5000 CBG plants in next 5 years
- Production off-take guarantee by OMCs
- Procuring price of biogas from the plants is very attractive

Indian Oil initiatives

- Retailing of Bio-CNG through Retail Outlets
- MoUs signed with 4 producers for automotive Bio-CNG
- Exploring Opportunities to produce Bio-CNG from Waste Streams through JV

Annual Bio-CNG Potential (India) : 50 MMT



Hydrogen Blended CNG

- **Using H2 as an additive to CNG provides:**
  - Lower risk due to very low energy content from H2 -safety properties similar to CNG
  - CNG infrastructure in place – can be used for HCNG
  - No major engine modifications required

- **Significant reductions in CO, HC, CO2 emissions and increased fuel economy**

HCNG for Demo in Delhi: APEX Court

IOC to SC: Conducting study on using CNG-hydrogen mixed fuel

PRESS TRUST OF INDIA
New Delhi, August 13

INDIAN OIL CORPORATION (IOC) on Monday told the Supreme Court that it was conducting a study on using mixture of CNG and hydrogen fuel for buses and would take around six months to come out with a "workable result" on it.

The IOC told a Bench of Justices Madan B Lokur, S Abdul Nazeer and Deepak Gupta that following the study, the corporation would conduct trials which would take around six months thereafter. It said that around ₹14 crore was required for implementation of the pilot project.

Advocate Aparajita Singh, assisting the top court as an amicus curiae in the air pollution matter, told the bench that the corporation should expedite the process and ₹14 crore could be given to IOC from the money collected under environment compensation charge (ECC).

Singh said the Delhi-National Capital Region (NCR) had a robust CNG infrastructure in place which would help in this process.

The court was told that hydrogen and CNG mixed fuel was a cleaner fuel compared to CNG and IOC has tried this technology

The Bench, while accepting the submissions of the amicus, said that ₹15 crore from the ECC be sanctioned to IOC to conduct the study and carry out the pilot project.

The court listed the matter for further hearing in November. The amicus had earlier told the court that buses running on hydrogen and CNG mixed fuel would help tackle air pollution.

The court was told that hydrogen and CNG mixed fuel was a cleaner fuel compared to CNG and the IOC has tried this technology. The Bench had earlier suggested that the possibility of using hydrogen fuel cell-powered vehicles, which are of hybrid nature, and considered cost-effective compared to CNG or electric vehicles, should also be explored.

The Bench, while accepting the submissions of the amicus, said that ₹15 crore from the ECC be sanctioned to IOC to conduct the study and carry out the pilot project.

THE TIMES OF INDIA

Conducting study on using CNG-hydrogen mixed fuel: Indian Oil to SC

PTI | Aug 13, 2018, 06.03 PM IST

NEW DELHI: Indian Oil Corporation Ltd (IOCL) on Monday told the Supreme Court that it was conducting a study on using mixture of CNG and hydrogen fuel for buses and would take around six months to come out with a "workable result" on it.

The IOCL told a bench of Justices Madan B Lokur, S Abdul Nazeer and Deepak Gupta that following the study, the corporation would conduct trials which would take around six months thereafter.

It said that around Rs 14 crore was required for implementation of the pilot project.

Advocate Aparajita Singh, assisting the top court as an amicus curiae in the air pollution matter, told the bench that the corporation should expedite the process and Rs 14 crore could be given to IOCL from the money collected under environment compensation charge (ECC).

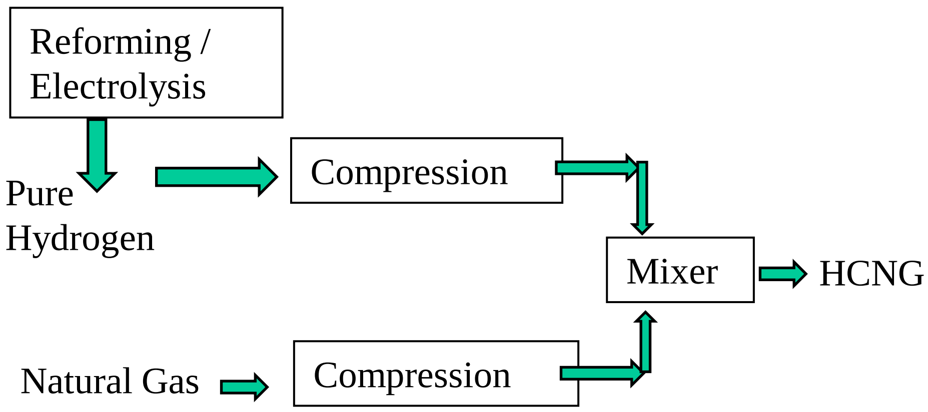
Pilot trials to convert and run 50 buses on 18%HCNG produced through IOC's compact reformer technology

IndianOil's HCNG Production Process

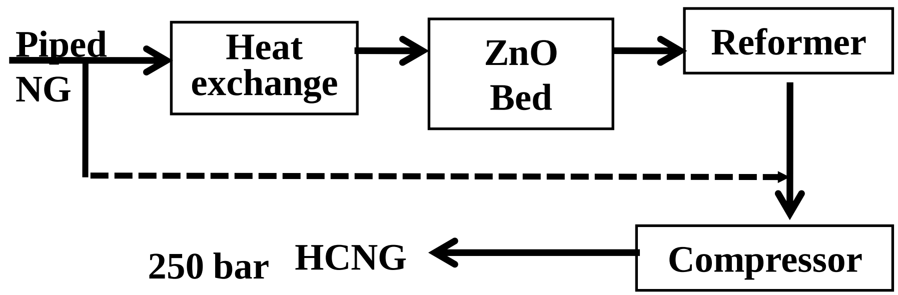
Salient Features

Cost can be reduced by innovative hydrogen / HCNG production technologies
Conventional process needs high pressure hydrogen blending
Multiple steps involved in the process adds to cost
Single step compact reforming of natural gas holds merit
Price differential w.r.t. CNG can be Rs.0.70/km with significant emission reduction

Conventional Process

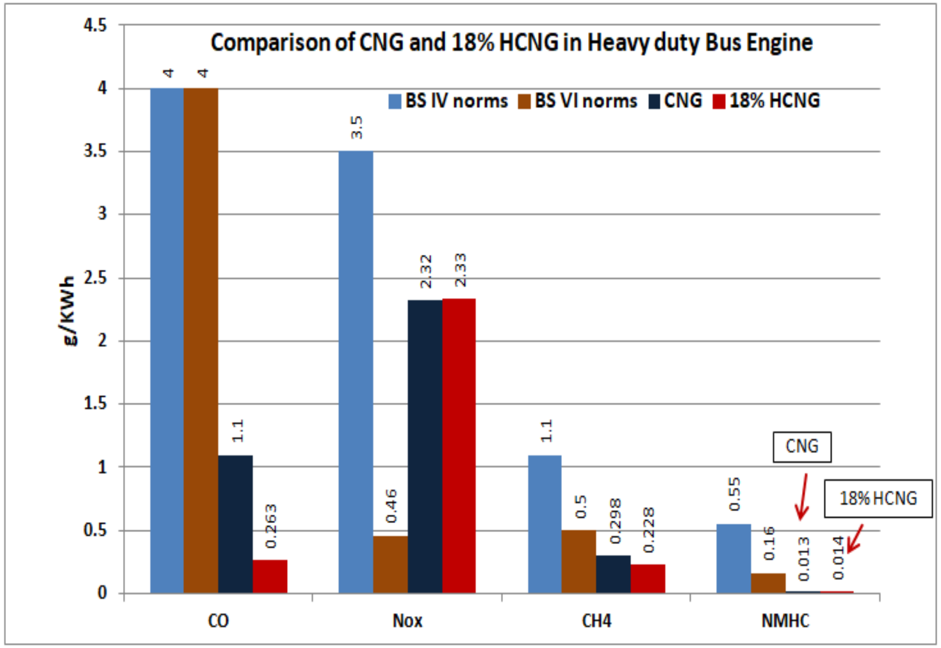


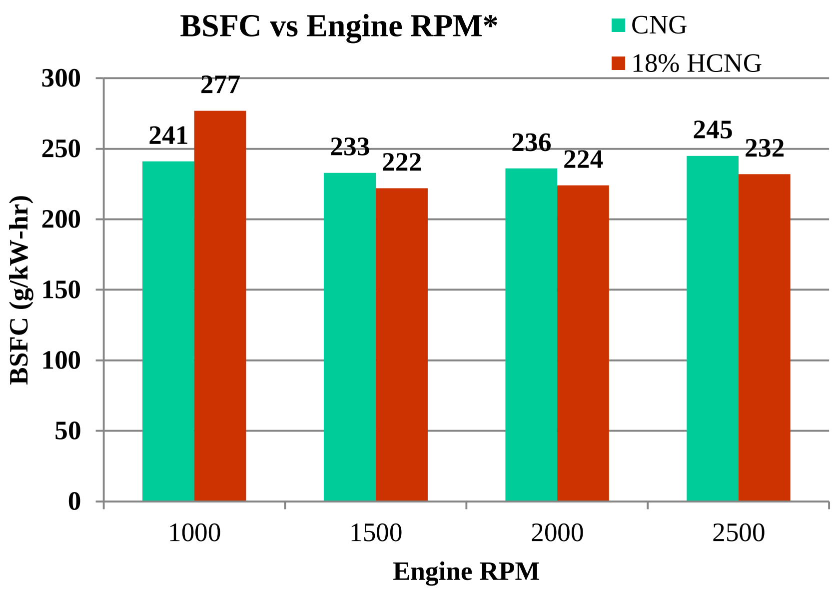
IOC's Compact Reforming Process



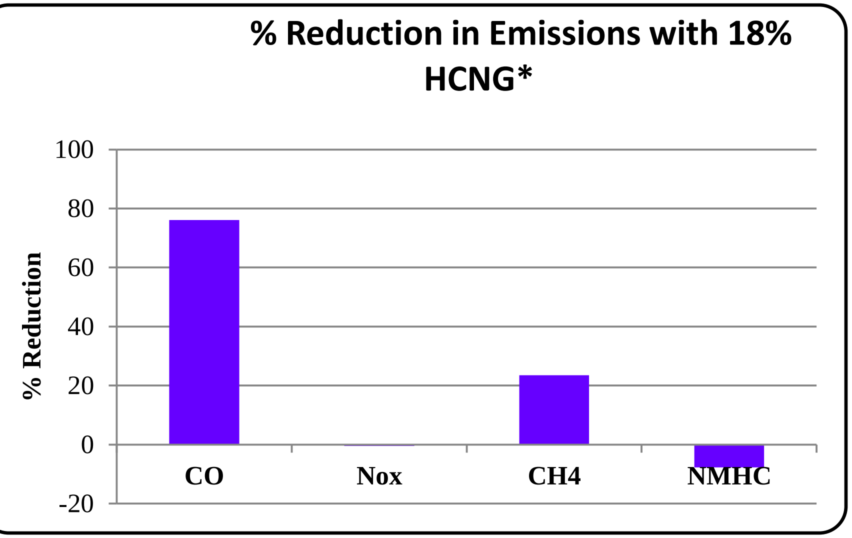
Indian Patent Granted (03/18)– 294969

HCNG for Heavy Duty Applications





- 18% HCNG can meet CO & HC emission limits set for BS VI
- Nox emissions can be reduced by suitable calibration / exhaust after treatment interventions
- 4% - 5% benefits in fuel consumption achieved at full load.



Source: IOC R&D-ARAI Studies

***Based on tests conducted at ARAI,Pune on Heavy duty bus engine**

Summary

India's demand for energy doubles by 2040

BS VI regime is fuel neutral and calls for huge investments in refinery

CNG, LNG, Bio-CNG shall be promoted for cleaner environment

Cap on CO2 emission & FE norms calls for serious actions

Sustainable biofuel production to be promoted

M15 Blends are under trial

HCNG is an excellent interim solution for achieving hydrogen economy

India is promoting Low carbon options

IndianOil R&D The Power of Possibilities

Thank You

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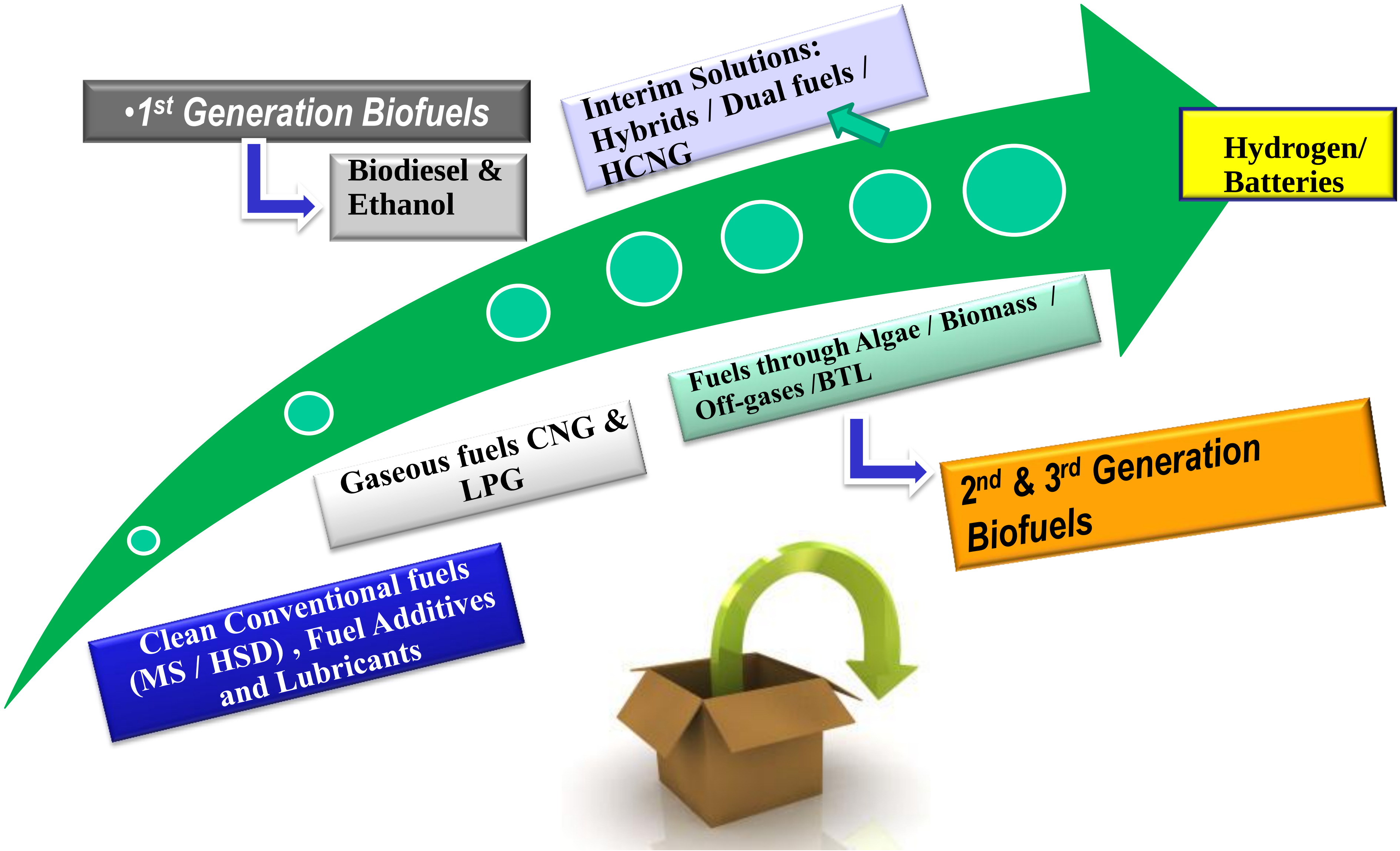
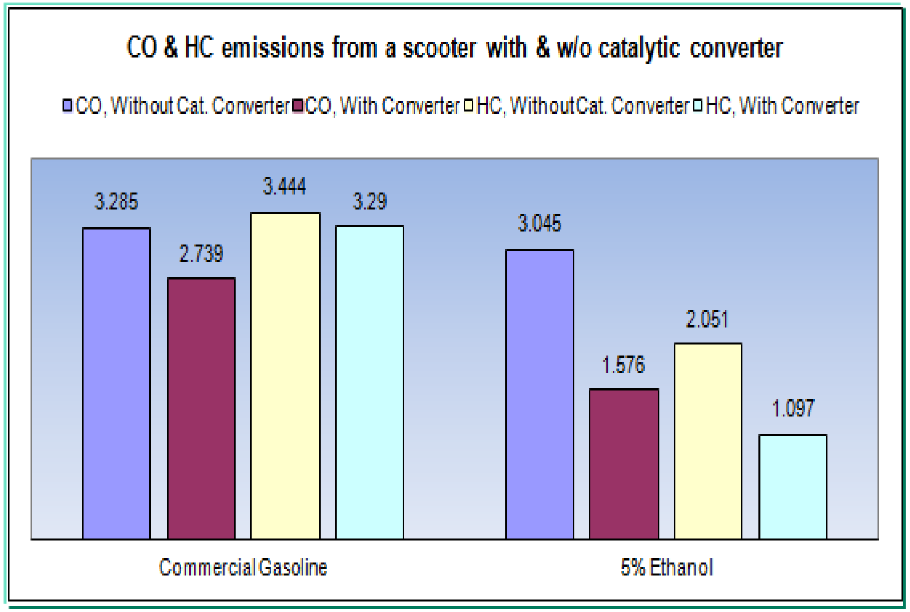
Low Carbon Options

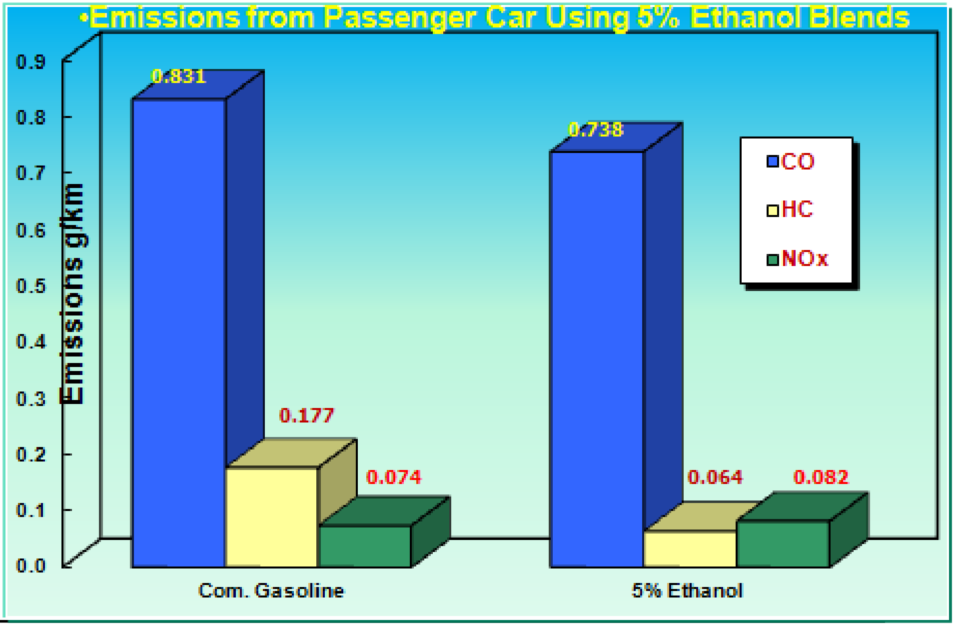


Disruptions on the anvil through Batteries & Fuel Cells in Mobility sector

Ethanol Gasoline Blends - Performance

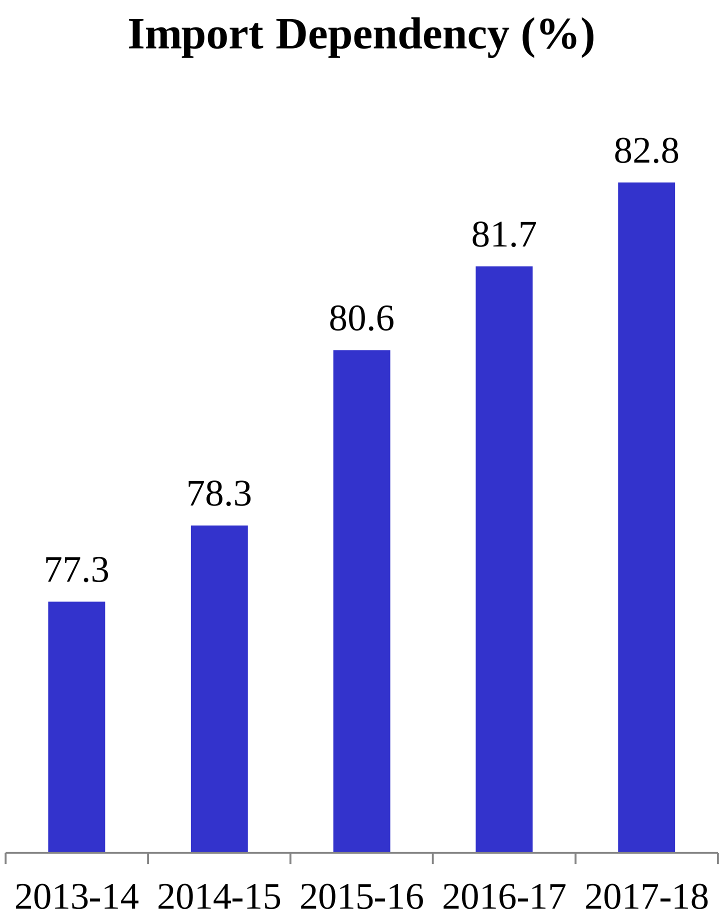
Properties	Com. Gasoline	Gasoline + 5% Ethanol	Gasoline + 10 % Ethanol
Distillation E70	30	36.5	45
RON	89.2	90.5	92.6
Potential Gum, g/m^3	40	140	180
RVP, kPa	55.9	63.3	63.0
VLI	769	885	945

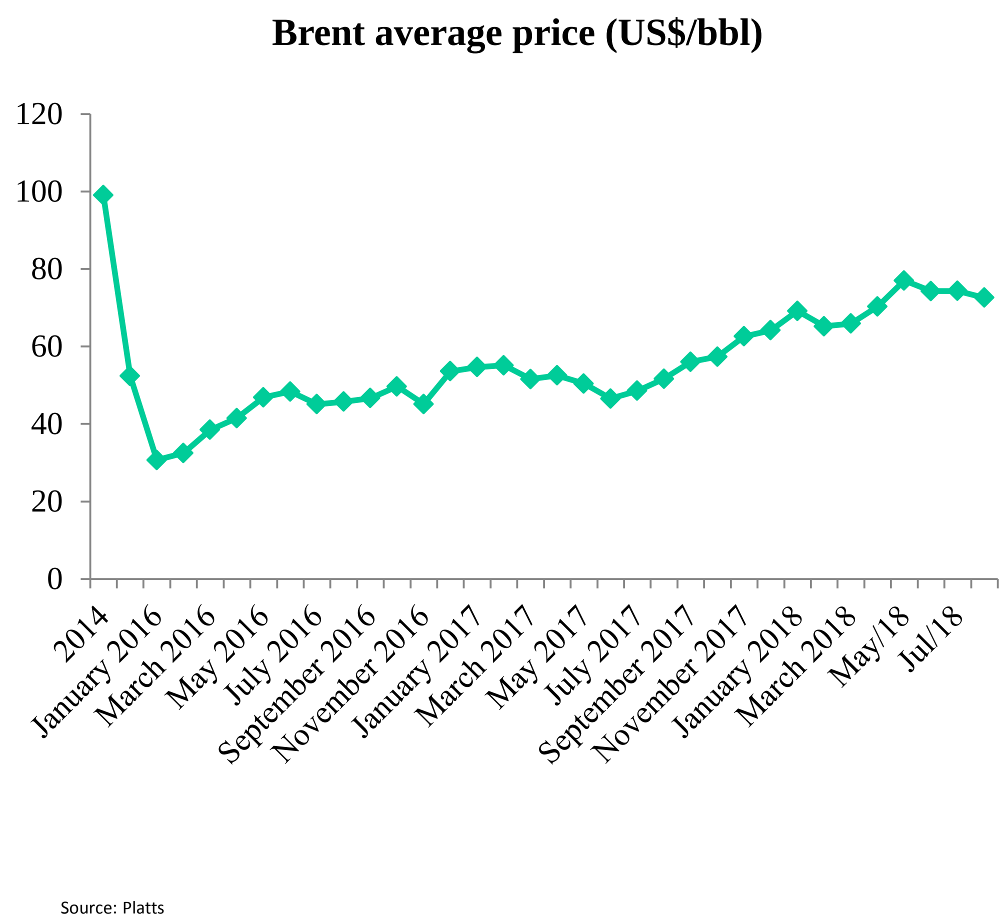




•SAE INTERNATIONAL

Increasing Import Dependence & Oil Price





Source: Platts

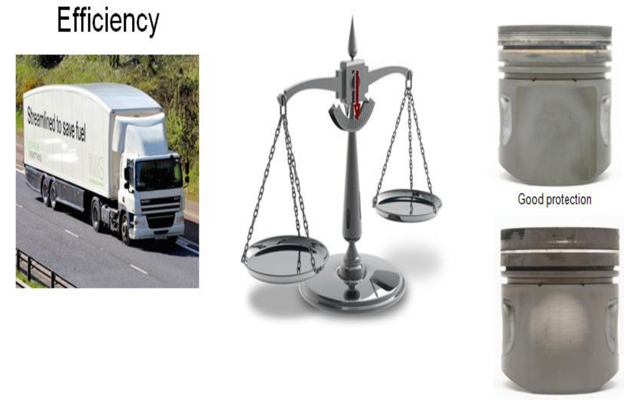
Increasing Import dependence and increase in crude price forcing structural change in the energy sector of India

Lubricant Technologies for Efficiency

✓ Energy Efficient Lubricants

- Ultra Low viscosity Grades

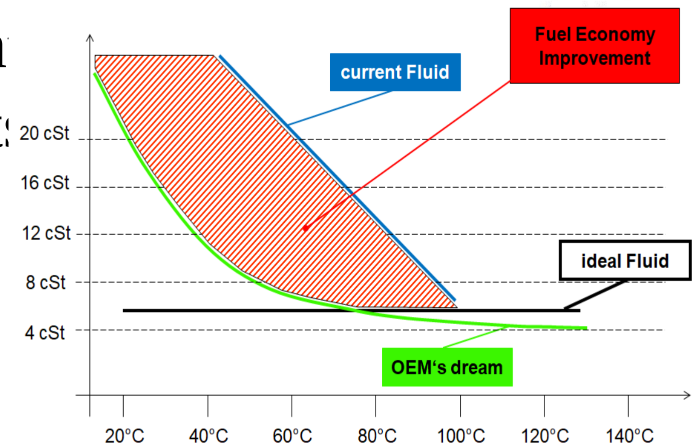
Increased FE translates to reduced CO_2 emissions



✓ Emission Compliant Automotive Lubricants

- Low SAPS ATD Compatible Lubricants

Inline with BSVI Emission Norms



Source: AFTON

✓ Long Drain Lubricants

- Engine Oils (ODI >1 Lacs),

Long drain capability translates into enhanced productivity/reduced downtime / Oil & Energy conservation

Greater Efficiency play part in reducing GHG emissions

Technology Intervention For BS-VI MS Pool

Sl. No.	Attribute	Process Units / Operational changes
1	Sulphur reduction	▪ FCC / Coker Gasoline desulphurization unit ▪ VGO hydrotreater
2	Octane Enhancement	▪ CCRU ▪ Alkylation ▪ Dimerization
3	Benzene reduction	▪ Feed management & operational changes ▪ Isomerization unit, pre & post reformate ▪ BENSAT unit ▪ FCC gasoline splitter
4	Olefins & Aromatic management	▪ Feed management & operational changes ▪ BENSAT ▪ FCC Gasoline desulfurization unit
5	Octane Booster	▪ MTBE units / Octane Boosting Additives

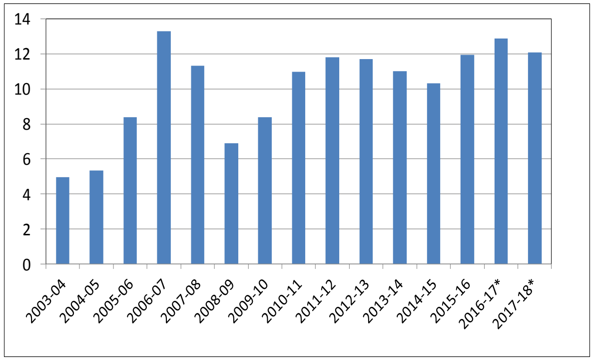
BS VI Diesel - Technological Options

- Catalyst replacement in existing DHDS/DHDT
- Capacity revamp of existing DHDS/DHDT vs setting up New DHDT
- Conversion of existing VGO hydro-treaters to mild hydrocrackers.
- Capacity revamps of hydrogen generation units vis-a-vis New HGU.
- Additional Sulphur Recovery Units vis-a-vis Sulphuric Acid.
- Kerosene De-sulphurisation to meet PCK (plug requirement of pipeline for pumping MS and HSD from refineries)
- Technological Intervention for meeting < 10 ppm at low H_2 severity

1st Generation Ethanol

- •1 •Food Vs Fuel (same land for both)
- •2 • Limited availability of molasses
- •3 •Fails to achieve requirements of Biofuels

Production of Molasses (Million tonnes)



INDIAN ETHANOL PRODUCTION CAPABILITY

10% Bio-ethanol allowed in India but only 3.4% achieved in 2016-17

376 crore litres (~3.76 billion litres) ethanol required in FY 18-19 to meet 10% EBP target

- **Molasses production , linked to sugarcane production, varies from ~5 MMTA (2003-06) to ~12 MMTA (2017-18)**
- **Sustained supply of ethanol debatable**
- **About 40% of total ethanol production as fuel grade**
- **Even at peak production , it can meet only about 5 % blend level in gasoline**
- **2nd Generation ethanol is sustainable**