

The logo consists of the letters 'JCB' in a bold, white, sans-serif font on a black background. The letters are contained within a yellow rectangular border with rounded corners.

OFF HIGHWAY TRENDS

Clean Air and Future Fuels

Key drivers of future



Always looking for a better way

modify



LARGE INFRA



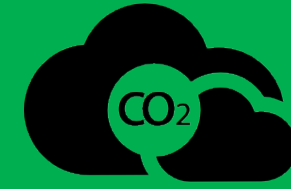
HYBRIDS /
ALTERNATIVES



CONNECTED /
AUTOMATION



ENGINE
DOWNSIZING



SUSTAINABILITY /
REGULATIONS



Bigger, More
Productive and
specialized
machines



Greater demand
for more fuel
efficient
machines



24/7 Remote
connectivity and
machine
operations,
Virtual Cockpit



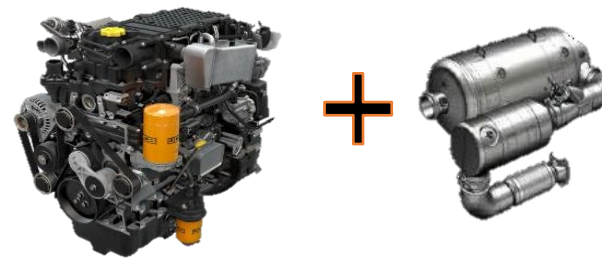
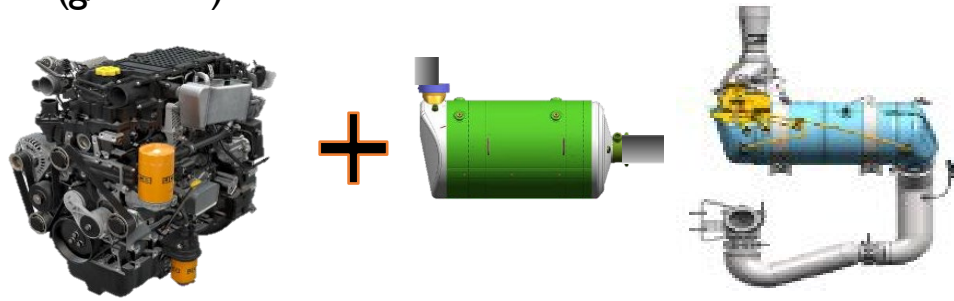
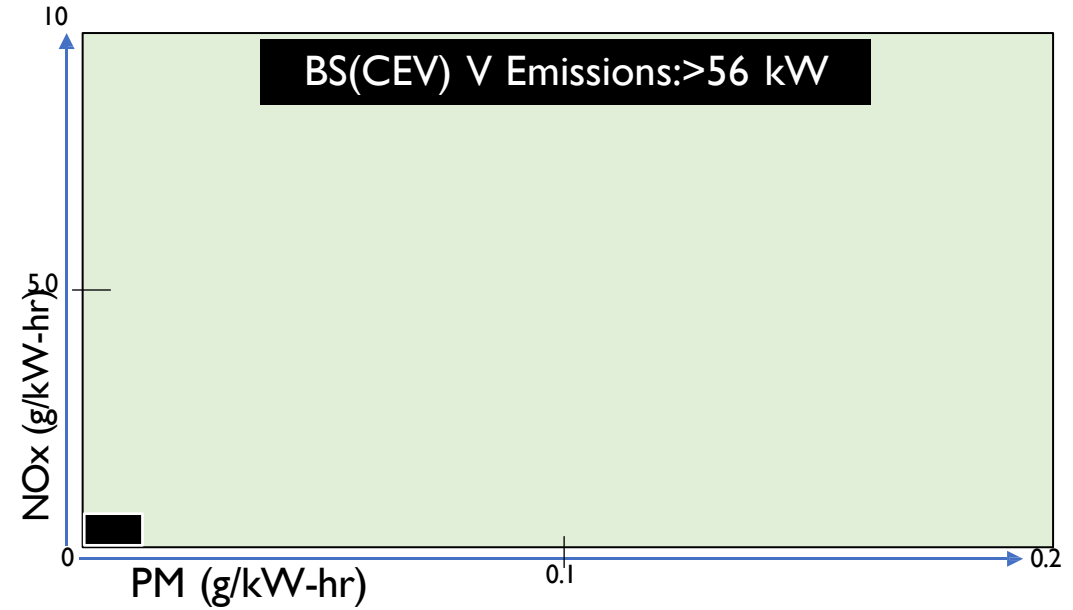
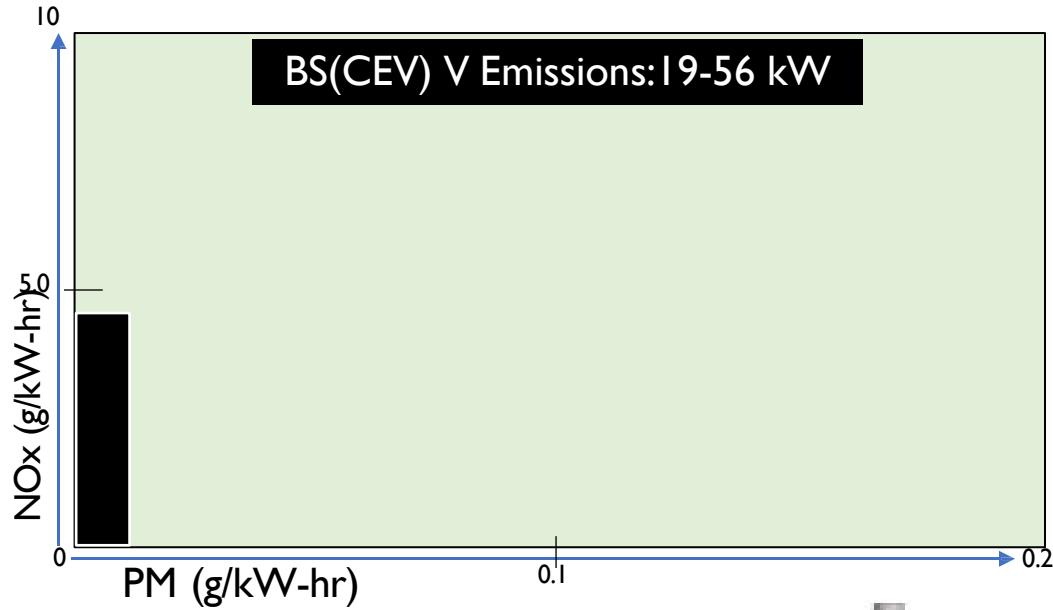
Smaller Engines
with added
benefit of all
round machine
visibility/ Hybrid



Stricter emission,
Sustainability and
safety regulations
/ legislations

FOCUS ON SUSTAINABILITY

Regulations



Further Reduction with Stage VI is on the way....

Near Zero Emissions: Significant reduction over the years

Engines

Fuel Eco/Low PM

Compact /Power

Fuel Eco/ Emissions

Low Nox/Fuel Eco

4 Valve Design

Higher BMEP

High Pressure CR

EGR

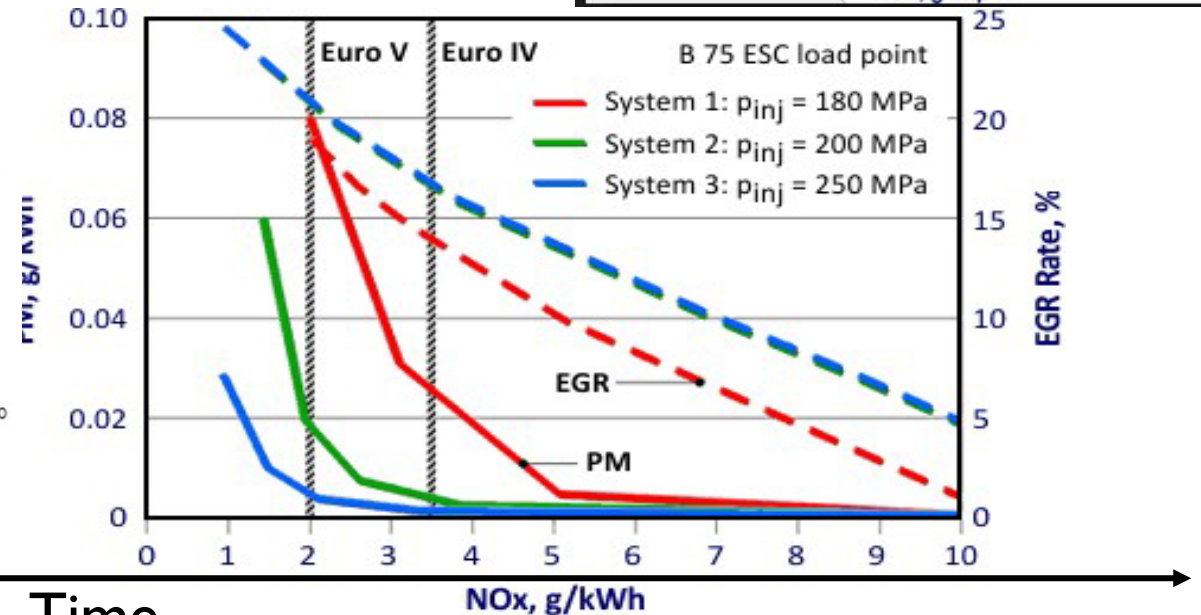
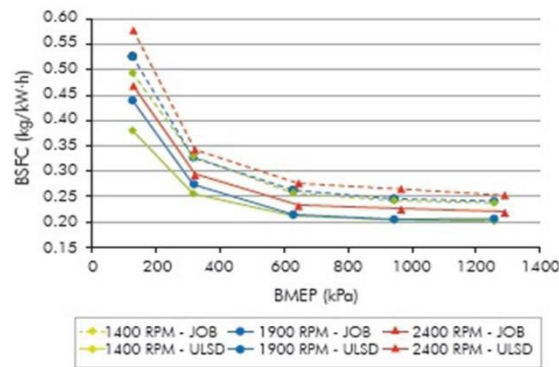
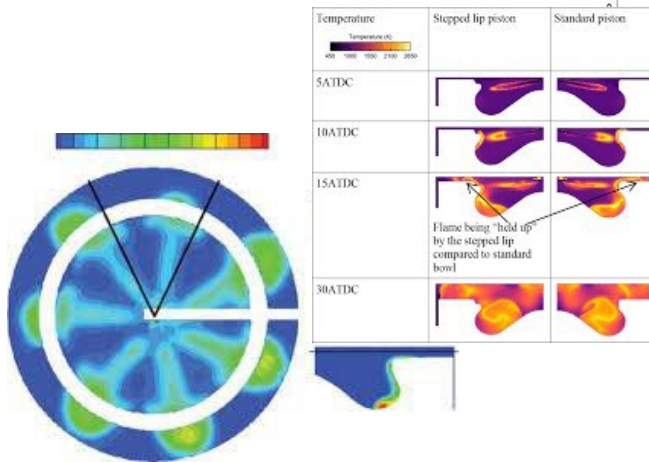
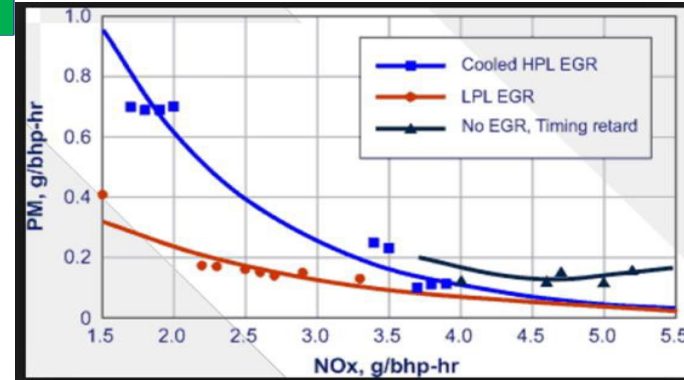
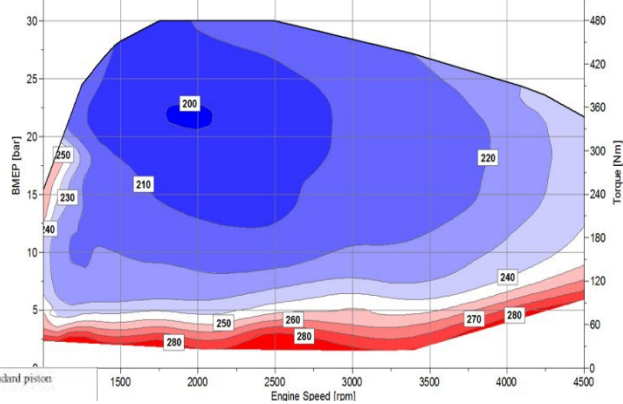
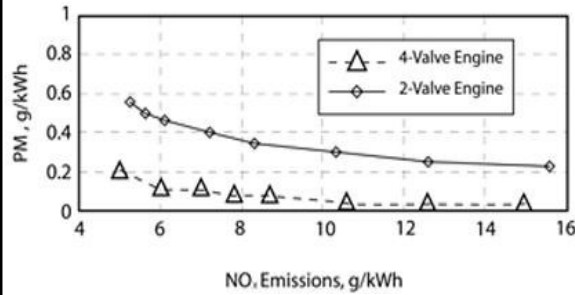
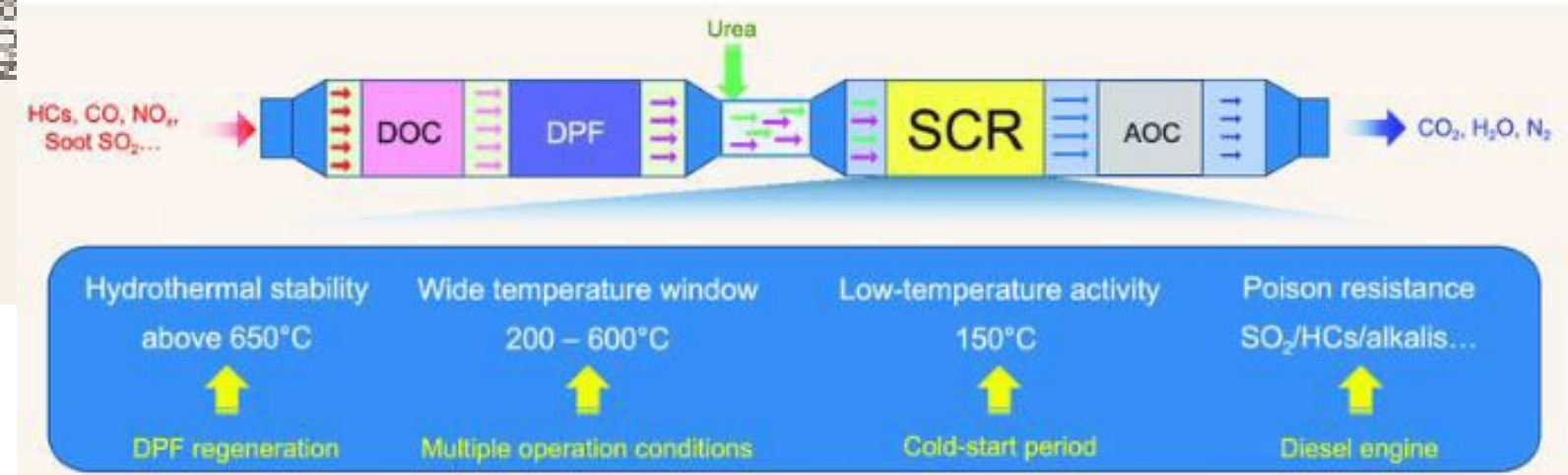
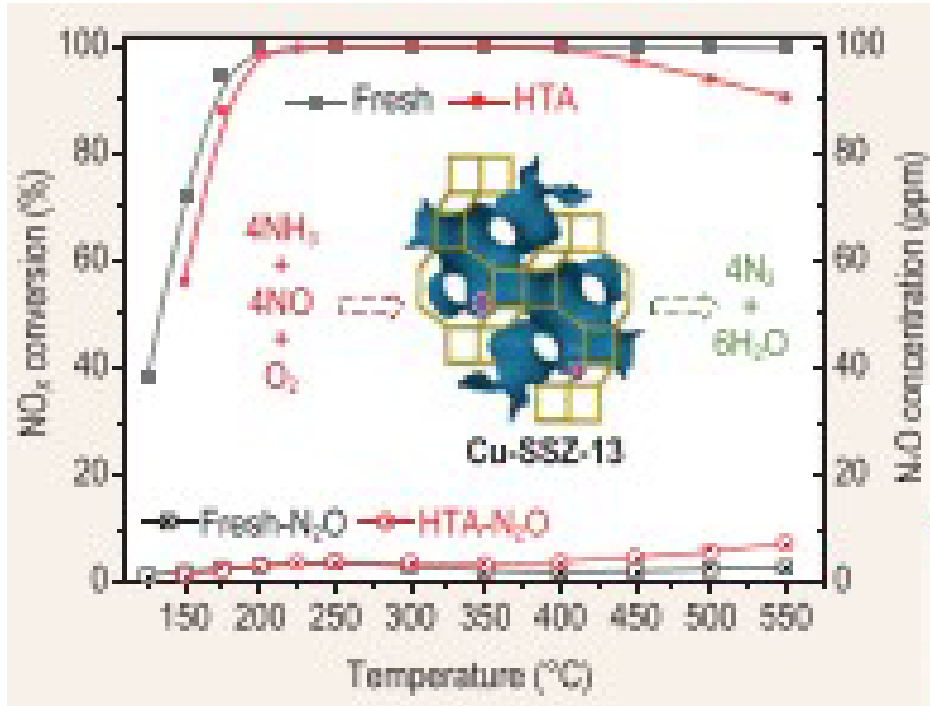


Figure 2. BSFC: Brake Specific Fuel Consumption. BMEP: Brake Mean Effective Pressure.

Technology Development, Time

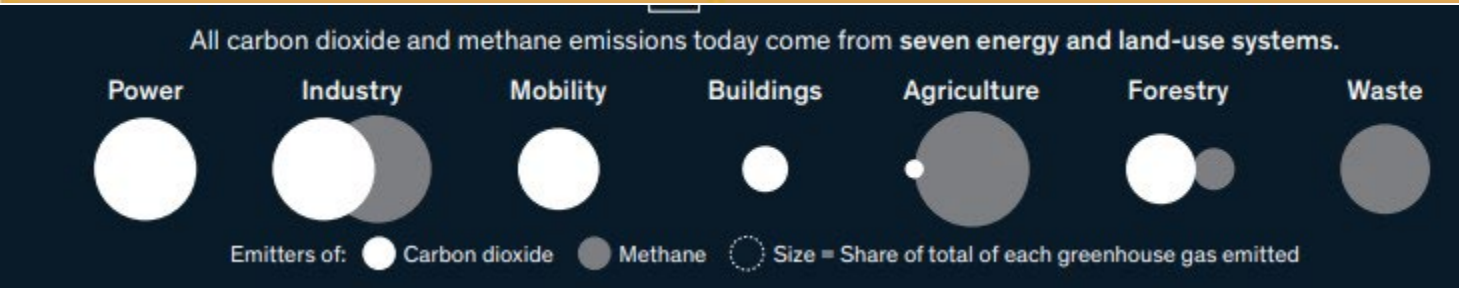
Benefit to Customer

Efficient SCR SYSTEMS



Technology Advancement: Conversion Efficiency and Range

Climate Change



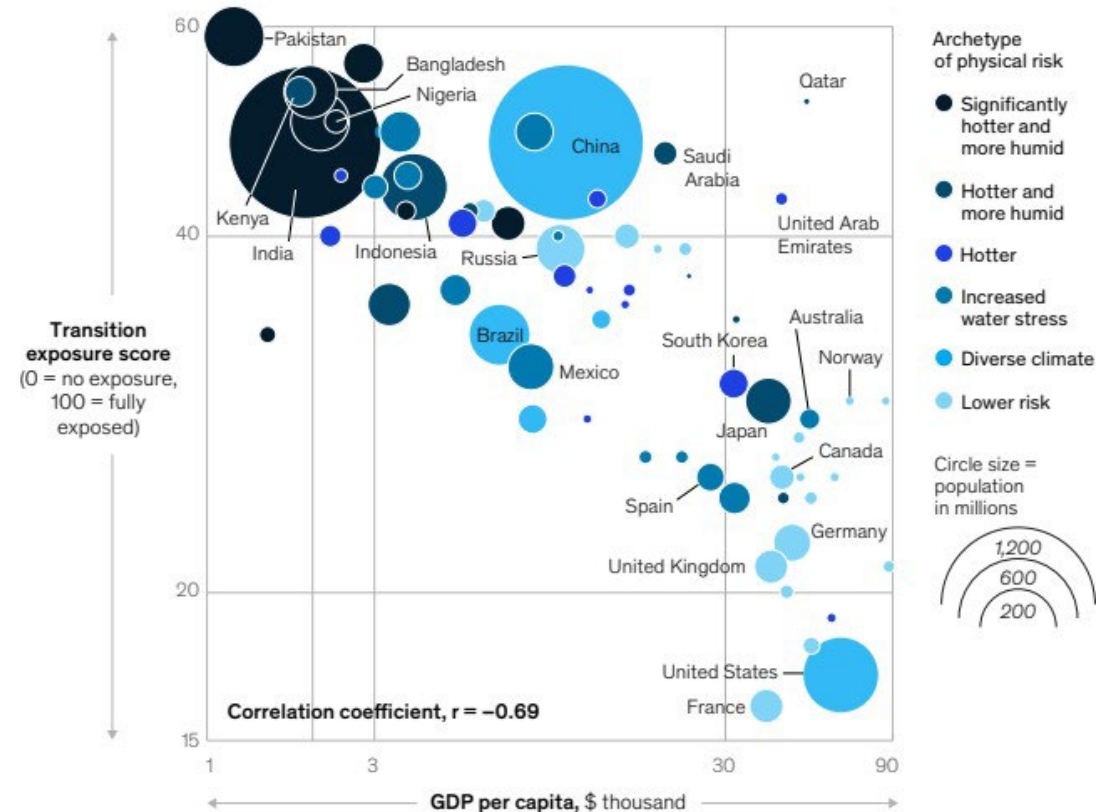
Focus on Climate change & GHG Emissions

Holistic View & GDP

Economics driver

Countries with lower GDP per capita and fossil-fuel resource producers have higher transition exposures.

Archetype of physical risk¹ through transition exposure vs GDP per capita by country² (logarithmic scale)



Green House Gas Emissions

Road to Zero Emission

Propulsion Fuels

Conventional Fuel

Alternate Fuels-
CNG/LNG

Alternate Fuels-
Bio Diesel/DME

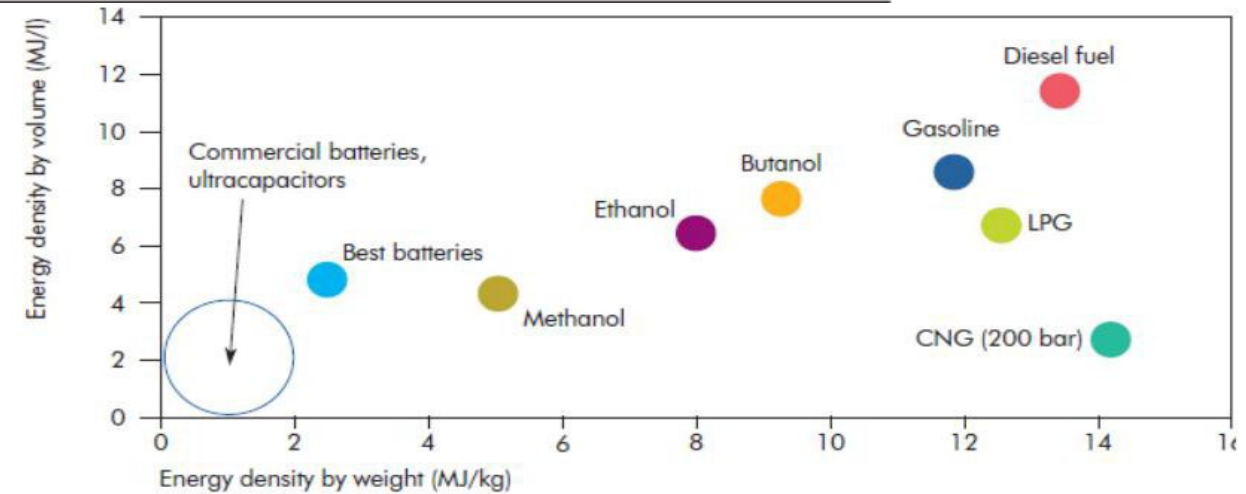
Alternate Fuels
Ethanol

Alternate Fuels
Hydrogen

Battery Electric
Vehicles

Fuel Cells

Criteria	CNG	LPG	LNG	Ethanol	Bio-Diesel	Methanol	DME	Hydrogen
Reduction of CO2 from Base fuel (Gasoline /Diesel)	+++	++	+++	+	+	+	+	++++
WTW CO2 emission	++	+	+	++	+++	+ (coal) ++ (biomass)	+	++++
Local Sourcing Possibility	+++	-	-	+++	++	+++	++	+
Replace / Reduce								

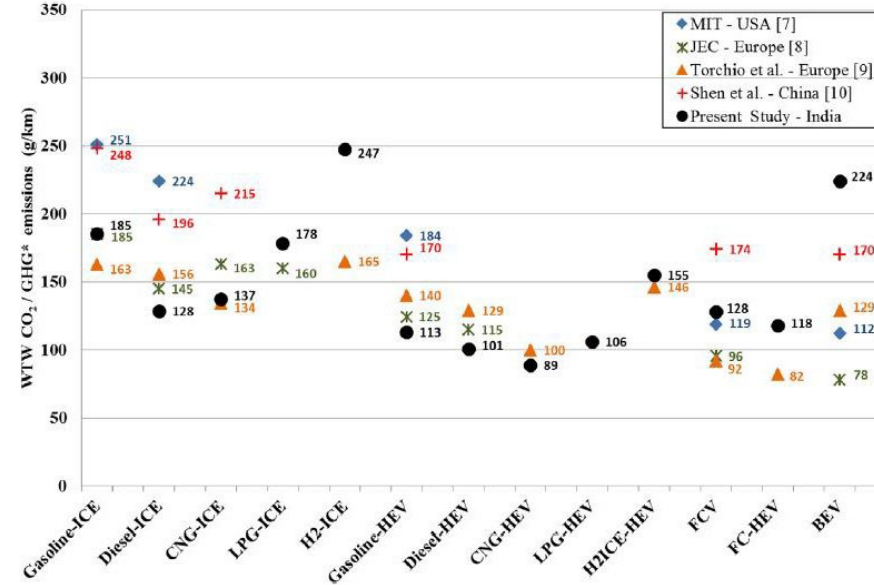
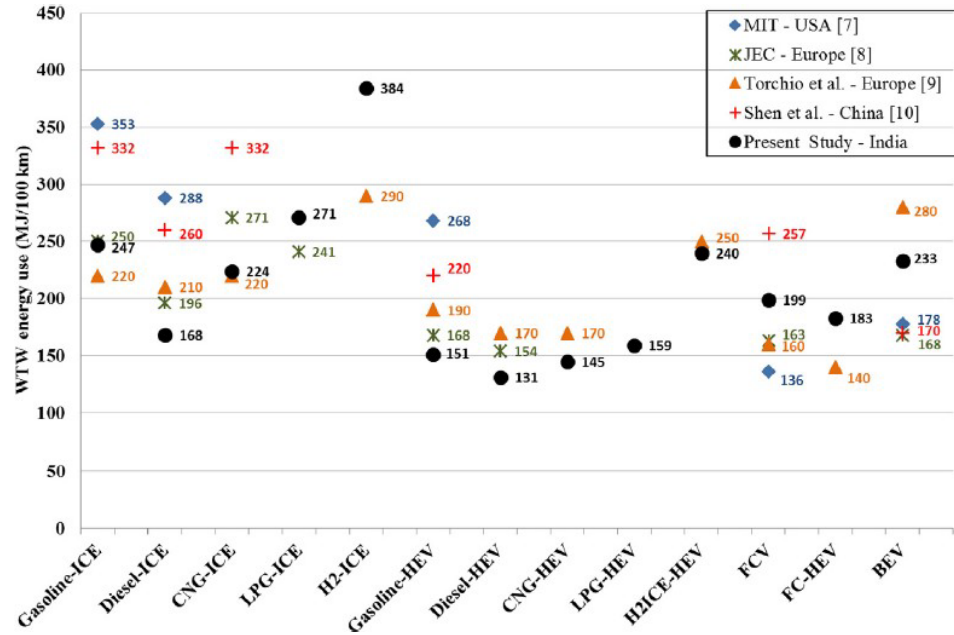


Source: Various, including IEA data on the relationship between volumetric and mass density of batteries and IEA assumptions on the efficiencies of engines (25% to 30% for internal combustion engines) and electric motors (90% to 95%).

Propulsion Technology and Fuel are integral part of Soln.

Energy Analysis

2015, IISC Bangalore Paper



Gasoline ICE	Diesel ICE	FCV	BEV	Context
Base	-32%	-19%	-6%	INDIA
Base	-18%	-61%	-50%	USA

- % Calculated based on Gasoline WTW Energy Use
- Lower the % better is the WTW efficiency
- India – Diesel, FCV, BEV
- USA - FCV, BEV, Diesel

*Source – Life Cycle Analysis of Energy & Green House gas emissions of Automotive Fuels in India: Part 2 - Well to Wheel Analysis, V. Patil et.al, Journal of Energy, Science Direct, 2015 Paper

Efficiency

Energy Efficiency	Well → Tank	Tank → Wheels	Overall WTW Energy Efficiency	
	4.1.2 Production	4.1.3 Delivery	4.1.4 Use	
FCEV	23~69% ^{228 233 234 235 236 227} <ul style="list-style-type: none"> Range is due to differences in hydrogen production pathways Production efficiency = Feedstock extraction efficiency X fuel to hydrogen efficiency See details in following pages 	54~80% ^{230 231 232} <ul style="list-style-type: none"> Energy loss during compressing, transportation (pipeline/truck) and storage (gaseous/liquid hydrogen) 	36~45% ^{230 232} <ul style="list-style-type: none"> Conversion of hydrogen to electricity, and electricity to mechanical energy The additional energy loss compared with BEV operation, is due to added step of hydrogen to electricity 	4~25%
BEV	35~60% ^{234 235 236} <ul style="list-style-type: none"> Range varies depending on different methods of electricity production, as well as grid-mix which varies dramatically between different countries 	81~84.6% ^{235 236 240} <ul style="list-style-type: none"> Average conversion rate during electricity transmission is about 90%-94% 90% energy efficiency during charging process 	65~82% ^{229 230} <ul style="list-style-type: none"> Energy loss during electricity conversion to move vehicle, including loss in motor, AC conversion, auxiliary parts and transmission system, excluding the charging process 	18~42%
ICE Vehicle	82%~87% ^{234 238 239} <ul style="list-style-type: none"> 13~18% energy loss during fossil fuel mining, refining processes 	~99% ²³⁷ <ul style="list-style-type: none"> Small amount of energy loss during transportation process, due to evaporation, spilling or adhesion to containers 	17~21% ²²⁹ <ul style="list-style-type: none"> Majority of energy lost as heat Current efficiency is near the limit of ICEs after years of improvements as the incumbent vehicle type 	14~18%

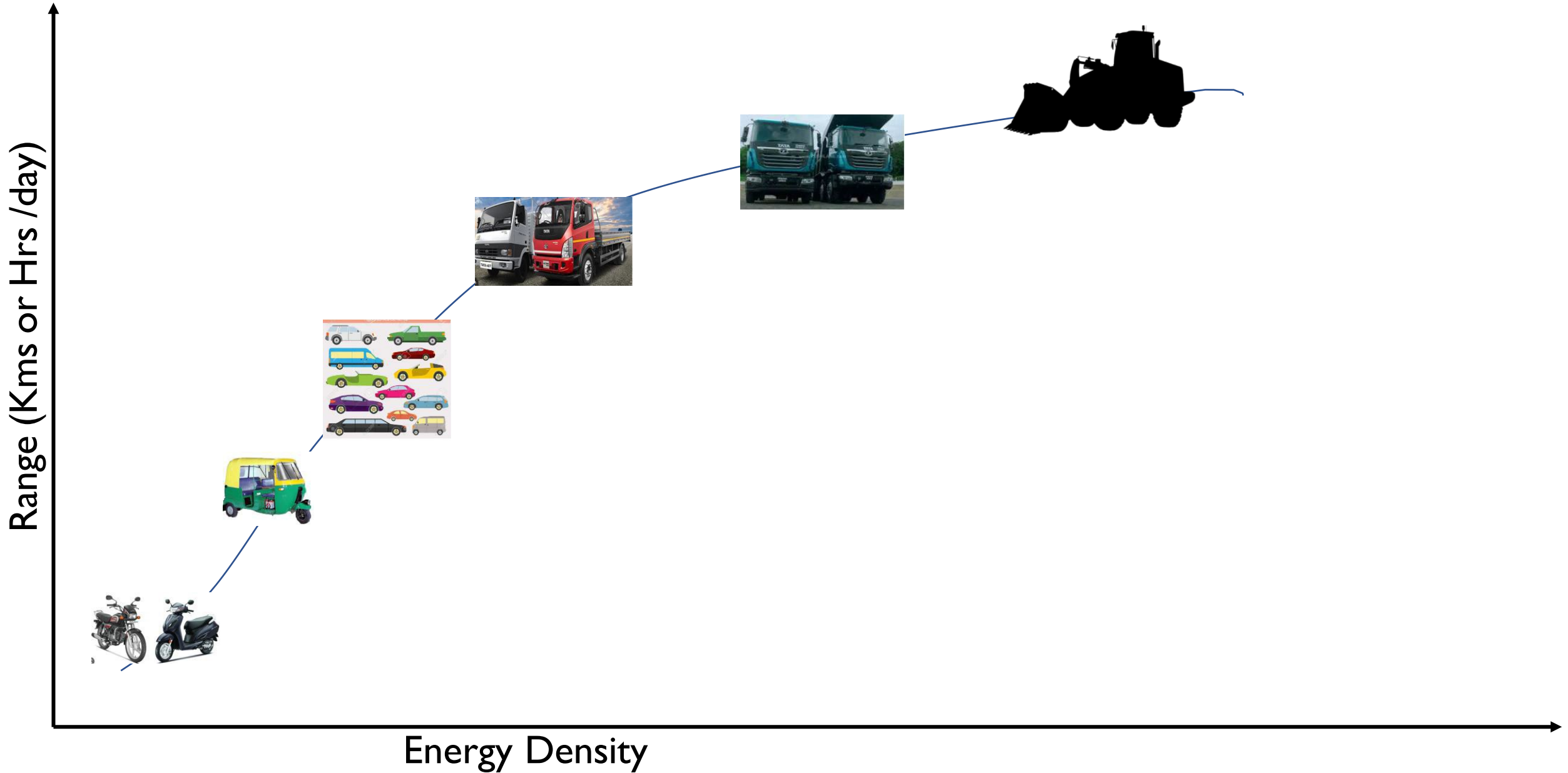
- Cost
- CO₂
- Infrastructure

- CO₂
- Cost & Energy Density
- Infrastructure

- Net Zero - Fuels

- Diverse energy demand from different markets.
- Alternate fuels provides wider Opportunities.
- Fuels to be key enabler –Road to Zero
- Economics is one of key variable – Dynamic.

THANK YOU



Cost of Hydrogen

Figure 42: Key components contrast of a bus In 2019

	U.S.	China	Europe	
Purchase cost (thousand USD)	FCEVs	• 1,000	• 314	• 720
	BEVs	• 700	• 229	• 452
	ICE vehicles	• 470	• 77	• 322
Fuel cell system (USD/per kw)	• 1,500	• 2,000	• 1,200	
Fuel price (USD/per unit)	Hydrogen (kg)	• 8	• 8.4	• 7
	Electricity (kwh)	• 0.11	• 0.14	• 0.18
	Diesel (L)	• 0.76	• 0.96	• 1.62
Infrastructure for a bus fleet (thousand USD)	Hydrogen station	• 6,500	• 6,400	• 8,000
	Charging infrastructure (BEV)	• 12,500	• 5,200	• 12,500
Vehicle lifecycle (years)	• 12	• 8	• 14	

Figure 31: US hydrogen price (Unit: USD/kg)



Weight & Volume of Energy Storage System for 500 km Range



Cost of 100% Petrol		
Elements	Unit	1.11.2020
Price to Dealers (excluding excise duty and VAT)	Rs/lit	25.77
Excise Duty	Rs/lit	32.98
Dealer Commission	Rs/lit	3.64
VAT (Including VAT on Dealer commission) in Delhi at 30%	Rs/lit	18.717
Retail Selling Price at Delhi	Rs/lit	81.107
Cost of E100 Fuel at Retail to equate running cost with Gasoline (30% lower)	Rs/lit	



Reduction in Fuel Usage

Major Revenue for Government

Alternate Forms: Absorb