S.Krishnan

Senior Vice President Ashokleyland

Independent Director IOCL

ZERO CRASHES
ZERO EMISSIONS
ZERO CONGESTION

Pollution

Global Warming

Economy & Productivity

Clean Air with Advanced After-treatment & Future Fuels ECT 2022

Euro VII HD Proposal Released on Nov 10th, 2022

Application:
M2, M3, N2, N3: July 1, 2027 (new vehicles)

Test conditions	Normal	Extended Limits x 2
Ambient T (°C)	-7 – 35	- 10 to +45
Max. Altitude (m)	< 1600	< 1,800
Max. Speed (km/h)	≤ 145	≤ 160
Payload	> 10%	< 10%
Trip composition	As per usual use	
Min. mileage (km)	5,000 for < 16t 10,000 for > 16t	> 3,000
Payload	All	< 10%

Lifetime:
300,000 km / 8 yrs. For N2, N3 < 16t
700,000 km / 15 yrs for N3>16t, M3>7.5t

Limits For M2, M3, N2 & N3 vehicles Units: mg/kWh	Euro VI	Euro VII proposal		
		Cold 100th percentile	Hot 90th percentile	Budget Trips < 3xWHTC
NOx	460	350	90	150
PM	10	12	8	10
PN (#/kWh) Euro VI : PN_{23} Euro VII : PN_{10}	$6x10^{11}$	$5x10^{11}$	$2x10^{11}$	$3x10^{11}$
CO	4000	3500	200	2700
NMOG	160	200	50	75
NH_3	10 ppm	65	65	70
CH_4	500	500	350	500
N_2O	-	160	100	140
HCHO	-	30	30	-

- The **Fourier transform infrared spectroscopy (FTIR) method** records all required components using a single instrument.
- It gives data consistent with the regulatory method, greatly simplifies the process, and provides second by second time resolution. But need to do miles deep.
- Non-methane hydrocarbons (NMHCs) are measured by identifying a group of hydrocarbons, including oxygenated species .
- NMOG (Non methyl organic gases) is then determined as per regulatory calculation solely from FTIR recorded emissions of NMHC, ethanol, acetaldehyde, and formaldehyde, yielding emission rates that also correlate within 5% with the reference method.
- An FTIR equivalent measure of NMHC that correlates within 5% to the regulatory flame ionization detection (FID) method.

- Nitrous oxide (N_2O) is called “laughing gas” **because it has a euphoric effect when inhaled**. It has a mildly sweet odor and taste.

- **Breathing nitrous oxide can cause dizziness, unconsciousness, and even death**. Long-term exposure can lead to infertility.

- **NO2 is nitrogen dioxide** which is reddish brown gas with a irritating odour.

- **We too hv CH4 , HCHO to get it measured , FID , FTIR**

- **Eu7** means need to get experienced accuracies of measurement , linearity , repeatability , calibration etc much more vigil by understanding principles of instrumentation

- By EU6 , we hv learnt that chemical engineers are more important , now need to hv instrumentation engineers too. Of course mechatronics , mechanical , automobile all became basics

- PN measurement we need more robustness in product/masurement

Euro 7 LD Proposal Released on Nov 10th, 2022

Application:
M1, N1: July 1, 2025 (new vehicles)

Test conditions	Normal	Extended Limits x 1.6
Ambient T (°C)	0 – 35	- 10 to +45
Max. Altitude (m)	< 700	< 1,800
Max. Speed (km/h)	≤ 145	≤ 160
Max. avg. P < 2km after cold start	< 20% P_{max}	> 20% P_{max}
Trip composition	Any	
Min. mileage (km)	>10,000	> 3,000
Payload	All	< 10%

Lifetime: 160,000 km / 8 yrs.
Ext. : 200,000 km / 10 yrs. Limits x 1.2

Limits M1, N1 vehicles Units: mg/km	Euro 6 WLTP, RDE : x 1.1 NOx, x 1.34 PN		Euro 7 Limits No CFs	Budget Trips < 10 km
	Gasoline	Diesel	Tech/fuel neutral	
NOx	60	80	60	600
PM	4.5		4.5	45
PN (#/km)	$6x10^{11}$ > 23 nm GDI only	$6x10^{11}$ > 23 nm	$6x10^{11}$ > 10 nm	$6x10^{12}$ > 10 nm
CO	1000	500	500	5000
THC	100	HC+NOx=170	100	1000
NMHC	68	-	68	680
NH_3	-		20	200

Can we Predict Future ? Are we fortune tellers ?

"Carbon is our enemy, not the internal combustion engine," says Akio Toyoda , Chief Toyota Motors.

- ***No one can predict the future. The best that humans can do is forecast.***
- ***What if EVs aren't the future we were hoping for?***
- ***By not putting all of its eggs in one basket, (Toyota's or AL's) diversity will enable to not just be flexible to what the future will be, but to be able to address carbon neutrality in a much swifter manner.***
- ***It's not the internal combustion engine is our problem, but rather, it's carbon dioxide emissions.***
- ***CNG,LNG, Bio fuels , Methanol , Ethanol , Hydrogen combustion engine, hydrogen fuel cell electric vehicle (FCEV), and other potential new technologies***

Diesel ban? The future of diesel cars - Industry experts ..2018

1. ***Volks wagen : diesel will still be a choice for long-distance drivers. And for the bigger cars, such as SUVs, diesel is the number one option. Diesel also becomes as clean as a gasoline car with Euro 6 emissions rules.***

2. ***Audi : in 2025. If you want to get CO_2 down, diesel has to play a role.***

3. ***Aston Martin : Mr. Andy palmer***

"It's dead. It has a future perhaps in heavy goods vehicles, but in passenger cars? I don't see it surviving this blow that it's taking. It's a pity, really, because as an answer to CO_2, it's the best answer the car industry has. "But the way that electric has been introduced to the British public, with the confusion over 2040 plus the air quality debate – I think it's too much for the technology to sustain."

4. ***Bently : But we're not going to pull it from the market on a principle point of view; customers buy them, customers love them and it's a brilliant proposition in Bentayga."***

5. ***Fiat Chrysler : Because of the regulations on emissions that are coming in the next decade, it is going to be incredibly cost-prohibitive to continue to be engaged in diesel. We are going to lessen the reliance on diesel substantially in the future.***

6. ***BMW : Diesel technology is important for meeting CO_2 targets, and we believe banning diesel vehicles is the wrong approach.***

7 . Duster /Renault : "Diesel is still dominant in Duster. For sure, the mix is lower, but that's also because we have very efficient petrol engines.

8. Lexus : We have our 2050 vision to reduce CO2 emissions by 90 per cent compared with the 2010 levels. "So electrification over diesel is not just something we've arrived at over the past 18 months; Toyota and Lexus – part of philosophy. "Right now, the market seems to be moving, yes. And let's be realistic: diesel is under pressure, not only in terms of sales but also on residual values, and so on."

9. Ford : "The whole industry is looking very hard at how it's balancing its investments in electrification with their investments in combustion engines. We've just launched our new EcoBlue diesel in the Transit, and on the passenger car side, we've introduced new generation of diesel in our EcoSport small SUV. "Will there be another generation of diesels beyond that? The new engines will last us a full cycle, so we have time to see how things develop. Let's wait and see. We think we're in a pretty good position because of our big investment in EcoBoost petrols."

10. JEEP : Diesel technology on the exhaust side has changed dramatically and will need to continue to change. But what also comes with that in the future is the cost of diesel compliance. Especially with many cities who are making statements about when they will stop diesel coming in."

11. Peugeot : They will hv petrol , diesel and Electric. Left the customers to choose. But will hv all models.

12. PSA Citrogen : Diesel is the best solution for keeping low CO2. we have several solutions: electric, plug-in-hybrid, diesel, petrol. We know that full electric on everything is not the best solution, even for the environment.

Market Dynamics

- CO_2 commitments not just by Government, but also by large customers such as Amazon, Flipkart, Jio, Shell etc.
- Large Investments in Green Energy > 10B by Reliance, investments by Public Sector firms like IOCL, GAIL etc.
- PLI schemes relevant to Automotive Industry – Battery cell ecosystem, Focus on BEV, Fuel Cell etc.
- CNG/LNG Pricing Policy by government (revised once in 6 months) and its implications.
- Investments in CNG/LNG by Governments and Private players, resulting distribution / availability etc.
- Vehicle scrappage policy.
- Shift of Market from Retail Customers to Fleet Customers (Key accounts).
- Regulations & Policy - Flex Fuels, Bio-Fuels, Fuel Economy, Safety (ADAS for example) etc.
- Customer Requirement - Bio Fuels, Increased Warranty etc.
- Increased Use of Railways for freight will compete with us (last mile connectivity is a challenge).
- Supplier/OEM partnership for value added services, customer oriented in New Technology Products like BEV, FCEV, etc.
- Market moving from Buying Product to Subscription model (Pay / km) (Different sales model)
- Price sensitive (value for money products) – Better service support.

Where is exhaust system functioning in purification of air ??

ASHOK LEYLAND

Vehicle's exhaust system we know

- **removes the harmful gases produced in engine,**
- **control noise**
- **treating gases and sending less harmful ones (Combustion time is less)**
- **improves engine performance and fuel consumption , by breathing (If quicker exhaust leaves , engine is free to take in more, fresh oxygen)**

Road & infrastructure : Challenging

Maintenance practices : Rudimentary.

Challenging environmental conditions: Vibration, Cleanliness, fuel/ lubrication quality.


What if, it can be re-written as..
Does only lockdown bring such a change?
Before
B S VI
After

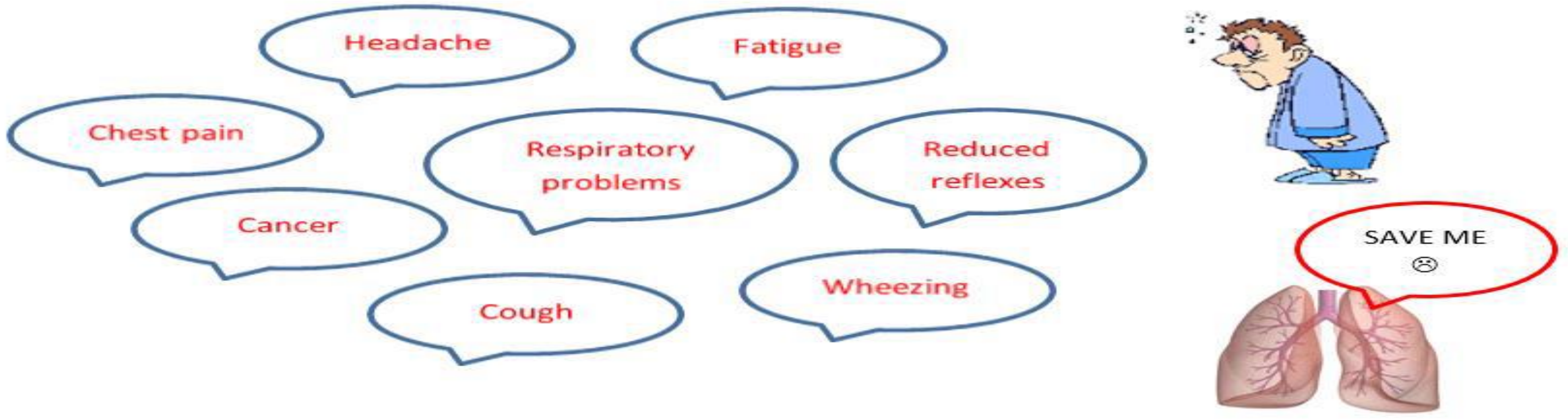
Need for Emission control

PAST…  PRESENT… 

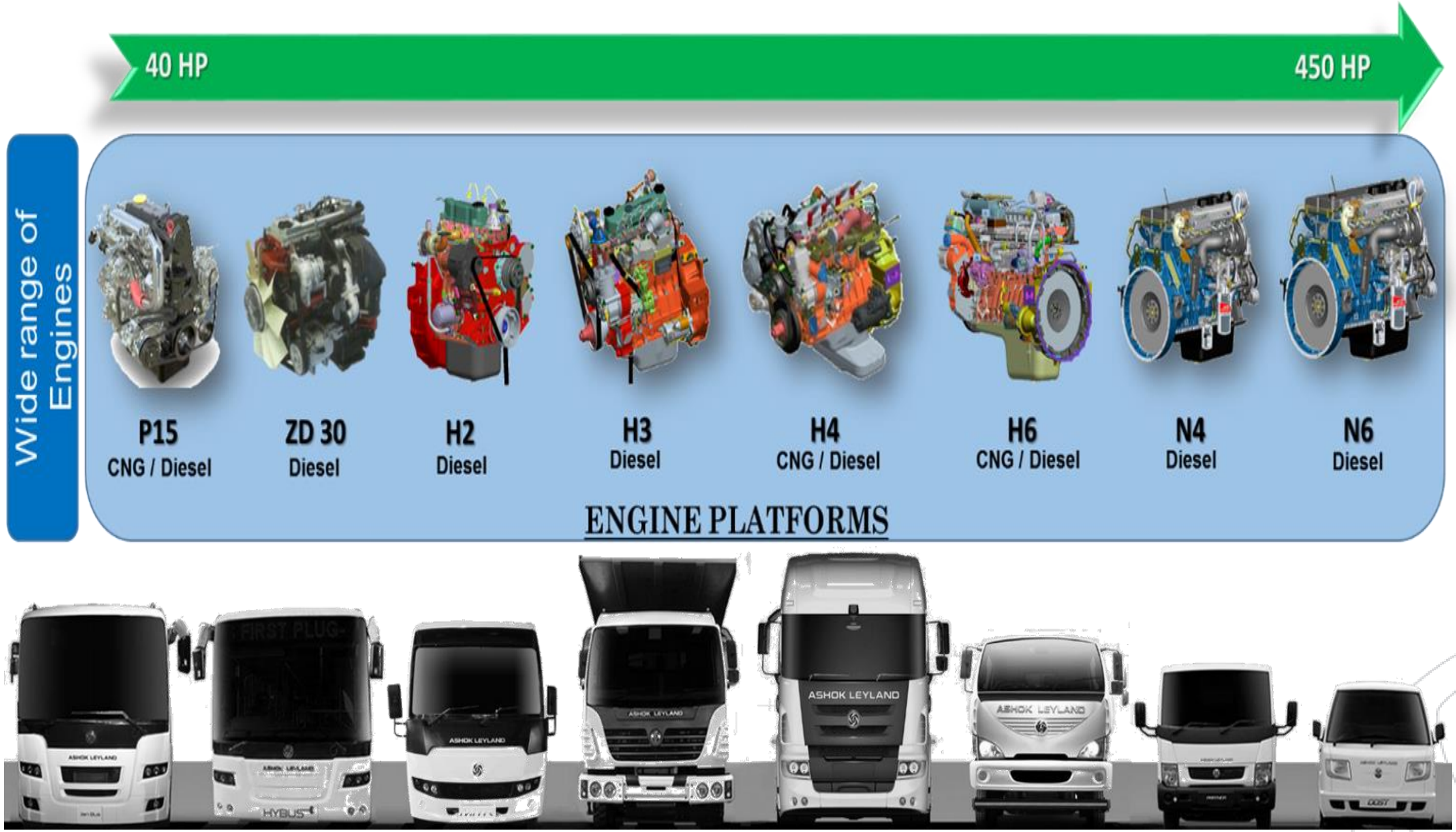
PRESENT…  FUTURE… 

Oxygen Banks?

HEALTH PROBLEMS due to the EXHAUST GASES

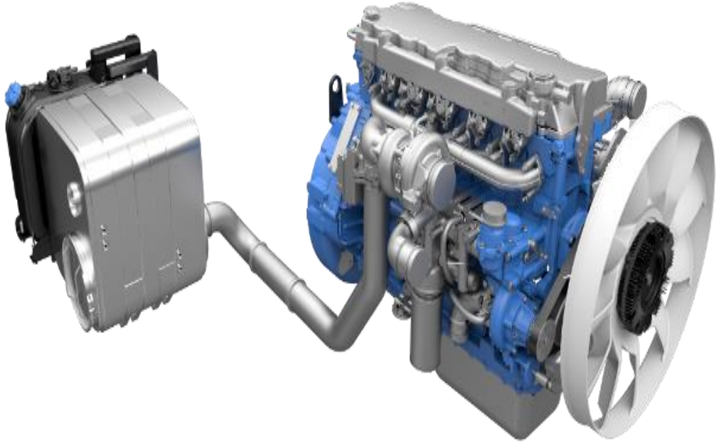


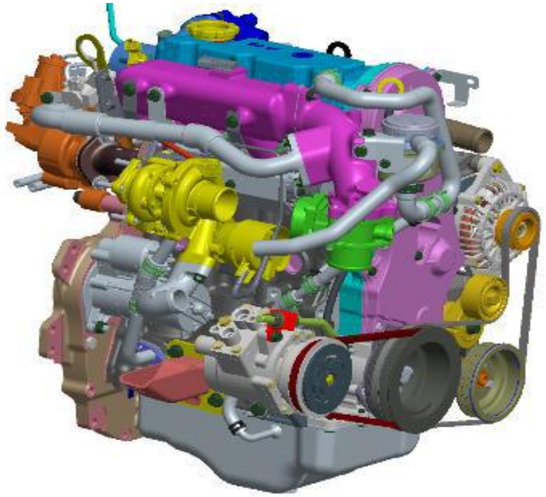
ASHOK LEYLAND



UNDERSTANDING EMISSIONS

ASHOK LEYLAND



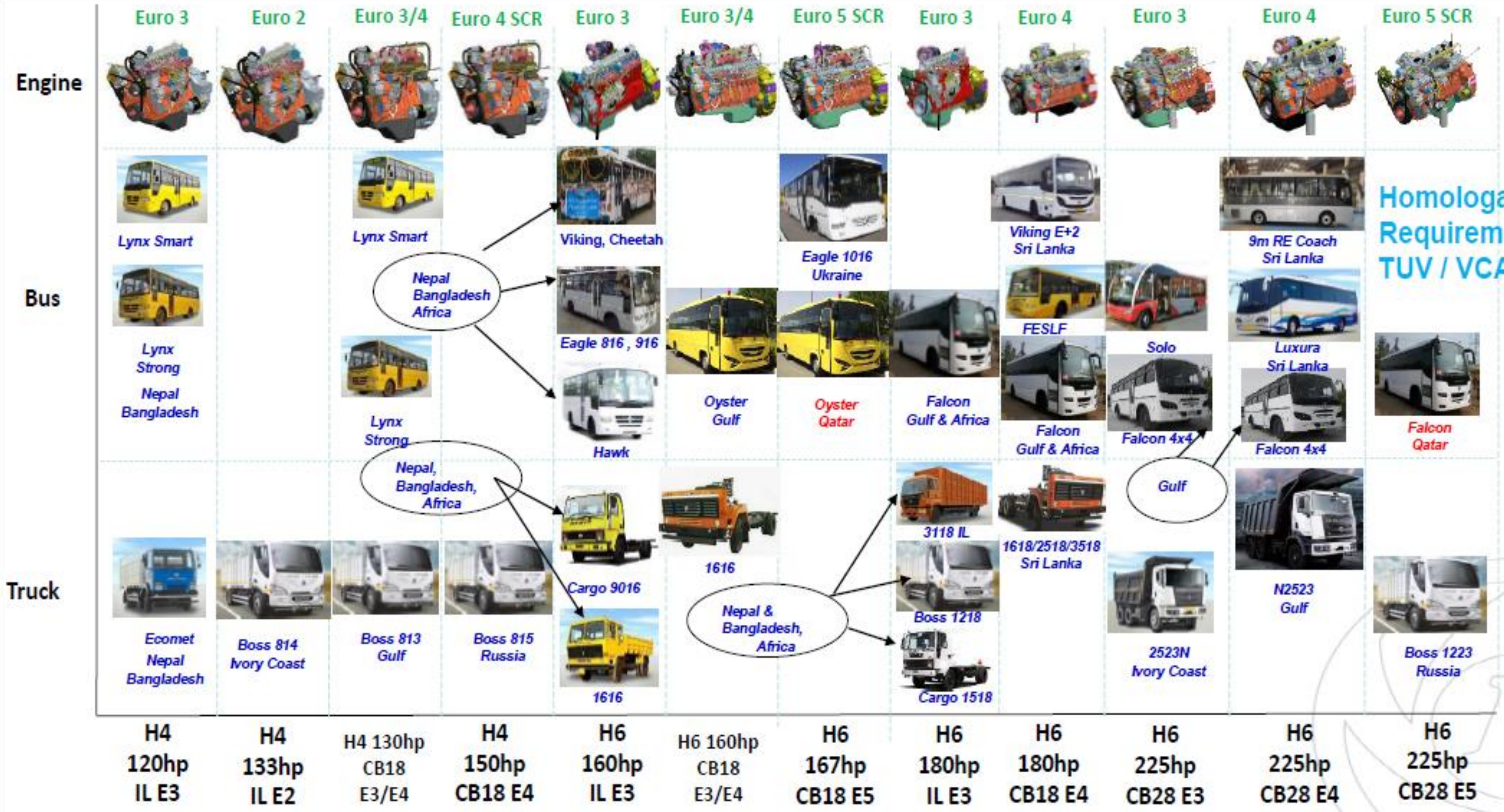


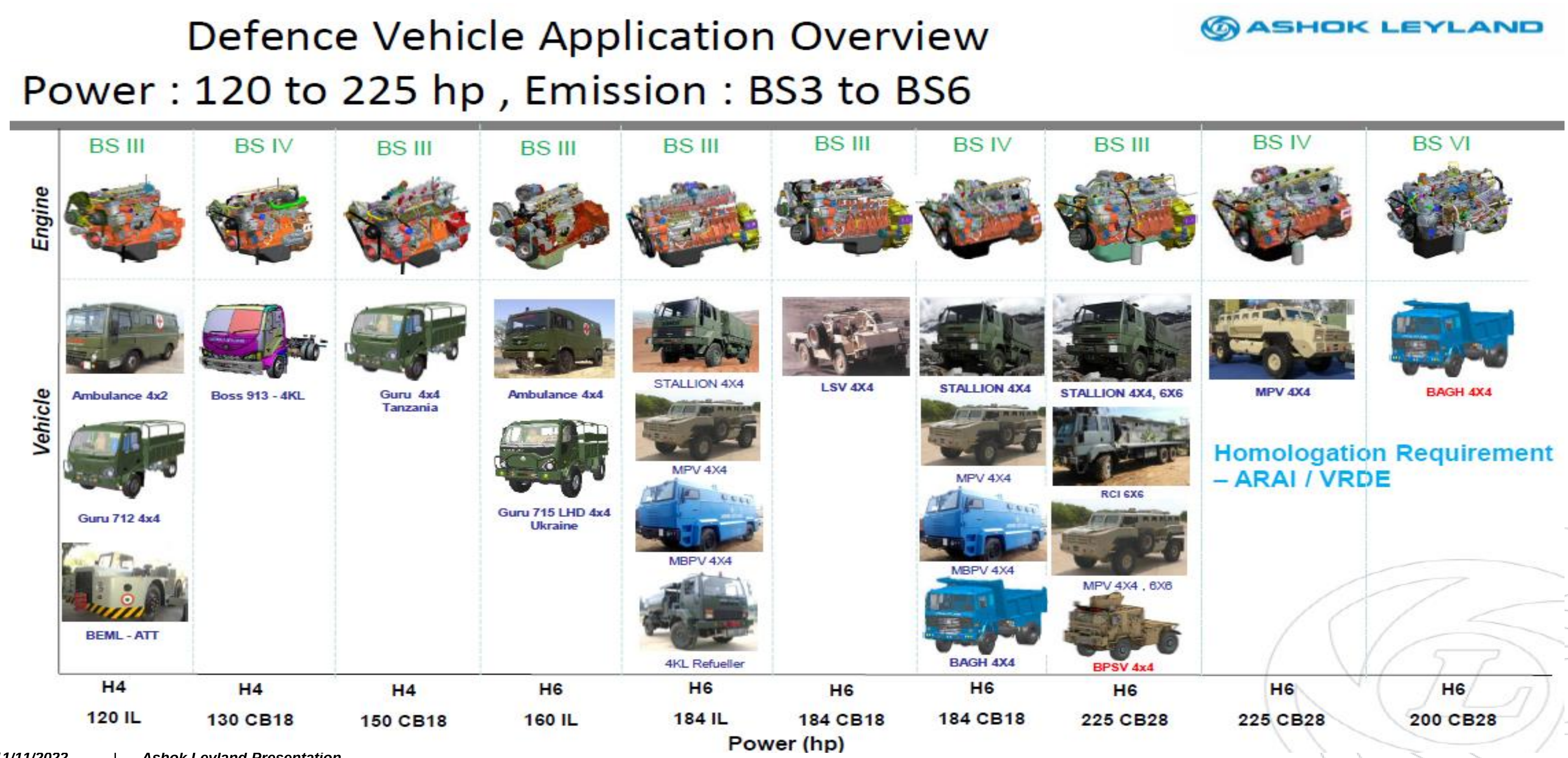
On-Road Engine Variants & Application

P15 70/80 HP 170/190 Nm	ZD 30 140 hp 360 Nm	H4 2V (12V) 150 HP 450 Nm	H6 2V 200 HP 700 Nm	H6 4V 230 hp 800 Nm	H6 4V 250 hp 900 Nm	N4 250 hp 900 Nm	N6 360 hp 1400 Nm
Dost 1.25 T Dost 1.5 T	Partner	E Comet Boss	MBP Truck 16 T to 40 T	MBP Truck – G91 Cab, 25 T to 49 T	MBP Truck – G91 Cab, 25 T to 49 T	MBP Truck - 25 T to 49 T	MBP Truck - 49 T
Phoenix under testing	MiTR	Lynx Smart Strong Sunshine	MDV Bus E+2, E+3	MDV Bus E+2, E+3	ULE, JAN Bus, SLF, MDV Bus - E+2, E+3	ULE, JAN Bus, SLF, MDV Bus - E+2, E+3	Coach Bus

Export Vehicle Application Overview

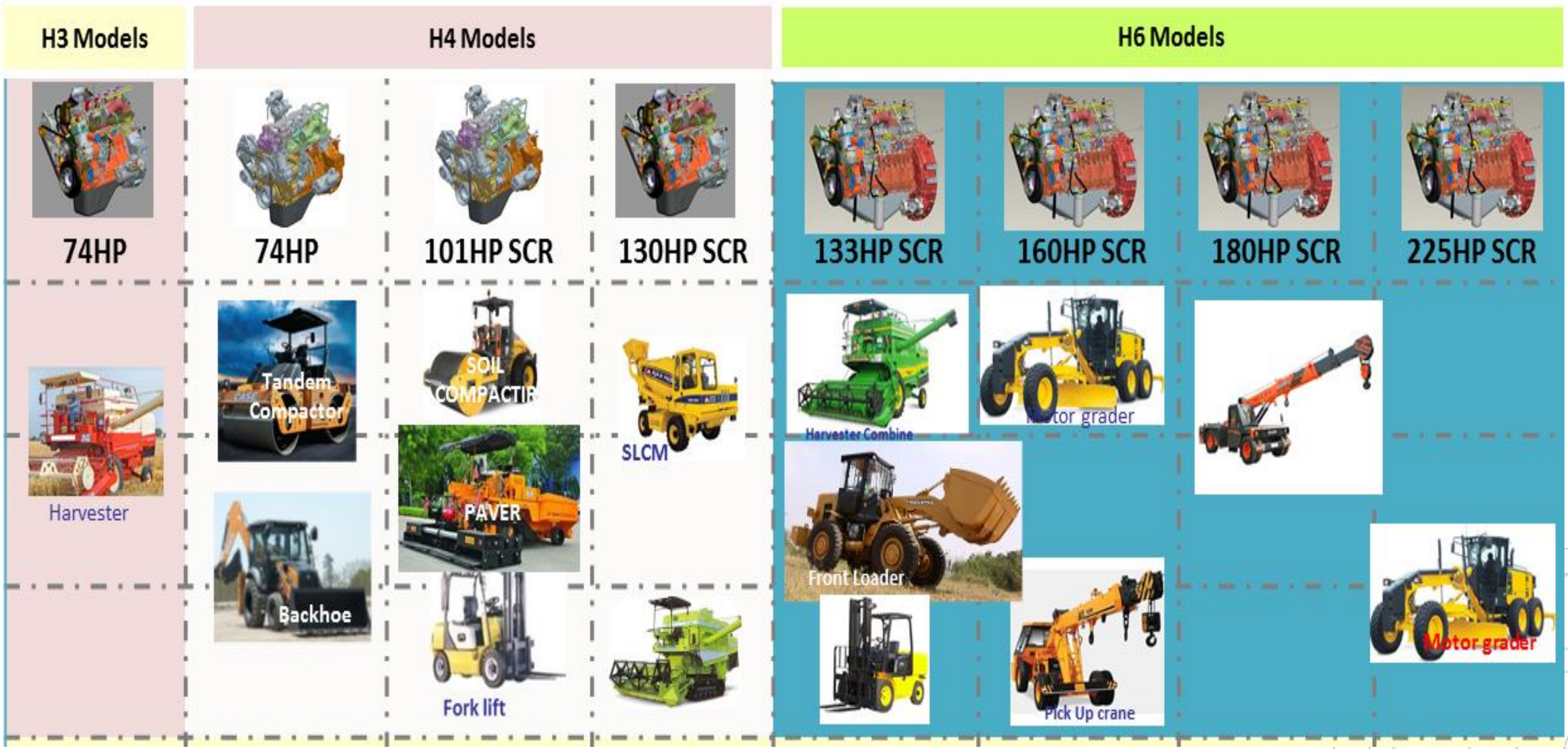
Power : 120 to 225hp , Emission : Euro 2 to Euro 5





Defence Vehicle Application Overview
ASHOK LEYLAND
Power : 120 to 225 hp , Emission : BS3 to BS6
Engine
Vehicle
BS III
BS IV
BS III
BS III
BS III
BS III
BS IV
BS III
BS IV
BS VI
Ambulance 4x2
Guru 712 4x4
BEML - ATT
Boss 913 - 4KL
Guru 4x4 Tanzania
Ambulance 4x4
Guru 715 LHD 4x4 Ukraine
STALLION 4X4
MPV 4X4
MBPV 4X4
4KL Refueller
LSV 4X4
STALLION 4X4
MPV 4X4
MBPV 4X4
BAGH 4X4
STALLION 4X4, 6X6
RCI 6X6
MPV 4X4 , 6X6
BPSV 4x4
MPV 4X4
BAGH 4X4
Homologation Requirement – ARAI / VRDE
H4 120 IL
H4 130 CB18
H4 150 CB18
H6 160 IL
H6 184 IL
H6 184 CB18
H6 184 CB18
H6 225 CB28
H6 225 CB28
H6 200 CB28
Power (hp)

Off Road (Power Solutions Business)

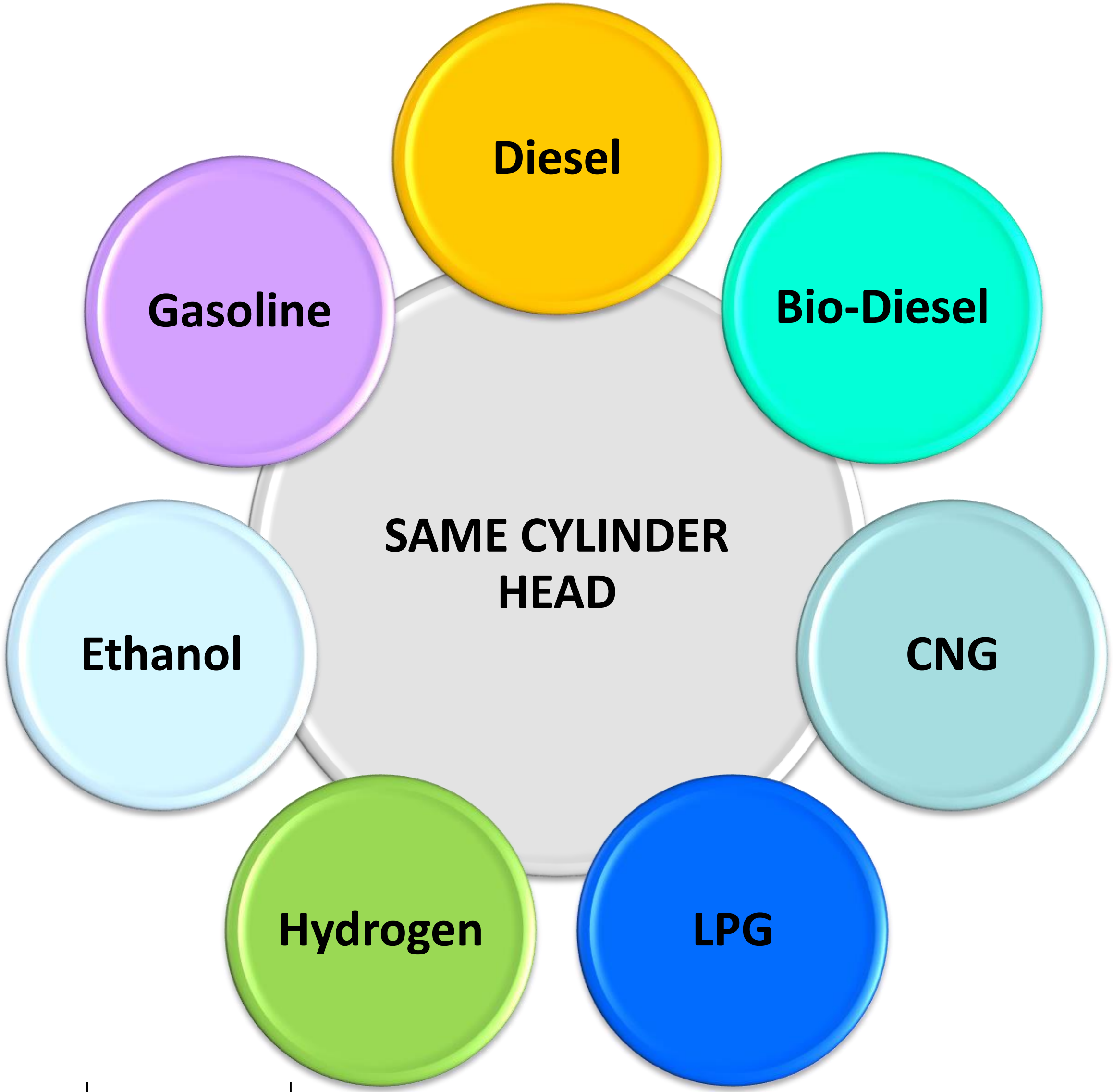


Engine + EATS Configuration of Various OEMs

Manufacturer	Engine	Displacement	Fuel Injection	Turbocharger	EGR	SCR	DPF	Urea consumption
		L						% of fuel
DAF	MX13	12.9	CRS (2500 bar)	VGT	Cooled	Yes	Yes	~3% est.
	MX11	10.8	CRS (2500 bar)	VGT	Cooled	Yes	Yes	~3% est.
Cummins	ISB	4.5/6.7	CRS	VGT	Cooled	Yes	Yes	~3% est.
Iveco	Tector4 /6	4.5/6.7	CRS (1800-2000 bar	VGT or WGT	None	95-99%	Yes	Up to ~8%
	Cursor9 /11	8.9/11.1	CRS (2200-2400 bar)	VGT or WGT	None	95-99%	Yes	Up to ~8%
	Cursor13	12.9	CRS (2200-2400 bar)	VGT or WGT	None	95-99%	Yes	Up to ~8%
MAN	D0834/D0836	4.6/6.9	CRS (1800 bar)	2-St. or WGT	Cooled	~90%	Yes	2%~3% est.
	D20/D26	10.5/12.4	CRS (1800 bar)	2-St. or WGT	Cooled	~90%	Yes	2%~3% est.
Mercedes Benz	OM934 /6	5.1/7.7	CRS	2-St. or WGT	Cooled	Yes	Yes	~3% est.
	OM470 /1	10.7/12.8	ACRS (2100 bar)	Asym. TC	Cooled	Yes	Yes	~3% est.
Scania	DC9/DC13	9.3/12.7	XPI CRS (2400 bar)	WGT	None	95-99%	Yes	Up to ~8%
	DC9/DC13	9.3/12.7	XPI CRS (2400 bar)	VGT	Cooled	Yes	Yes	3%~4% est.
	DC16	16.4	XPI CRS (2400 bar)	VGT	Cooled[a]	Yes	Yes	3%~4% est.
Volvo/Renault	MD5/MD8	5.1/7.7	CRS	WGT	Cooled	Yes	Yes	~3% est.
	D11K	10.8	CRS	WGT	Hot	>95%	Yes	~6%
	D13K	12.8	EUI (2-sol.)	WGT	Hot	>95%	Yes	~6%
	I-Torque D13	12.8	CRS (F2)	WGT	Cooled	Yes	Yes	~3% est.
	D16K	16.1	CRS (F2)	2-St.	Cooled	Yes	Yes	

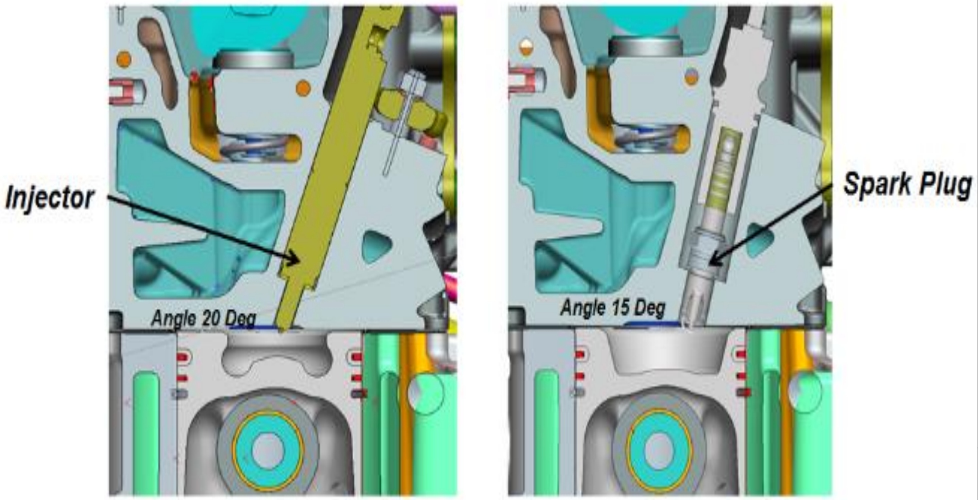
[a] 537 kW rating only. Ratings 478 kW and lower did not use EGR.

IC Engines to be made Fuel Agnostic



- Engine Design for Multi-Fuel configuration.
- All component below cylinder head remains same.

By introducing a spark plug provision, Multi Fuel Capability was introduced thereby bringing innovation and addressing sustainability

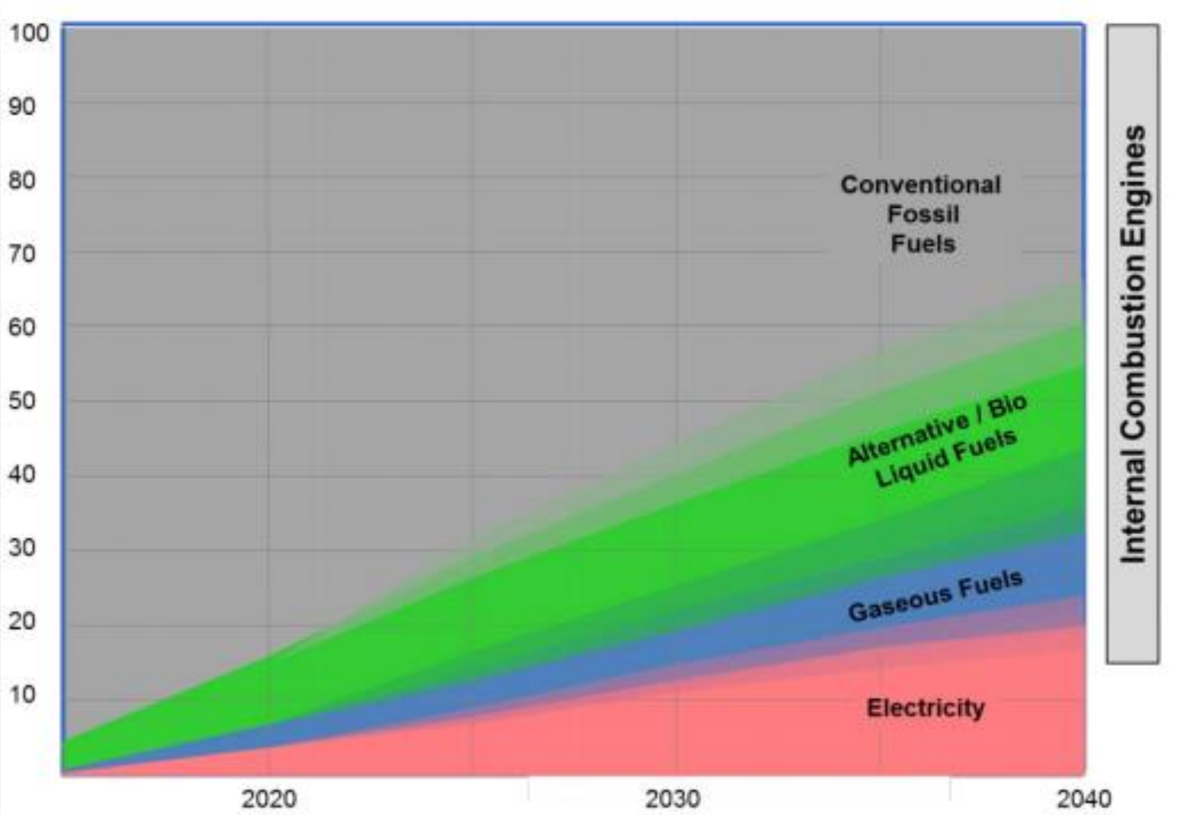


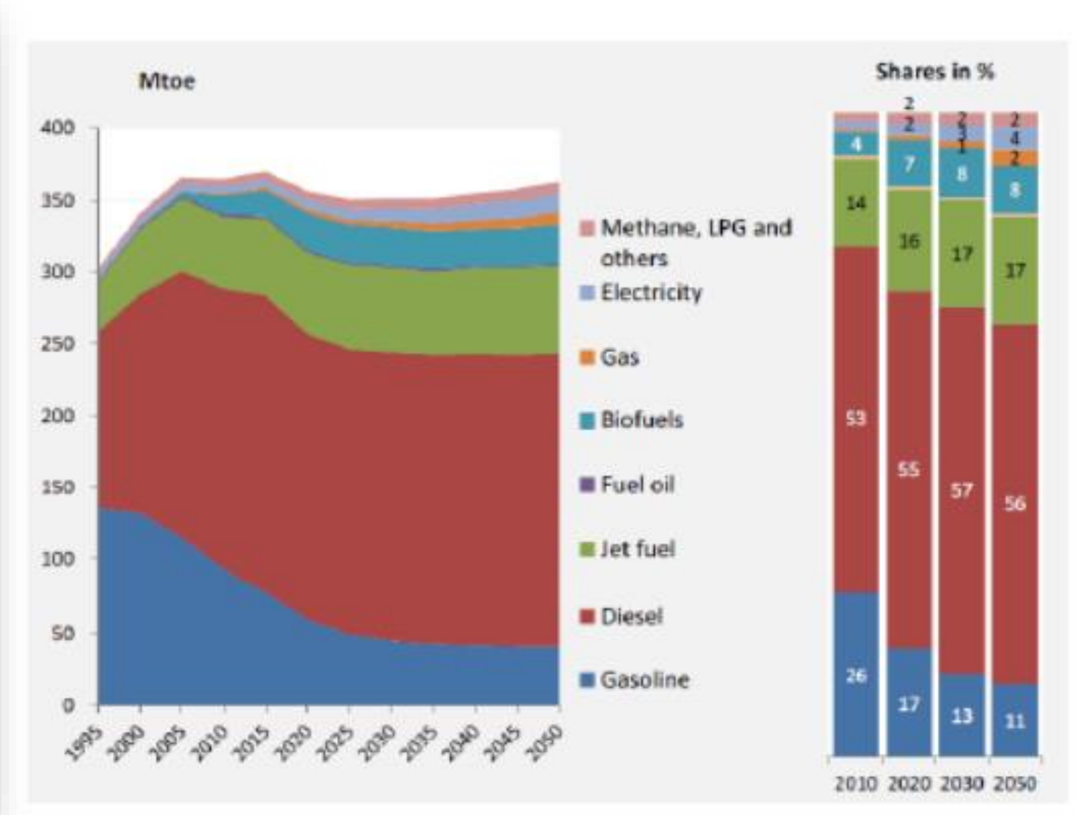
Parameter	Compression Ignition	Spark Ignition*
Casting	Diesel Version	<--
Machining	Injector Body and Nozzle Bore	Spark Plug Bore Drill and Tap

**Pentafuel capability*

Non fossil fuels and electric vehicles for future

ICE Vehicle Trend 2050





Major percentage of the commercial vehicle based on the viability of maintenance and durability, shows that ICE will be of the major share.

Hence continuous investment and development towards the higher brake thermal efficiency is inevitable

OUR MISSION AS AN INDEPENDENT COMPANY IS CLEAR

RESET PROFITABILITY

- Intense focus on fixing Europe
- Target profit benchmarks in each region
- No excuses: every region must deliver
- Grow services rapidly
- Commitment to strong shareholder returns

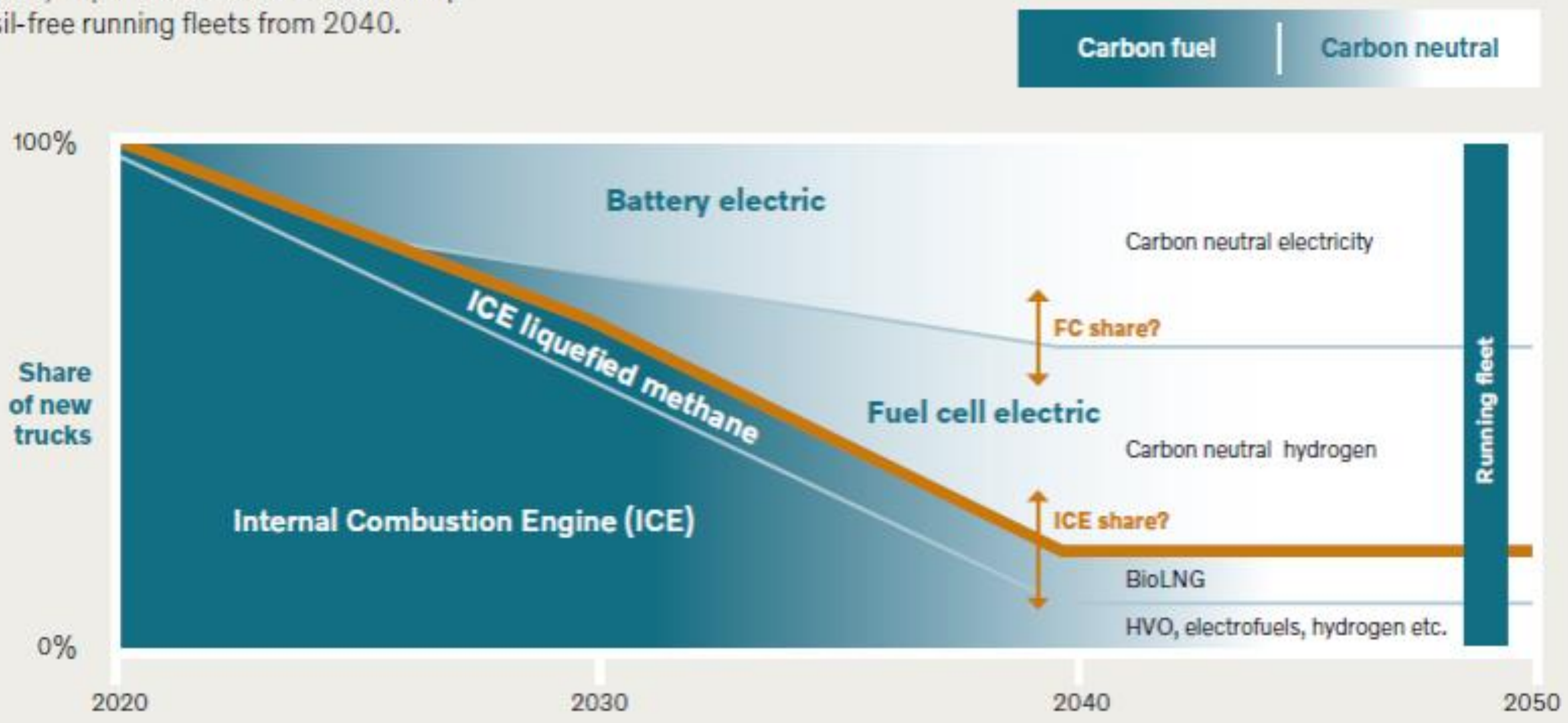
LEAD THE WAY TO ZERO EMISSIONS

- Seek cost and performance leadership
- Dual-track BEV and FCEV strategy
- Refocusing of R&D activities
- Kick-start infrastructure
- Sundown ICE with partners

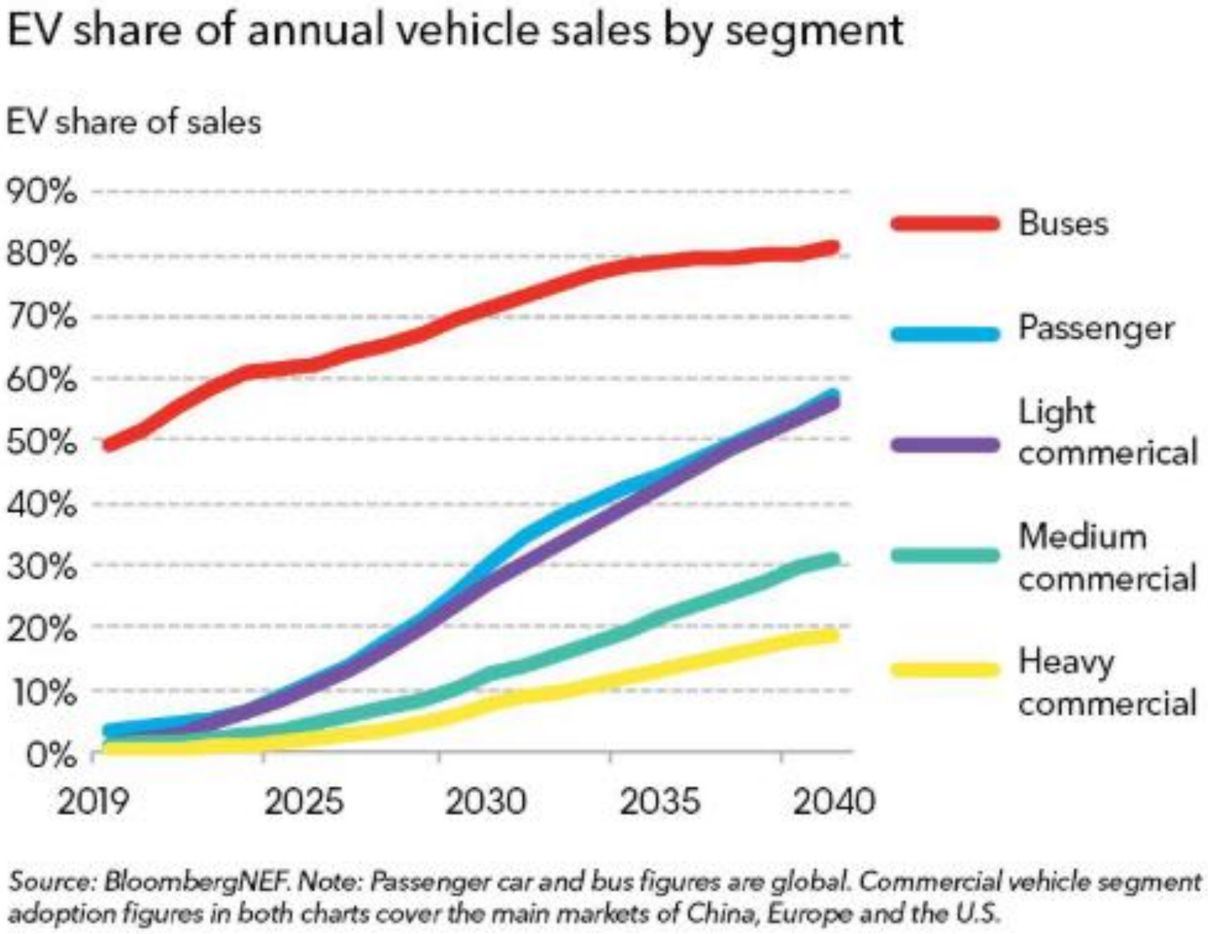
IN PURSUIT OF PROFIT AND TECHNOLOGY LEADERSHIP

Illustrative scenario for 1.5°C

In this scenario, all products from the Volvo Group enable fossil-free running fleets from 2040.

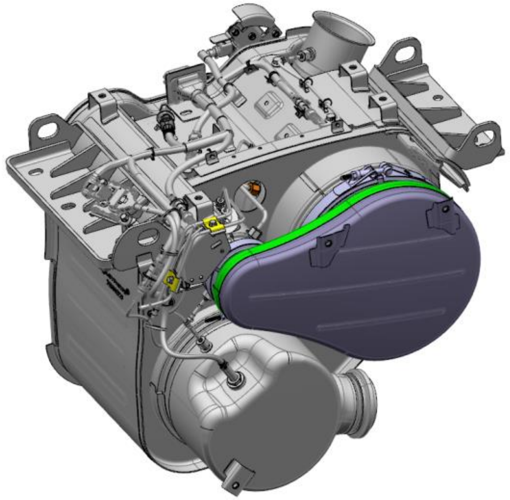


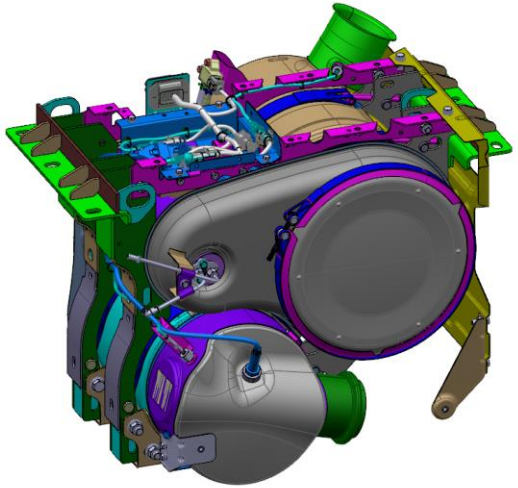
EV impact on Heavy Commercial vehicles

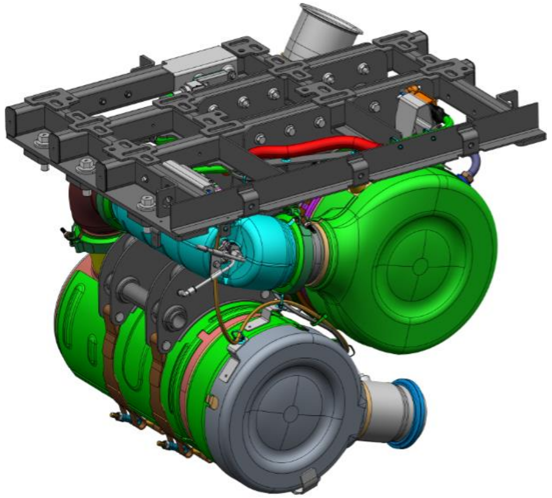


- **EV share on Heavy commercial vehicles will be lower.**
- **Need to focus on ICE efficiency improvement to meet CO_2 norms in near term.**
- **Alternative / renewable fuels technology is simple and viable option to meet lower emissions and CO_2 norms.**

BS VI EATS Developed by AL

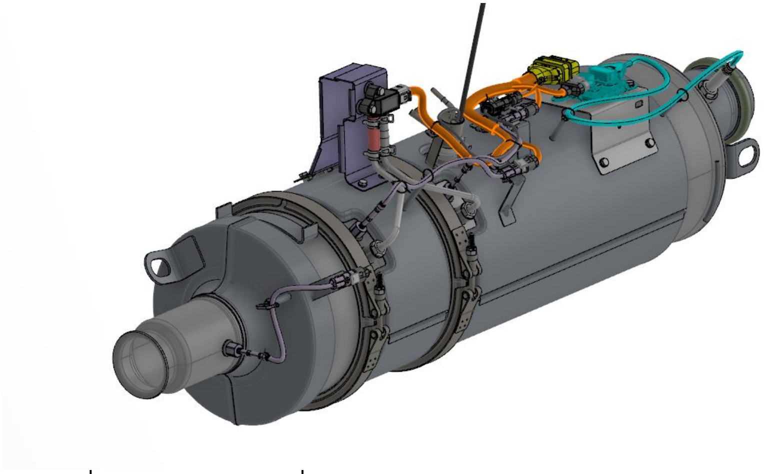


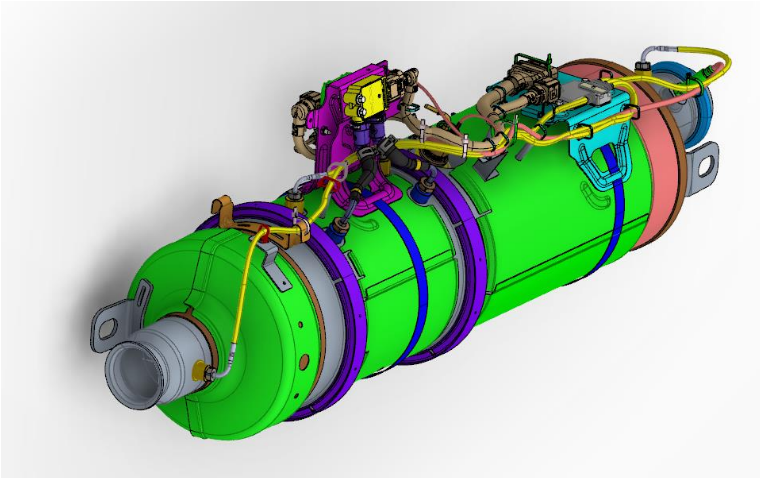




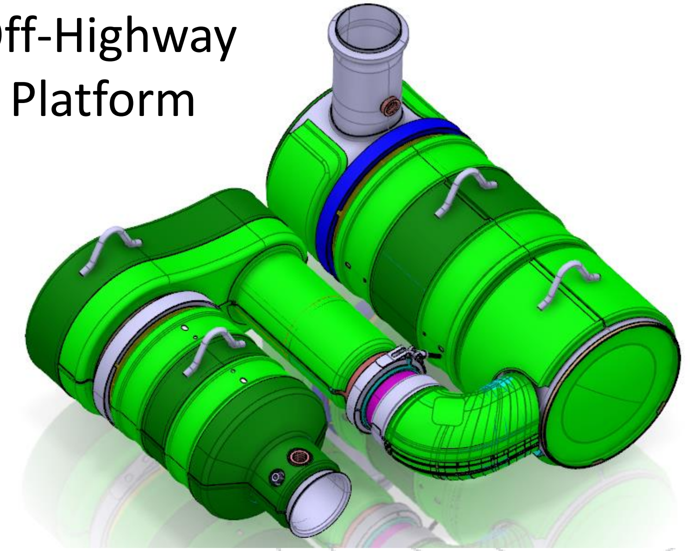
M&HCV Platform

ICV Platform





Off-Highway
Platform



Euro VI EATS from Various OEMs If we continue to use Diesel as fuel for future

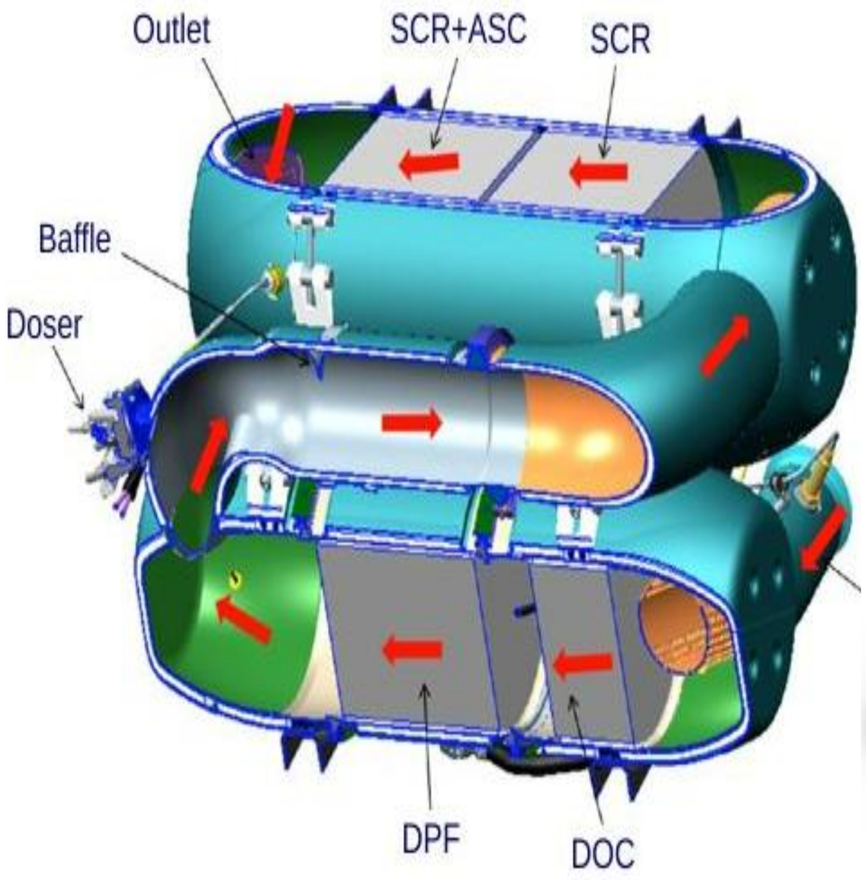


Figure 20. Aftertreatment system for Cummins Euro VI MidRange

(Source: Cummins)

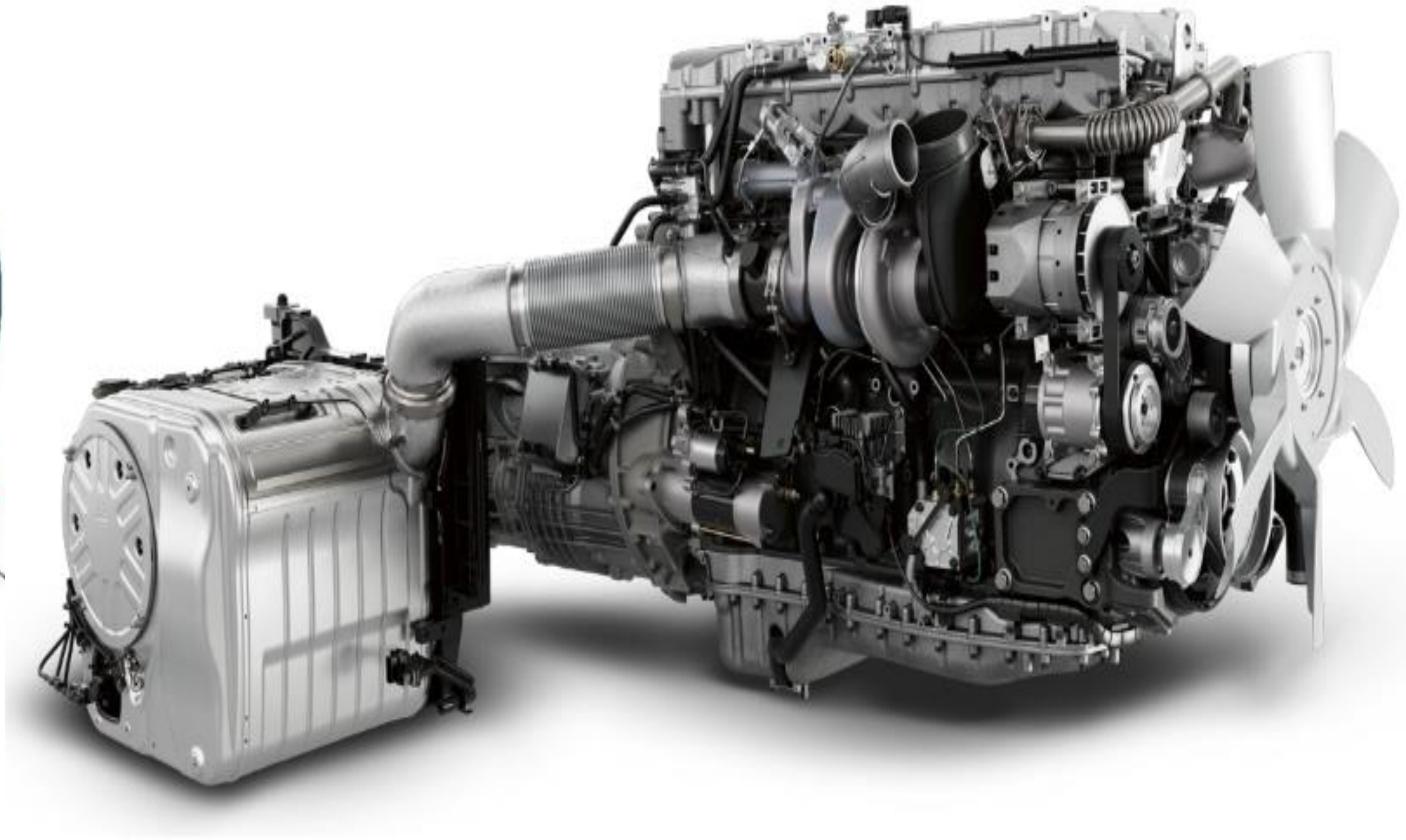


Figure 7. Navistar's S13 Integrated Powertrain

(Source: Navistar)

Euro VI EATS from Various OEMs (Diesel)

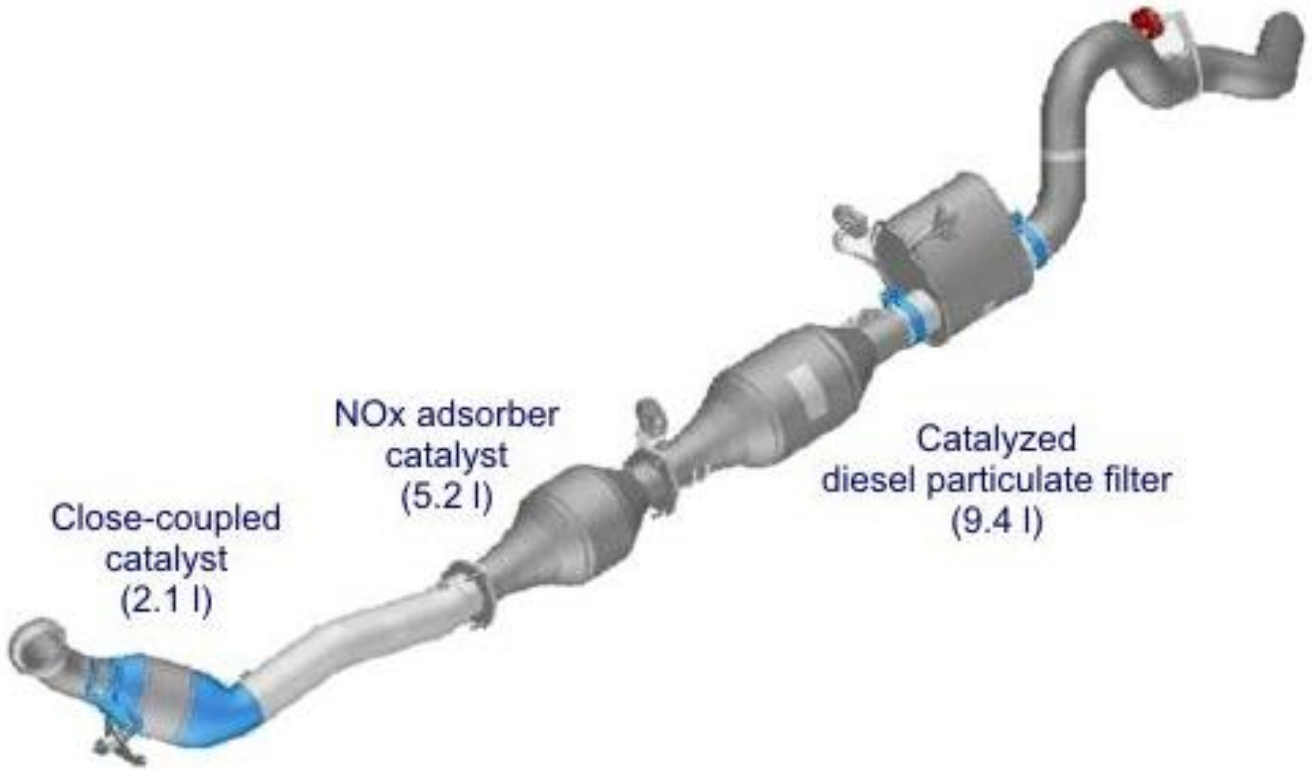


Figure 1. Schematic of exhaust system in 2007 Dodge Ram with 6.7 L Cummins engine

Drivers for Future Mobility

- Urbanization , Smart cities , 5G , Economic growth .. Mobility model ..Function of price ..(BEV,FCEV)
- Purchase/sale decisions by digital …Default is digital (used cars/trucks sale by digital)
- Climate change needs …decarbonize , reduce congestion , no pollution, clean air etc.
- Consumerism shift ………no ownership , connected /shared
- Technology ..new business models to save cost and improve efficiency

S.No	Old game	New game
1	Volume	Value (Mobility solutions)
2	Product focus	Service focus (prognosis/digital twin)
3	Customer owns	Customer uses (Pay by Km)
4	Personified (owner driven)	Shared vehicle
5	Market economy (inhouse innov)	Autonomous (software driven)
6	Mechanical engineers lead	Software engineers lead (platform economy)
7	Linear production	Circular economy

Automotive Mission Plan 2026

- Automobile industry will grow to 12 million.
- Policies : Fuels, emissions, safety, inspection, EOL, taxes, Infrastructure, skill etc.
- Charging infra, alternate fuels, safety… huge business opportunities ahead.
- Mobility becomes easier, flexible, customized, only usage than owning.
- EVs …massive network , Dynamic price, user centered, integrated and convenient.
- Earlier …energy companies were big like Exxon mobil , GE, Shell etc.
- Now… Google, Apple, Microsoft, Amazon, FB etc. are big.
- Commuting time avg.. 1 to 2 hrs. to be utilized… around billion dollars wasted in traffic.
- Circular economy.. Reuse, Recycle, Reduce wastage.

Difference between NA, EU and India approach

Regulatory and market differences between North America , Europe , India makes , general **aftertreatment architecture is similar**, but **the detailed technical solutions are different**

- The NOx limit for Euro VI is 0.4 g/kWh while for US 2010 it is 0.20 g/bhp-hr (0.27 g/kWh).
- Euro VI limits particle number (PN) emissions, while US EPA regulations do not.
- European trucks typically have the engine located underneath the cabin, rather than in front of it, as in North America. This creates challenges related to space.

The higher NOx limits for Euro VI means that at SCR conversion efficiencies above 95%, a European engine can operate at ~32% higher engine-out NOx levels and provide more potential to optimize the engine for better performance and fuel economy compared to US 2010 engines. The higher NOx limit allowed some Engines to certify without EGR for Europe, India.

Vanadia catalysts not being discussed for India though its was used for Euro VI applications.

For Euro VII (probably) , dual SCR or EGR plus SCR can be tried.

Control system is key and PN emission is critical

Difference between NA, EU and India approach (contd.)

- The ability of a DPF to comply with the Euro VI PN limit depends on its soot loading. When completely clean, a high-porosity DPF could allow sufficient particles to pass it to exceed the PN limit. However, as soot accumulates in the DPF, the filtration efficiency increases, and small particles are more effectively trapped.
- For Euro VI applications, a minimum soot accumulation on the DPF is required to control PN emissions and aggressive thermal regeneration events must be minimized.
- With the introduction of PN limits for In-Service Conformity (ISC) at the Euro VI-E stage, the issue of particle break-through during passive regeneration has also been raised. In this case, the filter is not completely clean, but it is believed the absence of sufficient particulate in the DPF wall can lead to the release of sufficient particulate to potentially exceed the PN limit during ISC testing. The issue is not entirely understood.
- In European heavy-duty on-road applications, less space is available on the vehicle. Frontal area available for air-cooled heat exchangers also less , so engine heat rejection needs to be minimized. Compared to North American applications, lower EGR rates (and higher engine out NOx) are common to reduce the amount of heat transferred to the engine coolant. (box-shaped.)
- For this reason, the fuel tank, air cleaner, urea tank and aftertreatment systems, are typically designed to fit into these box-shaped spaces. North American heavy-duty on-road application by contrast, tend have longer, cylindrical shaped spaces on the chassis that leads to aftertreatment systems that fit into these longer cylindrical spaces. India is compromised in between shapes.

Only SCR Vs EGR + SCR – To be Optimized for TFC

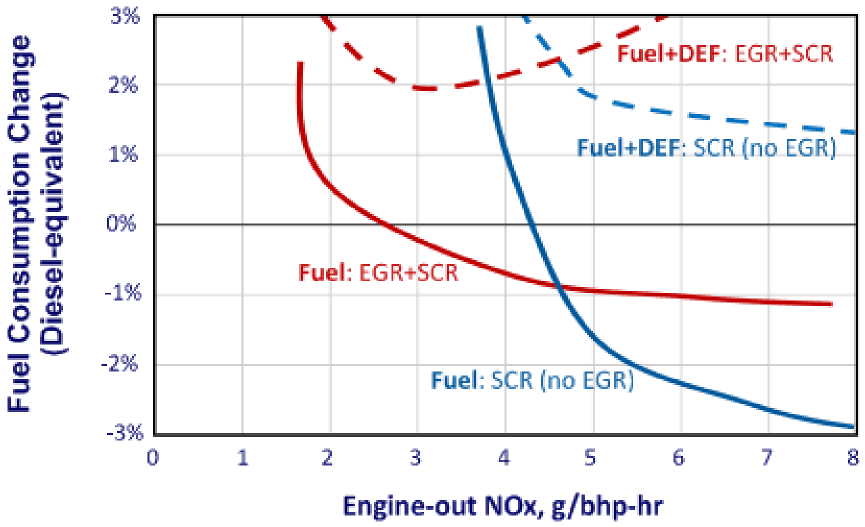


Figure 17. Relative fuel and urea (DEF) consumption with and without EGR

DEF to diesel cost ratio = 0.66

Source: Diese

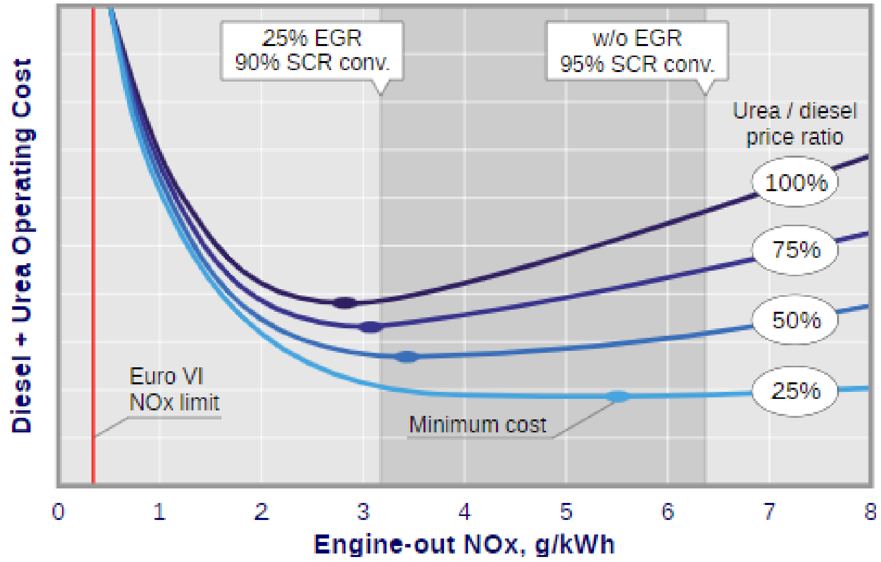


Figure 21. Engine-out NOx estimation for different urea/fuel price ratios

- Increased NOx conversions require increased consumption of urea (diesel exhaust fluid, DEF) that can offset the savings in diesel fuel consumption and create significant OBD challenges.
- Total Fluid Consumption (TFC) in engines utilizing EGR and SCR is minimum at engine-out NOx in the range of 4 – 5 g/kWh.
- Increasing engine-out NOx above this level causes an increase of the TFC and thereby operational costs.
- Difference in urea/diesel fuel price ratios would lead to different optimizations of engine-out emissions as shown in Figure 21 for Europe. In India, the DEF to Diesel cost ratio ~ 0.88.

Alternate Fuels – Current Scenario

Battery electric:

- EVs are likely to be the superior technology in distribution and in city-centric use cases.

Hydrogen/Fuel cell:

- Strong contender, in particular in heavy-duty transport, segments that require long range and high utilization.
- Key barriers to adoption are the required scale-up and industrialization along the value chain (e.g., of electrolyzers, fuel cell stacks) and the chicken-and-egg problem of establishing the refueling infrastructure and bringing models to market.

CNG/LNG:

- CNG/LNG prices fundamentally depend on underlying raw material prices and are thus as exposed to market cyclicalities as diesel.
- CNG/LNG can be regarded as a bridge technology, towards net zero transition.

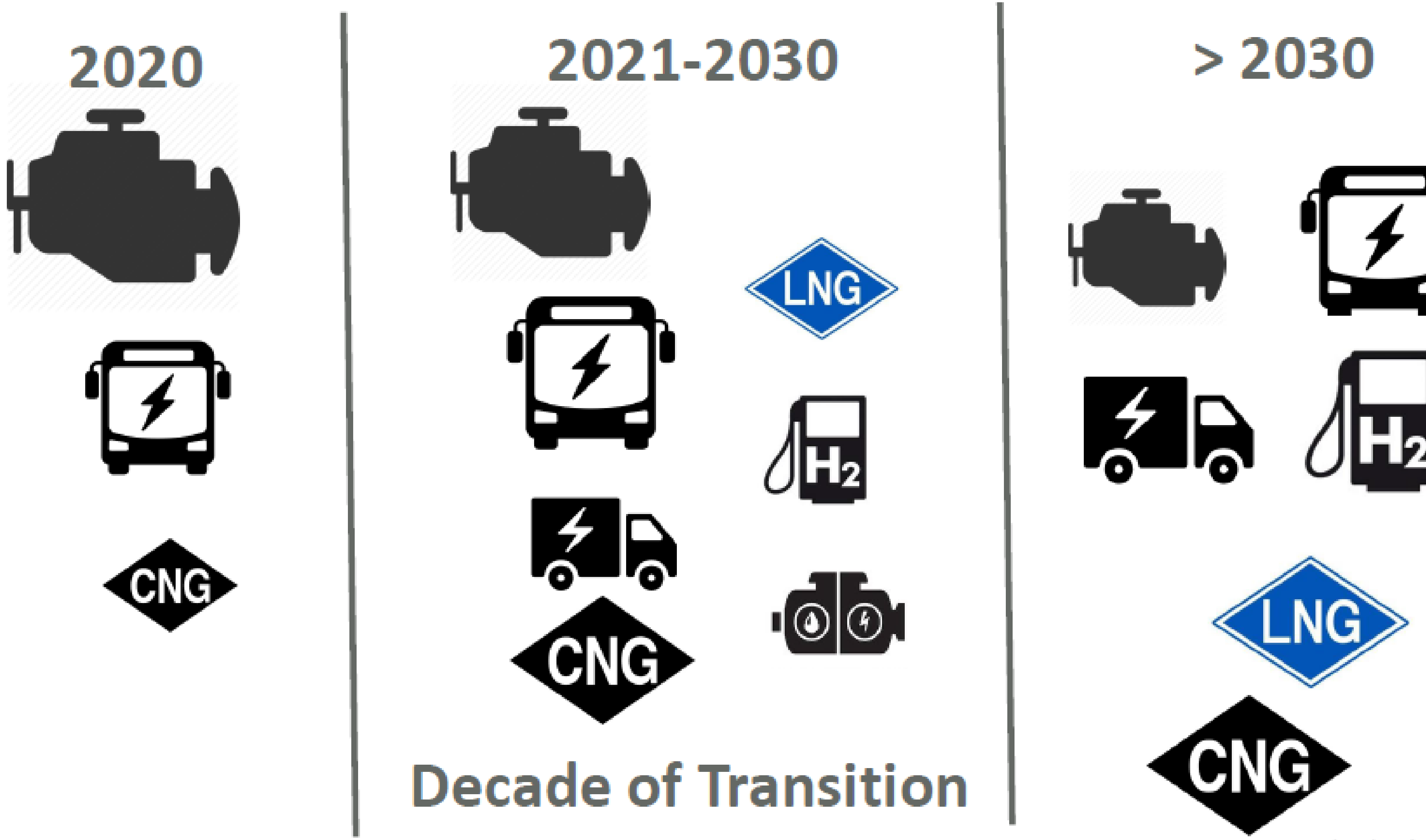
Biofuel:

- Predictions on the TCO delta vs diesel are highly volatile as they depend on the underlying raw material
- prices and taxation.
- From a well to wheel perspective, it remains questionable whether biofuels provide a net advantage over diesel.

Synthetic diesel (e-diesel):

- E-diesel (i.e., synthetic fuels produced from carbon dioxide and water) are still far away from being an economically viable alternative to diesel.
- Energy used to produce 1 liter of e-diesel is seven times less efficient than if the same amount of energy were to be used in a BEV directly.

Decade of Energy Transition



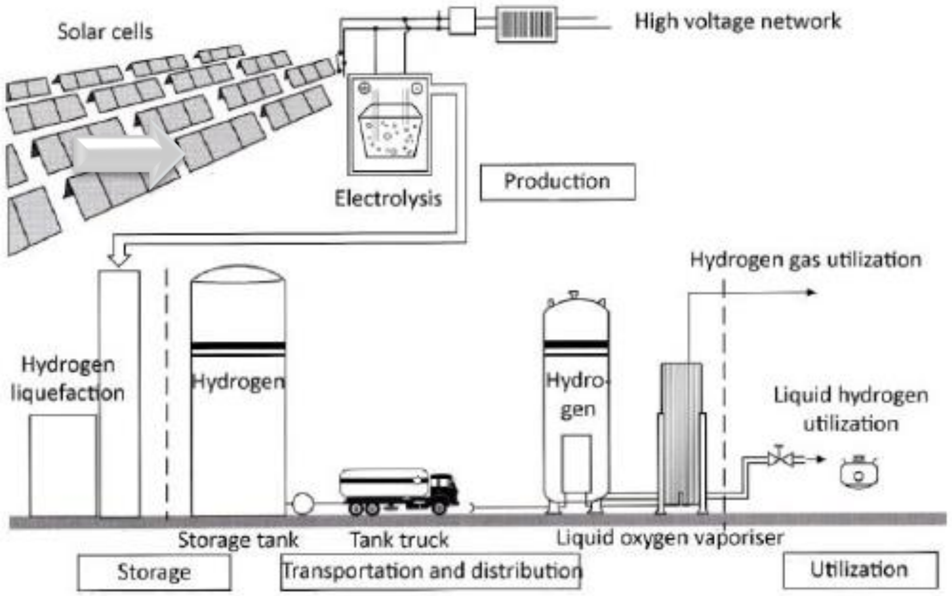
Opportunities with Hydrogen ICE

Renewed interest in H_2 based IC engines has been seen due to the following reasons:

- Efforts towards de-carbonization and tightened emission standards
- Advanced H_2 production technology (ex; solar thermo-chemical process)
- Advancement in usage (ex: high pressure DI technology)
- Advancements in storage technology => High pressure storage technology (up to 700 bar)

Large scale centralized hydrogen production (renewable electricity, biomass & nuclear power options are used)

Hydrogen can be transported over long distances by pipelines and trailers.



Renewable energy source

Zero CO_2

Infrastructure expected to be in place by 2023!

Promising Hydrogen ICE

	DIESEL	ELECTRIC	FUEL CELL	H_2 ICE
Costs	✓	✗	✗	–
Driving Ranges	✓	✗	✓	✓
Payload	✓	✗	–	✓
Reliability	✓	–	–	✓
Service Life	✓	–	✗	✓
Climate Protection	✗	–	✓	✓
Air Pollution Control	–	✓	✓	✓

Comparison: Reference Diesel

Assumptions: Lifecycle: 1.000.000 km (100.000 km / year) H_2-Price: 5 €/kg

	Diesel	Battery 500	Fuel Cell	H_2-ICE
Purchasing Price	80.000 €	x 8.6 times	x 7.5 times	x 2.6 times
TCO	822.000 €	x 1.7 times	x 2.3 times	≈ Diesel

- H_2 ICE scores better as compared to Diesel, Electric and Fuel cell counterparts on various aspects.
- Cost scores lower as a total system due to hydrogen storage system and cylinder cost.

Explore Advanced After-Treatment Technologies

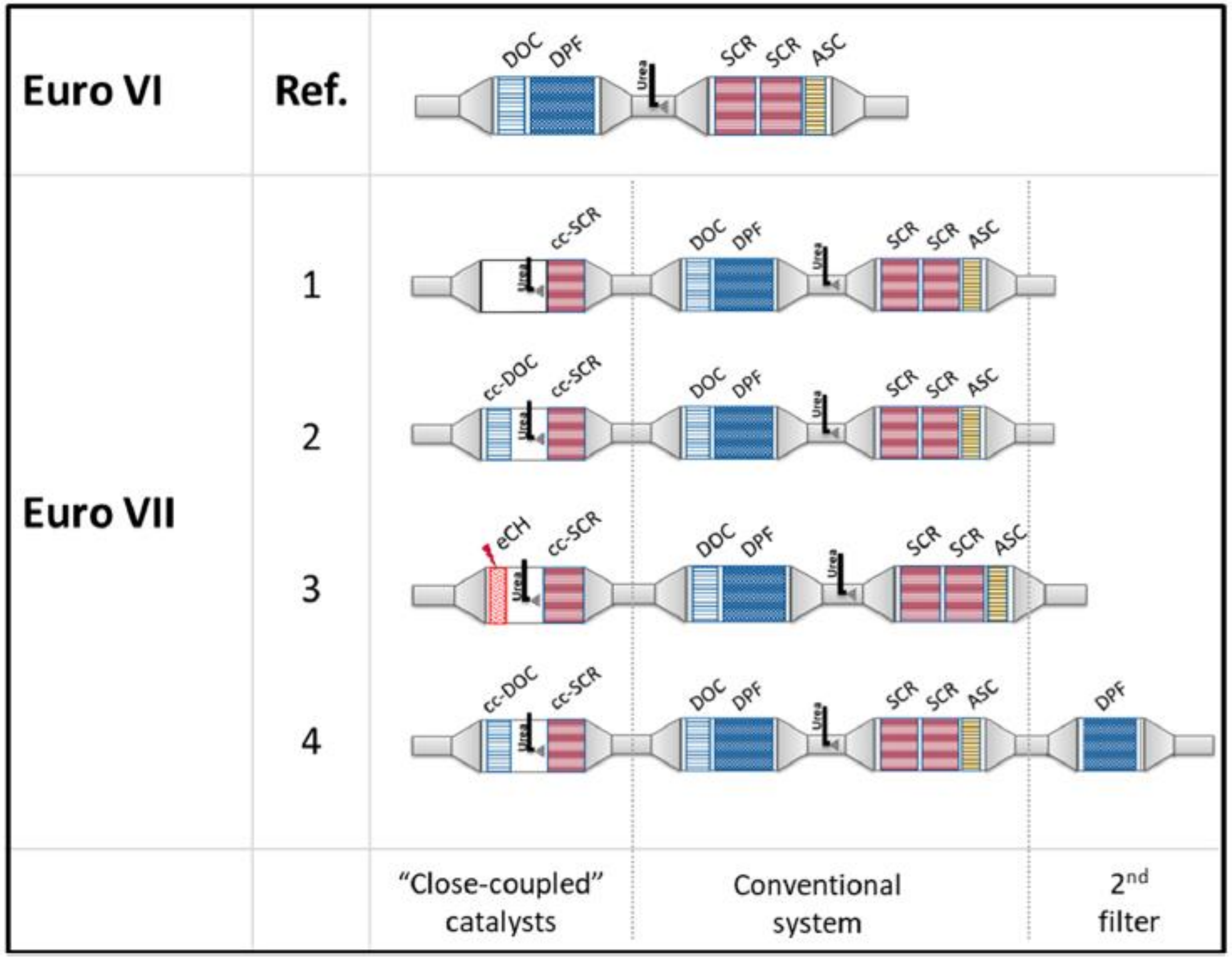


Fig. 4. Typical generic EUVI and potential EUVII aftertreatment architectures.

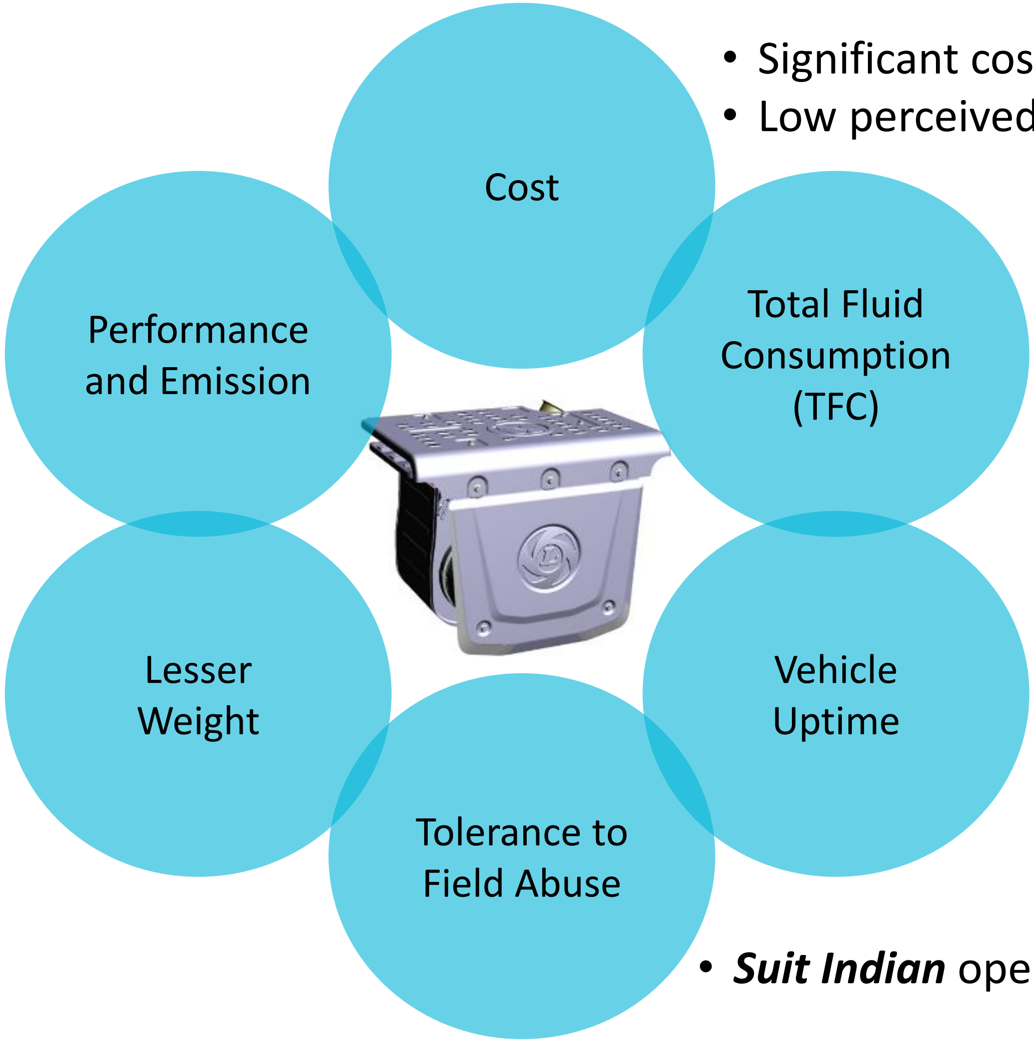
https://doi.org/10.1016/j.treng.2022.100129

- New substrate technologies – low thermal expansion, increase in cell density, more specific surface area, enhanced heat and mass transfer, reduction in the web thickness to maintain thermal mass and low pressure drop.
- New filter technologies - lowest coated pressure drop combined with high filtration efficiency.
- New electric catalyst heaters – improve cold start performance, low energy consumption.
- Improved Catalysts & Wash Coat Technology – low PGM, wider operation window, quick light-off, highly thermally stable etc.

Drivers for EATS Development

- Significant cost contributor
- Low perceived value by user

- ***Emission Useful Life – 7L km / 7 years***
- ***To be integrated with all other systems***



- Lower operation cost

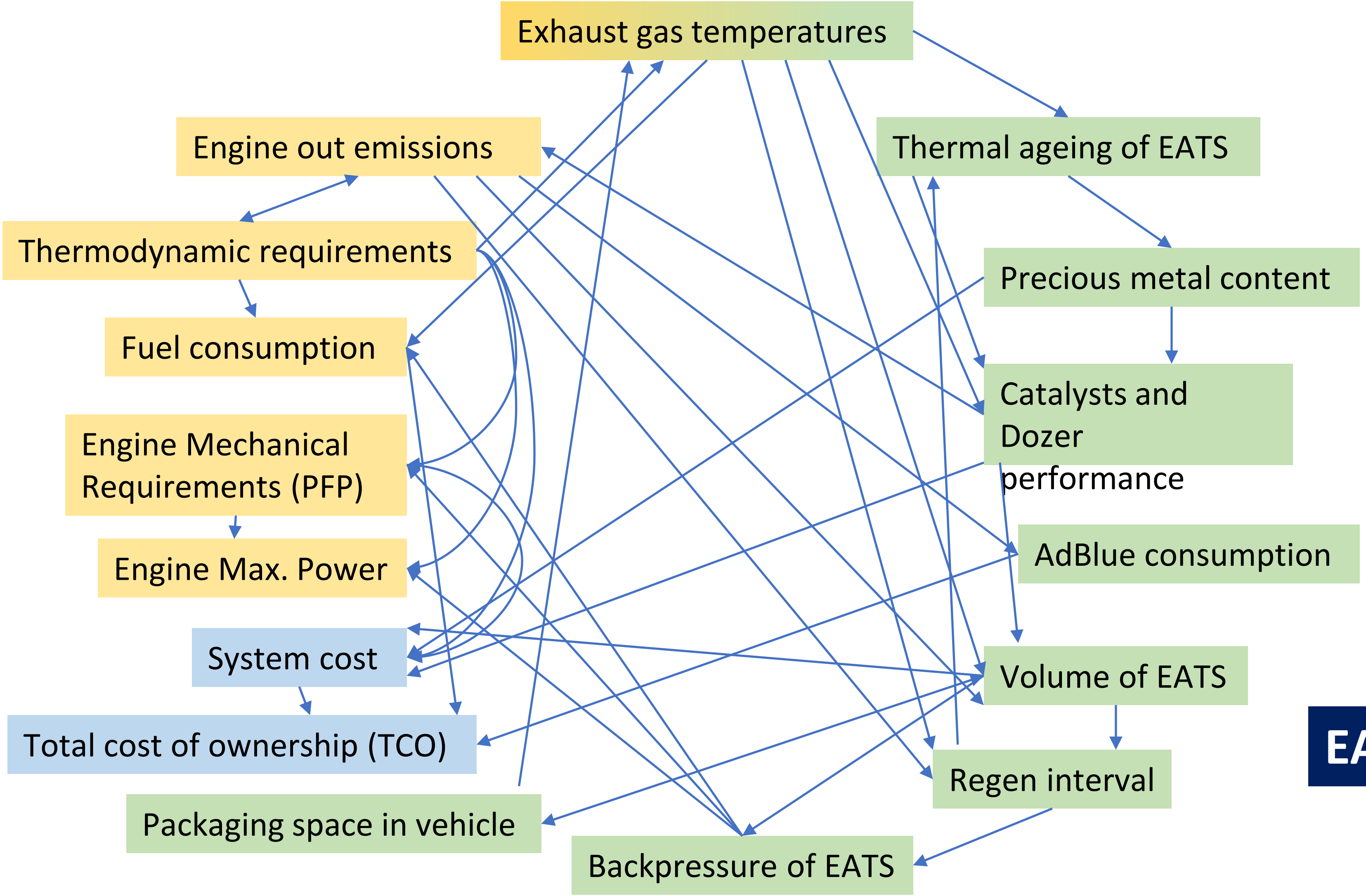
- ***Reliability***
- ***Durability***
- ***Serviceability & Ease of Maintenance***

- Optimized weight / Performance

- ***Suit Indian*** operating conditions

Transformation from Component to *Interactive System*

Challenges for EATS Development



- Mutual impact and dependency between Engine and EATS.
- "A Systems Approach" is necessary for EATS development to find optimum balance between conflicting targets.
- If attempted to optimize Engine and EATS separately, will result in a sub-optimal result as an overall system.

EATS is Not a Plug-N-Play Device

Source: AVL

EATS Development Approach

- Decision of strategy
- Catalyst configuration (substrate, coating….)
- Package definition

- Flow Distribution
- Uniformity Index > 0.95

- Perf & Emission

- DOC Exotherm
- NO2 conversion
- HC Slip

- Mass based SLE
- DP based SLE
- NOxidation

- Open loop
- NH3 storage
- Closed loop

- Faults Threshold Tuning & Verification

- Urea deposit assessment
- Duty cycle trials
- DTI / HALT
- Load Cycle Endurance

- Thermal Mapping
- RLDA / Vibration
- Static / Dynamic Regen
- Water wading
- Altitude

- Mileage accumulation
- Duty cycle trials

- Emission Cycles
- OBD
- PEMS Demo

- Mfg. trial & Sign-off

- Issues closure
- Production ramp-up

On-Road Validations (contd)

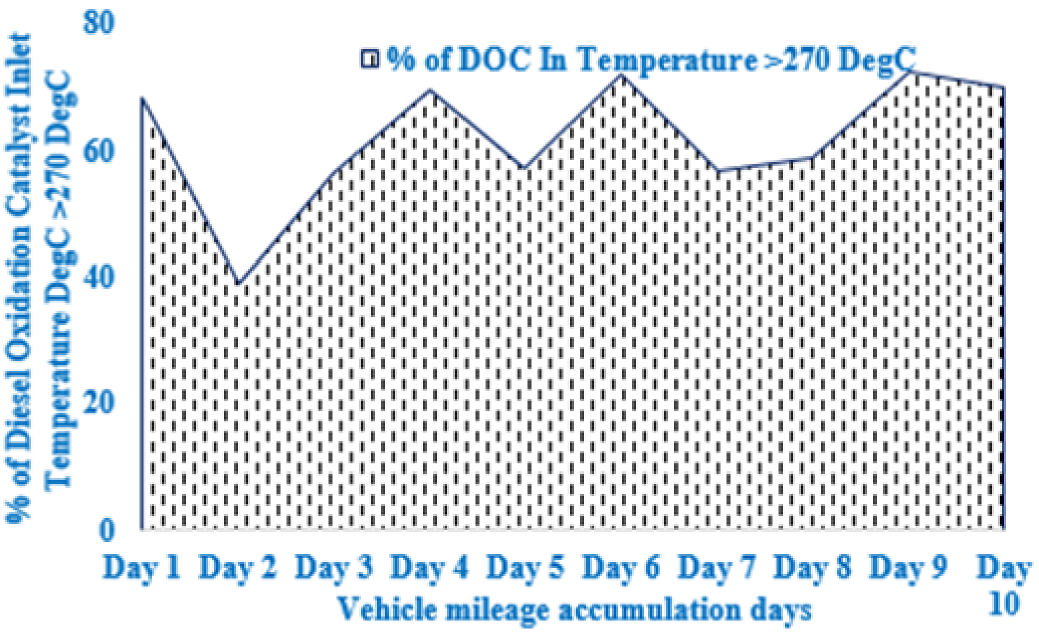


Figure 10. % of DOC inlet temperature (>270°C to initiate HC dozer)

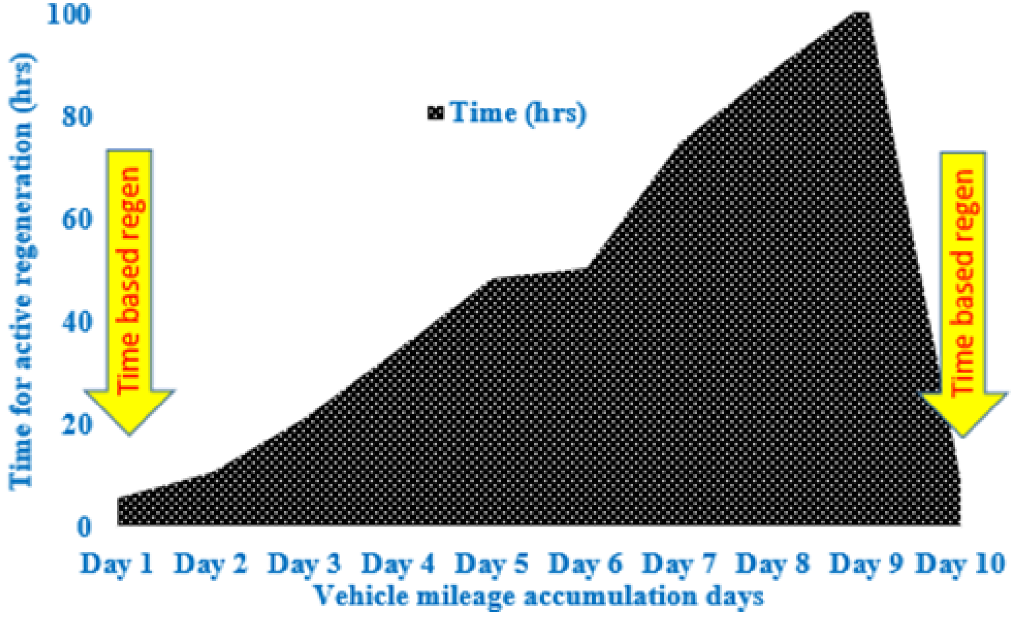


Figure 11. Time period for active regeneration

- ✓ DOC inlet temperature is favourable for most of the time to trigger the active regeneration condition.
- ✓ During highway driving conditions most of the time conditions are favourable for passive regenerations.

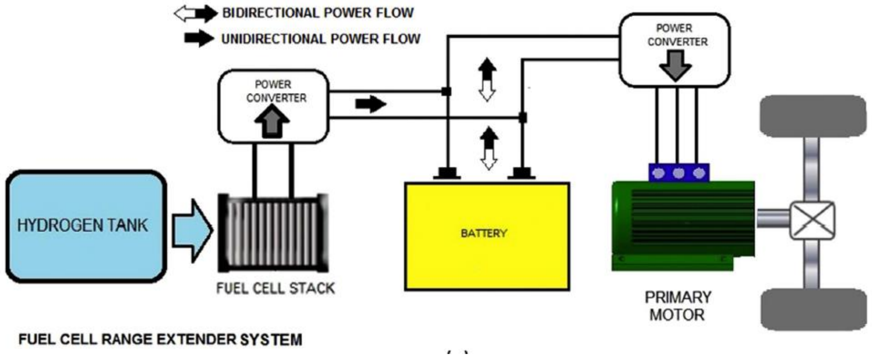
Summary and Conclusion

- **Internal Combustion Engine is here to stay !!!!** And our job is to make it more efficient, more reliable, improve TCO and deliver value to customers, more frugally.
- India is likely to see more electric 2W and 3W penetration, than 4W and heavy CVs.
- EV migration in Heavy CVs is expected to take the longest time. It might take the route of hydrogen fuel cell EV technology.
- Higher fuel cell costs and green hydrogen availability and cost are challenges right now and expected to improve over this decade.
- H_2 combustion engine is a strong contender to decarbonize the transportation industry and especially the heavy-duty sector, as it retains all the advantages of a conventional ICE (fuel density, availability, robustness, cost), while eliminating GHG CO_2 emissions.
- H_2 ICE being seriously considered as future powertrain by multiple OEMs.
  - Engine “evolution” from Diesel or natural gas engines.
  - Mainly lean, spark ignited combustion with low (NOX and PN) raw emissions.
- Start with Grey hydrogen and transition to Green / Blue hydrogen, as and when widely available.

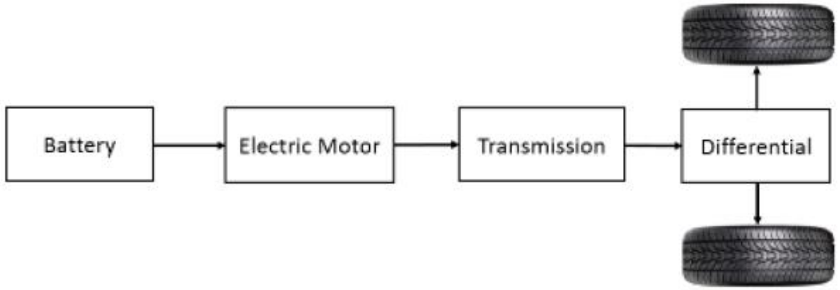
Summary and Conclusion

- BS VI OBD-I vehicles are well established and proven for India. Same configuration can be extended for the upcoming OBD-II norms, with tighter tolerances and wider monitoring windows.
- Continue to improve upon the existing proven technology to meet Euro VII equivalent. Electrically heated catalysts may be explored to improve cold start performance.
- Engine and EATS are mutually dependent. “A Systems Approach” is necessary to find optimum balance between conflicting targets.
- Control system is the key for robust performance and optimized cost.
- **Expectations from Substrate manufacturers:**
  - low thermal expansion, increased cell density, low pressure drop, low-cost substrates. New filter technologies with high filtration efficiency combined with low pressure drop.
- **Expectations from Catalyst manufacturers:**
  - improved catalyst performance with low / No PGM, highly thermally stable, tolerant to chemical poisoning, quicker light-off.
- **Expectations from Canners:**
  - low weight, lower temperature drop, low back pressure, higher push out load, improved uniformity index.

H2 ICE vs FCEV vs EV



FCEV



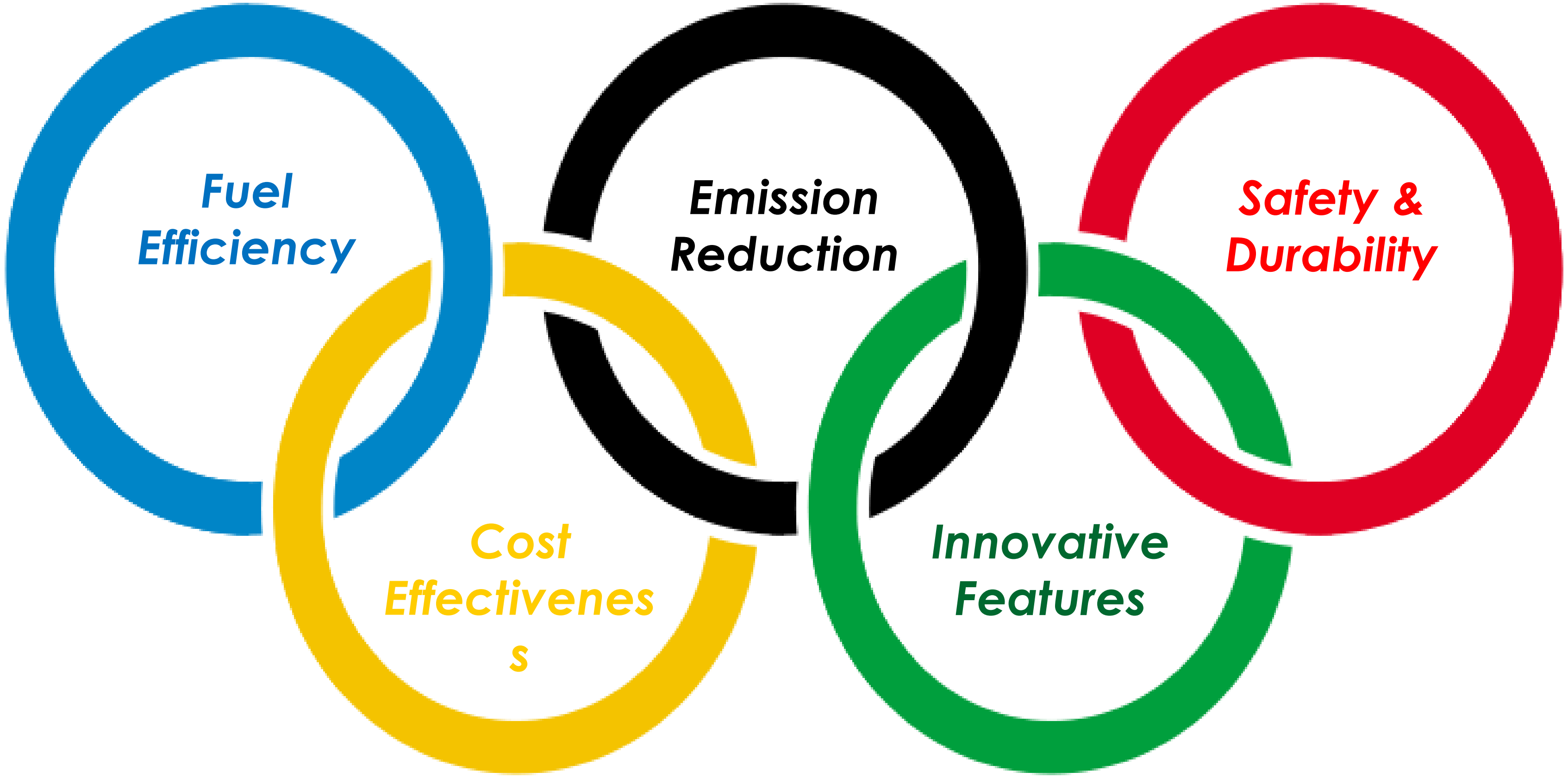
H2 ICE

H2 ICE is compatible for CNG and LNG

BEV

Future Vehicle

Facets of future technological competitiveness



An interwoven web of often conflicting requirements

Commitment

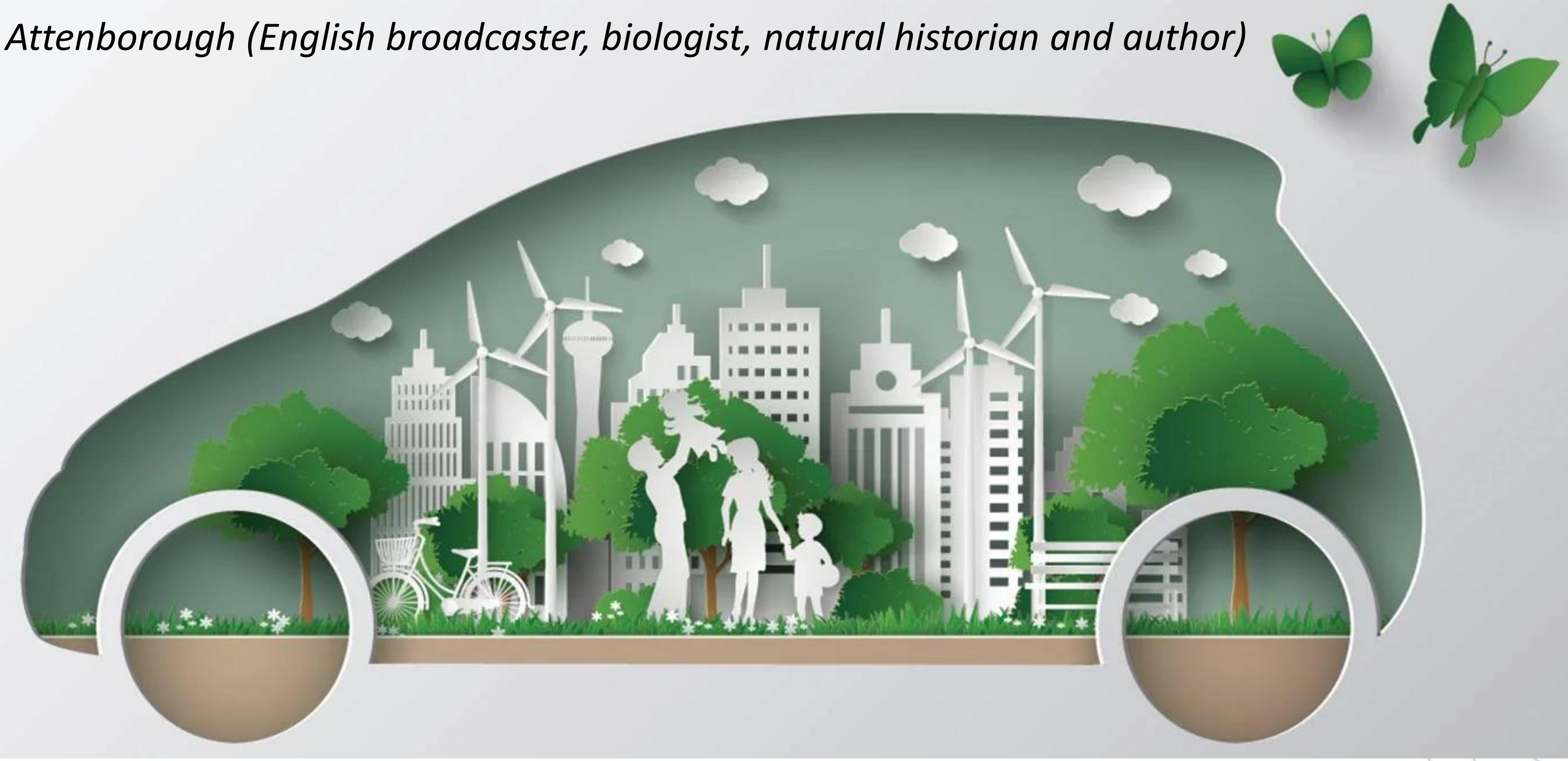
Besides regulations, we have the moral responsibility to pass-on a safer and cleaner planet to the Next Generation !!!

THANKS

Thank you !

"The future of the earth depends on our ability to take action. Many individuals are doing what they can, but real success can only come if there's a change in our societies and our economics and in our politics. ***Surely, we have a responsibility to leave for future generations a planet that is healthy, inhabitable by all species."***

– *David Attenborough (English broadcaster, biologist, natural historian and author)*



Thank you

ASHOK LEYLAND IS COMMITTED TO GREENER DEVELOPMENT