ASHOK LEYLAND

Oppurtunities around BS VI for India Commercial vehicle Perspective

Krishnan S
Vice President – Ashok Leyland (Engine R&D)

Ashok Leyland is a commercial vehicle manufacturing company based in Chennai, INDIA. Founded in 1948, flagship of the Hinduja Group is one of India's leading manufacturers of commercial vehicles, such as trucks and buses, as well as emergency and military vehicles with a turnover of US $ 2.5 billion in 2011-12

2.5 to 49 Tons

70 Million Passengers

19 to 80 Seaters

16170 Engines

101990 Vehicles

7 Plants

ASHOK LEYLAND
LIGHT VEHICLES

HINDUJA FOUNDRIES

ASHLEY ALTEAMS

Foundry Business

LEYPOWER

Engines & Gensets

Transmissions ZF

ASHOK LEYLAND

Defence Mobility M&HCV Buses

NISSAN

JOHN DEERE

LCVs Construction equipment

AVIA

Optare

Trucks Bus

AUTOMOTIVE INFOTRONICS

A Joint Venture between Ashok Leyland and Continental AG

Auto Electronics

Albonair

Exhaust System Technology

DEFIANCE

Engineering Manufacturing and Enterprise Services

ASHOK LEYLAND

Ashok Leyland

Product Portfolio

Trucks

- Mining & construction
- Long haul
- Distribution trucks
- Captain series

Buses

- City bus
- Staff & school buses
- Sub-urban buses
- Special Buses

Defense

- Stallion
- Super Stallion
- Rhino 6x6
- Special purpose vehicles

Light vehicles

- Dost
- Partner

AL – P15 Engine
A Brand New Addition to
Ashok Leyland

ASHOK LEYLAND

Ready for Wide applications (Truck, Van, Car, Industrial, Genset , CNG, etc.)

7 megatrends will dominate the global auto industry's future?

1. Endless powertrain advancement
2. Autos on a severe diet
3. Autonomous driving on horizon
4. Power shift to mega suppliers
5. New entrants afoot
6. Connected cars and shared mobility
7. Shift to emerging markets

Business Pleasures : Safety , environmental protection , Cost , Customer delight

Auto Industry Transformation …advanced powertrains, materials and electronics….. Emerging trend

Technology Drives Change… Application oriented.. like 2W, 3W, Car , buses(Mini, macro), trucks(SCV,LCV,ICV , M&HCV), tractor , Defence , special vehicles , Mining , Infrastructure many more

The pace of vehicle technology change is accelerating. Vehicles are Designed as a

- Response to consumer taste and expectations
- Higher safety standards
- Drive toward a low-carbon future including green transportation
- Affordable , operable and maintainable
- Entertaining

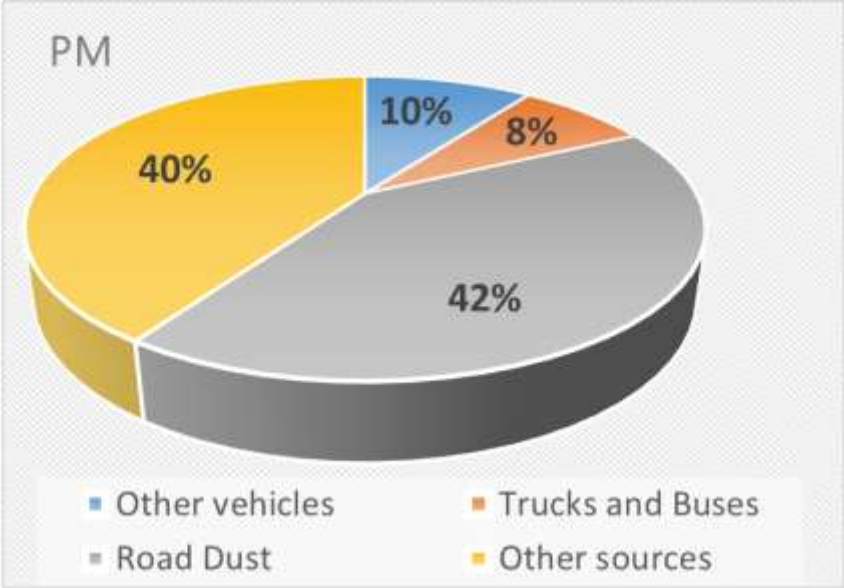
Virtual Reality Sweeps Auto Industry, From Designing Cars to Driving Them

- From R&D labs to factories to showrooms (Online Factory tour)
- Car companies are putting on the goggles building VR into apps for Customisation.. Technology and experience in real time
- Trying to push the technology to new limits in search of an edge over current practice—and the competition.
- Paint colors, wheel and tire packages, brake kits and more, according to *Road & Track,* or take a digital glimpse behind the real-life sheet metal

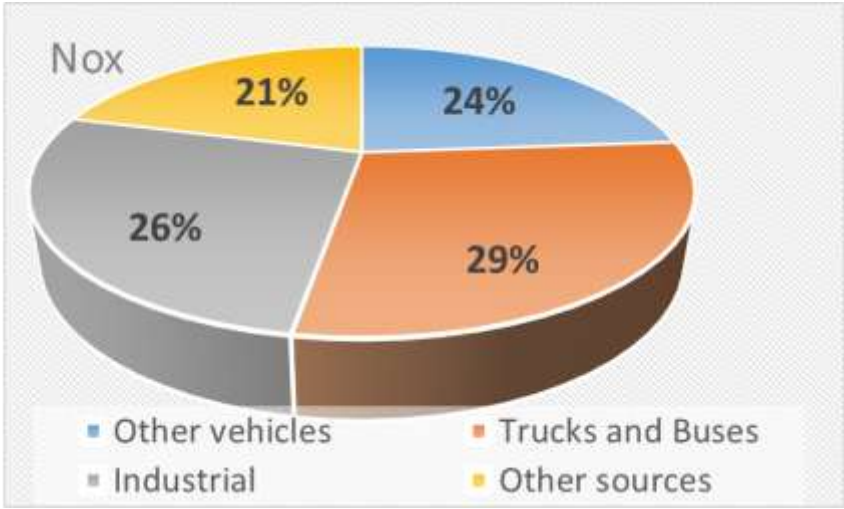
Now The Target shifts

Through the session

Emission Source Apportionment



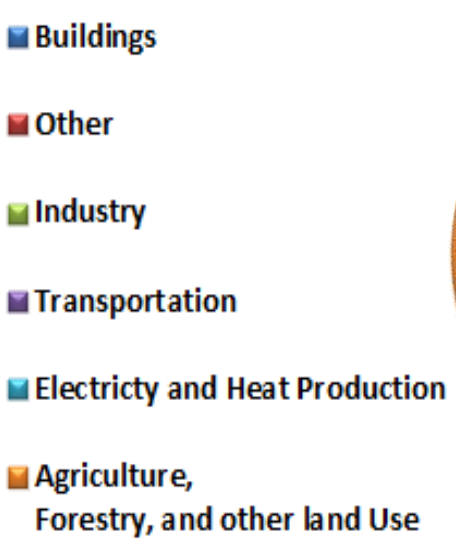
- On an average 18% of the of the total SPM in ambient (PM10) is from vehicular emissions.
- Trucks and Buses contribute only 8%
- **PM Norms can be re-looked**

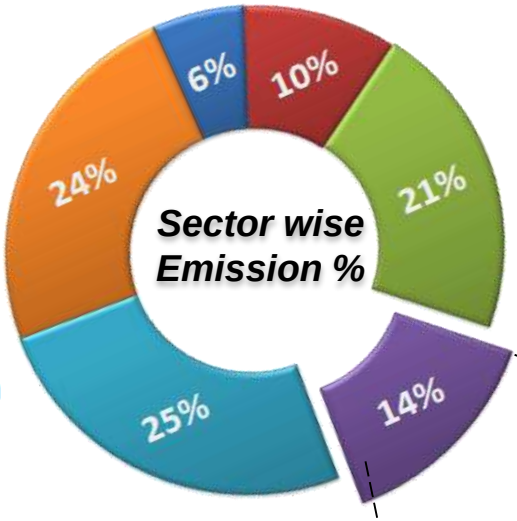


- On an average 51% of the of the total NOx in the ambient is from vehicular emissions.
- Trucks and Buses contribute 29%.

Source: Air quality monitoring, emission inventory and source apportionment study for Indian cities, CPCB, Feb 2011.

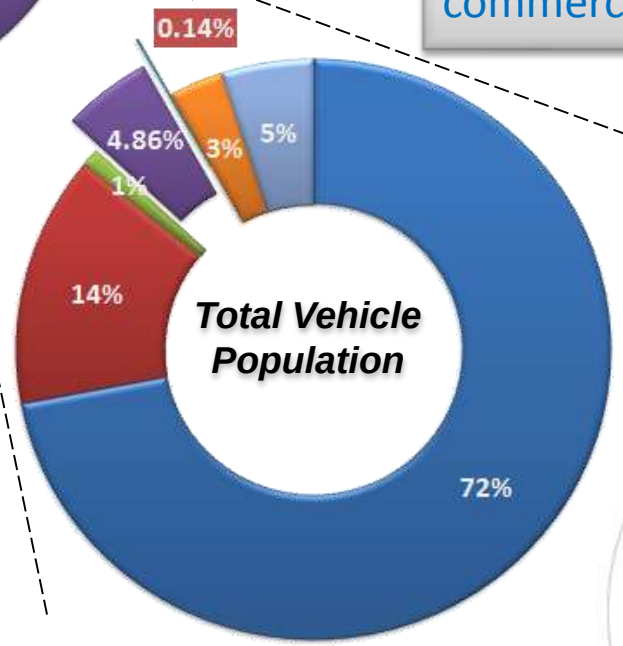
Even this Impacts Army Also





Army fleet accounts to 0.14% of the overall vehicle population.

Army's usage is 1/10th as that of other commercial vehicles



Why ?
Here Mobility is Important

Bs3 enough

Source: Source: IPCC (2014): based on global emissions from 2010

Source: MoRTH Annual Report 2010-11

Is euro6 is new ???

Displayed at Hannover

Under body Packaging Mirrored

BS VI norms – recap – challenging !!!!

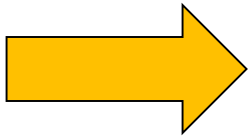
Norm	Year	NOx	CO	HC	PM	PN	Test Cycle
Bharat Stage I	2000	8.0	4.5	1.1	0.36	-	R 49
Bharat Stage II	2001/2005 (*)	7.0	4.0	1.1	0.15	-	R 49
Bharat Stage III	2005/2010	5.0	2.1	0.66	0.10	-	ESC
Bharat Stage IV	2010/2017	3.5	1.5	0.46	0.02		ESC
Bharat Stage VI	2020 -	0.40	1.5	0.13	0.01	6 x 10^{11}	WHSC

NOx 90% redn.

PM 50% redn.

BS VI from EURO VI – Implementation Timeline ??!!

EURO Norms	
Norm stage	**Year**
EURO 1	1992
EURO 2	1998
EURO 3	2000
EURO 4	2005
EURO 5	2008
EURO 6	2014



BS Nationwide	
Norm stage	**Year**
BS I	2000
BS II	2005
BS III	2010
BS IV	2017
BS VI	2020

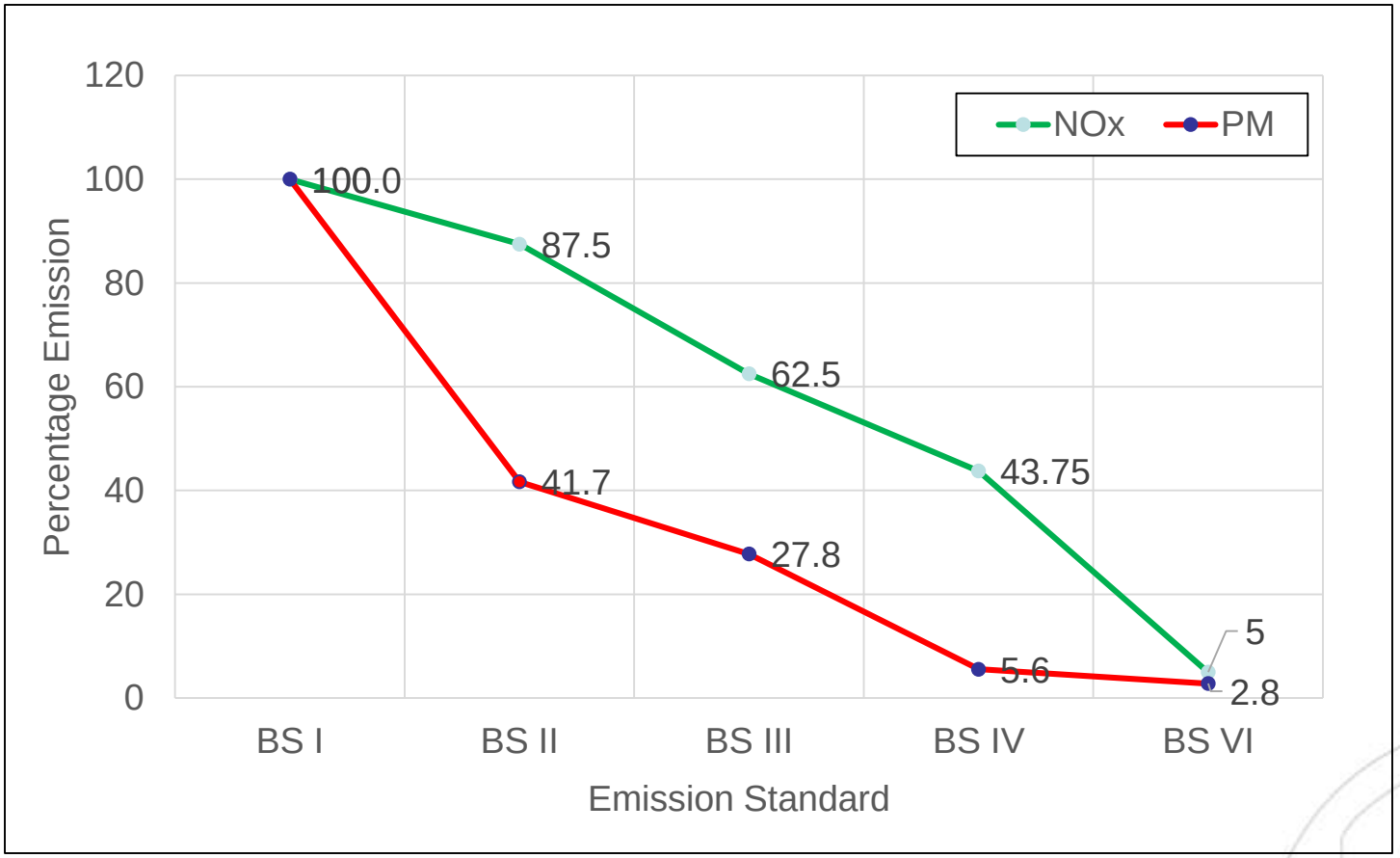
CHALLENGE TECHNOLOGY IMPLEMENATATION vs TIMELINE

EURO 4 – EURO 6 → 9 years

BS IV – BS VI → 3 years

Till date dual norm existed for sometime upto BSIV before all over india however now BSVI pan india across to be implemented

BS VI norms – Reduction Trend
How low are the emissions ?

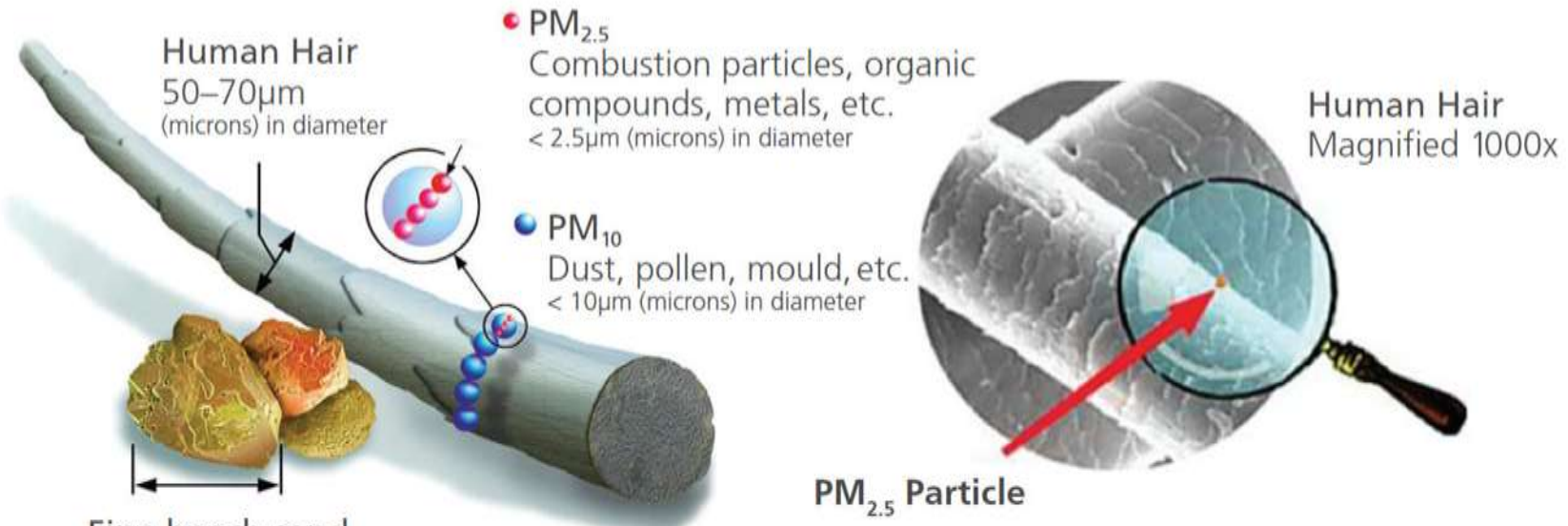


Drastic reduction from BS IV to BS VI in lowest time frame

Why Nox regulated ?

Courtesy: http://www.zoombd24.com/

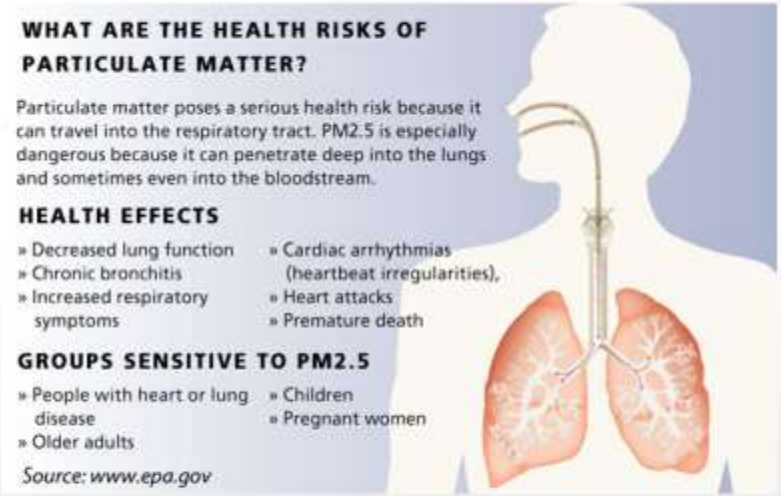
Particulate Sizing Estimate



Note – Larger surface area will lead to condensation of toxic VOC & PAH

Particle diameter (µm)	Relative number of particles	Relative surface area
10	1	10
1	10^3	1^2
0.1	10^6	1^4
0.01	10^9	1^6

Why PM & PN is regulated ?



- ***Numerous studies link PM to aggravated cardiac and respiratory diseases such as asthma, bronchitis and emphysema***
- ***PM can also have adverse effects on vegetation and structures, and contributes to visibility deterioration and regional haze***

Emission Introduction

PAST…

PRESENT…

PRESENT…

FUTURE…

Oxygen Banks?

Emission Introduction

HEALTH PROBLEMS due to the EXHAUST GASES

Headache

Fatigue

Chest pain

Respiratory problems

Reduced reflexes

Cancer

Wheezing

Cough

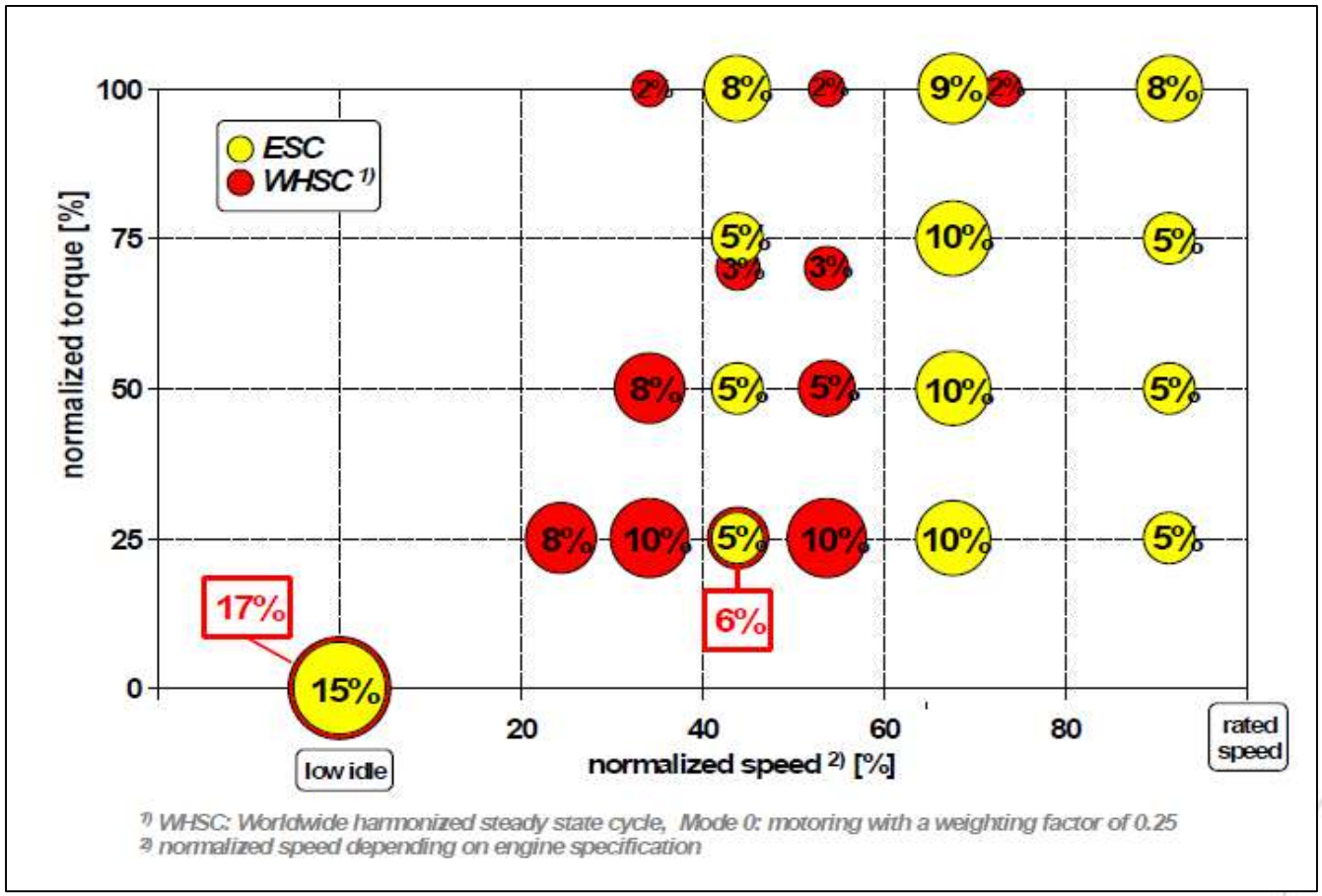
Accepted New Tests & Challenges

Tests	BS - VI	BS-IV
Test cycles	WHTC, WHSC, WNTE	ETC, ESC
Particulate Number (PN) Measurement	Yes	No
Crank case emissions	Yes	No
OBD (BS VI-A in 2020 / VI B in 2023)	Yes (WWH-OBD)	Yes (OBD-II)
IUPR- (Probability of OBD monitoring happening in Real driving cycles – Min 10%) *	Yes	No
In-service conformity (w/ PEMS) *	Yes	No
PEMS demo test during type approval *	Yes	No

* - From 2023

Requires – Engine Test Bed cycle change, Additional equipment, Emission protection throughout life and calibration throughout map, Control strategy robustness

Steady state cycle Changes



Low operation zone – challenge for emission conversion due to lower temp

Transient Cycle yet to get experienced

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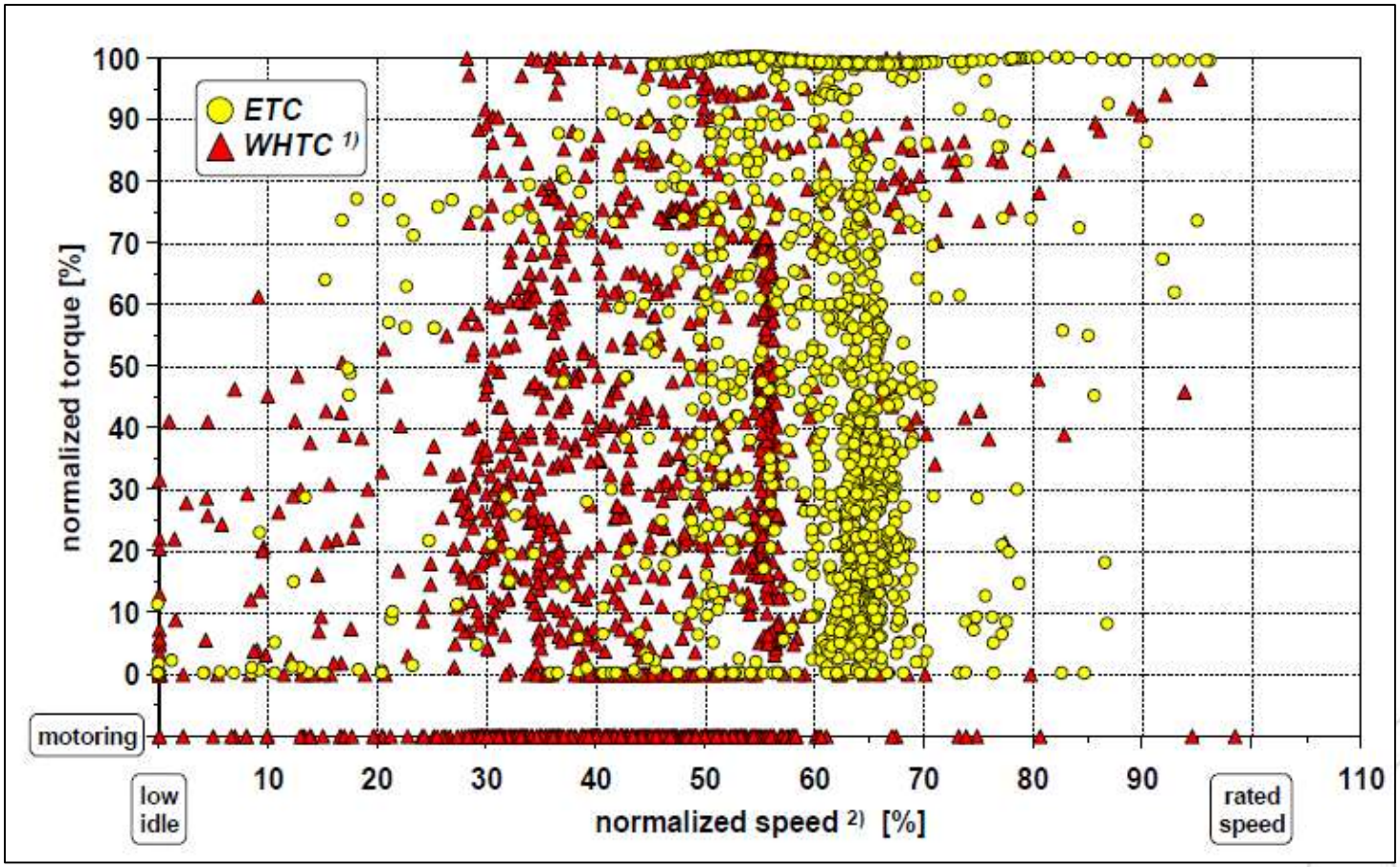
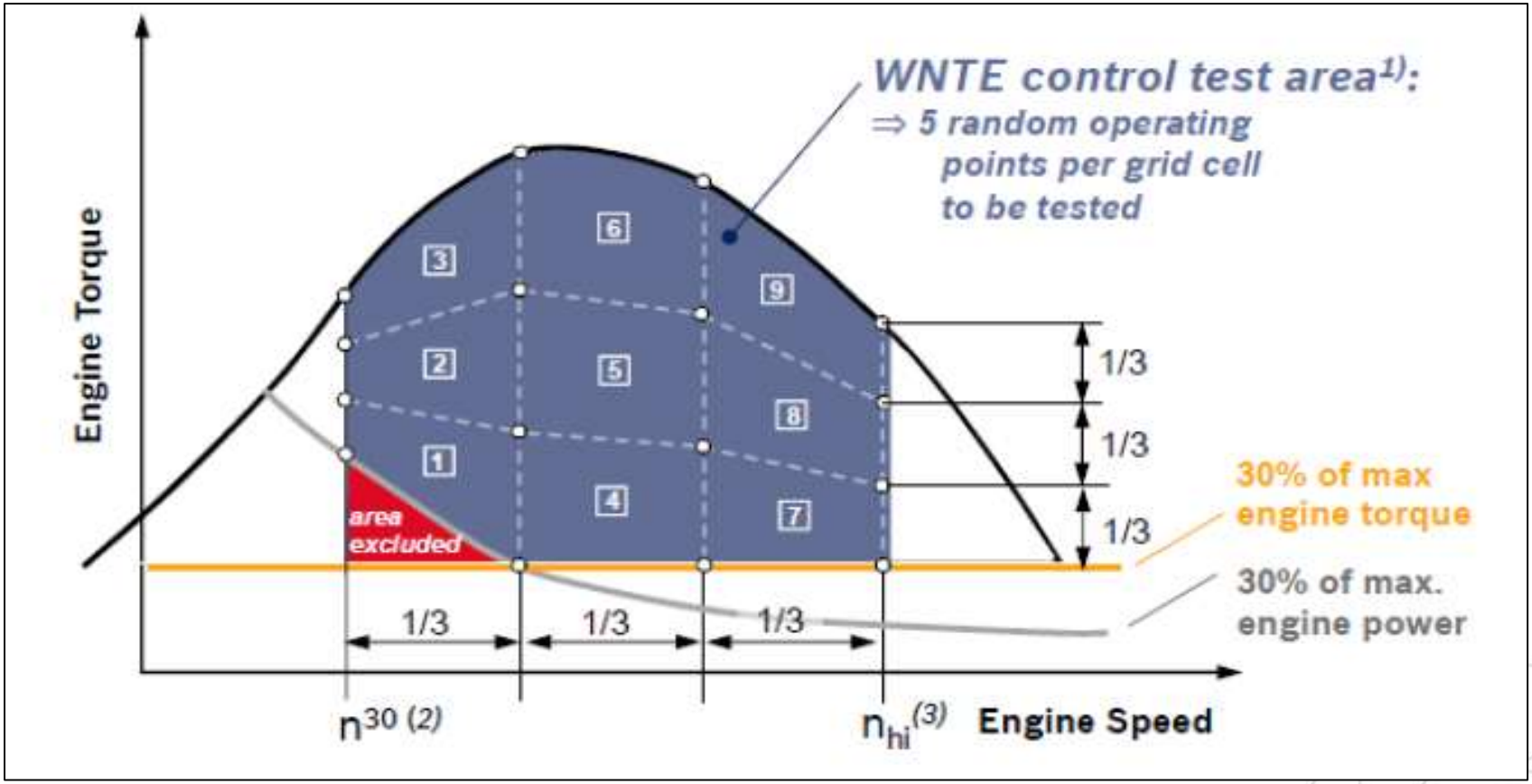
TRANSIENT CYCLE



Low operation zone – challenge for emission conversion due to lower temp

BS VI Off Cycle Emission



Emission to meet all points at stringent limits – challenge for transient operation all through

EURO VI vs BS VI Fuel

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Fuel parameter	BS VI	Euro 6	EPA RFG average (2005)	EPA convetional gasoline average (2005)	Japan	South Korea	Worldwide Fuel Charter (Category 4)
Sulfur, ppm, max.	10	10	30 ppm (Tier 2) 10 ppm (Tier 3)	30 ppm (Tier 2) 10 ppm (Tier 3)	10	10	10
Research Octane (RON), min.	91/95	95[a]	NS	NS	89/96	91/94	91/95/98
Motor Octane (MON), min.	81/85	85[a]	NS	NS	NS	NS	82.5/85/88
Anti-Knock Index (AKI), min.	NS	NS	87/87/91	87/87/91	NS	NS	NS
Olefins, vol%, max.	21/18	18	11.2-11.9	11.6-12.0	NS	16-19[b]	10

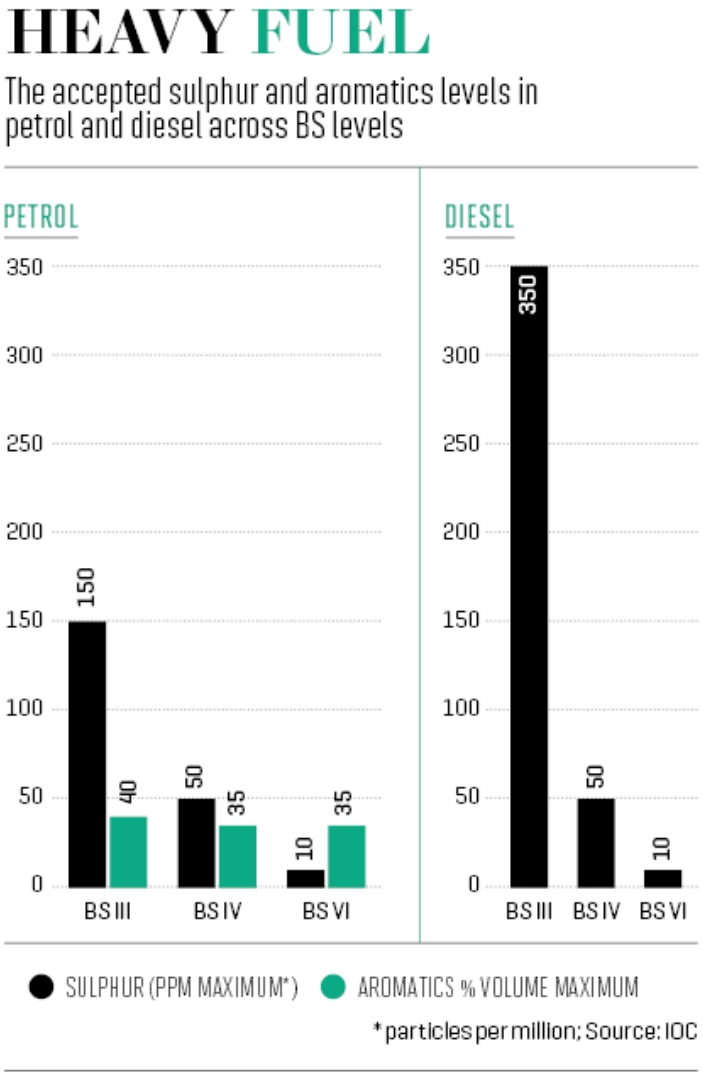
Fuel parameter	BS VI	Euro VI	EPA coventional diesel	CARB designated equivalent limit	Japan	South Korea	Worldwide Fuel Charter (Category 4)
Sulfur, ppm, max.	10	10	15	15	10	10	10
Cetane Number (CN), min	51	51	Cetane index ≥ 40 or aromatics ≤ 35%	53	45	52[a]	55
Density @ 15°C, kg/m³	820-860	845 (max)	NS	NS	NS	815-835	820-840
95% Distillation Boiling Point (T_{95}), °C, max.	370	360	NS	NS	360[b]	360[b]	340
Polycyclic aromatic hydrocarbons (PAH), mass %, max.	11	8	NS	3.5	NS	5	2
Flash Point, Abel, °C, min.	35	55	NS	NS	45	40	55

Impact of PAH to be taken care during engine development due to agglomeration of soot , PM , HC. Uncertainty due to non-availability of commercial fuel . Commercial fuel also shows gap.

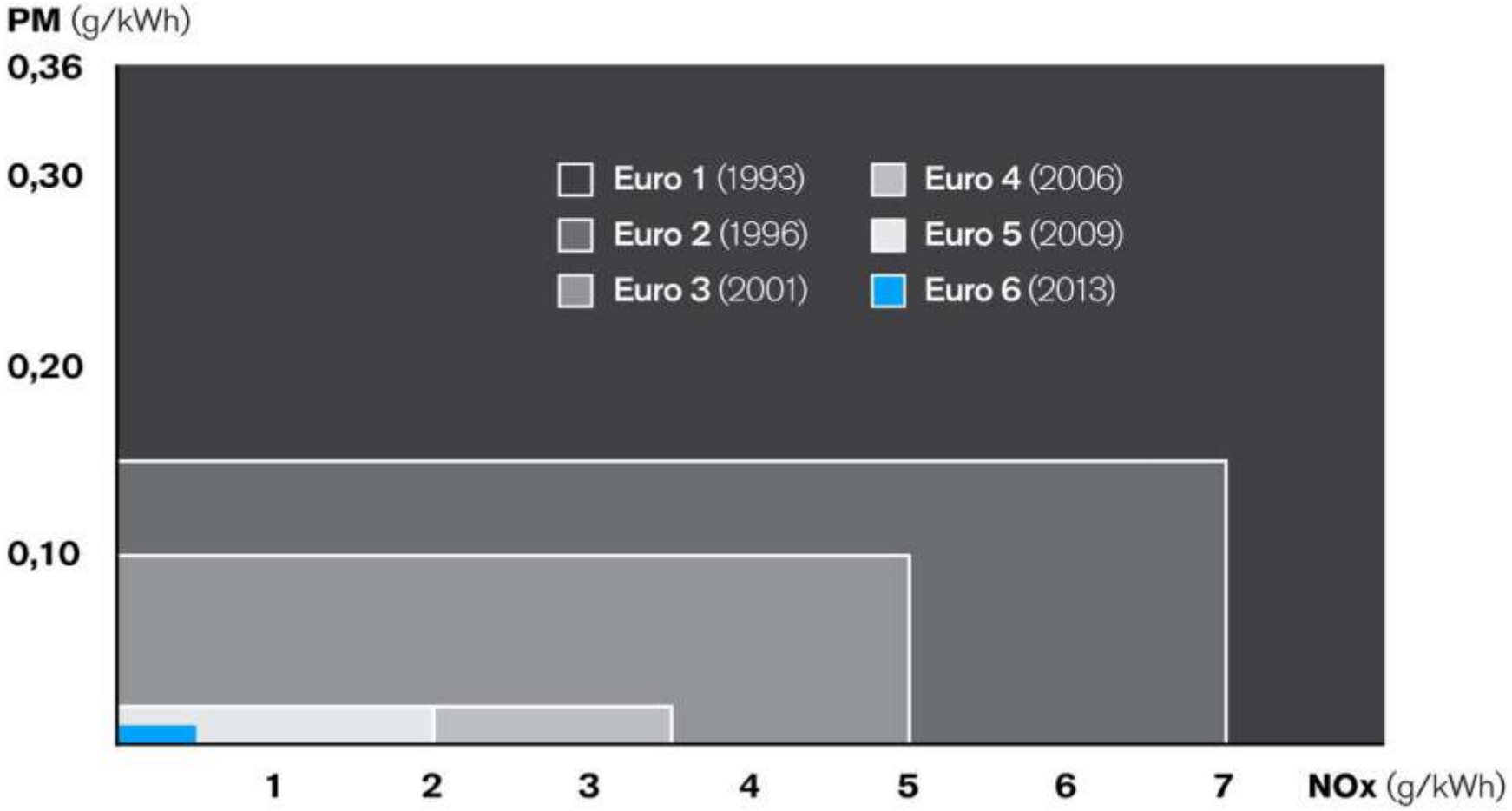
Source: http://www.theicct.org/

BS VI – Implementation Fuel Requirements

- BS VI Fuel Required for Development from 2017 in India without Importing (for lower cost)
- Fuel Adulteration to be eradicated
- Parallel pan India implementation to be done before April 2020



Emission Legislation Heavy Duty Diesel Engines



BSIV to BSVI there is 88% reduction in NOx emissions and 50% reduction in PM
There is an additional Particulate No limit which is new for BSVI.

BS VI Summary – Recap –Why paradigm shift

(70% of added Components, Suppliers, technology, test bed systems, software and controls all are new to India and AL)

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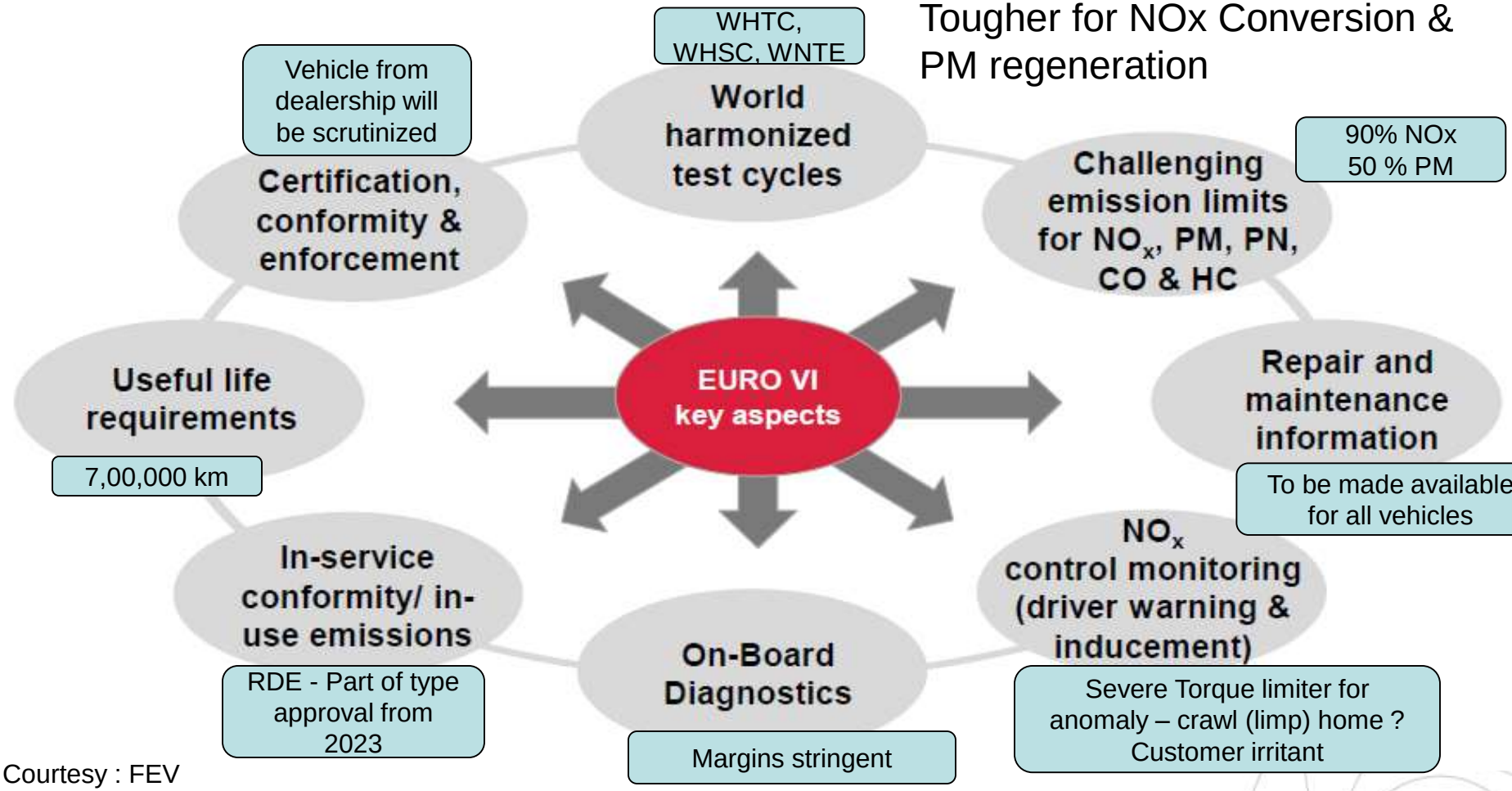
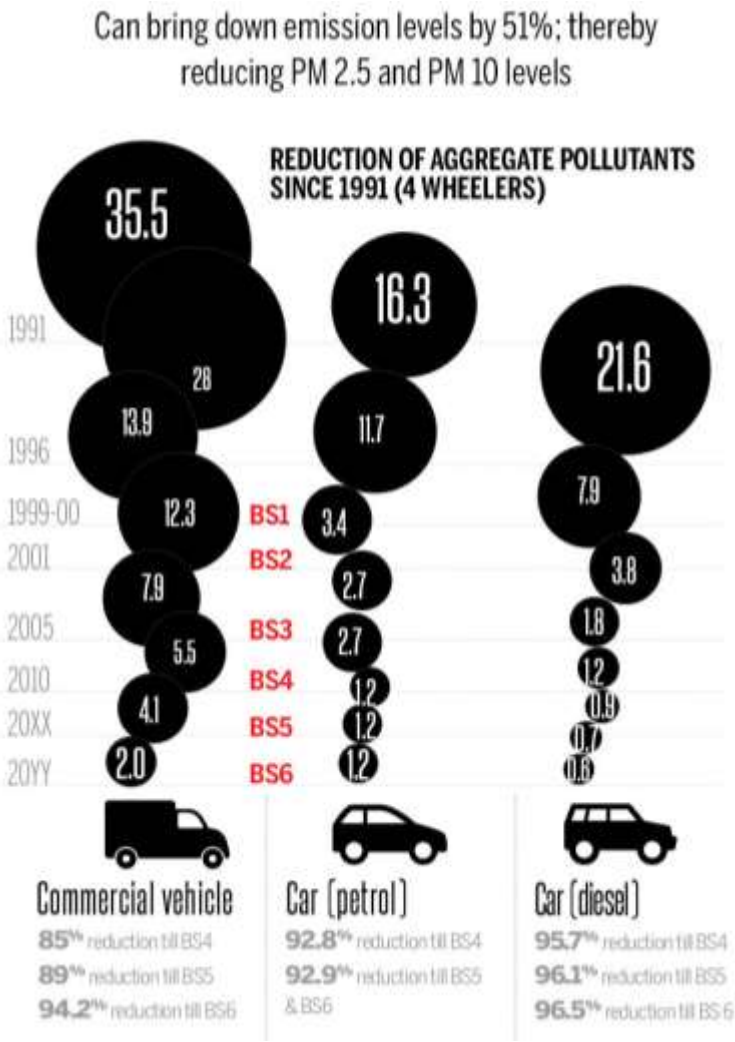


Courtesy : FEV

- Engine Test cycle changes warrants test bed software updates and additional equipment
- Emission compliance for life and OBD efficiency - to be demonstrated from 2023 only

BS VI – Impact on OEM



Courtesy : Newsflicks.com

BS VI – Tech way forward

BS IV

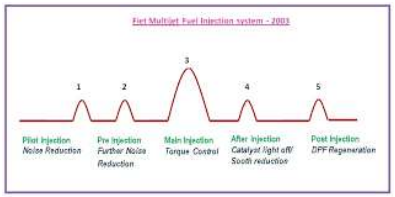
ADVANCED CONTROL TECHNOLOGY, SENSORS & ACTUATORS

ADVANCED EXHAUST TECHNOLOGY

ADVANCED ENGINE TECHNOLOGY with FUEL ECONOMY

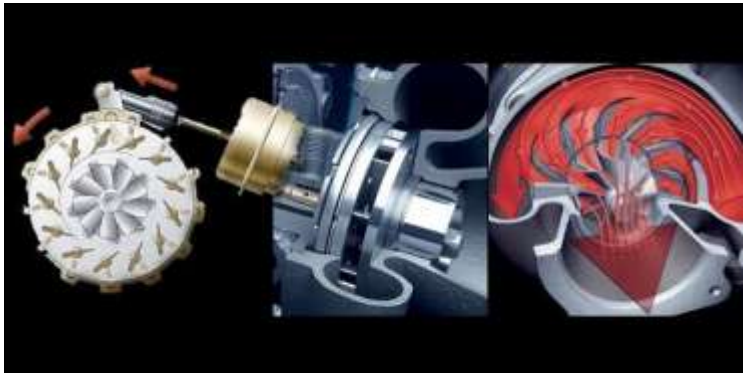
BS VI

BS VI – Adv. Engine Technology
Effective Combustion



- Targeted Engine Out Emission
- Efficient Combustion
- Best Air Path Management
- Best Fuel Efficiency

High Injection Pressure



Adv Turbo control

Increased Combustion Control

Variable Valve Actuation

BS VI – Adv. Engine Technology
Thermal Management

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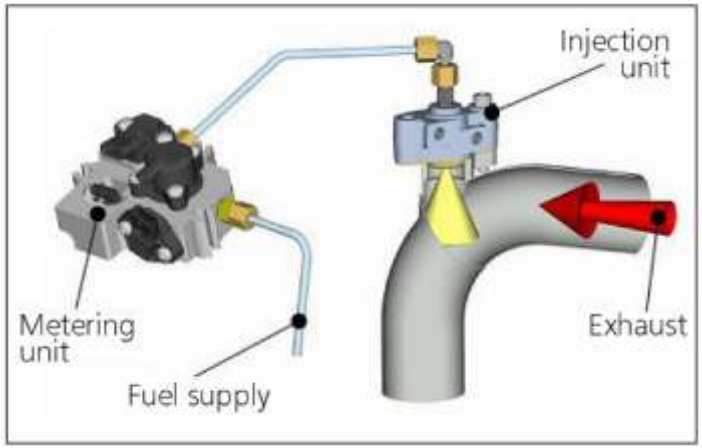
Intake Throttle



Hydrocarbon Injection

- **Temperature control for exhaust system**
  - **DPF regeneration**
  - **SCR Temperature control**

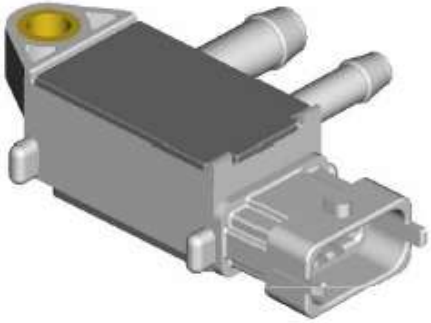
Exhaust Throttle

BS VI – Sensors to be focussed

Air Mass Flow Sensor

High Temp Sensor

Differential Pressure sensor



NOx sensor

PM sensor

BS VI – Calibration Effort Stringent OBD & IUPR

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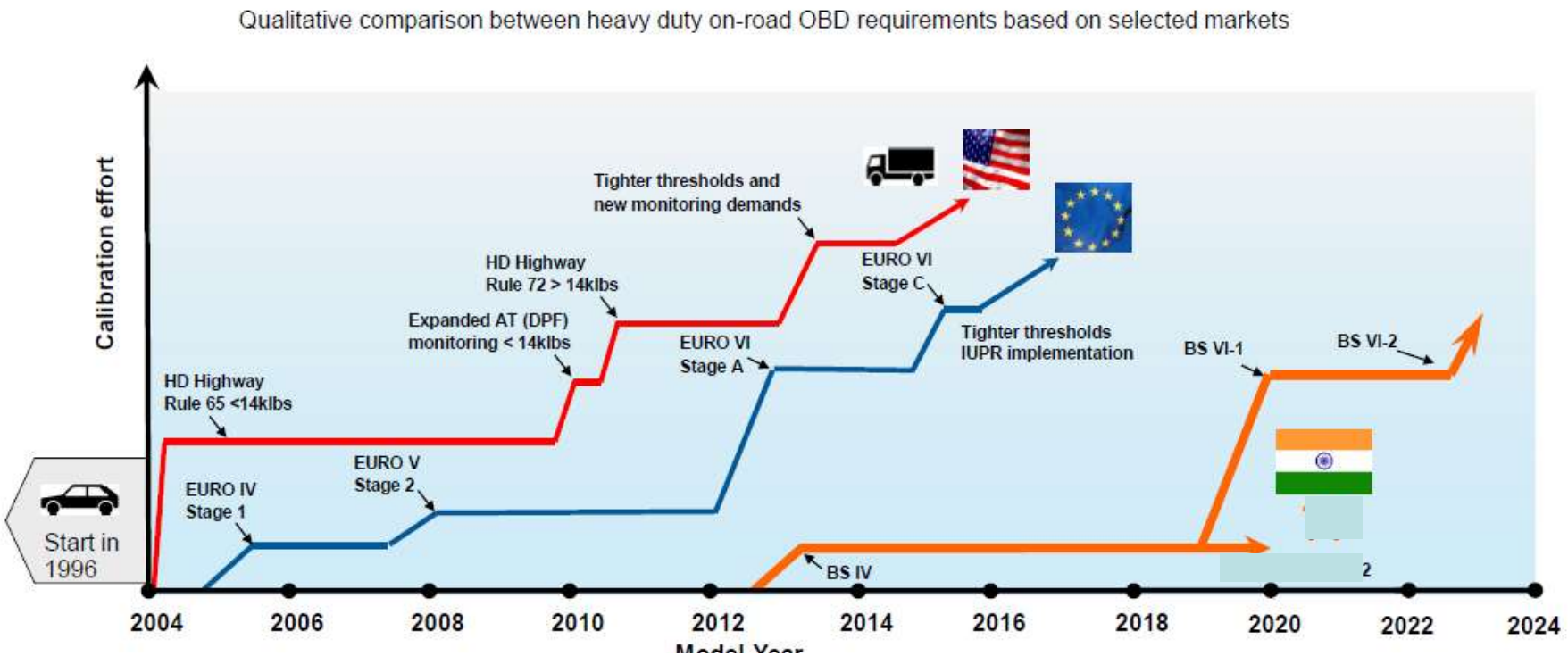
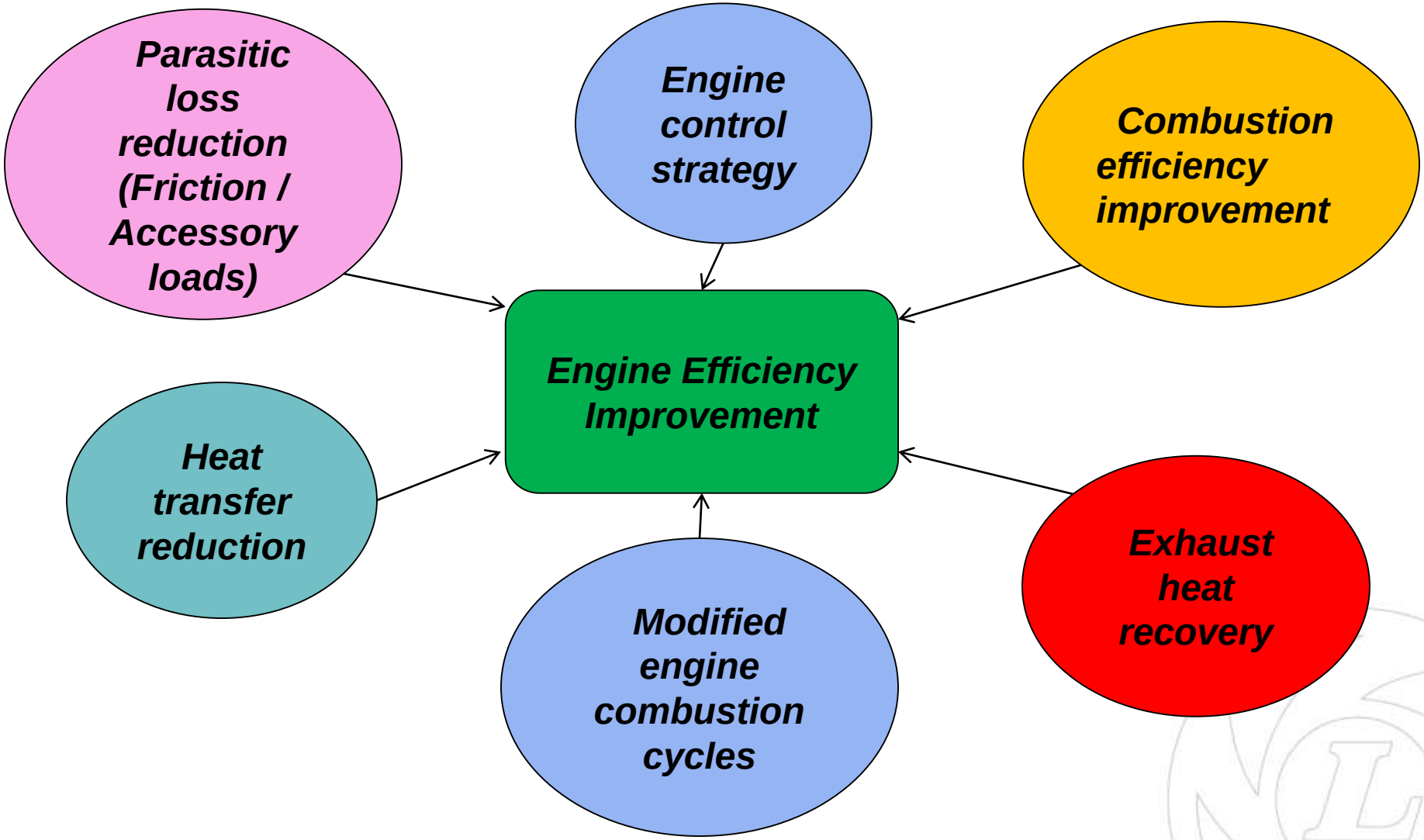


- ***Calibration Effort and Timeline → 2017 – 2020 – Steep development process → Huge resource requirement for man and material***
- ***Full Fleet of vehicle up gradation means parallel deployment***

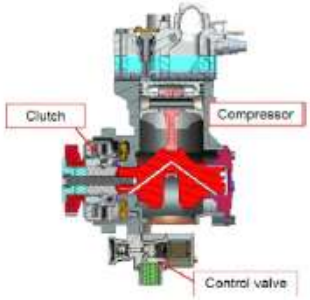
Courtesy : AVL

Post BS VI Towards Future Fuel Economy



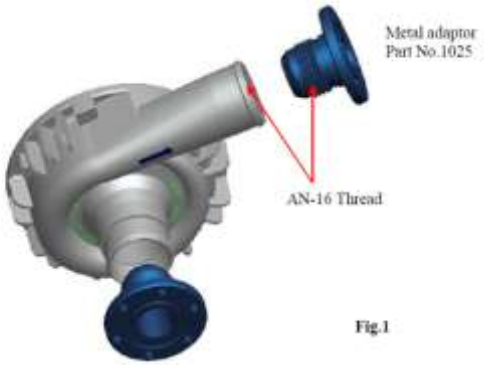
Post BS VI Towards Future Fuel Economy

Variable speed water pump



Clutched air compressor

Electric water pump

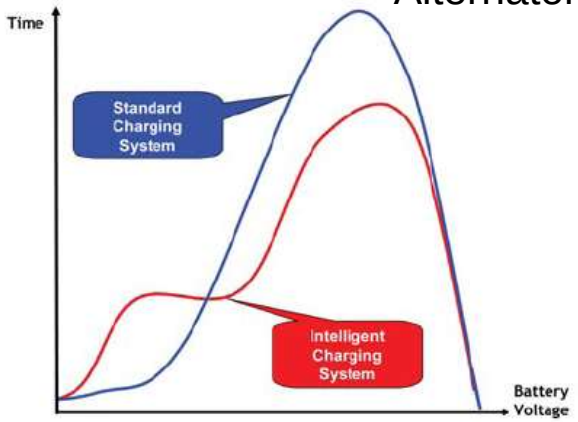


Reduced tension oil control rings

Miscellaneous related to pistons, liners, bearings

Low viscosity oil

Smart Alternator



BS VI – Adv. Control Systems
Sensors & Actuators

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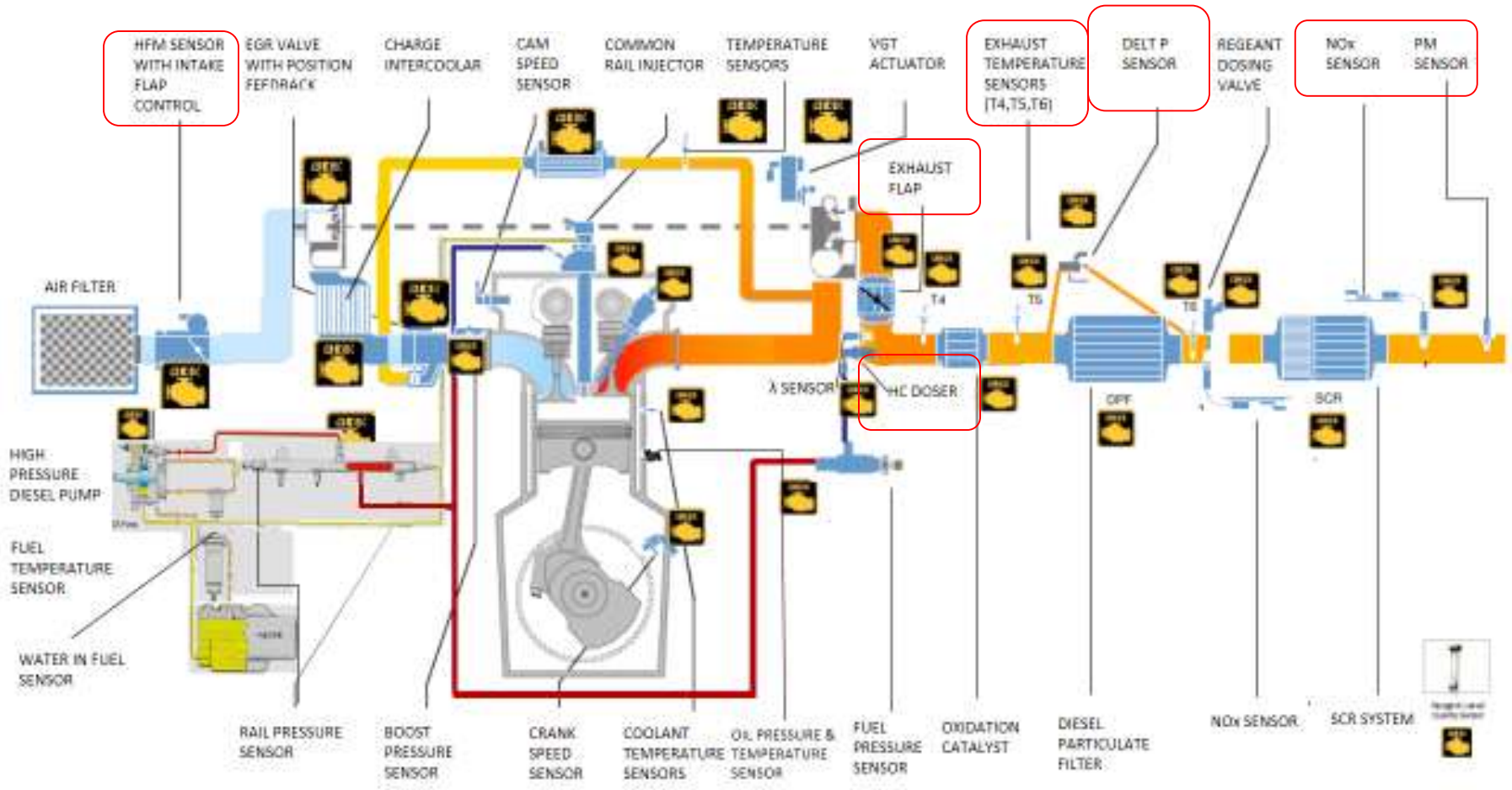

BS VI Adv. Exhaust Layout Parts & Sensors

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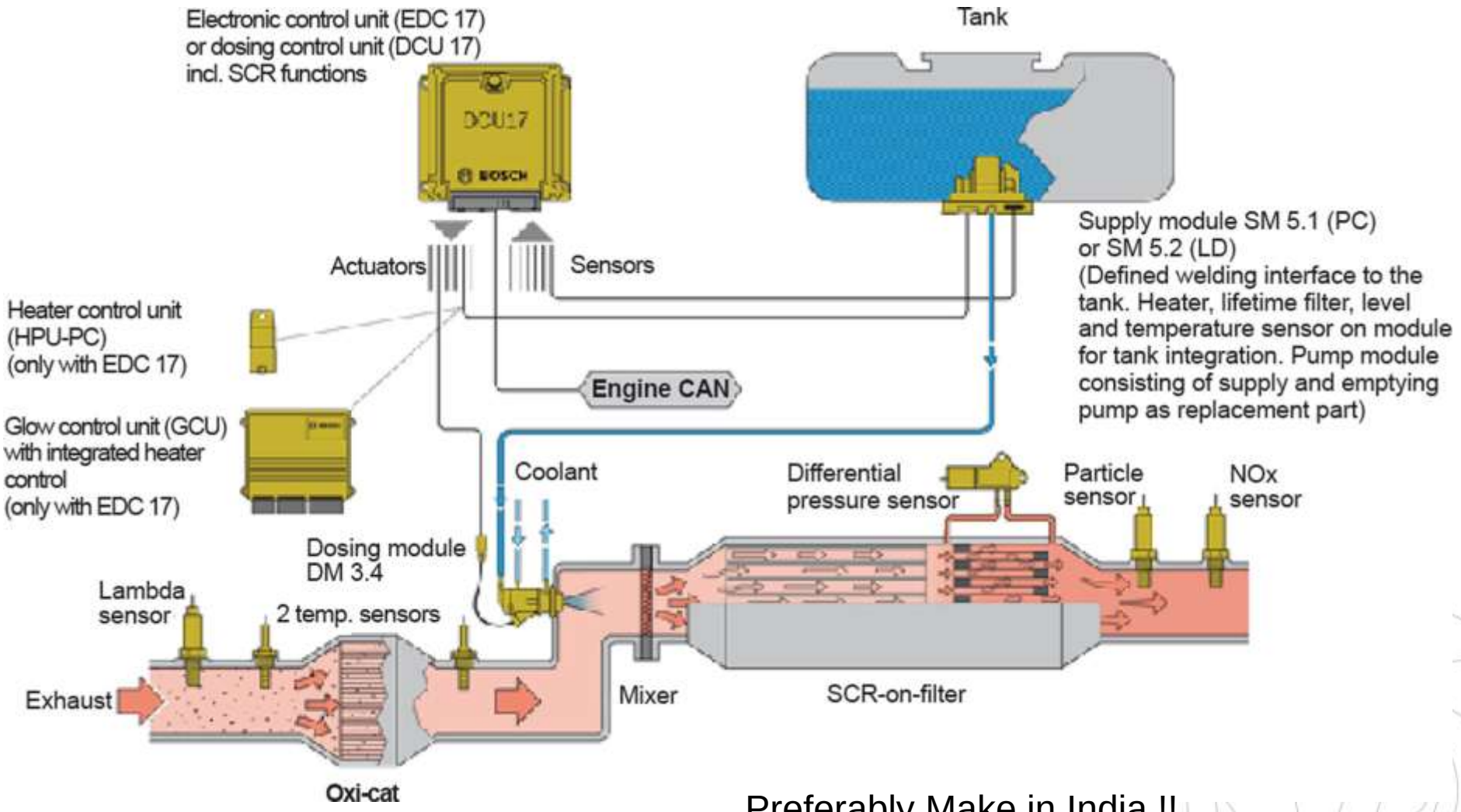
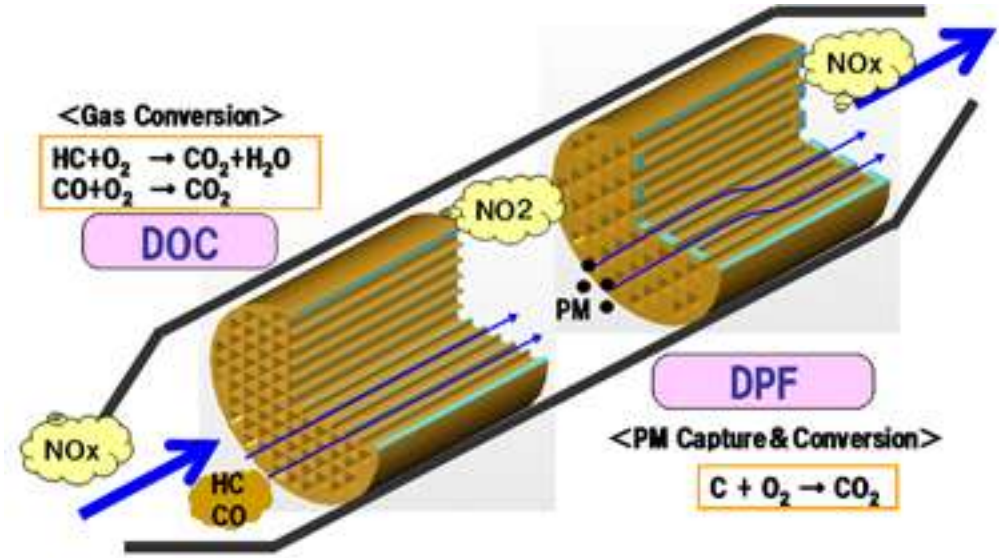


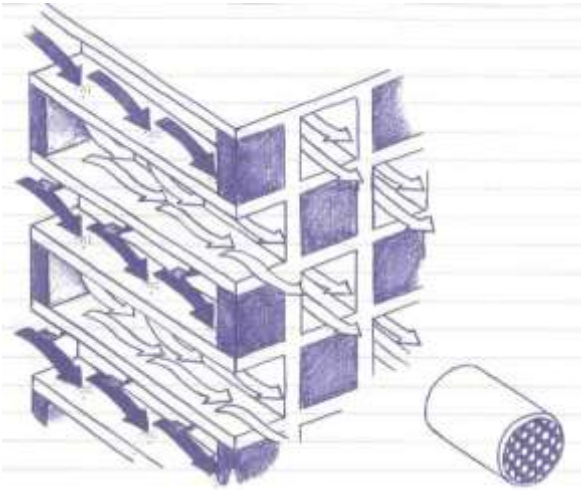
Preferably Make in India !!

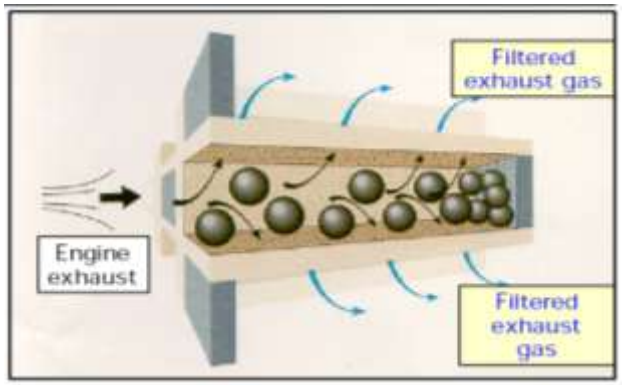
Courtesy : JM

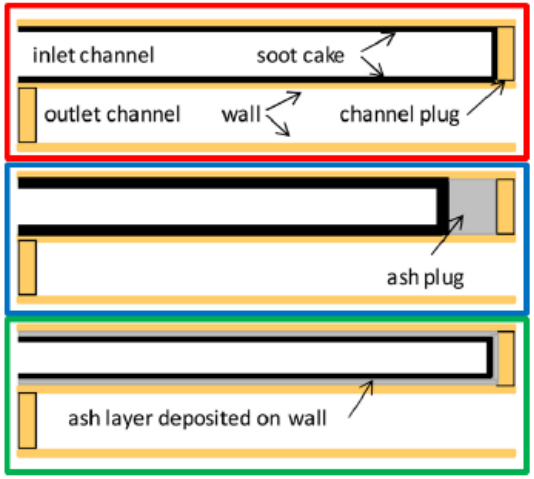
DOC & DPF Working



Diesel Exhaust Gas







Soot layer formation in a DPF without ash

Ash plug formation

Ash layer with soot cake on top

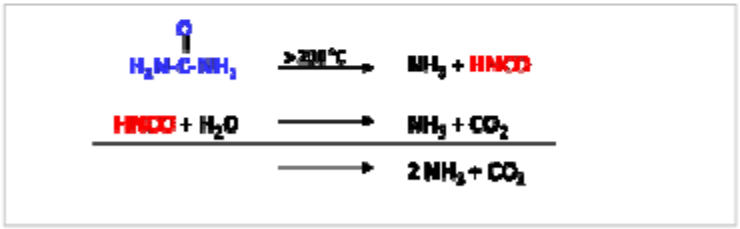
Regeneration of soot and cleaning of ash critical for DPF sizing, loading

SCR Working Principle

Key factors for a high SCR catalyst efficiency

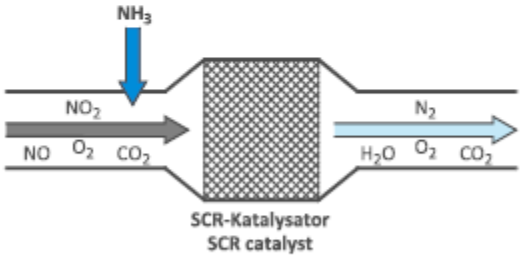
- Homogeneous distribution of the Ammonia in the exhaust
- Homogeneous distribution of the exhaust over the catalyst surface
- Avoiding of wall contacts causing urea fall out
- Fast droplet evaporation for Urea decomposition and Ammonia formation
- High Dosing Frequency at high Urea Mass Flows, .i.e. nearly continuous dosing at high rates/temperatures
- Excellent Dosing Accuracy over lifetime

Urea decomposition



Urea is used as an aqueous solution called „AdBlue®“ or “DEF”, which is injected into the exhaust pipe

SCR DeNO$_X$ reaction



$$NO + NO_2 + 2\,NH_3 \rightarrow 2\,N_2 + 3\,H_2O$$
$$4\,NO + O_2 + 4\,NH_3 \rightarrow 4\,N_2 + 6\,H_2O$$
$$2\,NO_2 + O_2 + 4\,NH_3 \rightarrow 3\,N_2 + 6\,H_2O$$

Courtesy : Albonair

BS VI Implementation – published info. recollect

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10 THINGS YOU SHOULD KNOW ABOUT BHARAT STAGE VI

Govt has advanced the date when new standard for cleaner auto fuel kicks in, aiming to leapfrog to BS-VI norms by April 2020

1 WHAT ARE THE NORMS?

- Bharat Stage emission standards are used to regulate output of air pollutants from internal combustion engine
- These were introduced by the Union government in 2000

2 DO OUR NORMS FOLLOW GLOBAL PRECEDENTS?

- The Bharat Stage norms are based on European regulations. Two and 3-wheeler emission norms are lenient

3 WHAT IS INDIA RUNNING ON RIGHT NOW?

- BS-IV auto fuels are being supplied in north India
- The rest of the country runs on BS-III grade fuel
- From April this year, Goa, Kerala, Karnataka, Telangana, Odisha, Daman and Diu, Dadra and Nagar Haveli and Andaman & Nicobar will get BS-IV fuel
- The remaining parts of the country will get BS-IV fuel from April 2017

4 HOW MUCH WILL SWITCH COST OIL COMPANIES?

- According to oil minister Dharmendra Pradhan, oil PSUs will invest about **₹28,750cr** for switching over to BS-VI auto fuels

5 WHY SKIP ONE ENTIRE STAGE?

'We are not going for Bharat Stage V (or Euro-V) petrol and diesel as there is not much difference between BS-V & BS-VI (Euro-VI) fuel. We will bring BS-VI fuel by 2020' – **DHARMENDRA PRADHAN** | OIL MINISTER

6 WHAT CHANGES WILL THE SWITCH BRING TO YOUR CAR?

- Vehicles will have to be fitted with DPF (diesel particulate filter), mounted inside the engine compartment
- In small-car crazy India a DPF in the bonnet will involve major re-engineering
- Bonnet's length may have to be increased, making cars longer than 4 metres and liable to come under higher excise duty bracket

7 WILL CARS GET COSTLIER?

PETROL CARS BY	DIESEL CARS BY	TRUCKS BY
₹10,000-20,000	₹80,000-1.2L	₹1.5L-2L

8 DIFFERENCE IN NORMS?

BS-VI norms not defined yet but will be equivalent to Euro-VI standards

PETROL EMISSION NORMS

Norm	CO	HC	NOx	HC+NOx	PM
BS-III	2.30	0.20	0.15	–	–
BS-IV	1.00	0.10	0.08	–	–
Euro-VI	1.00	0.10	0.06	–	0.005

DIESEL EMISSION NORMS

Norm	CO	HC	NOx	HC+NOx	PM
BS-III	0.64	–	0.50	0.56	0.05
BS-IV	0.50	–	0.25	0.30	0.025
Euro-VI	0.50	–	0.06	0.17	0.005

All figures in g/km Source: Indian Emissions Regulations/ARAI

Illustration: Arya Prabhat

9 WHY IS INDUSTRY RESISTING?

- Oil refineries will need a substantial investment to upgrade refineries to supply fuel types that match BS-VI standards
- The shift of technology from BS-IV to BS-VI likely to cost anything between Rs 50,000cr and Rs 80,000cr to oil cos
- Skipping a step like BS-V puts extra pressure on auto manufacturers to produce compliant vehicles

INDUSTRY SAYS

"The jump from BS-IV (equivalent of Euro 4) to BS-VI (equivalent of Euro 6) standards... will be too much of a significant technological jump for the auto firms"

PAWAN GOENKA | MAHINDRA & MAHINDRA EXECUTIVE DIRECTOR (March 2015, before the govt advanced the switch)

MINISTER SAYS

"I appeal to automobile industry to cooperate in the larger interest of the country"

NITIN GADKARI | TRANSPORT MINISTER

10 WHY IS INDIA SPEEDING UP BID TO CURB VEHICULAR POLLUTION?

- India pledged at the recent global climate summit to improve the carbon emission intensity of its GDP by 33-35% by 2030 from 2005 levels
- It has also pledged the creation of an additional carbon sink of 2.5 to 3 billion tonnes of carbon dioxide equivalent through additional forest and tree cover by 2030

Courtesy : TOI

BS VI Implementation – Concluding Statements

- BS VI implementation – Requires significant changes to Engine & After treatment systems
- Extensive calibration effort is required for latest OBD and IUPR standards
- BS VI commercial fuel quality & availability is critical for completion of development on time
- Public awareness and strict implementation required to ensure the practical success of BS VI norms pan India
- Make in India initiatives on all new technologies to have less impact on cost and availability.
- As already said impact on vehicular emission alone cannot curb ambient air pollutants !!

Emission Introduction

Work for a Greener Future

Save Mother Earth , Save our Future Generation

Future Vehicle

"Zero Accidents"

Truck of the future

"Zero Emission"

"Always On"

"Lowest cost of ownership"

Finally at year 2020

- If all our vehicles have not complaint to Bs6 then ….

All will have value of Rs.500 and Rs1000 note Booklets of today.

This makes a sense of urgency and hurry up to be sustainable ..

- Back up

ASHOK LEYLAND

STYLING STUDIO

ASHOK LEYLAND

- Boss
- U-Truck
- eComet
- Hy-Bus
- Eagle
- JanBus
- JanBus Midi

ASHOK LEYLAND LIGHT VEHICLES

NISSAN ASHOK LEYLAND

- Dost
- Dost Xpress
- Stile
- Partner
- Mitr (F24 Bus)

ASHOK LEYLAND DEFENCE

- APC
- Stallion
- Super Stallion
- Ambulance
- MPV

Buses

ASHOK LEYLAND

Small


Stag


Jan Bus Midi


Lynx

Large


Viking


JanBus


ULE


FE SLF


RE SLF


Coach

Very Large


Vestibule


Double Decker


City


Intercity


School


Staff


Tarmac


Tourist


Ambulance

Ashok Leyland

Pioneering “ ALL

1967 - Double Decker

1979 - Rear engine buses

1980 - Integral buses

1982 - Vestibule buses

1997 - CNG Bus

2002 - Hybrid Electric Bus

2005 – FE Semi low floor

2010 - CNG Hybrid Plug-in Bus

2012 - World’s first front engine single step full flat floor bus

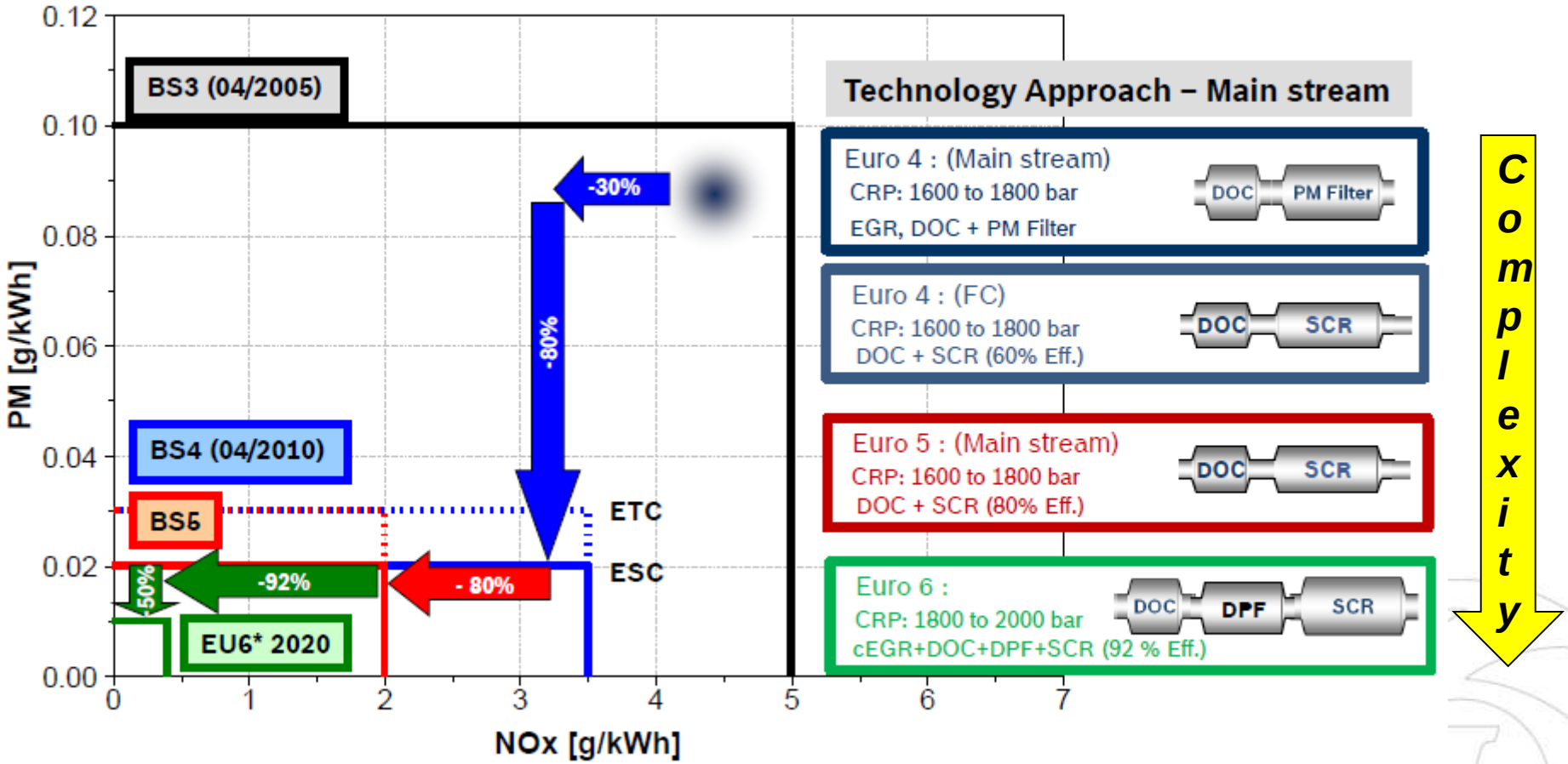
Upcoming – EV

Continuing the legacy ….

BS VI Adv Exhaust Technology Complexity increase

ASHOK LEYLAND

Challenges for Future Emission Norms



ESC = European Steady-state Cycle ETC = European Transient Cycle * EU6: WHSC & WHTC

Courtesy : Bosch

BS VI Adv. Exhaust > 3.5 T
After treatment Parts

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