

BS VI

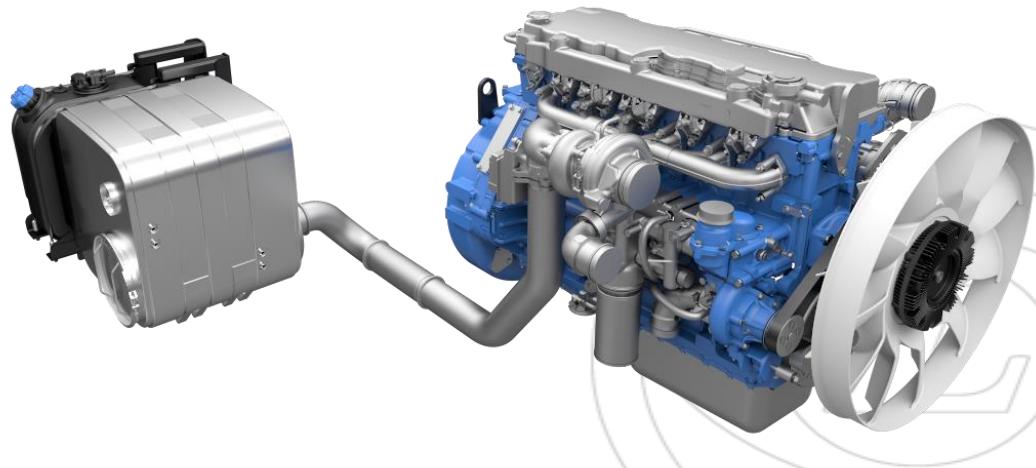


UNDERSTAND BS VI

@ ENGINE & EXHAUST SYSTEM LEVEL

FOR COMMERCIAL VEHICLES > 3.5 T

Atmanirbhar Bharat Abhiyan – Self Reliance



HINDUJA GROUP

Presented by
Mr. Krishnan Sadagopan

Sr. Vice President, Engines Development
Ashok Leyland Ltd



Technology for BS VI in India

20+
papers

15
patent
s filed

World's only Inline FIP
BS IV

India's only Vehicle
range with iEGR in
BSIV

LCV Engines with
Multi-fuel capability

LCV
Engine



Inaugural address by
Mr. Tenkasi S Jawahar, IAS
Principal Secretary cum Transport Commissioner
Govt of Tamil Nadu



AIF ROAD SAFETY – Vision 2030 Zero fatality

13/06/20 Saturday 17:30 to 18:30,
through ZOOM Video Conferencing
Moderated by: Mr. Ashfaq Ahmed
Hosted by: Mr. Sampathkumar

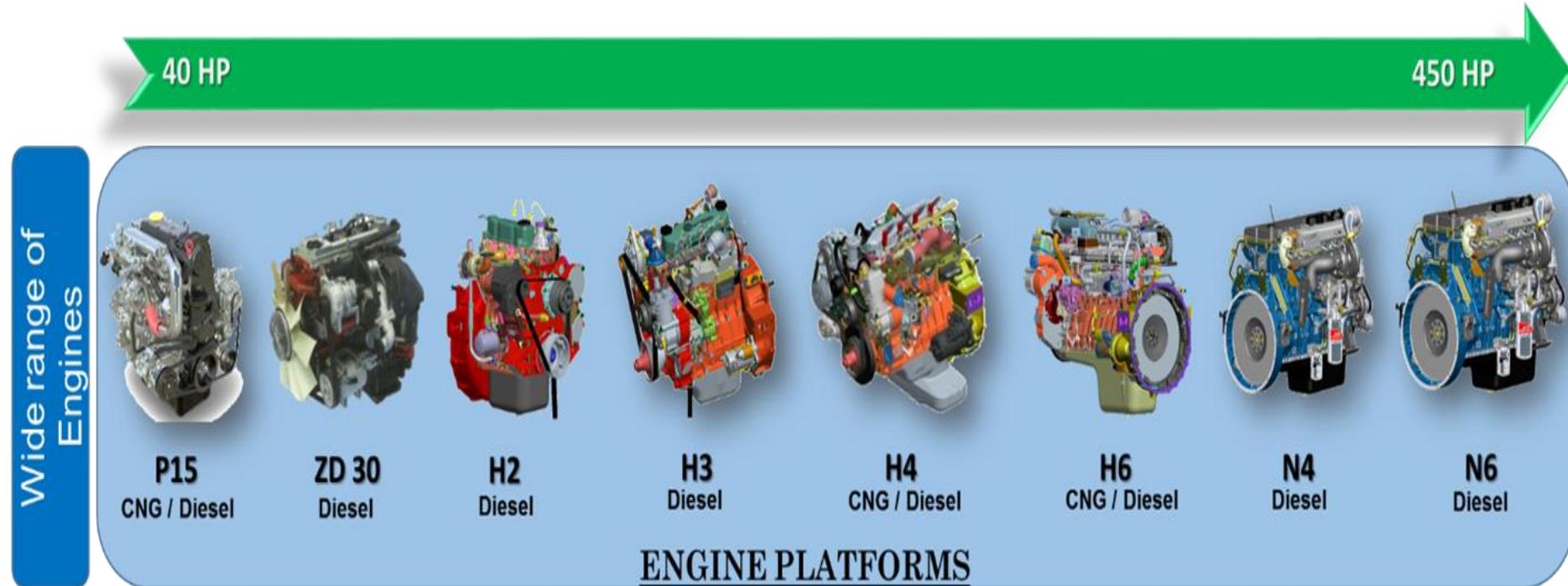
Webinar
Registration Mandator

Vision

To create conditions for a **safe, efficient, economical, seamless and environment-friendly transport system for the mobility of people and goods within the State.**

Mission

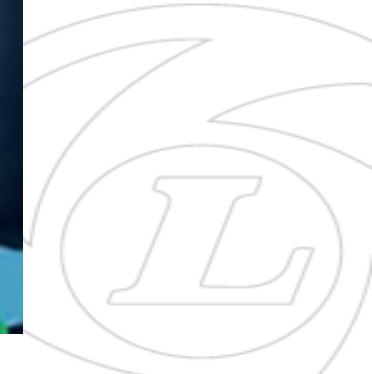
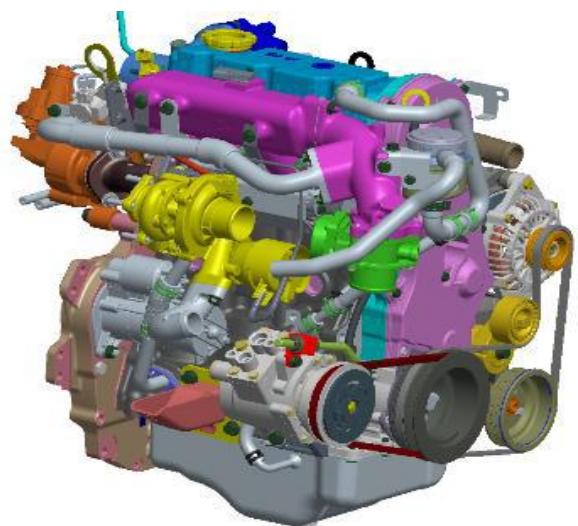
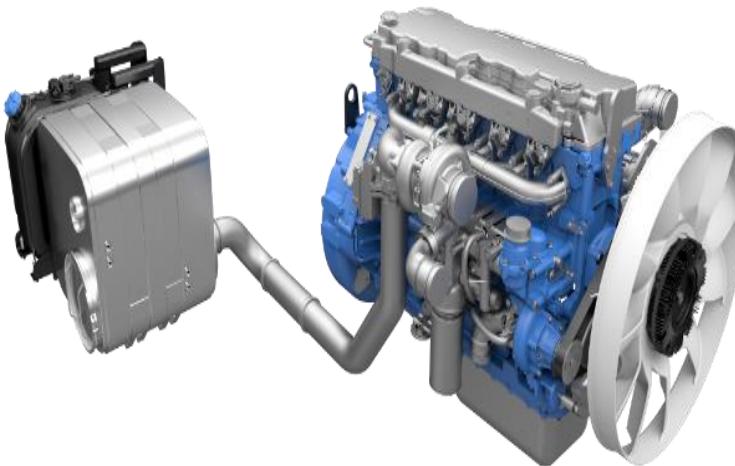
1. To ensure the **safety** of citizens using the road network. (Healthy)
2. To promote environment friendly transport services. (Clean air)
3. Upgradation of Human Resources & Infrastructure in the transport sector. (Derivative)
4. Integration of different modes of Transport with respect to cost, efficiency and convenience.
(Possible like no powered to optimized one , including electric future)
5. To provide a fair regulatory framework for the Transport sector. (Very fair)
6. To provide IT-enabled citizen services in the transportation sector **to increase transparency and service-delivery quality. (True)**
7. To generate revenues in Transport sector.



UNDERSTANDING BS VI



ASHOK LEYLAND



HINDUJA GROUP



Non fossil fuels and electric vehicles for future

WHY ????



WHY EMISSION STANDARDS....



EFFECT OF EMISSION...POOR AIR QUALITY...HEALTH HAZARD



Why BS VI? A Planned disruption – Economic Nationalism (3 Years timeline)



राजपत्र सं. दी० प्रा० - ३३०४/९९
REGD. NO. D. L.-3304/99

भारत का राजपत्र
The Gazette of India

अधिकारी
EXTRAORDINARY
वार्ष ११—काल ३—उप-खंड (१)
PART II—Section 3—Sub-section (i)
संसदीय से प्रभागीत
PUBLISHED BY AUTHORITY

मा० ६५१] नई दिल्ली, सुबह, विशेष १६, २०१६/वार्ष २५, १९३८
No. ६५१] NEW DELHI, FRIDAY, SEPTEMBER 16, 2016/BHADRA 25, 1938

मात्रक परिवहन और राजमार्ग व्यवस्था
विभाग
मात्रक विवरण, १६ विशेष, २०१६

मा०.का.वि. ८८९(ब)।—वैदीय योग्यतावाल अधिनियम, १९८८ (१९८८ का ५९) वारा २१२ की उपलब्धा (१) द्वारा या अधिनियम के अन्तीम योग्यता वाले के लिए प्राप्त नियम भारत सरकार में मात्रक परिवहन और राजमार्ग व्यवस्था की अधिनियमों में, या, का.वि. १८७ (४), वारीच १९ वर्षों, २०१६ द्वारा भारत के राजपत्र, अन्ताराच, भार्त II, वार ३, उप-खंड (१) में उल्लेख द्वारा संबंधित प्राप्तिकों द्वारा उस वारीच में जब प्राप्त नियमों में अंतिमीत उक्त अधिनियम की प्रतिक्रिया जनसाधारण की उपलब्ध करवाई गई थी, तो नीति दिन नीति व्यवस्था के द्वारा अंतिमीत करने के लिए प्रकाशित विवर यह थे :

उक्त राजपत्र अधिनियम की प्रतिक्रिया जनसाधारण की १९ वर्षों, २०१६ की उपलब्ध करवाई गई थी;

उक्त प्राप्त नियमों के संबंध में जनसाधारण में प्राप्त अंतिमीत और मुद्राओं पर वैदीय सरकार द्वारा विचार किया गया है :

वन्... वैदीय सरकार, योग्यता के अन्तीम योग्यता वाला नियम, १९८८ का ५

१. (१) इन नियमों का लक्षित :
(२) वे राजपत्र में उक्त नीति
२. कैदीय योग्यता वाला नियम, १९८८,
(३) उप-नियम (२), वे-

(४) यों (१), वे प्रत्यक्ष या, भारत संघ-वाले प्राप्तान्त वाला या हो, के लिए यह "भारत संघ-IV" वा "भारत संघ-VI" प्रतिष्ठित क्रमसः प्रतिष्ठित रखी जाएगी;

(५) यों (२), की नामिकाम में, "भारत संघ-IV" की प्रतिष्ठित जरूर भी हो, के लिए यह "भारत संघ-IV" वा भारत संघ-VI" प्रतिष्ठित क्रमसः रखी जाएगी;

(६) उप-नियम (७), के प्रत्यक्ष में, "भारत संघ-IV" की प्रतिष्ठित के लिए यह "भारत संघ-IV" वा भारत संघ-VI" रखा जाएगा;

REGULATION

4455 Q1/2016 (1)

INDIA RATIFIES PARIS DEAL: WHAT NEXT?

REPORTS ON P 10

THE ROAD AHEAD

- Countries will start framing rules for implementing the agreement, meant for actions to be taken in 2020-30, at climate conference (COP22) in Marrakech, Morocco, next month
- Climate actions till Dec 2020 — to be taken only by rich nations — are governed by Kyoto Protocol. India to seek action plan for 2016-2020
- India will insist on concrete roadmap from rich nations to mobilise funds to help developing countries move to a low carbon growth path

INDIA'S POST-2020 PROMISE

- Reduce emissions intensity, or emissions per unit of GDP, by at least 33% by 2030 compared with 2005 levels
- At least 40% of power to come from non-fossil fuel sources in 2030
- Additional carbon sink of about 2.5-3 billion tonnes by adding forest/tree cover

India becomes 62nd nation to ratify Paris climate deal



Vikram Kohli
@Timesgroup.com

New Delhi: India formally joined the Paris Agreement on climate change by submitting its instrument of ratification to the United Nations in New York on Sunday, the birth anniversary of Mahatma Gandhi and also the International Day of Non-Violence.

The country, however, signed off on it with certain conditions, keeping its development agenda in mind.

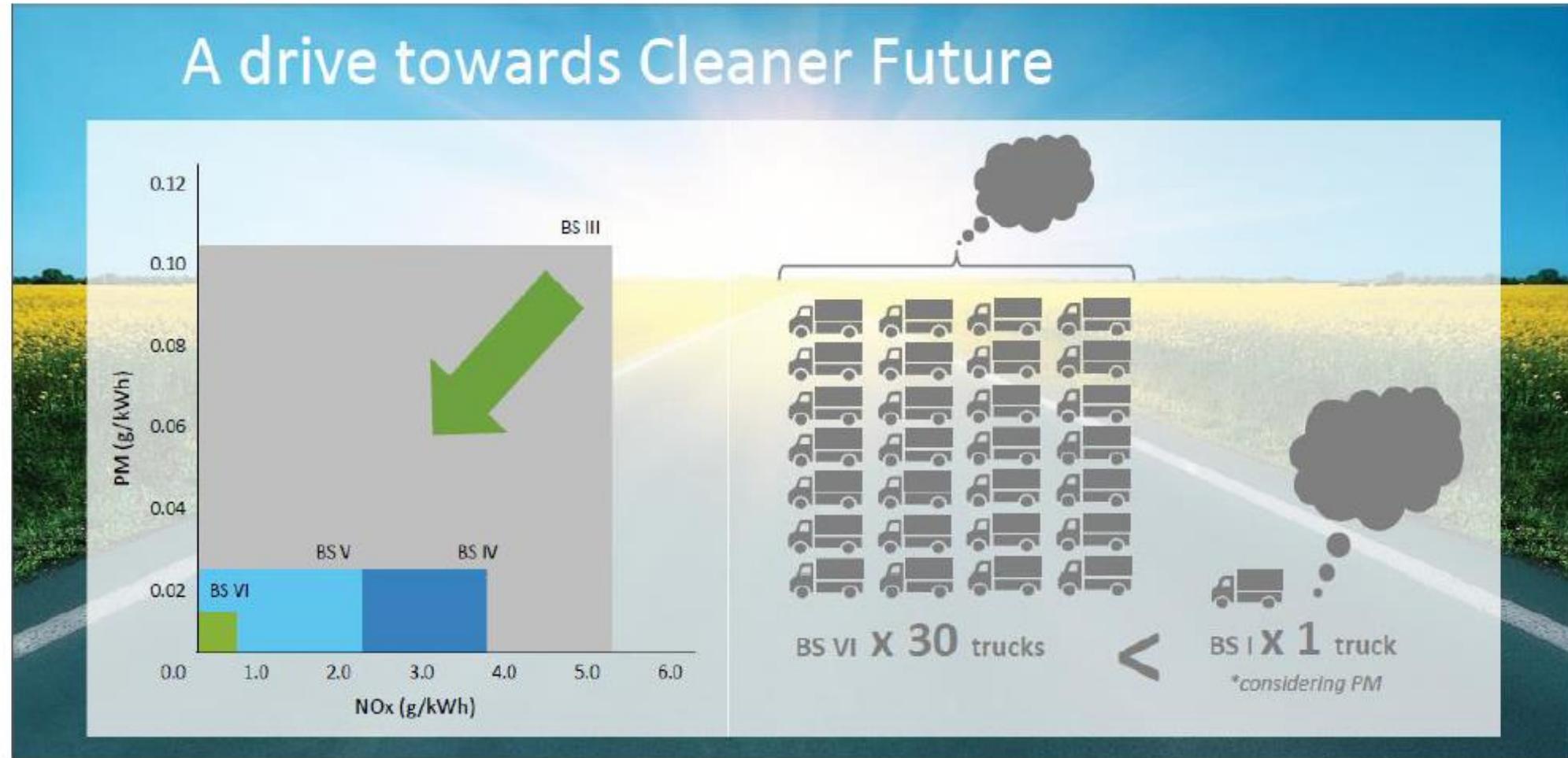
Though the country has not used the word "condition", it is made amply clear in its "declaration" that India would be able to take climate actions provided it gets financial and technological support to move towards a low carbon growth path.

India's permanent representative to the UN Syed Akbaruddin handed over the Paris climate deal document signed by President Pranab Mukherjee to Santiago Calatrava, the head of UN treaty division.

Activists say agreement not enough to contain temp rise

New Delhi: Environmentalists believe India's main role in addressing issue of loss and damage

- Create in India**
- Innovate**
- Inspiring**
- Simple**
- Speed**
- Frugal**
- Safe**
- Healthy**
- Value added**



WHAT ????



Tailpipe Emission Standards

- "Tailpipe" emission standards specify the maximum amount of pollutants allowed in exhaust gases discharged from a diesel engine.
- The tailpipe emission standards were initiated in California in 1959 to control CO and HC emissions from gasoline engines. Today, emissions from internal combustion engines are regulated in many countries throughout the world.



10 Things you should know about BS 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
₹10,000-20,000

DIESEL CARS BY
₹80,000-1.2L

TRUCKS BY
₹1.5L-2L

Diff between Bs5 and 6 fuel is the reason to cut Bs5 !! Challenges ??

10 Things you should know about BS VI

**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

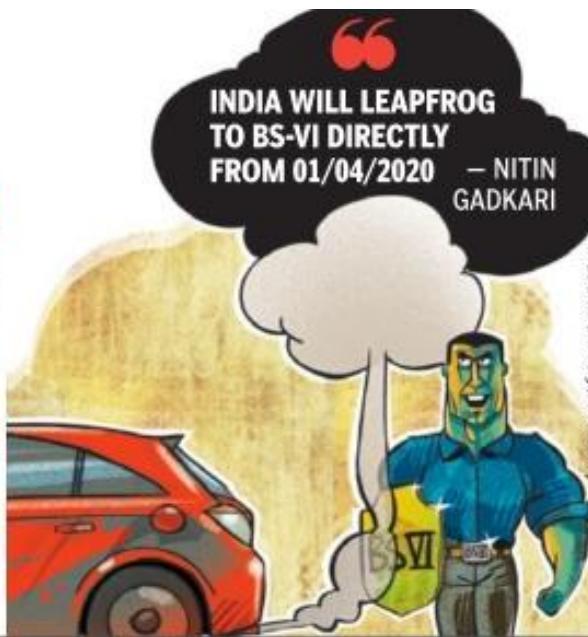
All figures in g/km Source: Indian Emissions Regulations/ARAI

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

**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

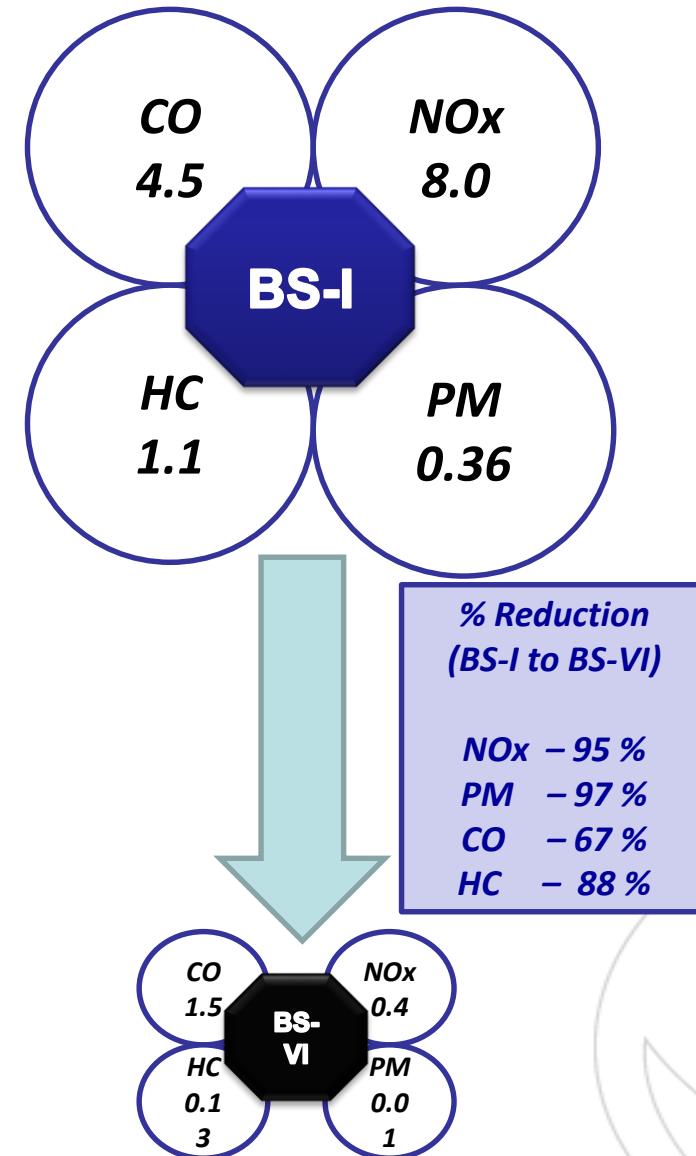
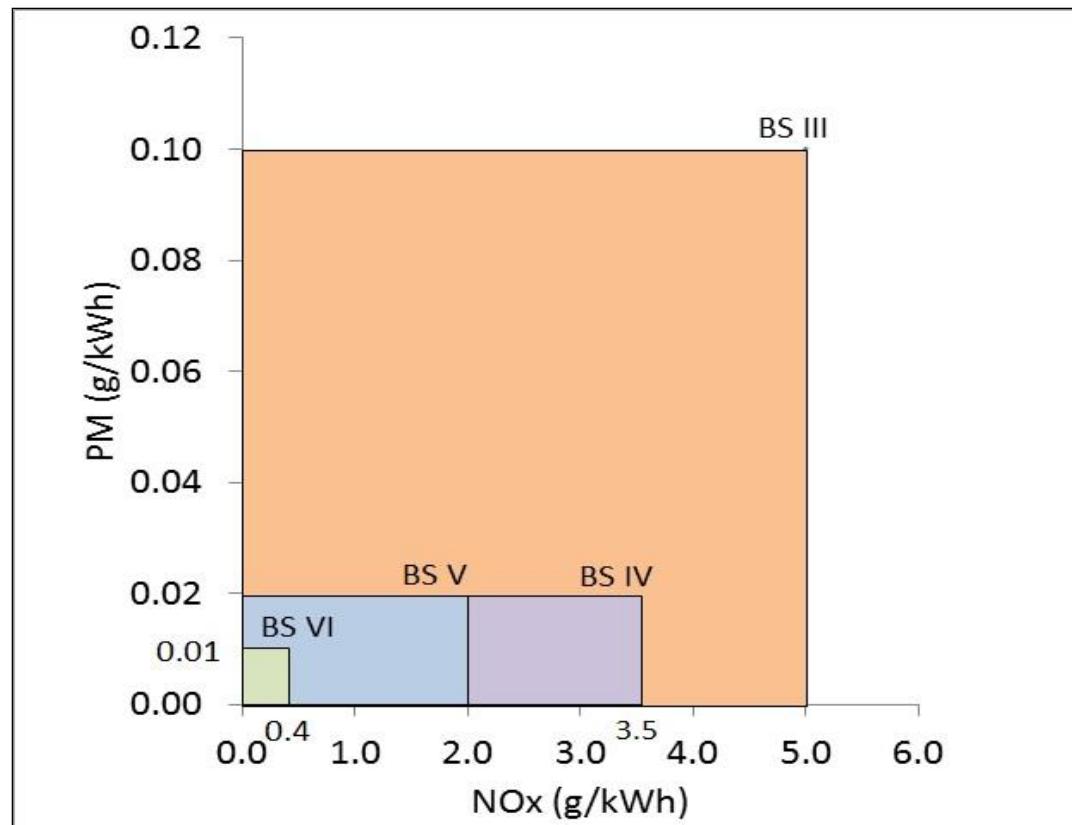
**Globally committed , now we need to work towards curb pollution
Locally it will benefit us . But time frame is a big challenge**

What is BS III, IV... VI..... In INDIA...



1999	2000	2001	2003	2005	2010	2013	2014	2015	2016	2017	2020
BS-1	BS-1	BS-2	BS-2	BS-2 Pan India	BS-4 NCR + 13 Cities	BS-4 OBD (ALL BS4)	BS-4 + 20 cities	BS-4 + 30 cities & North India	BS-4 in South India	BS-4 Pan India	BS-6 Pan India
NCR (Delhi) -Cars & LCV	PAN India	All Metros	NCR + 11 Cities	BS3 NCR + 11 Cities	BS-3 Pan India						

Overview – Emission Norms



WHY EMISSION STANDARDS....

EMISSIONS

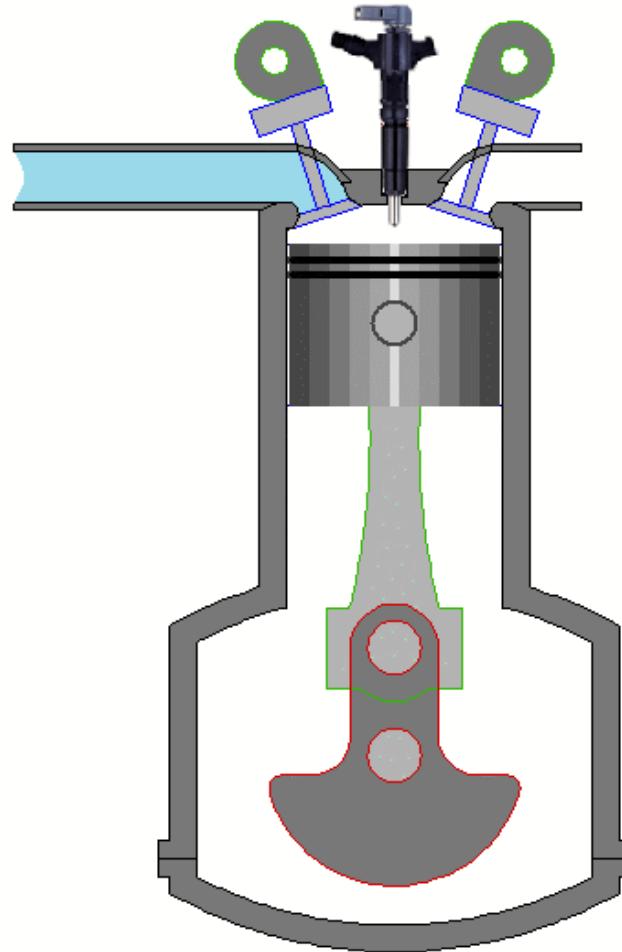
INPUT:

Theoretical:

Air (oxygen)
Fuel (Hydrocarbon)

Actual:

Air (oxygen , **Nitrogen**)
Fuel (Hydrocarbon, **Sulphur**)



OUTPUT:

Theoretical:

Carbon dioxide
Super heated Steam

Actual:

Carbon dioxide
Super heated Steam

No_x – Oxides of Nitrogen

HC – Partially burned Hydro carbon

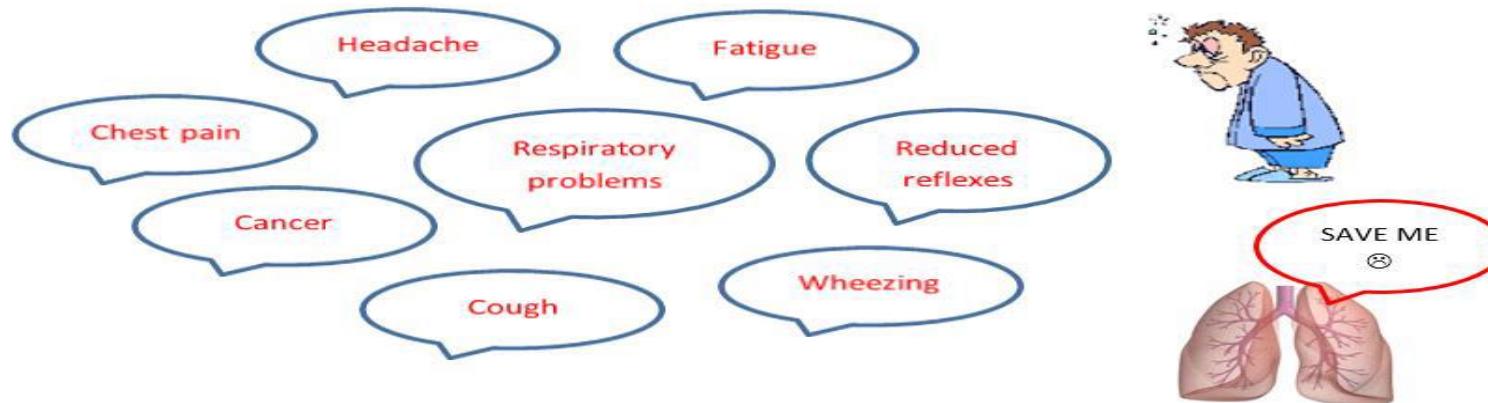
CO – Carbon Monoxide

PM – Particulate Matter

Need for Emission control



HEALTH PROBLEMS due to the EXHAUST GASES



Need for NO_x regulation



Need for PM & PN regulation

WHAT ARE THE HEALTH RISKS OF PARTICULATE MATTER?

Particulate matter poses a serious health risk because it can travel into the respiratory tract. PM2.5 is especially dangerous because it can penetrate deep into the lungs and sometimes even into the bloodstream.

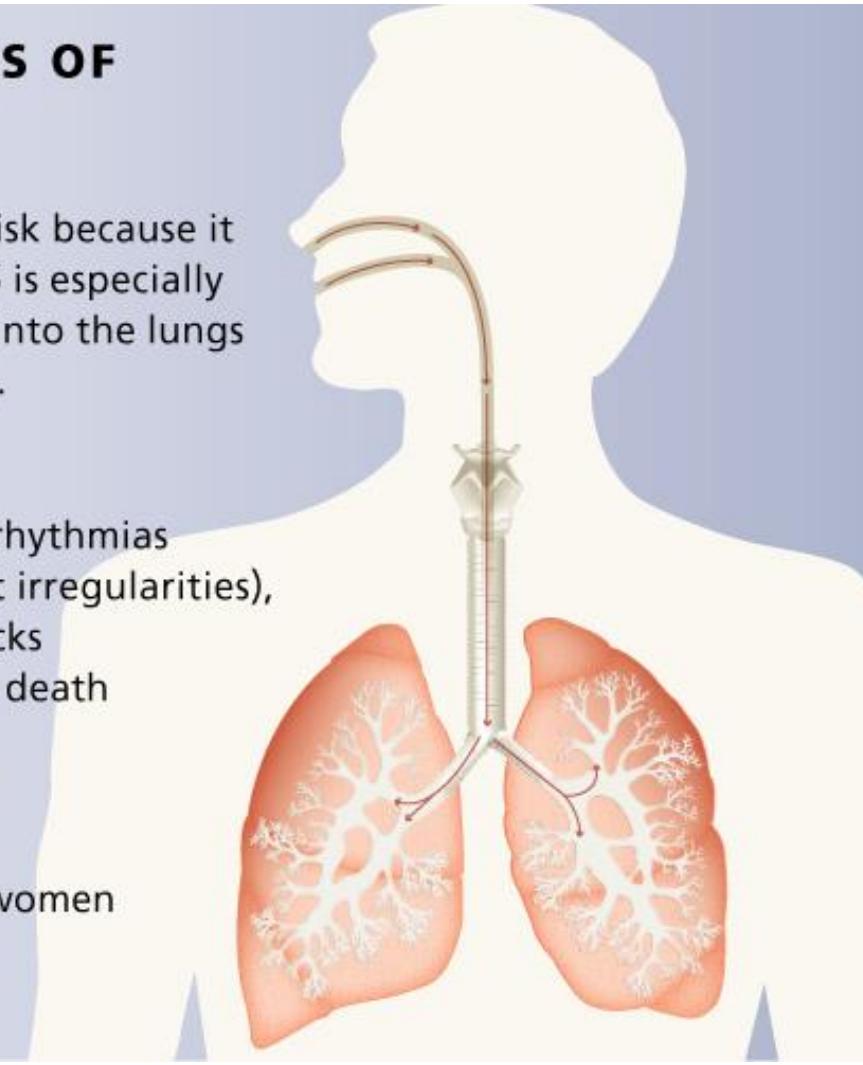
HEALTH EFFECTS

- » Decreased lung function
- » Chronic bronchitis
- » Increased respiratory symptoms
- » Cardiac arrhythmias (heartbeat irregularities),
- » Heart attacks
- » Premature death

GROUPS SENSITIVE TO PM2.5

- » People with heart or lung disease
- » Older adults
- » Children
- » Pregnant women

Source: www.epa.gov



Why PM is regulated?



HEALTH EFFECTS

AT RISK PEOPLE / INCREASED EFFECTS

PREGNANT WOMEN



HAVE HEART/LUNG
DISEASE; DIABETES



ACTIVES



SENIORS



CHILDREN &
INFANTS



ASTHMA
PREMATURE BIRTH;
INFANT MORTALITY



HEART
DISEASE



RESPIRATORY
ILLNESS;
LUNG CANCER



PREMATURE
DEATH

WHAT ARE THE HEALTH RISKS OF PARTICULATE MATTER?

Particulate matter poses a serious health risk because it can travel into the respiratory tract. PM2.5 is especially dangerous because it can penetrate deep into the lungs and sometimes even into the bloodstream.

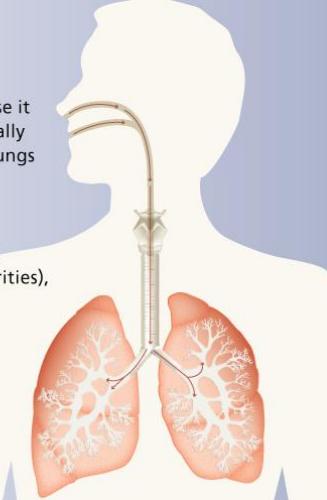
HEALTH EFFECTS

- » Decreased lung function
- » Chronic bronchitis
- » Increased respiratory symptoms
- » Cardiac arrhythmias (heartbeat irregularities),
- » Heart attacks
- » Premature death

GROUPS SENSITIVE TO PM2.5

- » People with heart or lung disease
- » Children
- » Older adults
- » Pregnant women

Source: www.epa.gov

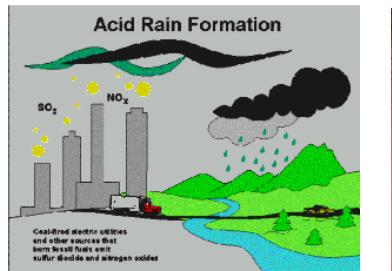


- Numerous studies link PM to aggravated cardiac and respiratory diseases such as asthma, bronchitis and emphysema
- PM can also have adverse effects on vegetation and structures, and contributes to visibility deterioration and regional haze

WHY EMISSION STANDARDS....

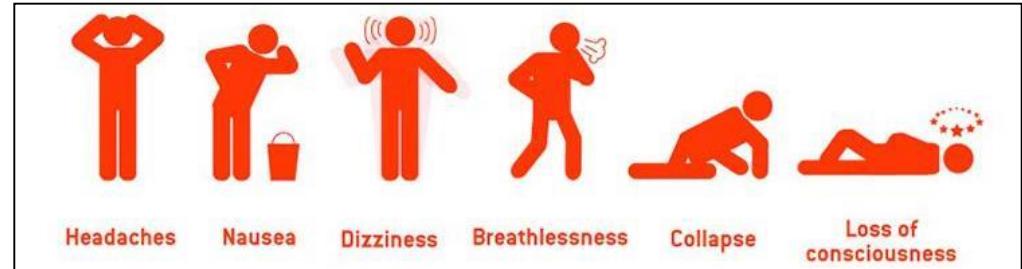
EFFECT OF EMISSION...

No_x – Oxides of Nitrogen



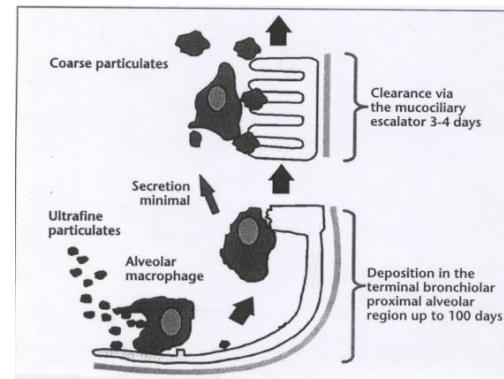
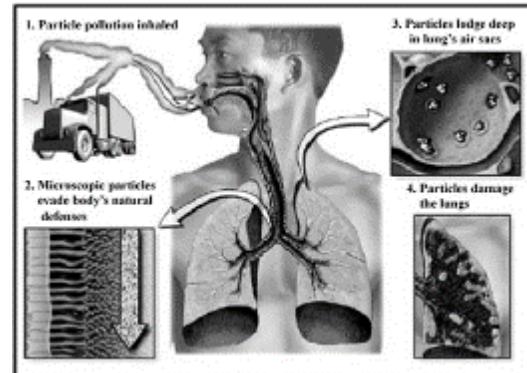
Irritation to Eyes, Lungs and Skin

CO – Carbon Monoxide



Combines with Hemoglobin to form carboxyhemoglobin

HC – Unburnt Hydro carbon & PM – Particulate Matter



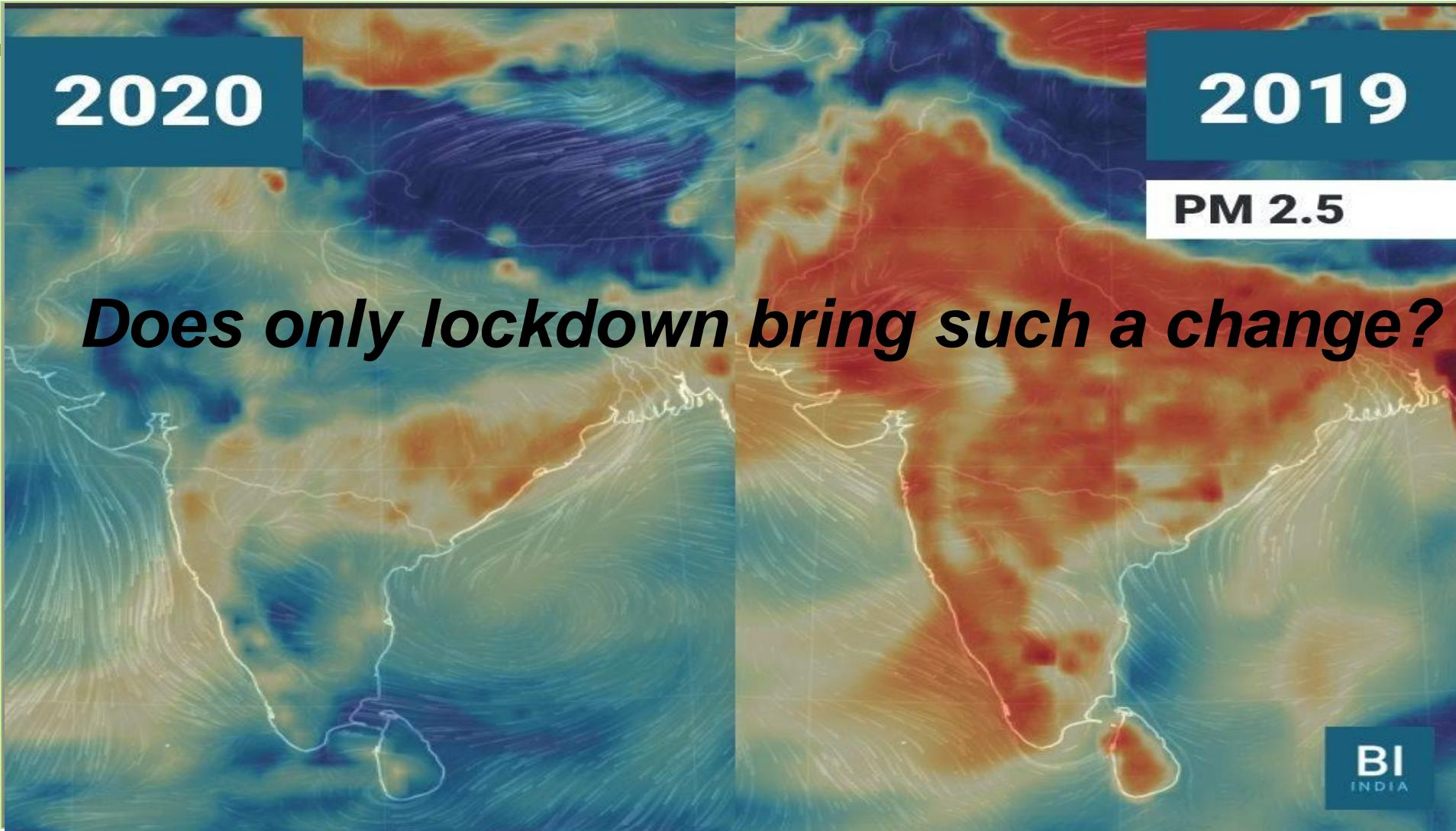


Does only lockdown bring such a change?





ASHOK LEYLAND





ASHOK LEYLAND

What if, it can be re-written as..

Does only lockdown bring such a change?

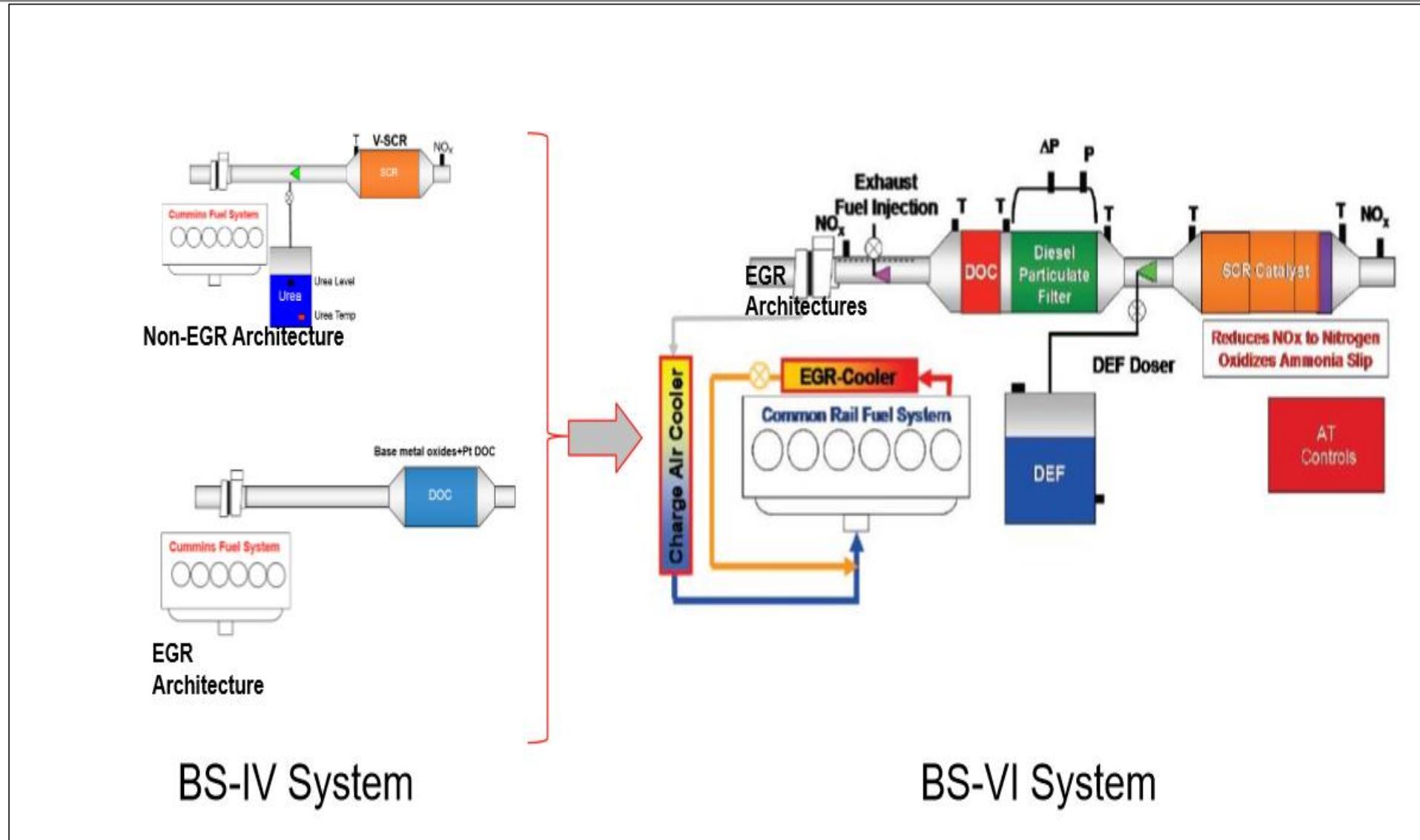
Before

B S VI

After



Changes BS IV to BS VI



Timeline Challenges

Time available:

Emission Level (India)	Introduced Year	
BS III	2010 (Pan India)	
BS IV	2017 (Pan India)	
BS VI*	2020 (Pan India)	

7 Year Interval

3 Year Interval

*Government of India decided to go for BS VI from BS IV skipping BS V stage

Emission Level (Europe)	Introduced Year	
Euro 3	2000	
Euro 4	2005	
Euro 5a	2009	
Euro 5b	2011	
Euro 6	2014	

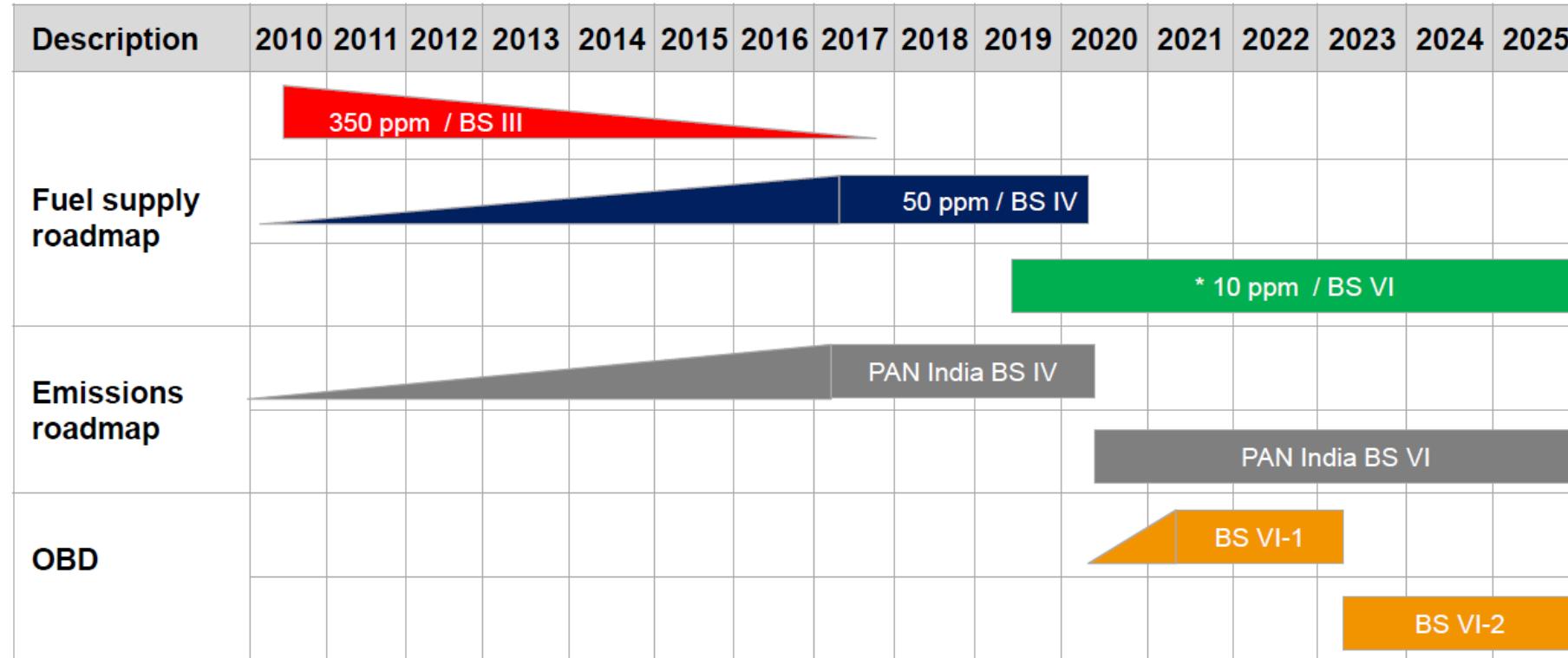
5 Year Interval

9 Year Interval

Inference:

- BS IV to BS VI skipping BS V – Technological migration implementation in shortest time frame

Fuel Sulfur - Overview



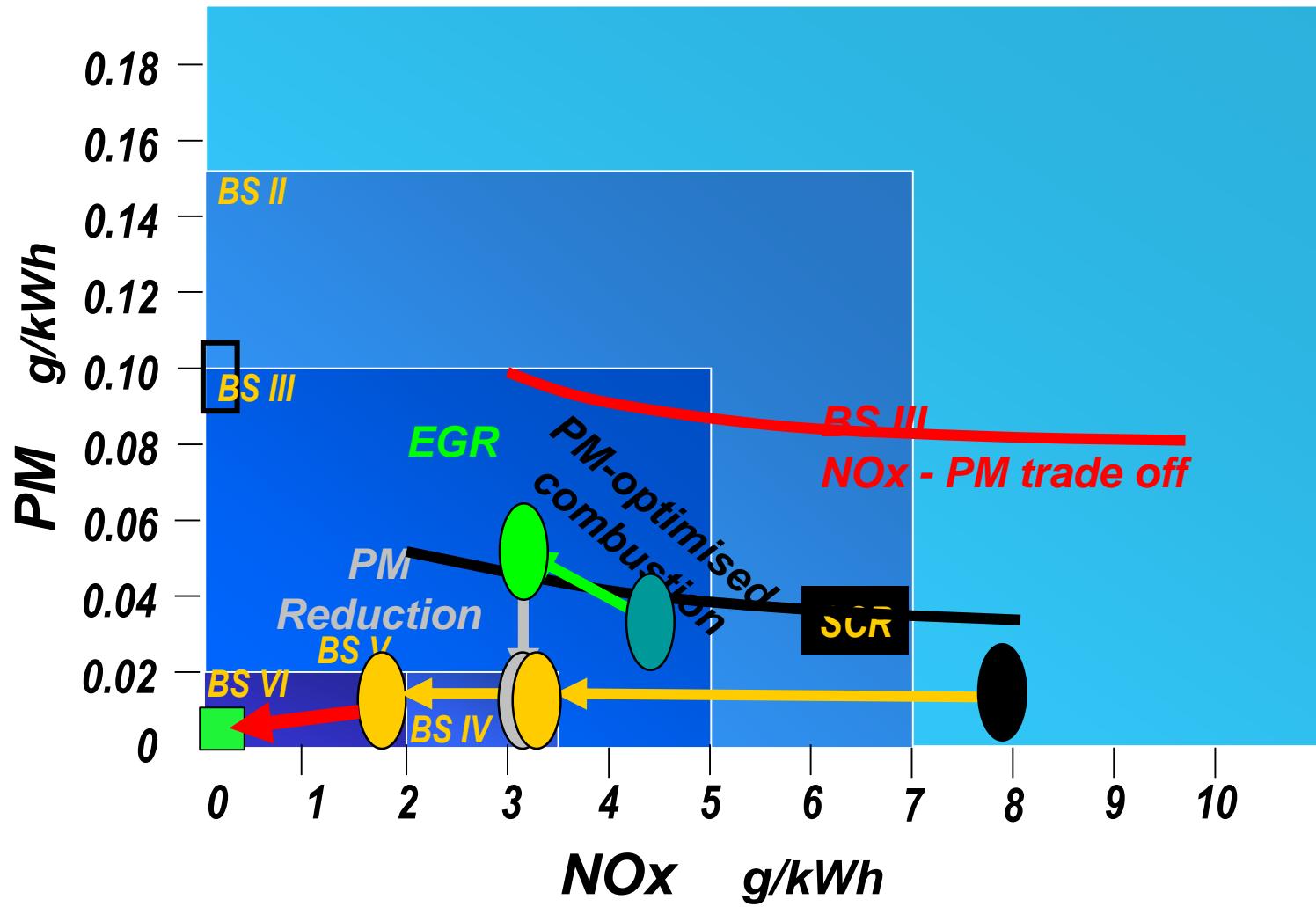
BS VI – NOx vs. PM Challenges



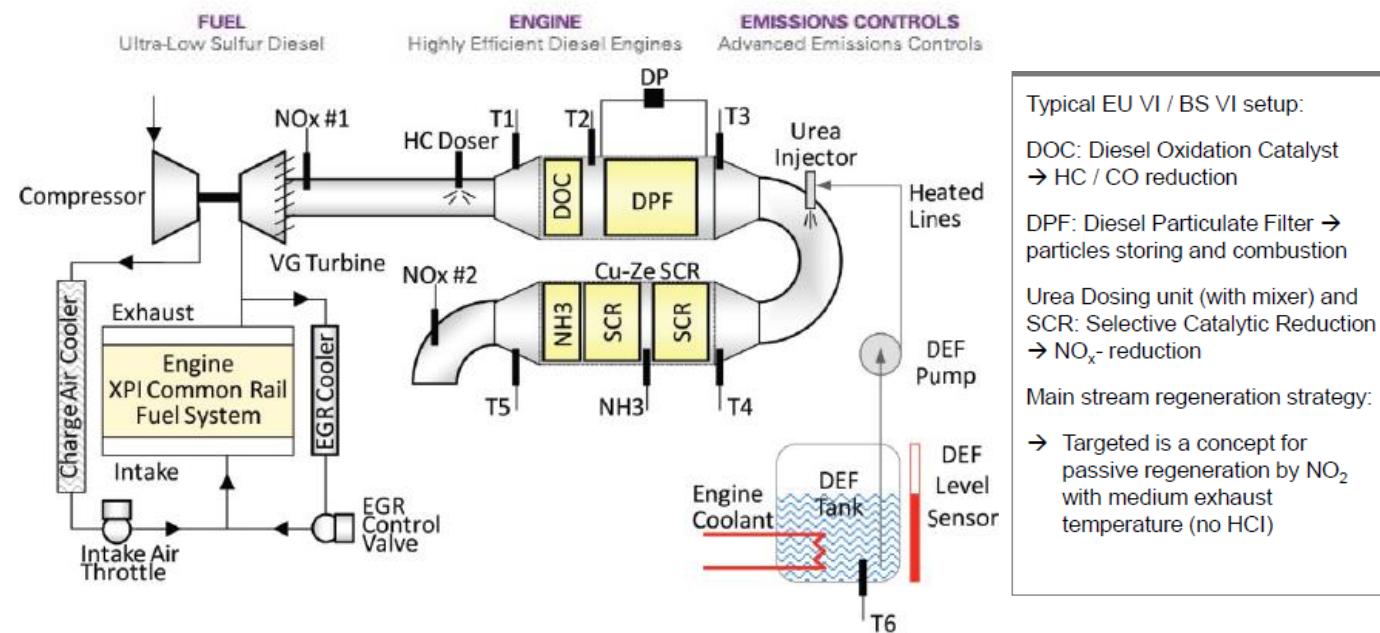
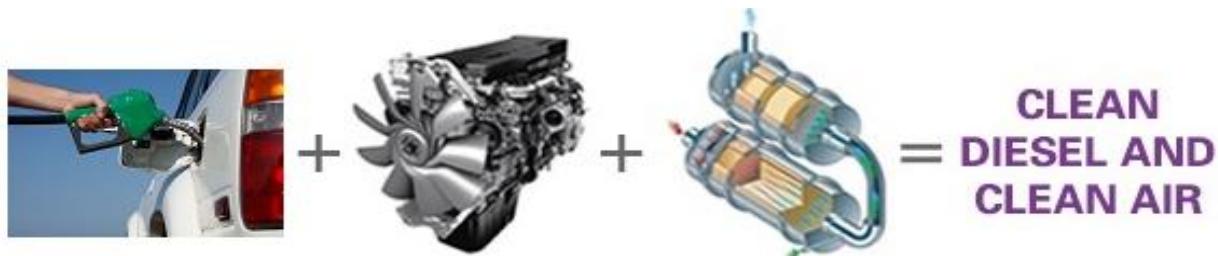
Parameter change	Effect on NOx	Effect on PM
Cycle temperature increases	↑	Better combustion conditions prevails
There is excess air in bowl	↑	Towards complete combustion
Longer premixed combustion phase	↑	Improved initial mixing, chances of better combustion

BS norms trend – PM vs. NOx

SCR (or) EGR + SCR for BS VI



BS VI – Intro





ASHOK LEYLAND

Implementation

- With the implementation of Bharat Stage (BS) VI emissions standards, vehicles are set to get costlier
- Because it requires advanced emission control technologies, which may lead to maintain and monitor those vehicles well. We had given self monitoring sensors , actuators and control systems to take care . Also display dash boards , torque controls , vehicle can be made inactive when non compliance.
- BS-VI norms comes following a Supreme Court order dated October 24, 2018, that states no BS-IV vehicle will be sold or registered in the country with effect from April 1, 2020 after which only BS-VI compliant vehicles will be sold. The new norms could reduce nitrogen oxide (NOx) and particulate matter (PM) emissions from vehicles by 90% and 56%, respectively.



ASHOK LEYLAND

Leap frog ??? No ..Its a Pole - Vault

- India is the only vehicle-producing region globally that will leap from BS-IV directly to BS-VI (by skipping the BS-V stage). “BS-VI will be a paradigm shift in emission control for polluted cities.
- Studies have indicated a 2.8 lakh cumulative reduction in deaths by 2030 owing to cleaner fuel usage,” said Anumita Roychowdhury, executive director (research and advocacy), CSE.
- “However, consumers have to pay attention to the maintenance and inspection of BS-VI compliant vehicles to ensure maximum benefit. The transport department will have to phase in new generation emission inspection system to ensure proper maintenance of advanced emission control systems, and prevent tampering.”

How ARAI- Viewed Bs6 ?

- The Automotive Research Association of India (ARAI), an autonomous body affiliated to the Union heavy industries ministry, estimated high initial cost due to BS-VI technology. The cost of heavy trucks is likely to increase by ₹1.75 lakh to ₹2.25 lakh, diesel cars by ₹65,000 to ₹95,000, petrol cars by ₹8,000 to ₹12,000, and ₹3,500 to ₹6,000 increase for two-wheelers.
- Environmentalists said the health benefits from lower vehicle emissions outweigh the rise in vehicle costs.
- The increased cost is attributed to major changes for tail pipe emissions. Along with 18 new sensors, BS-VI compliant vehicles will come with a diesel particulate filter (DPF) to trap fine to ultra-fine particulate matter, while an autograde urea tank will be attached to the exhaust system to neutralise nitrogen oxide emissions through selective catalytic reduction (SCR).
- More engine based improvements will also be implemented.

To leverage the BS-VI transition, it will be important to ensure following



- Strengthen the PUC system and its enforcement for the legacy vehicles
- Phase in more advanced on-road emissions inspection to ensure the advanced emissions control systems are performing optimally
- Introduce remote sensing monitoring that can measure a range of parameters even as the vehicles are moving on the road to identify and fix the gross polluters for maximum impact
- Strong surveillance of fuel quality to stop adulteration and misuse of high sulphur fuels
- Adopt measures of physical and other checks to prevent emissions frauds and emissions cheating by using defeat devices or by disabling advanced emissions monitoring systems
- Build consumer awareness related to this new technology to reduce risks

- **Tight fuel standards For Clean air**
- **Bold step by skipping BS-V to implement BS-VI in 3 years**
- **India will be the first country to make effective in short span of time.**
- **Not considered and not known about effect of BS VI fuel combustion related to driving conditions, speed and weather of India varies from that of Europe.**
- **Develop vehicles to Indian conditions and do validation**



Indian market Challenges for ATS robustness



- Challenging environmental conditions: Vibration, Cleanliness, fuel/lubrication quality
- Maintenance/ service practices still fairly basic.
- Road & infrastructure challenging condition.

alternate fuels to be thought of



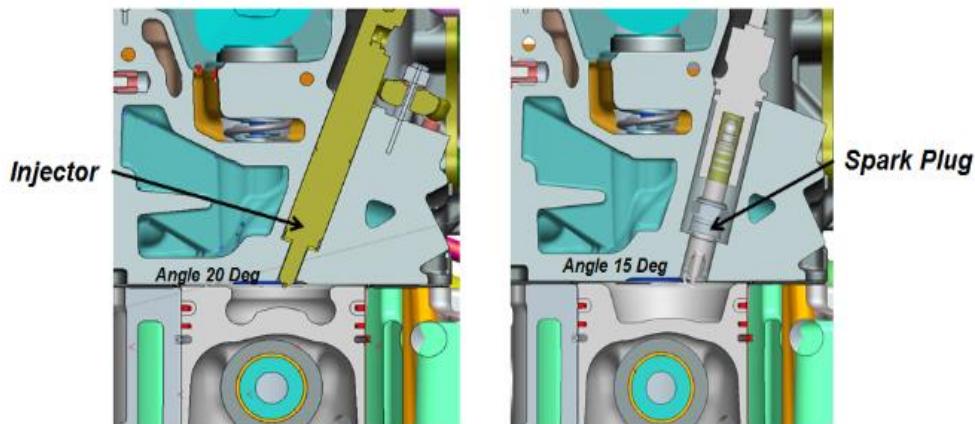
Futures in ICE

Fuel Preparation & Injection system – Multi Fuel Capability



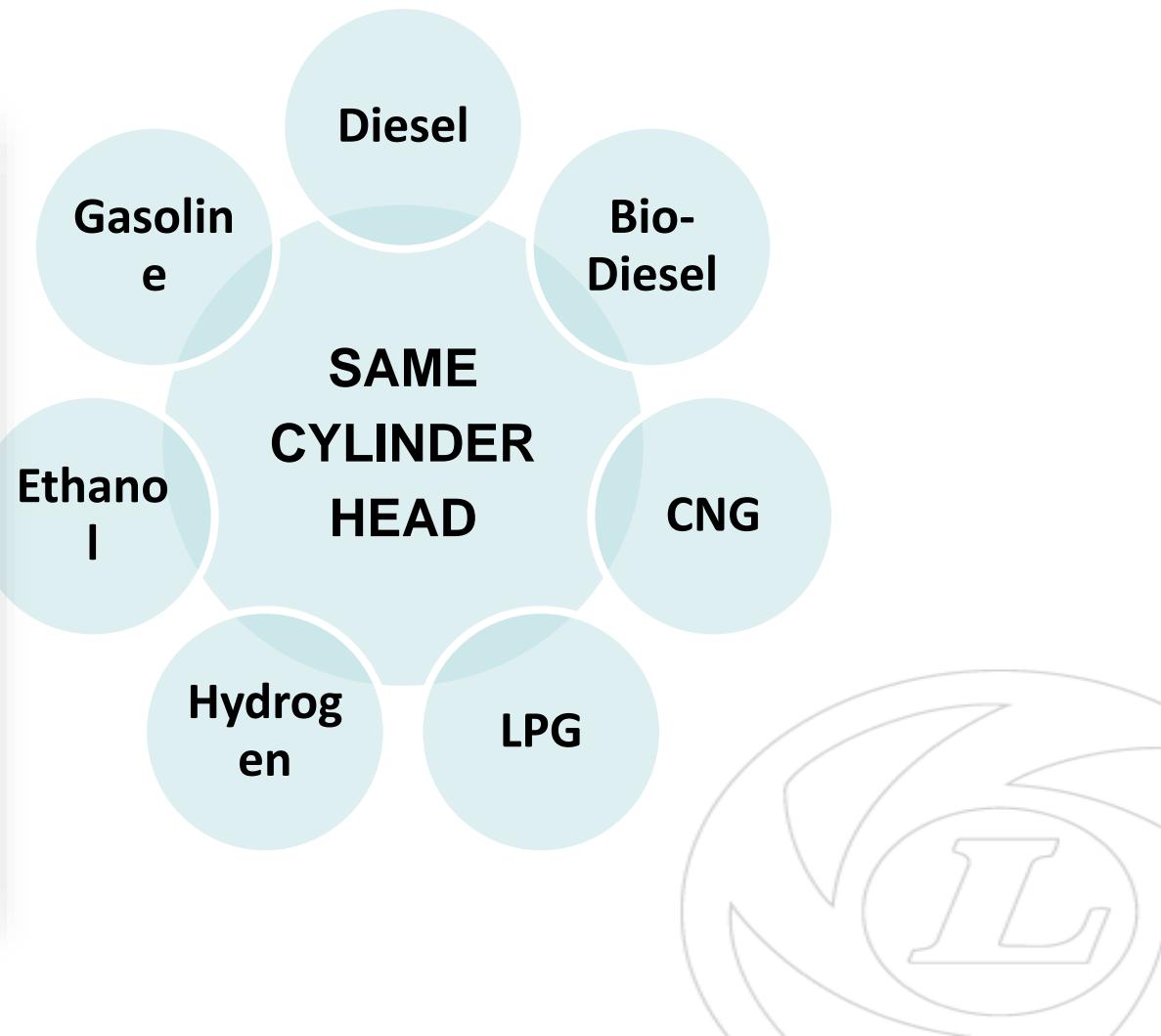
Multi-Fuel Configuration

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

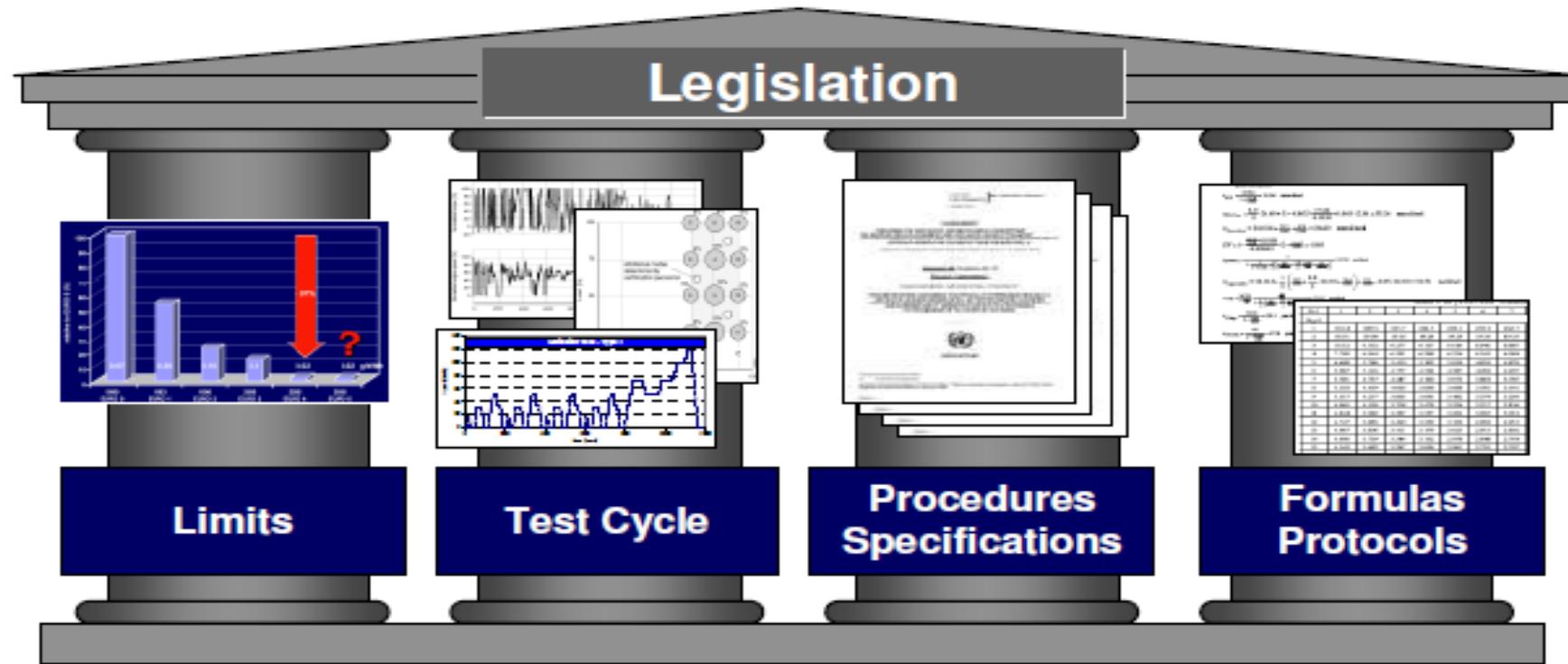
*Pentafuel capability



HOW ???



How it is monitored during development.....



All emission legislations are structured in 4 main parts.

1. Limits, which define the maximum allowed tailpipe emissions
2. Test cycle, how the engine or vehicle is operated
3. Test procedures and specifications for the test- and measurement systems.
4. Formulas and reporting, how the final result is calculated and reported.

How it is monitored.....

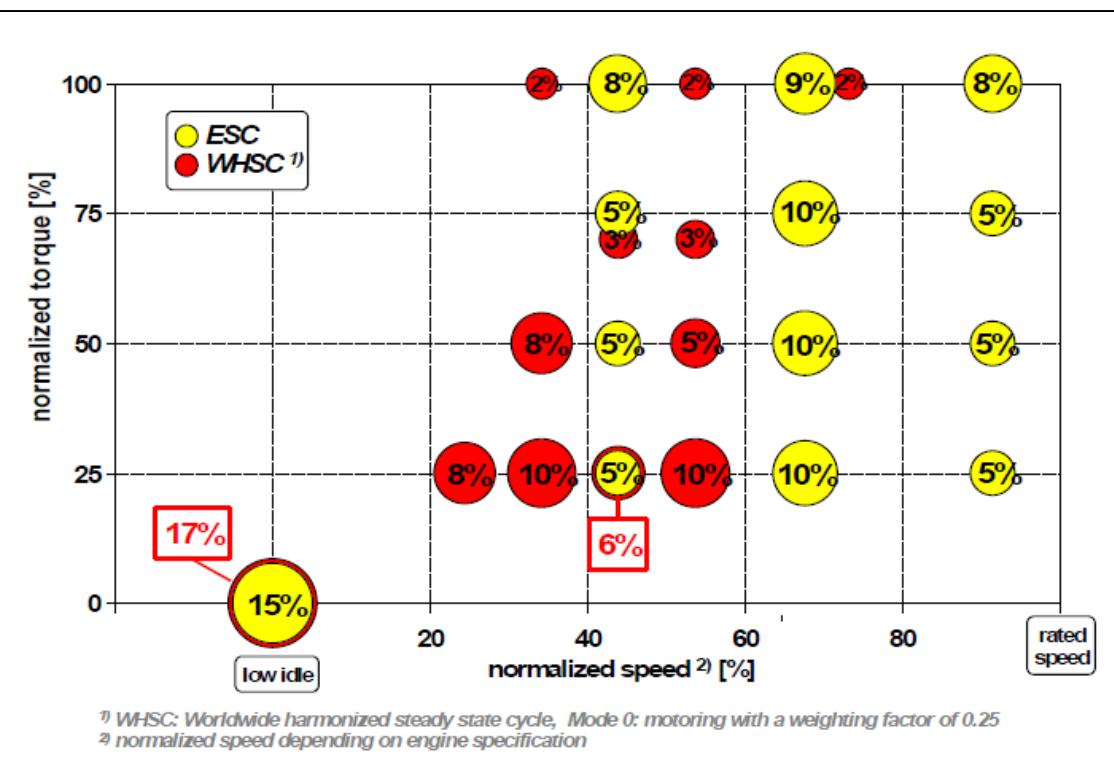
On Test Cycle – WHSC, WHTC (BS VI) vs ESC, ETC (BS IV)



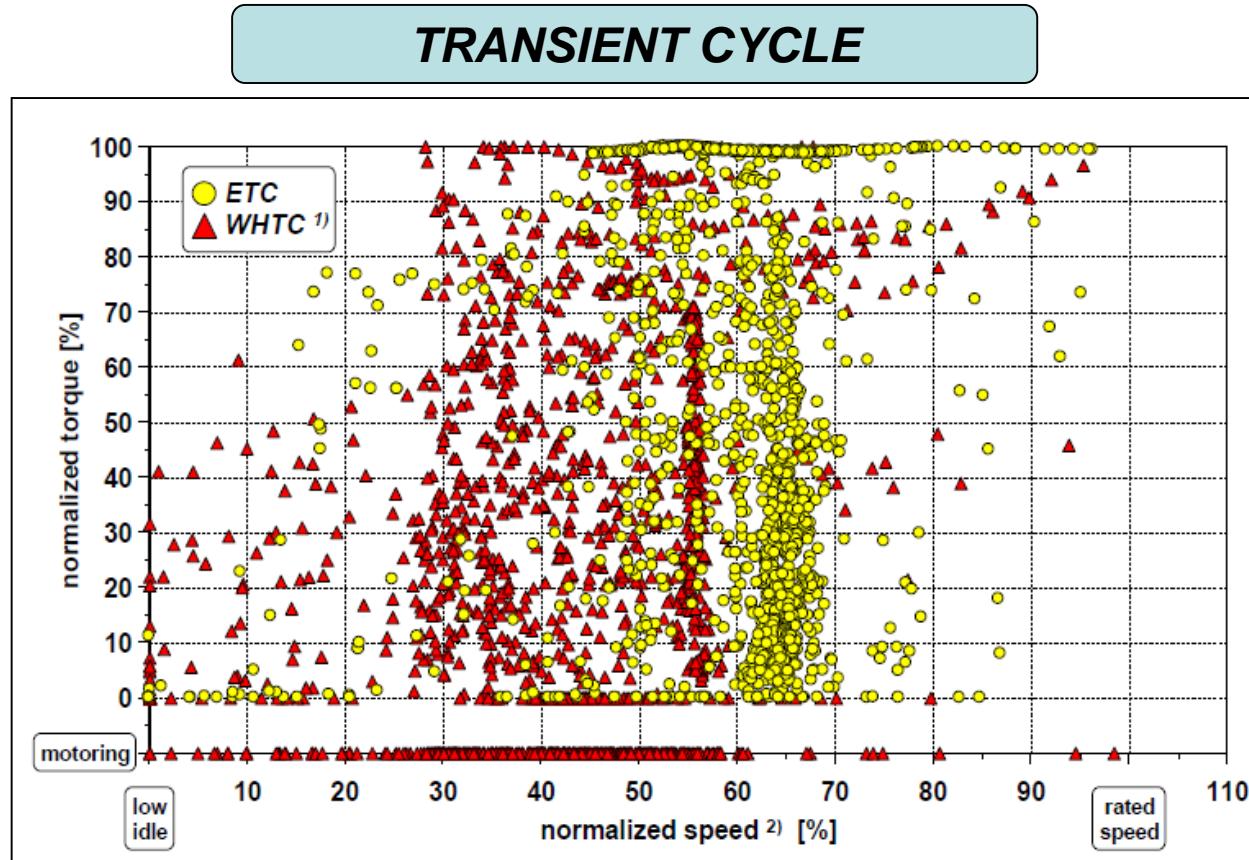
ASHOK LEYLAND

Norm	Year	NOx	CO	HC	PM	PN	Test Cycle
------	------	-----	----	----	----	----	------------

STEADY STATE CYCLE



TRANSIENT CYCLE

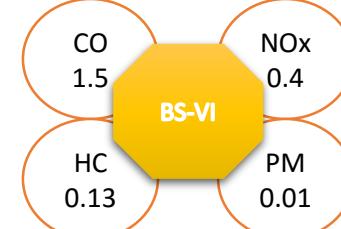
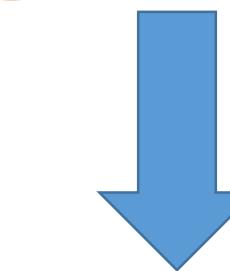
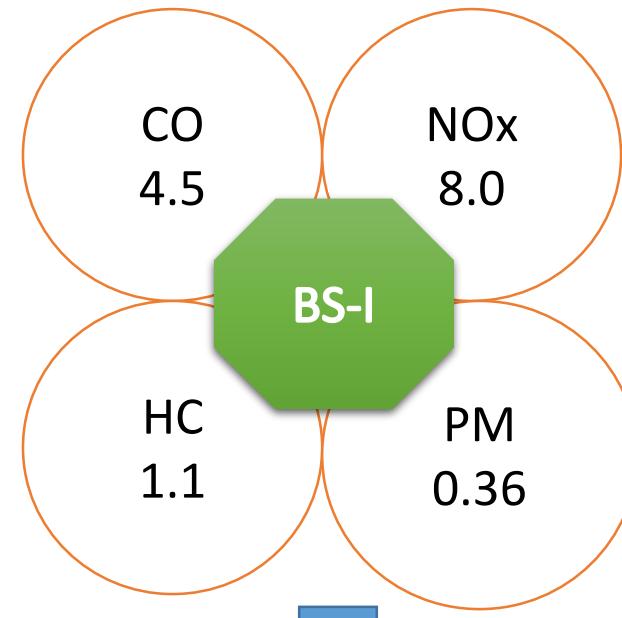
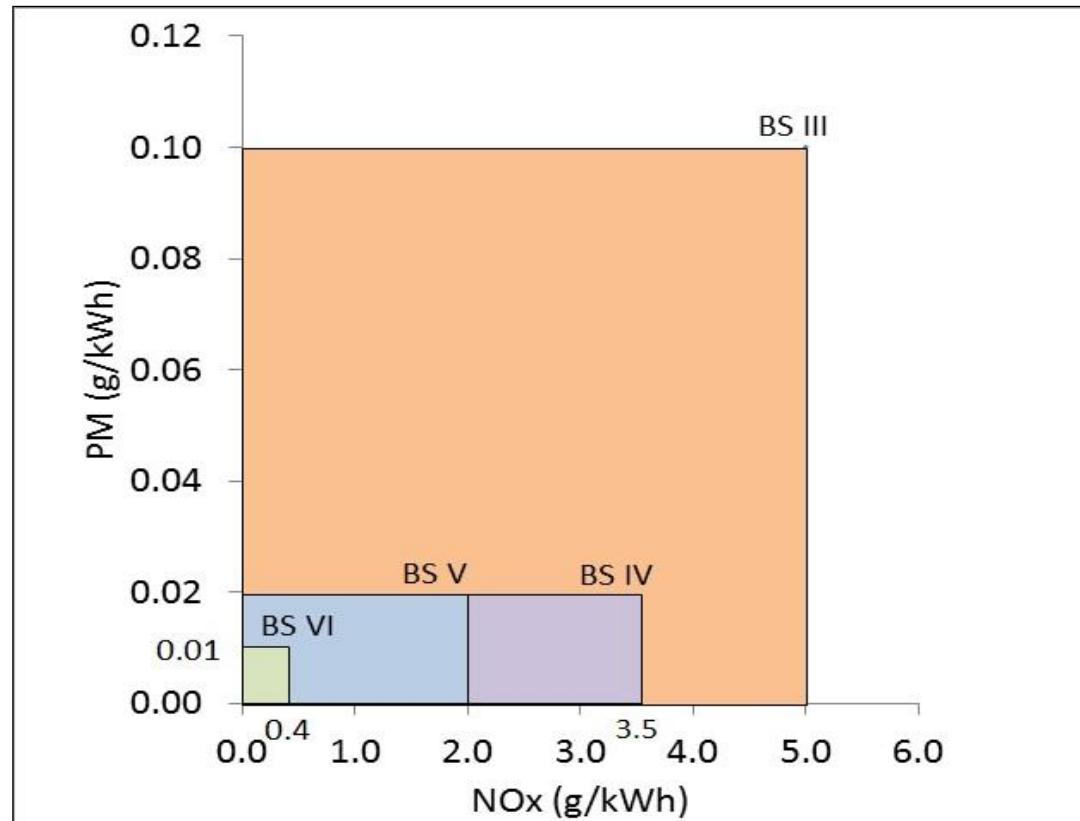


How it is monitored.....

On Test Cycle – WHSC, WHTC (BS VI) vs ESC, ETC (BS IV)



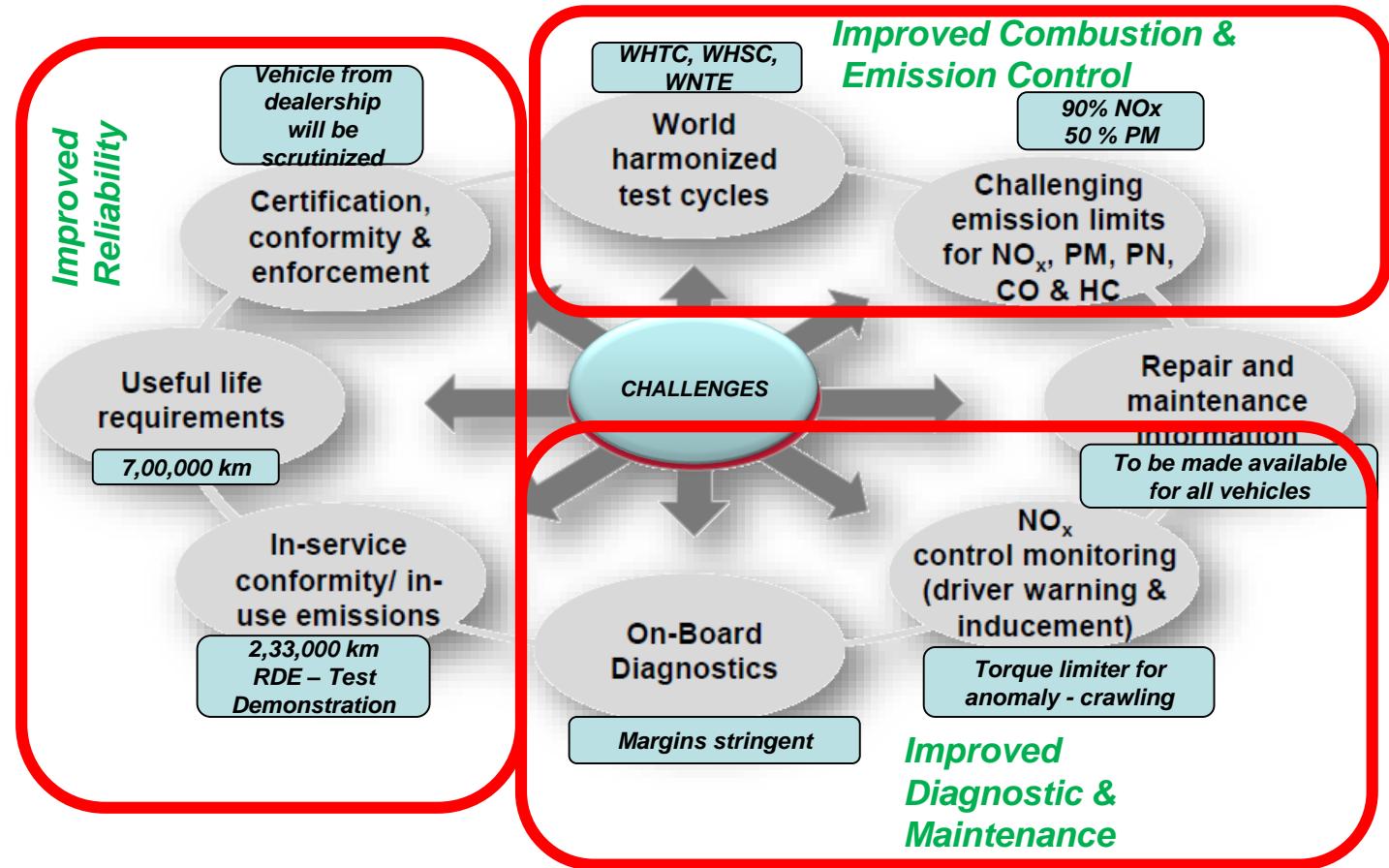
ASHOK LEYLAND



% Reduction (BS-I to BS-VI)
NOx – 95 %
PM – 97 %
CO – 67 %
HC – 88 %

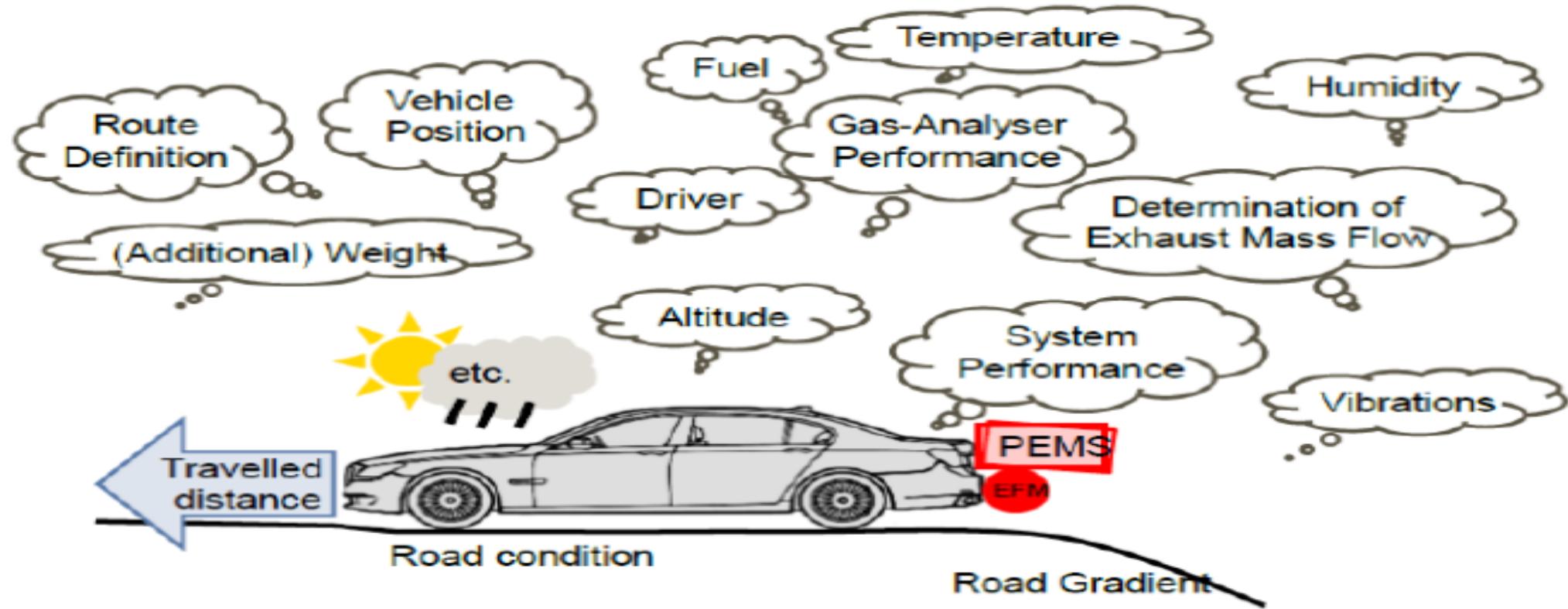


Key areas of BS VI Design challenges



Reference : FEV

RDE – Issues and Concerns



From Test Lab to Road Test , the increase in Complexity is a Challenge for Measurement Accuracy & Repeatability

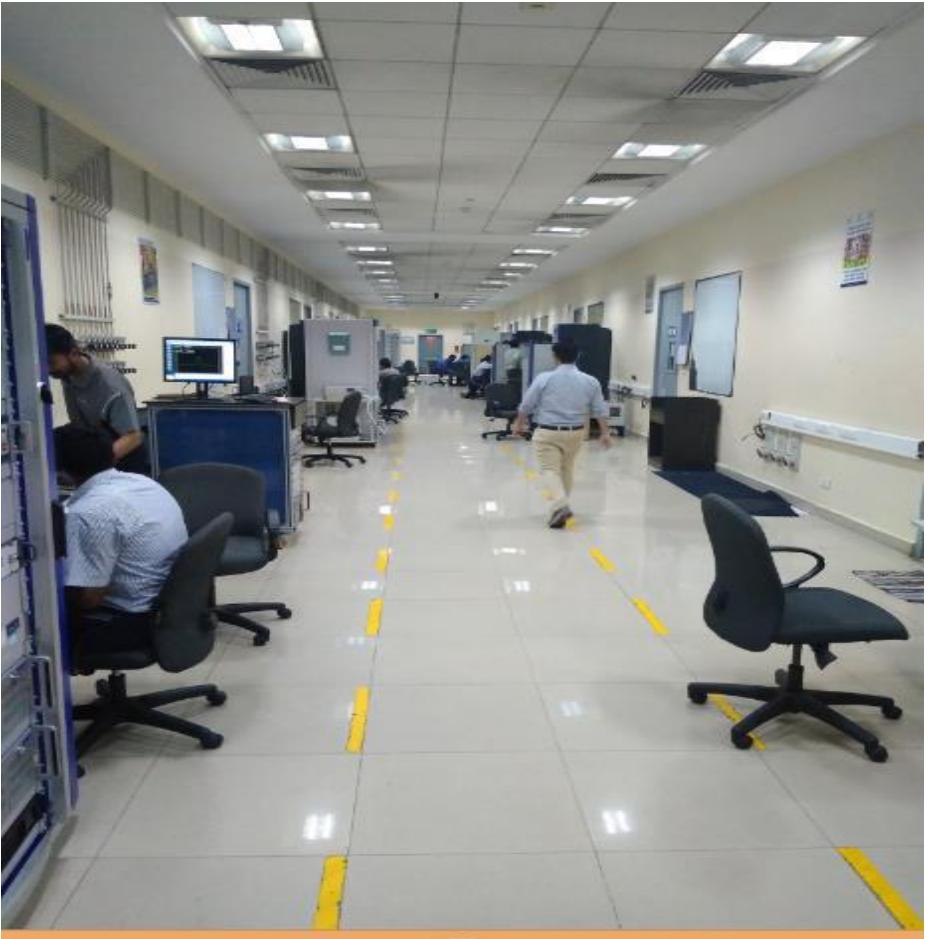
Engine Development Centre



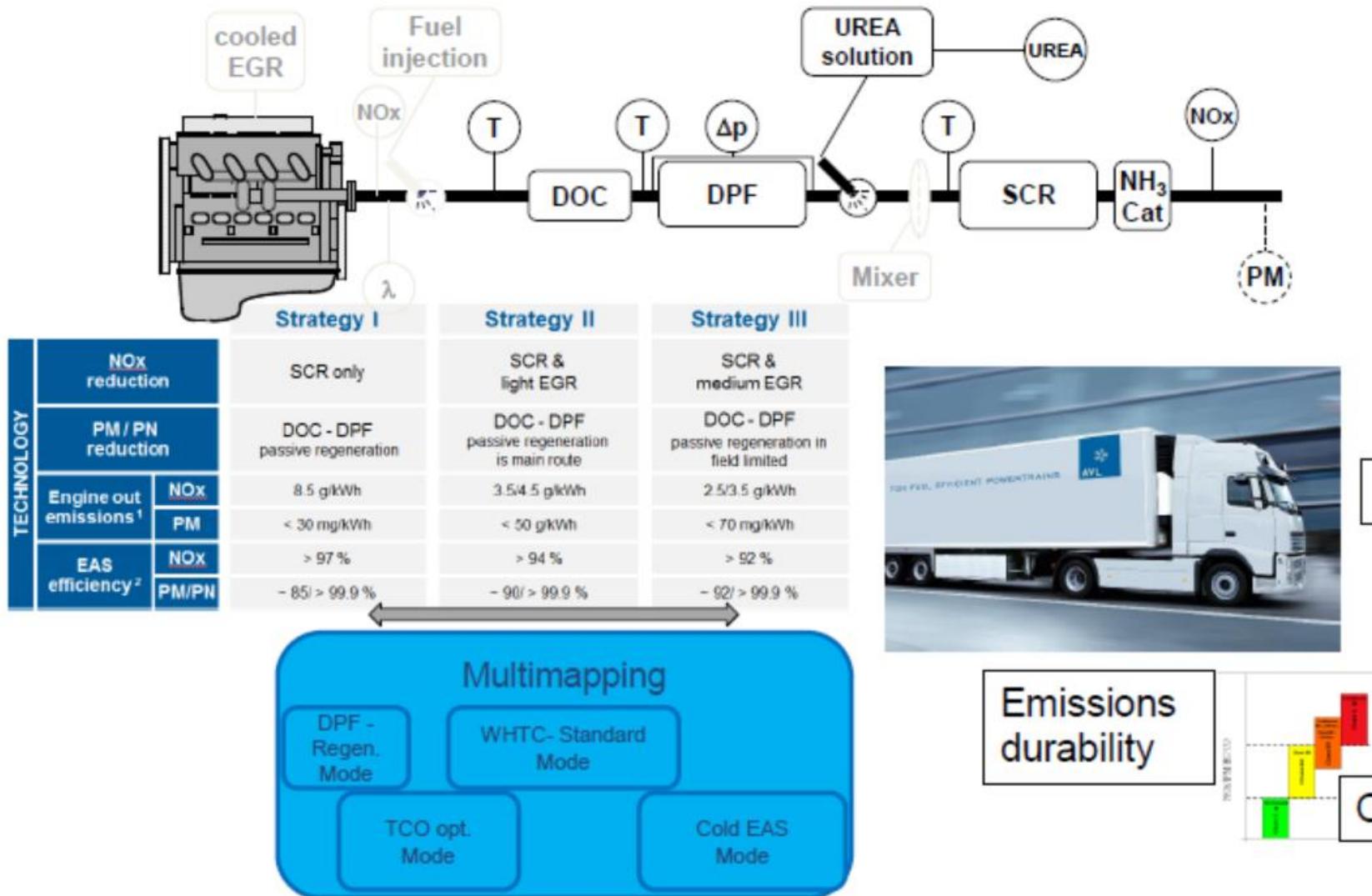
Engine Test Setup on Dynamometer



Engine Test Control Room

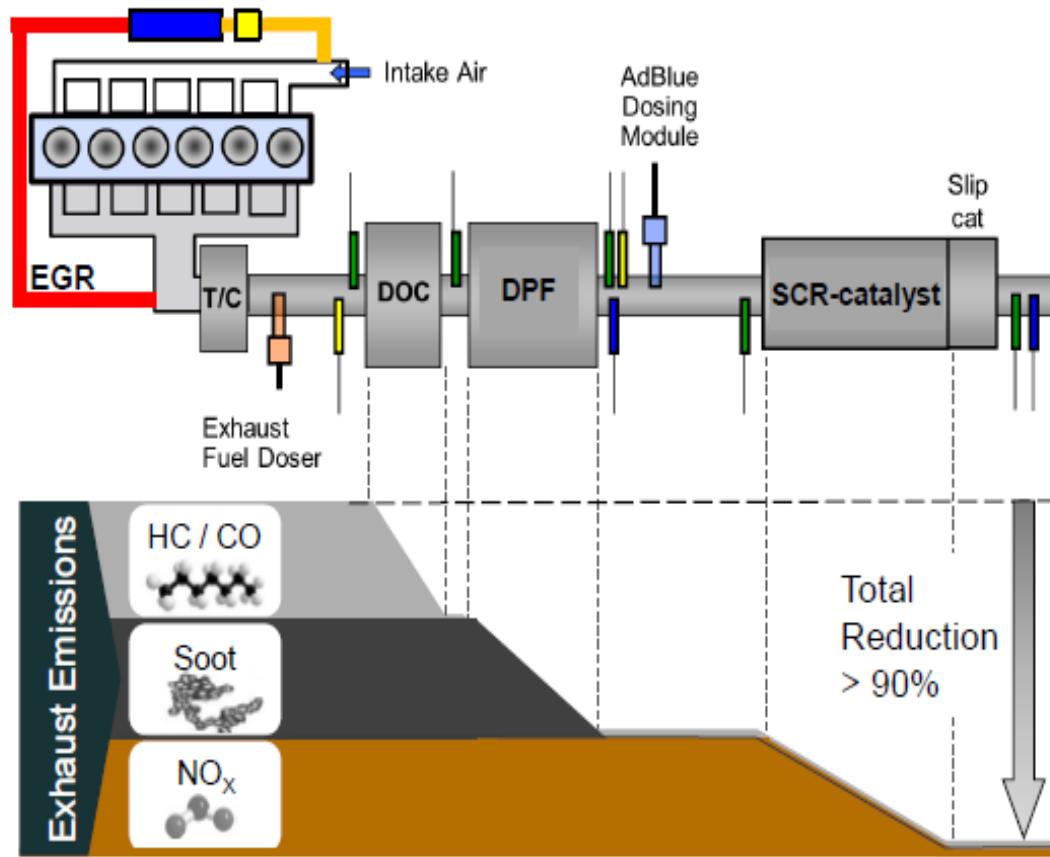


BS-VI – Typical Layout





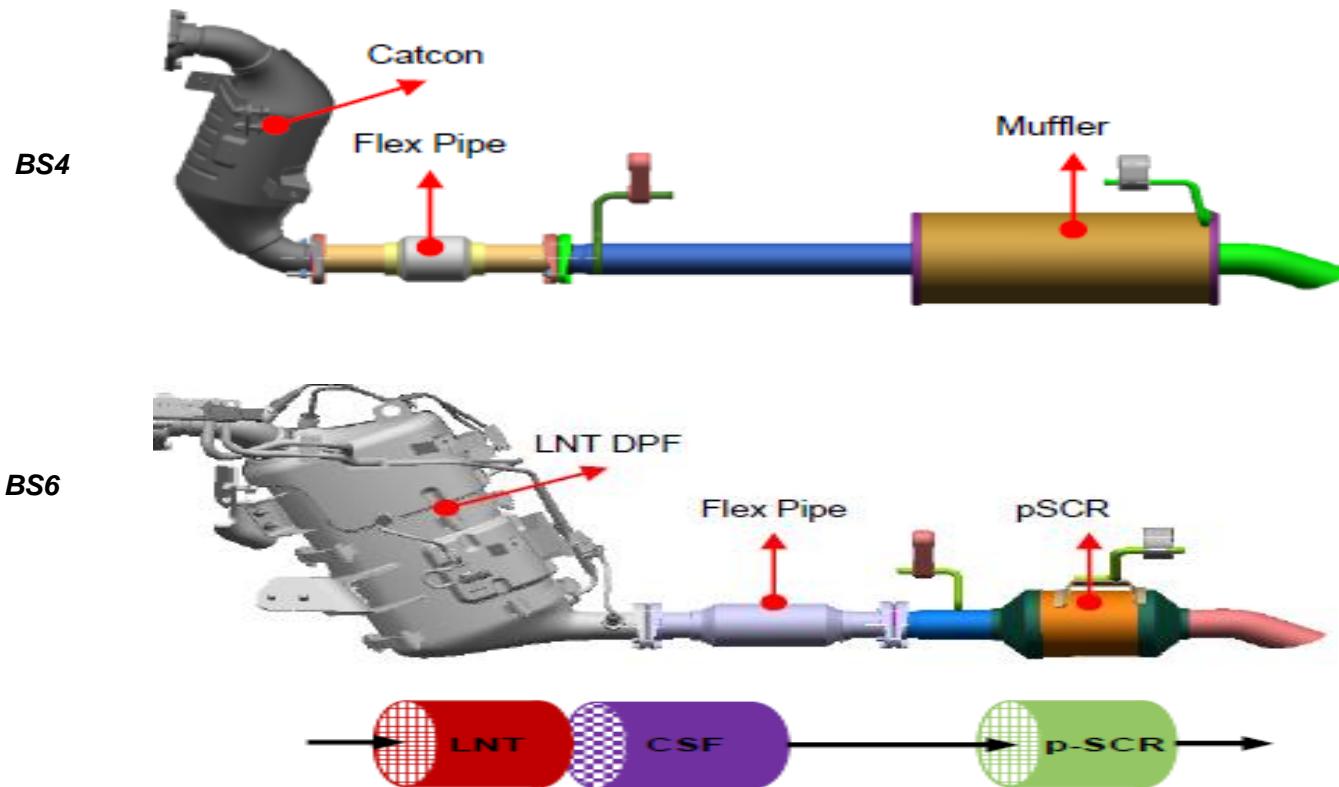
BS VI Heavy Duty Engines - Layout



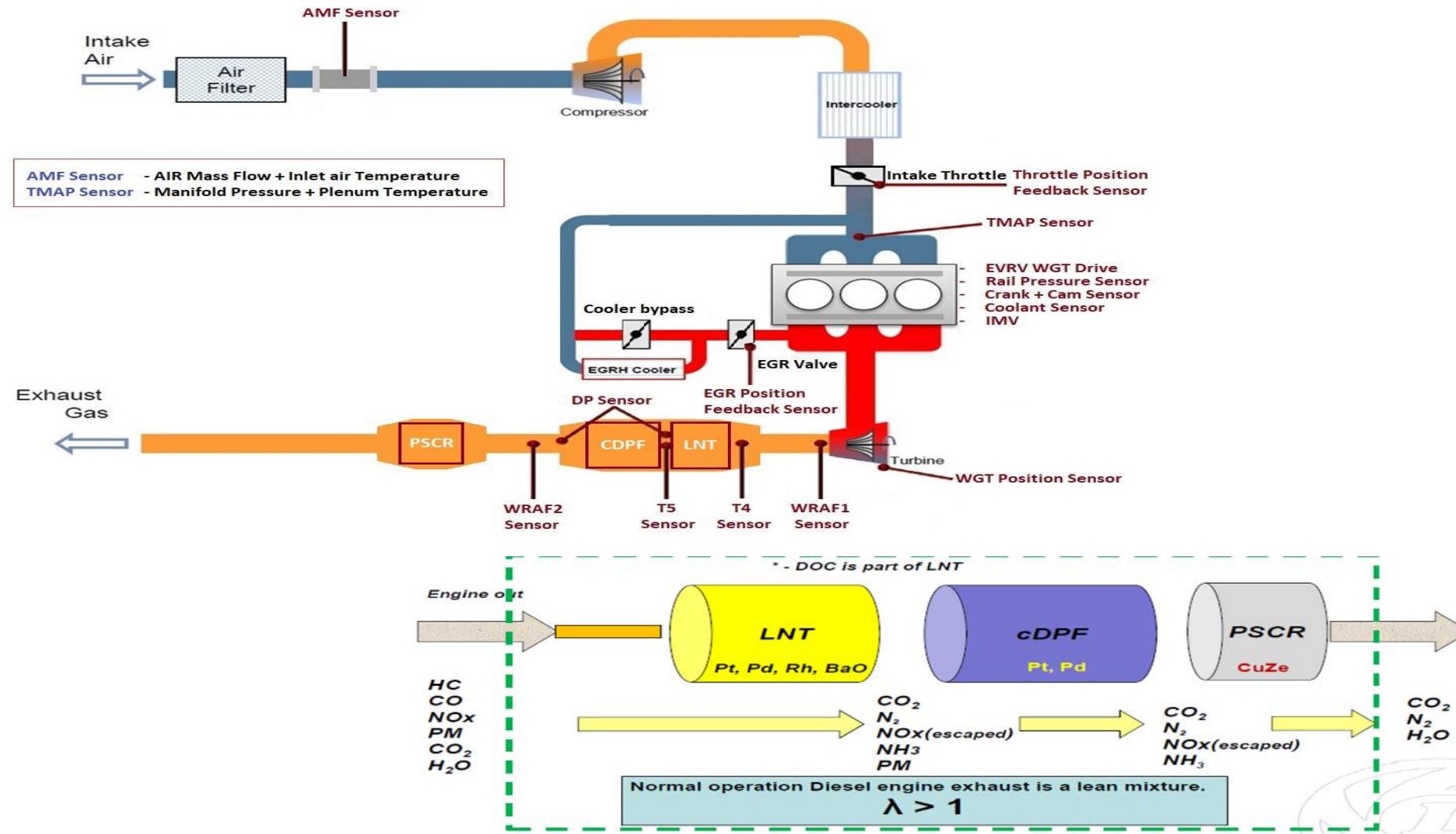
- State-of-the-art BS VI aftertreatment systems include the following key elements:
 - Diesel oxidation catalyst (DOC) for efficient reduction of CO and HC and optimization of SCR catalyst performance (NO/NO₂ ratio)
 - Diesel particulate filter (DPF) for filtration of soot particulates with > 99% efficiency
 - Selective catalytic reduction (SCR) for high-efficiency NO_x-reduction

Reference : FEV

LCV Exhaust after treatment systems



BS VI LCV Layout - Schematic

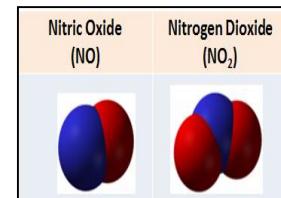


How emissions are generated....



How emissions are generated...

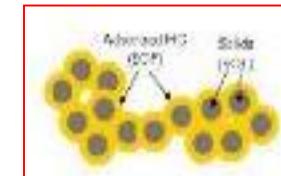
No_x – Oxides of Nitrogen



Reason - Higher temperature inside combustion chamber
 Solution – Reduce temperature / Reduction thru chemical reaction



PM – Particulate Matter

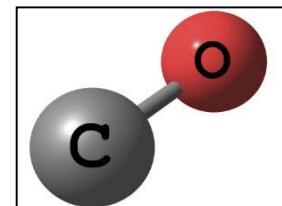
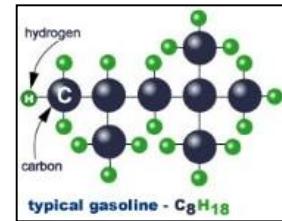


Reason - Left out Carbon surrounded by oil, ash, Sulphur

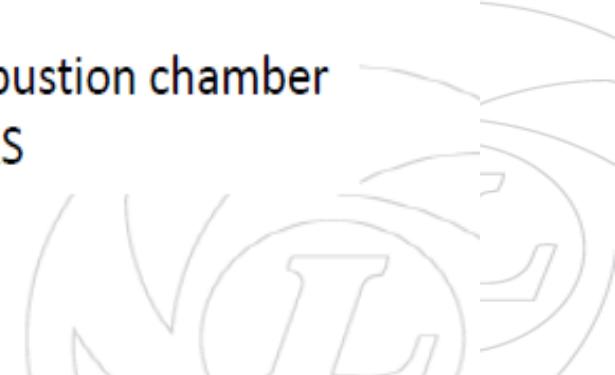
Solution – Filtration inside after treatment system



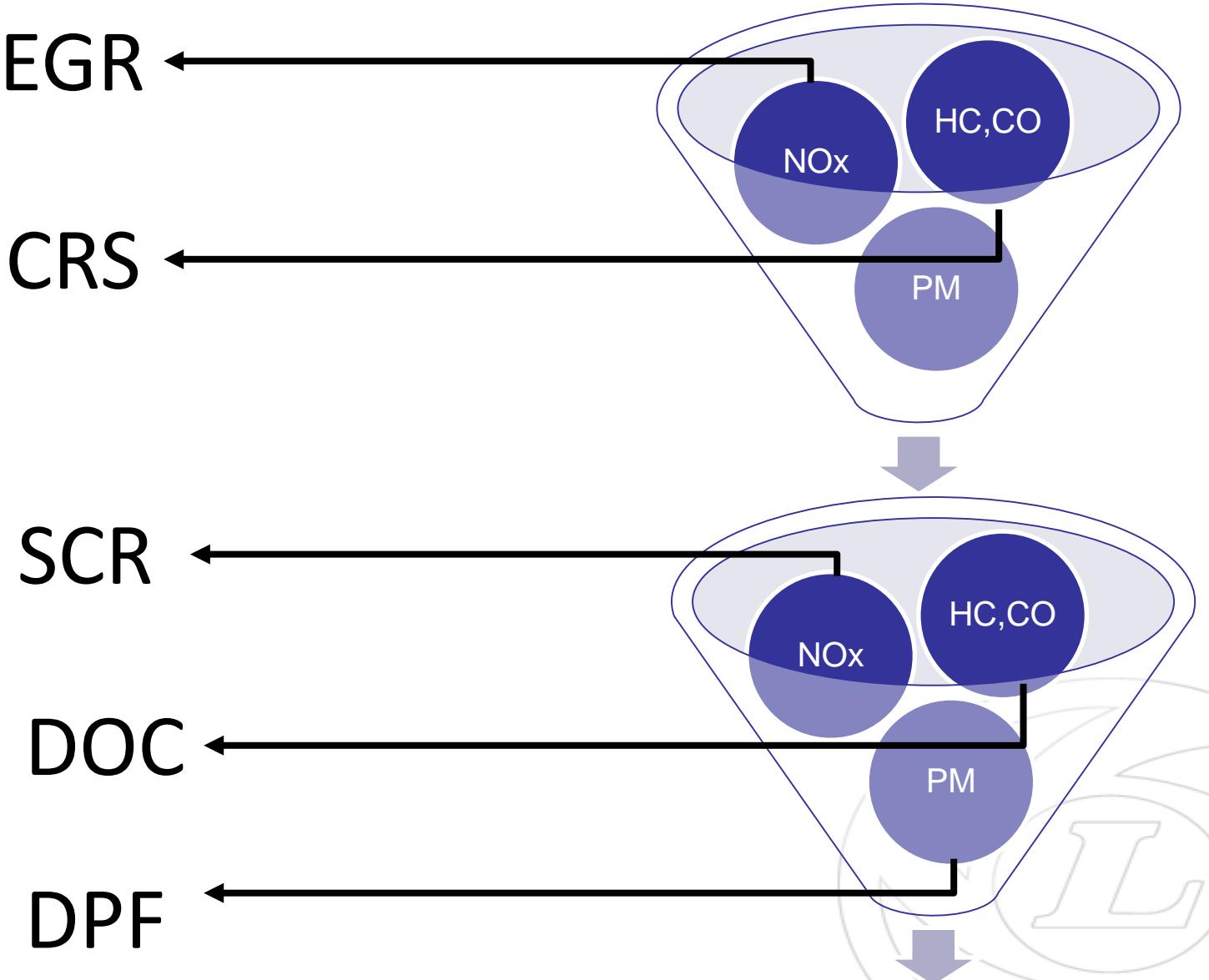
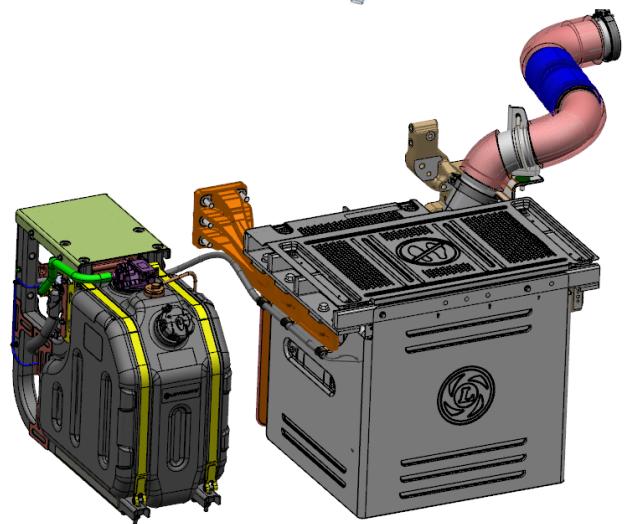
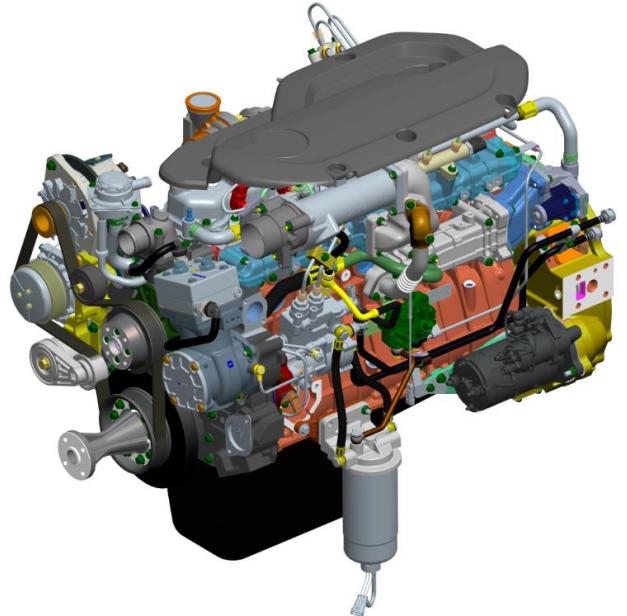
HC – Unburnt Hydro carbon



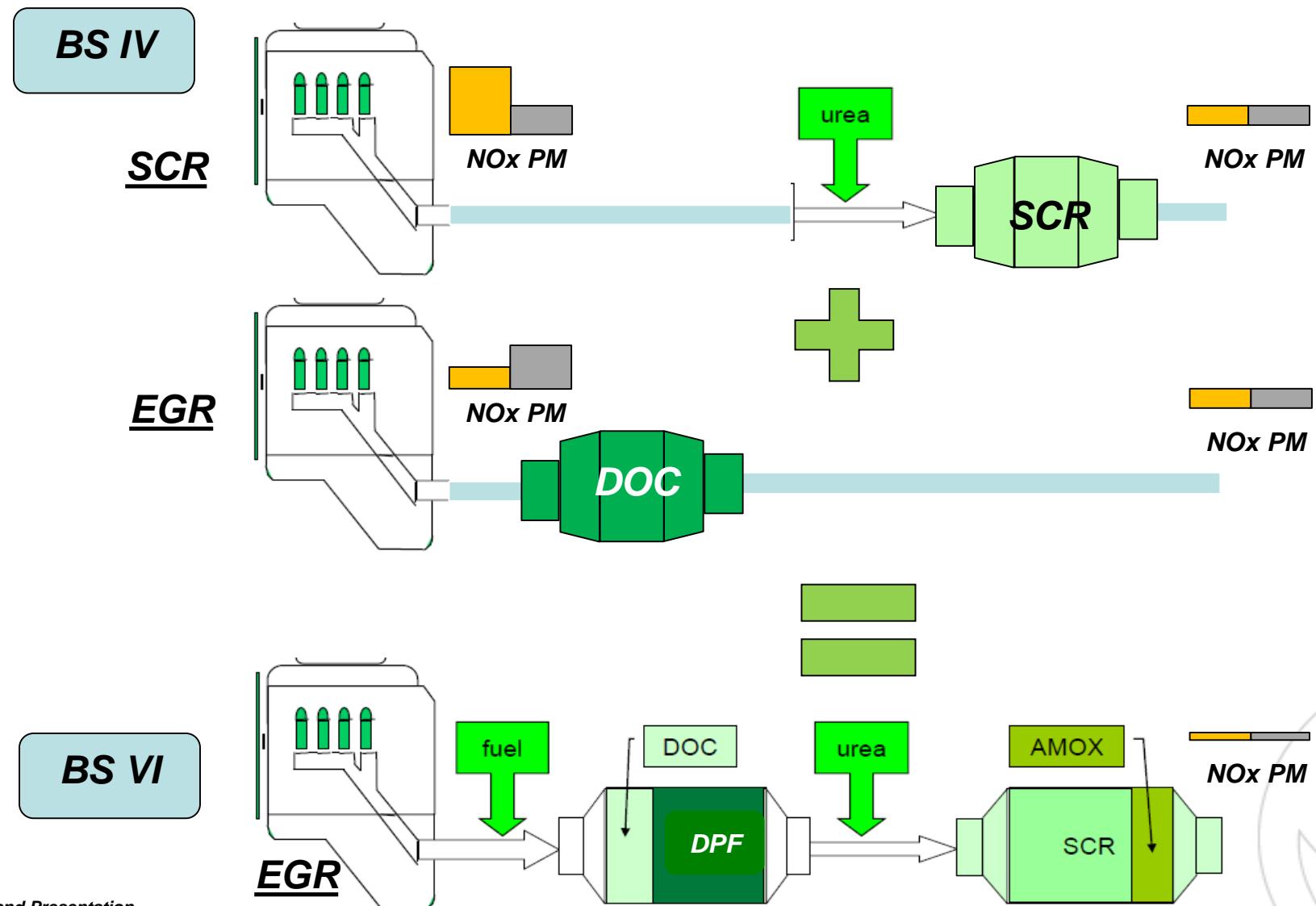
Reason - Improper combustion inside combustion chamber
 Solution – Better combustion control by CRS



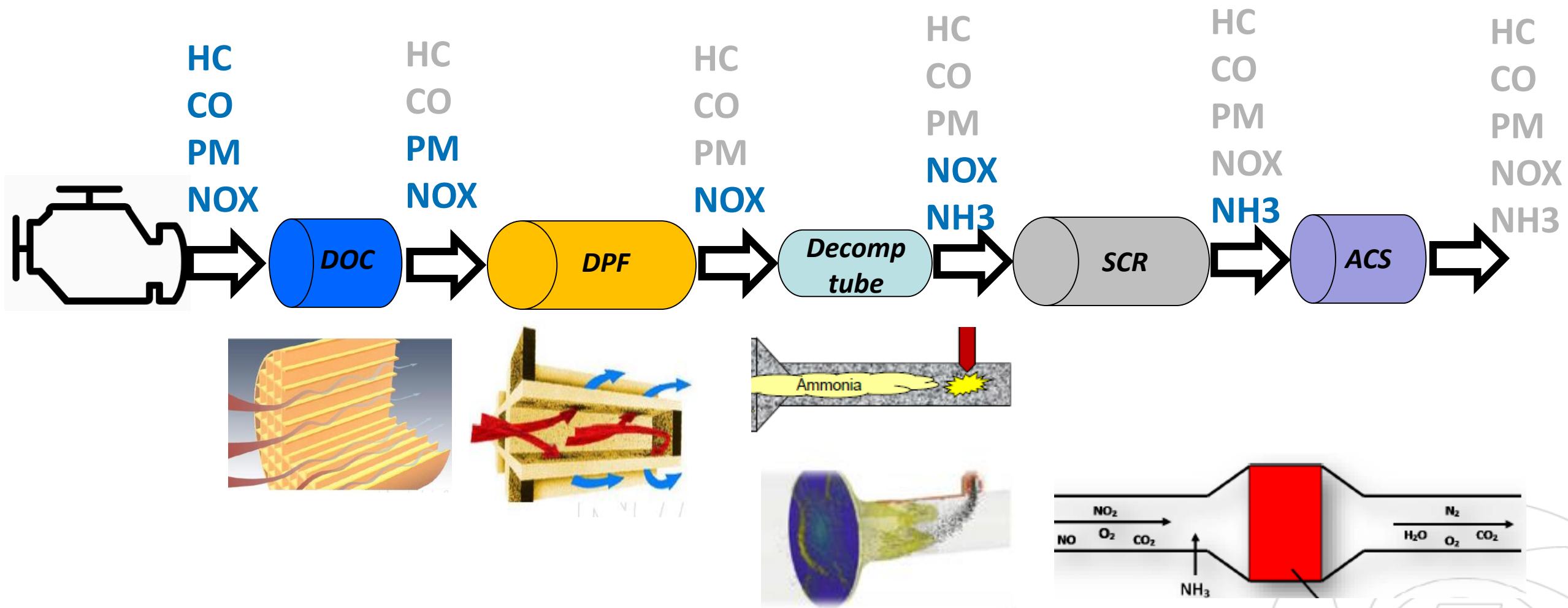
Emission Control



BS IV to BS VI EATS migration



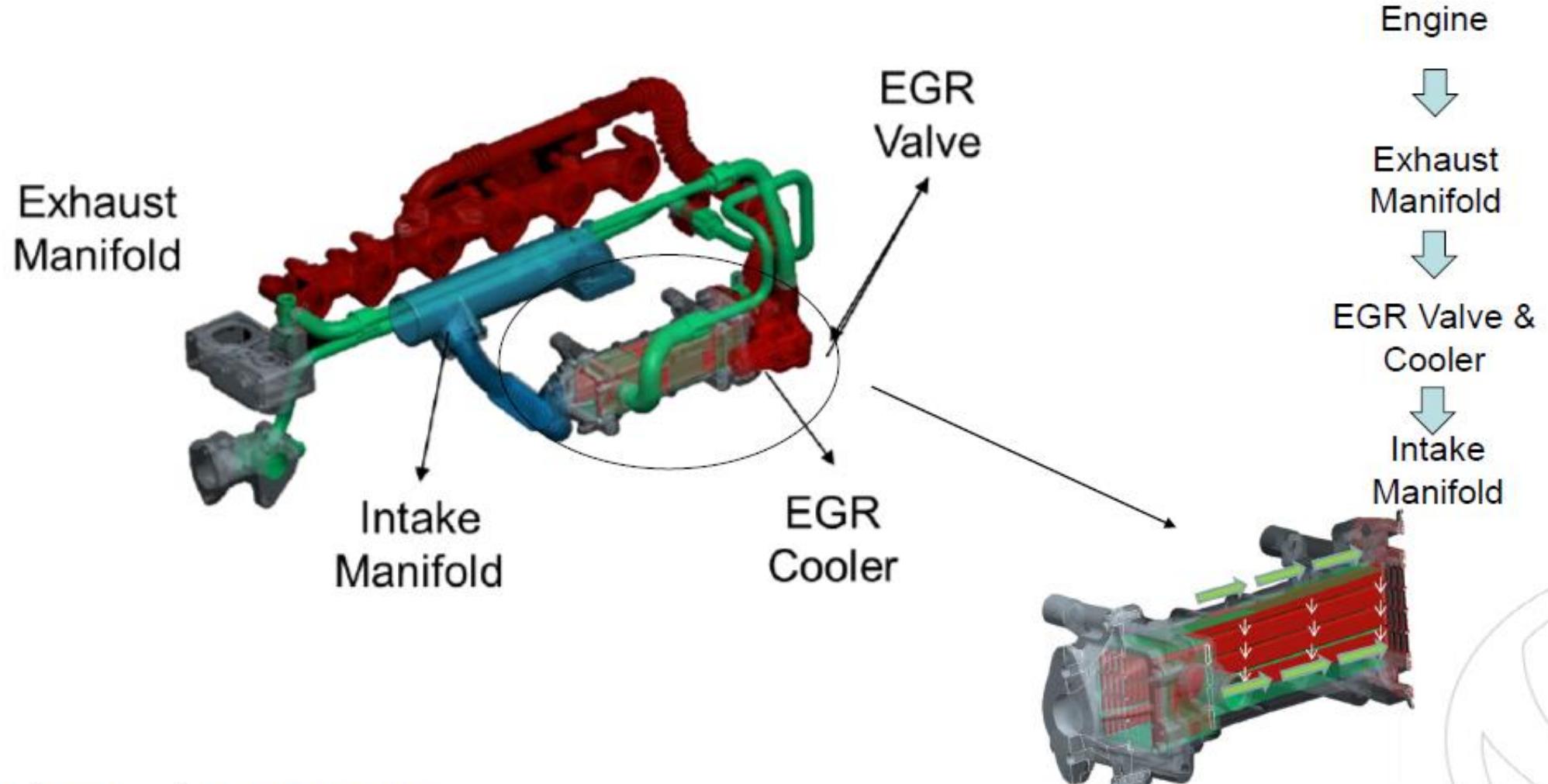
Emission Control – Outside engine Exhaust After Treatment System (EATS)



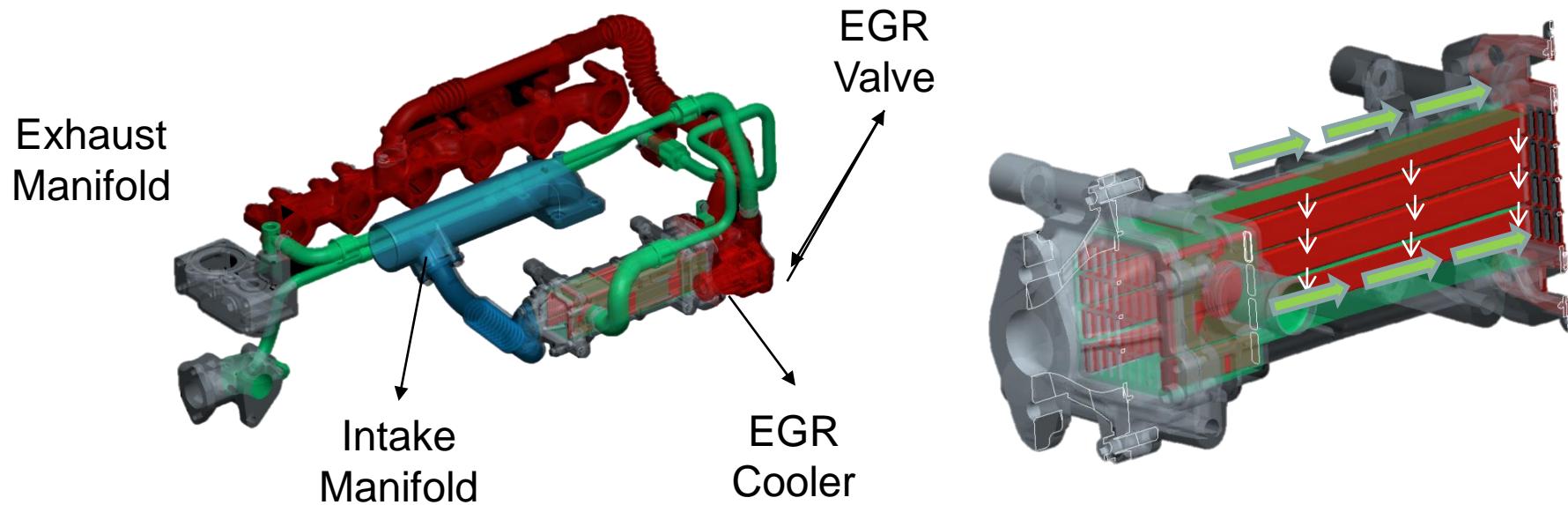
NOx reduction philosophy...

- What happens when you close a burning candle with a glass....
- Why does it go off.....
- Oxygen in air is required for burning.
- How NOx is generated – higher temperatures
- Higher oxygen content better is the combustion - Proper combustion increases temperature.
- Reducing oxygen content reduces combustion temperatures.
- Polluting fresh air intake with exhaust gas reduces oxygen content – EGR (Exhaust Gas Recirculation)





EGR an overview

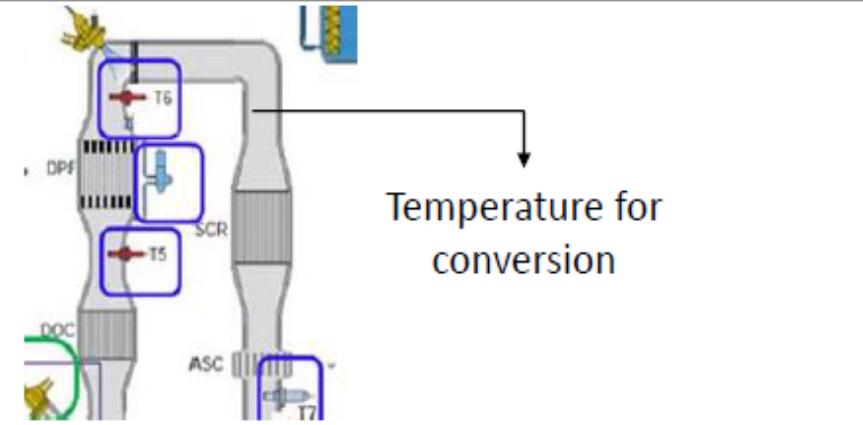


- The exhaust gas from exhaust, flows through the Piping and reaches the EGR Valve.
- Based on the engine condition, ECU actuates the EGR valve according to the amount of EGR to be sent inside the engine.
- Coolant from the cylinder block enters the EGR cooler.
- The exhaust gas sent through the valve is cooled by the coolant in the EGR cooler. EGR passes through the pipe and the coolant surrounds the pipe.
- The cooled Exhaust gas then reaches the Intake manifold.
- The coolant from the cooler, flows through the EGR valve back to the engine coolant outlet port.

Intake Throttle

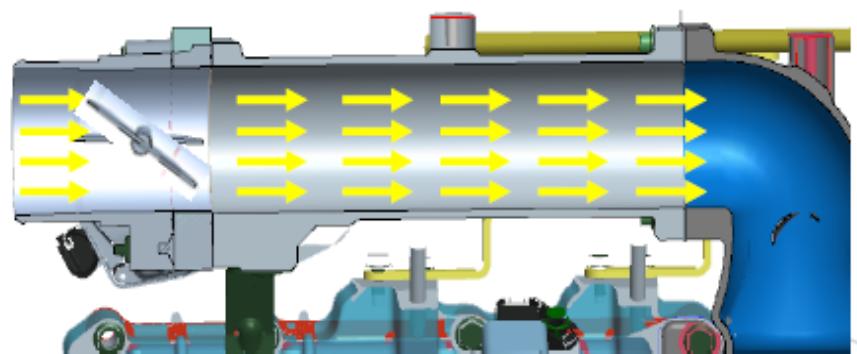
Purpose:

- Thermal management:
 - ✓ To maintain the exhaust gas temperature for better SCR conversion.



Function:

- Controls the air intake into the engine (at required conditions)
- By controlling the amount of fresh air taken inside, mixture is made rich, and the unburnt HC is burnt on the exhaust passage.
- Similar to a choke in vehicle...



Working:

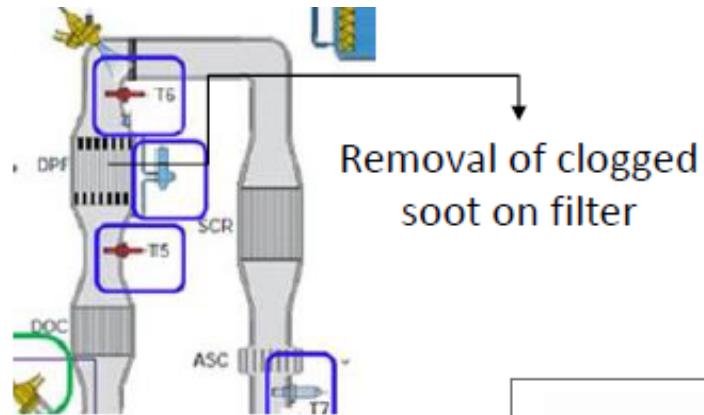
- Air intake is controlled by the throttle valve on Intake throttle valve
- The Flap is actuated based on input from ECU



HC doser

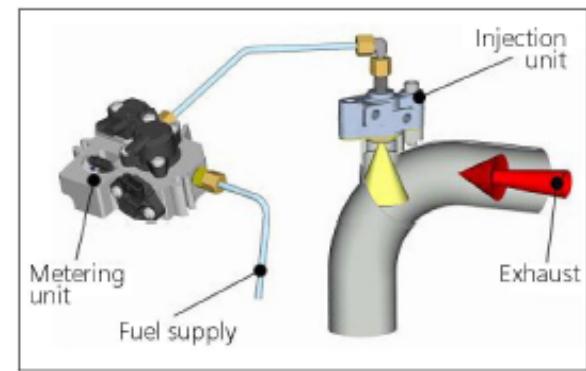
Purpose:

- Regeneration:
 - ✓ To remove the soot deposit on DPF system



Function:

- Sprays fuel in to the exhaust system
- With Higher HC content on exhaust system, exothermic reaction at DOC increases the temperature of exhaust gas.



Working:

- Fuel from filter is metered (Controlled by ECU) by Fuel metering unit and is supplied to the injector (HC Dozer)
- Injector opens on pressure and injects the fuel in to the exhaust pipe



Emission Control – Outside engine Exhaust After Treatment System (EATS)



Lets go back to Chemistry class...

- **Catalyst:**

A catalyst is a substance that speeds up a chemical reaction, but is not consumed by the reaction

- **Oxidation reaction:**

OXIDATION may be defined as chemical process in which a substance gains oxygen or loses electrons and hydrogen

- **Light off temperature:**

The catalyst light-off is the minimum temperature necessary to initiate the catalytic reaction

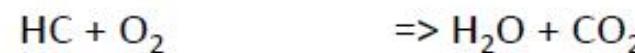
- **Exothermic Reaction:**

An exothermic reaction is a chemical reaction that releases energy through light or heat.

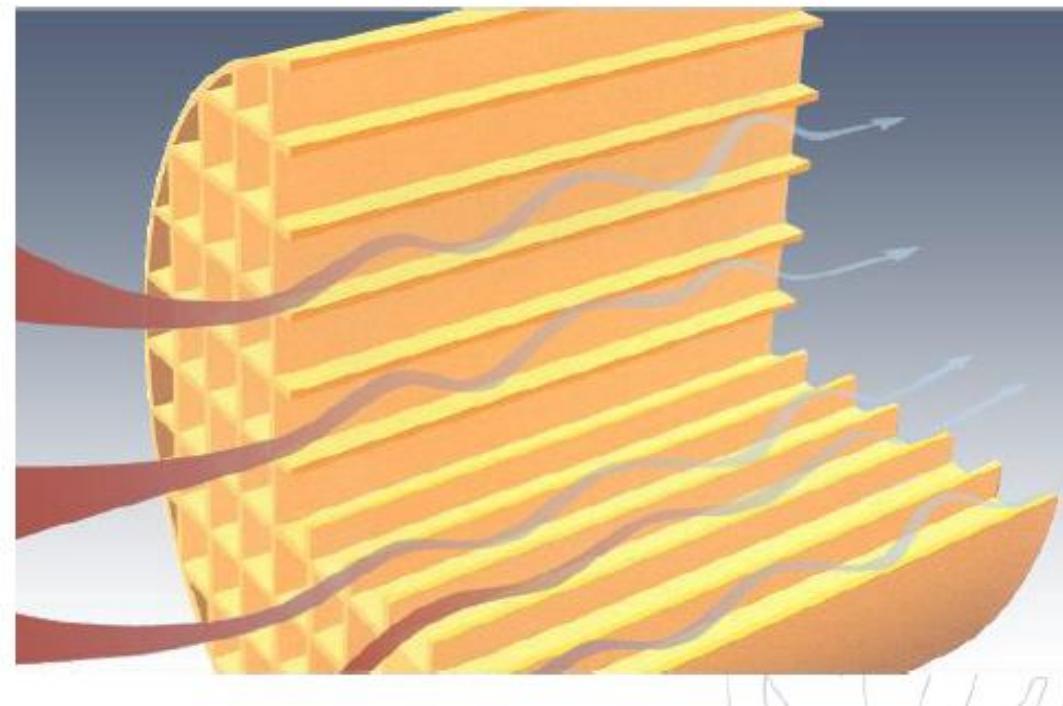
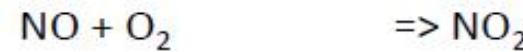
DOC – Diesel Oxidation Catalyst

- DOC is an open cell construction - Exhaust gas has a free route to flow through
- Removes 95 % of CO and HC together, ~ 30 % particulate reduction (upto 90% of SOF) and Reduces smell of diesel aldehydes.

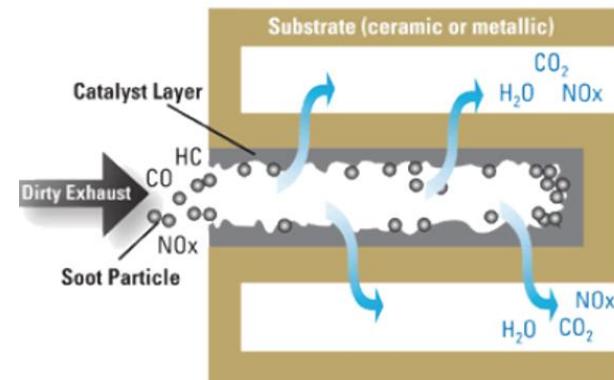
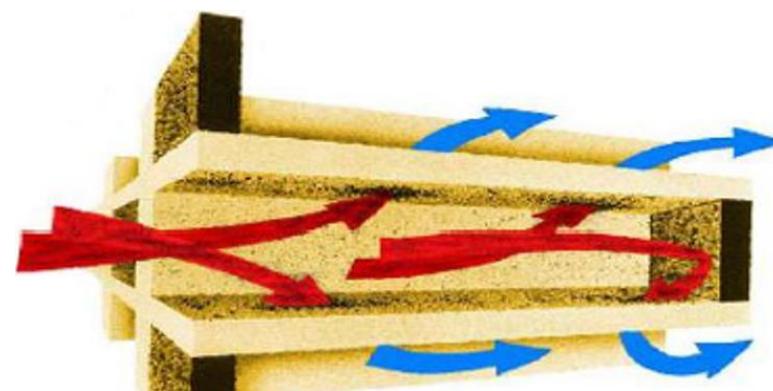
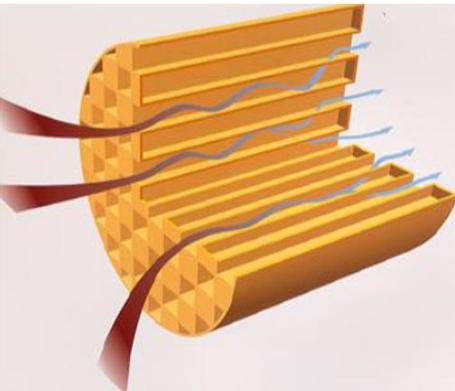
Primary



Secondary

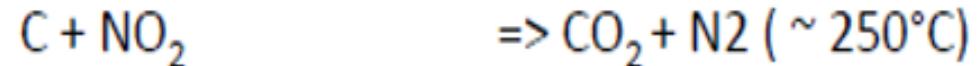


DPF – Diesel Particulate Filter



- Construction is similar to DOC but closed on one side.
- Exhaust gas pushed through the wall.
- PM gets filtered on the walls (Carbon particles with soot, oil, ash.....)
- So what happens on continuous usage....
- Cleaning process is called Regeneration...

Primary



- .

➤ Passive Regeneration:

Happens during normal engine running condition.

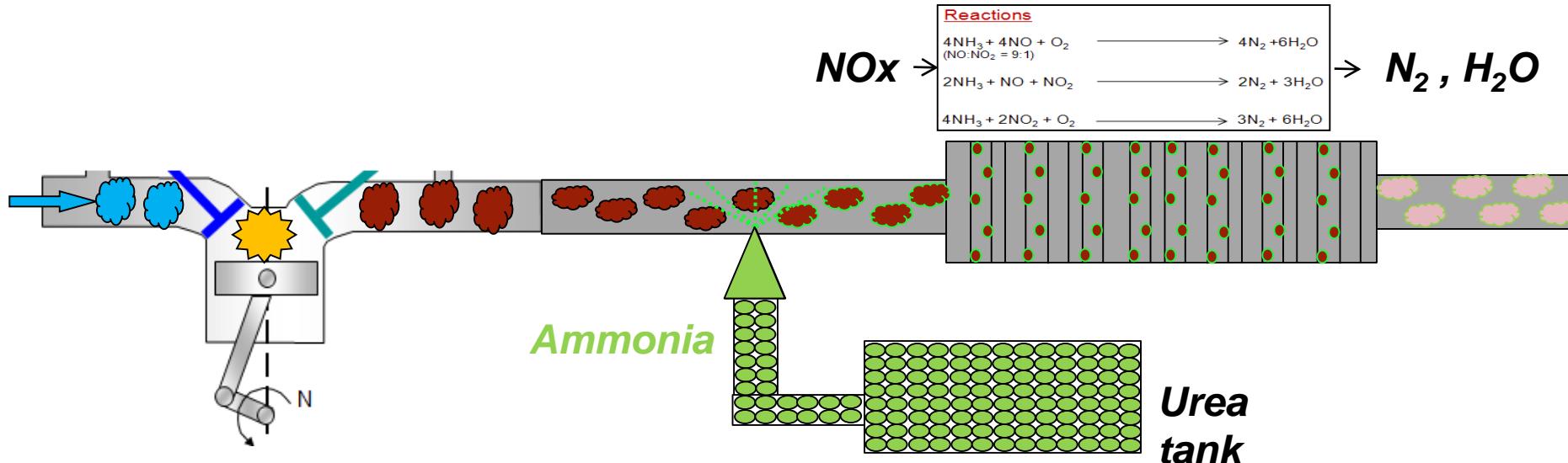
➤ Active Regeneration:

Is triggered by ACU, when the delta pressure increases beyond the limit

➤ Manual Regeneration:

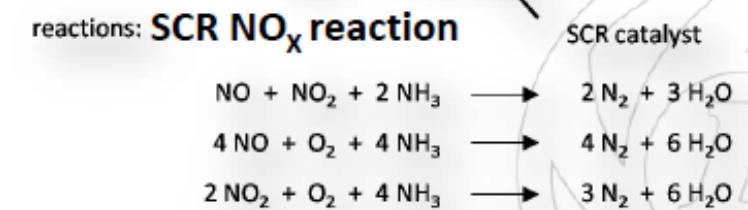
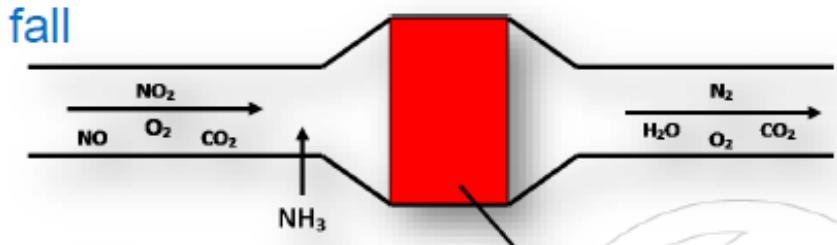
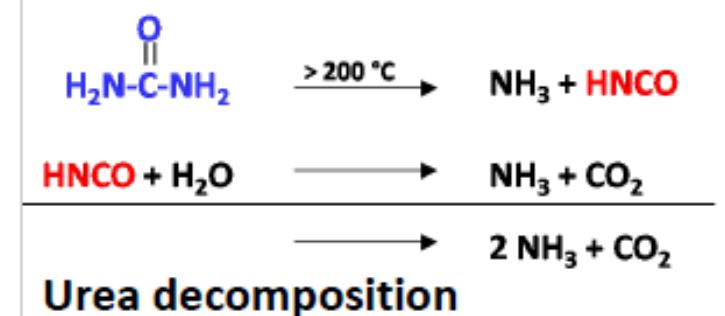
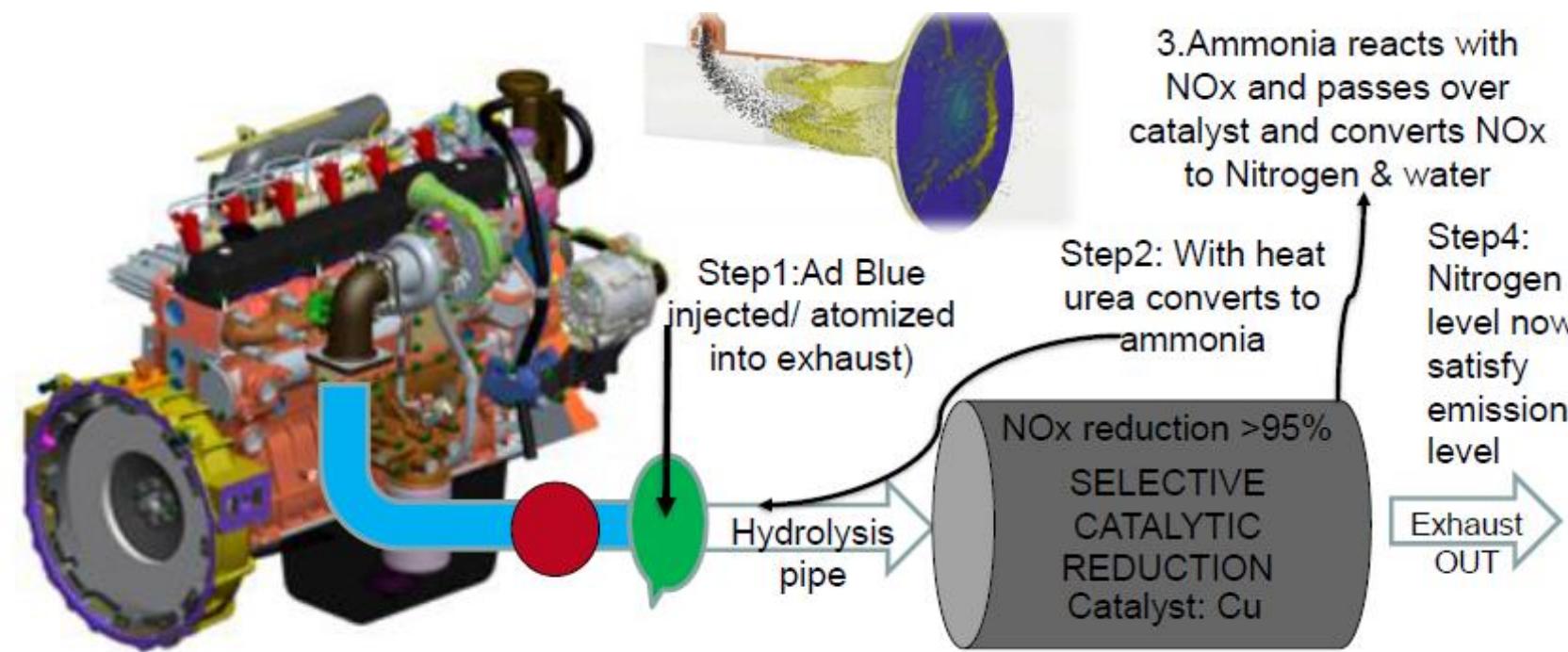
Is triggered by driver based on indication on dashboard.

EATS components - SCR



1. Exhaust from the engine is left through the tail exhaust pipe.
2. Ammonia is injected to the exhaust gas through a separate injector in the exhaust pipe.
3. The mixture of exhaust gas + ammonia reacts on the Catalytic convertor and conversion happens. NOx is converted in to N₂, O₂.
4. Also as an by product CO will be reduced.

EATS components - SCR



**BSVI emission....
For All ICV&HCV applications**

Changes from BSIV to BSVI

BSIV

Common rail fuel injection system

Exhaust Gas Recirculation (EGR)

SCR (Selective catalytic reduction)

(OR)

DOC (Diesel oxidation catalyst)

Engine

SCR (Selective catalytic reduction)

(OR)

DOC (Diesel oxidation catalyst)

Exhaust

EGR (Exhaust Gas recirculation)

Intake throttle Valve

HC Dozing system

T EGR sensor

Nox sensor

Exhaust brake

SCR (Selective catalytic reduction)

DOC (Diesel oxidation catalyst)

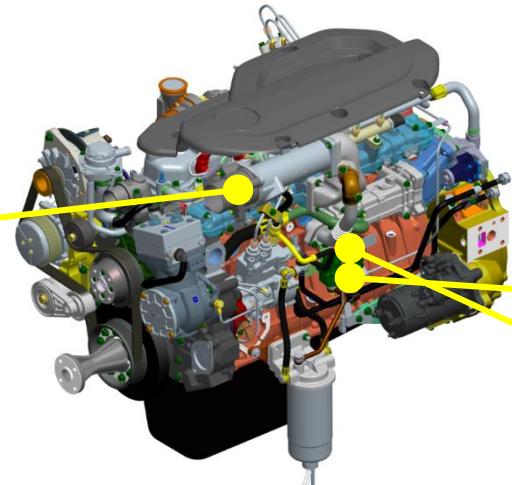
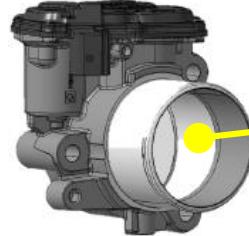
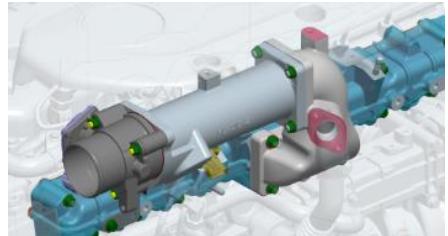
DPF (Diesel Particulate filter)

Temperature, pressure sensor)

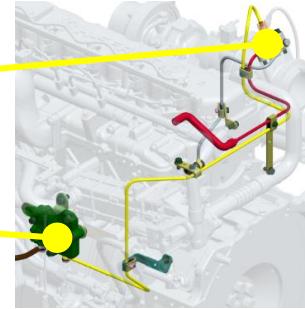
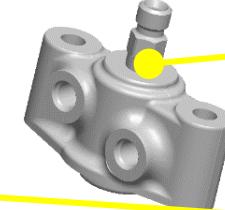
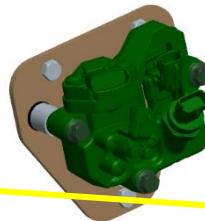
Engine level changes



Intake throttle Valve



HC Dozing system



For DPF regeneration

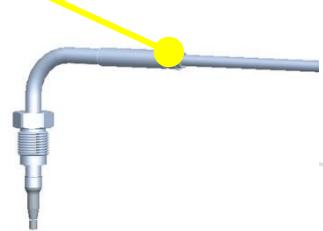
For Thermal Management

Nox sensor



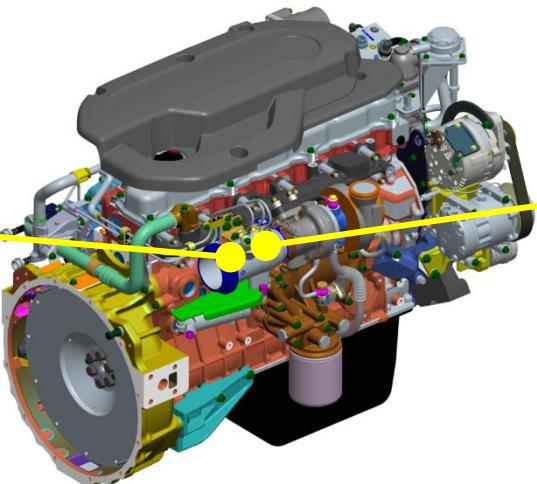
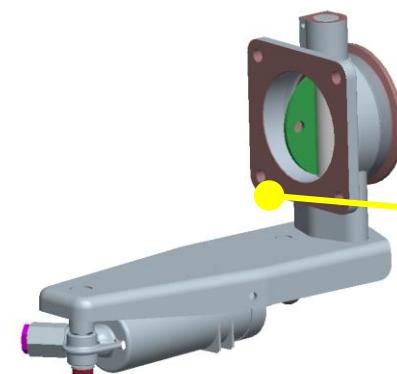
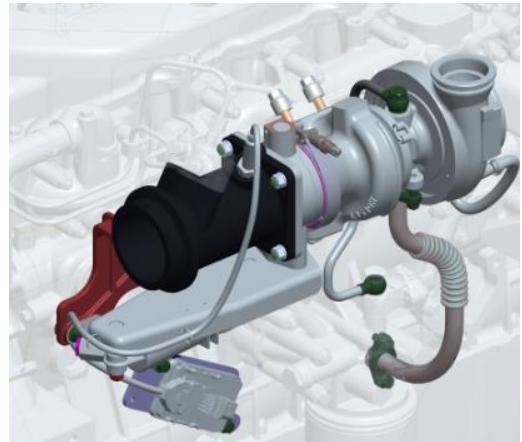
For measuring
Nox on
emission

T EGR sensor



For measuring
EGR
temperature

Exhaust brake



Part of engine from BSVI

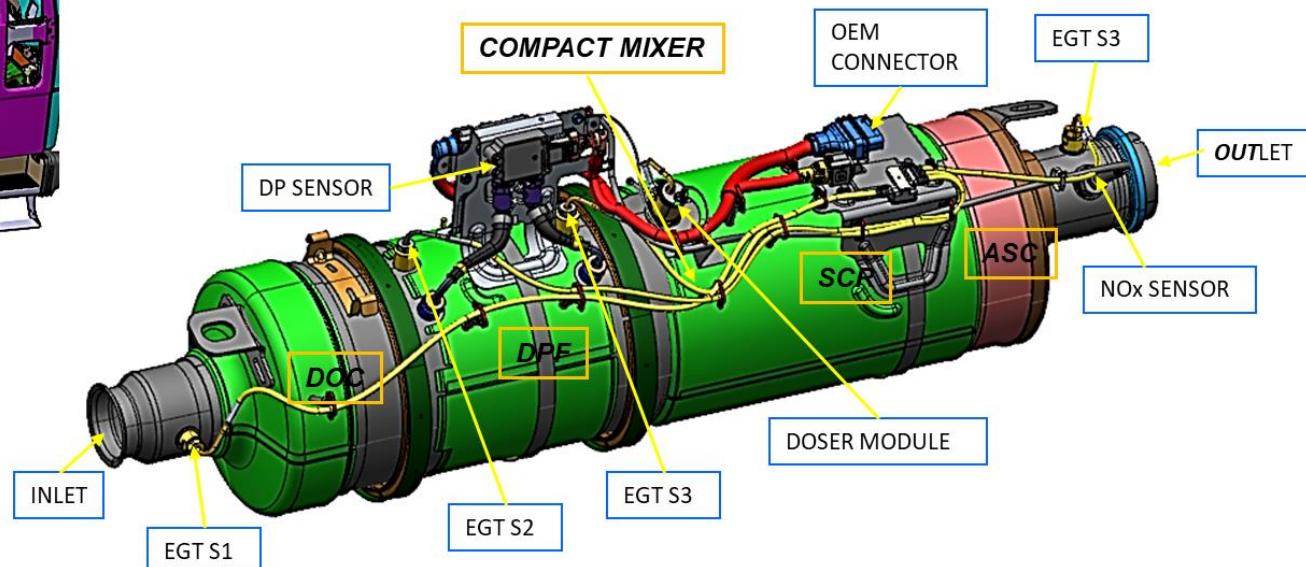
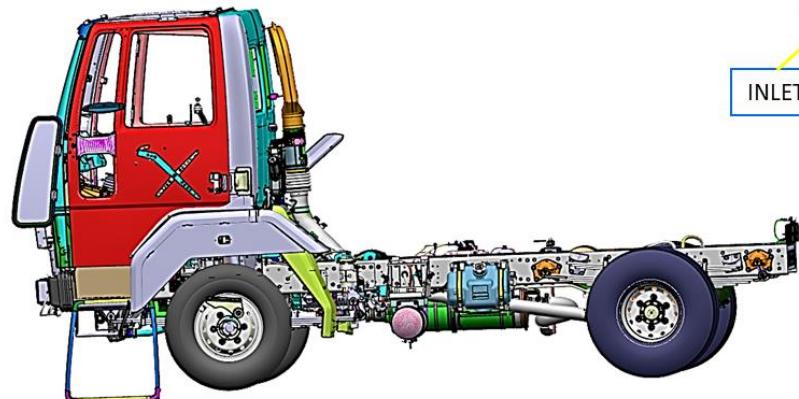
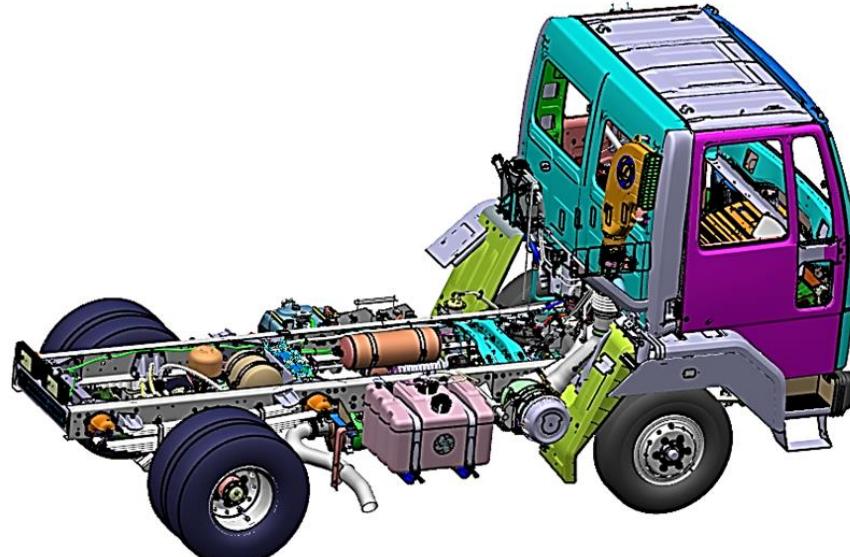
EXHAUST SYSTEM



Exhaust System – ICV



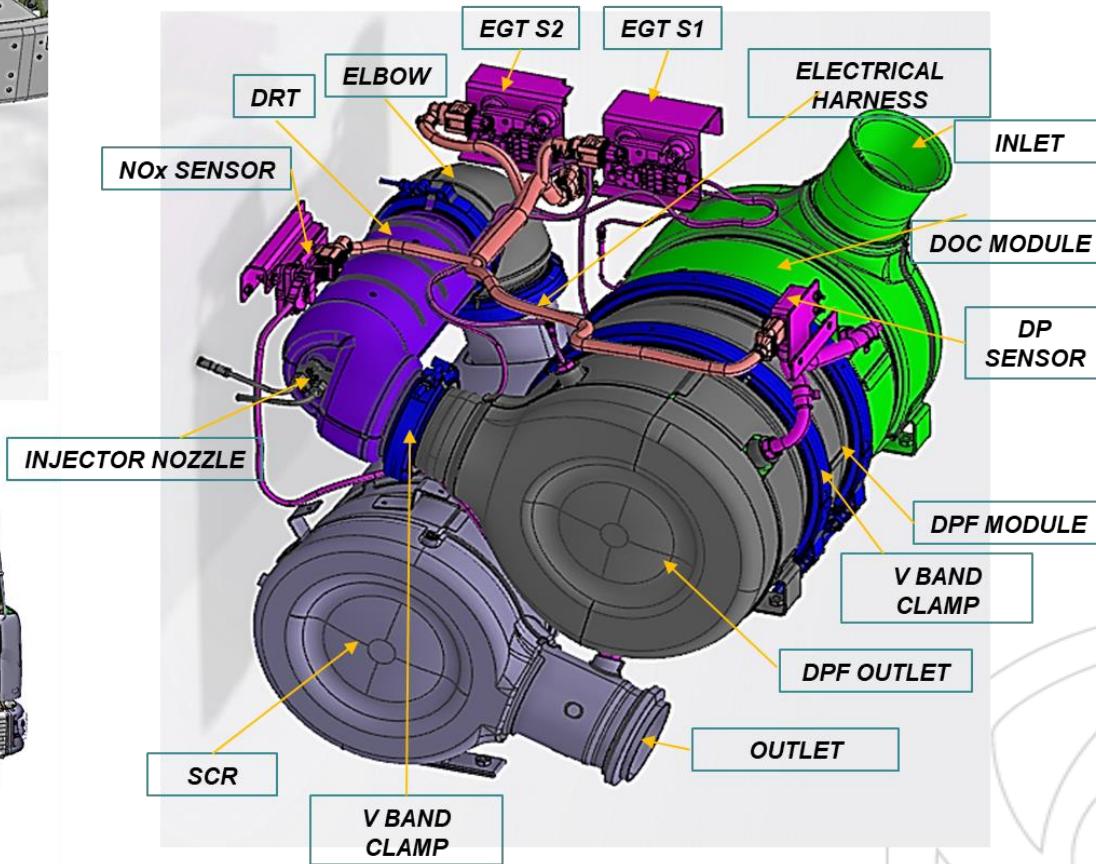
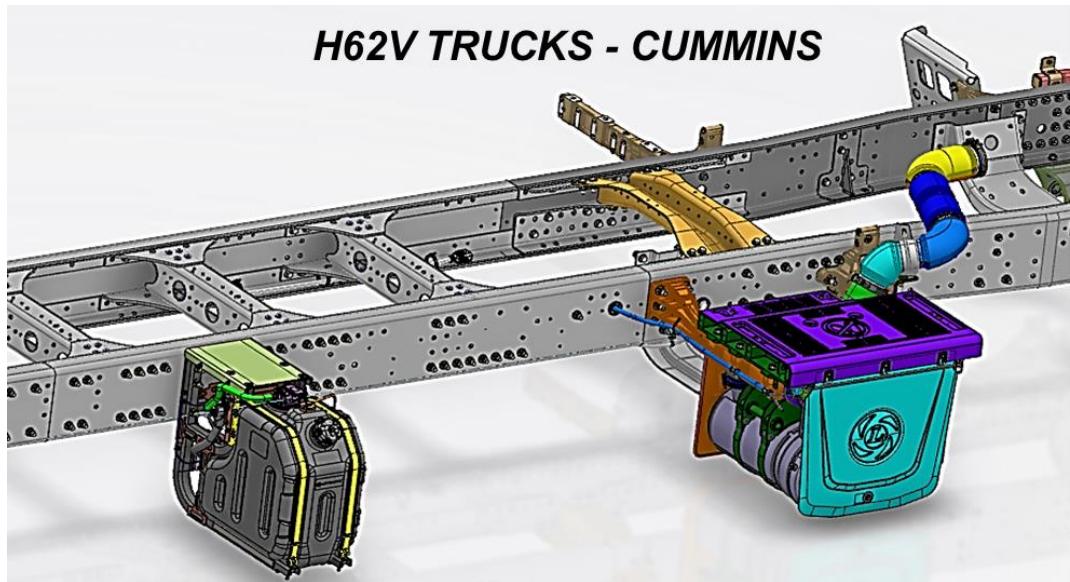
H4 TRUCKS - CUMMINS



Exhaust System - HCV



H62V TRUCKS - CUMMINS



AL BS IV – EGR Version schematic

For actuals – see next page (This is retained for BS VI)



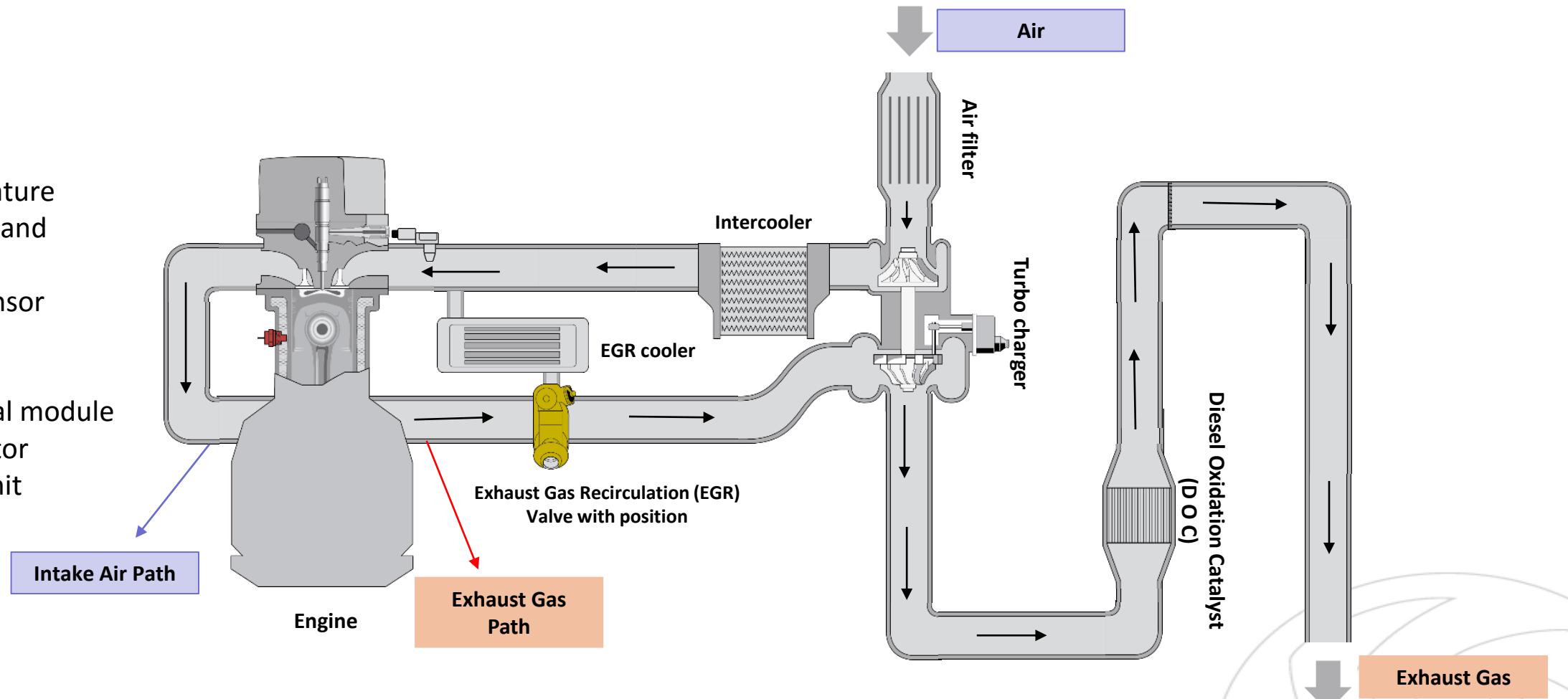
ASHOK LEYLAND

Sensors

- Crank speed
- Cam speed
- Boost pressure
- Coolant temperature
- Oil temperature and pressure
- Water in fuel sensor

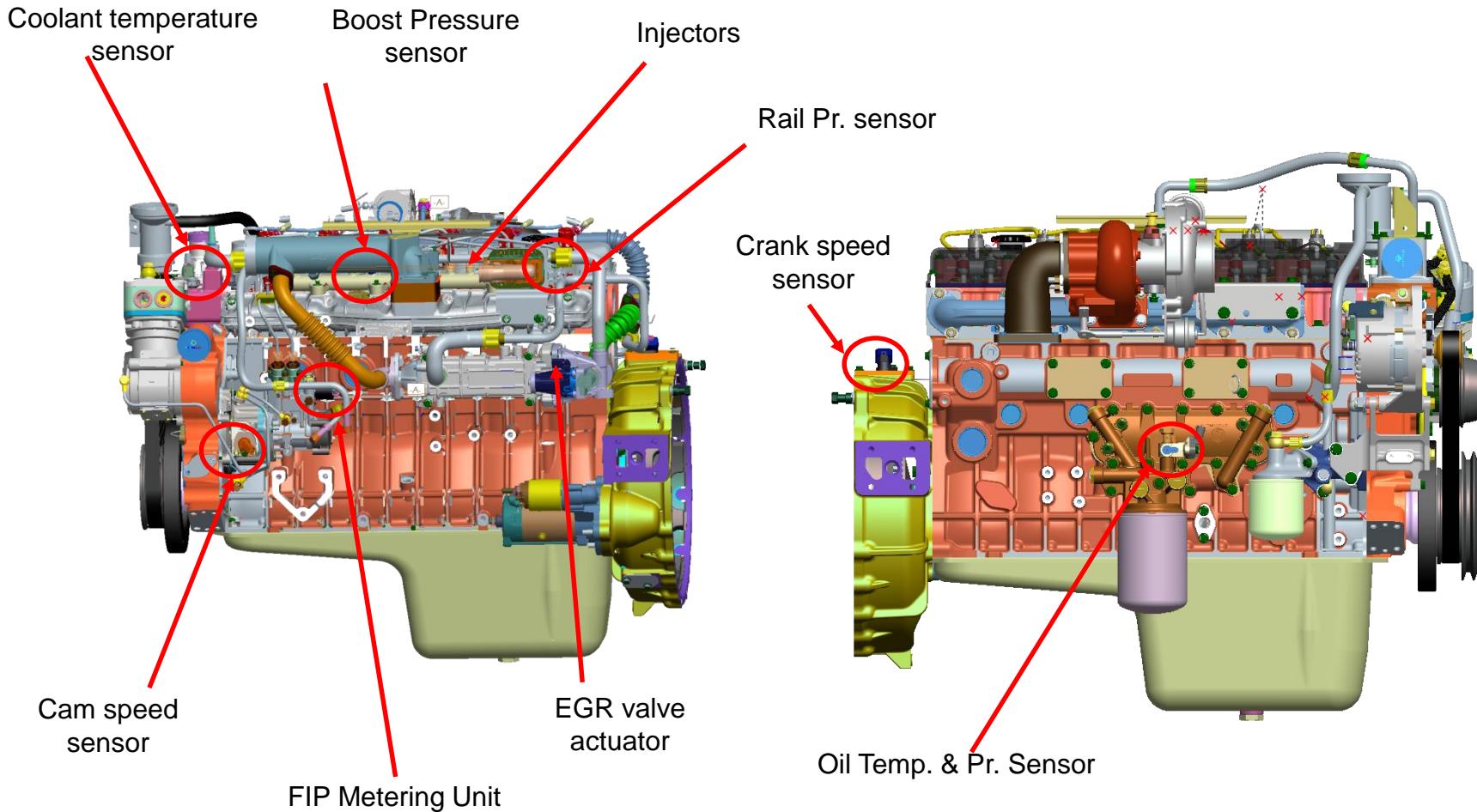
Actuators

- Accelerator pedal module
- EGR valve actuator
- Fuel metering unit



Minimal controls for EGR flow from engine ECU. Simple after treatment – Diesel Oxidation Catalyst – NO active controls.

AL BS IV – EGR Version schematic with sensor details



All BS IV sensors retained in BS VI also

Sensors

- **Crank speed** – To measure engine speed and Top dead center of cylinder
- **Cam speed** – To measure Fuel injection speed and Top dead center of cylinder w.r.t firing order
- **Boost pressure** – To measure inlet air pressure and temperature
- **Coolant temperature** – To measure engine coolant temperature
- **Oil temperature and pressure** – To measure oil temperature and pressure
- **Water in fuel sensor** – To measure oil level Engine mounted fuel filter

Actuators

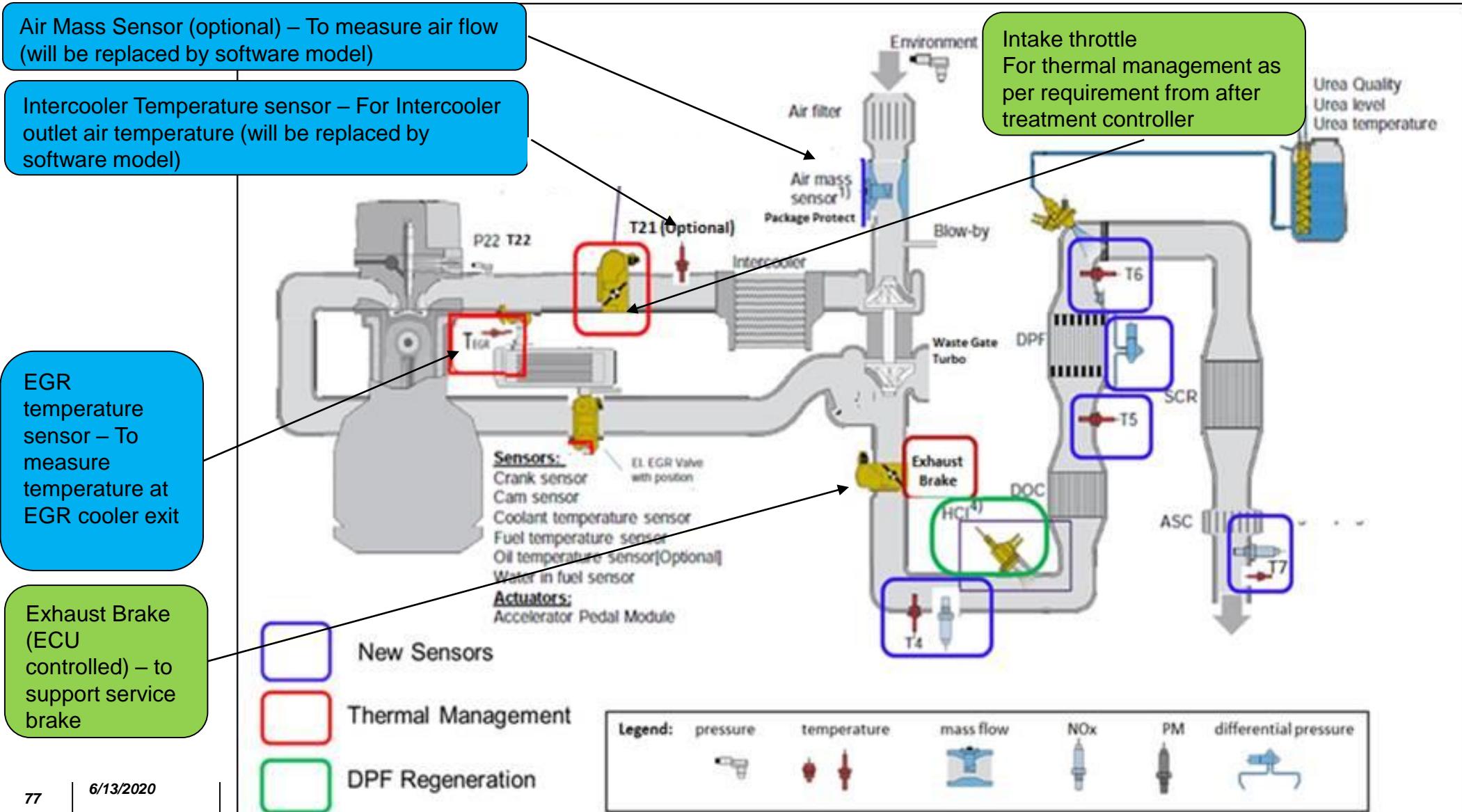
- **Accelerator pedal module** – To sense driver input
- **EGR valve actuator** – To control Exhaust Gas Recirculation flow into engine
- **Metering Unit** – To allow metered fuel into high pressure pump

BS VI System Detailed Schematic – Engine

New Sensors & Actuators compared to BS IV



ASHOK LEYLAND



BS VI System Detailed Schematic – EATS

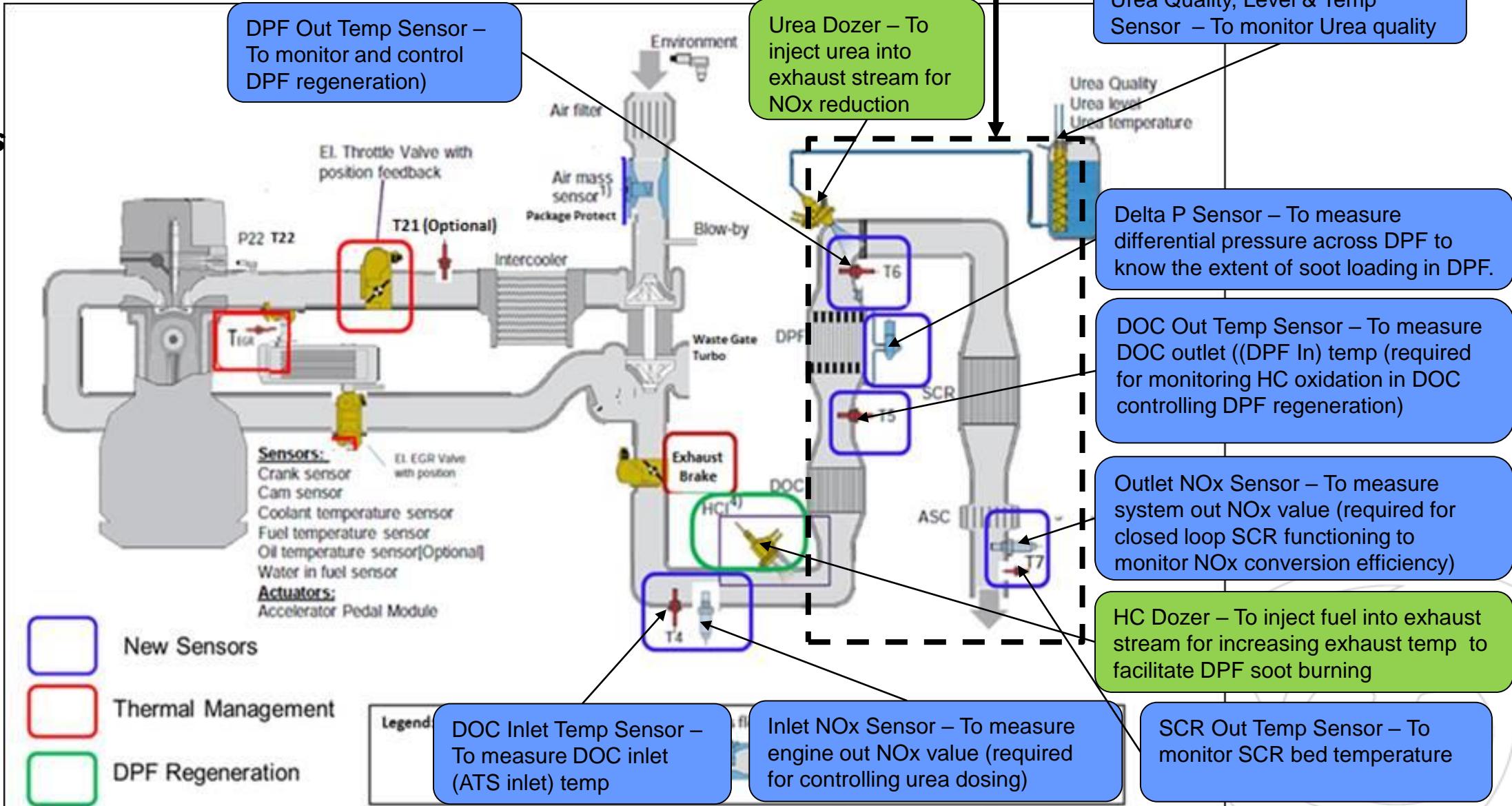
New Sensors & Actuators compared to BS IV



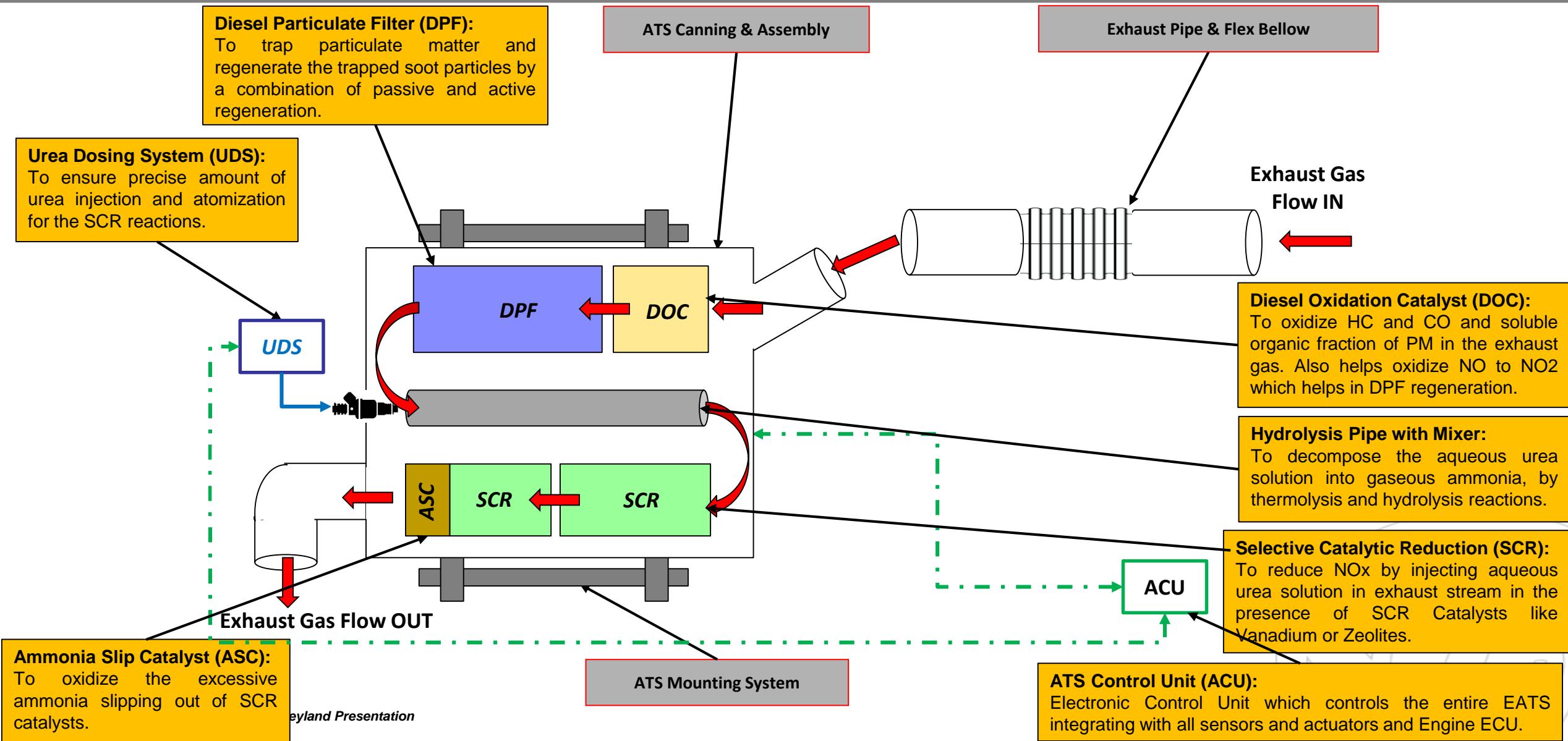
ASHOK LEYLAND

Sensors

Actuators



BS VI EATS Layout

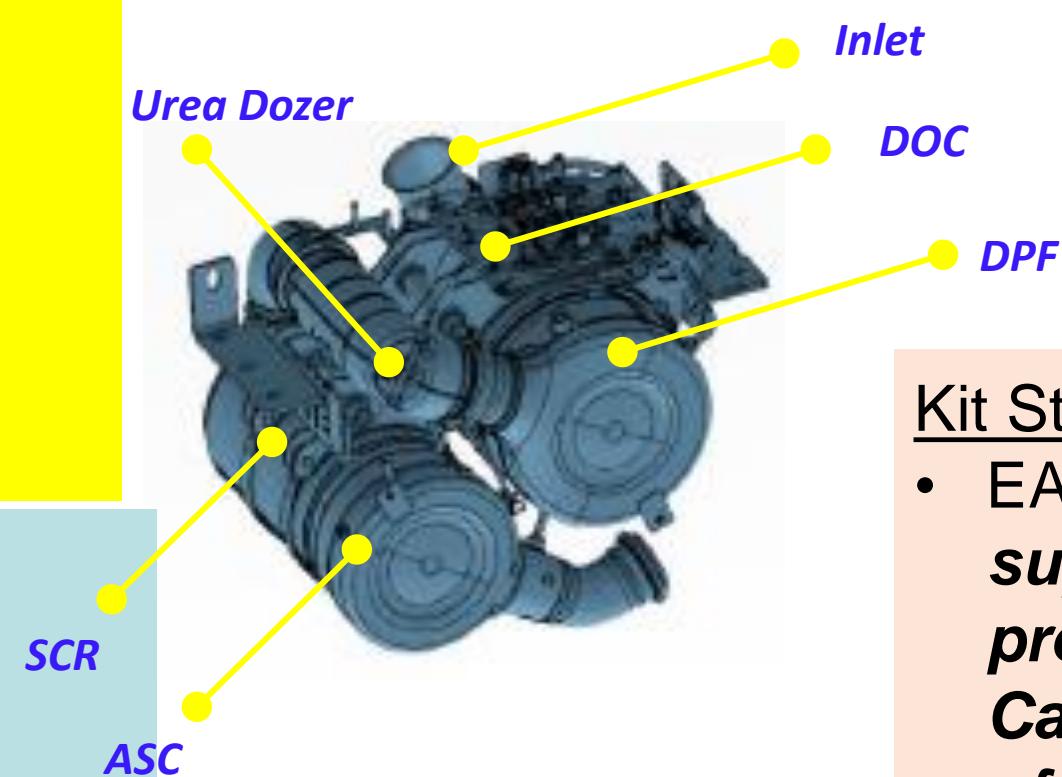


Handling

- Low Dust Area
- ***Unpacking only at Assembly stage***
- ***Damage to be prevented during handling***

Kit Unpacking during assembly

- ***Handling of Pipes / Sensors / Actuator without damage***
- ***DO NOT REMOVE SENSORS / CABLE / CATALYST CLAMP***



Kit Storage

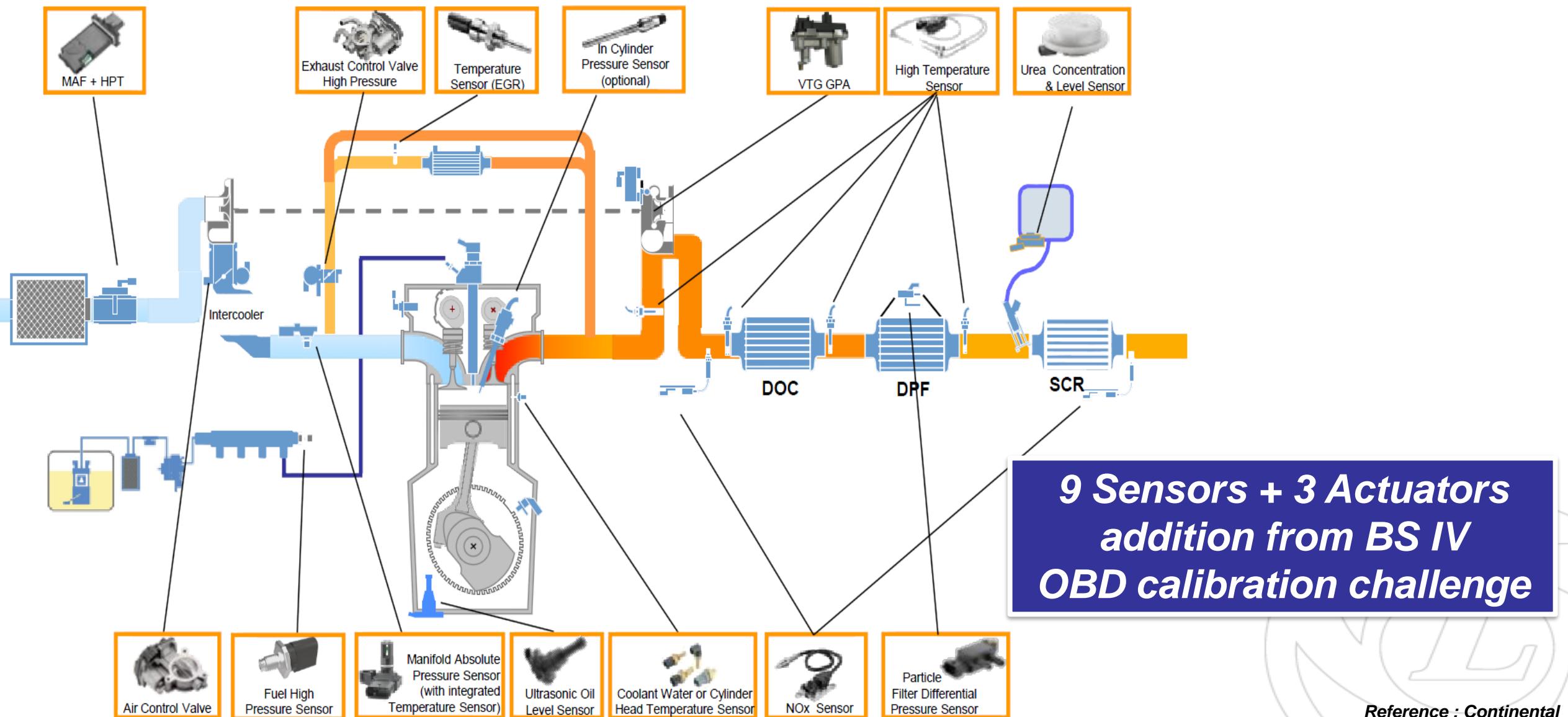
- EATS to be kept in stands ***supported properly to prevent damage to Catalyst or deformation of ends (bead adaptor & tail pipe)***
- ***ATS must be protected for any damages while handling / movement***
- Openings to be plugged

Design Challenges

General Electronics and Sensors



ASHOK LEYLAND

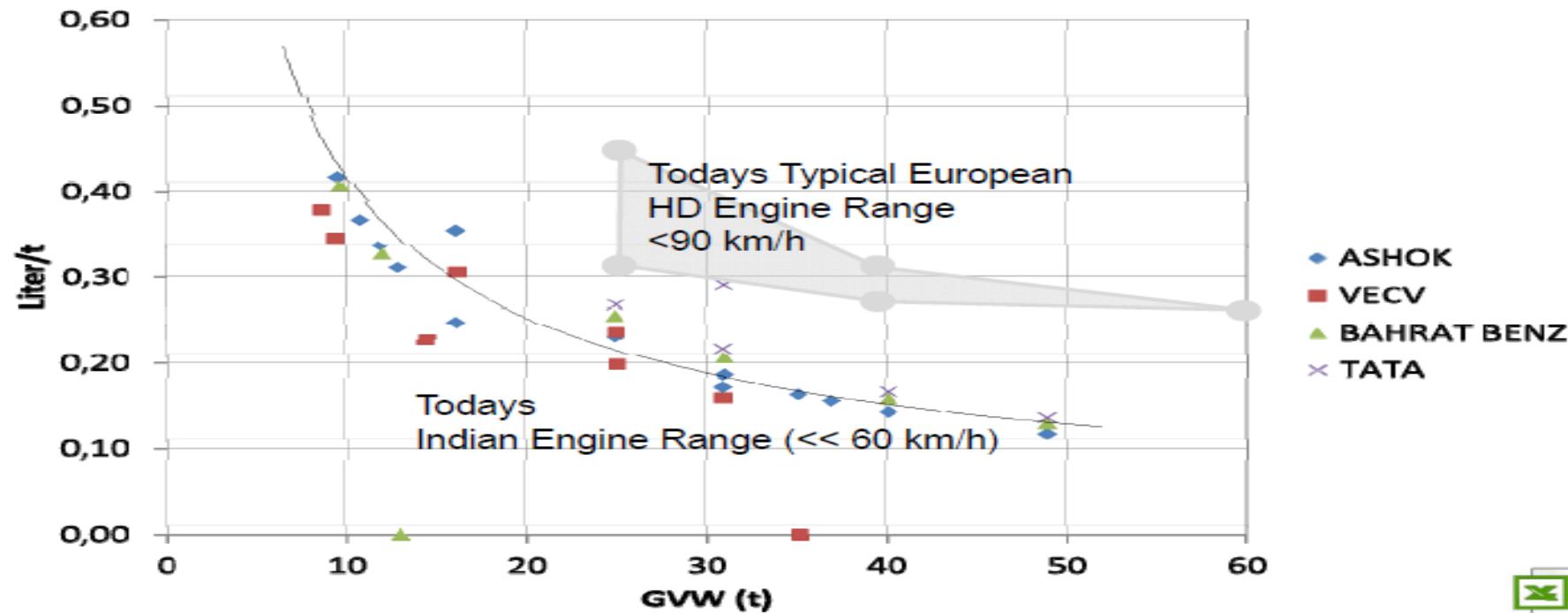




One approach to Indian truck industry

INDIAN TRUCK ENGINES VERSUS TYPICAL EUROPEAN RANGE

AVL



*European Benchmark show the trucks are powered enough to travel at cruising speeds (80kmph) on a typical highway gradient of 2%.
For Indian highways this speed is assumed to be 55kmph for M & HCV.*



Cruising speeds at 2% gradient

GVW	Engine Model	Powered speed at 0% gradient	Powered speed at ~2% gradient
12T	H4-150hp	>80	80
14T		>80	75
16T	H6-200hp	>80	80
25T		>80	75
31T	H6-200hp	>80	55
37T		>80	46
31T	N4-250hp	>80	65
37T		>80	56
40T		>80	53
49T	N6-400hp	>80	44
40T		>80	80
49T		>80	68

The above table shows the cruising speeds achieved for various vehicle GVW with current power nodes selected for BS VI.
Green- Cruising speed >60kmph, Yellow – >50kmph, Red - <50kmph.

Differentiated Technologies in BS VI Engines



No HFM, model based airflow



Air assisted urea Dosing



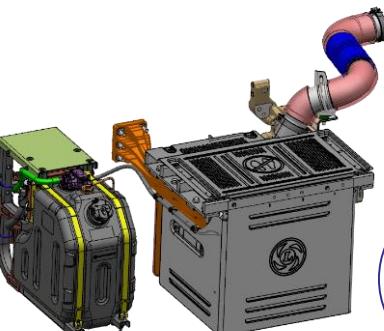
Mid NOx Strategy across platform



Intake throttle valve only
for thermal management



1600 bar common rail fuel system

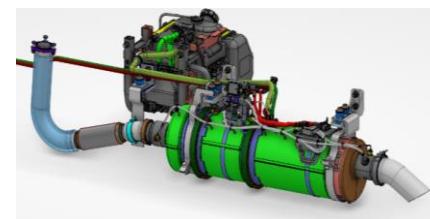


RTUG (Ready to use gasket)

Maintenance free OCV – Fit and Forget



Highest capacity Engine
Mounted AC compressor in
market – Better NVH

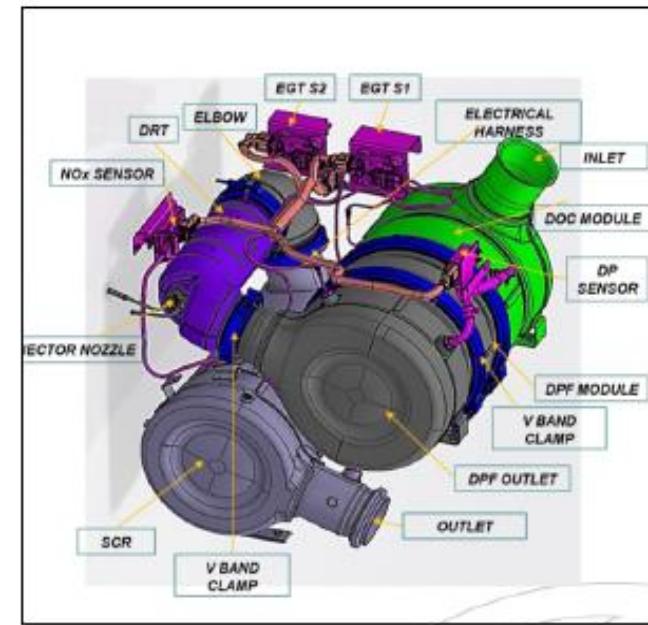
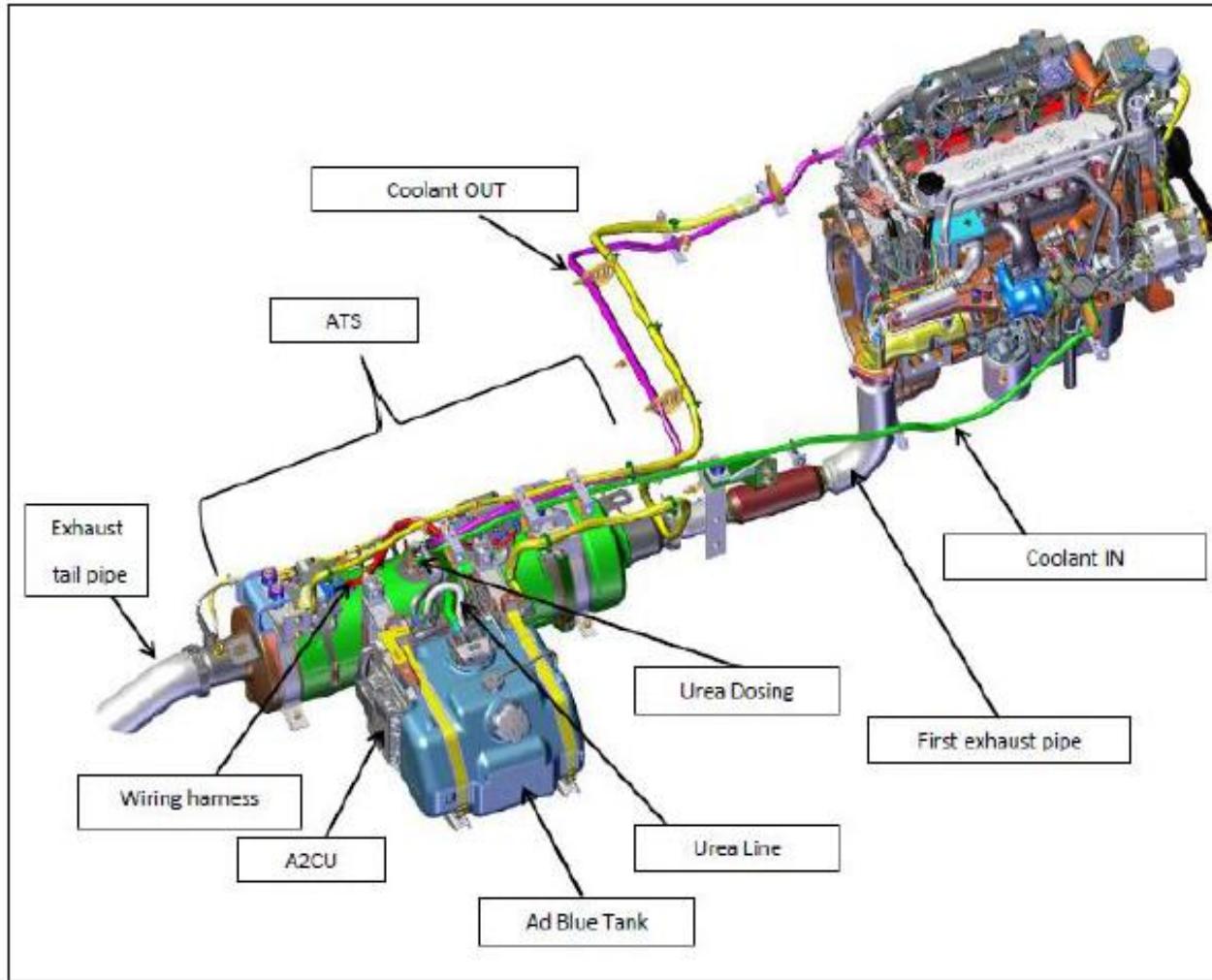


2 Valve/ cylinder in MHCV

External HC dosing for
Active regen– reduced Oil
dilution

The most compact modular EATS
in Indian market

Bs6 System

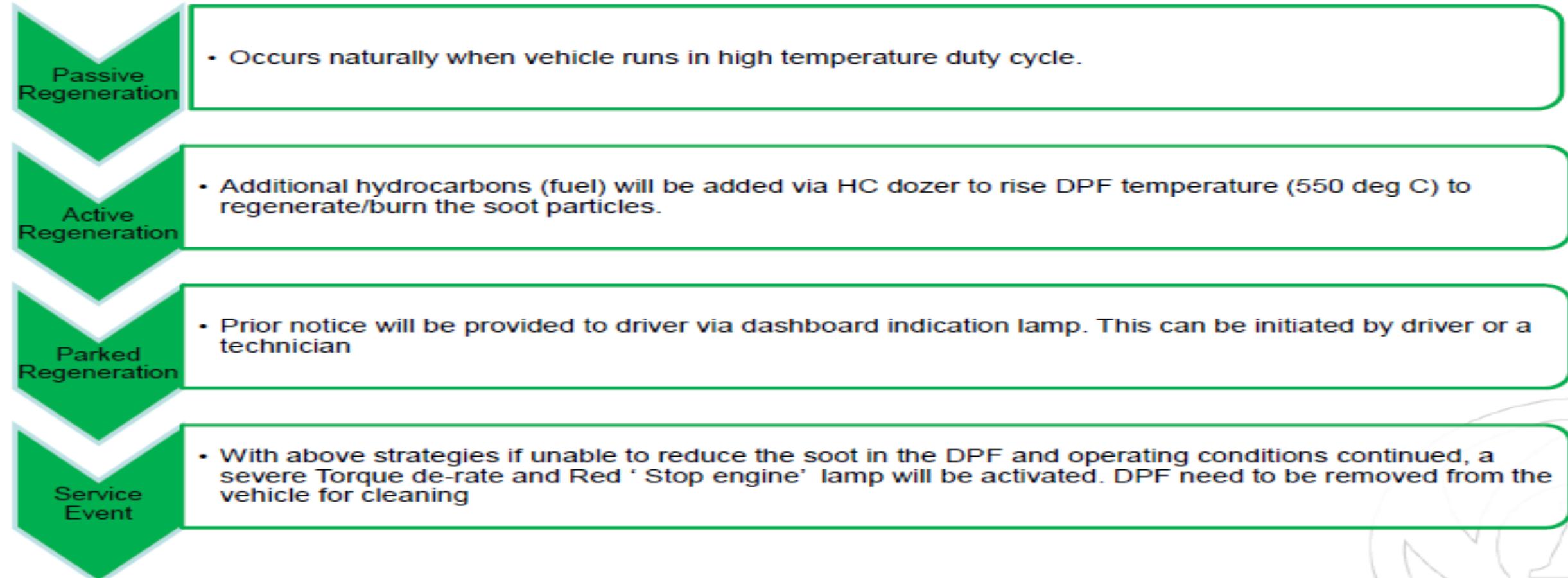




DPF Regeneration Strategy

What is Regeneration?

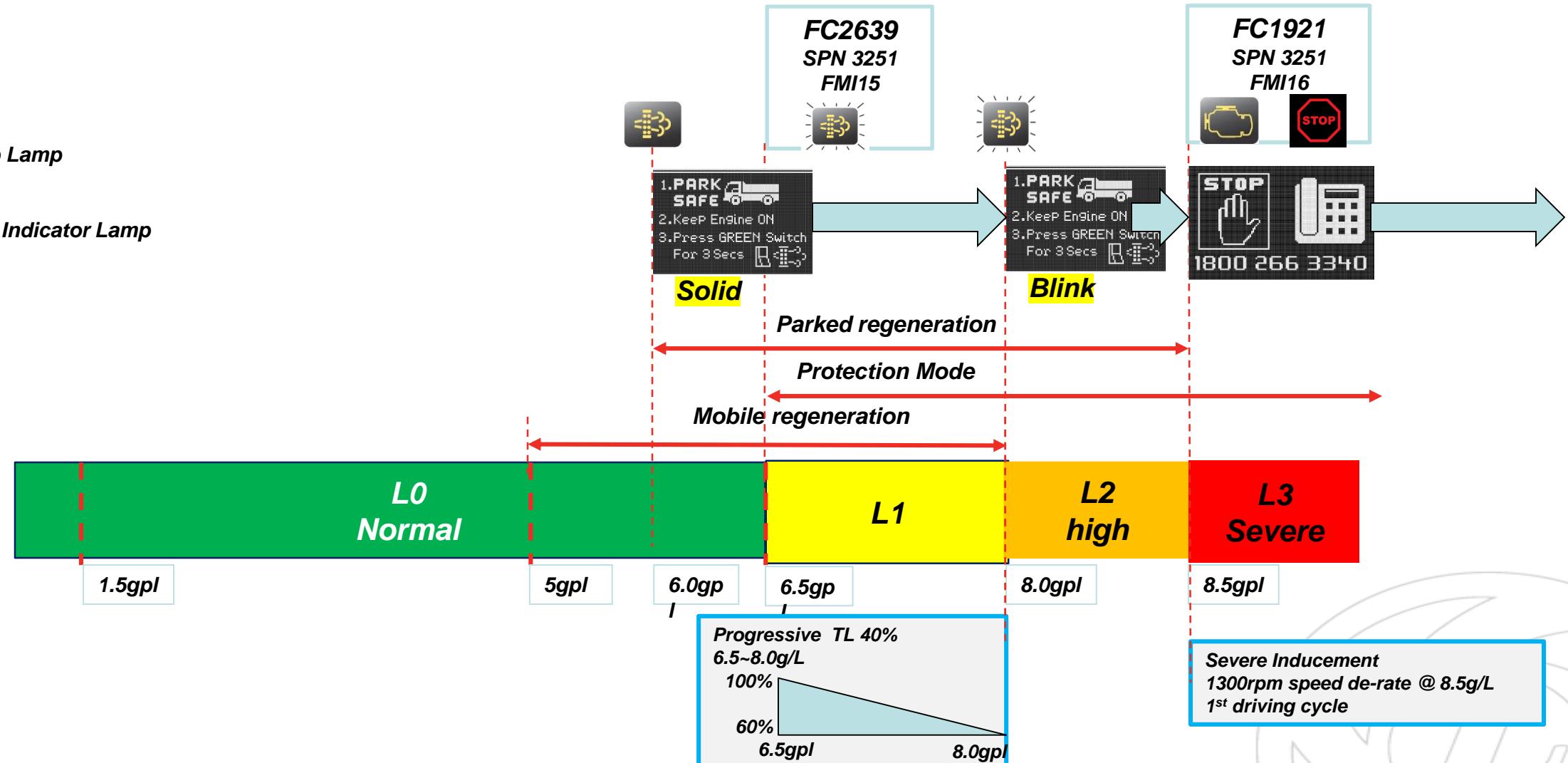
Process of removing accumulated soot by conversion into harmless CO₂





Soot regeneration and DPF protection – CES

- DPF Lamp
- Engine Stop Lamp
- Malfunction Indicator Lamp (MIL)





Instrument cluster and Tell-tale



Instrument Cluster



Grouping of telltales as per functionality





NOx related error



Low Adblue



Regen Needed 



Regen Inhibited 



High Exhaust Temperature 



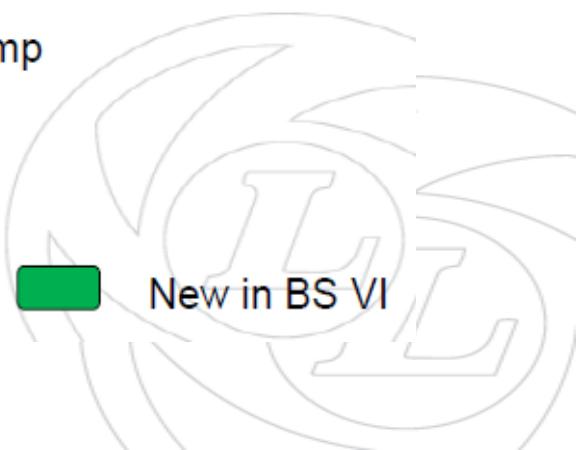
Non emission related
diagnostic check lamp



Malfunction indication lamp



Stop Lamp



New in BS VI



EATS related Telltales

Description	Symbol	Colour	Description	Symbol	Colour
Low Ad Blue Warning TT	AdBlue	Yellow	NOx related error	NOx	Yellow
High exhaust temp lamp		Yellow	MIL		Yellow
DPF regeneration Inhibit		Yellow	Engine Diagnostic Lamp	HEDC	Red
DPF Lamp (Regen needed)		Yellow	Stop Lamp		Red

Instrument cluster and Tell-tale

I. Critical Alert Tell tale that requires attention from Driver

Emission



High Exhaust System Temperature



DPF regeneration inhibit



DPF Lamp (Regen needed)



Low AdBlue warning



NOx related error

Safety



Stop Lamp

Performance



MIL



EDC Lamp



Low air pressure / Parking brake ON



Air filter blocked indicator



Low coolant level warning



Low fuel level warning

Switches



OFF



ON





S.No	Features	FVDP ML Cluster
1	Max No. of TT's	30
2	Max No. Of Gauges	6
3	No. of LCD's	1
4	Speedo meter & RPM meter	Gauge
5	Air pressure 1&2	Gauge
6	Coolant temperature	Gauge
7	Fuel level	Gauge
8	Oil Pressure	Bargraph in LCD
9	Battery Voltage	Bargraph in LCD
10	Adblue	Bargraph in LCD
11	Vehicle	U-truck EEA

BS6 Cluster



Cluster gauges:

1. Speedometer
 2. RPM meter
 3. Coolant temperature
 4. Fuel level
- Air pressure – Bar graph in LCD
Adblue - Bar graph in LCD

Telltale: 46
LCD: 3.5 inch dot matrix

- Push buttons : 2
- IP65 ingress protection
- Internal RTC to display date and time
- Flashing and diagnostics via AL tools
- Operating voltage is 12V / 24V

**More TELL TALES for BS VI &
More Info on LCD Display for Driver / Diagnosis**



1. Instrument cluster and Tell-tale

II. Understanding the Tell-tale specific to exhaust system

High Exhaust System Temperature



Effect on vehicle:

- No effect

Condition:

- This indicates regeneration is happening in vehicle.
- Regeneration is the cleaning process for Diesel Particulate filter in the Exhaust System
- Exhaust System temperature is above 500 deg C.

Driver action:

- Drive the vehicle away from flammable substance or heavy traffic immediately
- If above is not possible, press the Regen Inhibit Switch
- If the tell-tale does not go Off after pressing Regen Inhibit Switch, contact the nearby authorized Ashok Leyland Service Centre immediately

Instrument cluster and Tell-tale

II. Understanding the Tell-tale specific to exhaust system

DPF Regen Inhibit ON



Effect on vehicle:

- No effect

Condition:

- When *Regeneration inhibit switch* is switched ON by driver due to unfavorable surrounding.



Regeneration inhibit switch

- When switch is turned ON, DPF regen will be inhibited.

Driver action:

- When Inhibit switch is NOT switched ON and DPF regen inhibit telltale is ON, contact the nearby authorized Ashok Leyland Service Centre.

Regen Inhibit Switch - Usage



Regeneration Inhibit Switch

1. *Inhibit switch is a normal ON/OFF type switch which is used to stop any DPF regeneration (Regeneration can happen on its own while the vehicle is moving or can be initiated by the Driver on a Parked vehicle, when necessary)*
2. *It can be used whenever driver foresees any safety concerns during DPF regeneration in flammable environment (eg. fuel filling station / grassy / forest areas where high exhaust temperature can be exposed to flammable materials like dry grass etc. on the ground).*



- *When inhibit switch is ON, then indication on the switch will glow.*
- *Also inhibit lamp tell tale on dashboard will glow.*
- *Apart from that, LCD message will indicate "Inhibit switch active – DPF regeneration inhibited".*

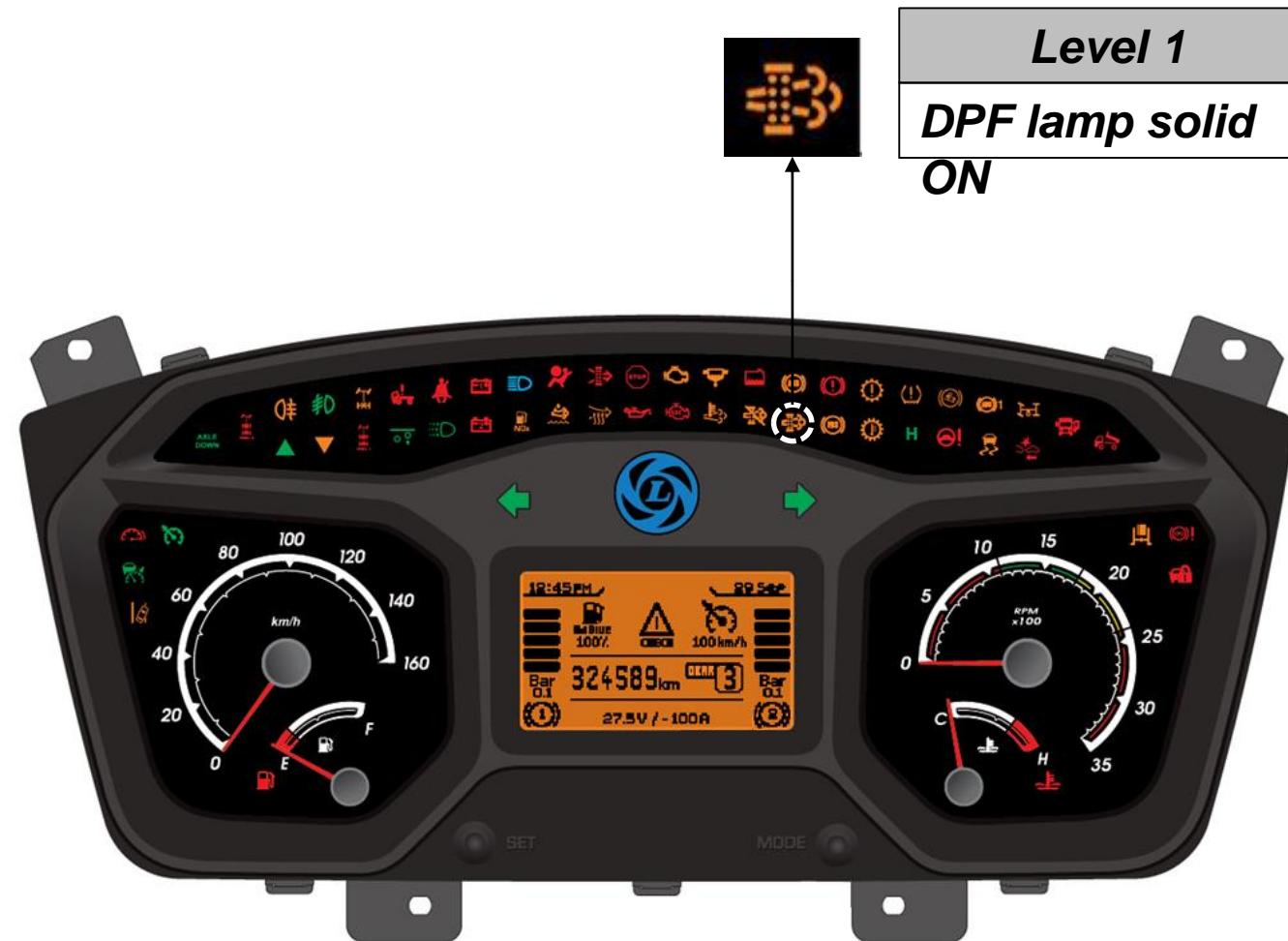


Do not use inhibit switch unless it is required. Otherwise DPF will accumulate excess soot load over a period of time which will result in Torque Limitation and Engine Shutdown in extreme condition. The DPF would require cleaning at authorized Ashok Leyland Service Centre.

Instrument cluster and Tell-tale

II. Understanding the Tell-tale specific to exhaust system

DPF Lamp



Effect on vehicle:

- No effect

Condition:

- When Diesel Particulate Filter (DPF) is choked and needs regeneration

Driver action:

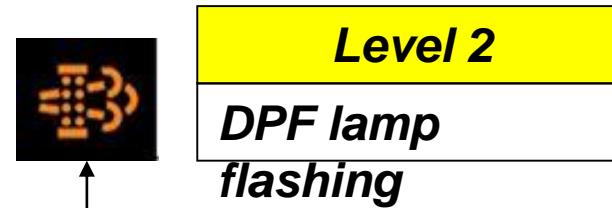
- **Drive the vehicle on a highway at high speed to increase exhaust system temperature.**
- **If the above condition is not possible, park vehicle in a safe location to start Parked regeneration.**



Instrument cluster and Tell-tale

II. Understanding the Tell-tale specific to exhaust system

DPF Lamp



Effect on vehicle:

- Vehicle pick up would be low when DPF Lamp starts flashing.



Condition:

- When Diesel Particulate Filter (DPF) is highly choked and parked regeneration has to be done at the earliest possible

Driver action:

- Park the vehicle in a safe location to start Parked regeneration immediately.

Parked Regeneration - Precautions



Precautions before attempting Parked regeneration:

CAUTION

Chock
Wheels



- Place wheel choke at the front and rear of at least one wheel
- Ensure the Fire Extinguisher is at easily accessible location and be aware of using it if required.
- During parked regeneration, stay near to the vehicle in order to supervise the procedure and prevent any object or person from coming close to the exhaust.
- Verify hood/front opening panel is closed and latched.



Ensure that the exhaust smoke does not come in contact with "dry grass, rags, grease, debris, fuel, oil soaked waste or any flammable substances" and also confirm that no such flammable substance is on or near the exhaust system, during parked regeneration.

Parked Regeneration – Necessary Conditions



Conditions to start Parked Regeneration:

1. **Park the vehicle in a well ventilated area and away from other vehicles.**
2. **Accelerator pedal should not be pressed or operated**
3. **Gear in Neutral position**
4. **Engine in warm condition (Coolant temperature to be more than 60deg C)**
5. **Engine at Idle RPM**
6. **Vehicle at parked condition. (Zero KMPH)**
7. **Inhibit switch : Switched OFF**
8. **DPF lamp : solid ON or Blinking**
9. **Parking brake : applied**
10. **PTO : switched OFF**
11. **Switch ON ignition, START the engine and then START the parked regeneration by pressing the Switch for more than 5 seconds**
12. **Engine RPM raises to 2000 RPM when parked regen is started**
13. **Do not press Clutch, Brake and Accelerator pedals or any other switches / controls on Dashboard**
14. **Keep an eye on vehicle surroundings on all sides when the regeneration is happening**



Press for more than 5

Parked Regeneration



Parked Regeneration Switch ON

1. To activate Parked regeneration, press “START” (bottom side of switch) for more than 3 seconds and release.
2. To confirm whether parked regeneration activation switch has been pressed properly , please check the LCD message which indicates “parked regeneration switch ON” .
3. After that, if all the other parked regeneration enable conditions are satisfied, then LCD message display as “Parked DPF regeneration active through Switch”.
4. After that DPF regeneration can also be confirmed through HEST lamp activation.



Press for more than 3 sec



High exhaust system
(temp solid ON)

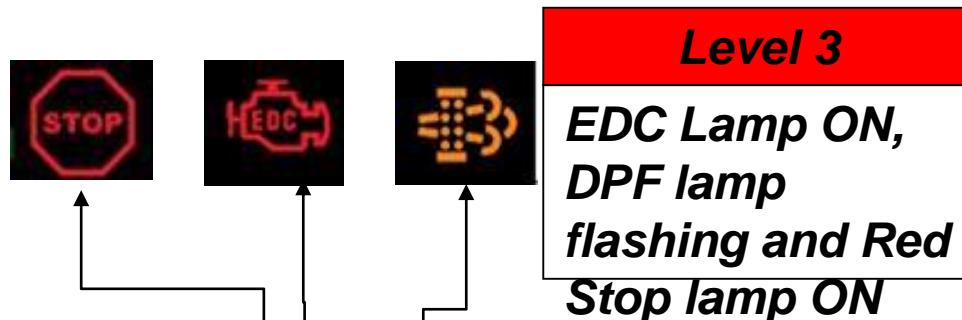
Parked Regeneration Completion

1. Once the Regeneration is complete, the Engine RPM drops to Idle RPM.
2. Both LCD messages, "Parked regeneration switch ON" and "parked DPF regeneration active" will not Display in LCD screen. Also after some time, HEST lamp goes OFF

Instrument cluster and Tell-tale

II. Understanding the Tell-tale specific to exhaust system

EDC Lamp + DPF Lamp + Stop Lamp



Effect on vehicle:

- *Pick up will be Low and Vehicle will not go beyond 20 Kmph when DPF Lamp starts flashing and red STOP lamp is ON*

Condition:

- *When Diesel Particulate Filter is choked completely*

Driver action:

- *Not safe to drive vehicle. Park the vehicle immediately and contact the nearby authorized Ashok Leyland Service Centre.*

Instrument cluster and Tell-tale

II. Understanding the Tell-tale specific to exhaust system



Low AdBlue Warning



Effect on vehicle:

- No effect

Condition:

- When AdBlue quantity is less than 10 %

Driver action:

- Fill the recommended AdBlue solution immediately.

GULF AdBlue



1. *Instrument cluster and Tell-tale*

II. Understanding the Tell-tale specific to exhaust system

Low AdBlue Warning

Level 2
**AdBlue warning
flashing**



Effect on vehicle:

- Some time after this tell tale starts flashing, there would be Low Pick up*

Condition:

- When AdBlue quantity is less than 5 % of total filling capacity and Low pick up when the level is less than 2.5%*

Driver action:

- Fill the recommended AdBlue solution immediately.*

GULF AdBlue

Instrument cluster and Tell-tale

II. Understanding the Tell-tale specific to exhaust system



NOx related Error



Effect on vehicle:

- Some time after this tell tale glows, there would be Low Pick up

Condition:

- AdBlue Quality might be an issue
- When errors related to Emission control happens

Driver action:

- Contact the nearby authorized Ashok Leyland Service Centre.

Instrument cluster and Tell-tale

III. Understanding the Tell-tale specific to Performance



MIL



Effect on vehicle:

- Some time after this Tell-tale glows continuously during engine run, there would be Low Pick up.

Condition:

- When MIL glows continuously during engine run, there may be error in Engine performance or Emission control

Driver action:

- Contact the nearby authorized Ashok Leyland Service Centre

Instrument cluster and Tell-tale

III. Understanding the Tell-tale specific to Performance



EDC Lamp



Effect on vehicle:

- May reduce the Torque / Speed or Engine RPM

Condition:

- When there is any abnormality with function of sensors or any electronic components controlled by ECU and EATS

Driver action:

- Contact the nearby authorized Ashok Leyland Service Centre

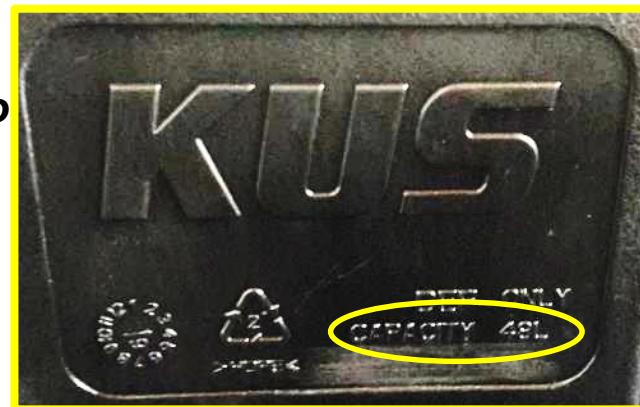


BS6 Diesel

- Please Use Only BS6 Diesel for all Ashok Leyland Trucks and Buses
- The amount of Sulphur is reduced by 80% in BS6 diesel (50 ppm to 10 ppm) when compared to BS4 diesel
- Usage of BS4 Diesel on BS6 Trucks or Buses would affect the life of DPF in Silencer.
- Consequently pick up of vehicle would be affected and result in huge cost of Repair

AdBlue

- Please fill only AL recommended AdBlue (Gulf – AUS32)
- Fill only the quantity as recommended on RH side of AdBlue tank (48 litres / 24 litres) (Refer Pictures)
- Ensure the cap is locked properly by taking out the key. Cap rotates freely after proper locking.
- Never run the vehicle without AdBlue tank Cap or not closed properly to prevent crystallization of AdBlue.
- Never run the vehicle without AdBlue as it will lead to low Pick-up of the vehicle



Application Challenges

BS IV to BS VI EATS migration



- Duty Cycle – Thermal Management requirement
 - Low exhaust gas temperature
 - Long idle (city) or low speed application (garbage collecting trucks)
- Fuel adulteration
- Urea quality
- Calibration challenges compared to BS IV
 - Thermal management
 - Urea dosing, deposit control
 - Ammonia storage measurement

Other Challenges



- *Availability of consistent quality ULSD all across India*
- *Use of BS VI ULSD fuel from the time of launch*
- *Implement lessons learnt from earlier trials related to contamination, cleanliness, water ingress, corrosion, effect of additives.*
- *DEF distribution network and availability at every fuel dispensing station will be key enabler.*
- *Ensuring DEF quality, consistency and handling / dispensing is key.*
- *Appropriate technology choices, robust system integration, understanding real world behavior, maintenance and service practices and end user awareness is critical for overall success and acceptance of BS VI products.*

Other Challenges



Prolonged low temperature operations due to challenging duty cycles:

- Coking of catalyst will remain a challenge without aggressive thermal management on specific applications**
- Possibility of catalyst face plugging due to use of Bio diesel**

Over - temperature exposure during operation:

- Managing DPF soot load / soot regeneration is very critical.**
- Pt contamination from DOC / DPF reducing De-NOx efficiency of SCR.**
- Prolong idle – HC Desorption**
- Frequent start – Stop and low temperature:**
- Effect of water condensation and effective drainage**
- Managing NOx sensor for dew point condition**

Other Challenges



- **Poisoning of NOx sensors**
- **Prolong elemental exposures and deposits such as Fe, Si, Mg can cause NOx sensor catalyst to poison and hence making it fail to perform it's function with desired accuracy.**
- **Lube oil borne ash and Sulphur as well as additives.**
- **Based on oil consumption, origin of elements such as Sulphur, Phosphorous will be required to manage closely. Lube additive impact on catalyst performance is key**
- **Ash from lube oil will be another aspect to be consider for DPF sizing and service**
- **Other fluid exposures**
- **Exposure to truck wash fluid and tap water does not lead to washcoat adhesion issue or active Cu species leaching (for Cu- Z SCR)**

Futures in IC Engines



21st Century Truck Partnership Technology Goals

Average payload: 11,800 kg (26,000 lbs.)

Total Mass: 25,220 kg (55,600 lbs.)

Freight Specific Fuel Consumption = 9.0 gallons/1000 ton-miles

9.4 mpg



Key Enhancements:

- Engine efficiency
- Aerodynamic Improvements
- Low rolling resistance tires
- Regenerative braking (HEV)

Average Power Use Inventory (Line Haul)

Fuel Input (211 kW)

Engine Losses
105 kW ($\eta_{eng}=0.50$)

Auxiliary Power Unit
0.8 kW

Engine Output (105 kW)

Accessory Loads
8 kW

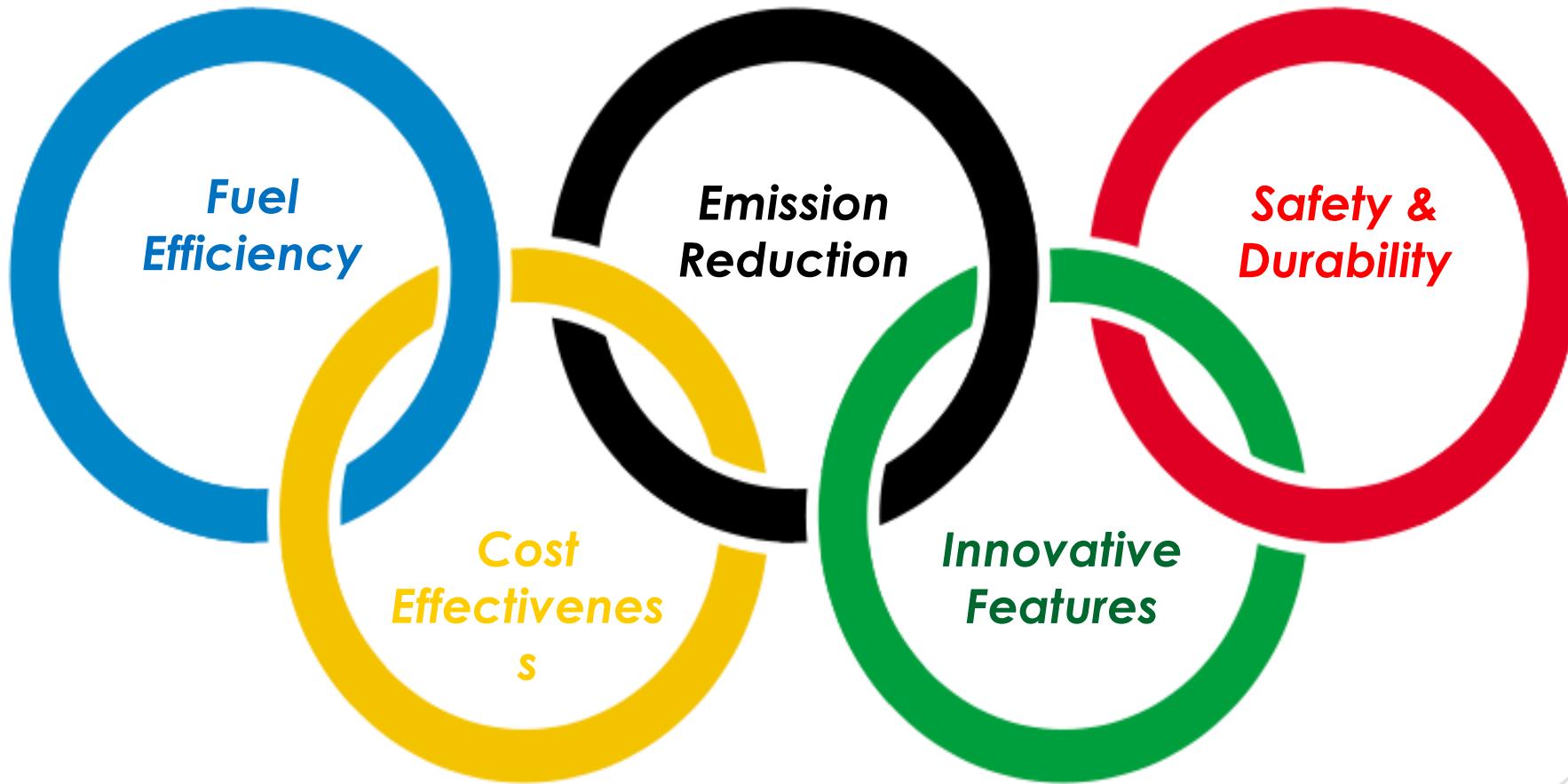
Drivetrain Losses
5 kW

Tractive Power (92 kW)

Aerodynamic Losses
53 kW ($C_D=0.52$)

Rolling Resistance
32 kW ($C_{RR}=0.0055$)

Inertia/Braking Losses
7 kW (60% regeneration efficiency)



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***

**ASHOK LEYLAND IS COMMITTED TO GREENER
DEVELOPMENT**



Question to be asked to the speaker (if any)

sl.no

- 1 What is the difference between BS4 and BS6 norms
- 2 Difference between Diesel and Petrol catalytic converter , explain briefly.
- 3 What are the technical changes in bs6 vehicles?
- 4 Where it notify the standards or the changes in a vehicle for each norms such as bs4, bs6 etc
- 5 how BS6 benefiting India
 - 1) any special precautions during conducting brake testing of BS VI vehicles at time of fitness renewal
 - 2) What precautions required to be taken while driving and preventive maintenance of BS VI vehicles according to the different technologies
- 7 What about drivers training to handle BS6 vehicles
How association works for the ASSISTANT Motor vehicle INSPECTOR and for the RTO
- 8 department?
how about having a concluding seminar on A Decade of action to be taken on Road Safety ..
- 9 The most neglected part since its beginning in 2011..
Efficacy of BS6 technology post covid from economy, redundancy of technology and Beed to push 10 forth for alternative technology.

- 11 Sir effect of lockdown on road safety related activities
- 12 What is technological difference between BS-6 and BS-8 Vehice ?
- 13 How to identify the BS6 vehicles over sight
- 14 If we use existing fuel in Bs6 vehicle. Will the emission level meet Bs6 norms?
- 15 Is the obd (on board diagnosing device)fitment in all class of vehicles made as a mantatory
- 16 What is the present scenario & effects of BSV1 norms ?
- 17 What are the parameters you have to adopt
- 18 Road safety recent scenario
- 19 Main technical differences, visually how to recognize both types
- 20 What is the difference between bs4 &bs6 while inspection of vehicles to be observed
Need of BS VI . From Govt side what has been done to bring BS VI. Changes adapted in
- 21 Transport/Non Transport vehicles.

Thank you

