

Perspective on emissions standards roadmap for India and the industry preparedness to leapfrog to Euro VI emissions standards

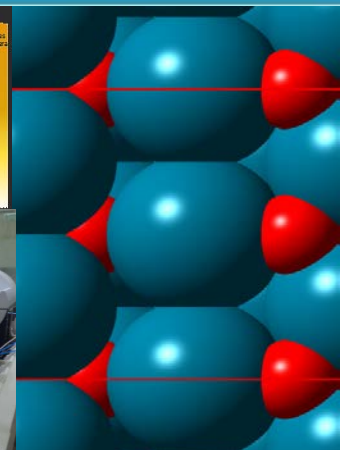
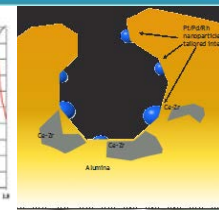
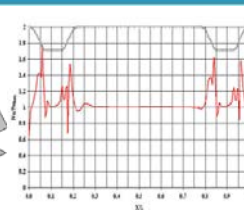
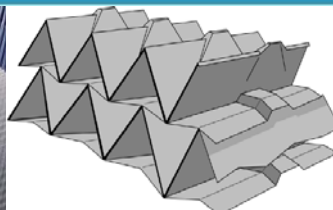
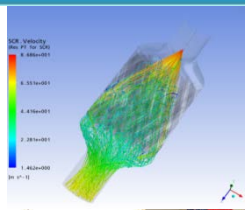
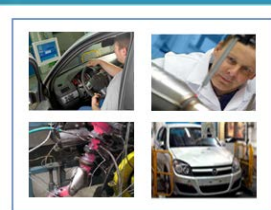
Alok Trigunayat ; Matti
Harkonnen ; Rajan Bosco
12 Mar 2015



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ECOCAT INDIA

CONTINUOUS DEVELOPMENT & DELIVERING EXCELLENCE

Developing advanced technologies



Ecocat India an exhaust gas catalyst manufacturer supplying after treatment system to vehicle & engine manufacturers. Supplying complete catalysts with substrate, coating and canning for different applications e.g. Petrol, Diesel, CNG, LPG, Bi-Fuel, SCR & VOC Catalyst. Particle Oxidation Catalyst. DPF & Urea Mixers.

Ecocat India in brief

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Ecocat India is an exhaust gas catalyst manufacturer supplying after treatment system to vehicle & engine manufacturers. Ecocat India is a 80:20 Joint Venture between Vikas Group and Ecocat OY head quarter at Finland. Focussing strongly on local R&D we supply complete catalysts with substrate, coating and canning for different applications e.g. Petrol, Diesel, CNG, LPG, Bi-Fuel, SCR & VOC Catalyst, Particle Oxidation Catalyst, DPF & Urea Mixers.

Our **Mission** is to clean the world's air with our **Values** of responsibility, networking, market intimacy and success. Therefore, Ecocat's **Vision** is to be an advanced ecological company with close proximity to its customers.

- Ecocat India focuses on substrates , coatings and canning and supplies products to OEMS , canners and system integrators.



CONTINUOUS DEVELOPMENT
DELIVERING EXCELLENCE





Metallic /Ceramic Diesel/Gasoline/CNG



Two wheeler Brazed
Gasoline

Passenger & Light
Commercial Vehicles



Three wheeler
Metallic
Diesel/CNG/Gasoline



Off road /After Market : Metallic
/ceramic Diesel/Gasoline /CNG



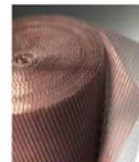
Off-road



Truth, Honesty & Integrity ; Respect & Discipline ;
Customer Delight ; Collaboration ; innovation

**ECOCAT
INDIA**

Heavy Commercial
Vehicles



Aftermarket



ECOCAT INDIA

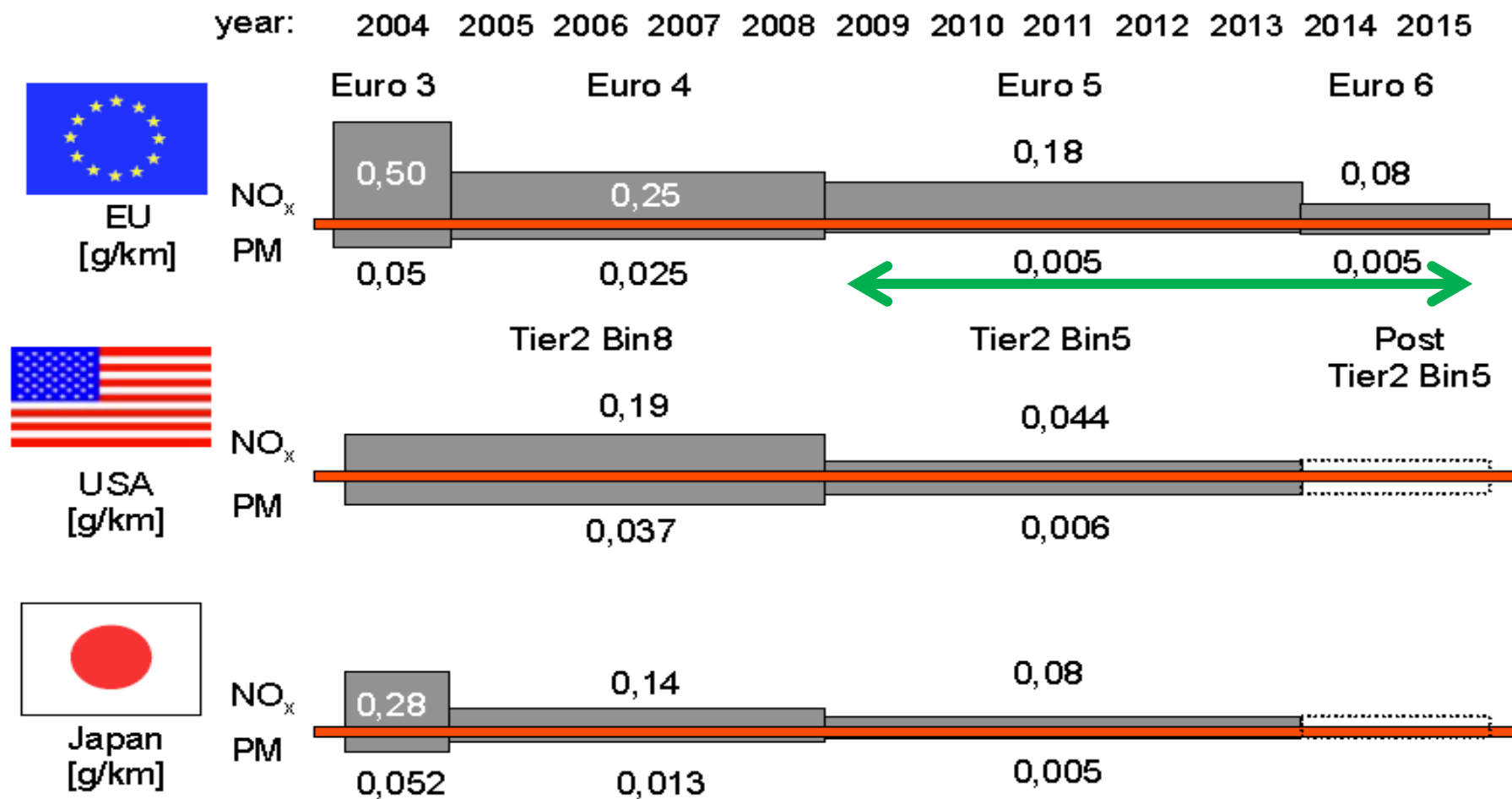
Fresh Ideas - Cleaner Future®

Developing advanced technologies



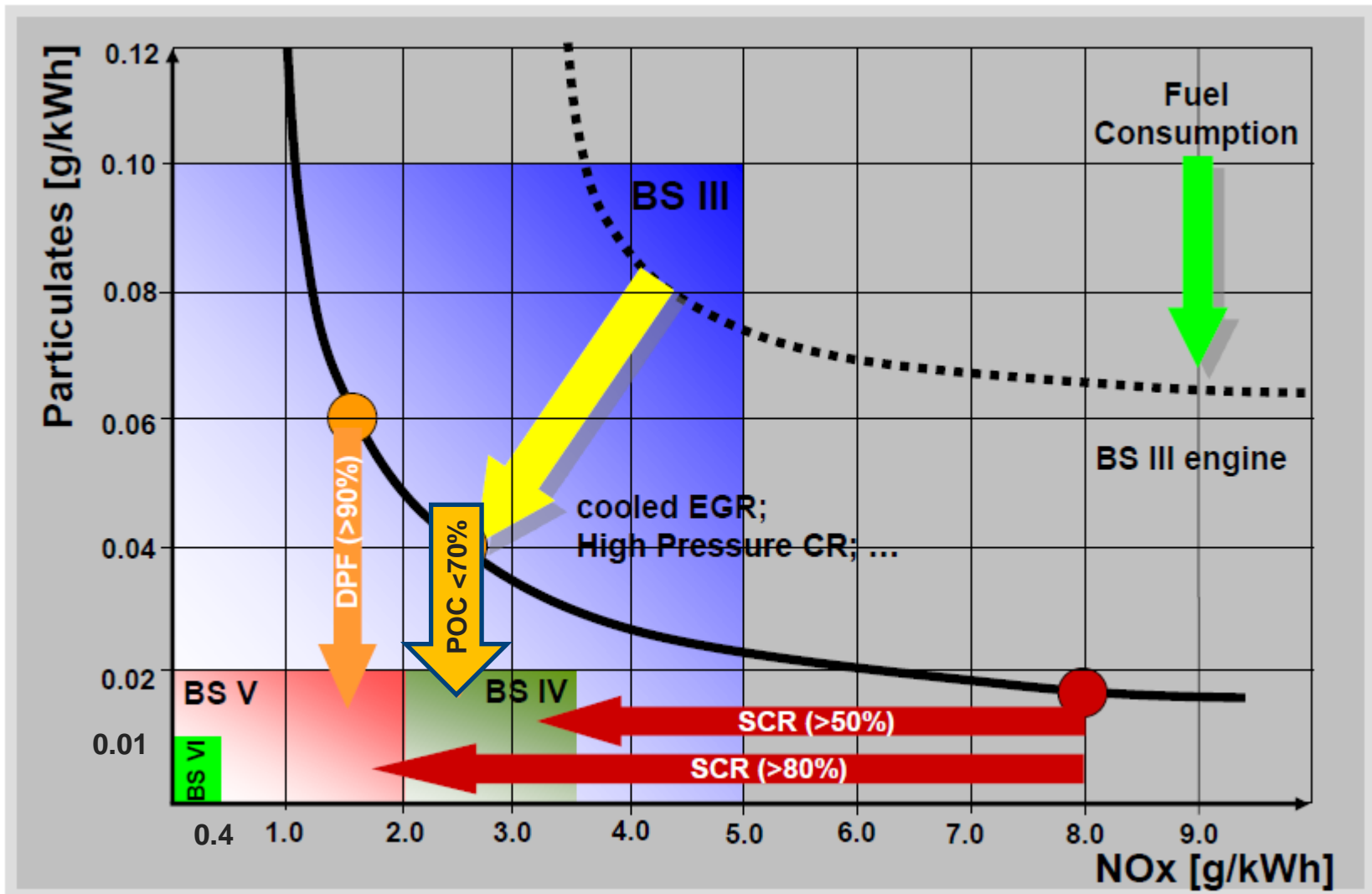
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Global Emission limits for passenger cars:



Emission limits HDD. diesel vehicles

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December, 2010

Air quality monitoring, emission inventory and source apportionment study for Indian cities

National Summary Report

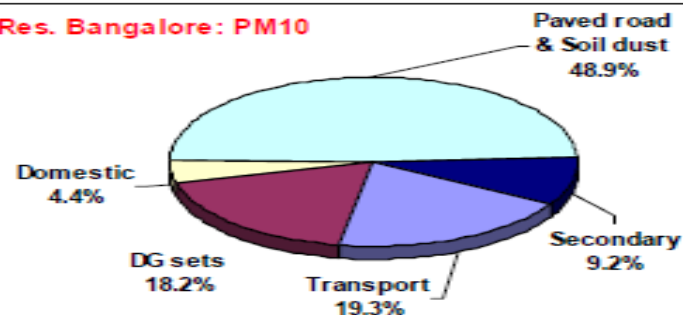
Evaluation of Control/Management Options and City Specific Action Plans

The results of air quality measurements, emission inventory, source apportionment based on receptor modeling, and dispersion modeling provide vital information in terms of status of air quality and sources contributing to it, in each of the six project cities. List of prioritized sources based on EI, receptor modeling (factor analysis and CMB8) is given in Table

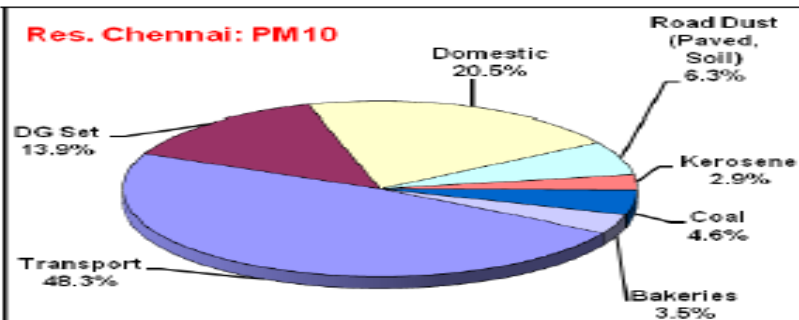
7.1. The levels of PM_{10} are high, and there are multiple contributing sources. Therefore, controlling a single source type may not yield desired results, and it is necessary to evolve a comprehensive action plan comprising a combination of control/management options. These options would vary from city to city depending on extent of problem and source configuration in the city.

PM 10 Sources in Indian cities

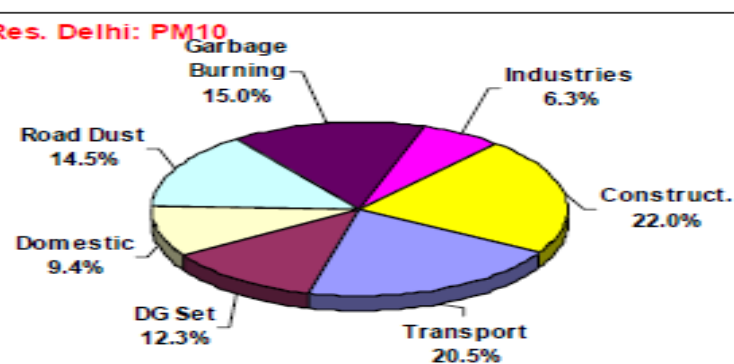
Res. Bangalore: PM10



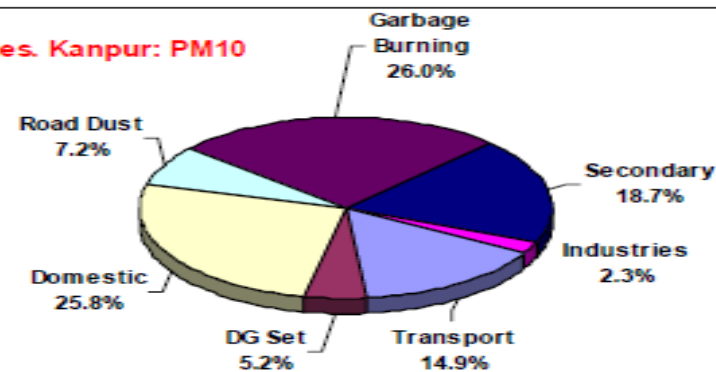
Res. Chennai: PM10



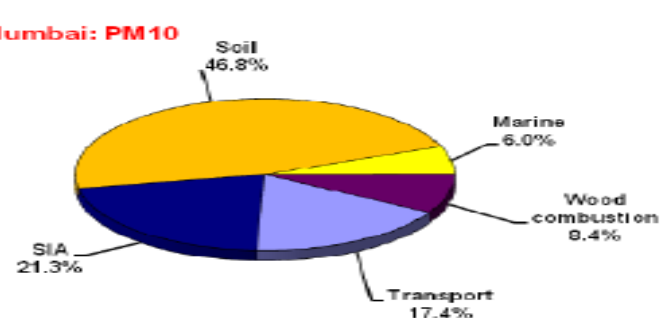
Res. Delhi: PM10



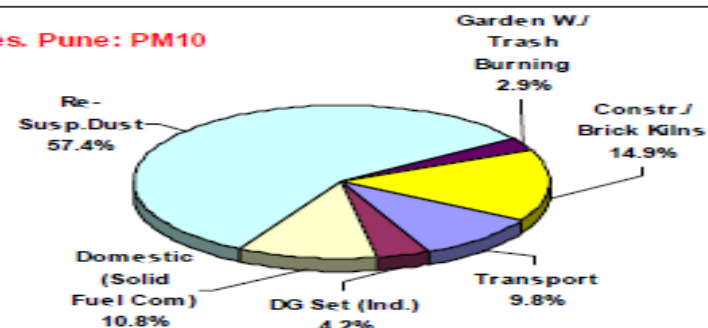
Res. Kanpur: PM10



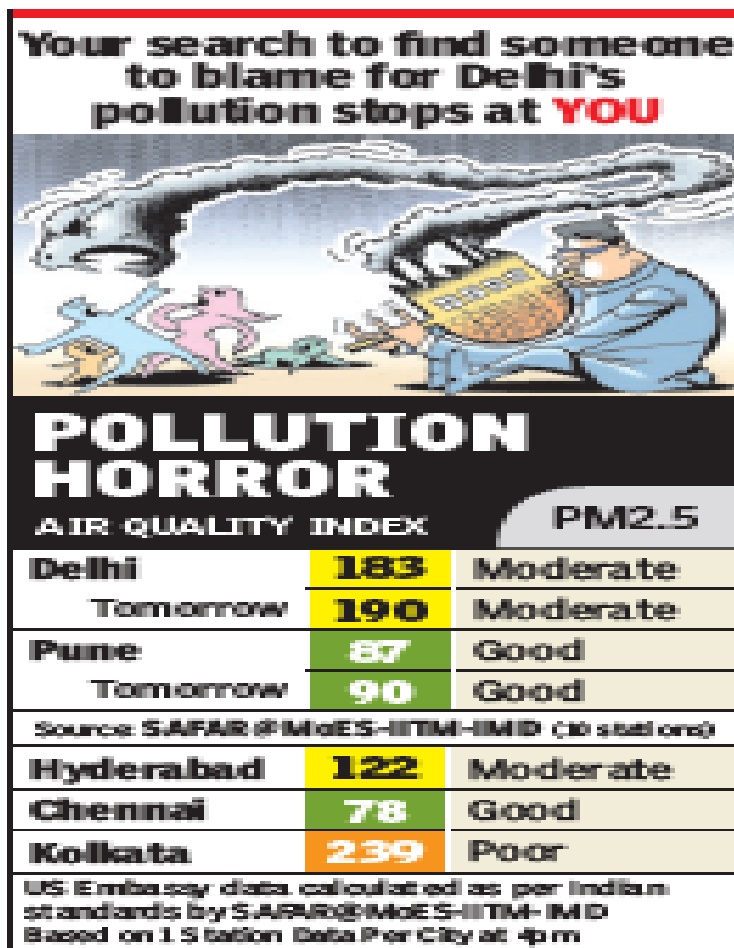
Res. Mumbai: PM10



Res. Pune: PM10



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DATED 11 MAR
2015



Greenpeace's recent survey inside 5 prominent schools showed PM2.5 levels were three to four times the safe standard

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Engine Technologies

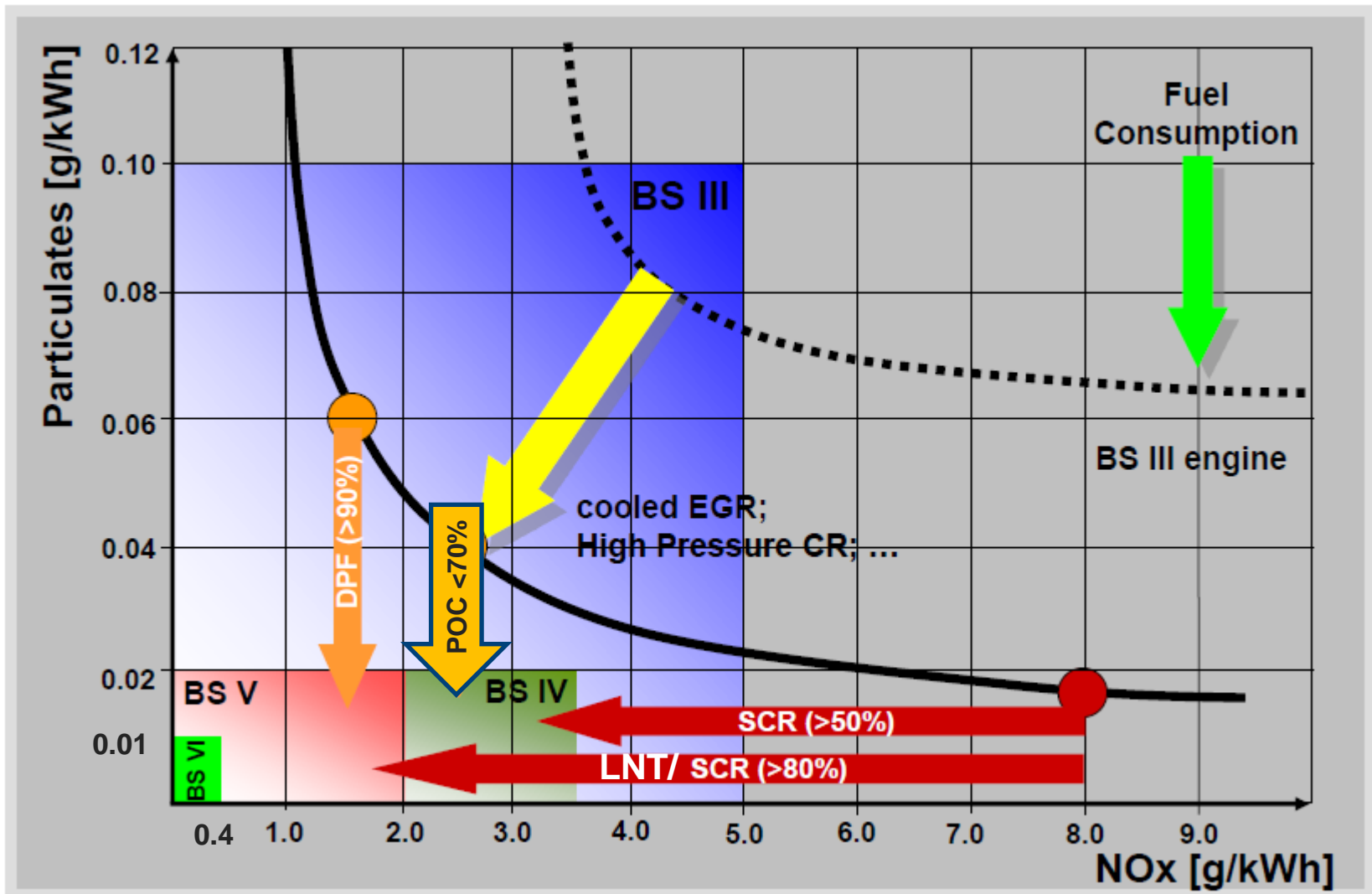
- During the years the diesel engine technologies have developed dramatically having now turbocharging, cooled EGR and advanced air handling systems.
- From emission wise engine technologies are named in Europe to E0, E1, E2, E3, E4, E5 and E6.
- Engine Efficiency has developed highly during the years.
- The same has happened to the thermal efficiency → cooler exhaust gases → problems in real city driving conditions for the after-treatment ?

3. Engine Technologies

- PM reduction can be achieved by improved fuel deliver systems,
 - by improved configuration of combustion chambers,
 - and turbocharging.
- NOx reductions can be achieved pricipally through
 - improved fuel delivery systems,
 - air-to-air cooling, EGR, etc.

Emission reduction strategies diesel vehicles

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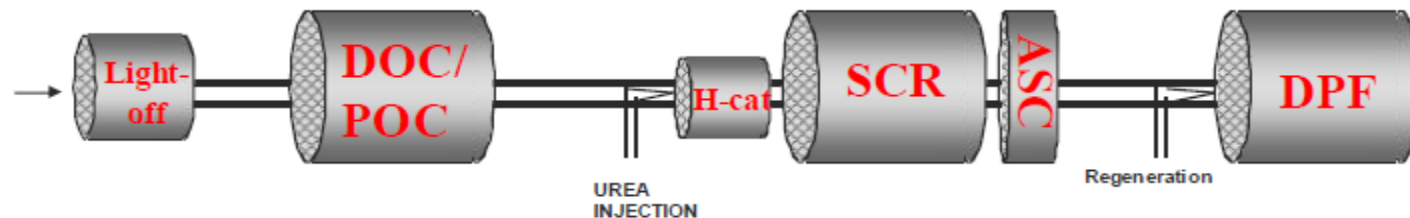


4. Diesel After-treatment Technologies

- A series of technologies exist for a typical Diesel after-treatment system.
- They consist of Oxidation catalyst, Catalyzed particle traps, and NOx systems (SCR, LNT etc.).

Euro IV / V / VI aftertreatment

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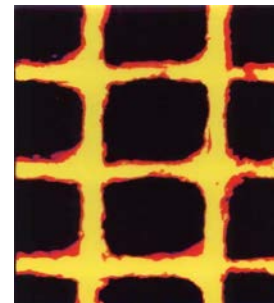


GASOLINE/DIESEL/CNG/LPG/BIFUEL

Based on application, normally only some of above are needed

4. Diesel After-treatment Technologies

- The performance efficiency of all these after-treatment systems
 - depends heavily on:
 - Substrate material,
 - Substrate dimensions,
 - Cell density,
 - Washcoat design,
 - Washcoating process
 - Optimized packaging.



Integrated knowhow Substrate/Coating&Canning



SUBSTRATES

- Variety of Metallic Substrates with own design and production
- Ceramic substrates of other suppliers
- Together with chemical know-how, substrate design is optimised .

CHEMICAL COATING

- Selection from wide coating portfolio, tailored for application needs ON METALLIC AND CERAMIC
- Together with substrate know-how, coating formula is optimised for Euro 4/Euro 5 as required.
- *Coating for Gasoline, Diesel, CNG and Bi-fuel ,SCR and DPF applications. Washcoats produced locally .*

CANNING

- Cost efficient, done in a single location locally

MAIN BENEFITS

1. Development Speed
2. Flexibility in Applications
3. Integrated Know-How
4. Cost Reduction
5. Ready solution for customers' needs
6. For customer projects we can fix easily:
 - Size of the substrate or
 - coating/loading or
 - Canning

Ecocat Substrates for various applications

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Straight Channel Substrates : OFC/Brazed/Ceramic



- Brazed substrates for two wheeler applications
- OFC Straight channel substrates for CNG/Diesel
- Thin walls and high CPSI ; Customised in size and shape
- Ceramic substrates outsourced from suppliers

Turbulent flow EcoCat(DOC)



- Turbulent flow Metallic with Optimal durability by mechanical locking .
- Good fluid dynamics , improved heat and mass transfer
- Easy integration into exhaust systems and customised in size and shape.

POC X / L / F open filter)



- Maintenance free solution for efficient particulate emission reduction up to 70%
- As coated, enables a continuous regeneration of the product and a longer life length
- Low back pressure required compared to other filtering solutions

DPF (Full filter)



- Outsourced from suppliers
- Effective Coating for better regeneration and avoiding blocking risk while reducing the backpressure

EcoXcell(Mixer substrate)



- Excellent durability
- Improved flow distribution & efficiency due to mixing properties
- For NOx reduction (mainly for HD) in SCR-system

- **Three-way catalysts Metallic (Brazed/OFC) /Ceramic**
- **Diesel oxidation catalysts (OFC/Ecocat D/Ceramic)**
- **Catalyzed partial filters (Metallic POC)**
- **Coated DPF**
- **CNG catalysts (Ceramic/Metallic OFC)**
- **Urea hydrolysis catalysts (Metallic EcoXcell)**
- **Vanadia based SCR catalysts (Ceramic/Metallic)**
- **Ammonia slip catalysts (Ceramic/Metallic)**

Nox is controlled in the engine and the balance CO / HC / Particulate emissions can be controlled thru following technologies

Diesel oxidation catalyst (DOC)

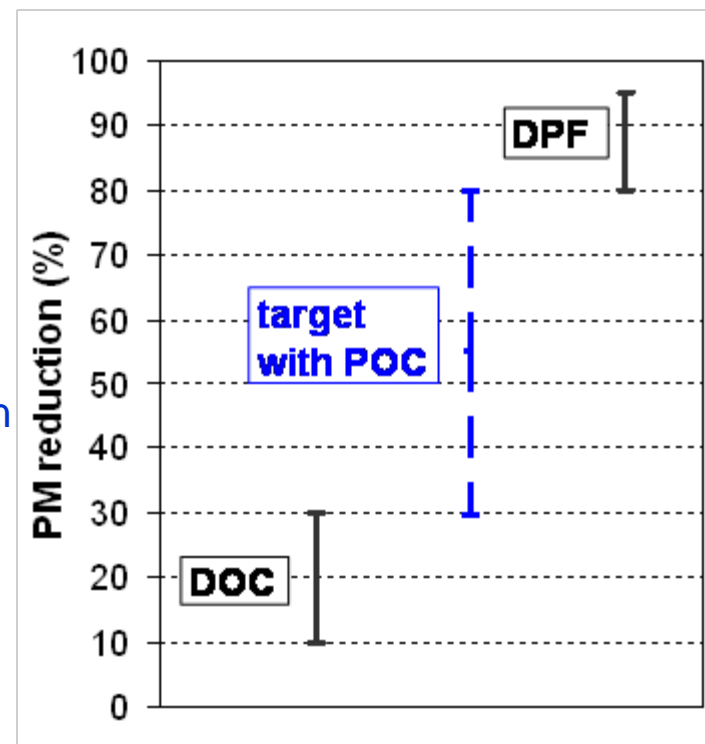
effective reduction of HC and CO
some reduction of PM (reduction of VOF)
typical PM reduction 10-30%

Particle oxidation catalyst (POC)

first target: to increase particle deposition in oxidation catalyst without significant back pressure increase. Can reduce PM upto 75%.

Diesel particulate filter (DPF)

effective reduction of PM (soot)
typical PM reduction 80-95%
regeneration of filter needed (to avoid back pressure increase, blocking risk)



Use for EuroV and EuroVI

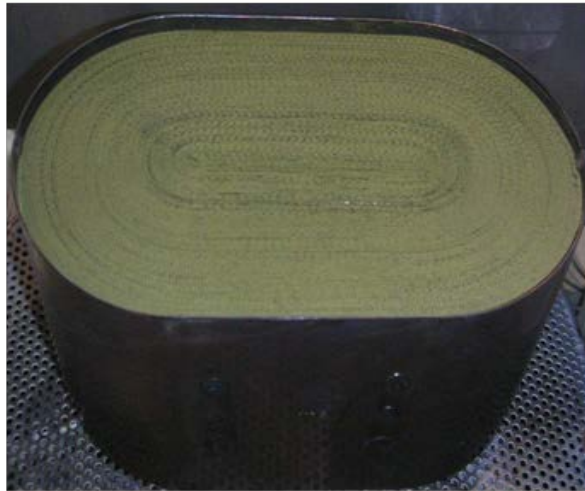


- To be used together with pre-oxidation catalyst (DOC).
- Provides >85 % particulate matter removal.
- Requires active regeneration system, based on electrical heating, fuel injection, something else.
- Coating on pores by sol-gel coating and process to provide longer regeneration interval and lower regeneration temperature.
- Pt added as active material on coating.

SCR based solutions for Euro V / VI

(Nox reduction 50 ~ 95 %)

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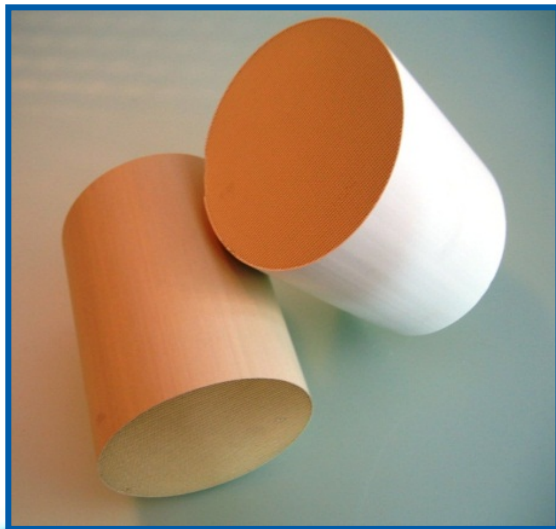
SCR systems

Urea Hydrolyser

V-SCR catalyst

ASC catalyst

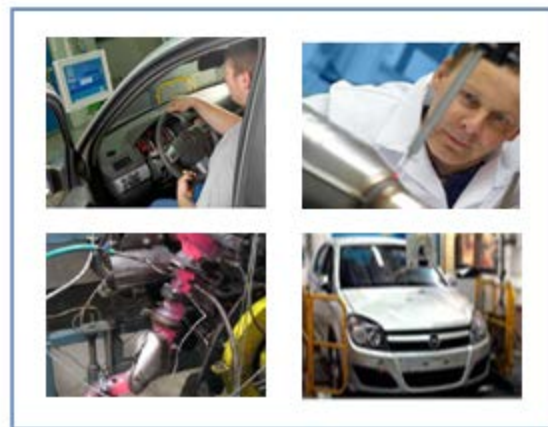
dosing units and control



SCR catalysts with Special coatings either metallic (round, rectangular & race track) or ceramic substrates with different geometries .

Combined Chemical and Mechanical Know-how

- Research and development efforts are focused on metallic substrate based catalyst technology in three main skill areas:
 - Metallic substrates (3 D , CFD , FEM)
 - Chemistry (PGM,Washcoat,Emissions)
 - Coating technology (Process,Quality,Reliability)
- Own R&D labs and external emission laboratories support the application engineering and long term development.
- Long term development co-operation with external high technology organisations and chemical manufacturers.



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To develop optimized after-treatment devices for diesel fuelled vehicles to consequently reduce pollution in the indian cities :

- Application of new catalyst technologies to achieve better vehicular emissions (Euro V/VI). Sufficient time to be provided.
- Provide 10ppm S Euro V/VI fuel .
- Improved durability (temperature and poisons):
- Molecular scale modifications.Nanotechnology (PGM support interactions)
- Real driving conditions in Indian big cities vs. the European CVS cycles used for homologations. What is the real benefit to reducing the pollution level in the city?
- Cost efficiency : Value benefit of the vehicle cost increase to be evaluated .



REAL-WORLD EXHAUST EMISSIONS FROM MODERN DIESEL CARS

A META-ANALYSIS OF PEMS EMISSIONS DATA FROM EU (EURO 6)
AND US (TIER 2 BIN 5/ULEV II) DIESEL PASSENGER CARS.

PART 1: AGGREGATED RESULTS

AUTHORS: Vicente Franco, Francisco Posada Sánchez, John German, and Peter Mock

EXECUTIVE SUMMARY

This report presents the general assessment of the on-road emission behavior of several different modern diesel passenger cars tested in Europe and in the US using portable emissions measurement systems (PEMS). The level of detail of the analysis and the large number of vehicles (15) and trips covered in the assessment (97, for a total of more than 140 hours and 6,400 kilometers driven) make this the most comprehensive report on the on-road behavior of the latest generation of diesel passenger cars published to date.

The data for US vehicles come from a measurement campaign sponsored by the ICCT (and whose results were previously reported in Thompson, Carder, Besch, Thiruvengadam, & Kappana, 2014). The European vehicle data were generously provided by third parties, all but one of which are stakeholders in the European Commission's working group in charge of amending the Euro 6 regulations to include real-driving emissions testing as a part of the type-approval process of light-duty vehicles in the EU, the Real Driving Emissions of Light-Duty Vehicles (RDE-LDV) group.

The main findings of the assessment are consistent with the existing body of evidence indicating that modern diesel passenger cars have low on-road emissions of carbon monoxide (CO) and total hydrocarbons (THC), but an unsatisfactory real-world emission profile of nitrogen oxides (NO_x). Particulate matter (PM) and particle number (PN) measurements were absent from most of the datasets and are therefore excluded from this report.

This report presents strong evidence of a real-world NO_x compliance issue for recent-technology diesel passenger cars, both for the EU and US test vehicles. The high temporal and spatial resolution of PEMS datasets was used to link the elevated NO_x mass emission rates to the driving conditions that cause them. It was found that a sizeable share of NO_x emissions over individual test trips (typically lasting about one hour) were concentrated over a number of discrete emission spikes spanning a few seconds. These emission events, which varied in frequency from vehicle to vehicle, could not be attributed to “extreme” or “untypical” driving in most cases. Instead, they were due to transient increases in engine load that constitute real-world driving (e.g., uphill driving, acceleration on a ramp, or positive accelerations from a standstill), or to regeneration events that are part of the normal operation of diesel exhaust aftertreatment systems.

The average, on-road emission levels of NO_x were estimated at 7 times the certified emission limit for Euro 6 vehicles. There were, however, some remarkable differences among the performance of all the vehicles tested, with a few vehicles performing substantially better than the others (Figure 1). *This supports the notion that the technologies for “real-world clean” diesels (i.e., vehicles whose average emission levels lie below Euro 6 emission limits under real-world driving) already exist.* Policies are needed to ensure that manufacturers will use these technologies and calibrate them to effectively control emissions over the large majority of in-use operating conditions, not just those covered by the test cycle.

REAL-WORLD EXHAUST EMISSIONS FROM MODERN DIESEL CARS

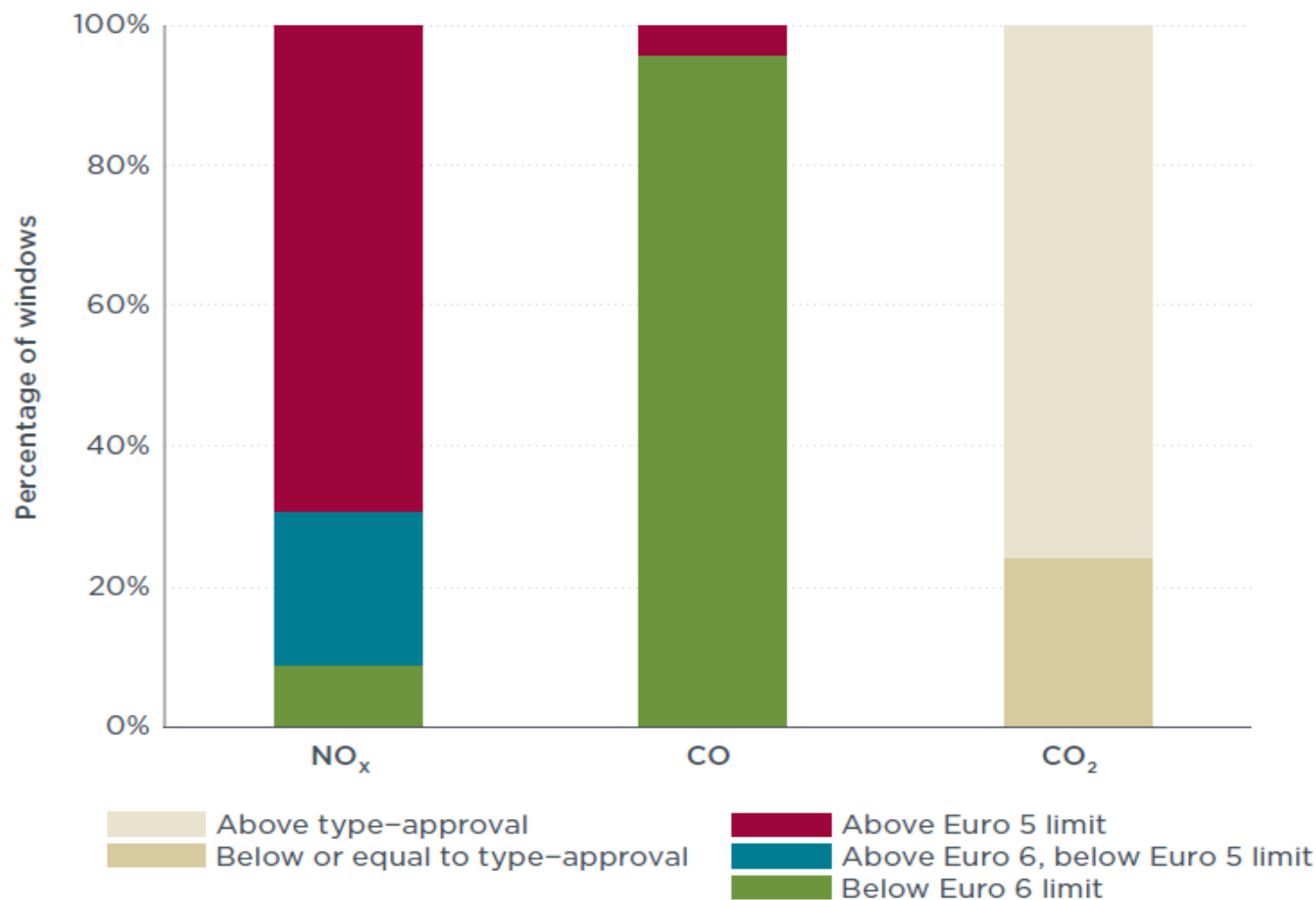


Figure 11: Evaluation of windowed emissions against Euro 5/6 emission limits and type-approval CO₂ values (all windows)

6 CONCLUSIONS AND RECOMMENDATIONS

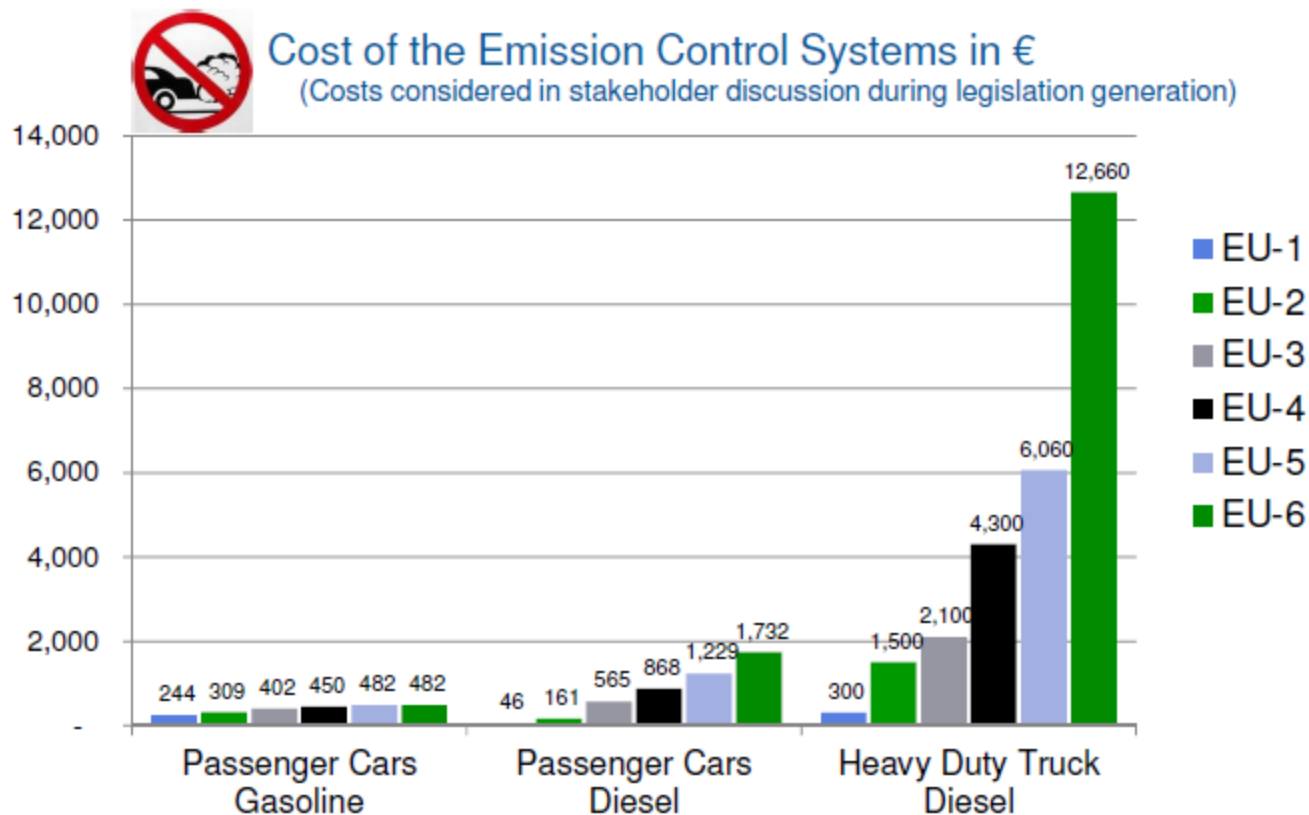
In this report we have presented our PEMS meta-analysis of modern diesel passenger cars, for which we assembled a large dataset of measured on-road emissions and applied a consistent framework for the analysis and reporting of the results. Thanks to the generous contribution of third parties, which is gratefully acknowledged, the broad experimental basis of our assessment gives us a good level of confidence in the results and encourages us to share our thoughts with the regulatory and scientific community.

The average on-road emissions of CO and THC remained consistently low for all the vehicles under test. This otherwise praiseworthy behavior was overshadowed by a generalized unsatisfactory emission profile of NO_x. High NO_x emissions were observed across vehicles, regions (US and EU), manufacturers, and aftertreatment technologies. They were heavily present not just in the more demanding driving situations (e.g., uphill driving, instances of high acceleration*velocity), but also during the situations that would in principle be most favorable to achieve low NO_x emissions. This points to the application of NO_x control strategies that are optimized for the current type-approval test procedures (on the chassis dynamometer laboratory, using a standard test cycle), but are not robust enough to yield acceptable on-road performance. This engineering approach, albeit legal in the current regulatory context, entails a risk for manufacturers that are heavily invested in diesel technology, because it can steer environmentally conscious customers away from their offerings. Ultimately, it is also unlikely to be sustainable after PEMS testing is introduced for the type-approval of passenger cars in the EU in 2017.

4. Diesel After-treatment Technologies

ISSUES

Low emissions are not for free



Source: The Global Market for Motor Vehicle Pollution Controls, 2011, Michael P. Walsh
AVL Emission Test Systems, K. Engeljehring

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- Technologies are available to achieve the Euro V /VI standards .
- Euro V/VI 10 ppm S fuel will be need for the new technologies .
- Time to develop the upgraded version of vehicles/engines for EuroV/VI to be carefully considered .
- Indian norms will need to be evolved for single/two cylinder engines which are unique to India for application in Threewheelers/LTV's .
- Actual Indian local driving patterns and road conditions need to be reviewed when the optimal after-treatment devices are validated to benefit real pollution levels in the Indian cities .
- Ecocat India has all the capabilities for after-treatment device manufacturing under the same roof, thus making it a one-stop-solution provider for after-treatment devices.

THANKS

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