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Implementation and Challenges of RDE with BSVI Norms - 2020

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- Introduction
- RDE PN testing results at EU (Diesel and Gasoline)
- RDE challenges in India
- Summary

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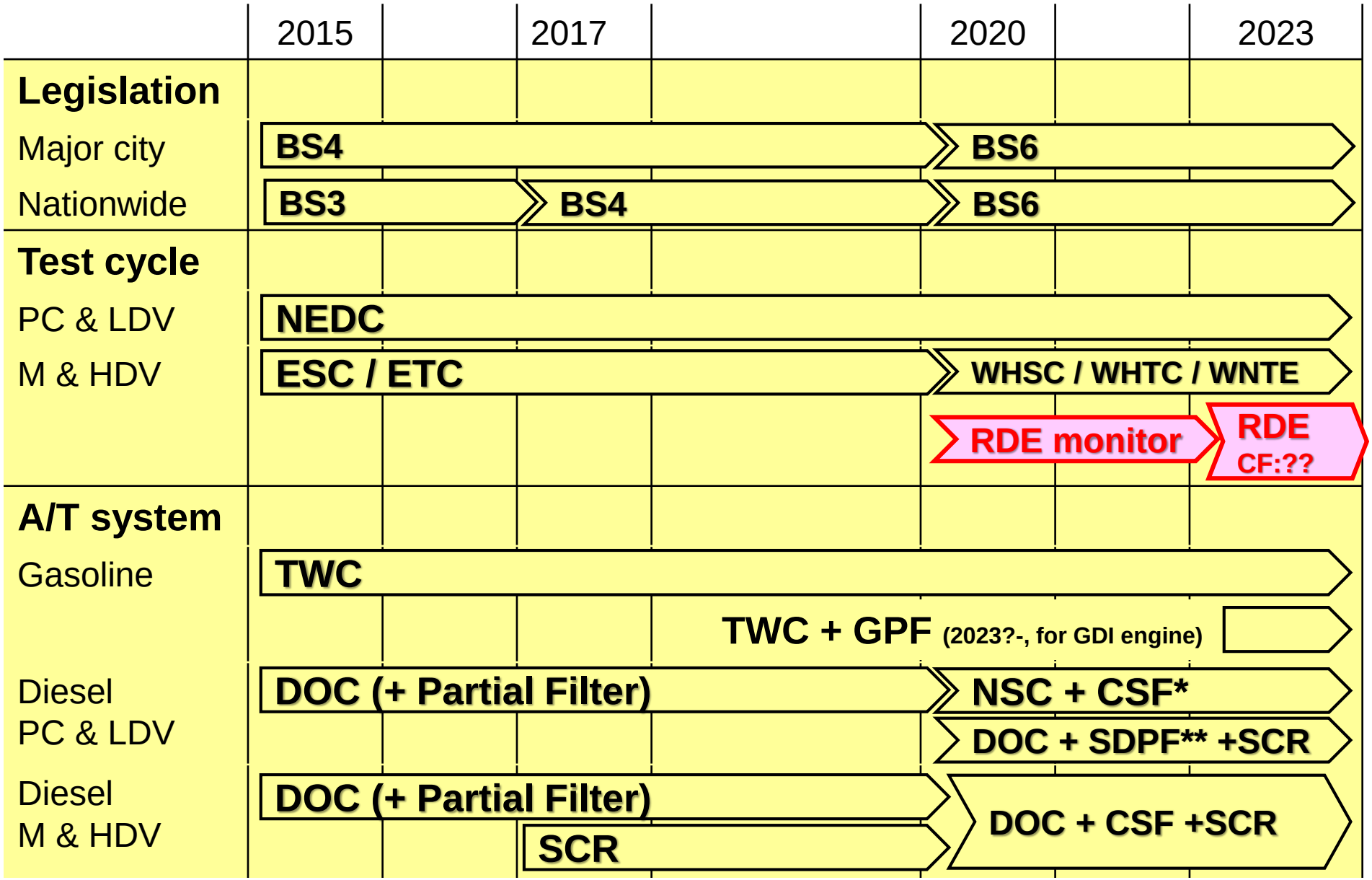
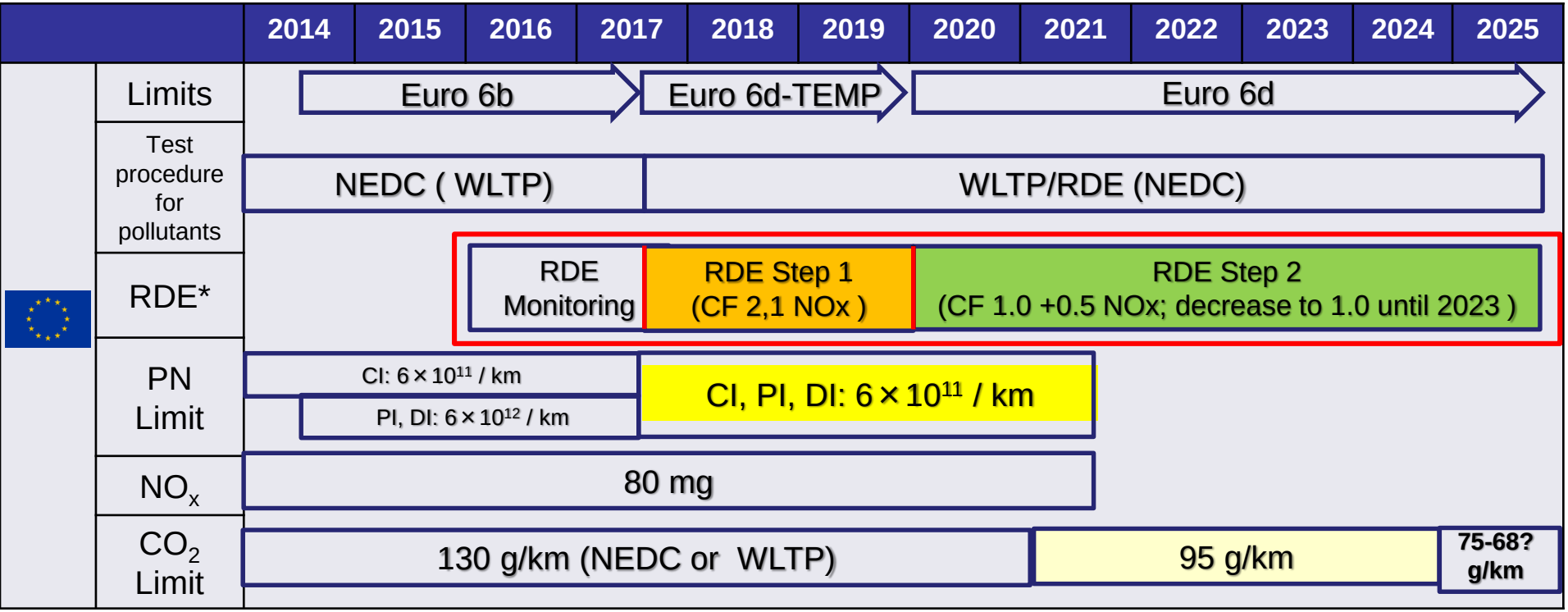
Legislation & After treatment system estimation in India



* Catalyzed Soot Filter ** SCR on DPF

RDE information in EU (for PC & LDV)



RDE monitor → from 2016
RDE Step 1 (CF:2.1) → from Sept. 2017
RDE Step 2 (CF:1 + 0.5) → from 2020
RDE Step 2 (CF:1) → from 2023

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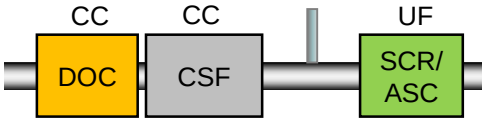
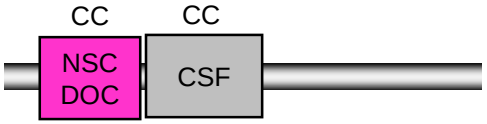
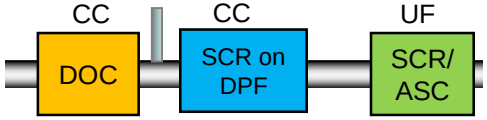
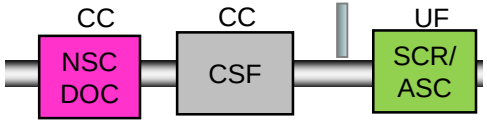
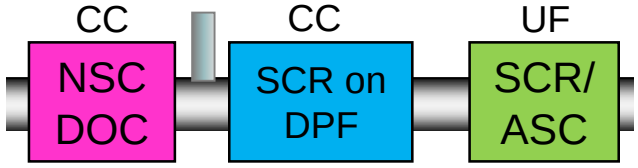
EU after treatment system trend for diesel PC & LDV

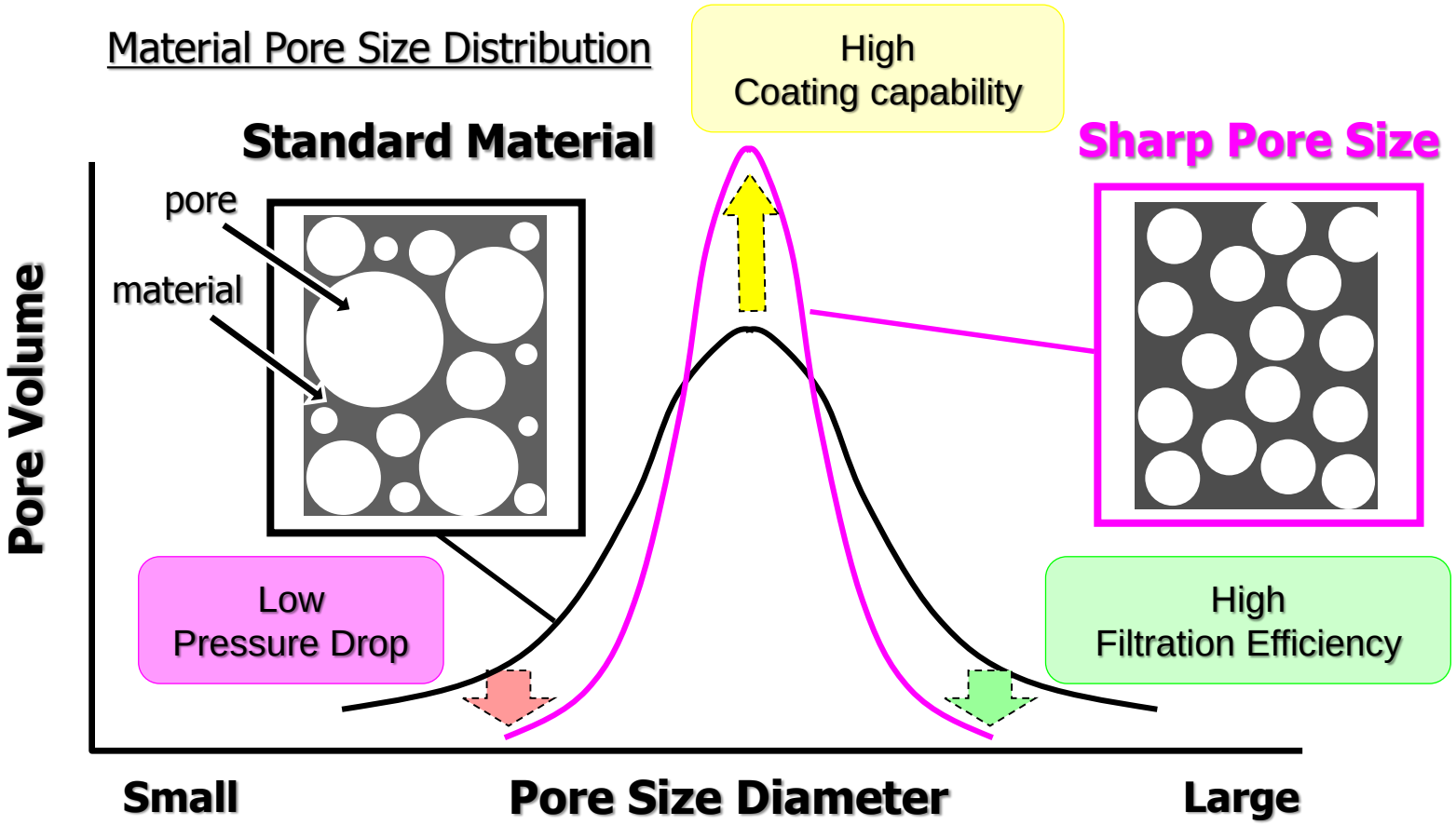
	Emission Control Systems	
	CSF system	SCR on DPF system
Serial DeNOx System (EU6b)	DOC + CSF + SCR  NSC + CSF  	DOC + SCR on DPF + SCR 
RDE/EU6d DeNOx Systems	NSC + CSF + SCR  	NSC + SCR on DPF + SCR 

Major system

One of key technology for diesel after treatment for future tighter regulation is SCR on DPF

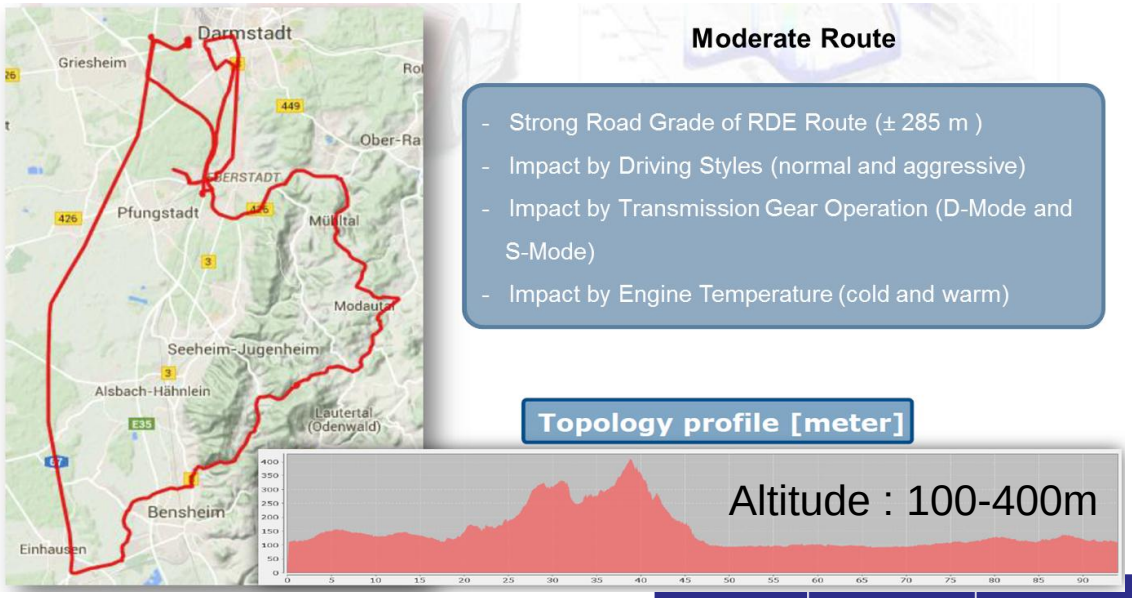
DPF material for SCR on DPF / Design concept

SiC-DPF with High Porosity (HP) + Optimized Pore Distribution



To achieve market requirement, special material is considered for SCR on DPF

RDE testing – Comparison of different driving styles



Vehicle information

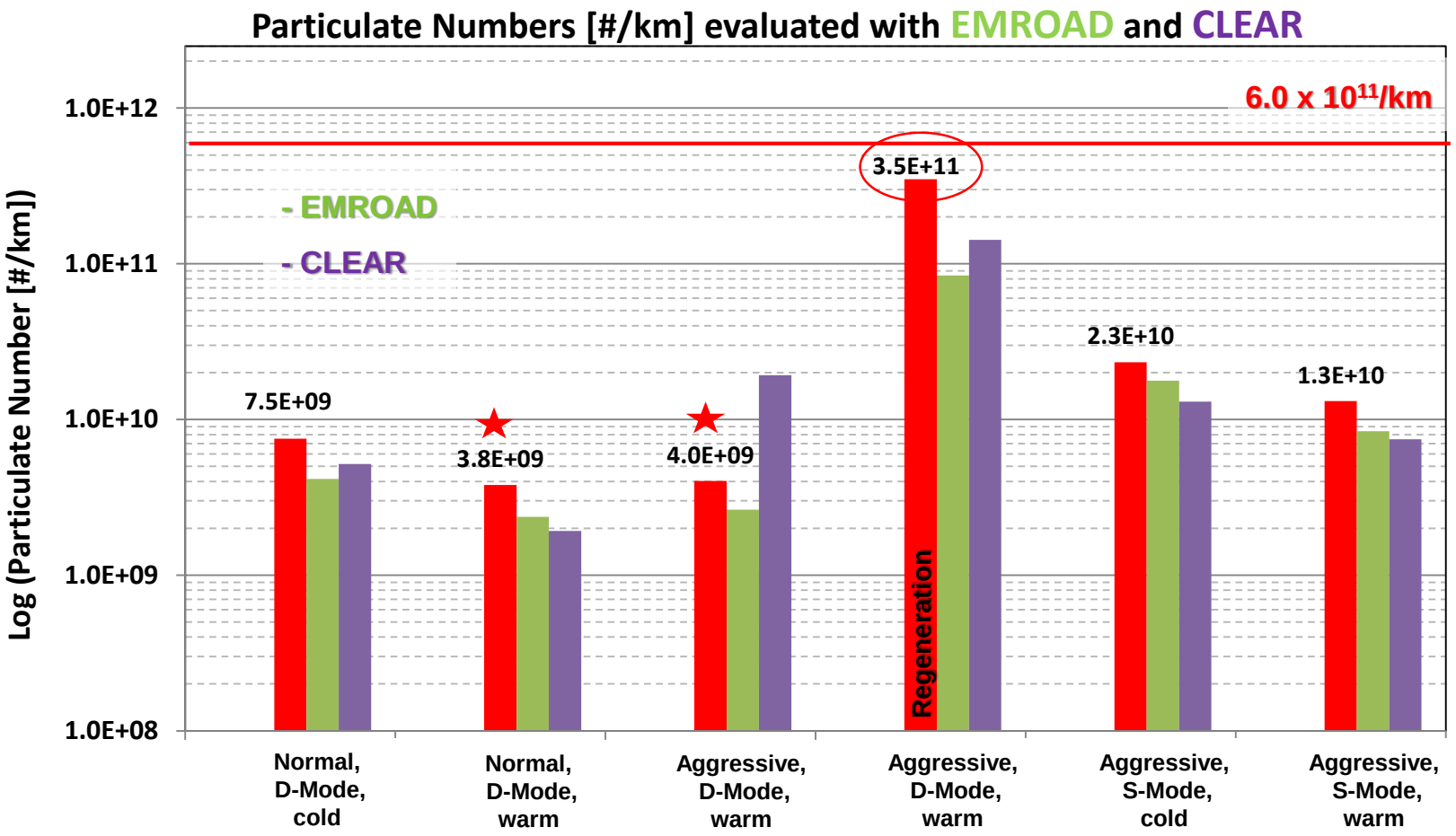
Diesel Turbo Direct Injection;
4cyl. 2,0 l
EU6
Automatic Transmission

Emission Control System

SCR on DPF system
(High Porosity DPF)

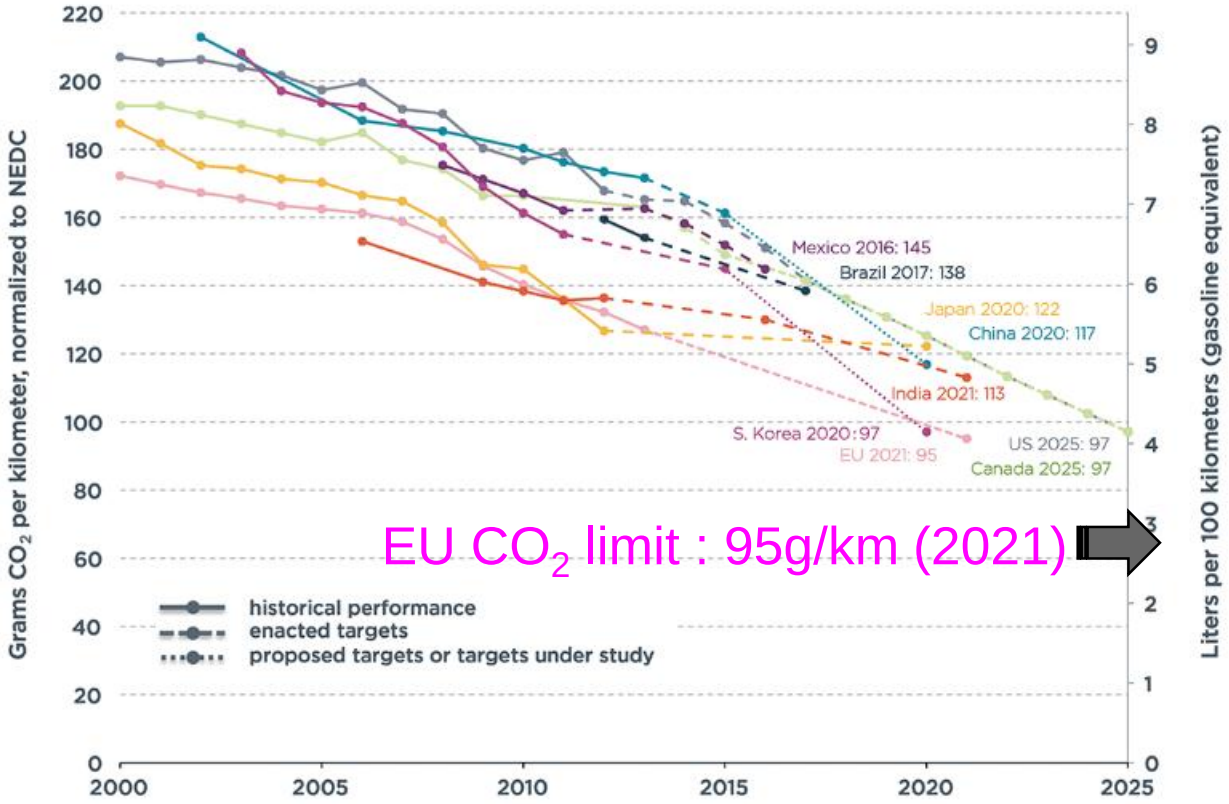
RDE-Test	Route	Driving style	Transmission Gear Operation	Engine condition (coolant Temp. °C)	Min. Outside temperature [°C]	Distance [km]
RDE#1	Moderate	normal	D-Mode (economic)	cold (< 30 °C)	3	98 km
RDE#2*	Moderate	normal	D-Mode (economic)	warm (> 55 °C)	-1	98 km
RDE#3*	Moderate	Aggressive (more dynamic)	D-Mode (economic)	warm (> 55 °C)	-1	98 km
RDE#4	Moderate	Aggressive (more dynamic)	D-Mode (economic)	warm (> 55 °C)	5	97 km
RDE#5	Moderate	Aggressive (more dynamic)	S-Mode (Sport Mode)	cold (< 30 °C)	5	97 km
RDE#6	Moderate	Aggressive (more dynamic)	S-Mode (Sport Mode)	warm (> 55 °C)	6	97 km

RDE testing – Evaluation of RDE data with EMROAD and CLEAR



High Porosity SiC DPF fulfills requirements for PN emissions in RDE.
Even by having an active DPF regeneration during Testing RDE limit can be achieved

EU after treatment system trend for gasoline PC



Source: http://www.theicct.org/blogs/staff/improving-conversions-between-passenger-vehicle-efficiency-standards

Gasoline DI engines (GDI)

to reduce CO_2 emissions

→ Further market share increase

GDI engine tend to

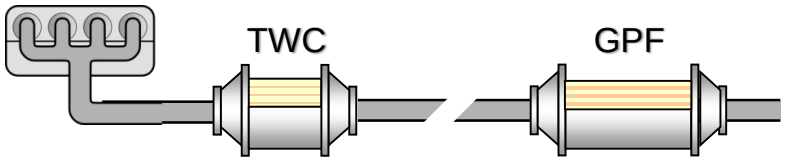
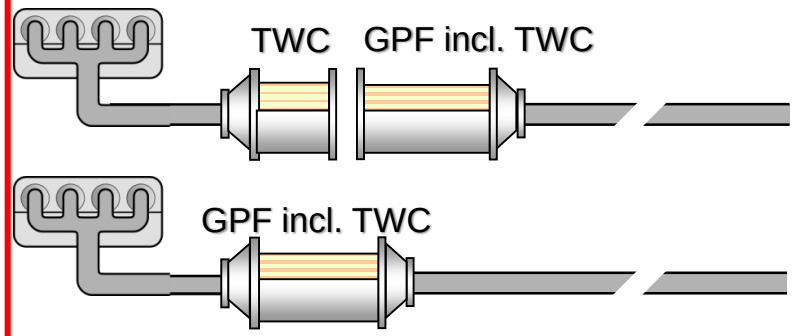
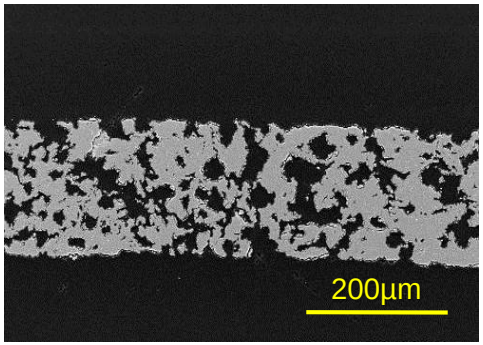
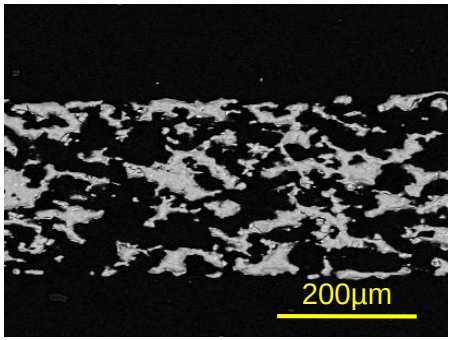
high PN emission

Higher engine load driving cycles /

RDE higher PN emission ?

One of key technology for gasoline after treatment in EU is GPF

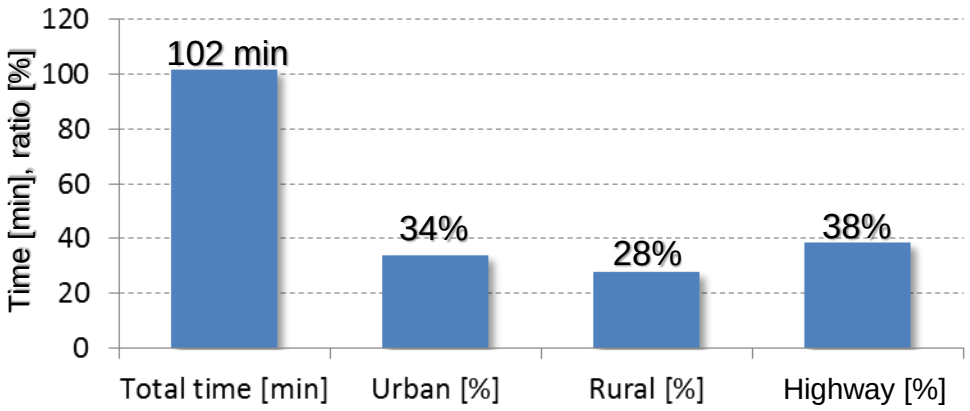
Material lineup for Non catalyzed and catalyzed type GPFs

Material	Cordierite Gasoline Particulate Filter	
Porosity	**45 - 55 %**	**60 - 65 %**
System Layout Example		
Micro Structure [SEM]		
Wall Thickness / Cell Density	**5 - 8 mil / 200 - 400 cpsi**	**8 - 12 mil / 300 cpsi**
Application	**Non catalyzed GPF**	**Catalyzed GPF**

Tested system

GPF Real driving emission evaluation – Driving route

Driving route (in Germany)

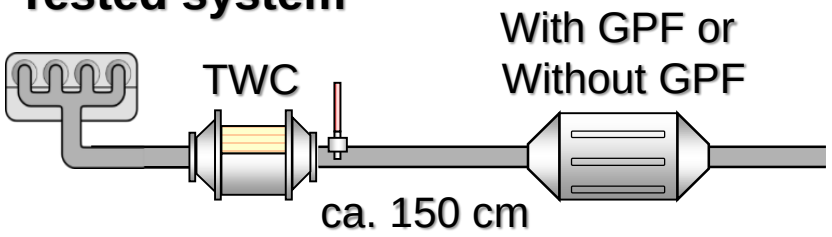


Vehicle information

Gasoline Direct Injection λ = 1 ;
4cyl 1,8 l direct + port fuel injection
Close Coupled TWC
EU5
Manual Transmission

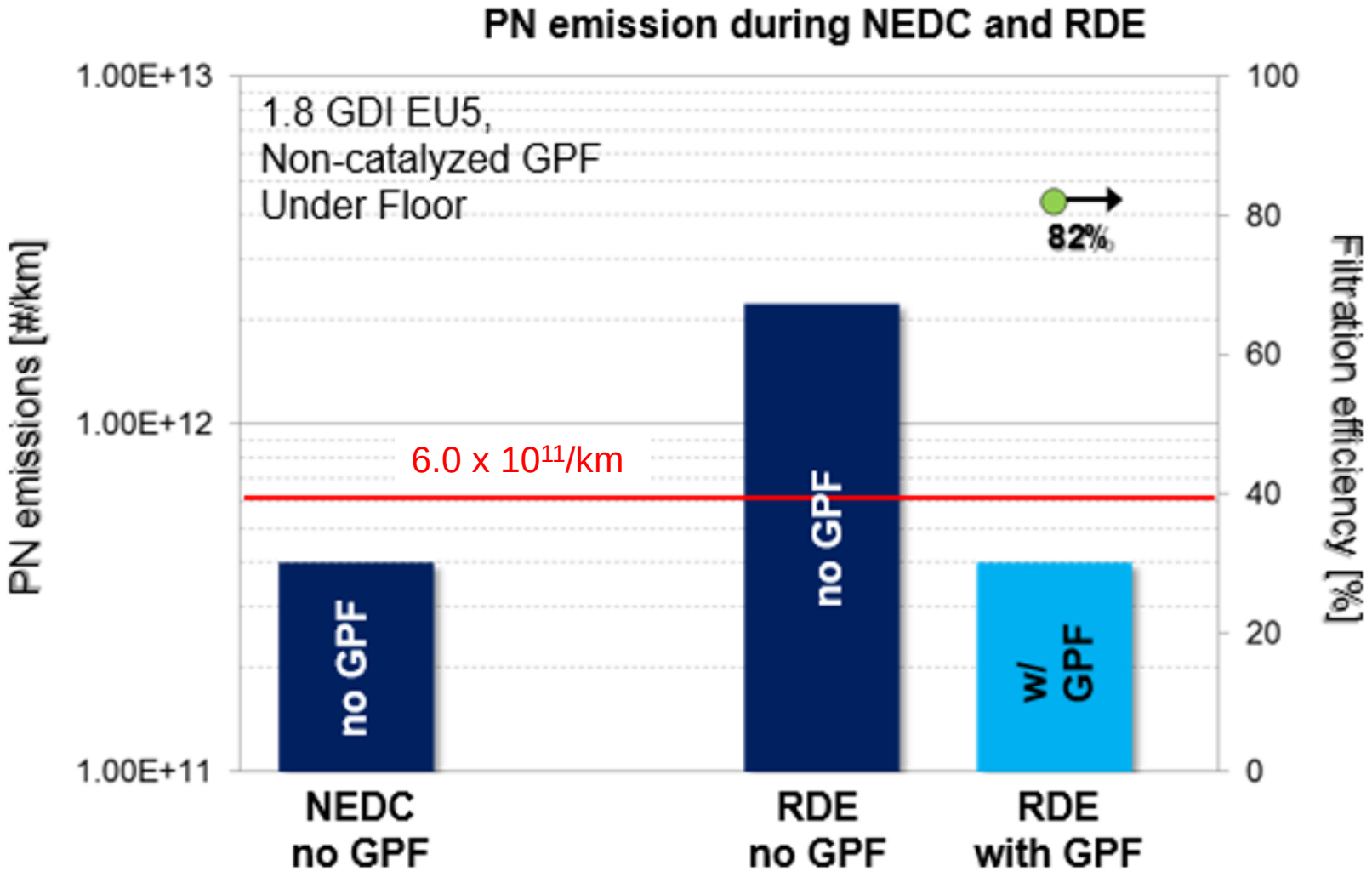
PN PEMS

Tested system



Non catalyzed type GPF was installed and RDE PN emission was measured by PEMS

GPF Real driving emission evaluation – PN emission results



Test vehicle GDI without GPF exceed RDE PN limit
GPF shows high filtration efficiency under RDE condition

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How is the Indian RDE driving cycle?

Heavy traffic

Non-paved road

Highly dynamic driving

Comparison of India City Driving vs NEDC*

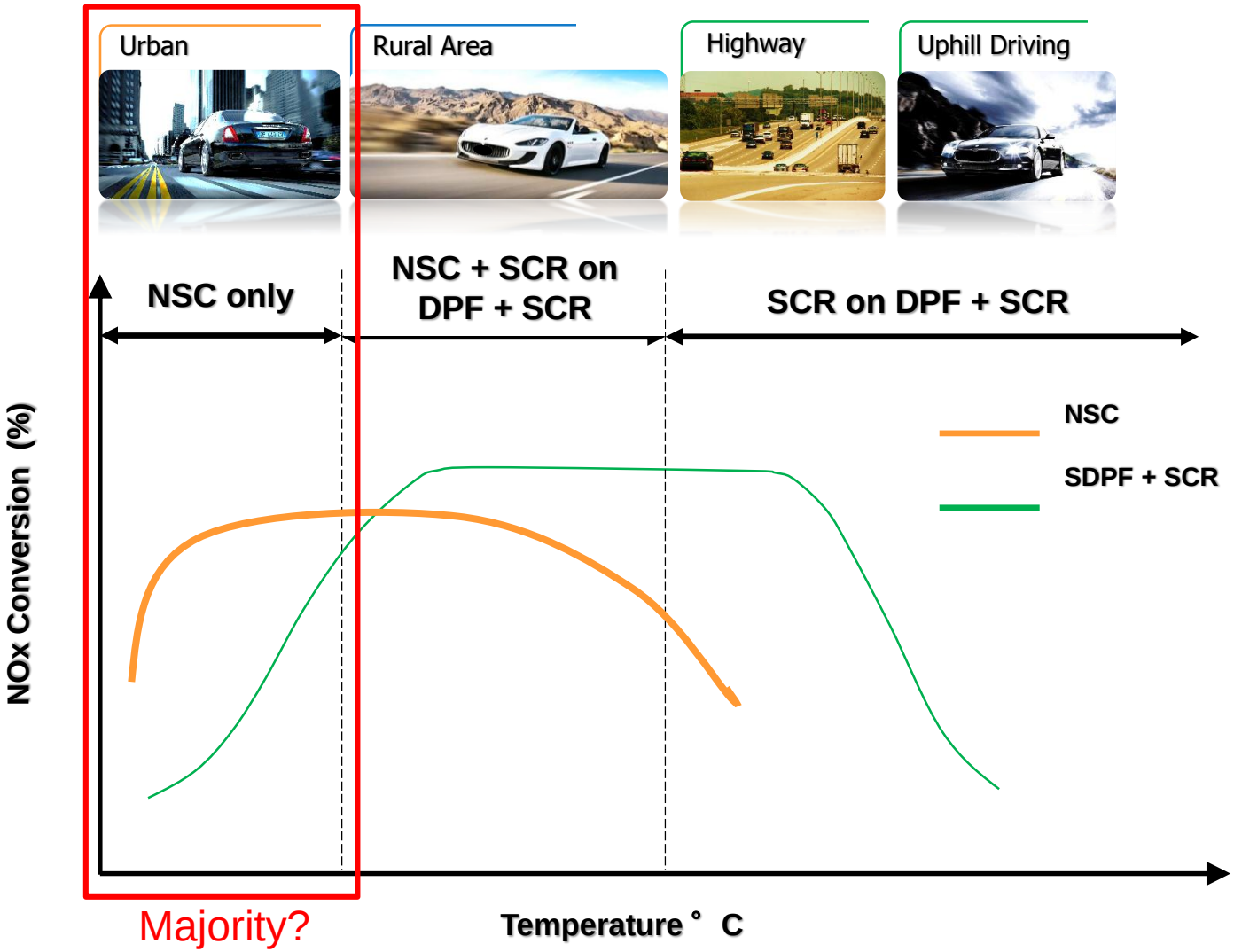
	NEDC	Pune City	Impact
% <10km/hr	0%	**32%**	Low temperature gas
Ave. Accel. m/s^2	0.5	**3.7**	High Torque, RPM = High Soot
Average Speed	33.4	**19.6**	Low temperature gas

**: Case Study by Central Institute of Road Transport Pune, India*

Compare to EU, Indian RDE could be focused on low speed zone?

Low speed driving impact for after treatment system

Diesel PC & LDV case



NSC contribution is higher than EU?

RDE Challenges in India

Challenges for Emission

Comparing EU RDE to Indian RDE:

- NOx

→ Requirement for NSC could be higher

→ Due to complicated system, cooperation of engine operation and after treatment technology is necessary

Challenges for Implementation of RDE

- How to decide RDE driving cycle

→ Large variation of driving

→ Driving ratio of Urban : Rural : Highway = ? : ? : ?

- Tighter CF may come in effect (ex. 1.5?)

→ Start from tighter level

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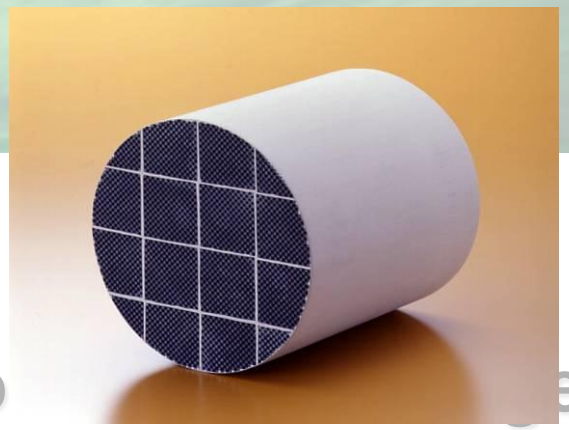
Summary

- *In case of EU, filter technology (SCR on DPF, GPF) has possibility to meet RDE PN limit*

- *In case of RDE in India, DeNOx system could be complicated hence optimized engine operation and emission control systems are necessary*
  → OEM and supplier cooperation is required

Thank you for your attention!

DIESEL PARTICULATE FILTER



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