Challenges and Strategies for BS7 compliance: Addressing NOx, N_2O and NH_3 Emission Challenges

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Agenda

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Euro 7: What's New?

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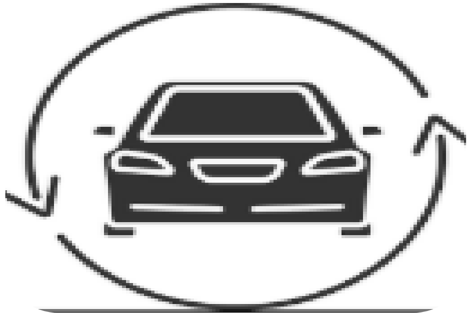
Fuel neutral emission limits

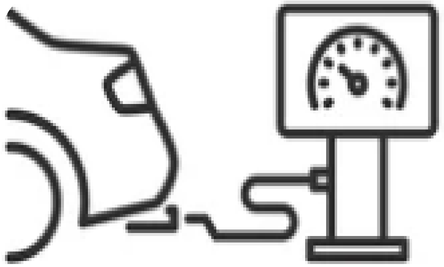


Compliance with emission rules for longer period

Broader range of driving conditions in on road tests

Digital monitoring of compliance

Regulating additional pollutants



More stringent emission tests

Limits for emission from brakes

Rules on micro plastic emission from tyres

Key Aspects: Emission Control

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Key Aspects

Additional pollutants added.

1. Achieving tradeoff between NOx, N_2O and NH_3 a key challenge
2. NMOG and CH4 added as new pollutants

Emission Durability

1. Main lifetime 7L kms. or 12 years
2. Additional lifetime 8.75L kms. or 15 years

Particulate number

1. Particle size to be measured reduced from 23nm to 10nm

RDE/ PEMS

1. Payload 50%→10-100%
2. Power Window 10%→6%
3. Cold Start included

Overview Emission Limits: Euro 7

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Same Limits for Steady State and Transient Cycles

Pollutant	Units	Euro7 Limits	BS6/Euro6 Limits		Remarks
		WHTC and WHSC	WHTC	WHSC	
NOx	mg/kWh	200	460	400	
PN	# x 10^{11}	6 (10nm)	6 (23nm)	8(23nm)	Particle size changed
PM	mg/kWh	8	10	10	
NH_3	ppm	-	10	10	
	mg/kWh	60	-	-	Mass Based
N_2O	mg/kWh	200	-	-	Newly added
CH_4	mg/kWh	500	-	-	Newly added
CO	mg/kWh	1500	4000	4000	
NMOG	mg/kWh	80	NA	NA	Newly added
THC	mg/kWh	-	160	130	Removed
HCHO	mg/kWh	-	-	-	To be reviewed

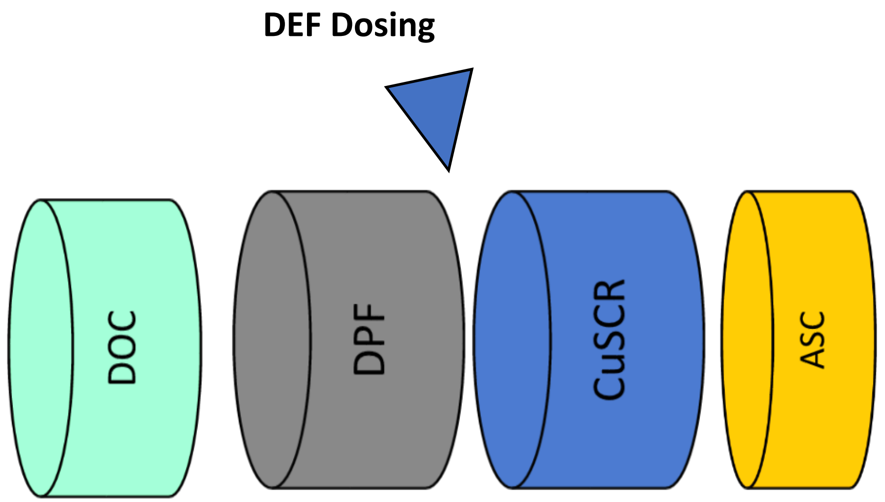
RDE

- **Payload 50% → 10%-100%**
- **Power Window 10%→6%**

Pollutant	Units	Euro7 Limits	BS6/Euro 6 Limits	Remarks
NOx	mg/kWh	260	CF of 1.5 for NOx, CO and THC	
PN	# x 10^{11}	9(10nm)		Newly Added
PM	mg/kWh	-		
NH_3	ppm	85		Newly added
N_2O	mg/kWh	260		Newly added
CH_4	mg/kWh	650		Newly added
CO	mg/kWh	1950		
NMOG	mg/kWh	105		Newly added
THC	mg/kWh	-		Removed
HCHO	mg/kWh	-		To be reviewed

Experiments with Single Dosing set up

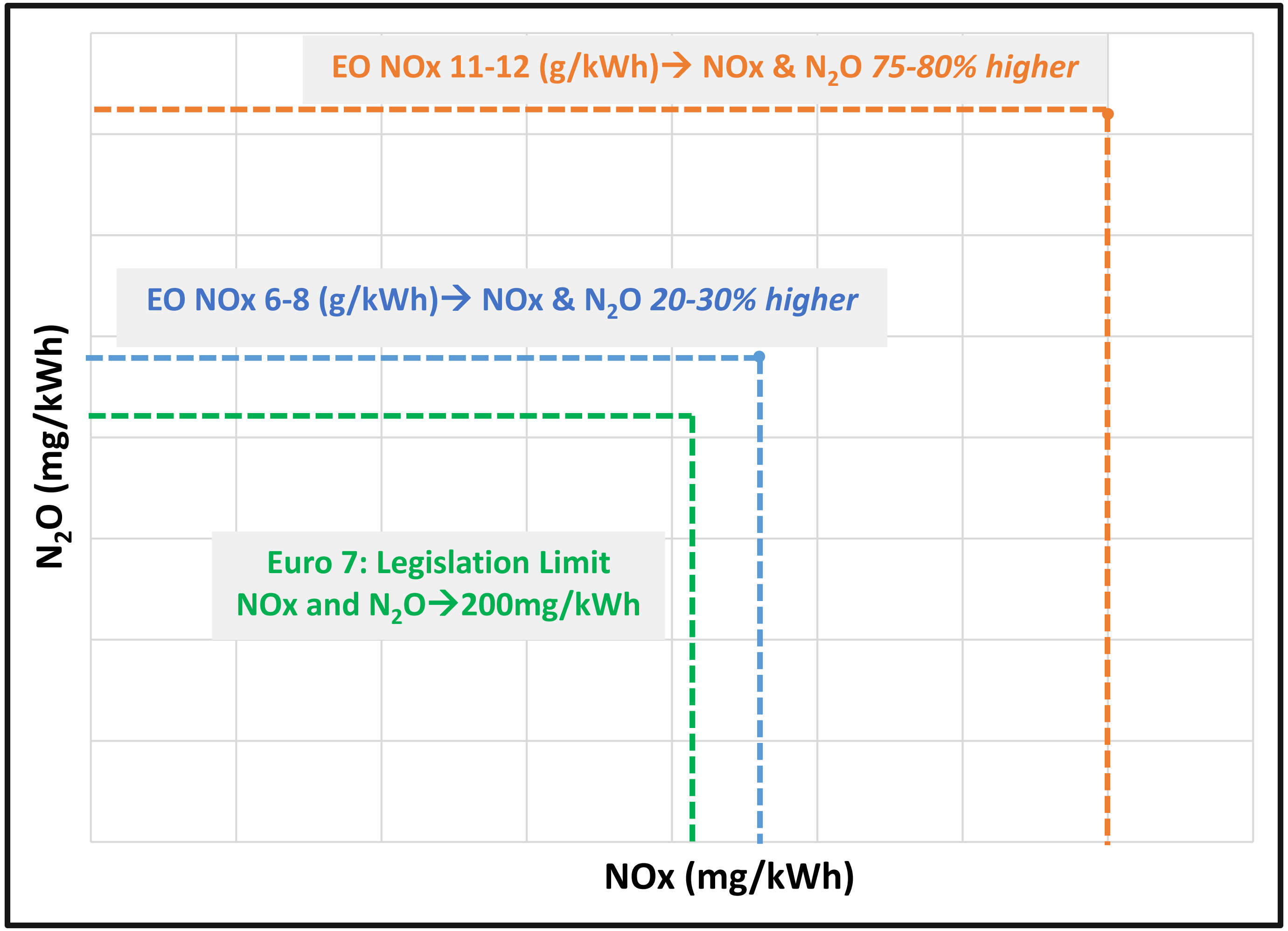
- **EATS configuration(BS6 Formulation)**



- EO NOx at 6–8 g/kWh: Results close to Euro 7 limits; further NOx/N_2O reduction needs system and thermal management changes

- Meeting engineering targets a further challenge.

- EO NOx at 11–12 g/kWh: Emissions significantly elevated, dual dosing or alternative strategies needed for compliance.

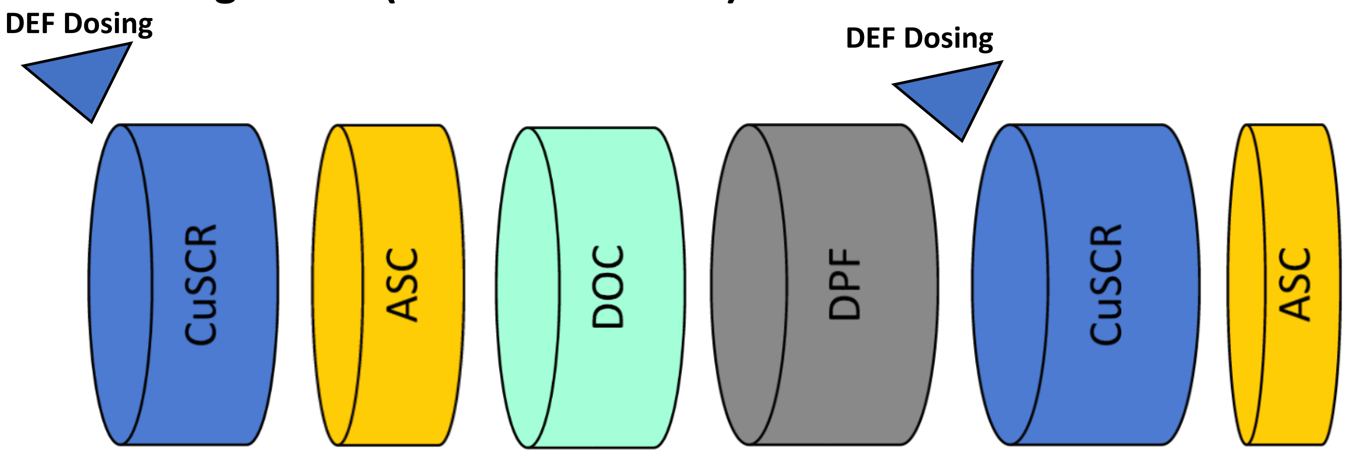


Probable Thermal Management Options

Feature	ETV + Heater	ITV + ETV	ITV + Heater
Packaging & Integration	Major Architectural Change • Adding a heater may call for a 48V architecture	Incremental Change • Modification in wiring harness required for adapting both.	Major Architectural Change • Adding a heater may call for a 48V architecture
WHTC Cold Start Performance	Best • Instant heater response+ Sustained heat from ETV	Weak • Relies solely on engine heat	Good • Excellent start from heater but weaker sustained heat from ITV
PEMS/ISC Compliance	Best • Robust and responsive to real world Conditions	• Challenging under Cold Start conditions	Good • Heater covers cold start, but lack of ETVs sustained heat.
Fuel Efficiency (BSFC)	Medium • Heater Electric load penalty	Medium-to-Poor • High fuel penalty from ITV+ETV • Frequent DPF regenerations	Medium • Heater Electric load penalty
Cost	• High cost for adding a heater	• Lowest	• High cost for adding a heater
Key Risk for Euro 7	• Lowest technical risk for compliance.	• Potential challenge in meeting cold-start PEMS targets	• Low technical risk for compliance.

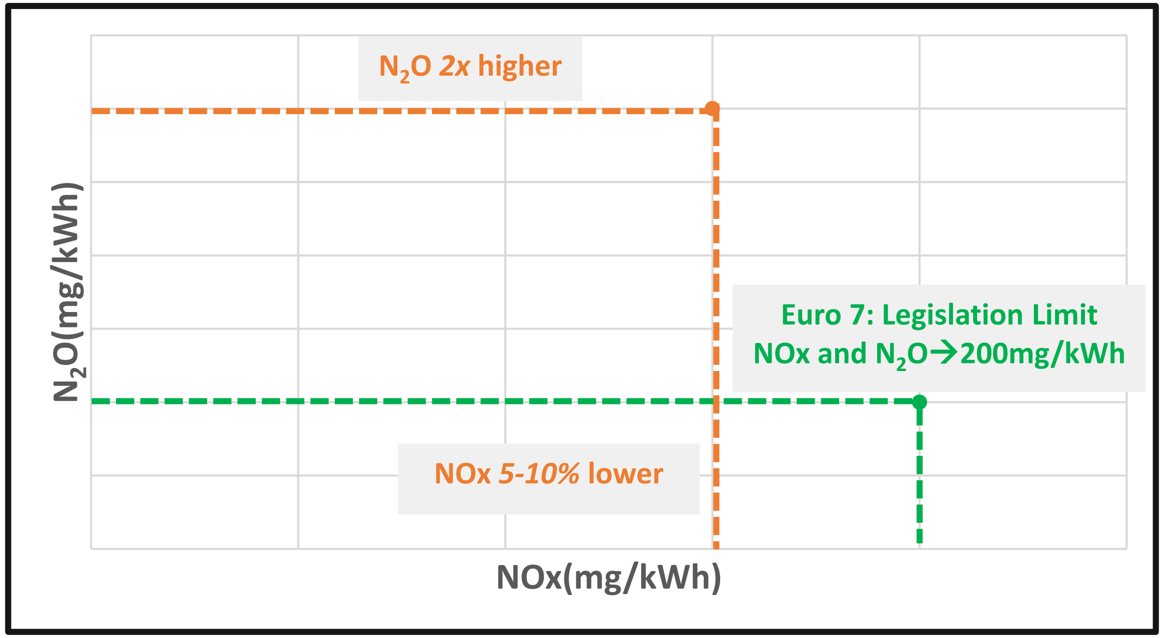
Experiments with Dual Dosing Set up

- **EATS configuration(BS6 Formulation)**



- Dual dosing with existing SCR formulations achieves Euro 7 NOx limit marginally.
- Euro 7 N_2O and NH_3 limits are not met, indicating the need of different SCR formulations for controlling N_2O alongside NOx.
- Higher volume ASC systems needed for NH_3 control.
- In addition to above points dosing strategies also need to be revisited

Trials Conducted with EO Nox Range 11-12g/kWh		
Dosing strategies for Euro 7	**ANR**	Pros • Good PN_{10} control as major urea injection before DPF Cons • Majority NOx gets consumed before DPF, affects DPF passive regeneration.
Upstream Doser	1.2 - 1.4	
Downstream Doser	0.5 - 0.7	
Upstream Doser	0.5 - 0.7	Pros • Passive Regeneration is not affected Cons • PN_{10} emissions can increase, major urea injection is after DPF
Downstream Doser	1.2 - 1.4	



Probable Layouts Based on EO NOx

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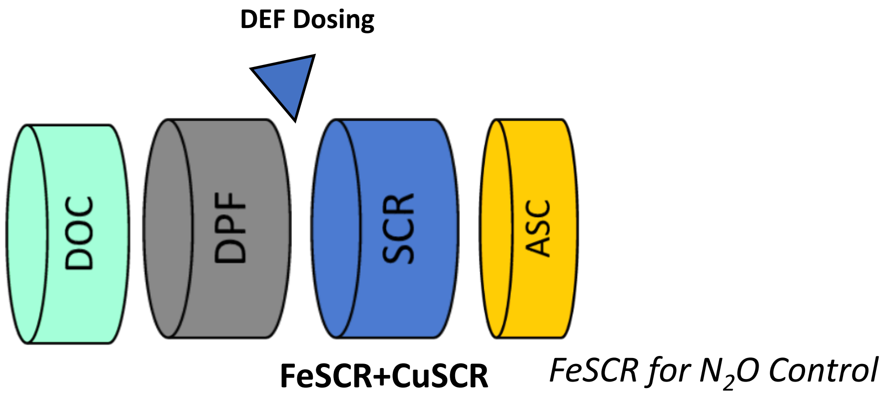
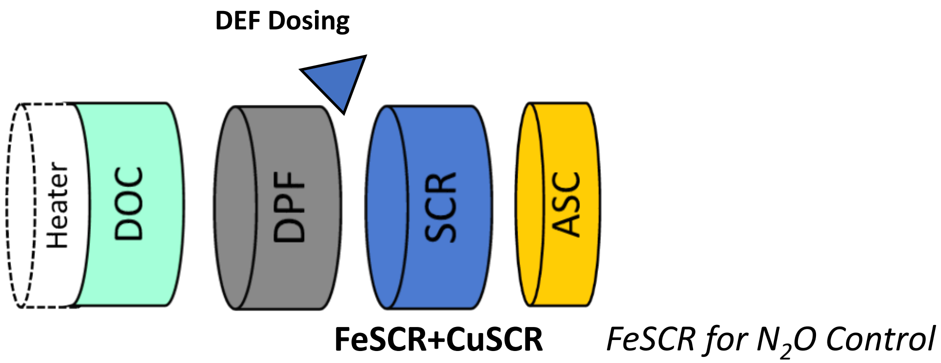
EO NOx < 8g/kWh→ Single Dosing Systems

- *Configuration 1 (ITV + ETV)*

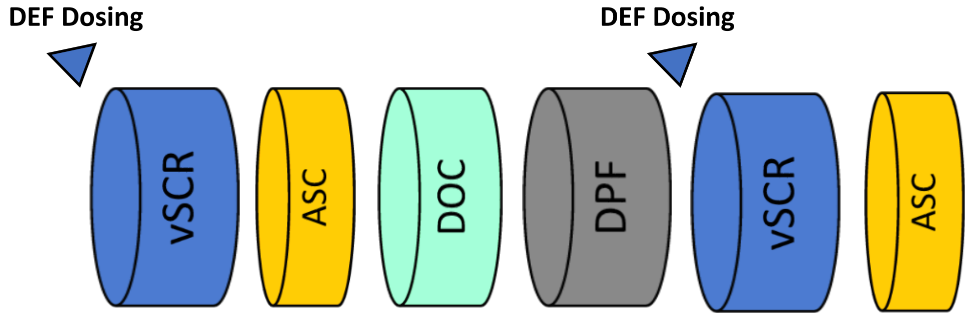


- *Configuration 2 (ETV/ITV + Heater)*



EO NOx > 11g/kWh→ Dual Dosing Systems

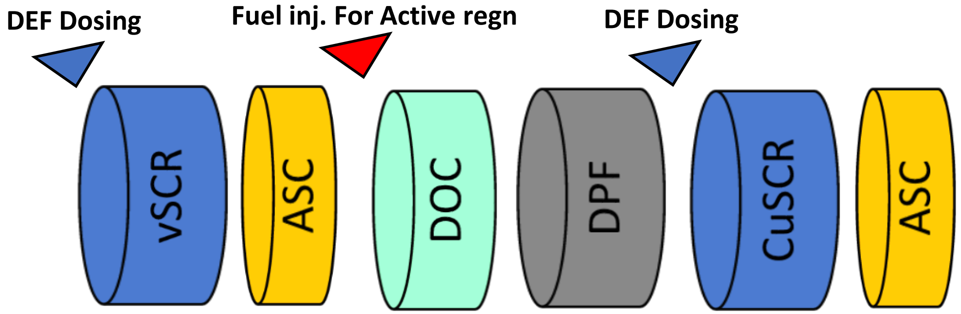
- *Configuration 3*



Passive regenerating System

Applicability in India ?

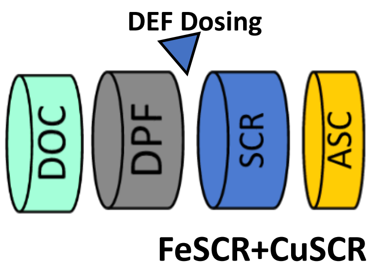
- *Configuration 4*



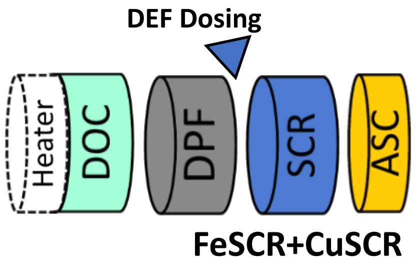
HC doser required for active regeneration, to avoid vSCR poisoning

Comparison of Probable Layouts

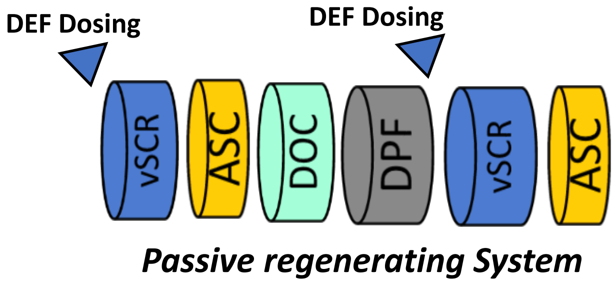
- ***Configuration 1***



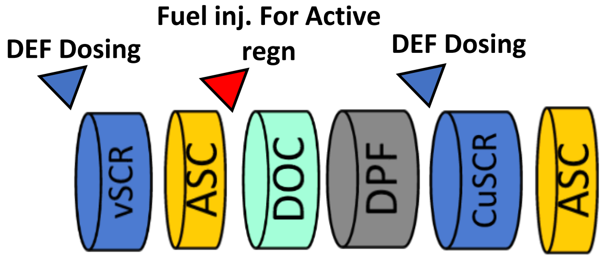
- ***Configuration 2***



- ***Configuration 3***



- ***Configuration 4***



	EO NOx < 8g/kWh		EO NOx > 11g/kWh	
	Configuration 1	Configuration 2	Configuration 3	Configuration 4
Cost	Low	High	Medium	High
Complexity	Low	High	Medium	High
Emission Robustness	Low	Medium	High	High
Calibration efforts	Low (Proven for BS6)	Medium	High	High
Urea Consumption	Low	Low	High	High
Packaging	Less efforts	Medium efforts	High efforts	High efforts

Comparison of Various SCR Catalyst formulations

Parameter	Cu-SCR	Fe-SCR	Vanadium-SCR
High-temp SCR performance	Medium	Good	Poor
Low-temp SCR performance	Good	Poor	Good
High-temp Durability	Good	Good	Poor
Sulphur Resistance	Poor	Moderate	High
Performance in low NO_2	High	Low	Medium
Performance in High NO_2	Medium	Medium	Low
N_2O Formation Risk	High	Low	Low
Toxicity Concern	None	None	Yes (Vanadium compounds)
Relative Cost	High (expensive)	Medium	Low (cheapest)

Thank You