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HDD aftertreatment design for BS7

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Outline of the Presentation

- Legislation – new pollutants
- Exhaust aftertreatment architecture
- Performance trends of different ATS architecture Engine test
  - Next Gen CuSCR Technology with better NOx and N_2O performance
  - Durable EFC technology for PN filtration
- Simulations Study
- Summary

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BS7 Emission limits | Expected to follow Euro7

Comparison of EUVI, Eu7 HD , NSVII

	Heavy Duty >3.5ton			
Emissions	**EUVI**	**EU7 HD / BSVII**	**EU7 RDE**	**NSVII ?**
NOx mg.kWh^{-1}	**460**	**200**	**260**	**140** ***460*** *Cold WHTC NOx*
PM mg.kWh^{-1}	**10**	**8**	**-**	**10**
PN #/km	**6x10^{11}** PN23	**6x10^{11}** PN10	**9x10^{11}** PN10	**6x10^{11}** PN10
CO mg.kWh-1	**4000**	**1500**	**1950**	**670**
NH_3 mg.kWh-1	**10** ppm Avg.	**60**	**85**	**65**
CH_4 mg.kWh-1		**500**	**650**	**400**
N_2O mg.kWh-1		**200**	**260**	**195**
Main lifetime km/yr	**700k / 7**	**700k / 12**		
Add. lifetime km/yr		**875k / 15**		

Emission limits are fuel neutral
BS7 & NSVII not decided

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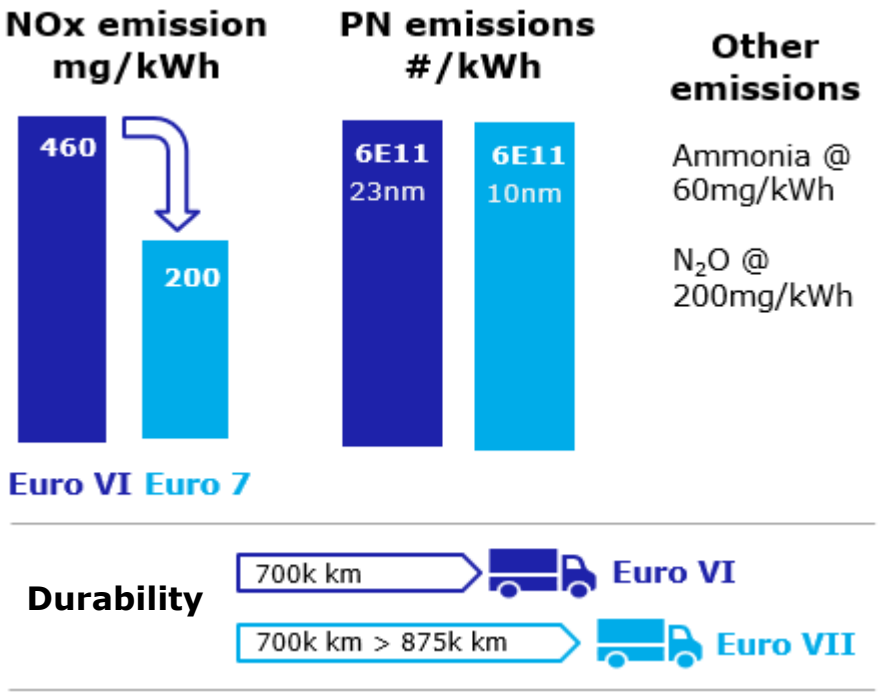
Eu7 HDD Emission limits and ATS architecture to meet

An optimised BS6.2 system can be the way forward for transitioning to an optimised BS7

Eu7 Emission limits



Dual Injection

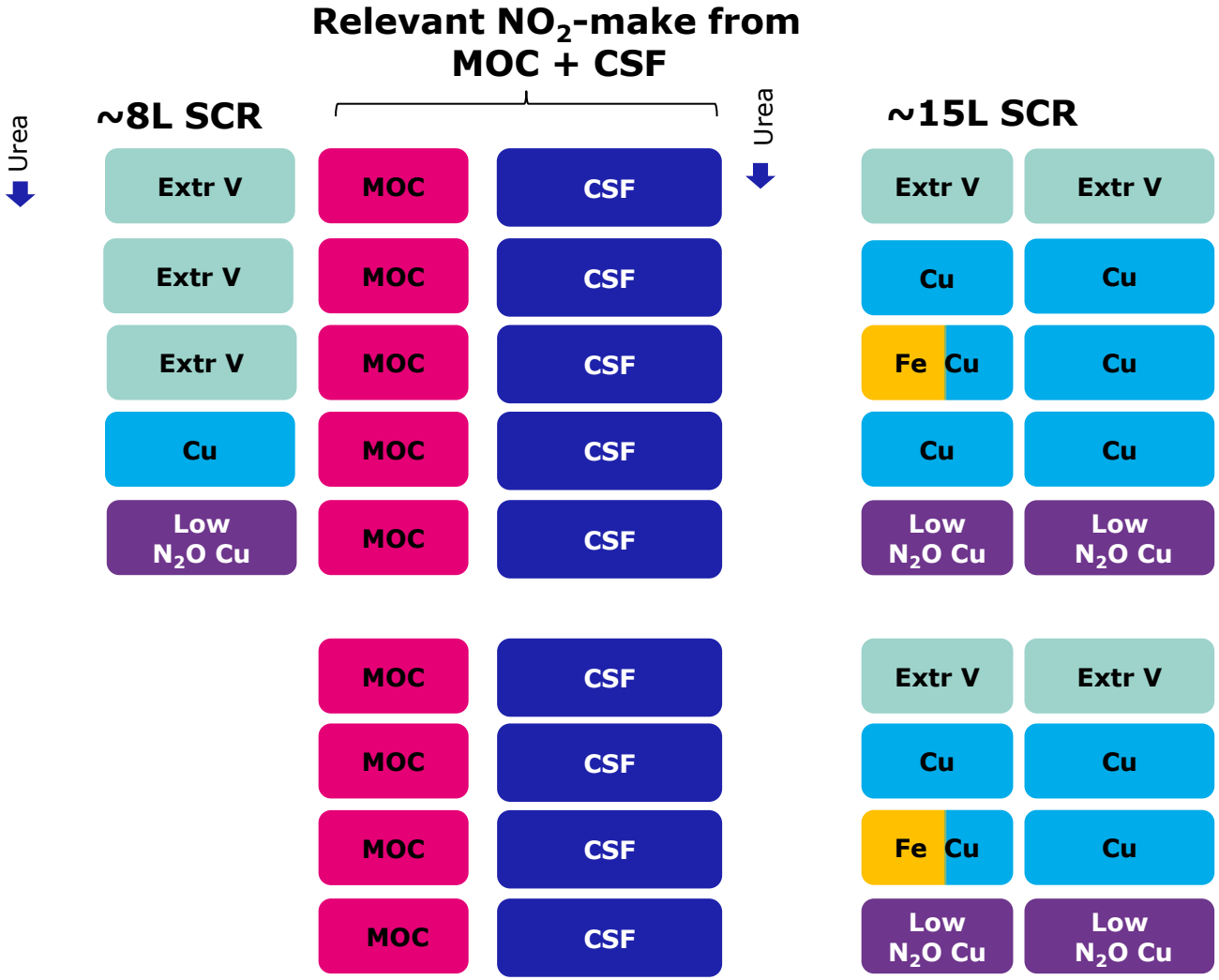
? SCRT®

Heating Element location?

- CSF - Enhanced Filtration Coating (EFC) for PN_{10}

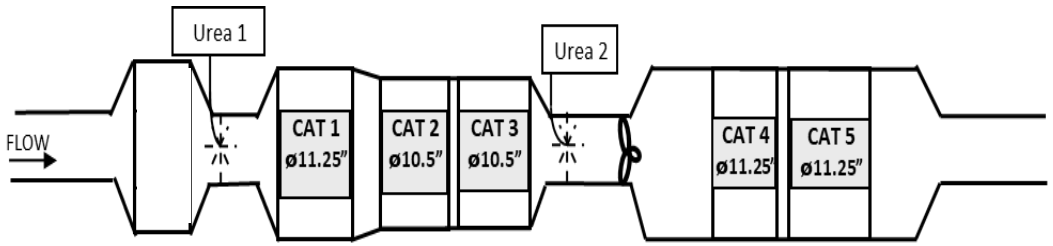
EATS Layouts Evaluation

Multiple combinations of SCR catalysts were assessed



Aged performance only
HT-ageing
All Cu- & Fe-based SCRs aged 650°C 100h
V-SCR aged 580°C 100h

MOC = multi-function Oxidation catalyst



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Testing and Setup

Using **7L engine EuV no EGR** in

Cold WHTC, 30 min

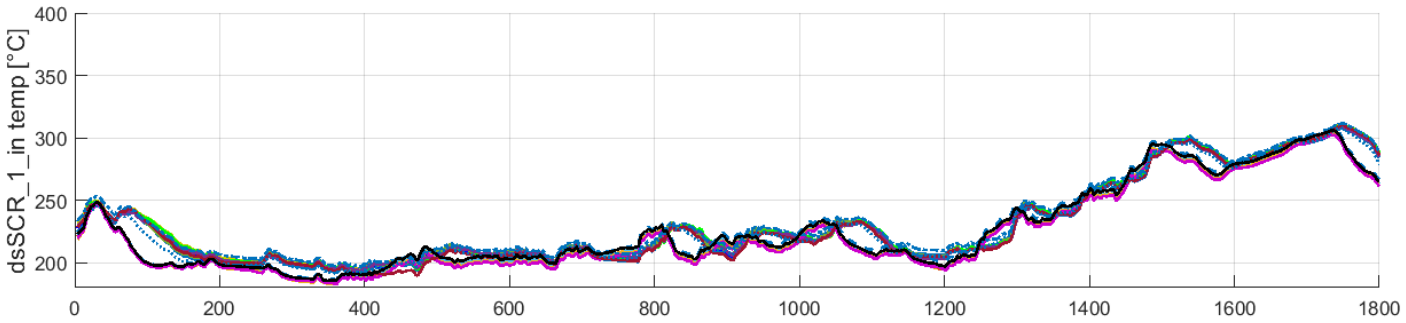
ccANR: 0.8 (0 for SCRTs)

rear ANRs: 1.2

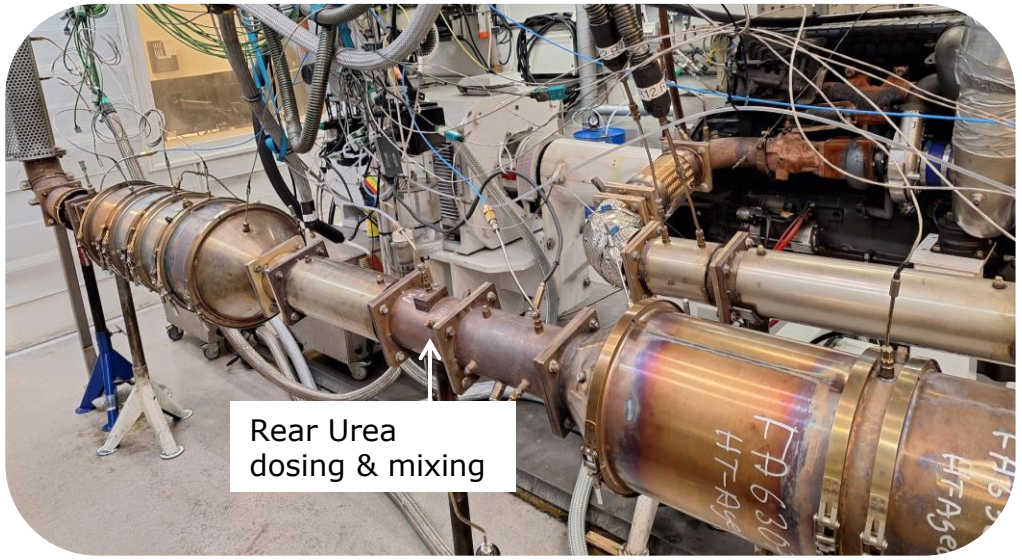
Warm WHTC cycles, 30 min 180-310°C (2 cycles at each ANR)

ccANR: **0.5** (0 for SCRTs)

rear ANRs: **1.1**, 1.2

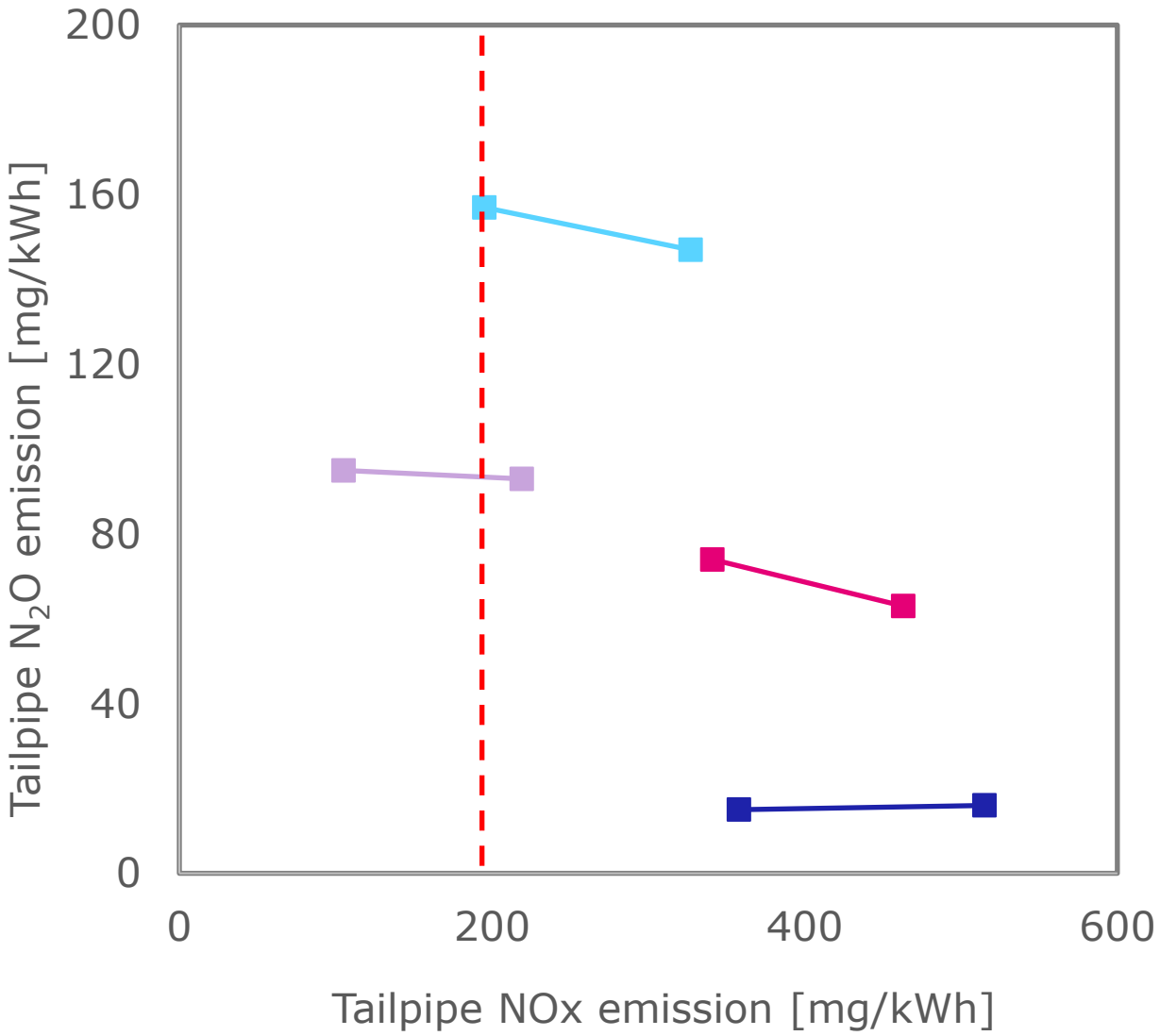


Cycle rear SCR-in temp range: 180-310°C
Engine-out NOx range: 0-1430 ppm, ~6.0 g/kWh



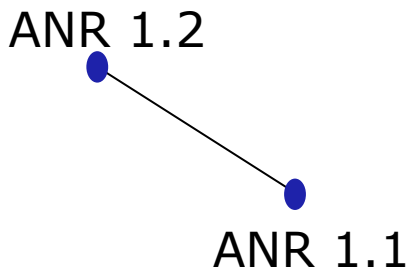
WHTC Hot cycle performance of SCRT® System

Low N_2O Cu-SCR achieves best NOx with acceptable N_2O level



SCRT systems

- **VSCR**
- **Fe/CuSCR**
- **CuSCR**
- **Low N2O CuSCR**



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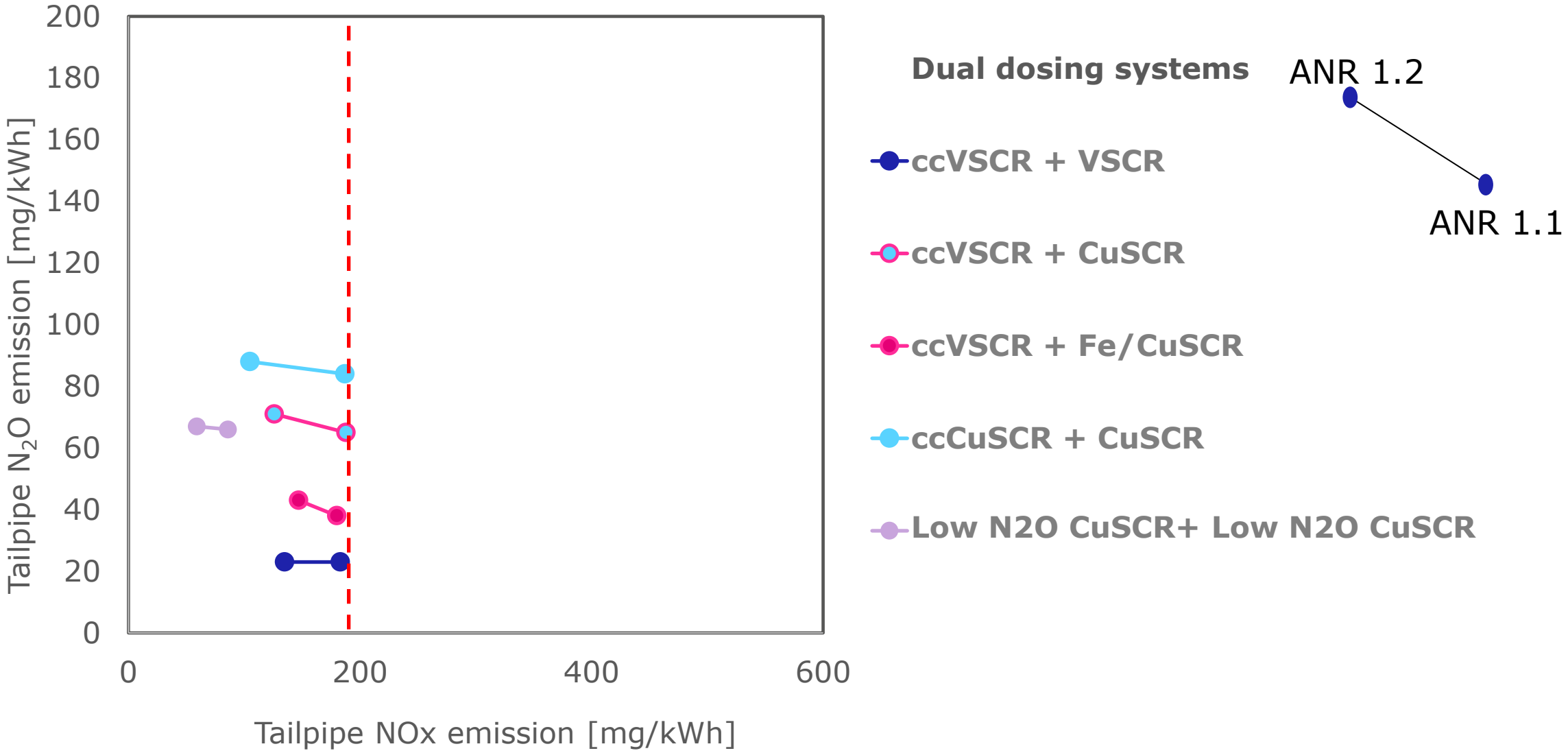
WHTC hot cycle performance of Dual Dosing System

Low N_2O Cu-SCR achieves best Nox, while VSCR shows best N_2O control



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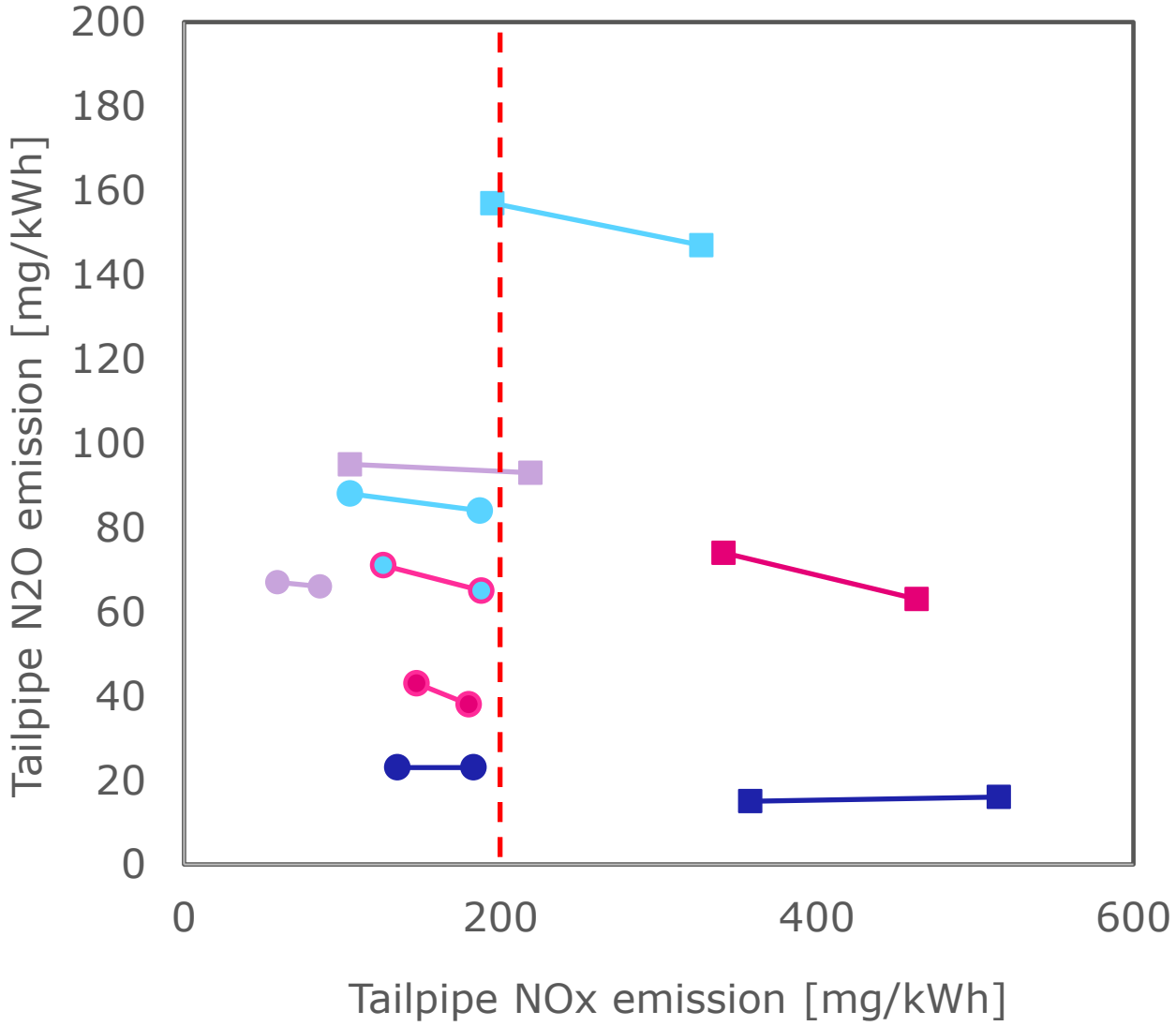
Dual Dosing system has better control over NOx and N_2O

Low N_2O Cu-SCR and VSCR show best NOx with N_2O control

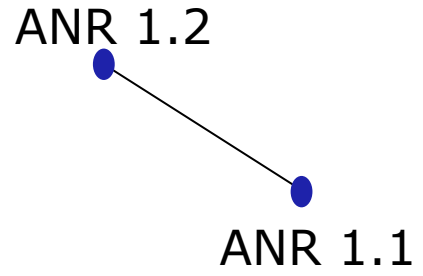


Dual dosing systems

- ccVSCR + VSCR
- ccVSCR + CuSCR
- ccVSCR + Fe/CuSCR
- ccCuSCR + CuSCR
- ccLow N2O CuSCR + Low N2O CuSCR

SCRT systems

- VSCR
- Fe/CuSCR
- CuSCR
- Low N2O CuSCR



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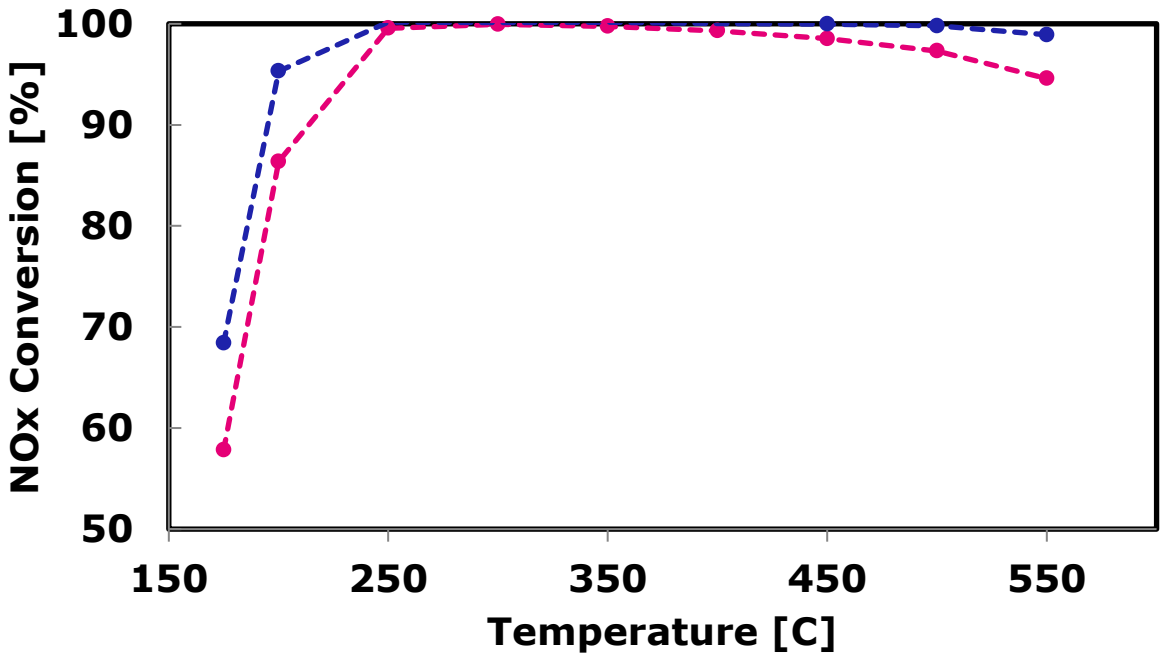
Better low and high temperature activity with advanced Cu-SCR Technology

BS6

BS7



NO = 1000ppm, α = 1.1, 60k SV
350ppm CO, 8% CO2, 10% O2, 5% H2O
650°C 50h HT aged

- 10% conversion improvement at 200°C
- BS7 SCR catalyst is suitable for SCRT® and Dual Injection formulation
- Exact formulation can also be tuned to suit the intended urea injection strategy
- For SCRT® configuration, it can be used with an Fe-SCR slice for N_2O control (if necessary)

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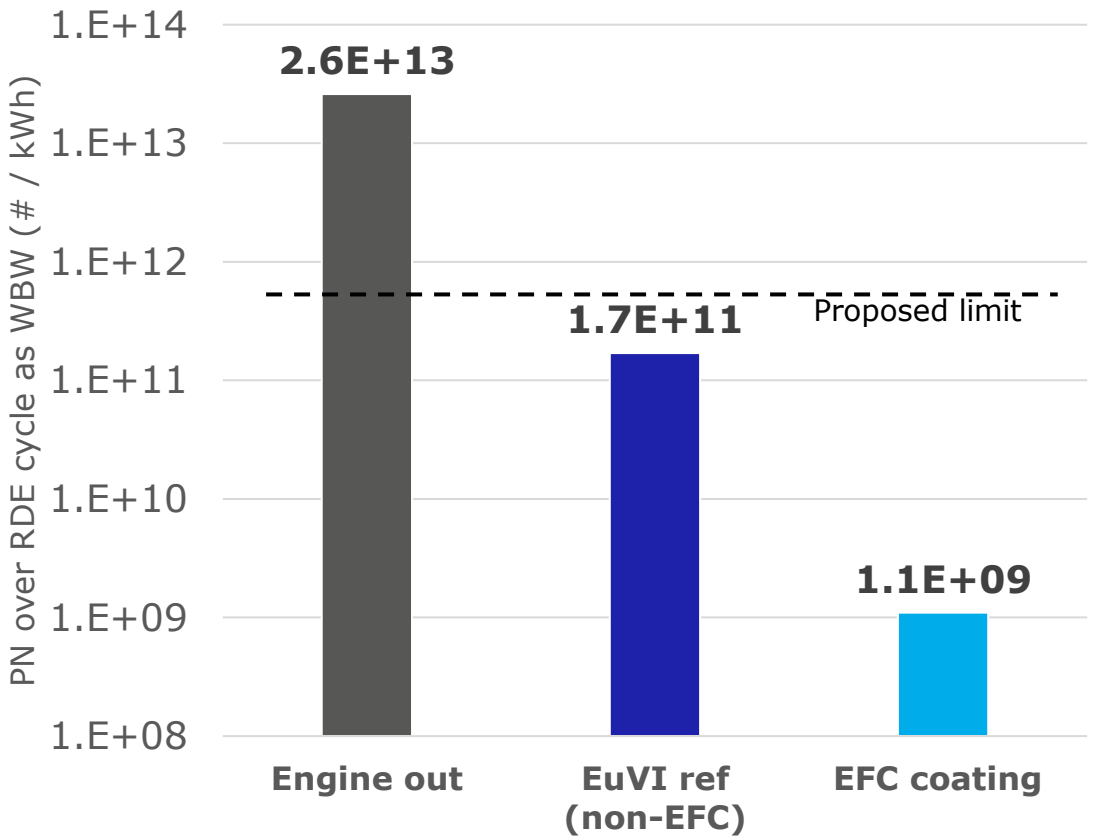
Filter: Enhanced Filtration Coating (EFC) for tightest particulate legislation

There will be a need for higher filtration efficiency as regulations are set to tighten

JM's EFC is a catalytic coating that significantly enhances filtration efficiency

- Permeable coating with high filtration efficiency
- Tolerant to water & ash cleaning processes
- Can be applied to various filter substrates
- Maintains excellent catalytic properties of the coated substrate



12L engine, 7L DOC + 17L CSF
4g/L soot loaded, high load RDE cycle

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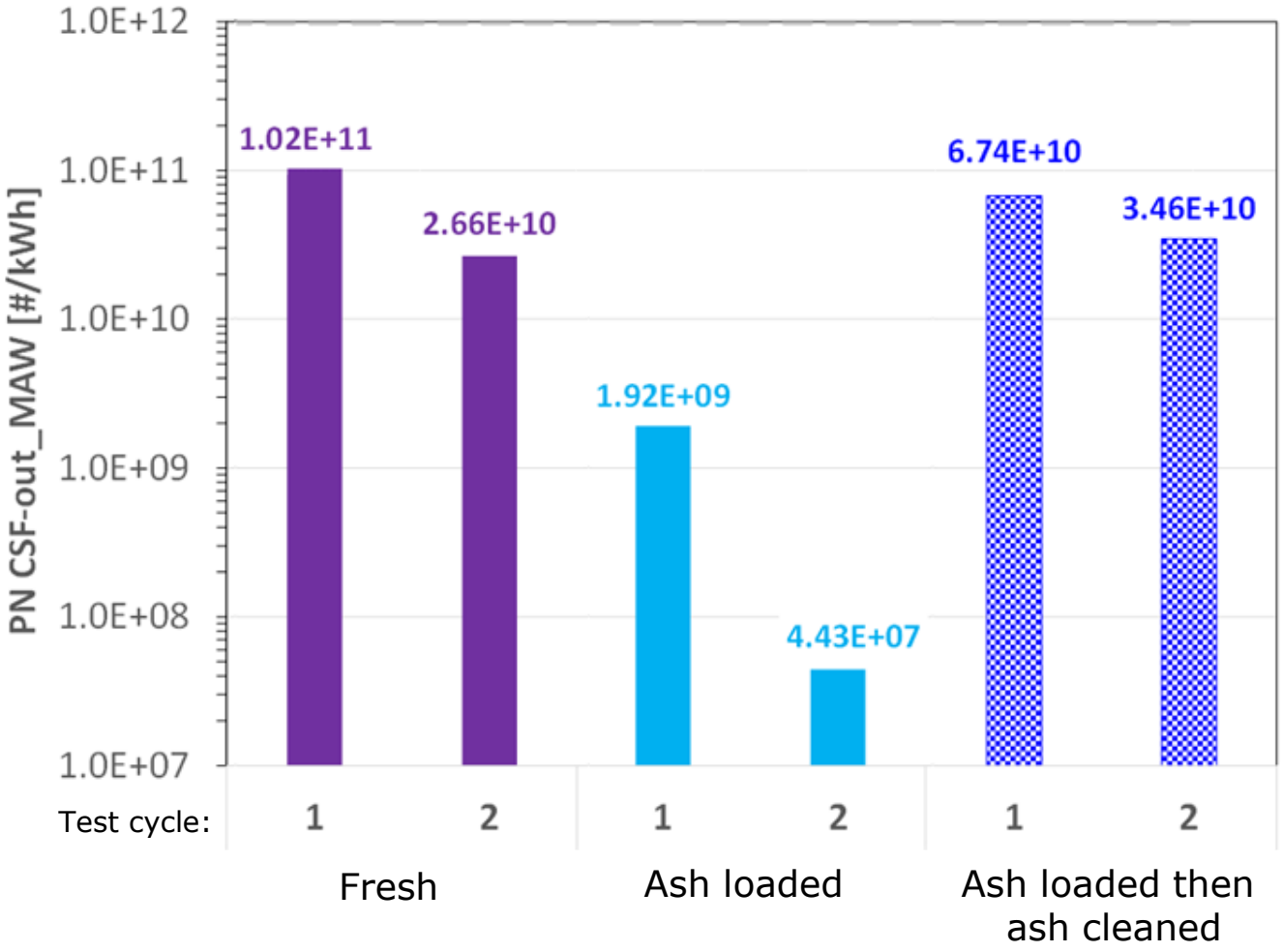
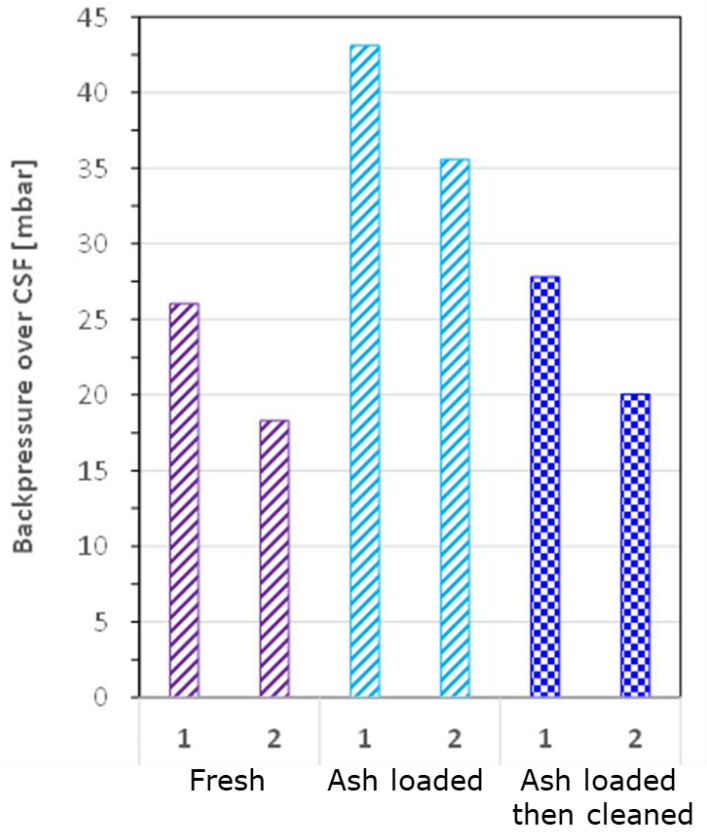
Durable EFC Technology for PN filtration

Low PN maintained after ash ageing/cleaning (MAW processed)



Cycle-averaged Backpressure over CSF



Inspection by endoscope suggests a small amount of residual ash after cleaning.

PN_{10} engine out: 2.6E+13 #/kWh

11L engine, 5g/L soot loaded, 2x 5 hr high load RDE cycles run back to back, WBW values

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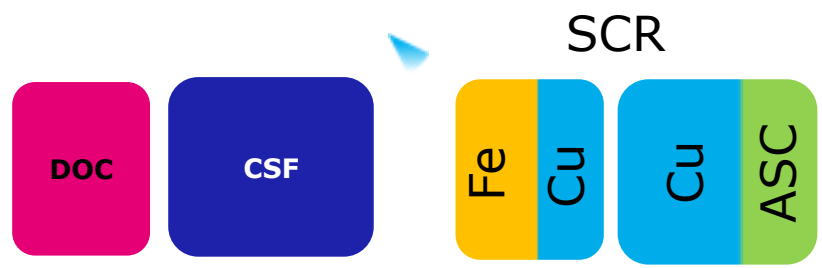
Simulation Studies

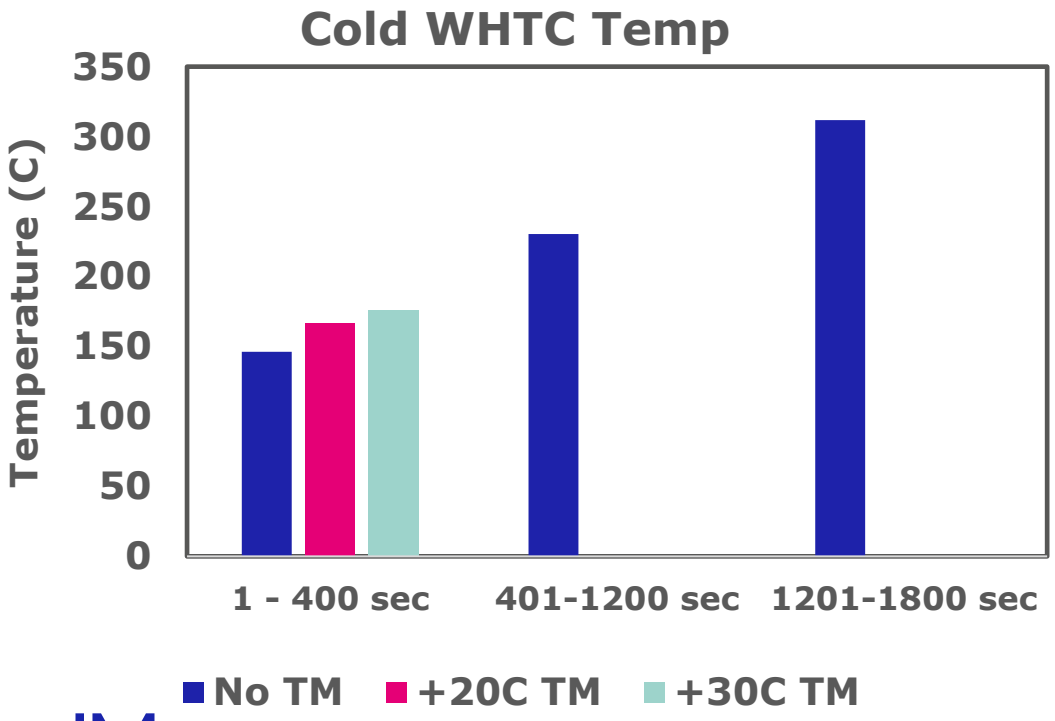
Heating can help for high NOx engine
Effect of Engine temperature on NOx cold start

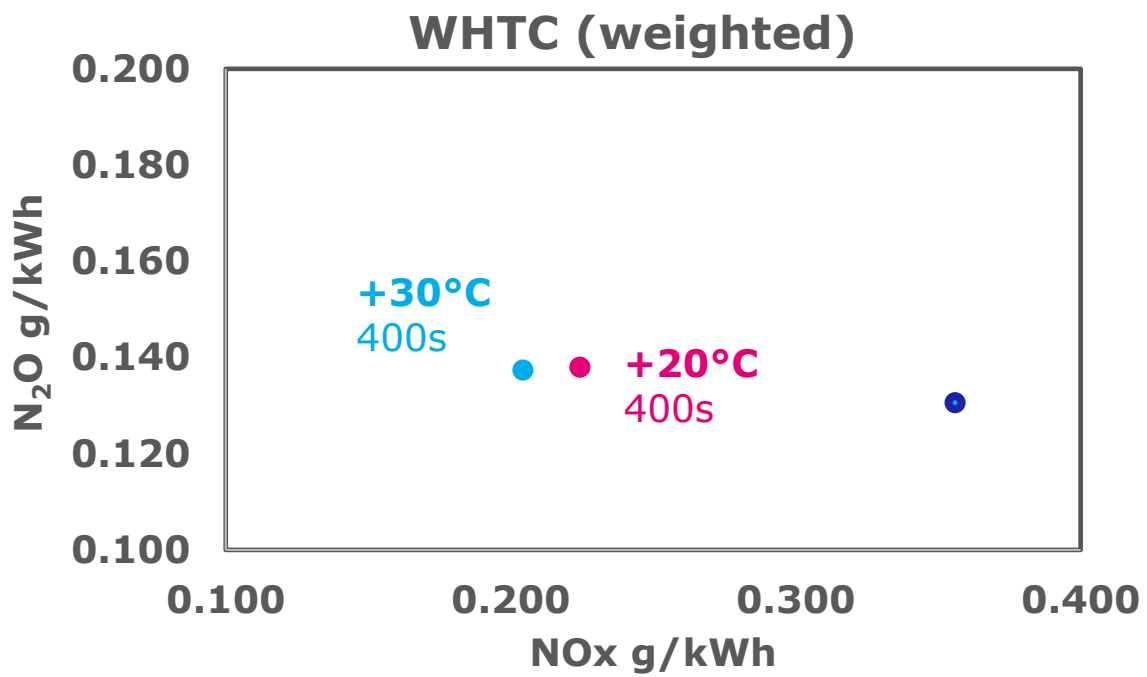
- With SCRT® configuration, heating element is most likely required for high NOx
- With Dual injection, less temperature management is required



11g.kWh^{-1} NOx

WHTC	Avg Temp
Cold	238
Hot	260





TM= Temp increase in initial 400sec of Hot WHTC

Summary

- ✓ For future legislations, both single dosing (SCRT®) and dual urea dosing are available as solutions
- ✓ Dual Dosing configurations allows for lowest NOx and N_2O – better fuel efficiency
- ✓ Different SCR Technologies approach possible to meet N_2O & NOx
- ✓ Low N_2O Cu SCR is a new option to consider
- ✓ EFC technology for PN filtration allows compliance with PN_{10} future regulations; it is compatible with existing ash cleaning solutions
- ✓ Simulation is key for system design and optimisation

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