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Heavy Duty Diesel Exhaust Aftertreatment System development towards Euro7

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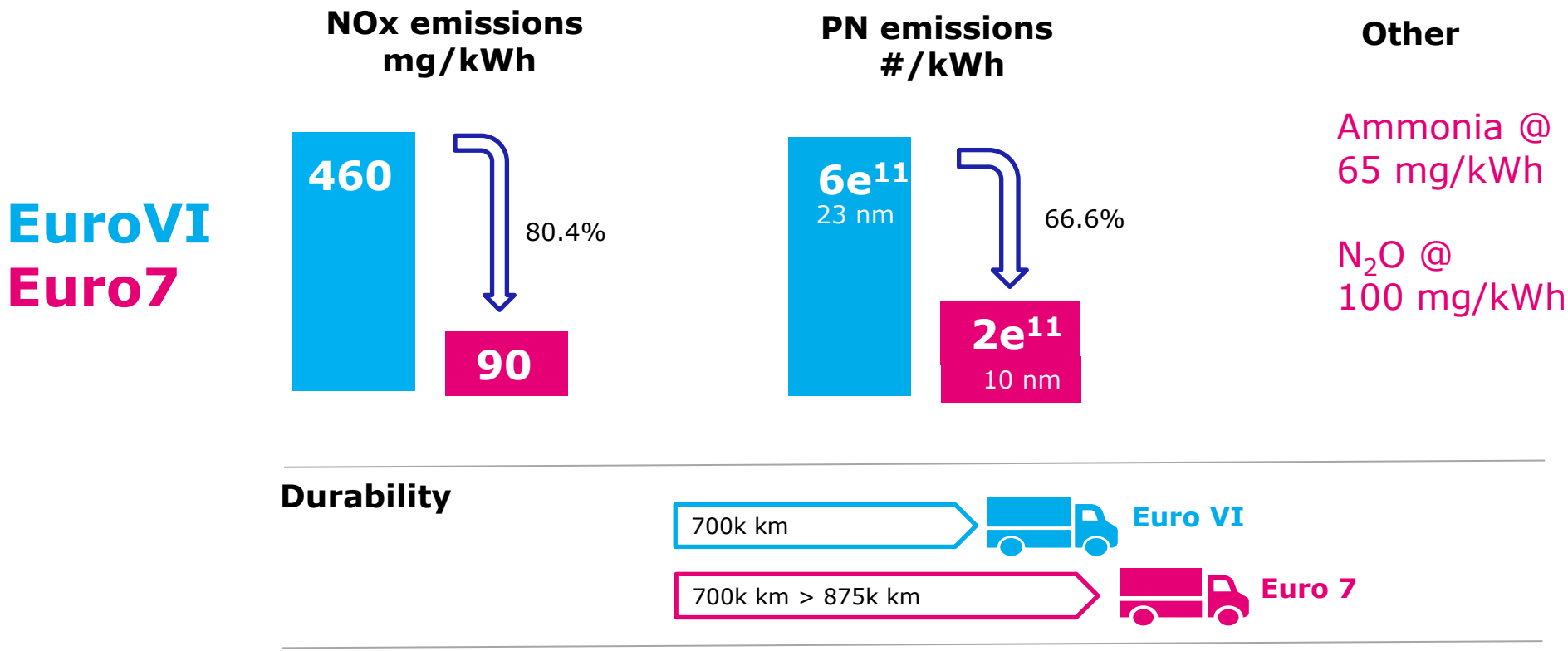
Initial Euro7 proposal from European Commission (October 2022)



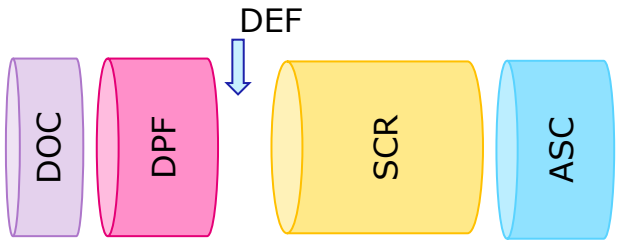
Initial Euro7 proposal set high ambition for HDD and triggered intensive development work on system and component levels

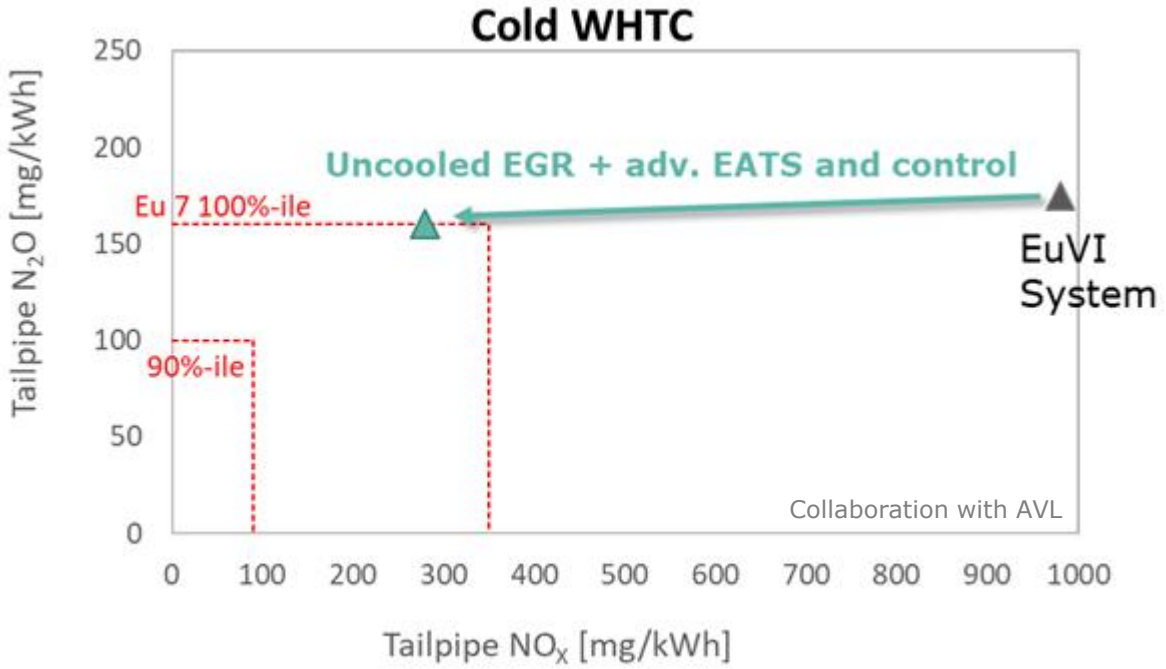
Technical limits of EuroVI-type systems

Measures to reach low emissions in cold start

- Engine hardware
- Advanced control
- Improved catalysts

EuroVI-type system





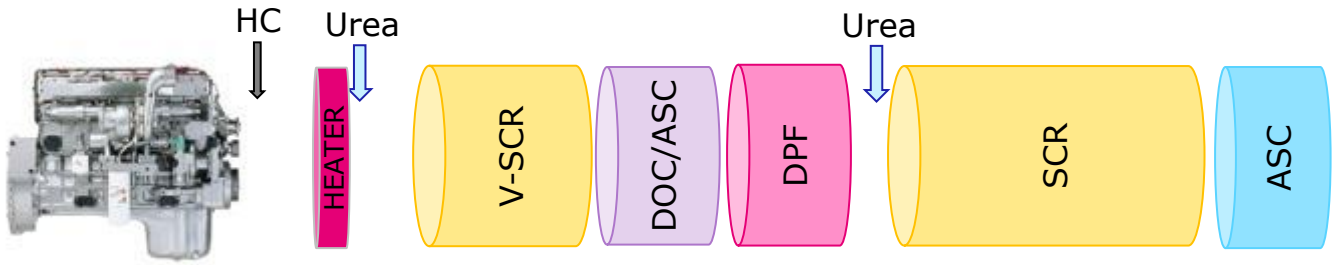
EuroVI-type systems are not likely to meet Euro7 limits

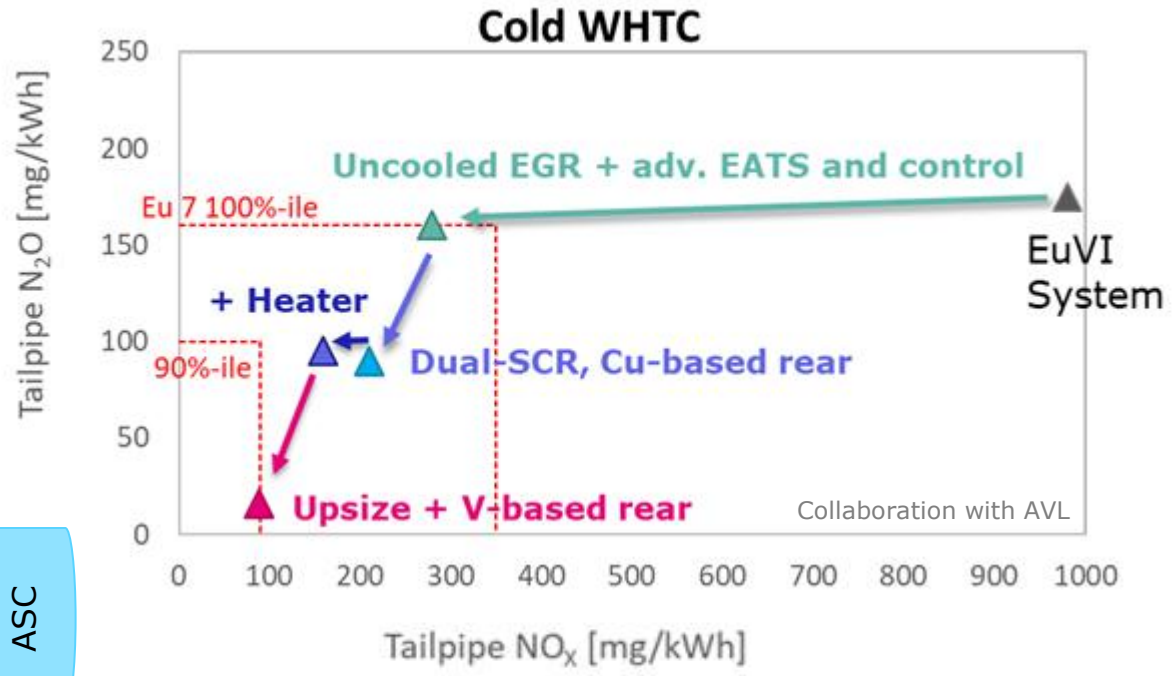
Improved system design for Euro7

Measures to reach ultra-low emissions in cold start

- Engine hardware
- Advanced control
- Improved catalysts
- Dual-SCR (ccV-SCR)
- External heating
- Low N_2O SCR

Euro7 dual dosing system

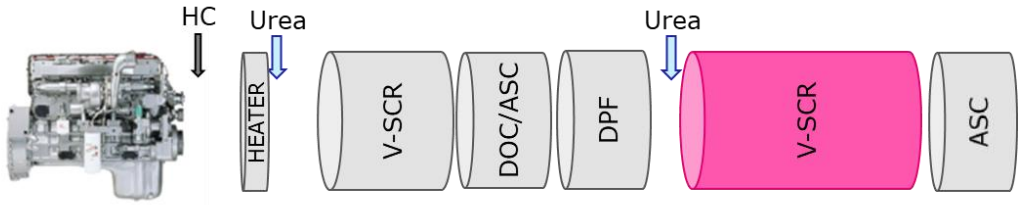




Dual-SCR system is key to reach very low NOx and N_2O emissions in cold cycles

Downstream SCR considerations for a Euro 7 system

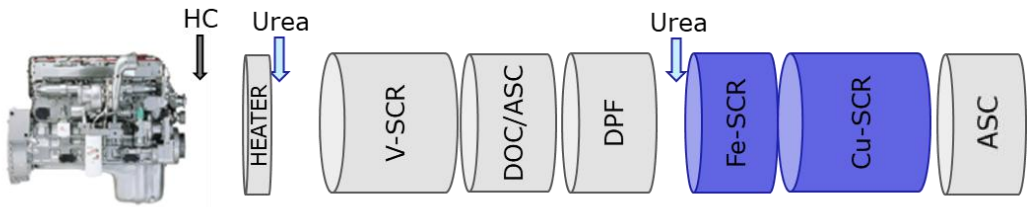
rear V-SCR Passive system



+ Faster transient response
+ Low N_2O from SCR under normal operation
+ Low demand for de-sulphation

- Lower NH_3 storage and earlier NH_3 slip
- High temperature limitations >550°C

rear Fe/Cu-SCR Active system



+ Good activity at higher temperature
+ High NH_3 buffer

- Higher N_2O from SCR under normal operation
- Need for de-Sulphation at higher temperatures
- Slower response from empty NH_3

There is not one system design that is best in all cases and each application need select the system best suited for its conditions

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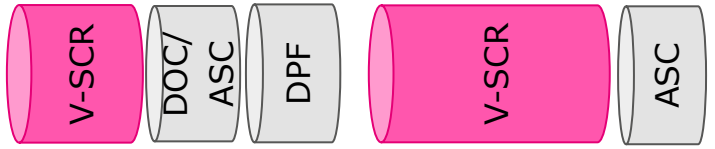
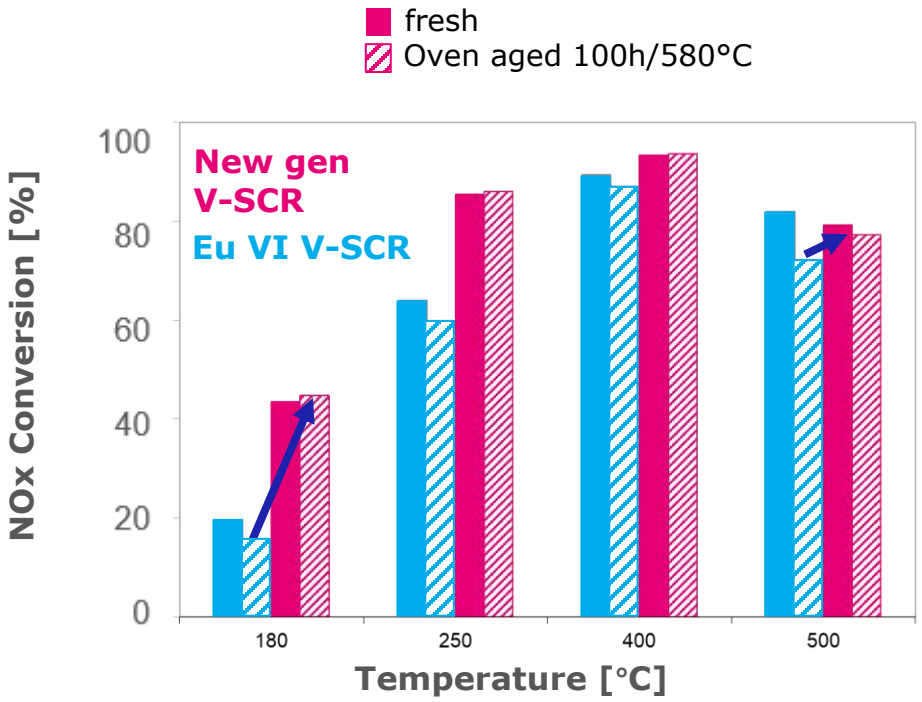
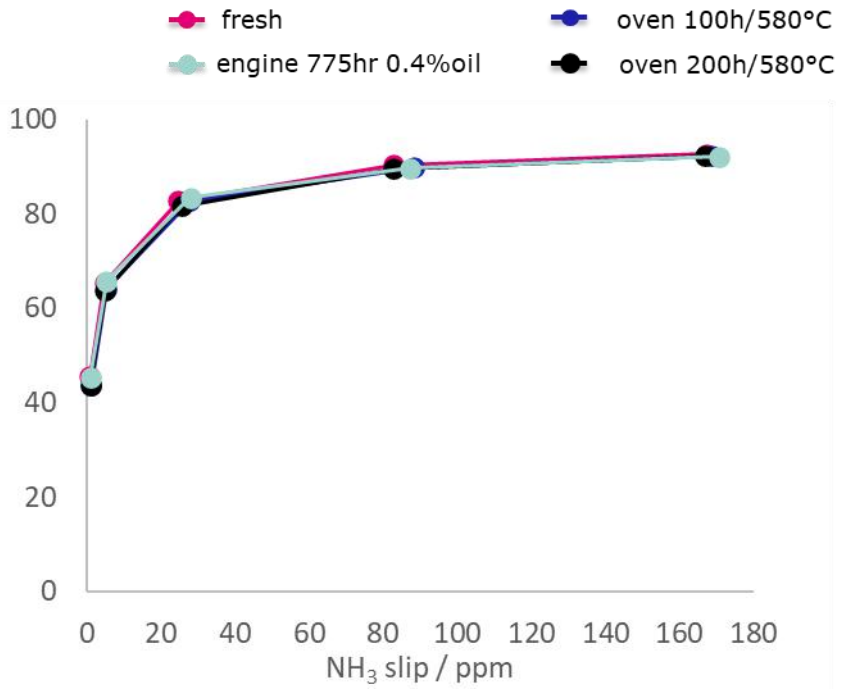
V-SCR with improved performance and durability







Euro7 dedicated V-SCR formulations show significantly improved NO_x conversion and durability

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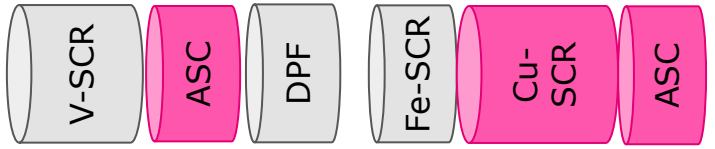
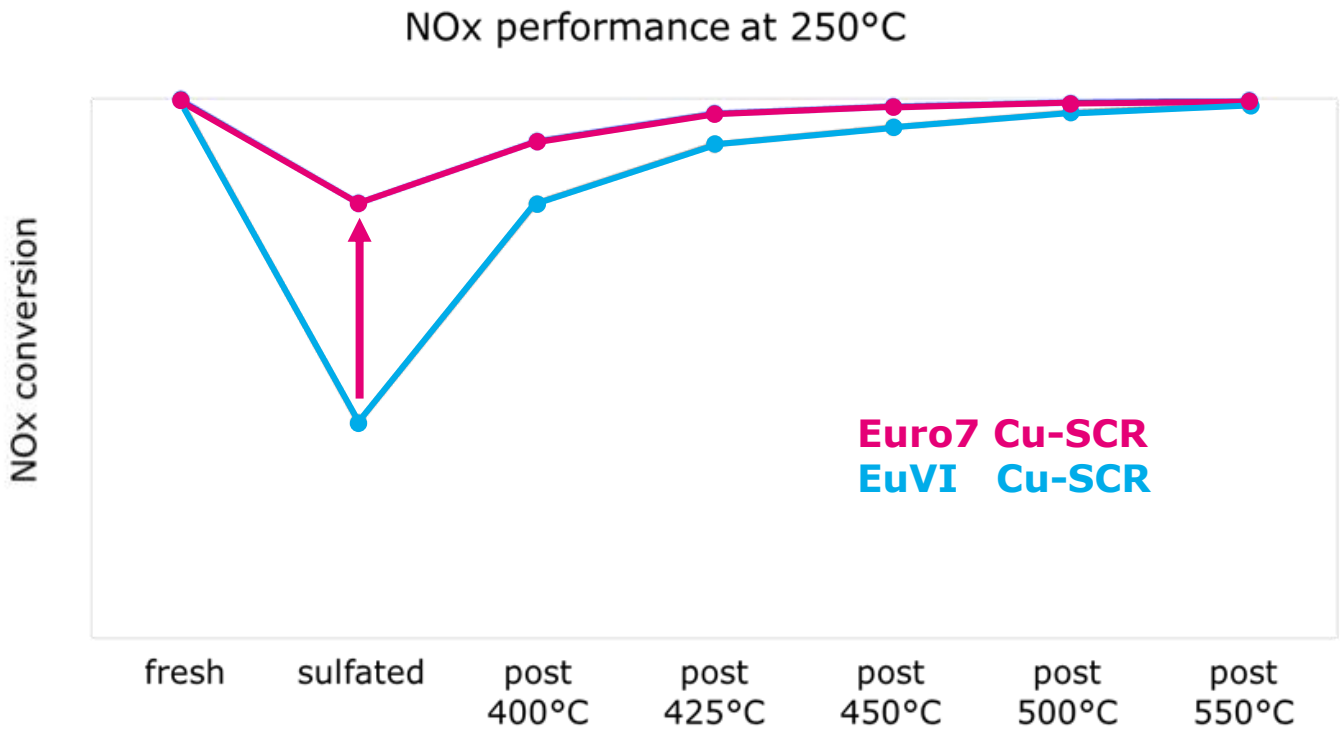
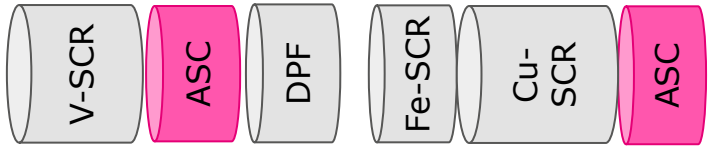
Improved Sulphur tolerance of Cu-SCR

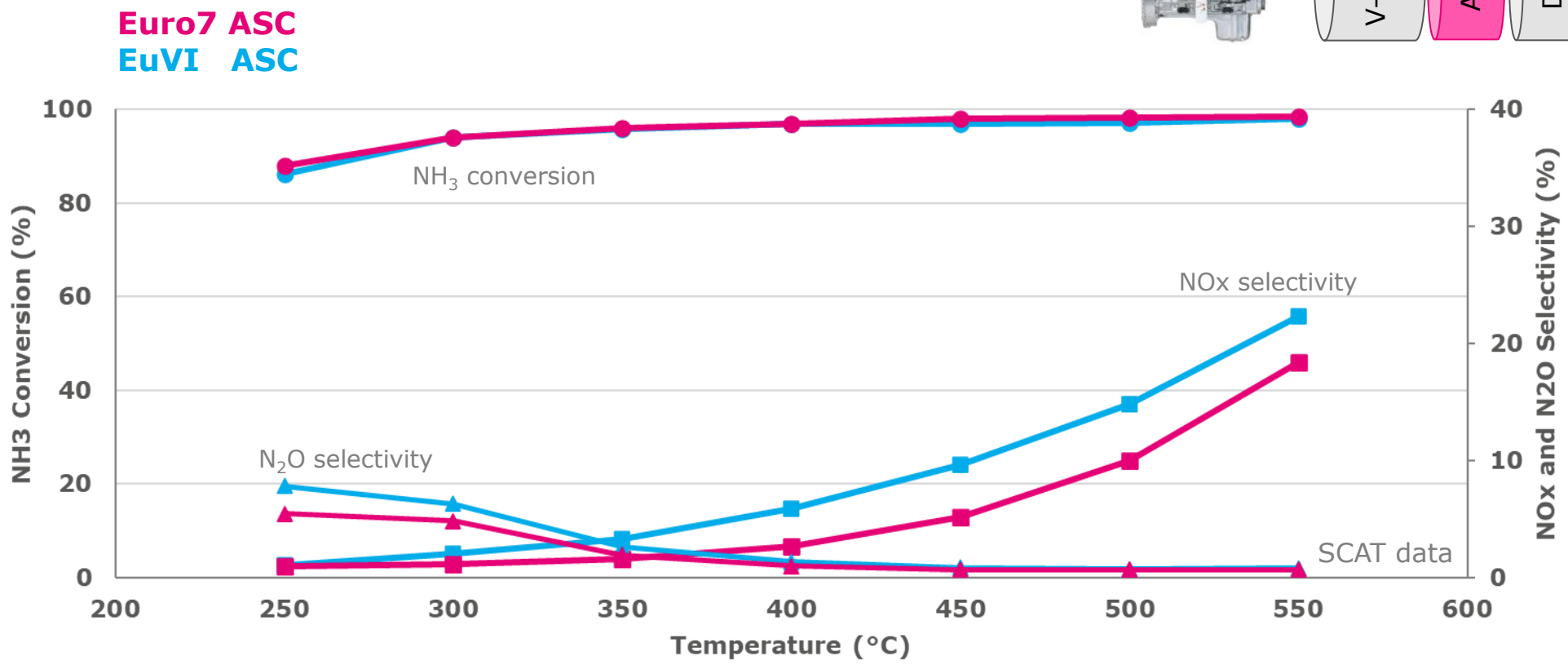




Euro7 dedicated Cu-SCRs show much better tolerance to sulphation and desulphate at lower temperatures

New generation of Ammonia Slip Catalyst (ASC)





Euro7 dedicated ASCs shows extremely high NH_3 conversion and improved N_2 selectivity

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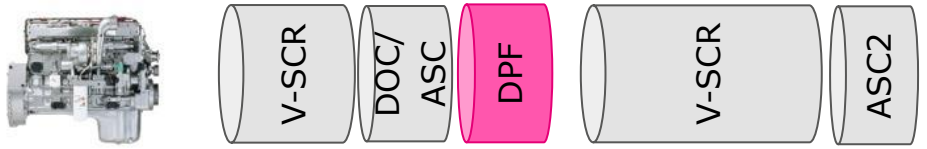
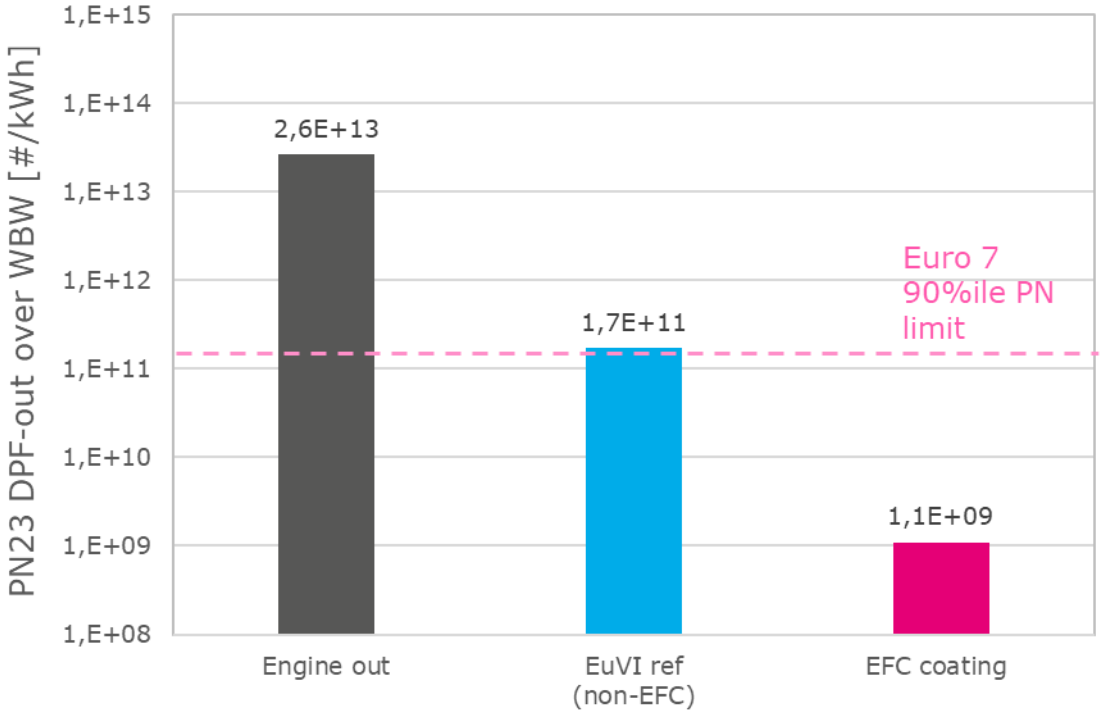
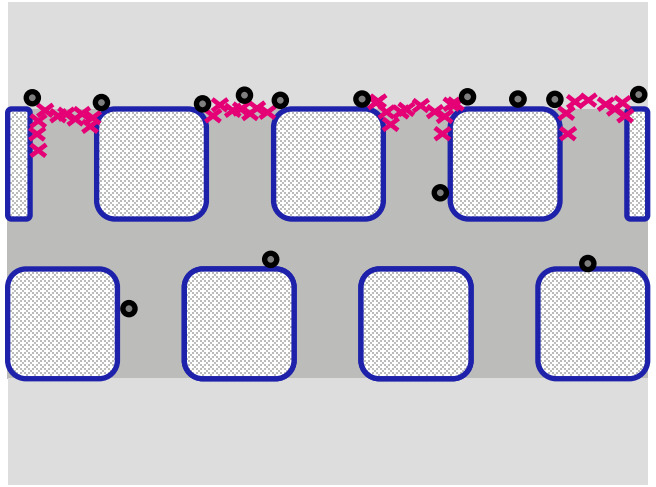
Enhanced Filtration Coating (EFC) on DPF for Euro 7



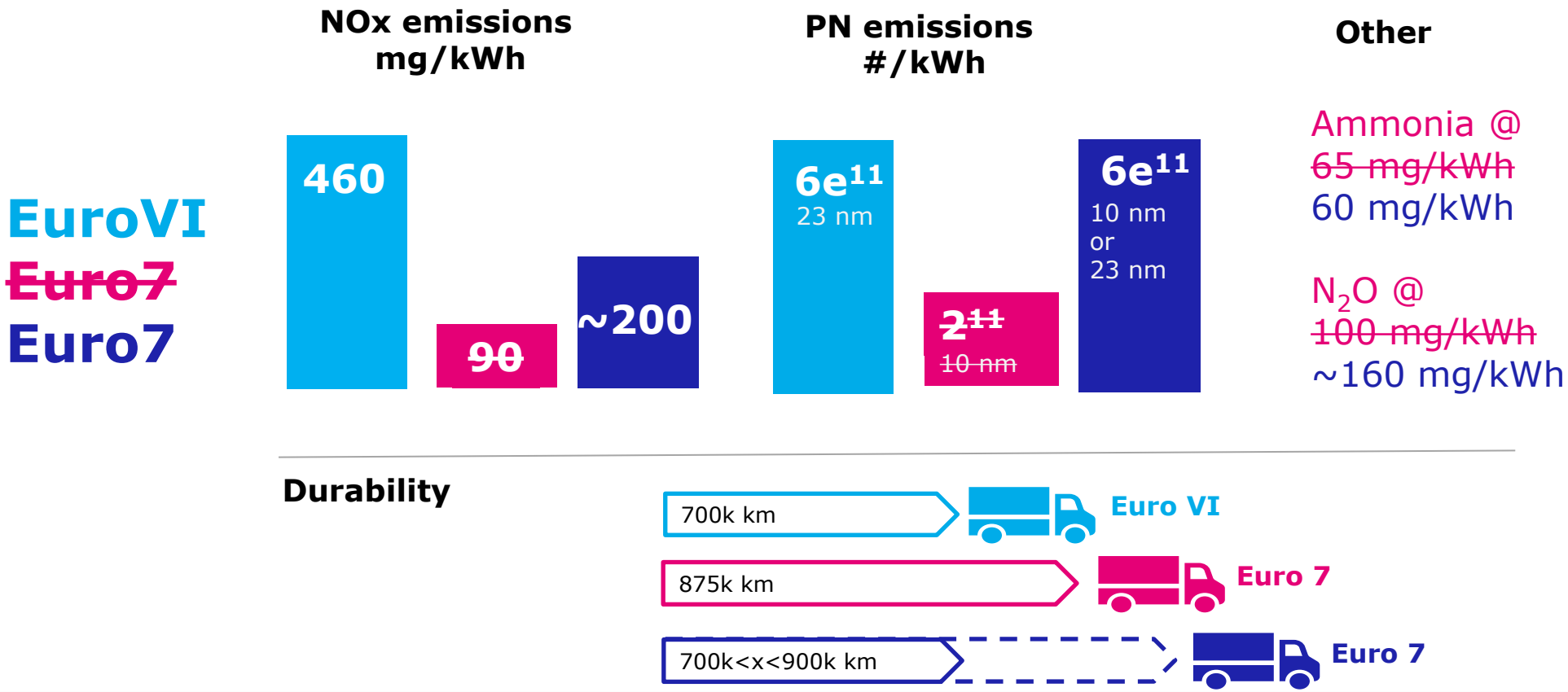




Better filtration as soot needs to penetrate **EFC** layer

Enhanced Filtration Coating on DPF significantly reduces PN in RDE testing. EFC is also resistant to wet ash cleaning

Recent changes to the Euro7 proposal by European Council and Parliment (October 2023)



Despite recent dilution of the Euro7 limits, the industry maintains efforts to adopt the new generation of the EATS

Summary

- Euro7 development resulted in significant improvements on system and component level
- Urea Dual Dosing systems are preferred way to achieve extremely high NOx conversion and low N_2O
- Several system layouts, both Passive (V-based) and Active (Fe/Cu-based) can meet the proposed Euro7 limits
- Johnson Matthey offers new generation of catalysts with improved efficiency, wider operating window, higher durability and better sulphur tolerance
- EFC DPF is needed to achieve tighter PN regulation
- **All presented technologies are already selected by European OEMs and available for Indian OEMs for efficiency improvements, strategic downsizing and cost reduction of exhaust aftertreatment systems**