

Towards Bharat Stage VII

Advanced SCR Technologies, Exhaust Aftertreatment Architectures and Thermal Management

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The HDCV Dilemma & BS-VII Mandate

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Active Exhaust Thermal Management (CatVap®)

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WHTC and Indian RDE Bench Test Results

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EATS Optimization and Outlook

Balancing commercial transport with severe air quality challenges



The Backbone of Logistics

Diesel-powered HDCVs remain indispensable for the Indian market (robustness, reliability, cost-effectiveness)



The Regulatory Challenge

BS-VII will mandate substantial NO_x reductions under Real Driving Emissions (RDE) conditions



The Technical Hurdle

Reduced RDE power thresholds (e.g., down to 6 %) force evaluation at very low engine loads



The Consequences

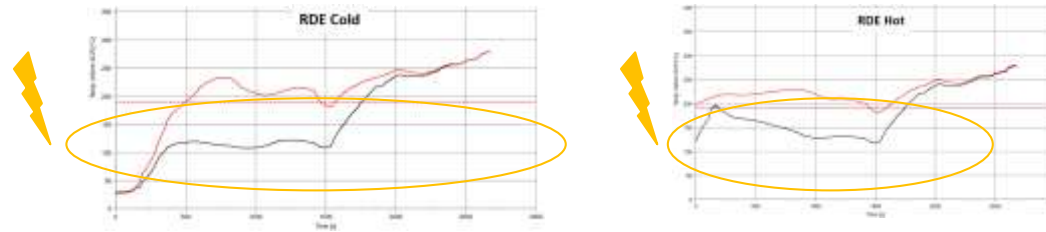
Exhaust temperatures drop significantly; effective SCR NO_x reduction becomes difficult.
Cost and development challenges of new engine and EATS platforms.

BS-VII and Urban Traffic: The (Thermal) Challenge of Real Driving Emissions



The Worst-Case Scenario:

Indian urban traffic means extreme congestion, prolonged idling, stop-and-go, 6 % power threshold



The Consequence:

Exhaust gas temperatures drop below the required operating range



The Drawback:

Suboptimal NO_x conversion. Temperature falls below the SCR light-off threshold, making compliance with BS-VII and beyond impossible



A technical solution must utilize an intelligent and cost-effective retrofit system (e.g., CatVap®) to correct this thermal deficit independently of the engine's operation.

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 - 2 **Active Exhaust Thermal Management (CatVap®)**
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BS-VII Enabler: Active Exhaust Thermal Management by the Albonair CatVap® System



The Concept:

Intelligent system architectures (CatVap®) that generate thermal energy via catalytic fuel conversion



Cost-Efficient Transition:

Enables compliance using existing series-production BS-VI EATS



Plug & Play Integration:

No modifications to the base engine or engine control system (ECU) required.

Opportunity to upgrade existing BS-VI architectures



The Result:

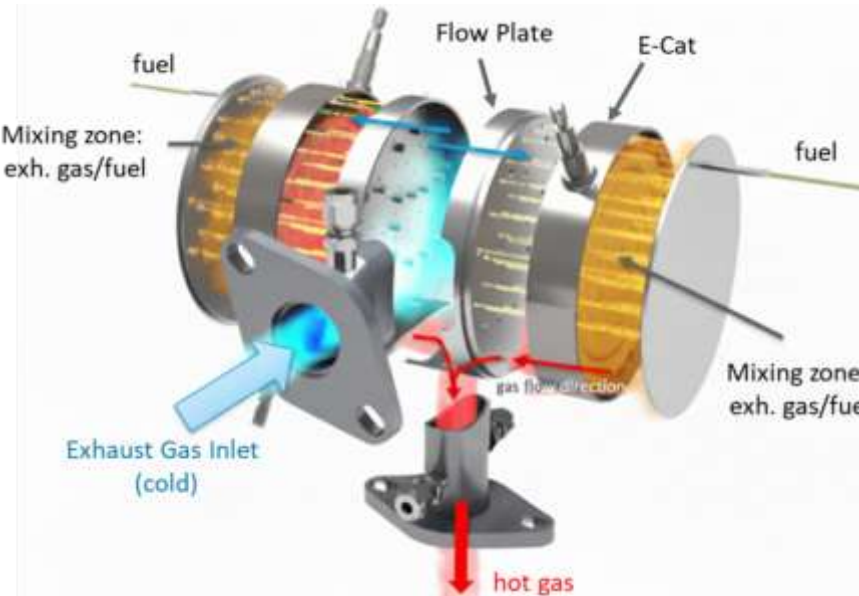
Extends the operating range of efficient NOx conversion into extreme low-load conditions

CatVap®

Flexible system for heating up and keeping the exhaust gas warm

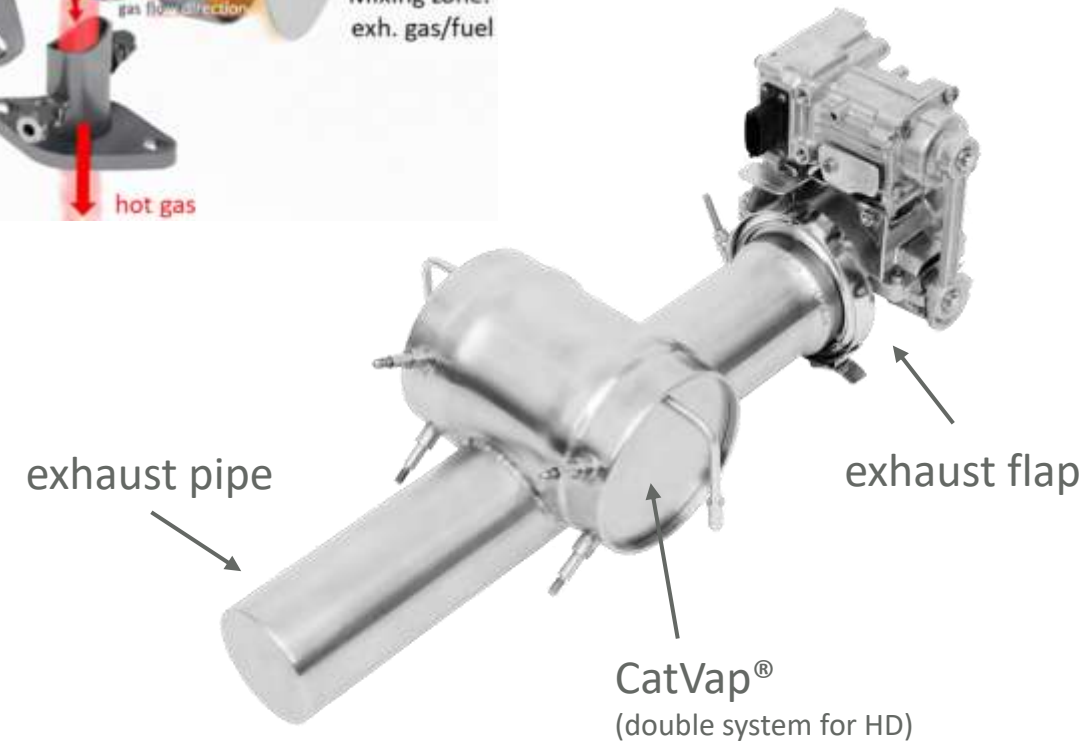
CHARACTERISTICS:

- catalytic heating system
- fuel-powered after electrical start-up
- fuel-agnostic (Diesel, HVO, e-fuels)
- no electric power during continuous operation
- decouples temperature from engine operation
- enables active DPF regeneration
- maintaining optimal temperatures for NO₂ production (for CRT effect)



KEY OPERATING MODES:

- **Heating** rapid heat-up from cold for quick catalyst light-off
- **Heat Retention** protects EATS from cooling during low-load operation
- **DPF Regen.** provides heat for active regeneration if required
- **DOC Mode** rich operation generates reactive species (H₂ and CO) for low-temperature DOC light-off

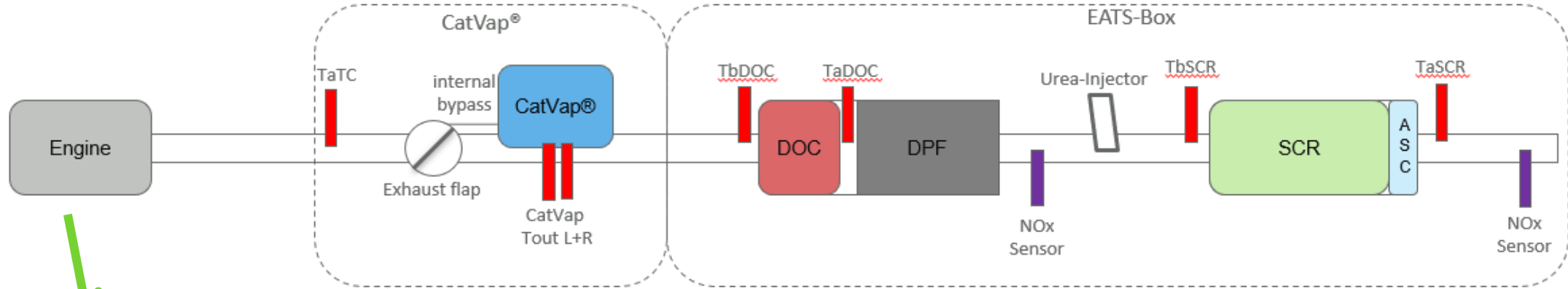
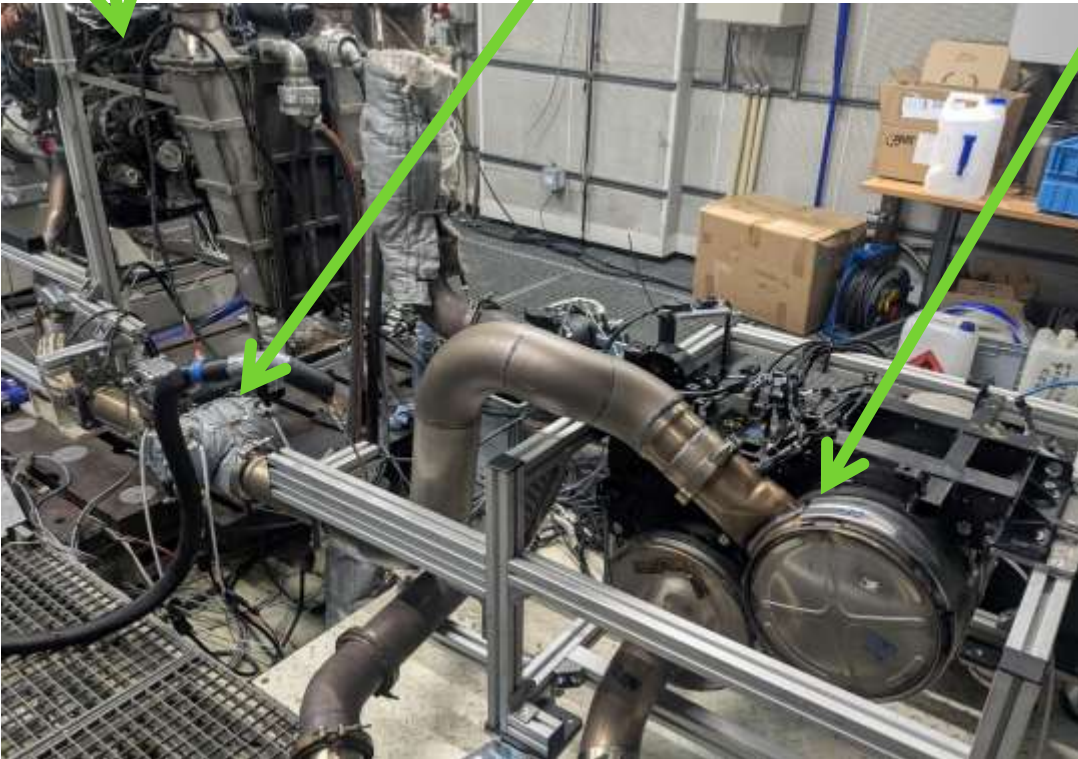


	Single Reactor	Double Reactor
Power, max. heat-up mode	10 kW	20 kW
Power, max. DOC mode	50 kW	100 kW
Power, min. (heat retention) (deactivated when engine exhaust temperature is high enough)	1 kW	2 kW
max. electrical power of electrical preheating	2 kW	4 kW
max. amperage of CatVap® during start period at 24 V	90 A	180 A
max. operating duration of electrical preheating	150 s	150 s
Pressure drop across the complete system	40 mbar	40 mbar

✓ **Scalable Architecture:** Modular design allows seamless integration across different engine displacements and performance classes from MD to HD (e.g., suitable for Ashok Leyland H4 / H6 applications).

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CatVap® Setup on the engine test bench



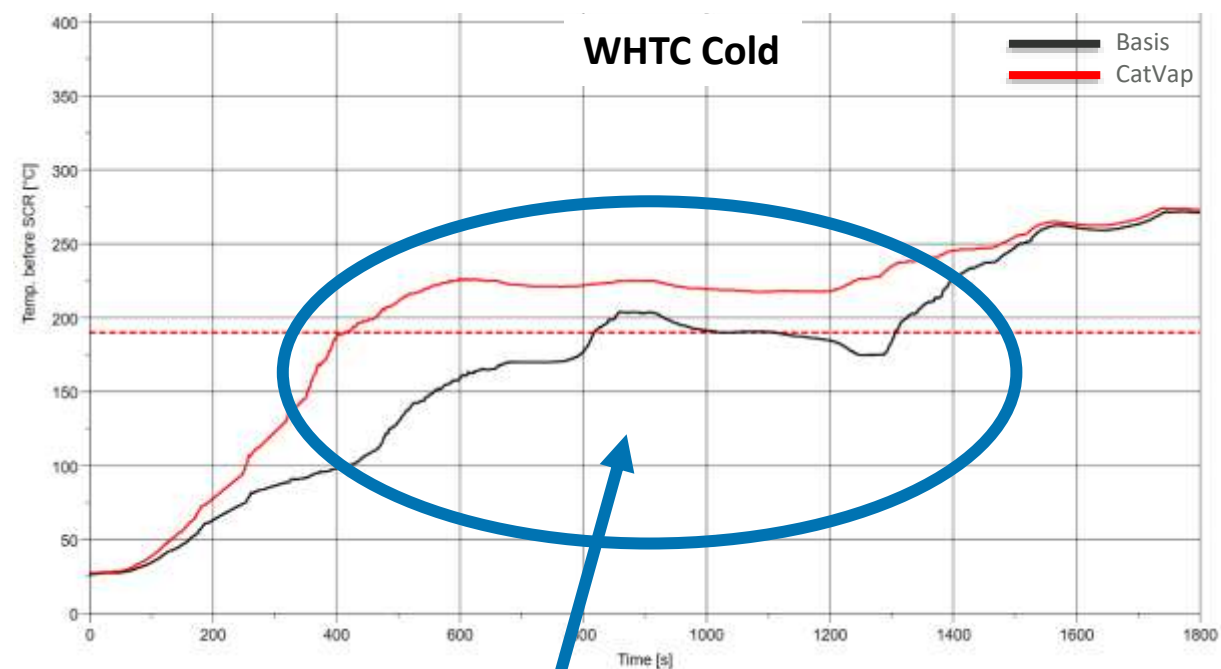
Engine

- $V_H = 5.2 \text{ L}$
- $P = 140 \text{ kW}$
- $N = 510 \text{ Nm}$
- EURO VIc
- no changes to the engine, ECU or software

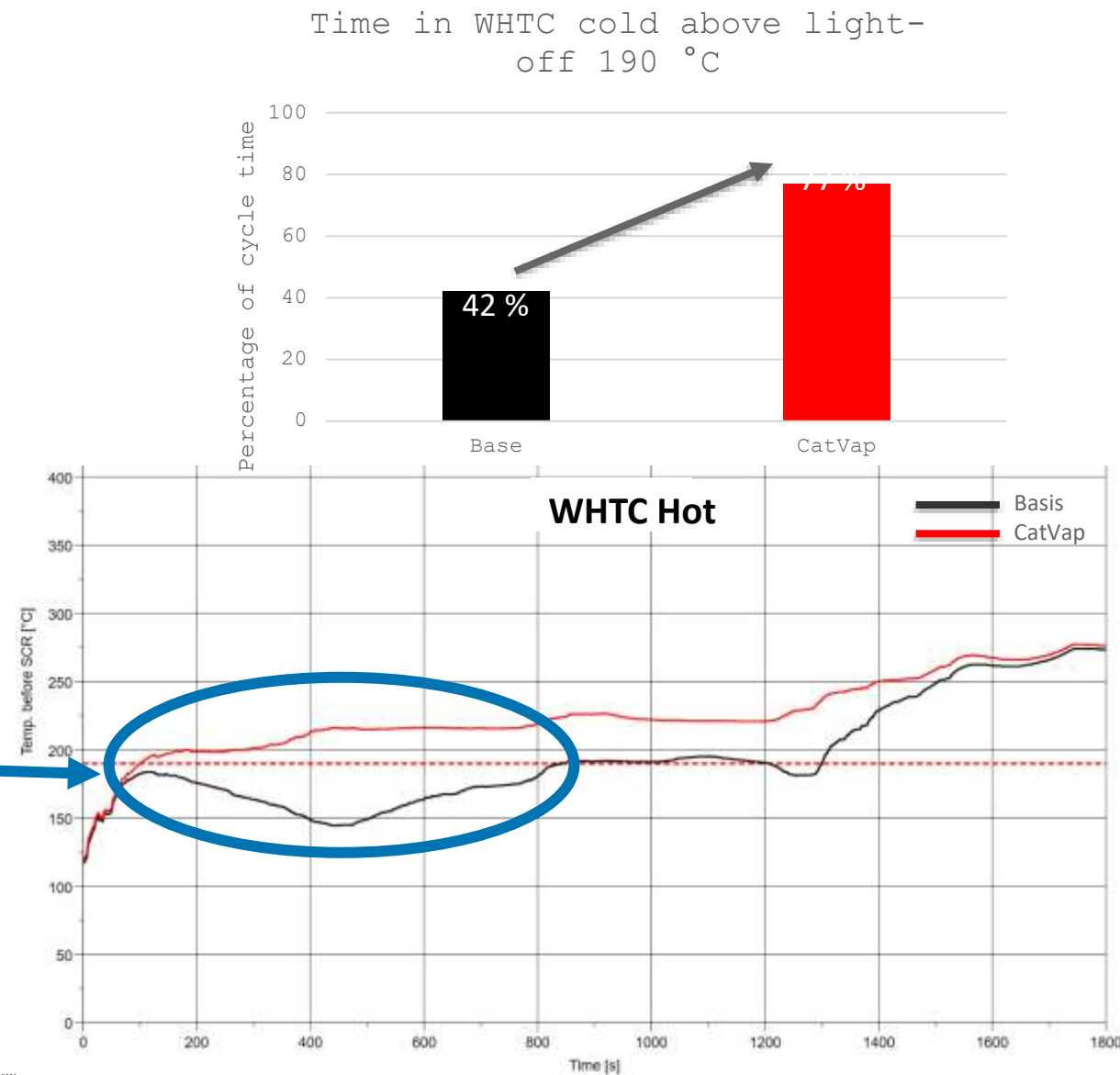
Albonair EATS:

- BS-VI series configuration, Air Assisted BSVI AdBlue Dosing system with BS VI calibration
- installation of the CatVap® downstream of the turbocharger, upstream of the BS-VI EATS

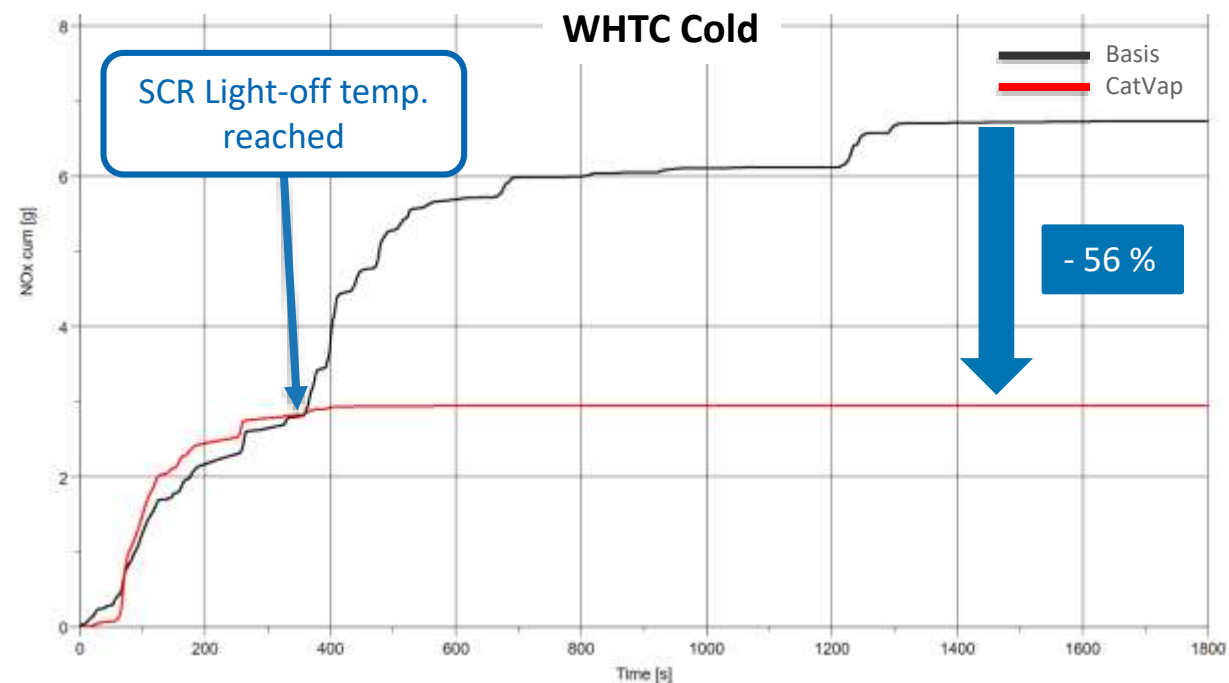
WHTC Performance – CatVap® significantly extends operation above 190 °C



CatVap®:
extended operation above the target temperature



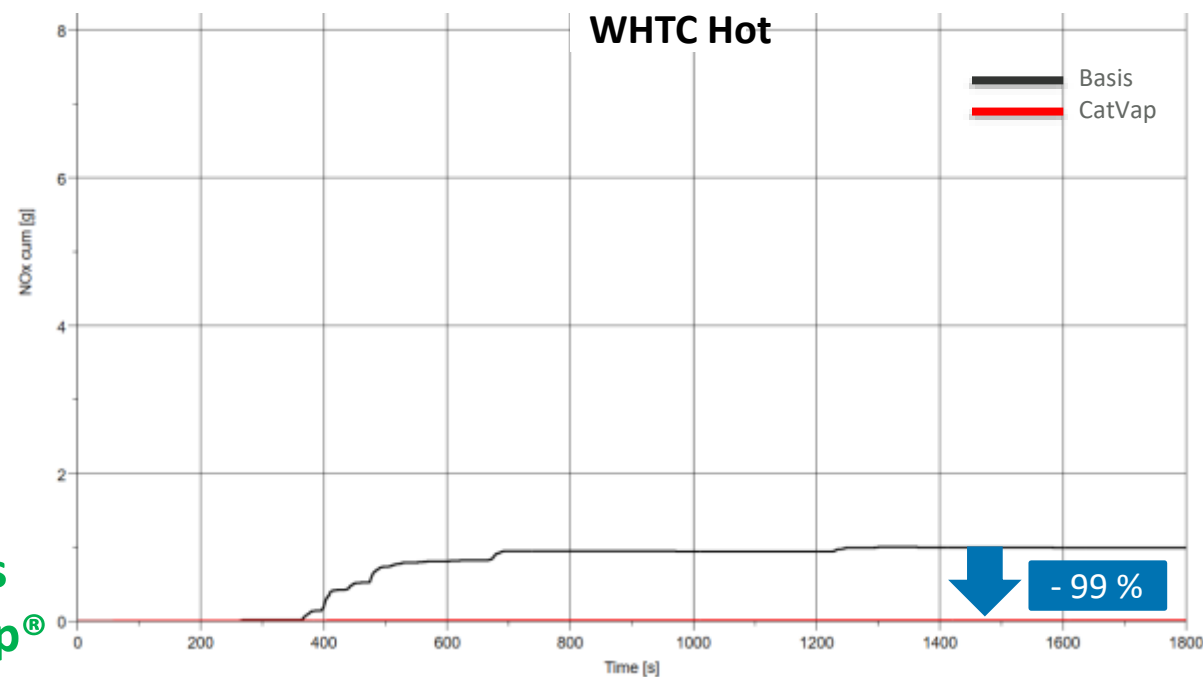
CatVap® Performance – cumulative NOx emissions reduced by 56 % in WHTC cold



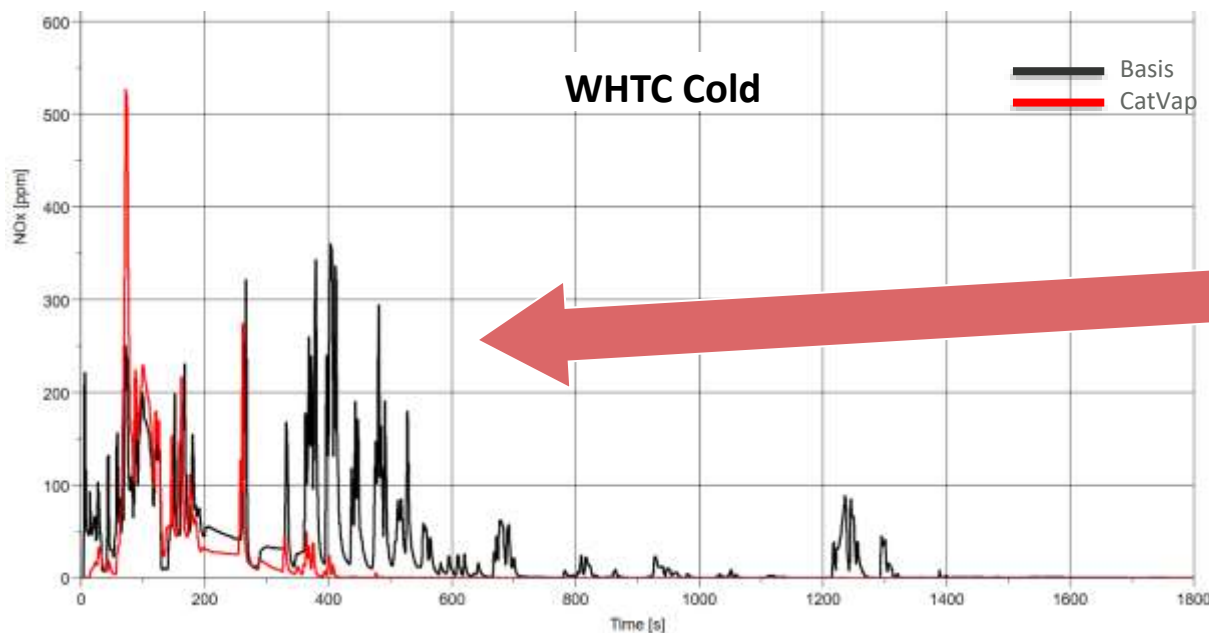
✓ 56 % NOx reduction in total

✓ 99 % NOx reduction after SCR light-off

✓ near-zero NOx emissions in WHTC Hot with CatVap®

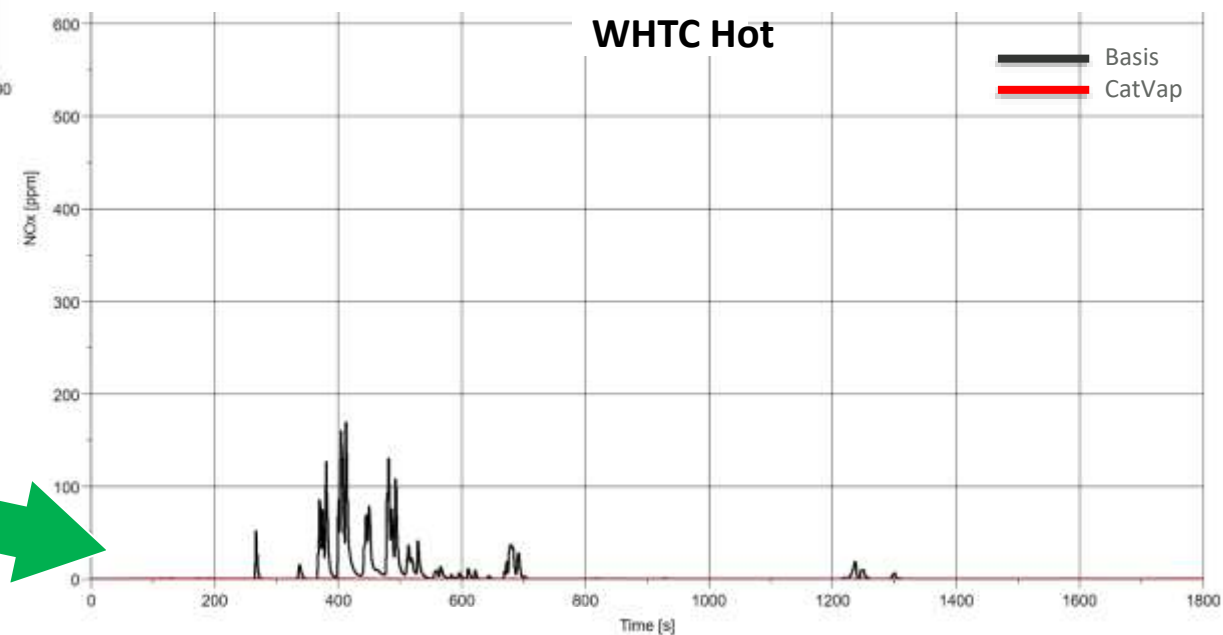


WHTC Performance – no NOx peaks with CatVap®



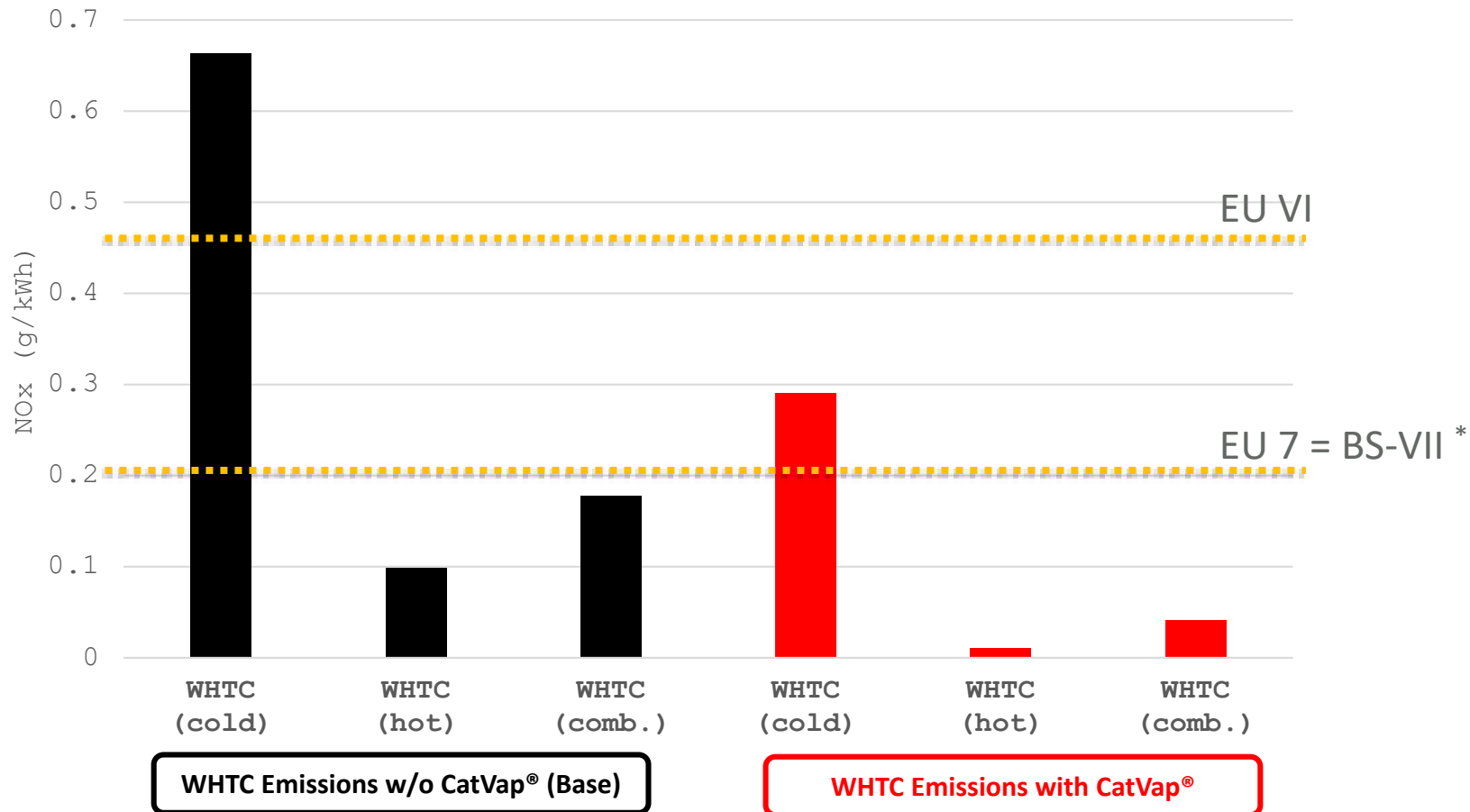
X High NOx Peaks in the baseline configuration

✓ NOx emissions with CatVap® mainly below 5 ppm.



WHTC-Performance – up to 77 % NOx Reduction in WHTC cycle

Specific WHTC NOx Emissions



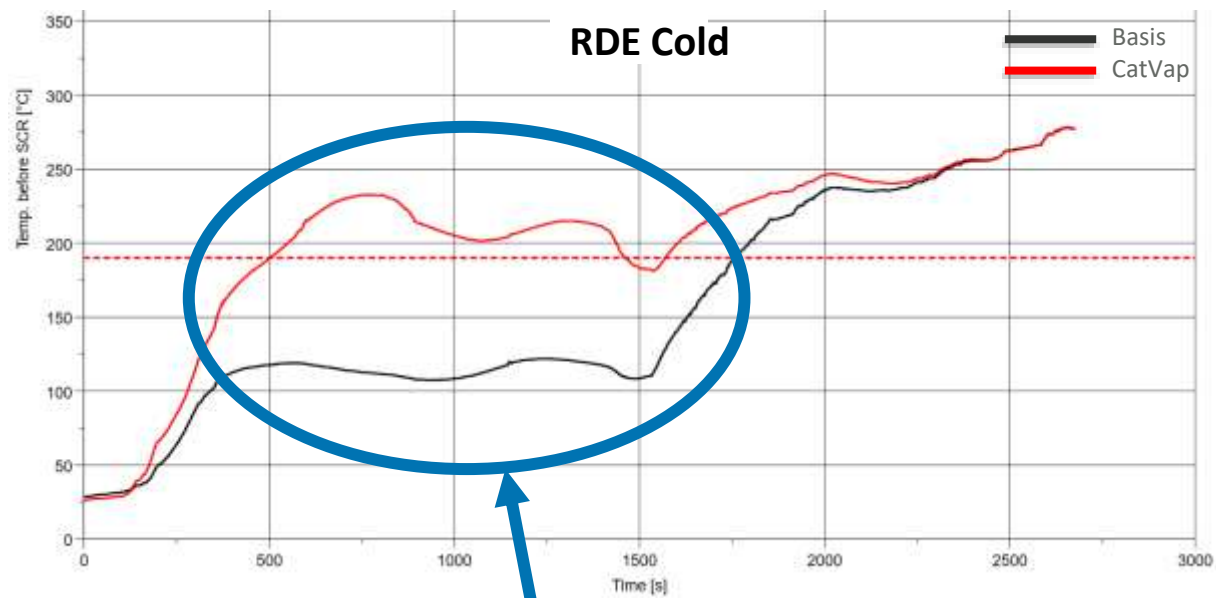
Without CatVap® the Engine-EATS system is often operated at insufficient exhaust temperatures.

CatVap® increases the exhaust temperature:

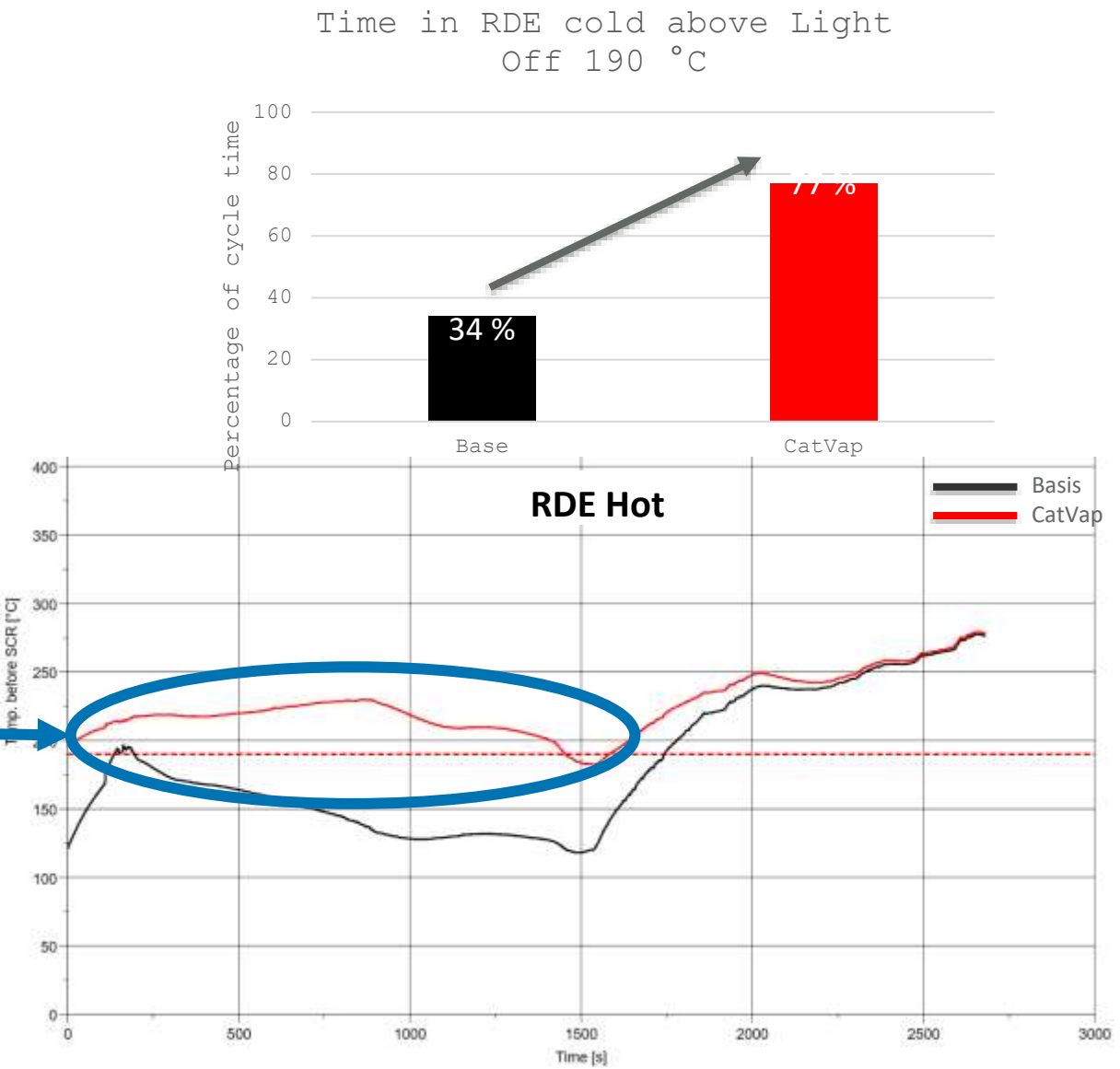
- ✓ potential elimination of forced DPF regeneration
- ✓ SCR operates at sufficient NOx conversion efficiency under WHTV tested conditions

*expected: BS-VII will mirror EU 7

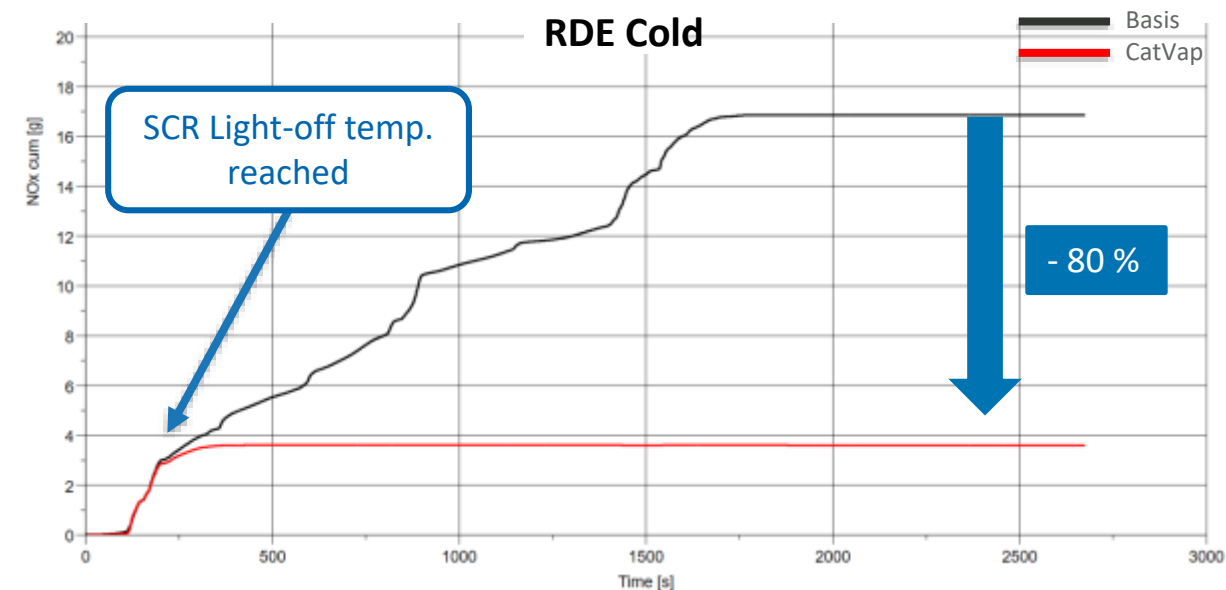
RDE Performance – CatVap® significantly extends operation above 190 °C



CatVap®:
extended operation above the target temperature



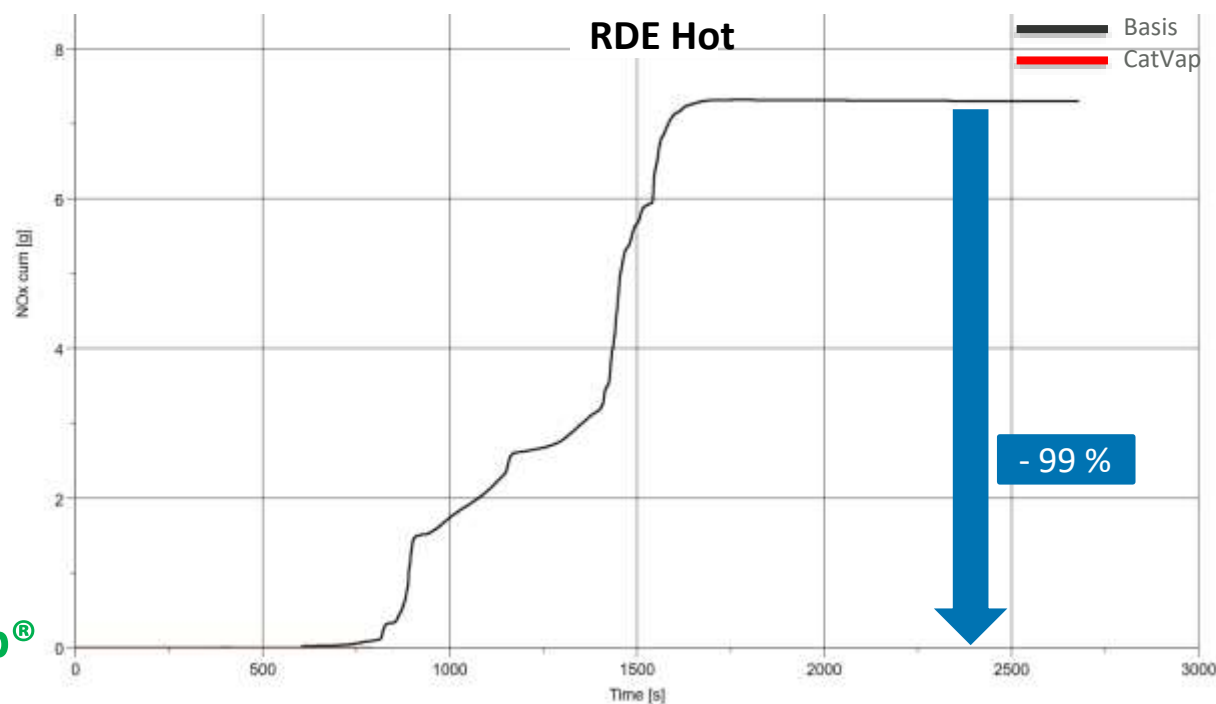
CatVap® Performance – cumulative NOx emissions reduced by 80 % in RDE cold



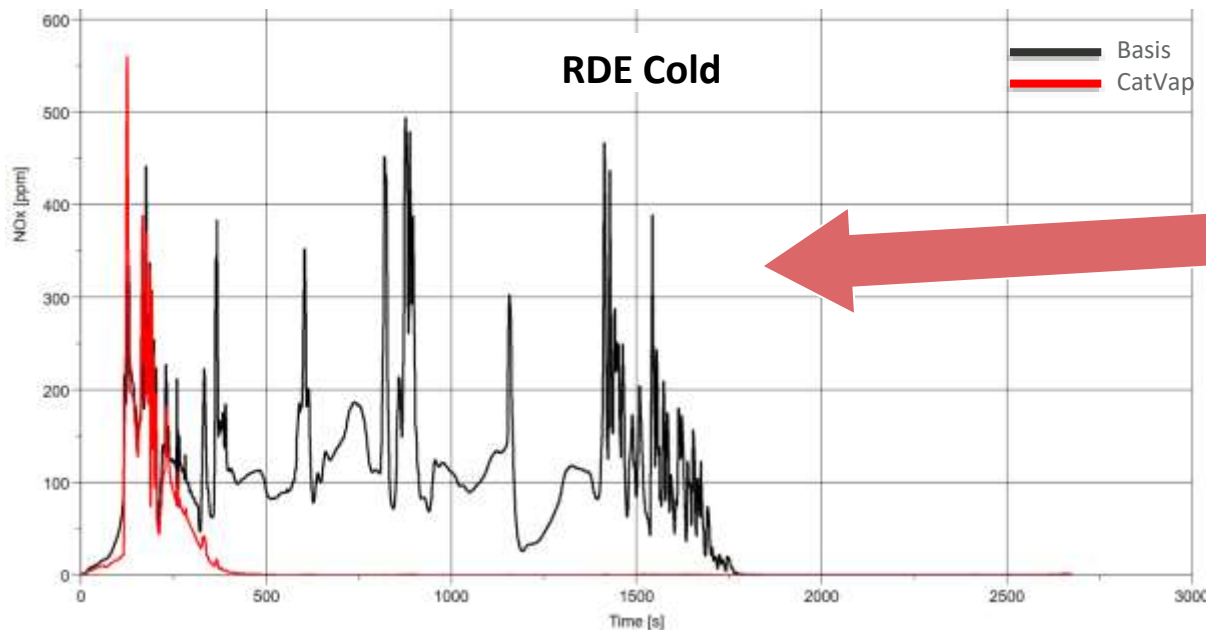
✓ 80 % NOx reduction in total

✓ 99 % NOx reduction after SCR light-off

✓ no NOx emissions in RDE Hot with CatVap®

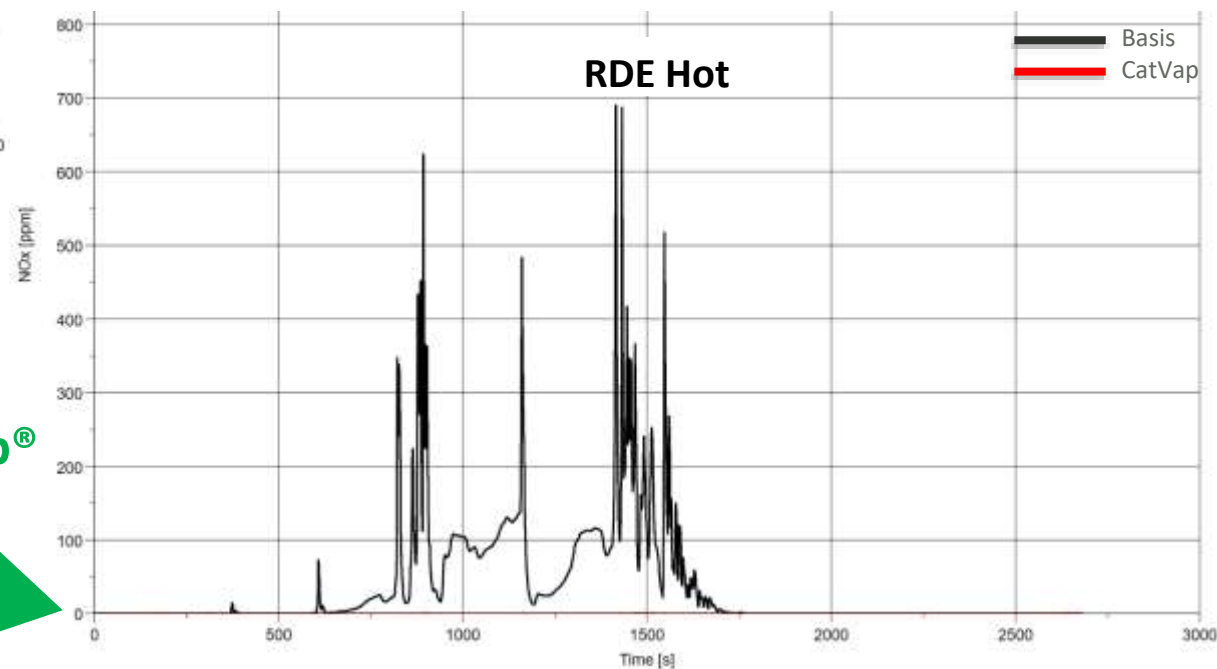


RDE Performance – no NOx peaks with CatVap®

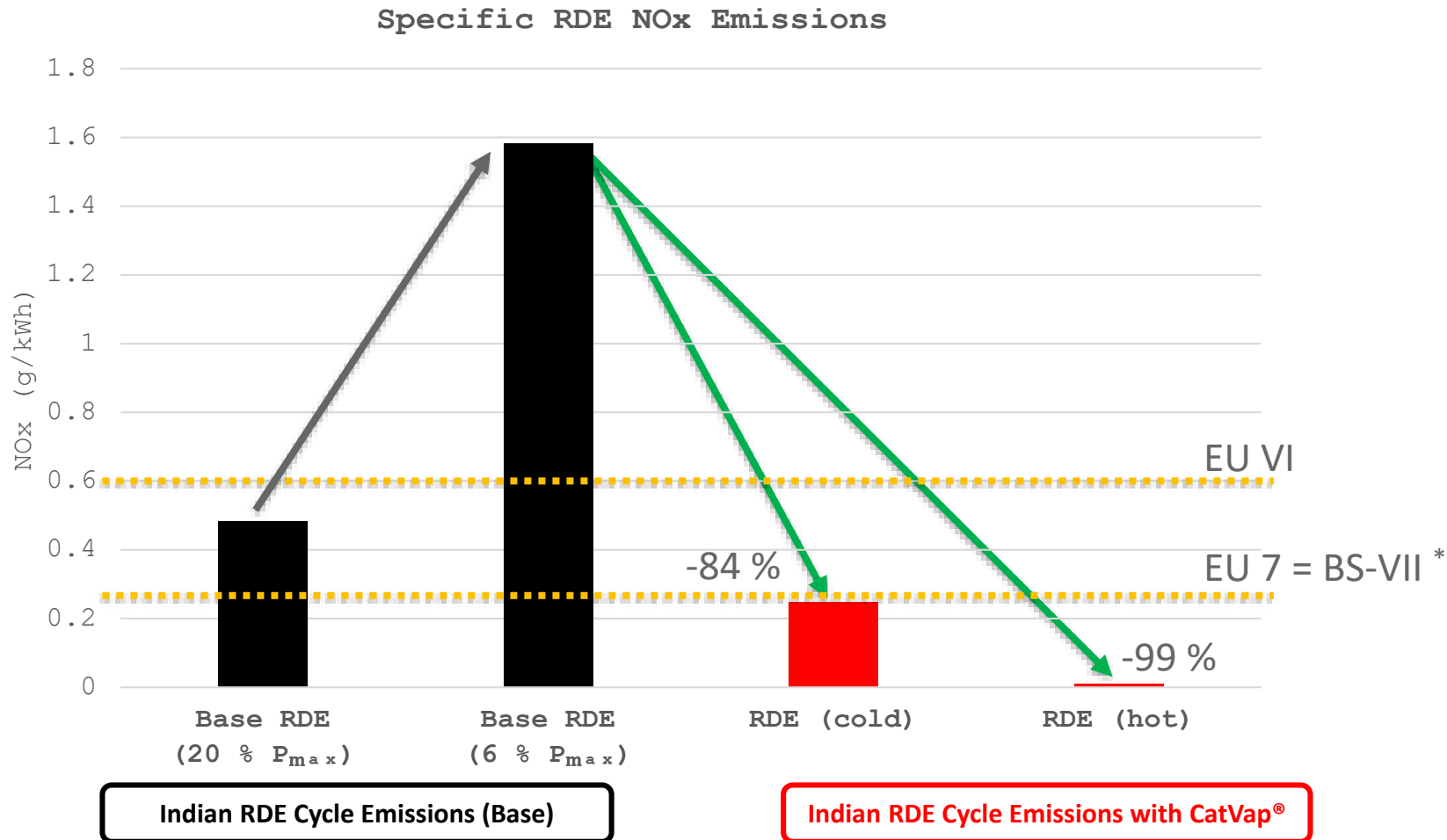


✗ High NOx Peaks in the baseline configuration

✓ NOx emissions with CatVap® mainly below 5 ppm.



RDE-Performance – up to 99 % NO_x Reduction in Indian RDE tests



Without CatVap® the Engine-EATS system is often operated at insufficient exhaust temperatures.

CatVap® increases the exhaust temperature:

- ✓ potential elimination of forced DPF regeneration
- ✓ SCR operates at nearly 100 % NO_x conversion efficiency under the tested conditions

*expected: BS-VII will mirror EU 7

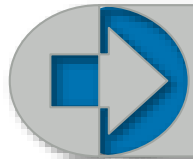
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Additional Benefits with CatVap®:

Passive DPF regeneration the path towards fuel-neutral thermal management

- Elevated exhaust temperatures support NO₂-assisted soot oxidation (CRT)
- CRT principle enables continuous passive regeneration under suitable conditions
- Potential reduction of active regeneration events
- DOC platinum loading may need optimization to increase NO₂ availability
- CatVap® can provide heat for active regeneration when required
- Engine calibration optimization to reduce engine-out NO_x and fuel-consumption trade-offs
- Reduced conventional active DPF regeneration
- Optimized CatVap® heat demand
- Potential reduction or compensation of the inherent fuel demand of the CatVap® system (e.g., optimizing engine calibration, no EGR, etc.)

CatVap[®] demonstrates significant potential to meet future BS-VII emission requirements using existing BS-VI engine and EATS architectures.



CatVap[®] offers a promising pathway towards BS-VII and beyond

Thank you very much for your attention!



German Engineering for Clean Air

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