ECT topic: Advancement and Innovations in Emission Control Technologies for Off-road (Tractor, CEV) and Non-road (genset, locomotive, marine) segments

Revolutionizing Exhaust Management: A Dual Nox Control Architecture for High-Power Diesel Engines

ALBONAIR Global

Incepted in 2007…

Dortmund, Germany
- » Headquarter
- » R&D
- » Sales/ Customers Service
- » Urea Dosing System Assembly Line

Key Facts:
- »250 000 dosing systems/year
- »>2 000 000 Systems overall
- »300+ employees
- »160 Mio. € revenue

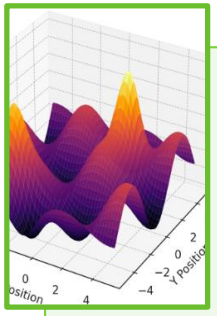
Ennore, India
- » Sales
- » Customer Service
- » Tank Assembly Line
- » Urea Dosing System Assembly Line
- » Nozzle Assembly
- » Filter Assembly
- » Muffler (Pass through)

Taicang, China
- » Sales
- » Customer Service
- » Urea Dosing System Assembly Line

High power Diesel V Engines - Common Challenges

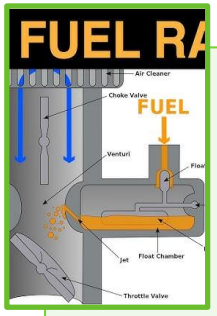
1.Design & Manufacturing	• Complex geometry and precision machining with durability and cost challenges.
Balancing & NVH	• Balancing, vibration, and noise - demands advanced crankshaft and damping solutions.
Maintenance & Service	• Compact design complicates access, raising service time and cost.
Fuel Efficiency	• Achieving high fuel efficiency requires precise control of air-fuel mixing
Emissions Compliance	• Uneven exhaust makes emission compliance and fuel efficiency harder.

V Engine - Emission Compliance challenges

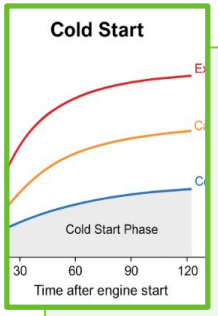


1. Uneven Exhaust Temperatures Between Banks

2. Longer & Uneven Exhaust Routing

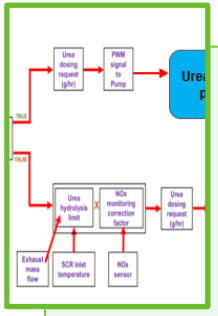


3. Complex Air & Fuel Management



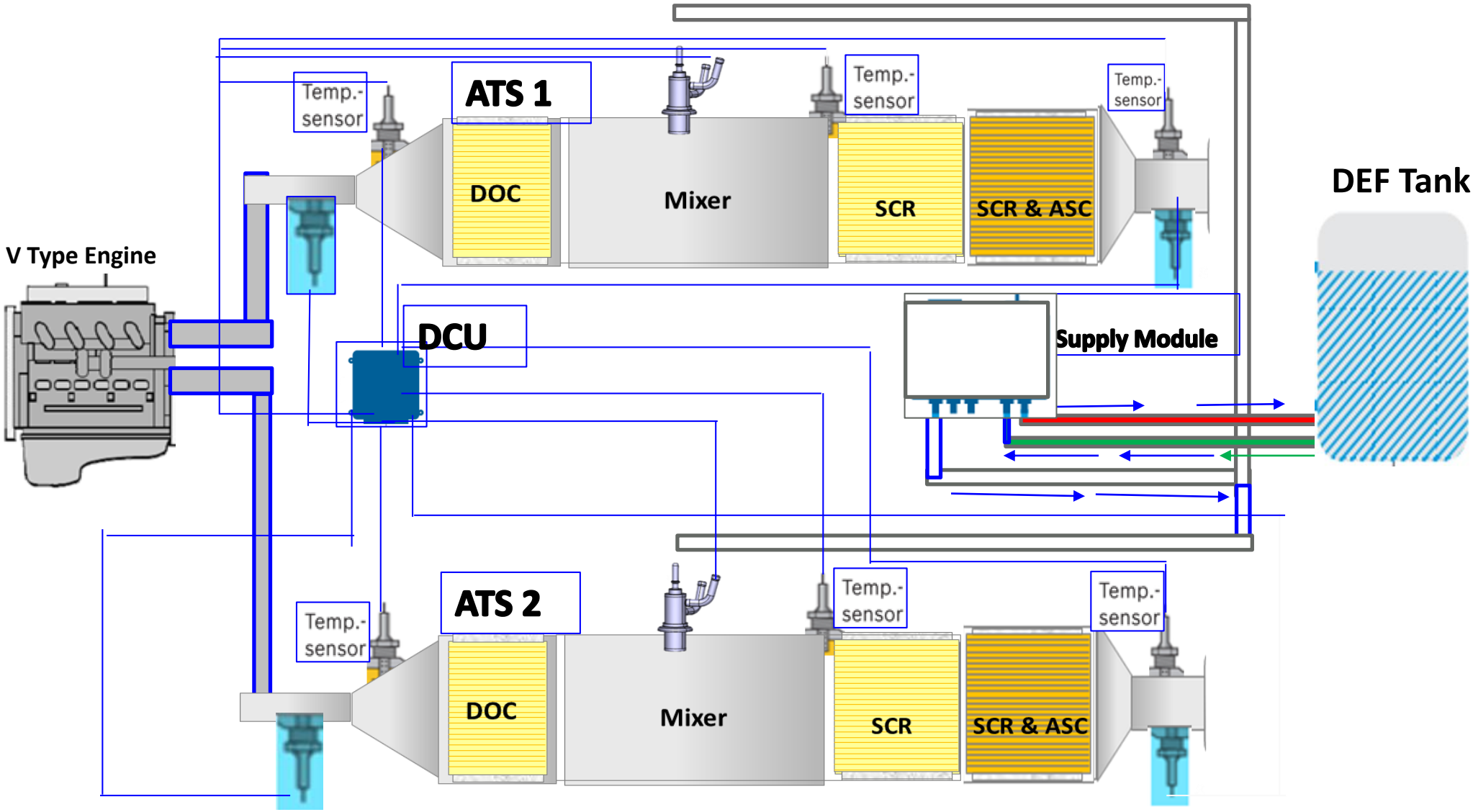
4. More Cold-Start Challenges

5. Control System Complexity



6. Higher Calibration Effort

Dual dosing system - Common Architecture



Solutions in the Market Today – Value analysis

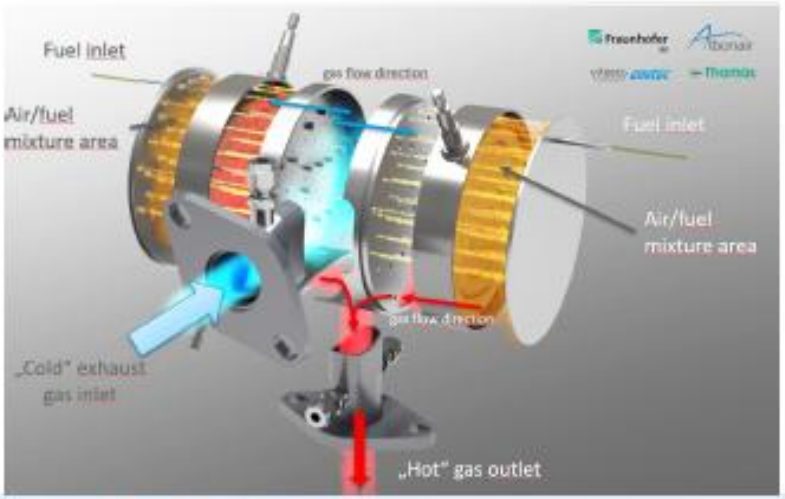
S.no	Possibile solutions	Availability in Market	Status
1	Close-coupled catalyst per bank (one DOC/SCR next to each head)	Predominantly Available	
2	Equal-length exhaust headers & matched runner geometry	Predominantly Available	
3	Thermal isolation and insulation of manifolds	Moderately Available	
4	Exhaust mixing collector / tuned merge geometry	Predominantly Available	
5	Active thermal devices (E-heaters / electric catalyst heating)	Less Prevelant	
6	Bank-specific sensing and closed-loop control	Less Prevelant	
7	Bank-wise fuel/ignition/after-treatment strategies	Less Prevelant	
8	Controlled Calibration Solution	Less Prevelant	
9	Bank Wise Independent Control System	Less Prevelant	

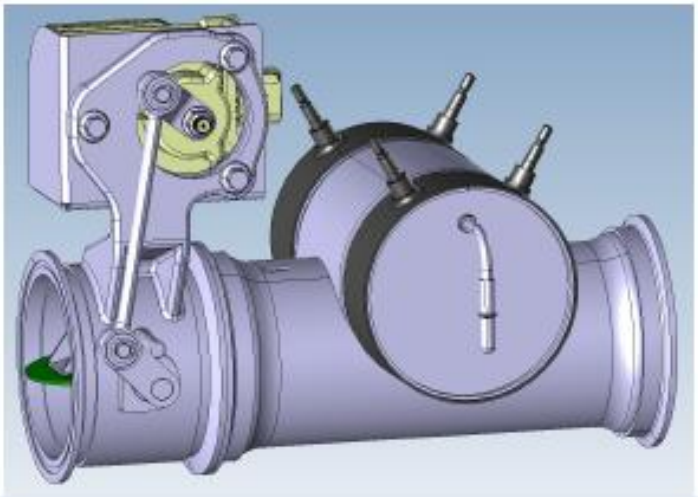
How Albonair Addresses the Challenges

S.no	Possibile solutions	Status	Albonair Solution	Status
1	Close-coupled catalyst per bank (one DOC/SCR next to each head)		Our Architecture is Close coupled Catalyst per Bank	
2	Equal-length exhaust headers & matched runner geometry		Our Solution take care of the variations in the exhaust length & runner geometry	
3	Thermal isolation and insulation of manifolds		Thermal insulation in ATS and exhaust pipes minimizes heat loss and boosts catalyst performance.	
4	Exhaust mixing collector / tuned merge geometry		Our Mixer is globally engineered for precision and proven in real-world use.	
5	Active thermal devices (E-heaters / electric catalyst heating)		Albonair's CAT VAP solution ensures efficient EATS thermal management	
6	Bank-specific sensing and closed-loop control		Albonair Hardware and Software Architecture independently controls each engine bank, ensuring stability and enabling dynamic exhaust-based adjustments.	
7	Bank-wise fuel/ignition/after-treatment strategies			
8	Controlled Calibration Solution			
9	Bank Wise Independent Control System			

Active Thermal Device - CATVAP

flexible System for ATS Heating and Keeping the Temperature

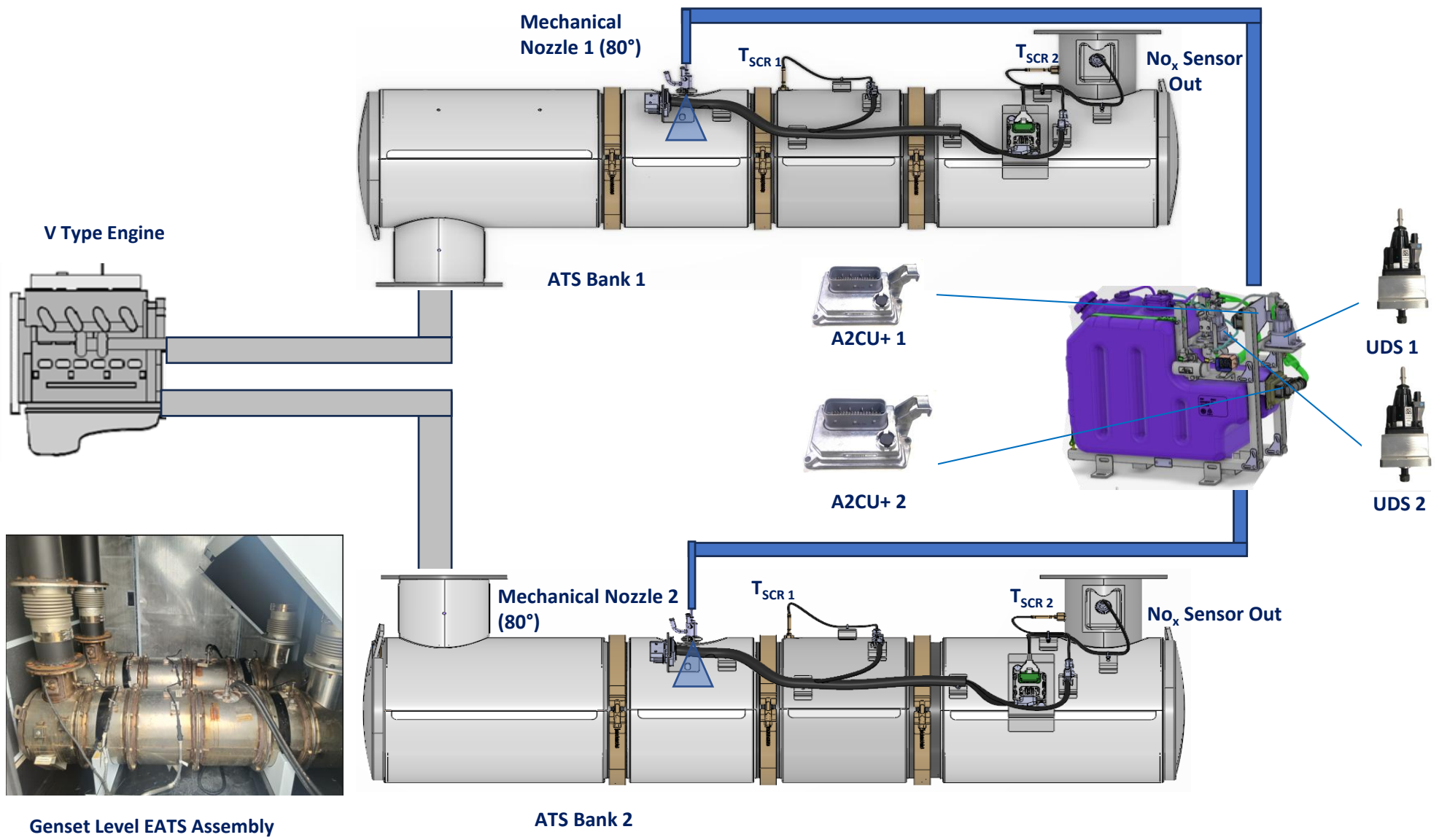




System Characteristics

- CatVap is a catalytic heating system using already existing components
- Efficient and flexible aftertreatment thermal-management
- Powered with fuel only, after short electrical system start
- No electric power consumption during further operation
- Keeps the exhaust temperature at target level independent of engine operation
- Continuous DOC / SCR temperature stabilization in "Heat retention mode"
- Enables active DPF regeneration (replacing HC doser) with high efficiency
- No engine thermal-management required

Albonair Dual Dosing System



Genset Level EATS Assembly

Albonair EATS Modular Approach

ATS Inlet Chamber can be Rotated 360°as per application and packaging requirement

ATS outlet Chamber can be Rotated 360°as per customer application and packaging

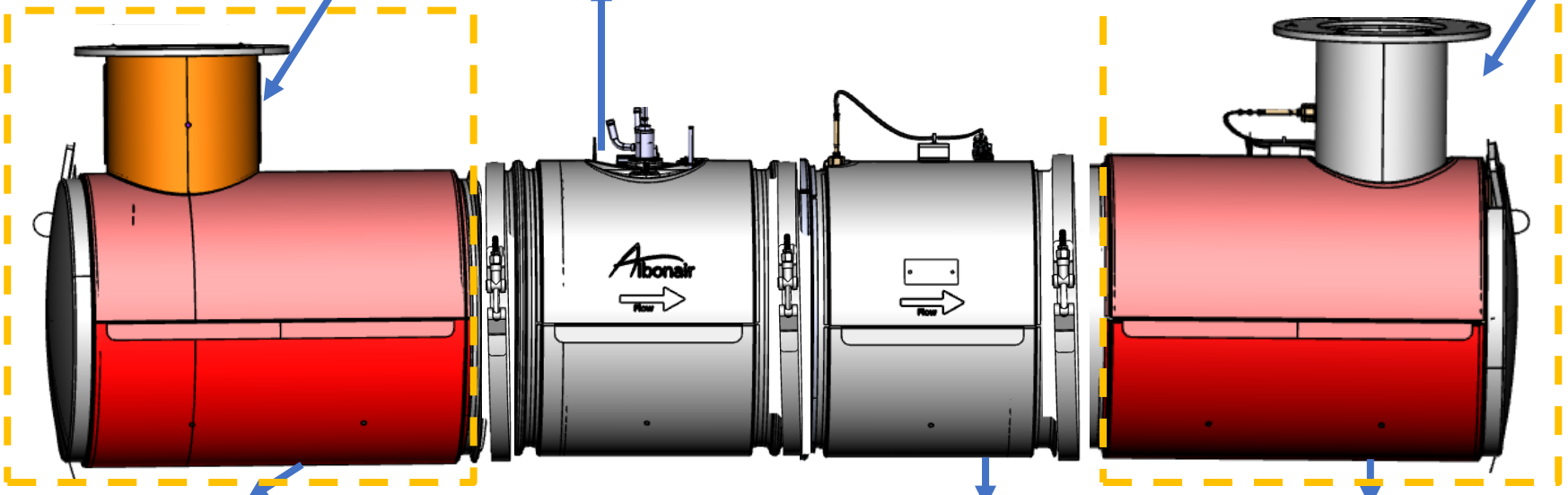
V Band for Service Purpose

Inlet Pipe

Mixing Chamber (Interchangeable)

Albonair Patented

Outlet Pipe



DOC Canning assembly

SCR Canning assembly (Interchangeable)

SCR with ASC Canning assembly

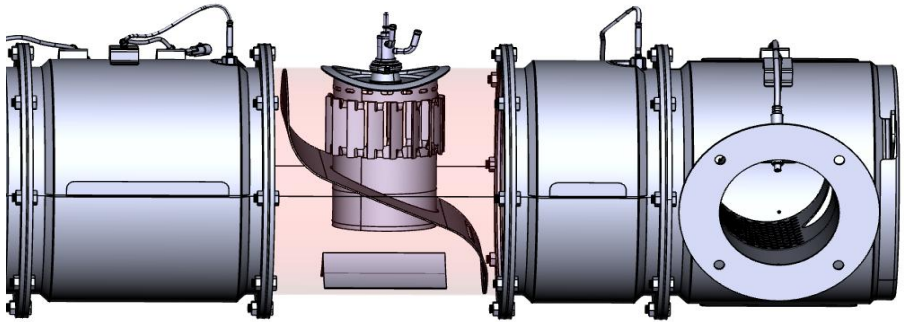
Albonair Unique Mixer for High Conversion Efficiency

Product Information

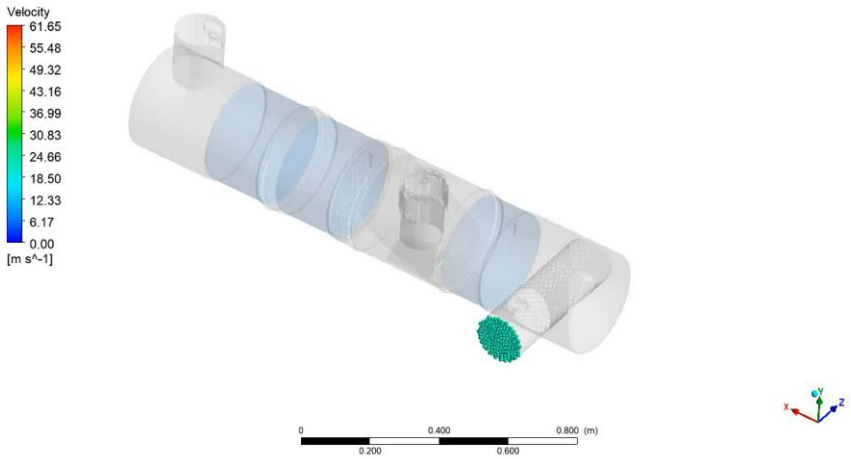
- Customized Design Layout
- High flow and N3B Uniformity
- High resistance to urea deposit
- Modular system easily adoptable to all application
- NH3 UI : >0.96
- NH3 Conversion rate : >95%
- Mixer Back pressure : 3kpa @ 1500kg/hr ,
  550 C Temperature

Cross Section view

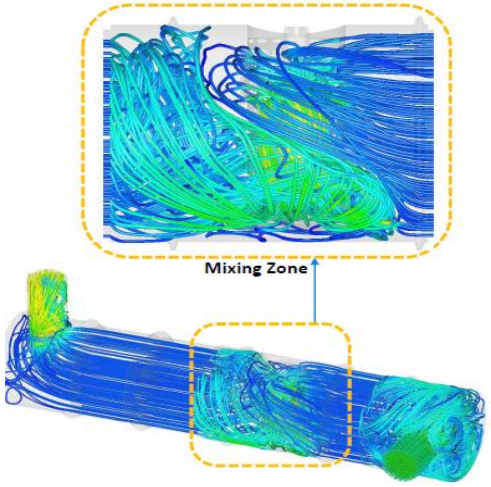
Albonair Linear flow Swirl type mixer



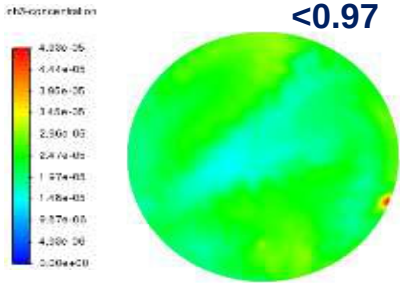
Animation



Swirl Pattern

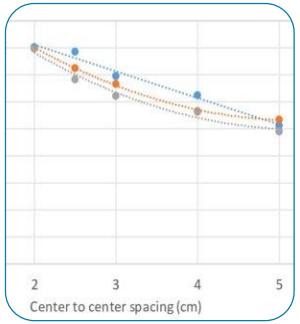


NH3 Uniformity index at before SCR Face at <0.97



Challenges in Urea Dosing system

Urea crystallization & nozzle clogging – deposits block injectors and lines.



Dosing inconsistency – poor control causes under/over-dosing, ammonia slip.

Freeze & thermal limitations – AdBlue freezes; high/uneven temps affect conversion.

Pump & injector wear – moving parts prone to corrosion, fatigue, and failure

Complex system architecture – multiple components increase failure points.

Maintenance & service challenges – cleaning, replacement, and diagnostics are labor-intensive.

*Images are for reference purpose only

Urea Dosing Solutions in the Market Today – Value analysis

S.no	Possible solutions	Predominant in Market	Status	Albonair Solution	Status 2
1	Purge Systems	Moderately Prevailent		By the virtue of desing enabling no free Urea in line , purging is eliminated in Albonair System	
2	Sensor & Control Strategies	Moderately Prevailent		Albonair injector assembly is completely mechnaical avaoiding complex control system requirements	
3	Active Cooling Systems	Predominant in Market		Engine Coolant acts as Cooling medium for Nozzle	
4	Redundant Cooling Paths	Predominant in Market		With Albonair Smart Pump which gets actuated only on request from controller , dosing is precise and accurate	
5	Manual Cleaning Possibility	Less Prevalent		Manual Cleaning with HOT water /flame Cleaning	
6	High-Temperature Materials	Less Prevalent		Albonair Injector Nozzle is made of Special Alloy Material which can withstand upto 800 Deg C	
7	Simplified Mechanism	Less Prevalent		Construction is simple which has no moving parts	
8	Service-Oriented Design	Less Prevalent		Nozzle is 100% recoverable in case of clogging which make the requirement for repalcement almost Zero	

Pump , Nozzle & ACU

Albonair Airless Dosing System

- **Reliable & Durable**: Uniform urea dosing with seamless integration
- **Consistent**: 4Kg/hr (12V) & 8Kg/hr (24V) with stable pressure control
- **Precise**: Built-in UREA pressure sensor for accurate dosing
- **Versatile**: Compact, maintenance-free design for on-road, off-highway & stationary use

Advanced SCR Nozzle

- **Robust**: Withstands up to 800°C, compact & zero-maintenance
- **Efficient**: Optimized atomization (~90µm airless) for better DEF usage
- **Consistent**: No DEF deposition or performance interruptions

Advanced EATS Controller

- **Flexible**: Dual-mode (Master/Slave) for dosing or full ATS management
- **Adaptive**: Supports standalone or end-to-end control
- **Robust**: –40°C to 85°C, IP6K9K protection
- **Compatible**: Works with wide ECU range via J1939 protocol

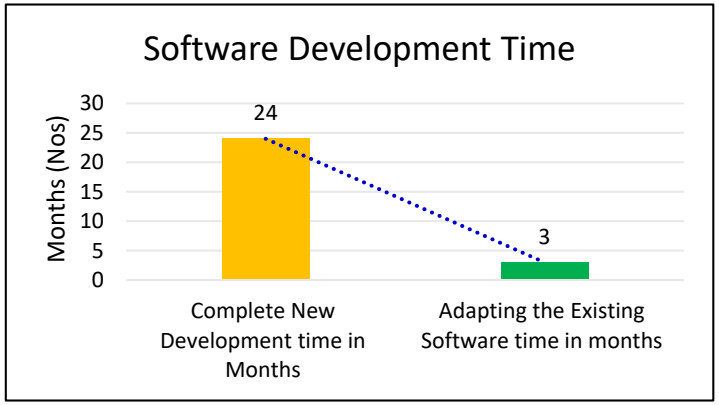
QCIS Benefits

Quality

- Independent bank-wise control enhances accuracy and system stability.
- Dynamic adaptation to exhaust variations ensures long-term reliability.
- Thermal insulations on ATS minimizes heat loss, improving catalyst efficiency
- Robust hardware & software architecture reduces calibration variations and failures.

Cost/Time

•Even with 2 Controllers and 2 Pump , our overall system cost is competitive adding value to OEMs overall system



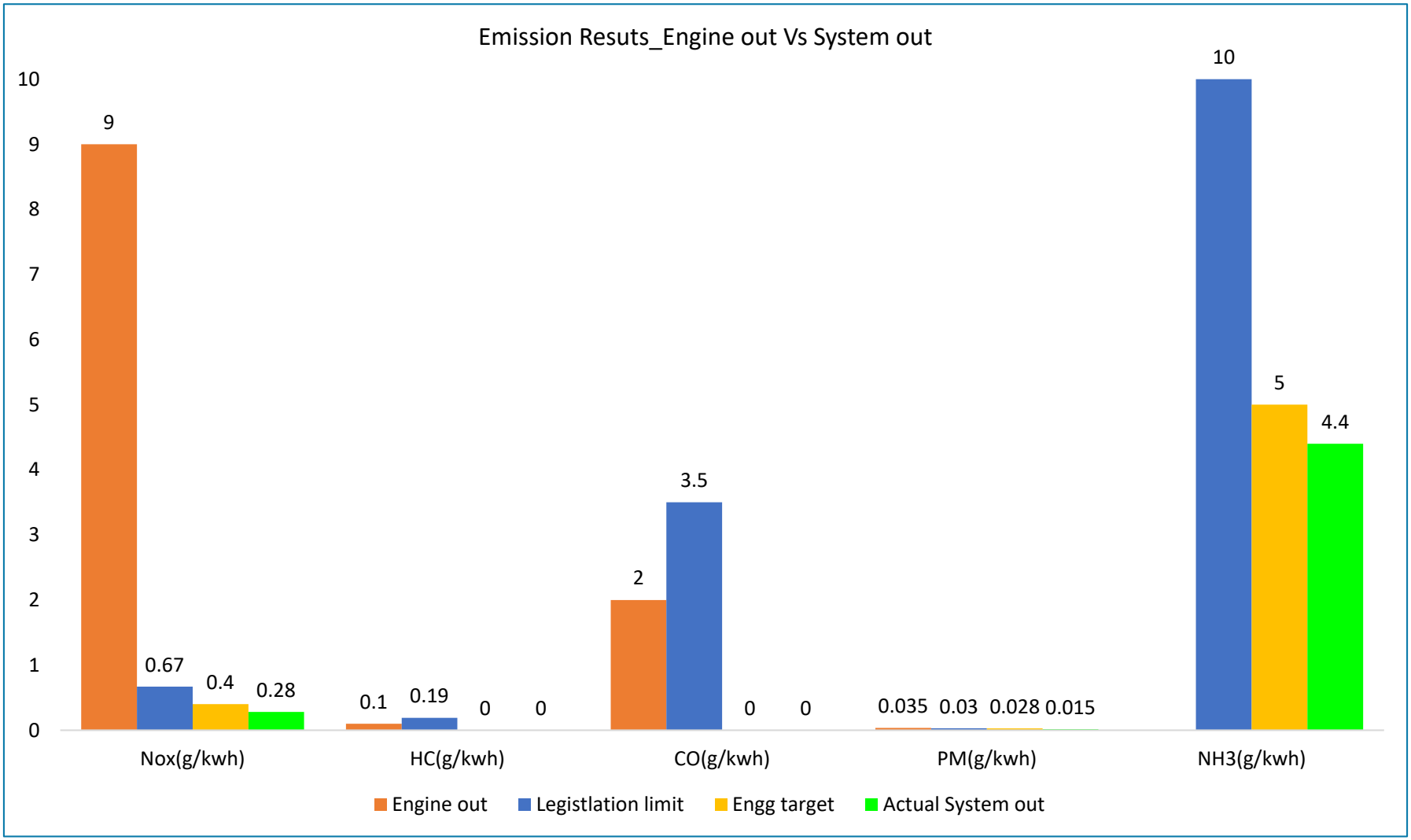
Innovation

- **Robust Control –** Software architecture Robust to varying Engine and emission conditions.
- **Smart Operation –** Pump actuates only on ACU request, ensuring efficiency and reduced wear.
- **High Conversion –** Advanced mixer achieves >95% NOx reduction efficiency.
- **Robust Design** – Mechanical nozzle free from temperature limitations, ensuring durability.

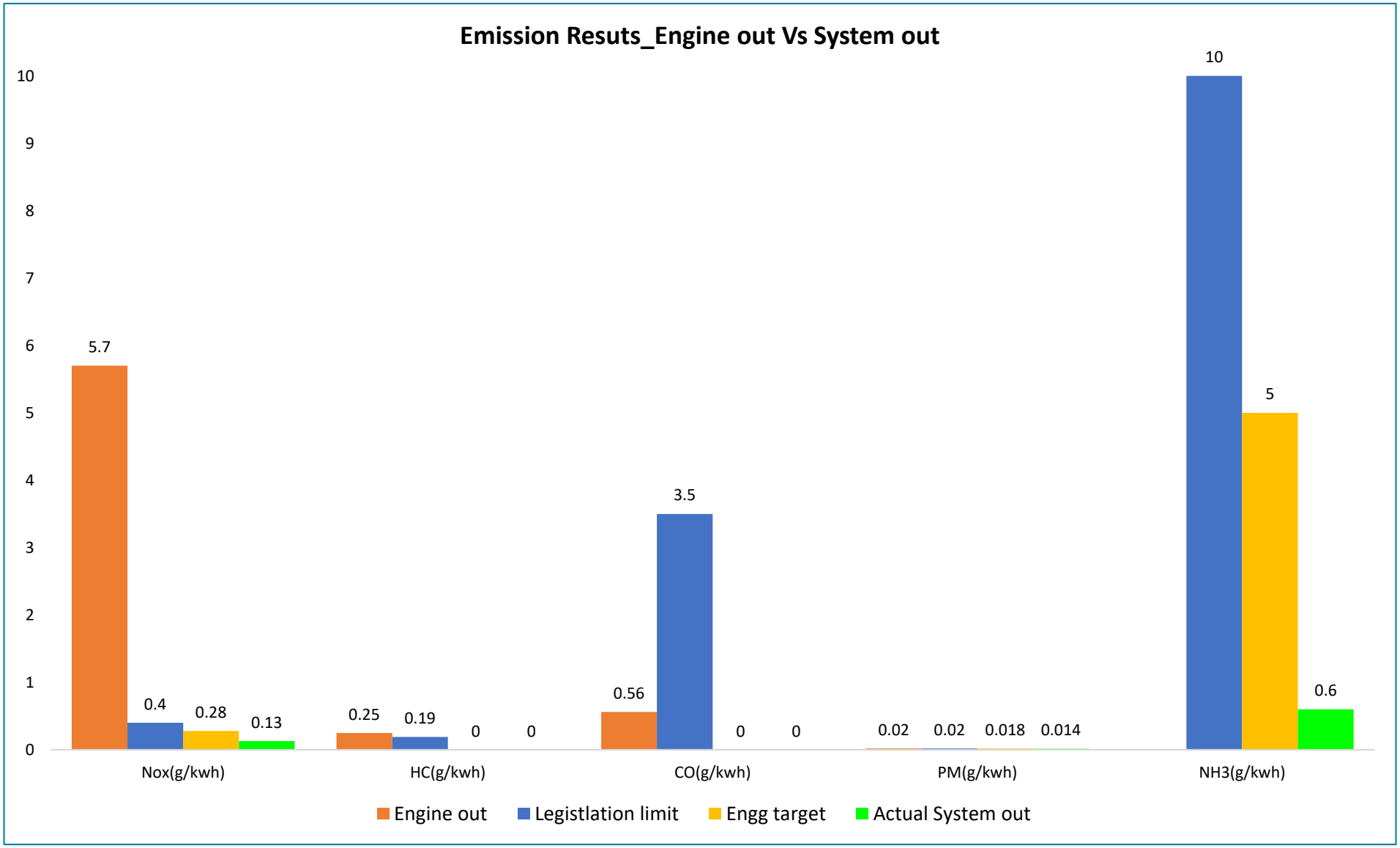
Sustainability

- **Lower Emissions –** Enhanced NOx reduction ensures cleaner air and compliance with stringent norms.
- **Resource Efficiency –** Optimized urea utilization minimizes wastage and reduces ammonia slip.
- **Extended Product Lifecycle** – Longer component life reduces replacements and lowers environmental footprint.
- **Energy Efficiency** – System operates only when needed, minimizing unnecessary energy consumption.
- **Robust & Reliable Design –** Durability against heat, crystallization, vibration, and long-term usage, ensuring sustainable operation.

Emission results 1



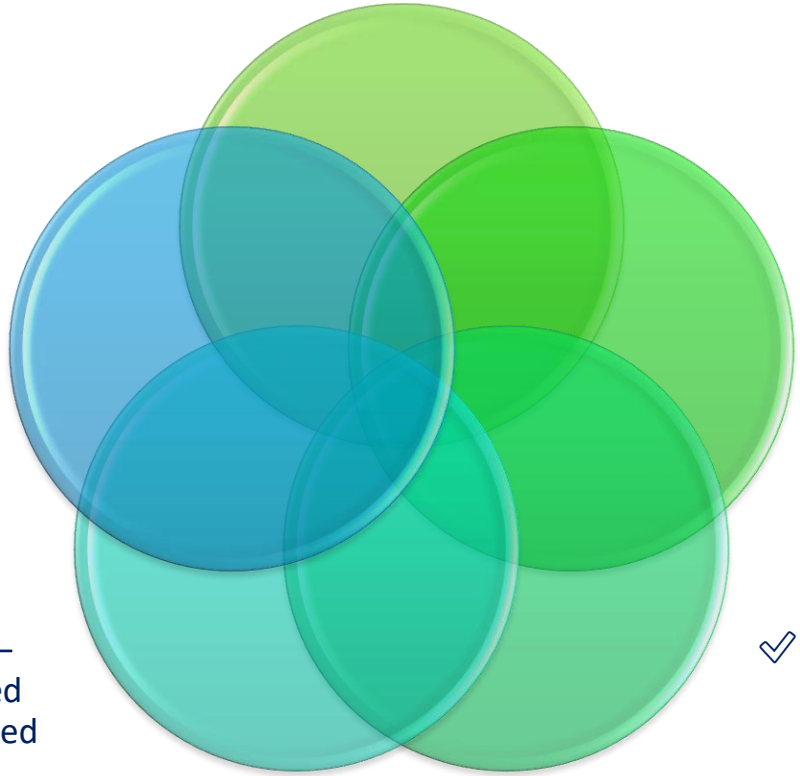
Emission results 2



Conclusion

✓ **Superior Quality** – Independent bank-wise control, dynamic adaptation, and robust architecture ensure accuracy, reliability, and minimized failures.

QCIS delivers a reliable, efficient, and future-ready solution for OEMs, ensuring long-term value and compliance with stringent emission norms



✓ **Cost & Time Advantage** – Competitive system cost with significant software development savings (24 months → 3 months with adaptation).

✓ **Sustainability Impact** – Lower emissions, optimized resource utilization, extended component life, and minimized energy consumption.

✓ **Innovative Design** – Robust control, smart pump actuation, and advanced mixer technology enable >95% NOx reduction efficiency.

Thank You

German Engineering for clean air