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Next Stage Emission Legislations: Challenges and Technical Solutions for Exhaust Gas After-Treatment

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BASF Environmental Catalyst and Metal Solutions

ECMA 15th International Conference 22-23rd Oct. 2024, New Delhi, India

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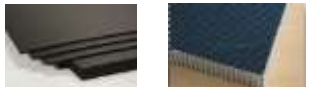
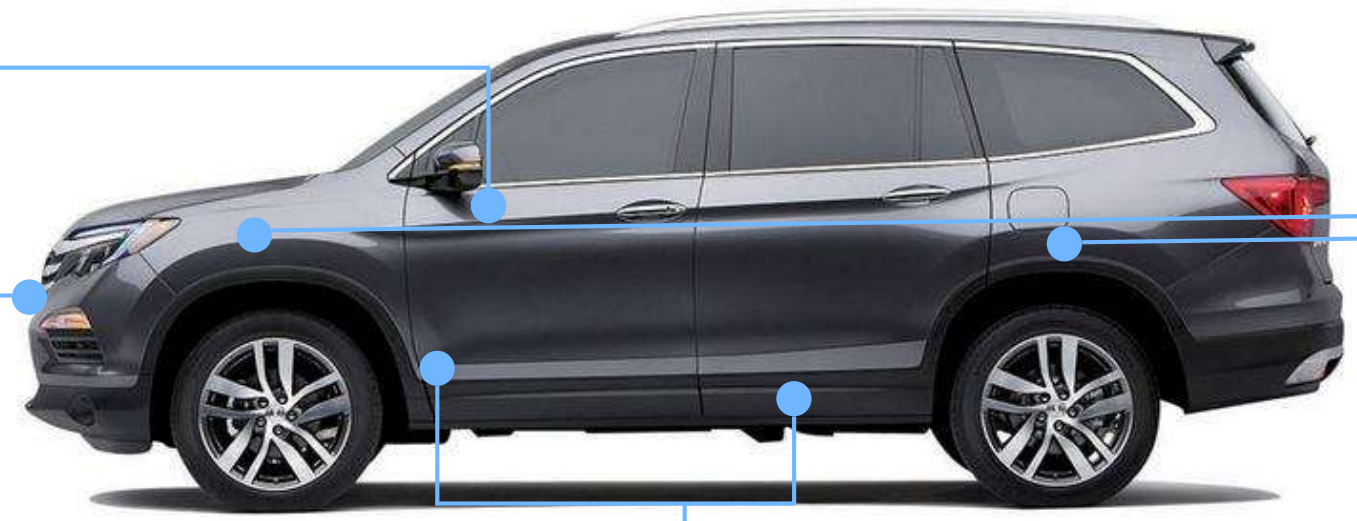
BASF Environmental Catalyst and Metal Solutions contribution to

“Cleaner Air Today, Every Day”

Cabin air VOC removal
Formaldpure ™



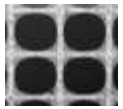
Ozone removal
Premair®



Red. of evaporative emissions
EvapTrap™ XC

Exhaust gas-aftertreatment for Diesel, gasoline, CNG, H_2, Ethanol...
TWC, FWC, SCR, AMOx, DOC ...


TWC


TWC


FWC


PGM


Recycling

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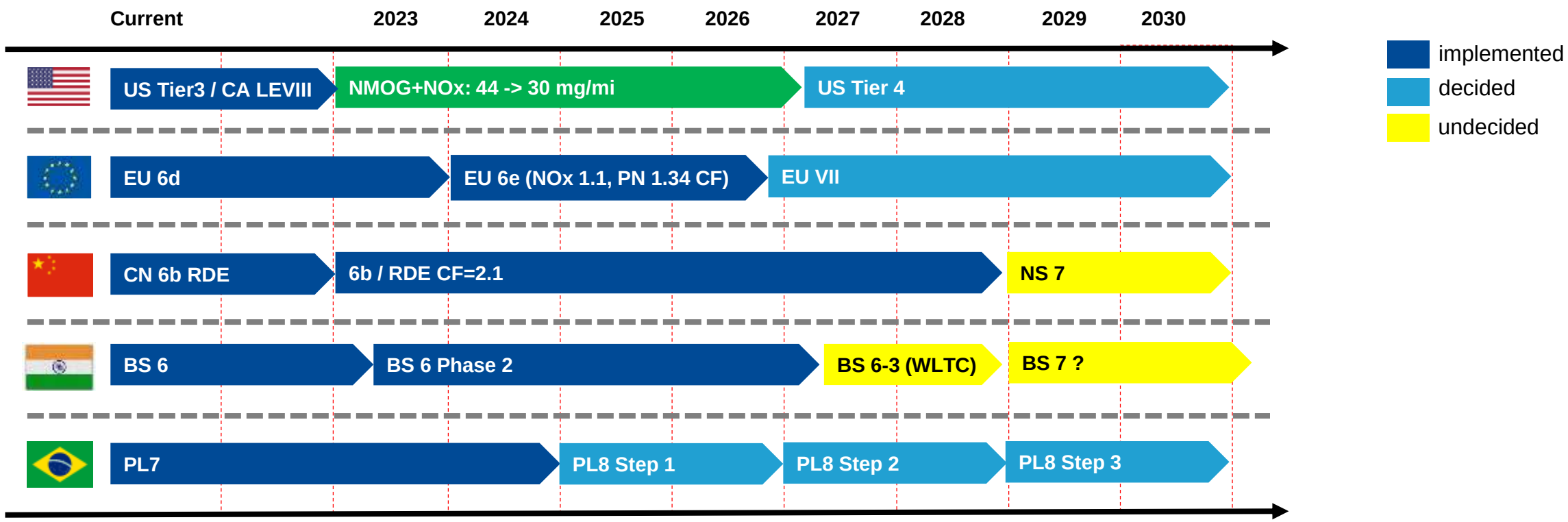
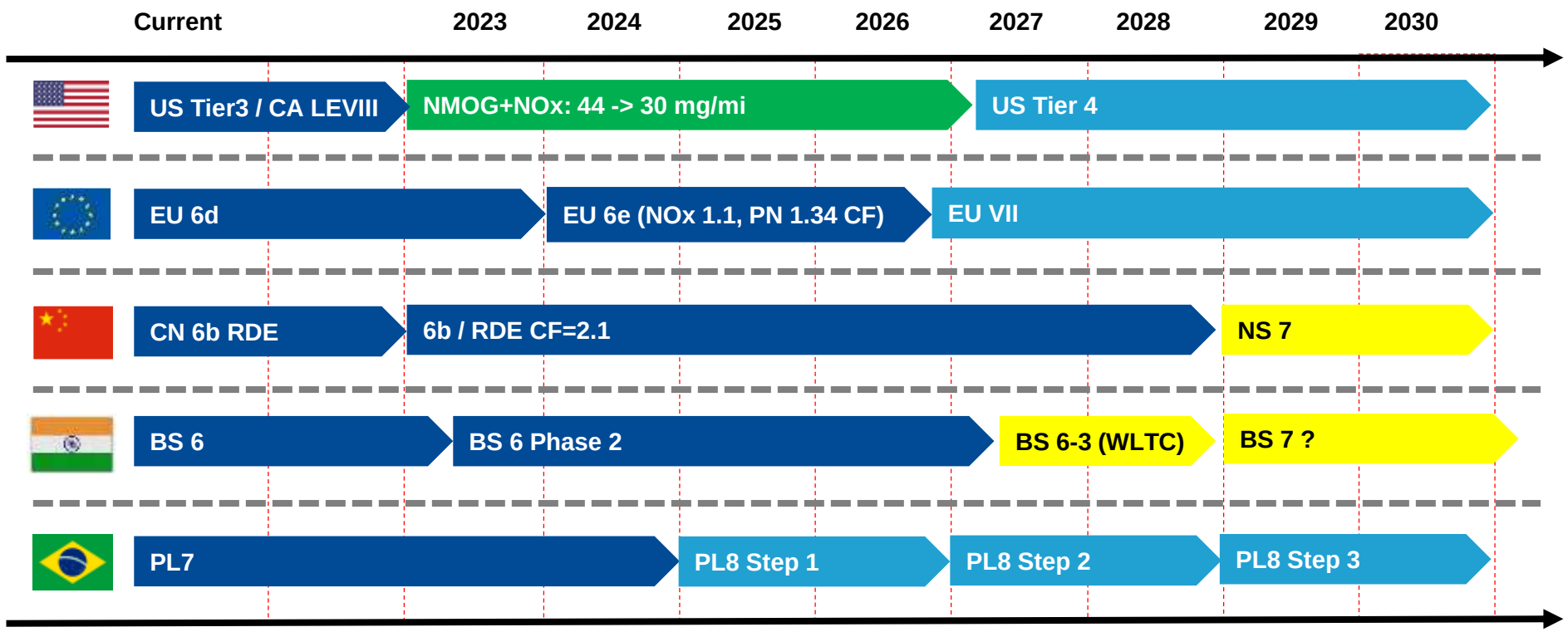
Global Regulation Timeline & Trends Light Duty Passenger Cars



Global Regulation Timeline & Trends Light Duty Passenger Cars



- implemented
- decided
- undecided

Fuel diversity

- CNG
- Ethanol
- Methanol

Secondary pollutants

- NH_3
- N_2O
- HCHO

Particle emissions

- Low PM
- PN_{10}

Test cycles

- WLTC
- RDE w/ enlarged boudnary cond.

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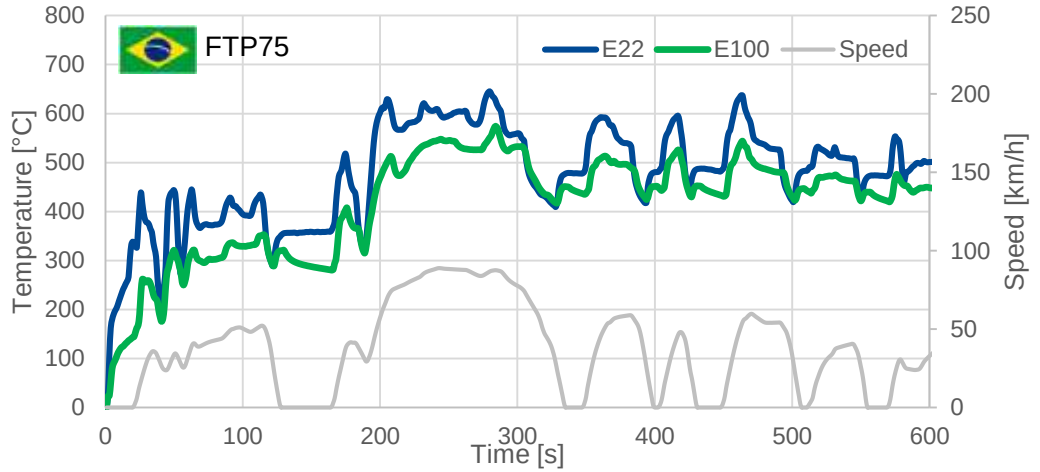
Ethanol as a fuel

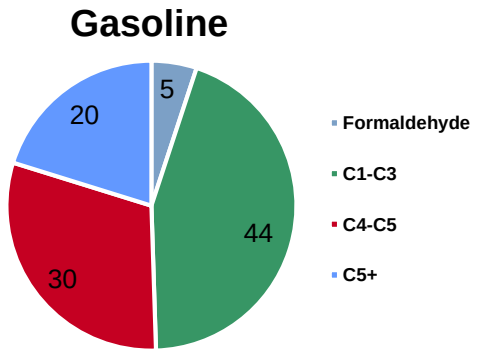
Fuel properties

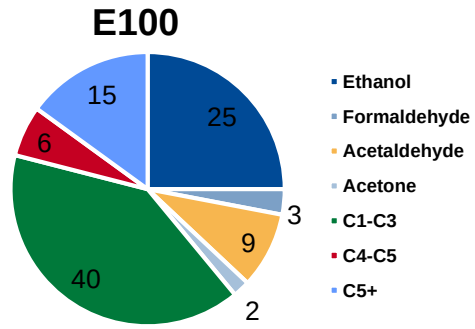
	Gasoline	Ethanol
Formula	C4 to C12	CH_3CH_2OH
Density (kg/L at 15 °C)	0.69–0.79	0.79
Vapor pressure (kPa at 38 °C)	48–103	15.9
Latent heat of vaporization (kJ/kg)	349	923
Octane number	88–100	108.6
Stoichiometric air–fuel ratio	14.7	9
Heat of combustion (MJ/kg)	42.4	26.8

*Koç M., etc., Renewable Energy, 34(10), 2009, 2101-2106.
*Nakata K.,SAE Technical Paper, 2006-01-3380

Typical engine out Temperature and HC emissions







- Challenge: slower catalyst heat up and different hydrocarbon mixture with high amount of Ethanol and other oxygenated organic gases

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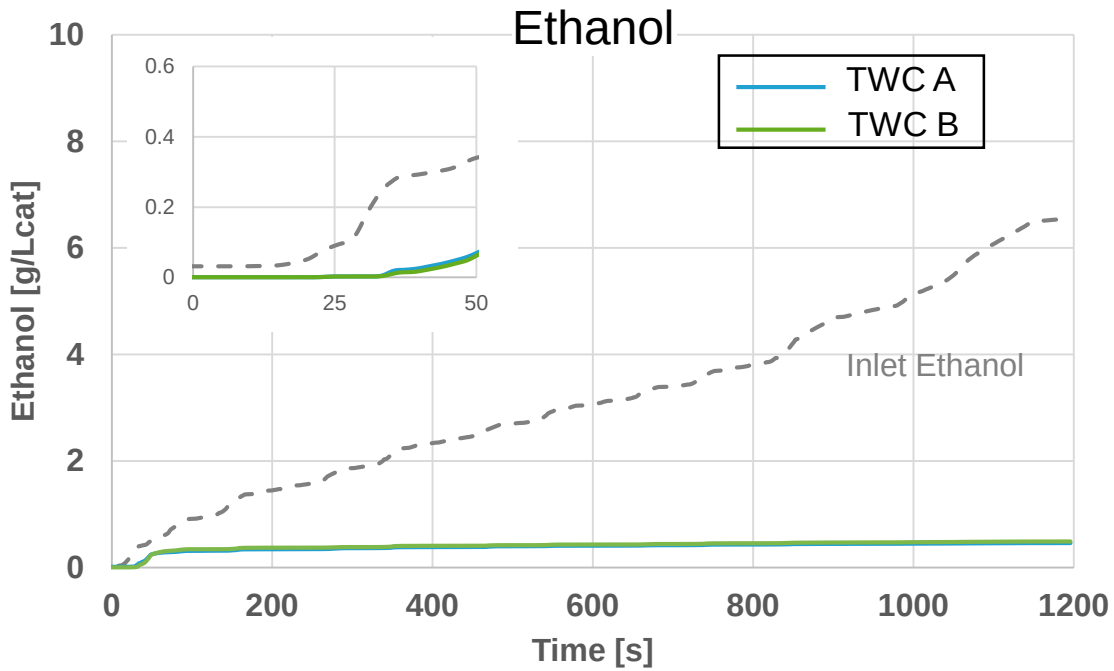
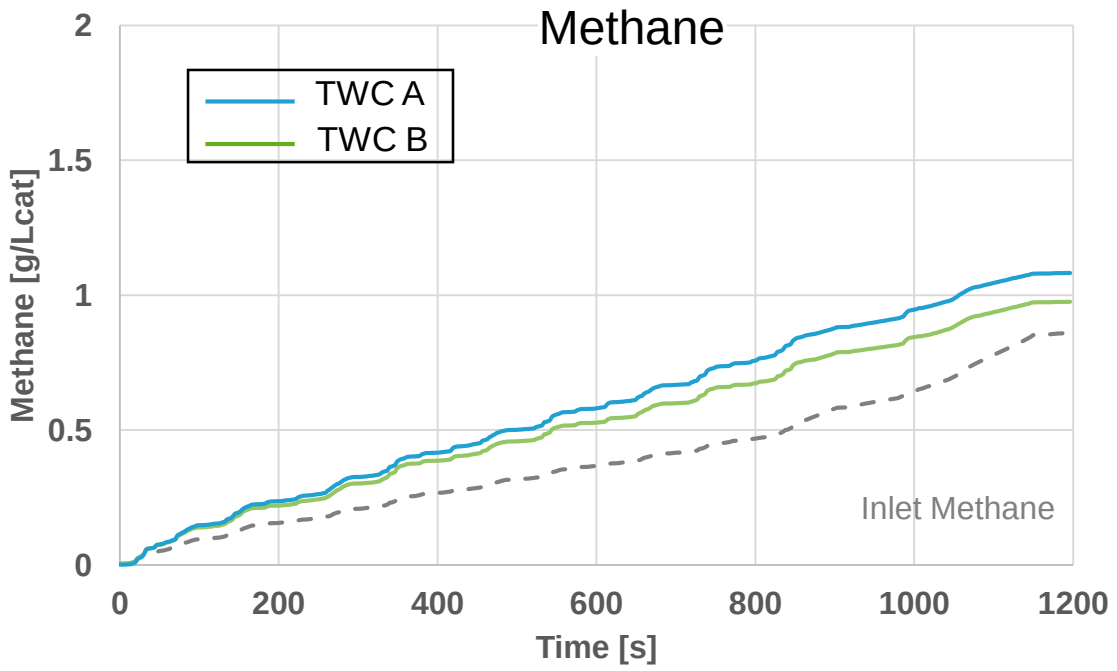
Ethanol as a fuel

- FUL aged TWCs with identical PGM loading
- Tested on reactor simulating a E100 MIDC





- High Ethanol conversion can be achieved after cold-start
- Methane make due to Ethanol decomposition observed
  - Temperature and catalyst design critical
  - Methane included as THC in BS-6 legislation (compared to NMOG in Brazil)

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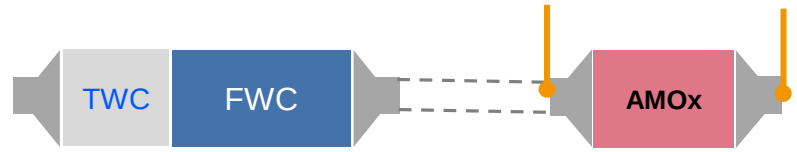
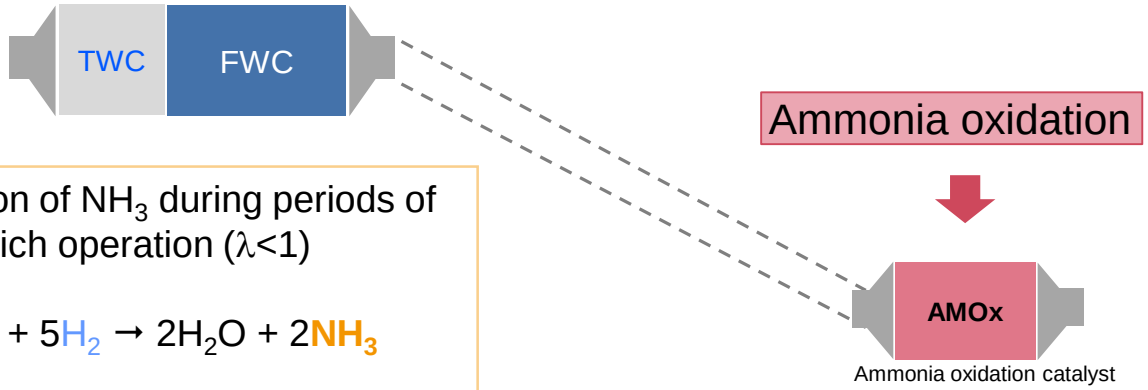
Secondary Emissions: NH_3





Ammonia oxidation

Formation of NH_3 during periods of rich operation ($\lambda<1$)

$2NO + 5H_2 \rightarrow 2H_2O + 2NH_3$

Minimize NH_3 formation

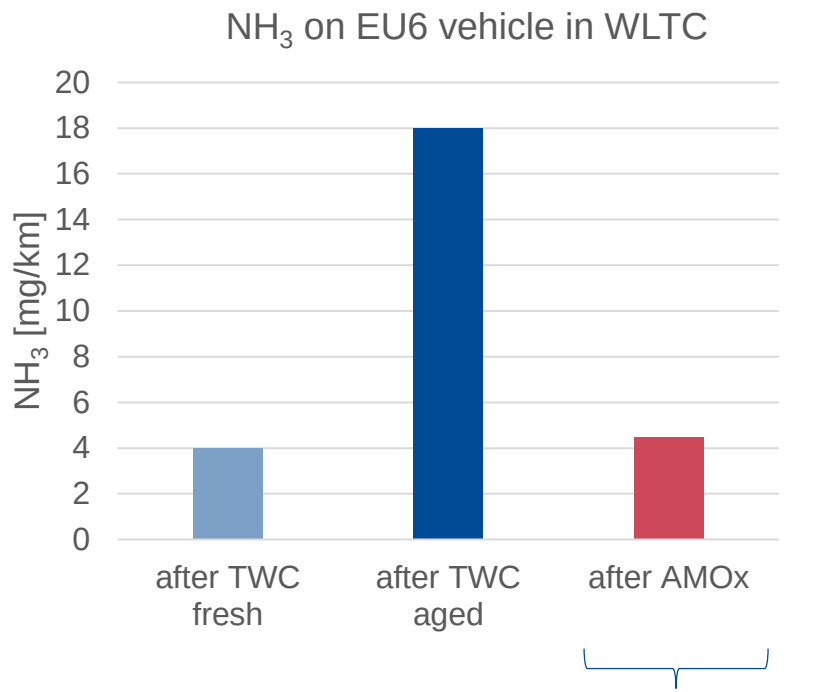
- Optimized TWC for low NH_3 make
- Improved calibration / λ-control
  - Less / shorter rich phases

AMOx can oxidize NH_3 to N_2

$4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$
$4NH_3 + 4NO + O_2 \rightarrow 4N_2 + 6H_2O$

and store NH_3 during rich operation

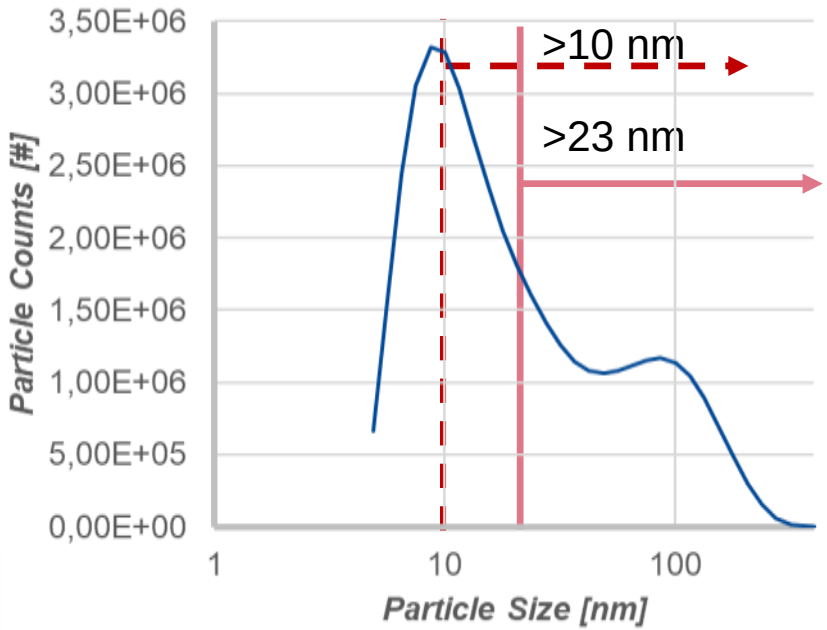
Example



AMOX™ = Ammonia Oxidation Catalyst

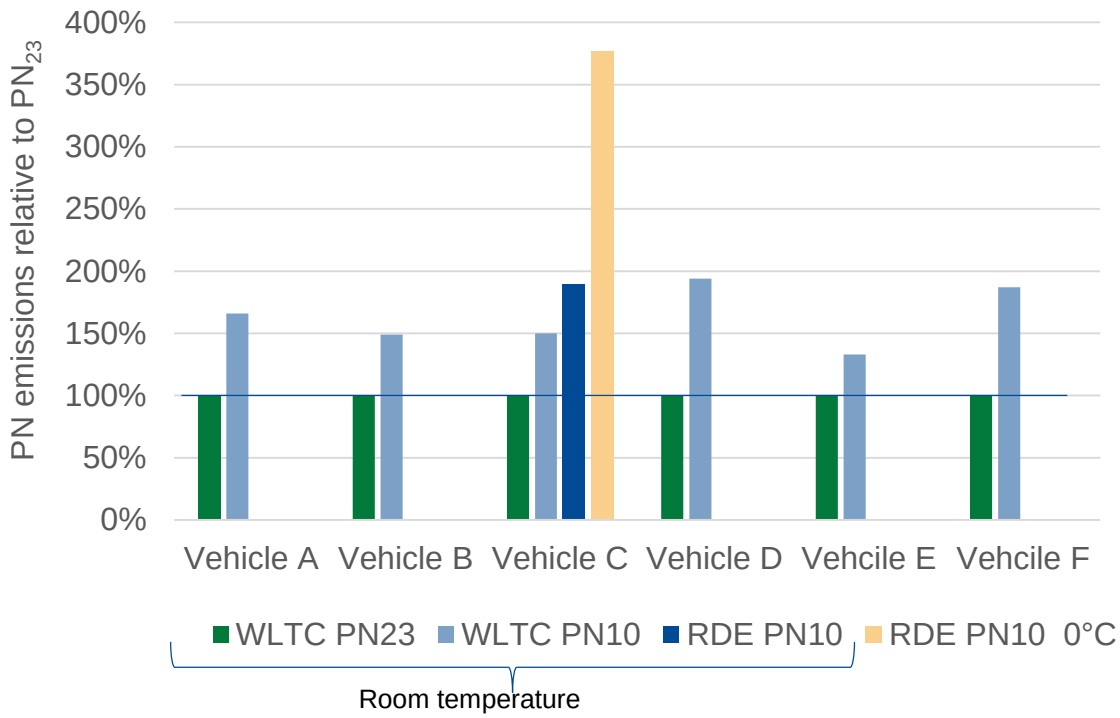
Particle Emissions PN_{10} challenge

Engine out particle size distribution start peak (0 – 35 s) on 2.0 L T-GDI engine (RT*)



Measured with DMS500

PN_{10} vs PN_{23} engine out emissions for different vehicles



BASF Shanghai Engine Lab

Measured with APC 489 PN_{10} and PN_{23} at RT

- Including particles between 10 to 23nm size, the engine out PN emissions increased by 30 to 100%
- Lower ambient temperature leads to strongly increased amount of particles

*RT = room temperature

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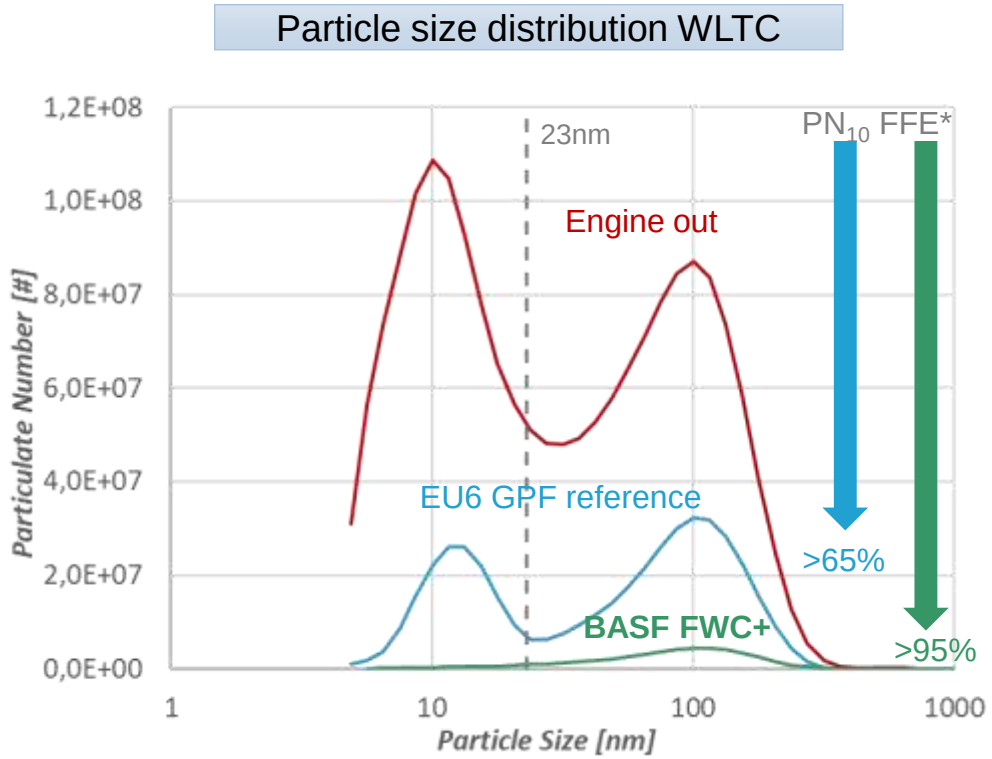
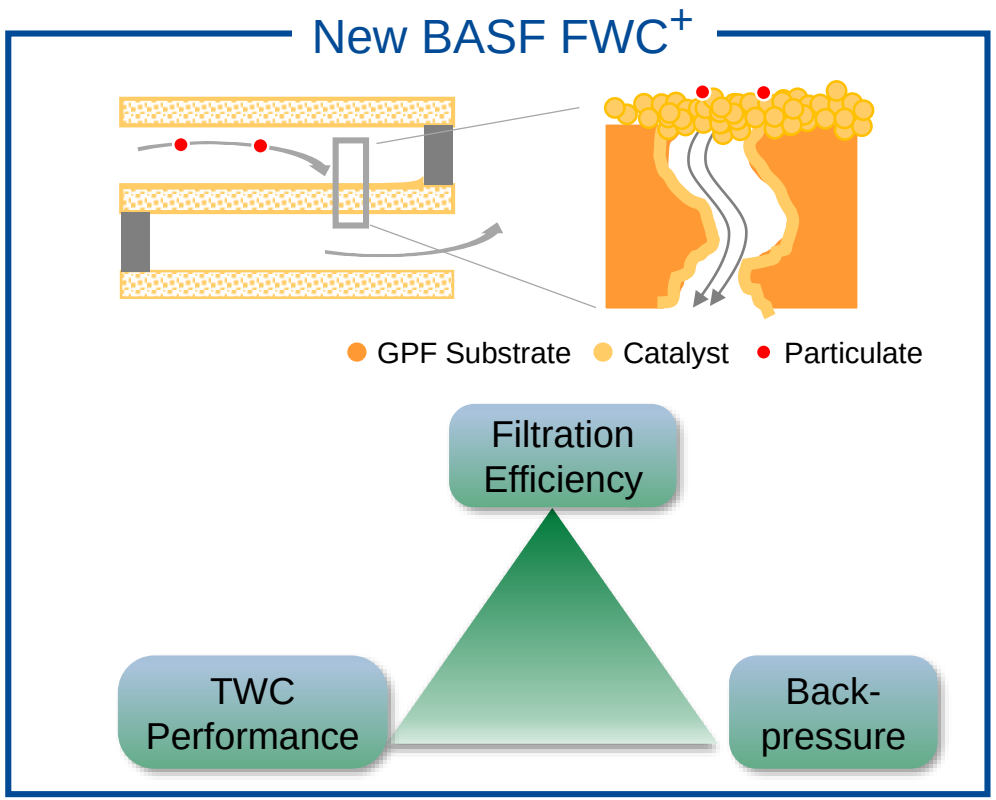
Particle Emissions PN_{10}

New solution for High Filtration Efficiency: FWC^+





- New FWC^+ exhibits excellent Fresh Filtration Efficiency also in PN_{10} size range with overall FFE >> 95 possible
- State-of-the-art BASF Filter Technology FWC^+ balancing TWC activity, backpressure and FFE
- In serial production in India

* FFE = Fresh Filtration Efficiency

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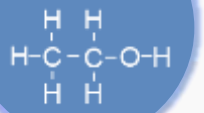
Challenge

NH_3
PN_{10}

New pollutants

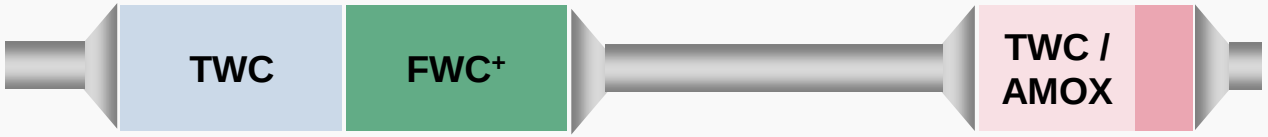
CH_4



Fuel Diversity

Extended test cycles

BASF ECMShas dedicated technologies and co-development capabilities to tackle the challenges of future emission legislation



- Fast Light-off
- High performance
- Durability

- Cover Dynamics
- Super high FFE
- Low Δp

- NH_3 & CO/NO breaktrhoughs

together

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ECT – 2024

15TH INTERNATIONAL CONFERENCE & EXHIBITION

Theme - "Clean Air Today, Every Day"

22nd & 23rd October 2024

New Delhi

BASF ECMS is firmly determined to innovate with new solutions for Cleaner Air Today, Every Day

New R&D Lab in Chennai opened by our CEO and CTO

Fully equipped laboratory for state-of-the-art catalyst development

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