Evolution des technologies de l'échappement

Emmanuel JEAN, 25 octobre 2017

Agenda

1 Faurecia 2016 Highlights

2 Exhaust Technologies Evolution

- 2.1 Diesel Hot End
- 2.2 Gasoline Hot End
- 2.3 Cold end & Lightweight
- 2.4 Energy Recovery

3 Conclusion

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Ranking #1 worldwide with each of its 3 Business Groups

VALUE-ADDED SALES 2016

Seating
€6.6 Billion

Seats structures, manual and electric seat mechanisms, comfort products and systems, trim covers, complete seat assembly

Interiors
€4.8 Billion

Instruments panels, door panels, center console and acoustic modules

Clean Mobility
€4.2 Billion

Technologies for air quality, Energy efficiency & thermal management, lightweight, acoustic performance

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Global market leader acting for a Clean Mobility

HIGHLIGHTS 2016

€4.2 Billion
Value-added Sales
€7.3 Billion
Total Sales

27
Countries

8
R&D Centers

21,700
Employees

79
Sites

3 130
Engineers & Technicians

** Value-added sales : Total Sales w/o Monoliths*



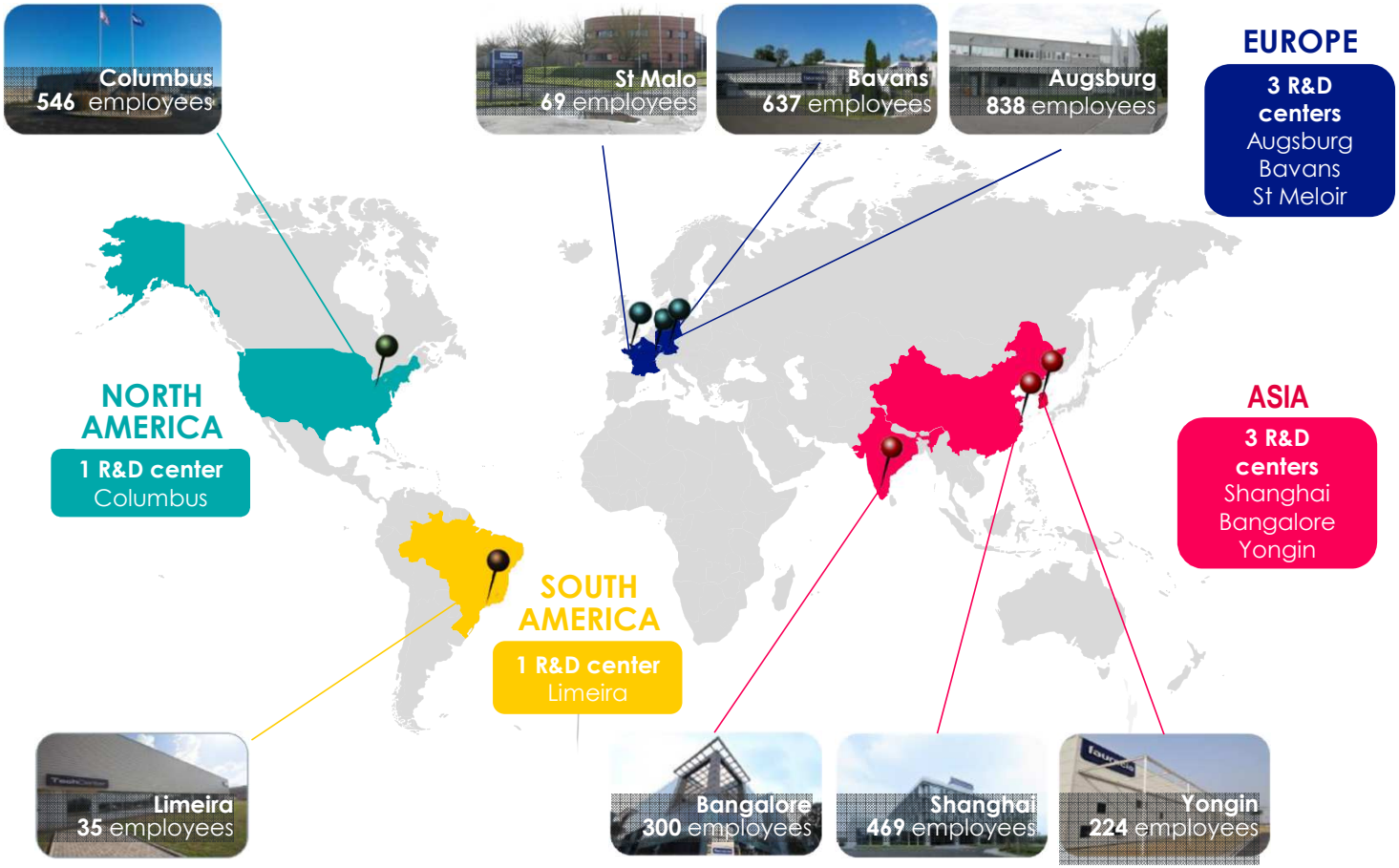
Worldwide global engineering footprint

3 130
Engineers & Technicians

> 1 000
Patents

8
R&D centers

240
Programs in development



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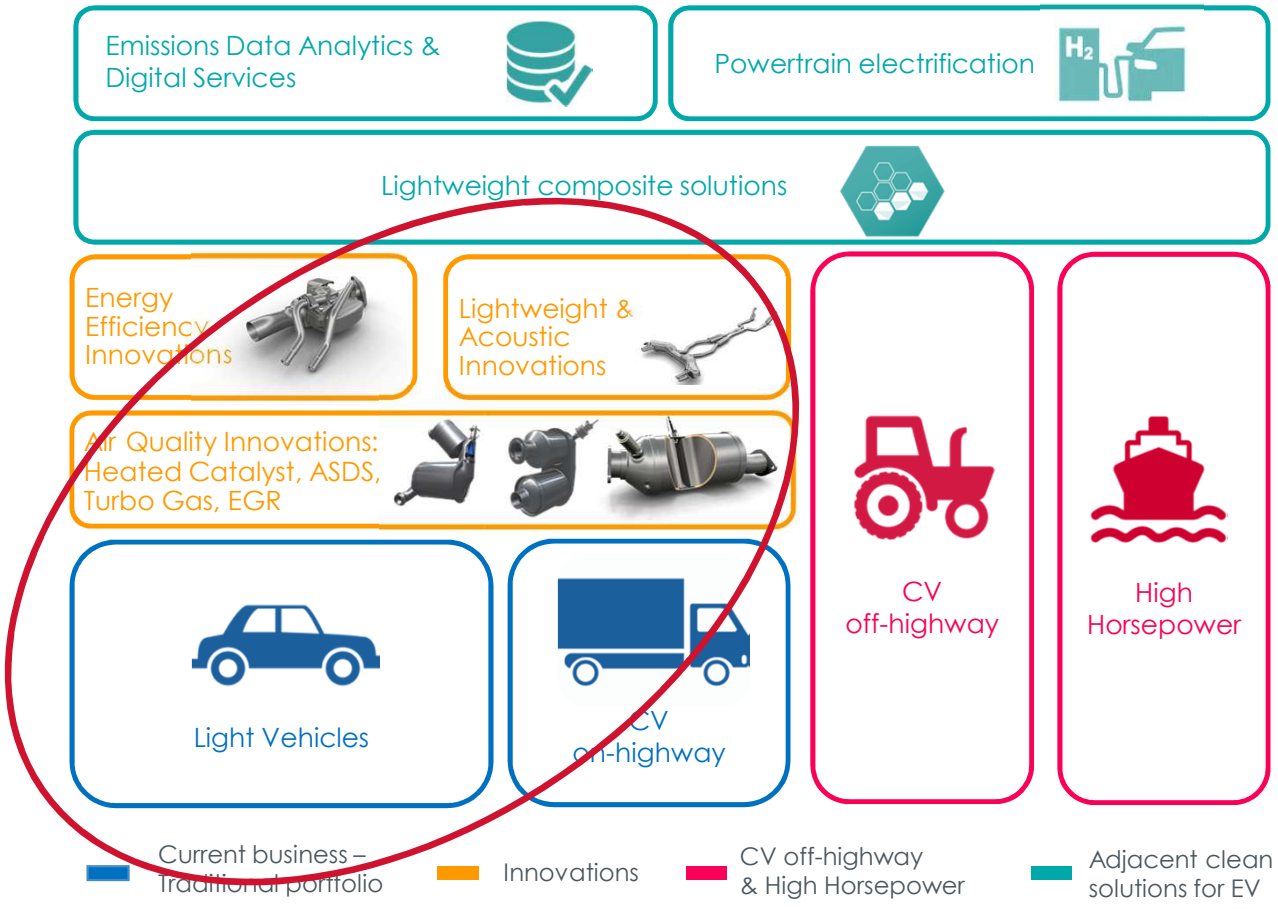
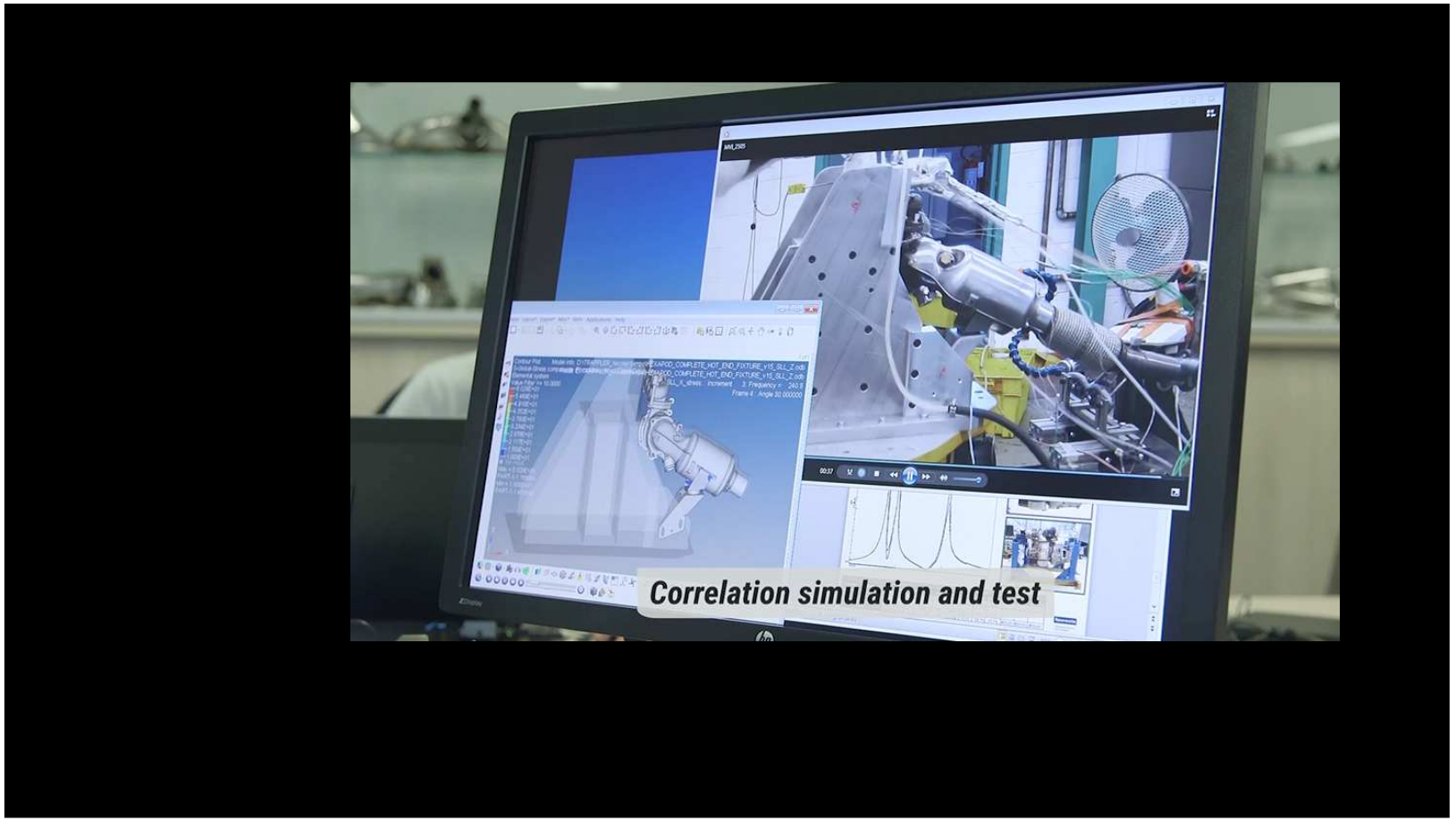
Expanding our portfolio of solutions to new value spaces



Engineering competencies for Clean Mobility



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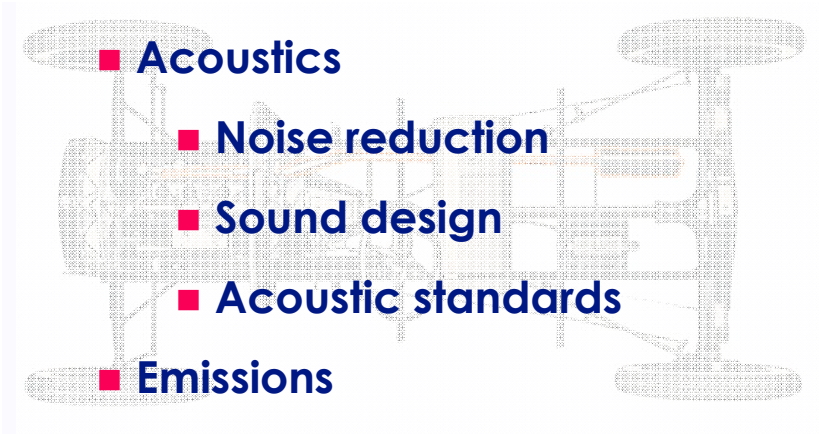
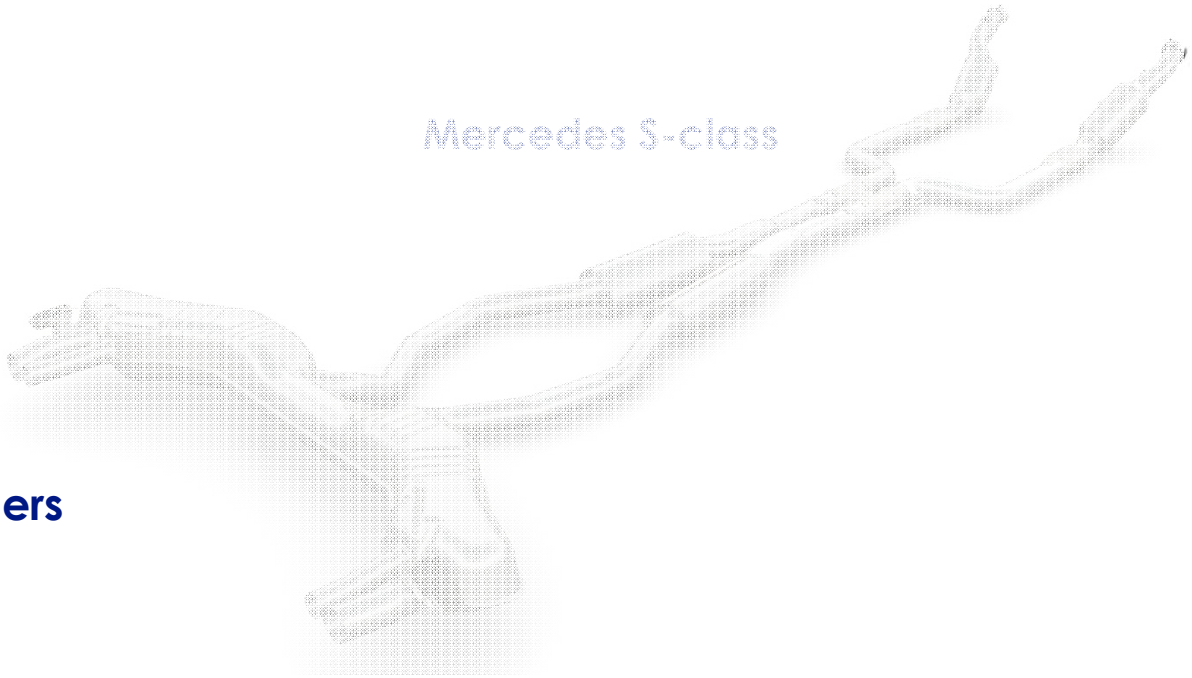
Exhaust system evolution

- Main Drivers:
  - Acoustics
    - Noise reduction
    - Sound design
    - Acoustic standards
  - Emissions
    - Emission standards
  - Powertrain technology
    - Combustion, number of cylinders
  - Durability





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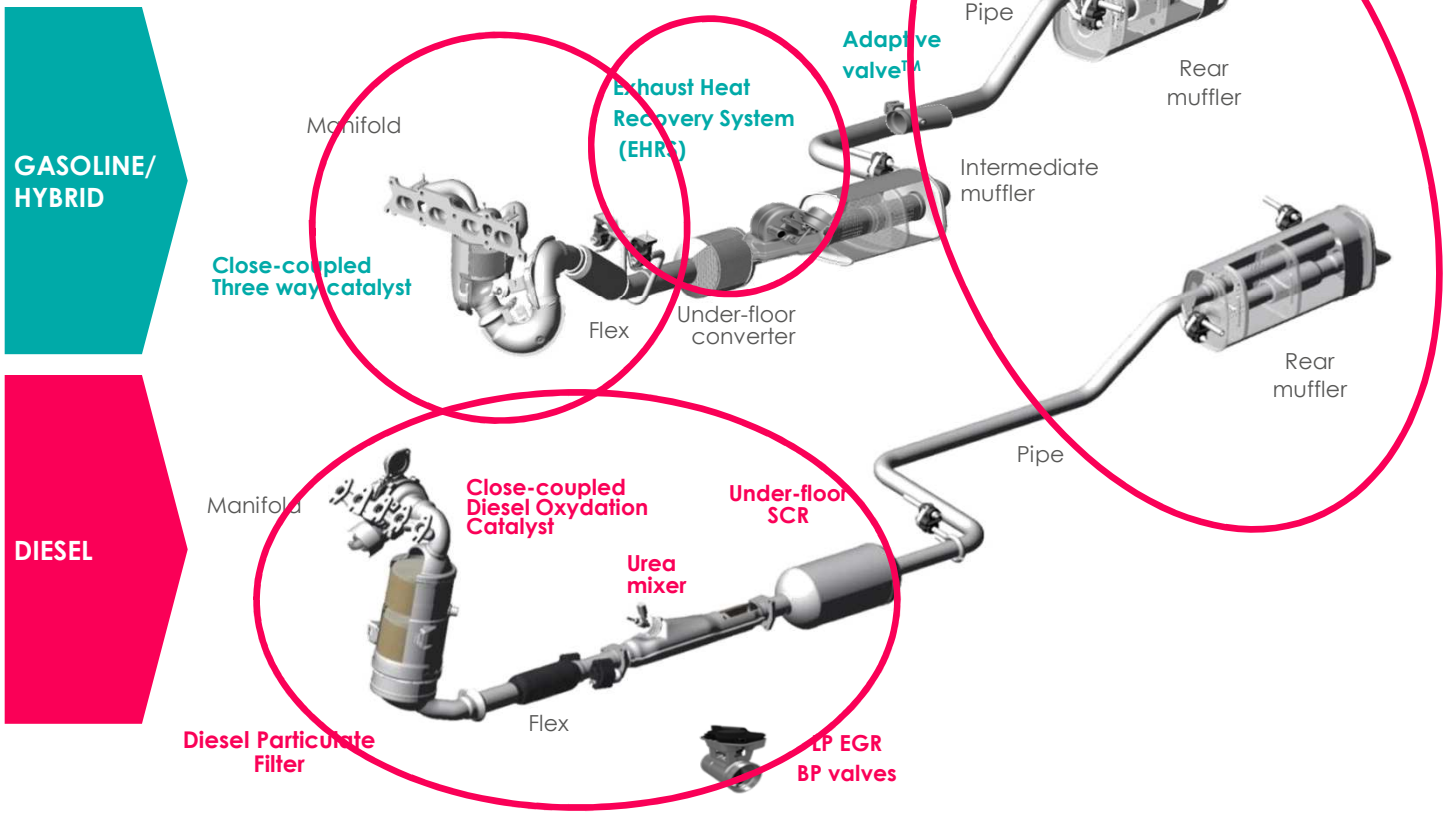
Typical exhaust system for Gasoline and Diesel powertrain



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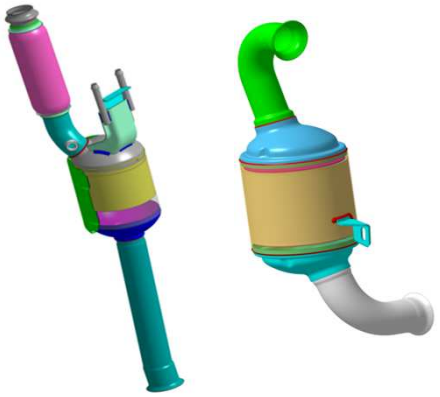
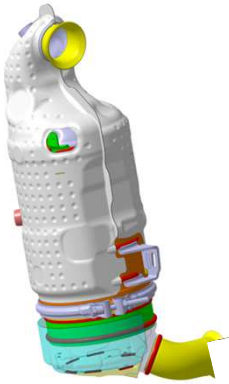
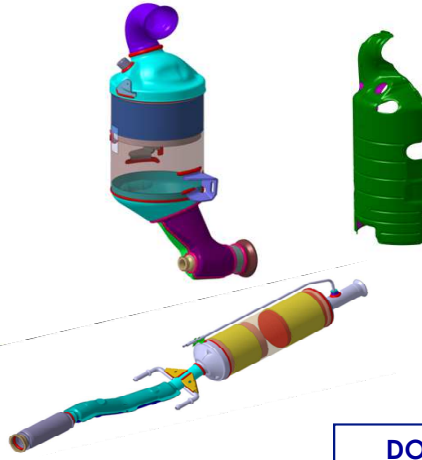
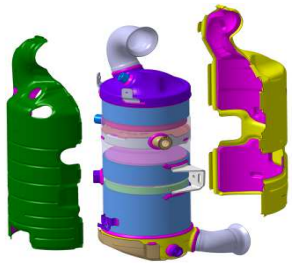
Diesel Hot End Architecture: Evolution with regulations

DOC: **D**iesel **O**xidation **C**atalyst
DPF: **D**iesel **P**articulate **F**ilter
LNT: **L**ean **N**ox **T**rap
SCR: **S**elective **C**atalytic **R**eduction

Euro 1	Euro 2	Euro 3	Euro 4	Euro 5	Euro 6b	Euro 6dT
						
No converter	**DOC**		**DOC** **Or** **DOC + DPF**	**DOC + DPF + Thermal Insulation**	**DOC + DPF** **Thermal Insulation** **+ Denox system** (SCR or LNT)	**DOC + SCRF** (Compact Mixer) **+SCR** **+Thermal Insulation**
1992	1996	2000	2005	2009	2014	2017

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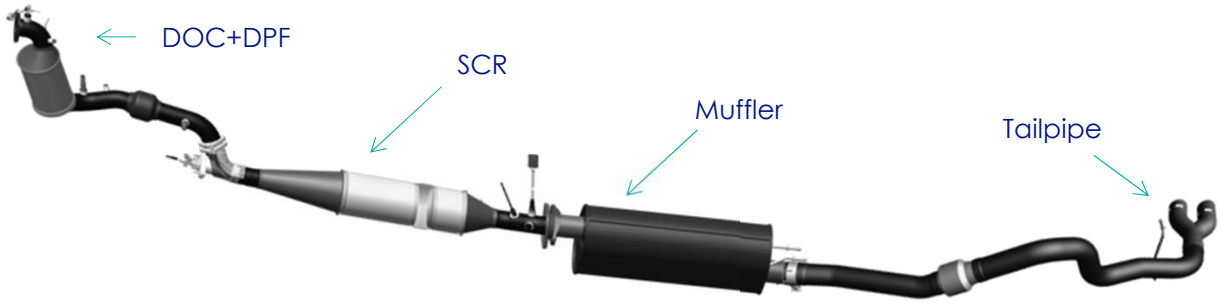
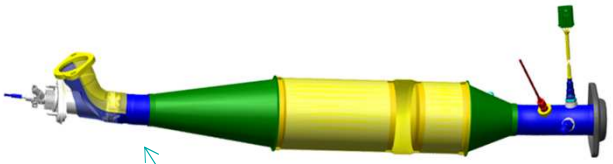
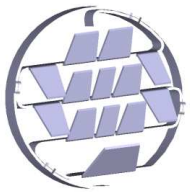
Underfloor SCR



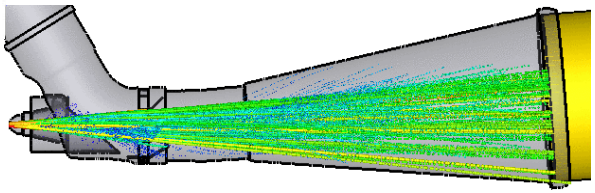


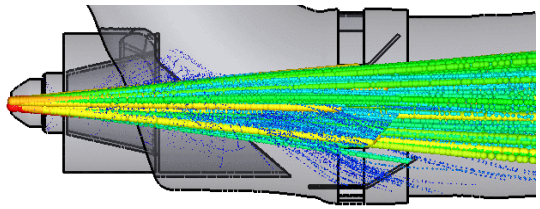
SCR system



Urea mixer

- **An additional reductant (AdBlue® is 32.5% urea water solution) is injected into the exhaust**
- **Main challenge: evaporation/ transformation of the AdBlue® into NH_3 and homogeneous distribution on SCR-catalyst**





CFD calculations

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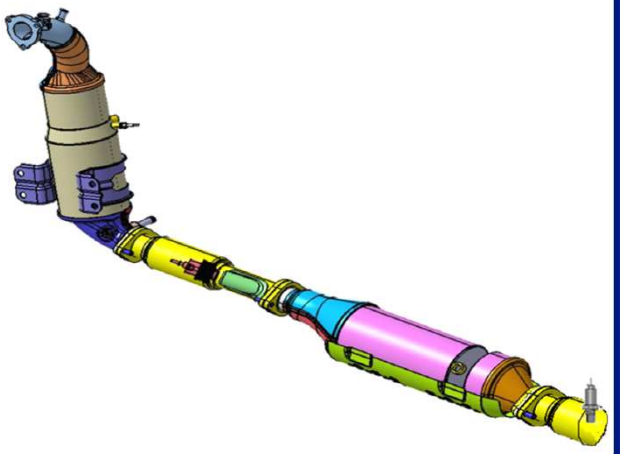
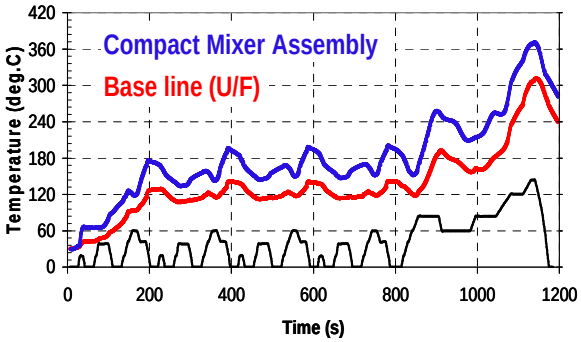
From Underfloor to Close-coupled SCR architecture

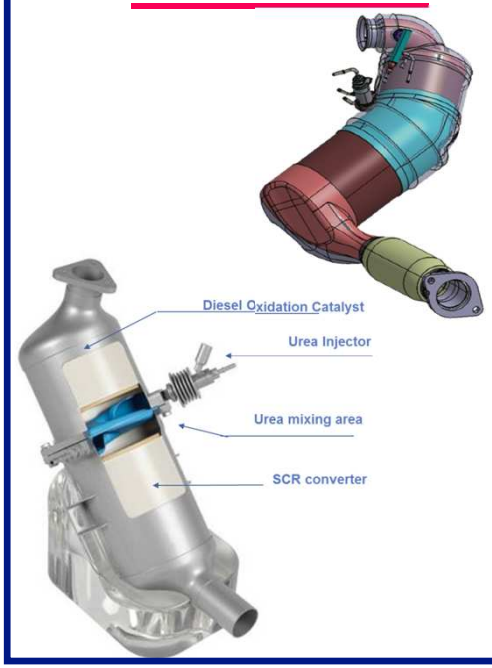
Underfloor SCR



SCR inlet catalyst temperature **increases by ~40°C**:



Close-Coupled SCR



Better efficiency at low temperatures through compact mixer and SCR_on_DPF

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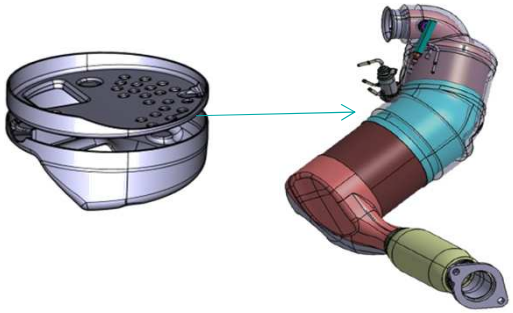
Compact mixer has to adapt to all packaging constraints

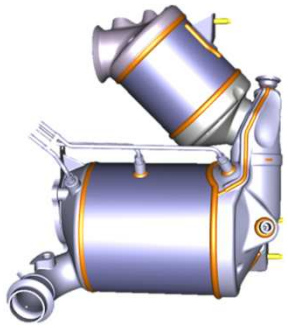
- **SCR mixer in development with different shapes :**

U-Shape Mixer

I-Shape Mixer



V-Shape Mixer



3 “standard” compact mixers configurations to cover the market needs

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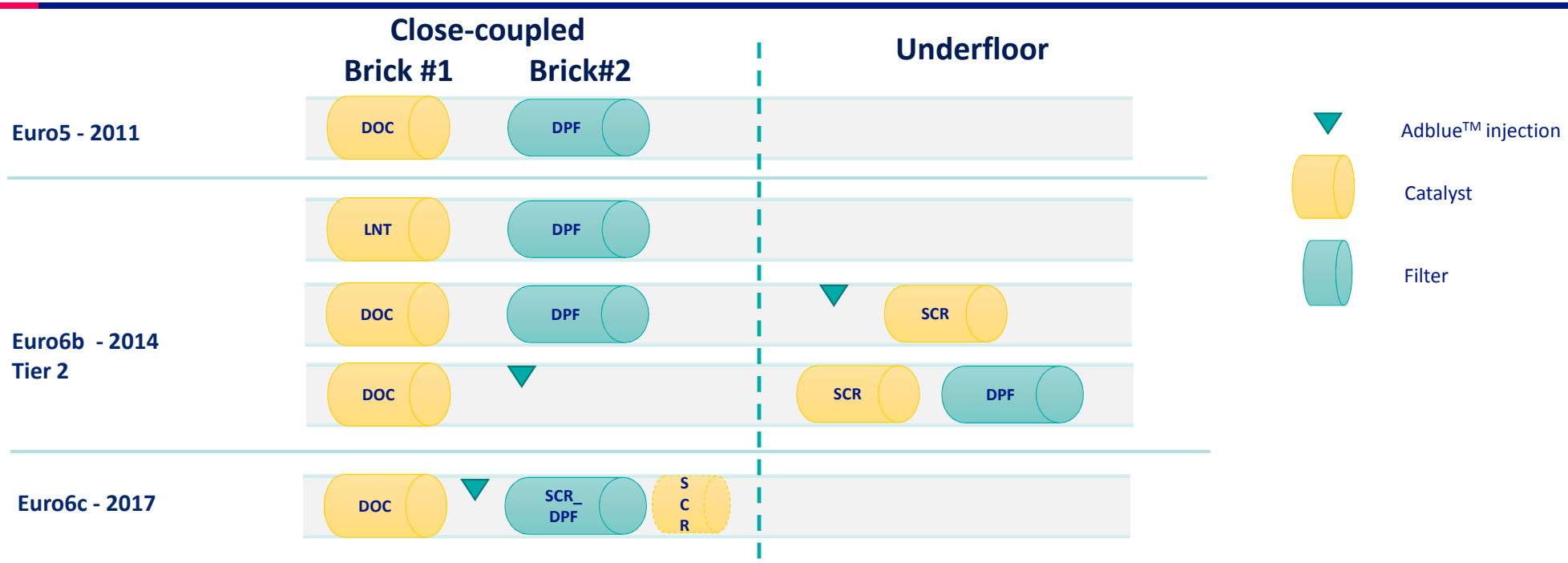
Evolution of diesel aftertreatment architecture technologies



Continuous evolution to address emissions reduction, thermal management and packaging

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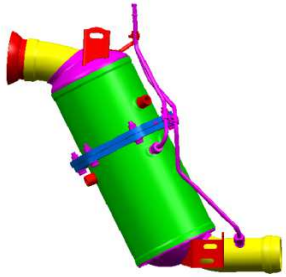
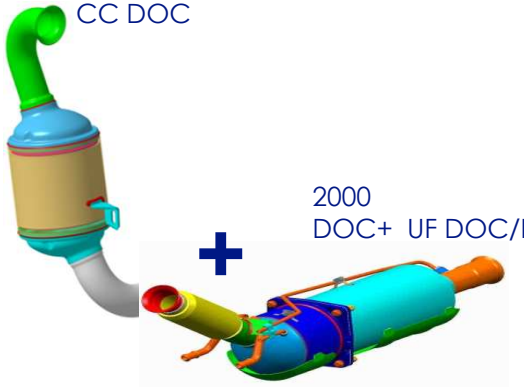
Diesel aftertreatment: further evolution

2004
CC DOC+DPF

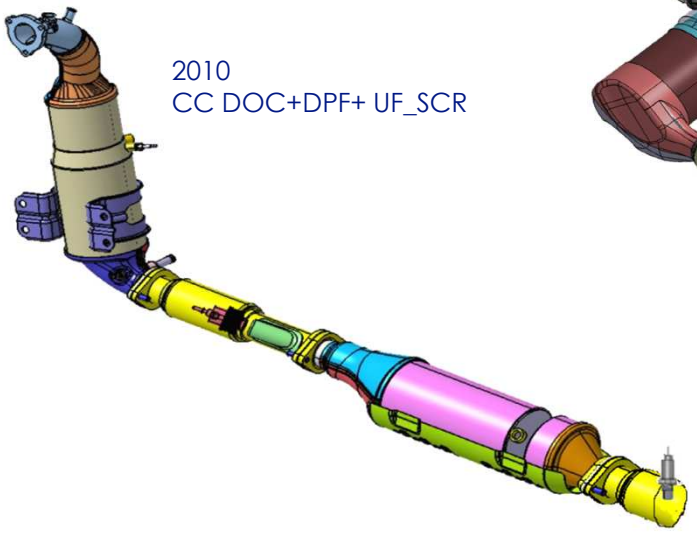


2000
CC DOC

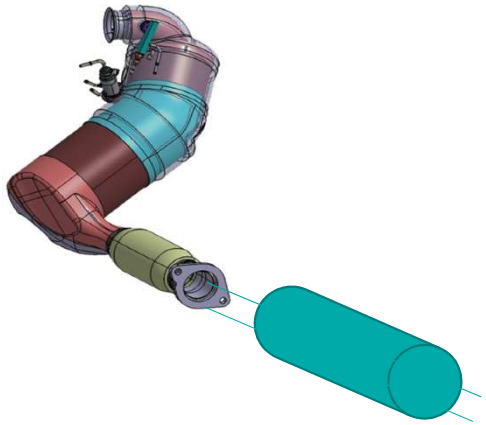
2000
DOC+ UF DOC/DPF



2010
CC DOC+DPF+ UF_SCR



2015
CC DOC+SCR_Filter



2017 +
Additional
UF-SCR

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ASDS™: an alternative SCR deNOx technology

- ASDS™: **A**mmonia **S**torage and **D**elivery **S**ystem
- System storing and dosing ammonia for use in SCR catalyst
- Ammonia is stored safely in a salt, strontiumchloride (SrCl2), the saturated salt is called AdAmmine™
- Slightly heating the AdAmmine™ cartridge will release controlled amounts of ammonia to the SCR
- ASDS™ can start dosing ammonia for the catalyst as low as 150°C (optimal for city driving conditions)

AdAmmine™ cartridge

Vertical ASDS™

Horizontal ASDS™

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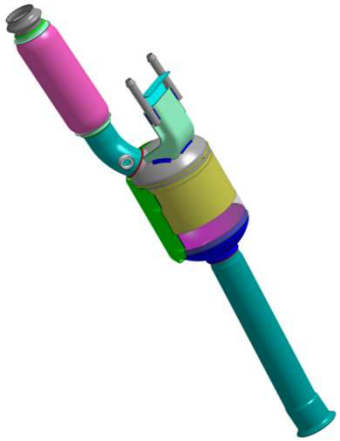
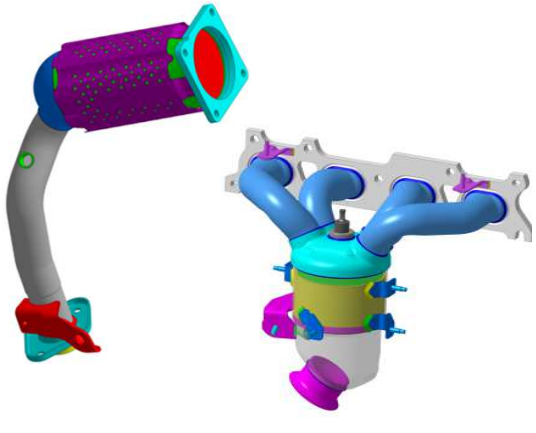
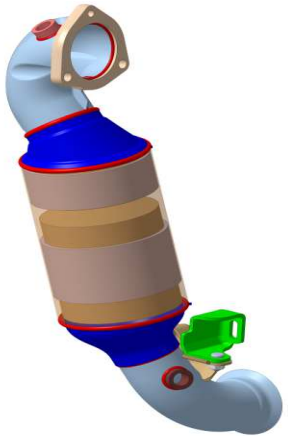
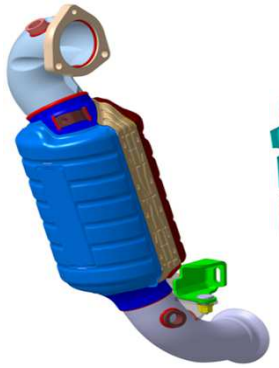
Gasoline Hot End Architecture: Evolution with regulations

TWC: Three Way Catalyst
GPF: Gasoline Particulate Filter

Euro 1	Euro 2	Euro 3	Euro 4	Euro 5	Euro 6b	Euro 6dT
						
		TWC Close coupled EOBD (2 02 sensors)	TWC Close coupled and Maniverter	TWC Close coupled Integrated manifold or Turbo Engine	TWC Close coupled Thermal Insualtion	
TWC Underfloor position 1 O2 sensor						TWC + GPF
1992	1996	2000	2005	2009	2014	2017

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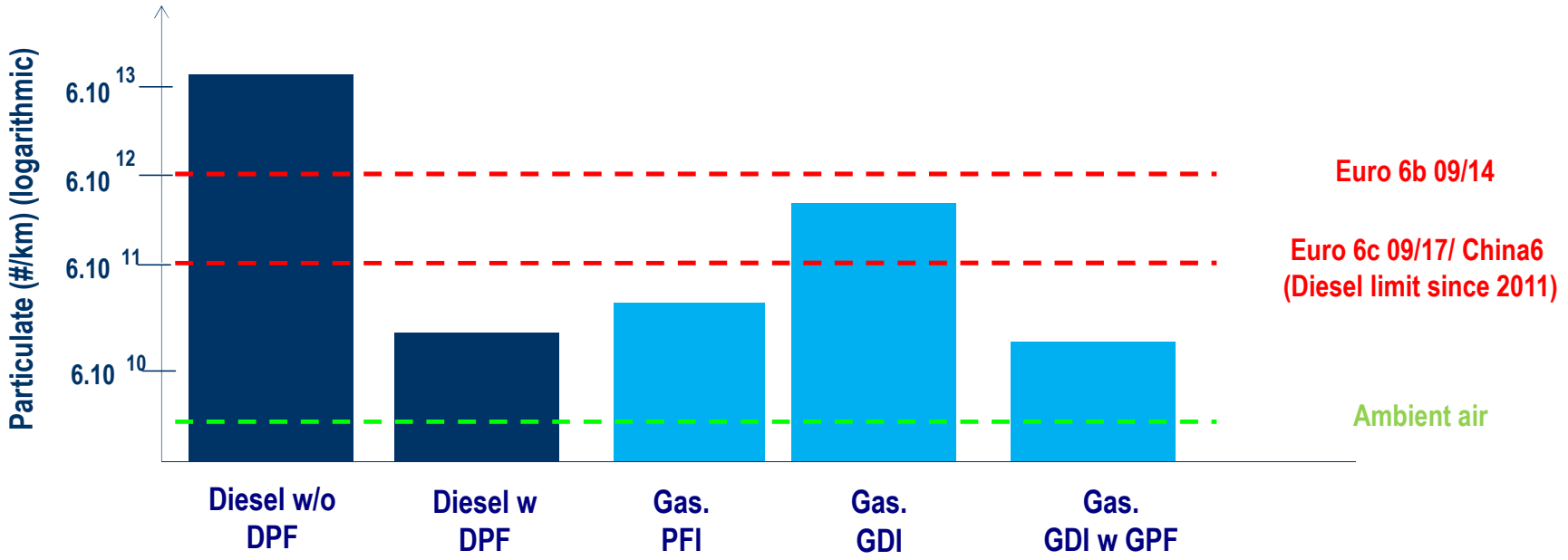
Particulate tailpipe emissions



Gasoline Particulate Filter necessary to reach European and Chinese regulations

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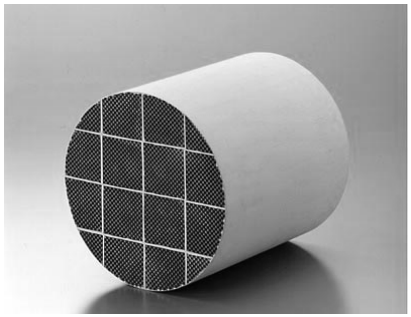
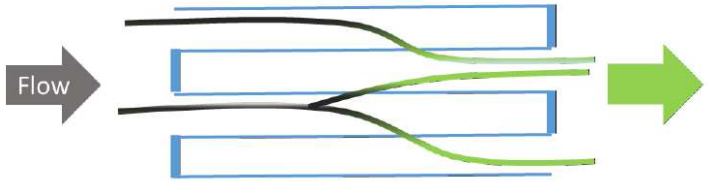
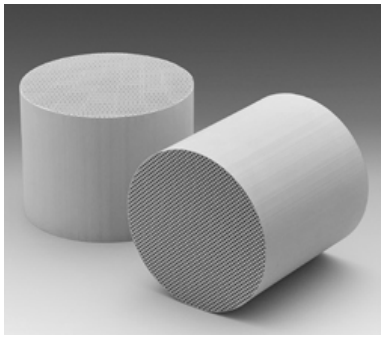
DPF versus GPF wall through substrates







DPF

- High resistance ceramics: SiC or TiAl
- Very high filtration efficiency
- Volume ~ 2x engine displacement

GPF

- Cordierite (similar to Catalyst)
- Moderate filtration efficiency
- Volume ~ 1x engine displacement

Pictures: Corning, NGK

Common technological basis, different applications for GPF and DPF

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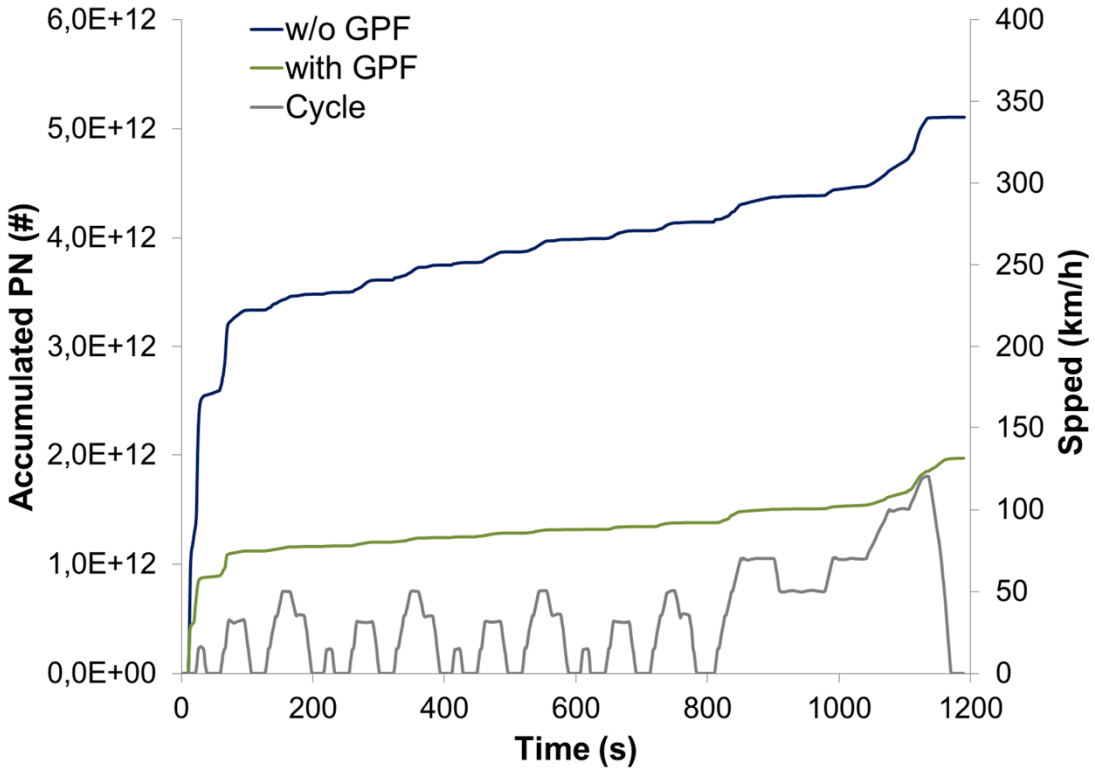
GPF Filtration performance on NEDC

- Typical filtration performance between 60 - 80% for first generation GPF
- Filtration efficiency affected by the low amount of emitted soot



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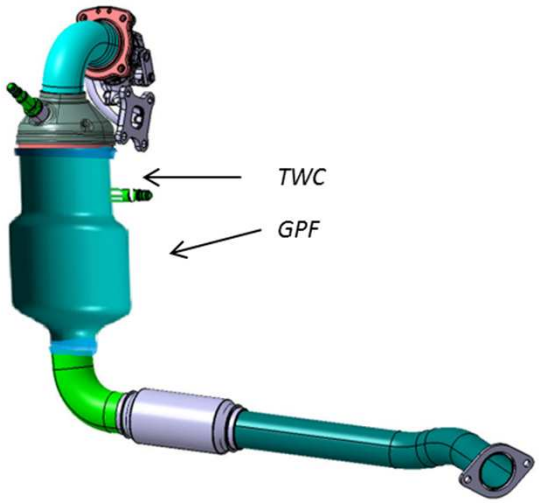
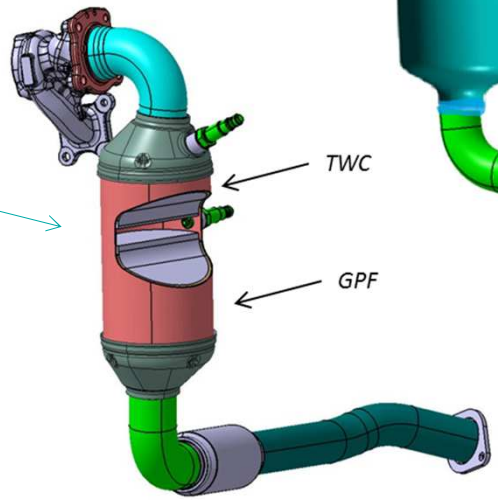
Filter integration in an existing vehicle platform (Coated or non-coated GPF)

Basis:
Euro 6b design
TWC

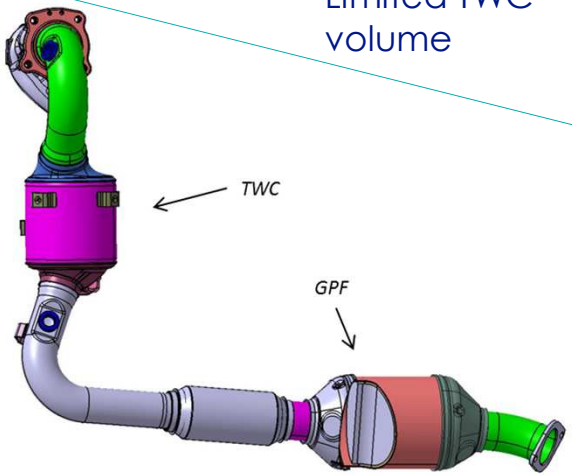
GPF close coupled
"cascade catalyst"
design



GPF close coupled
Limited TWC
volume



GPF underfloor



As for DPF, configuration is driven by packaging space

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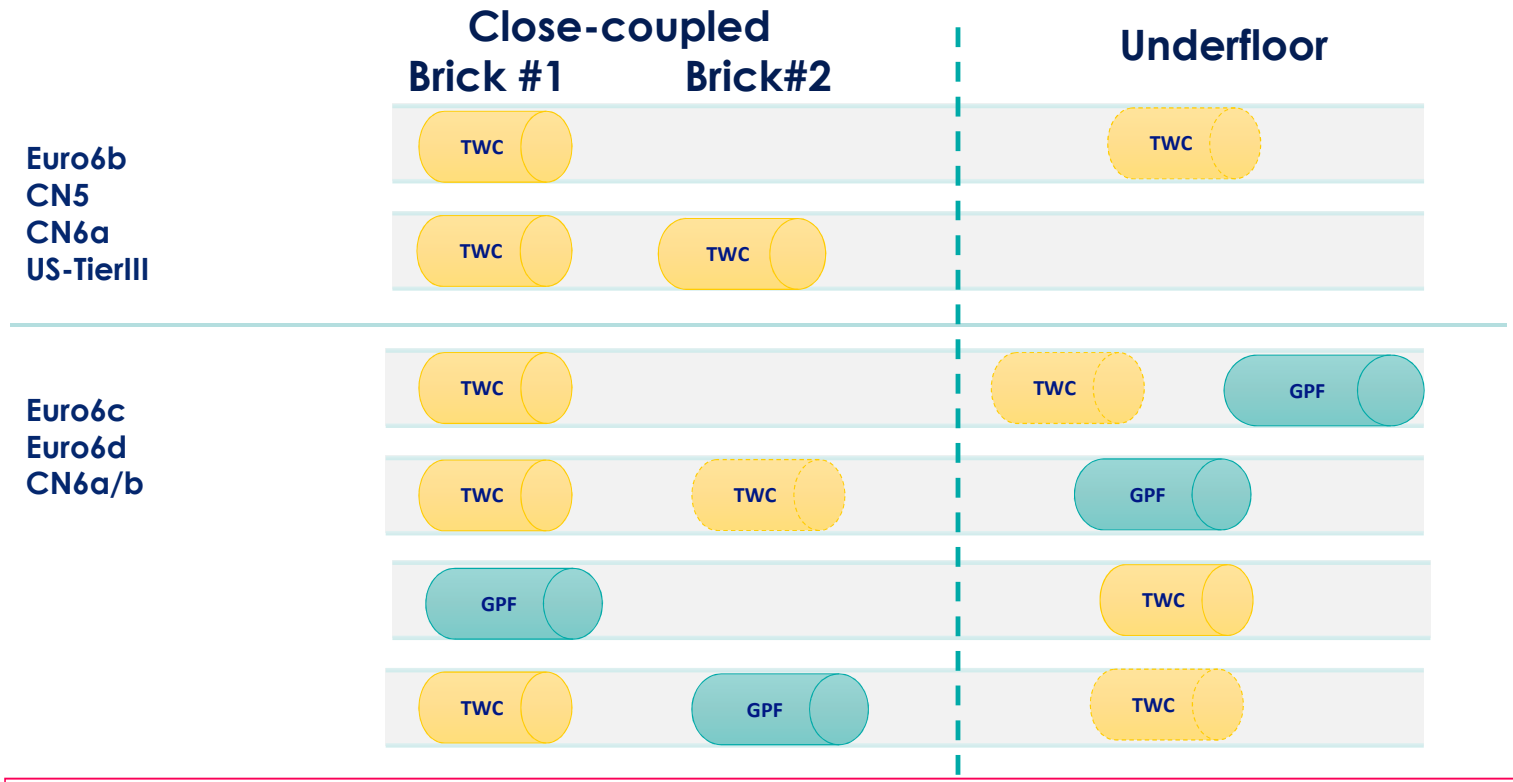
Evolution of Gasoline Direct Injection aftertreatment architecture



Increasing number of system variants,
Different GPF configurations, depending on packaging and system strategy

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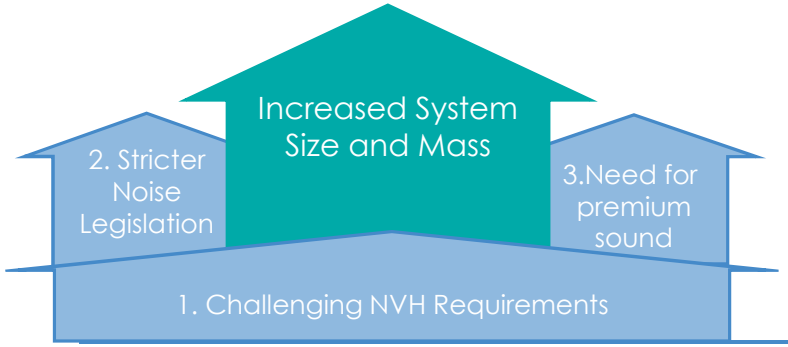
Antagonistic market trends create opportunities for development of Cold End Technologies



Powertrain Evolution deteriorates exhaust sound

Downspeeding
- Lugging (low rpm/high load)"

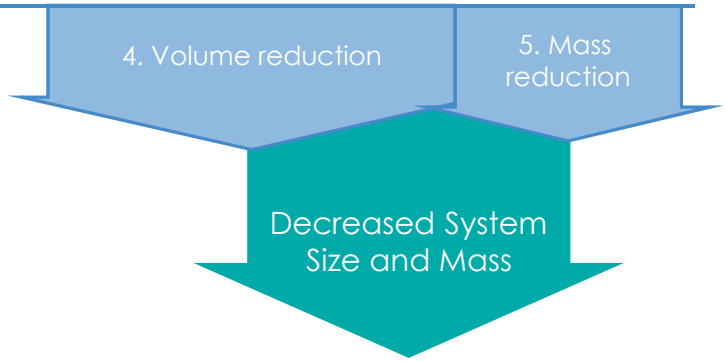
Downsizing
- Lower Displacement and Cylinder Count
- Increased Noise (Low Frequency)

New combustion
- Variable Displacement
- Variable Compression

Packaging space required for…
- Hybrid/Batteries
- AdBlue® Tanks

Mass Reduction
- Improved Fuel Eco / CO2

Platforms evolution requires small & light systems



From passive to active acoustic performance solution development

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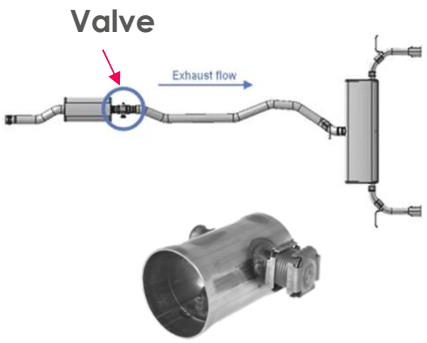
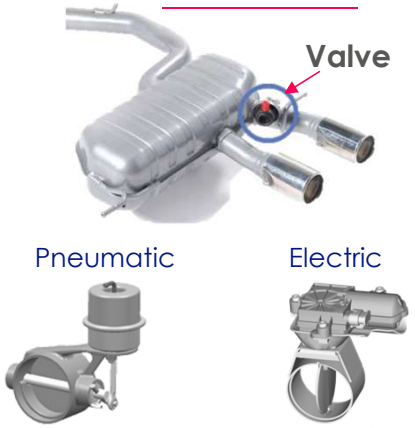
A complete portfolio of acoustic valves

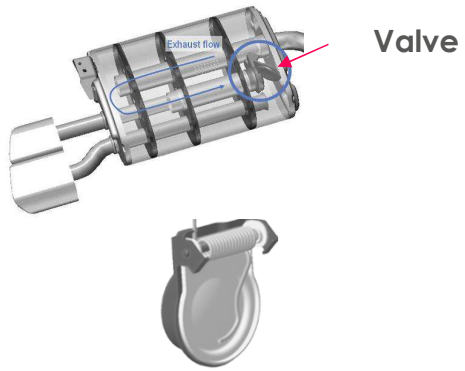
Adaptive® Valve
(Mass-flow / Intermediate pipe)



Actuated Valve
(Actuated (Pneum., Elec.) / Tail pipe)



In-muffler
(Mass-flow / Coil-spring)



1.Challenging NVH Requirements

2. Stricter Noise Legislation

3.Need for premium sound

4.Volume reduction

5. Mass reduction

Exhaust Valves

- ISV In-Silencer Valve
- Adaptive® valve
- EAV –Electric Actuated Valve

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Our solutions for acoustic performance (Valves / EDST)

Exhaust Dynamic Sound Technologies

A loudspeaker is integrated into the exhaust system to tune the sound and reduce the packaging constraints

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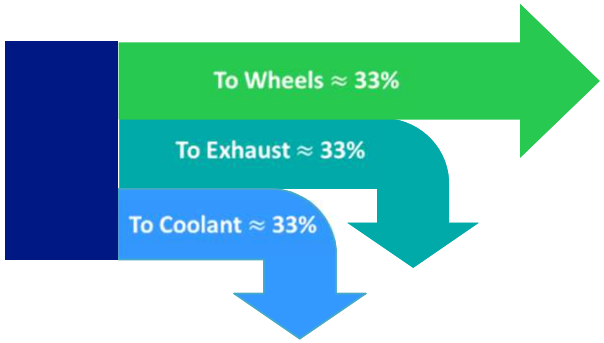
Exhaust heat recovery: Introduction

The energy recovered from an exhaust system can be used either to support the thermal system or to generate on-board electricity

ICE Energy balance (1)



About 1/3 of the fuel energy is lost through the exhaust gases

To support the thermal system : Heat to Heat

Comfort in cold weather

Coolant heating in hybrid vehicles

Friction reduction engine & gearbox

To generate on-board energy: Heat to Power

NOTE (1): indicative values

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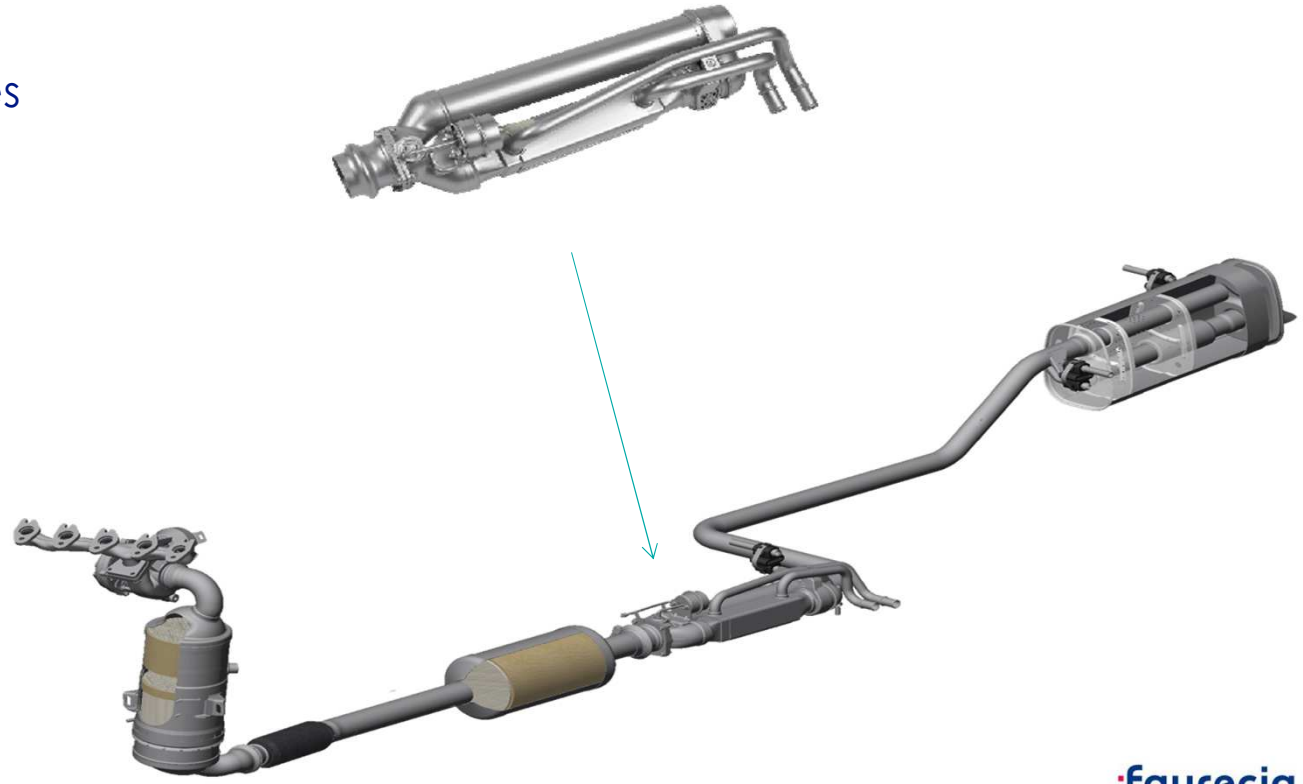
2005 – EHRS Exhaust Heat Recovery System - 1st Generation

- **Application:**
  - Diesel, Minivan
  - Cabin heating / cold climates
- **Position:** underfloor, behind DPF
- **Size:** 500x200x150 [mm^3]



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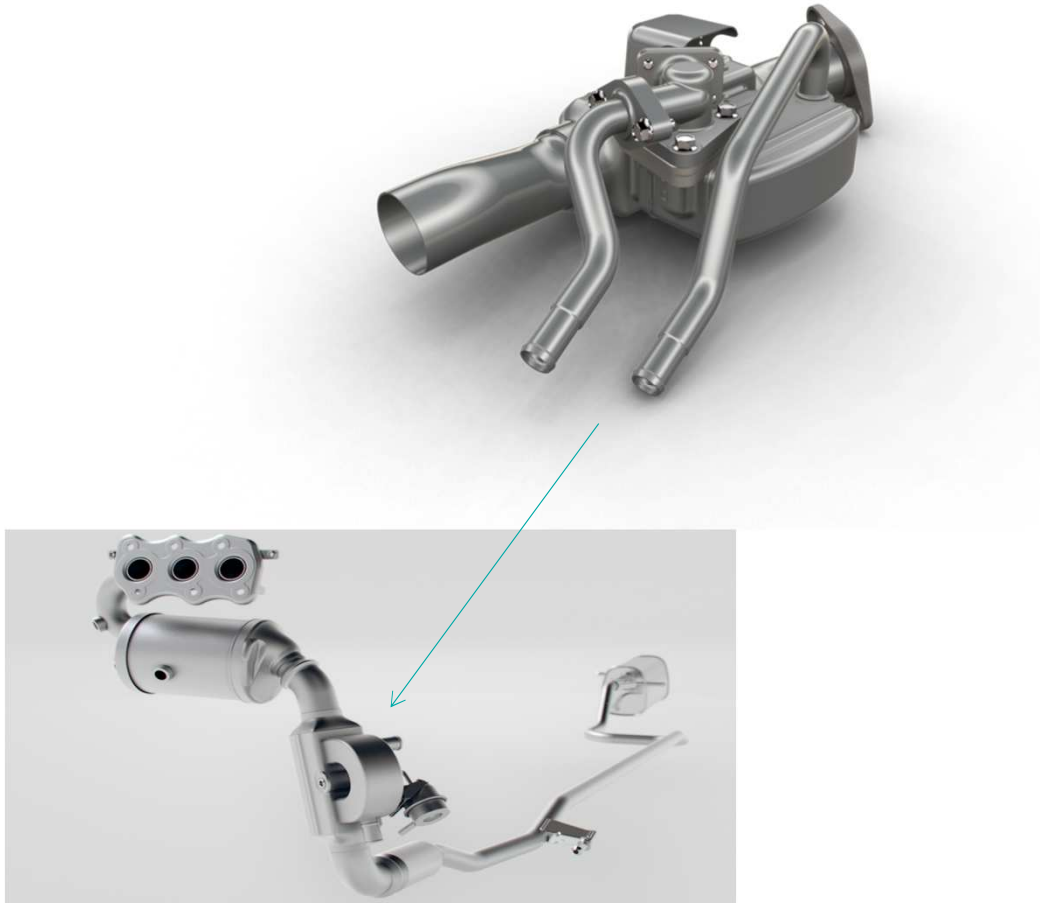
2015 – EHRS Exhaust Heat Recovery System - 2nd Generation

- **Application:**
  - Gasoline Hybrid
  - Engine heat up
- **Position:** intermediate, behind TWC
- **Size:** 150x150x150 [mm^3]



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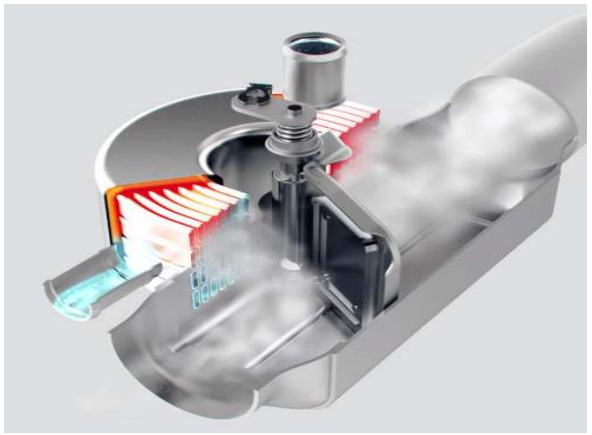
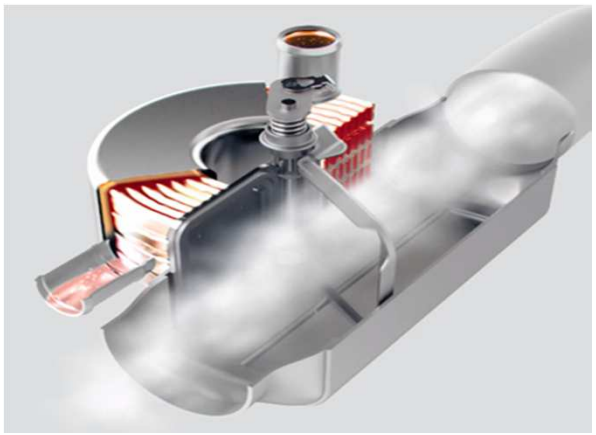
EHRS: How it works?





- **Energy recovery mode**
  - Bypass closed
  - Exhaust gas is heating engine coolant
- **Bypass mode**
  - Bypass open
  - Low backpressure

Pneumatic, Electric or Wax actuators technologies can be used,
More than 80% of the exhaust heat is extracted

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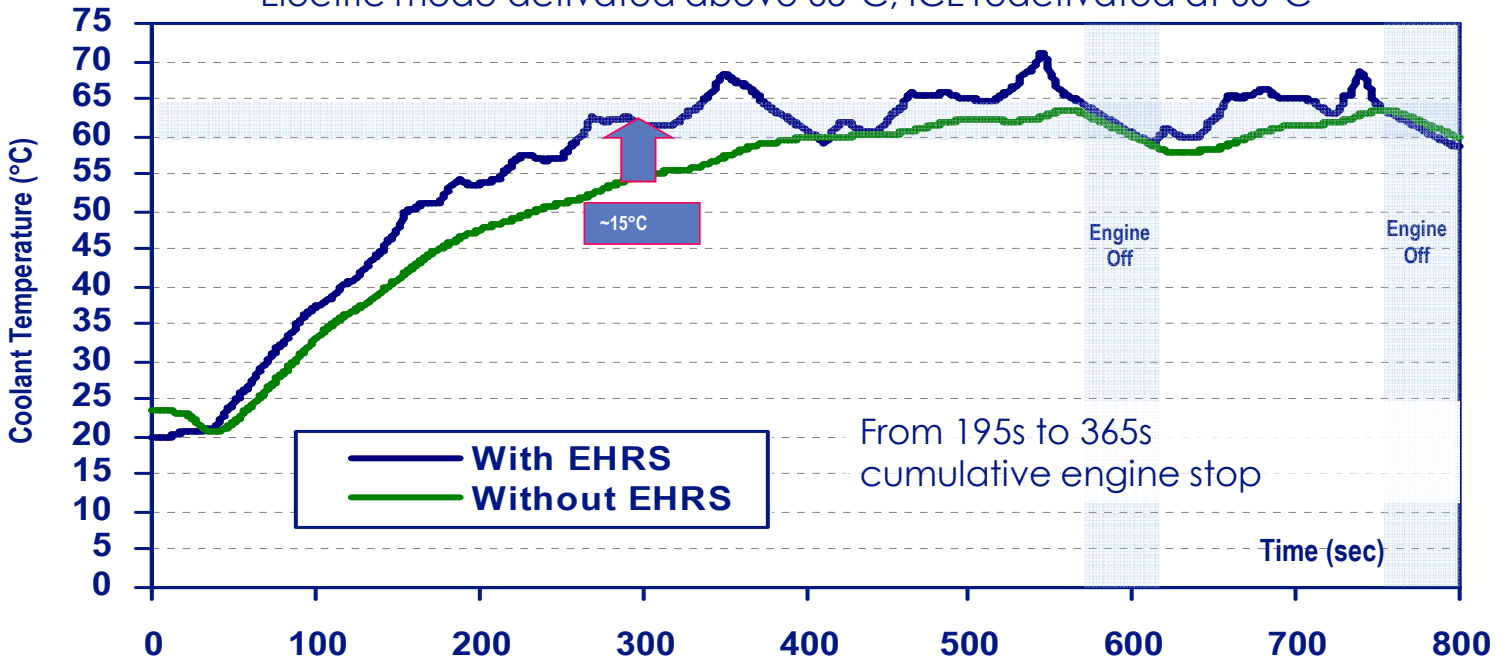
EHRS technology improves warm-up on a hybrid vehicle

Experimental investigation: Coolant temperature evolution with and without EHRS – Toyota Prius
Electric mode activated above 65°C, ICE reactivated at 60°C



On a hybrid vehicle, the increase in coolant temperature achieved with an EHRS enables to maximize electric driving

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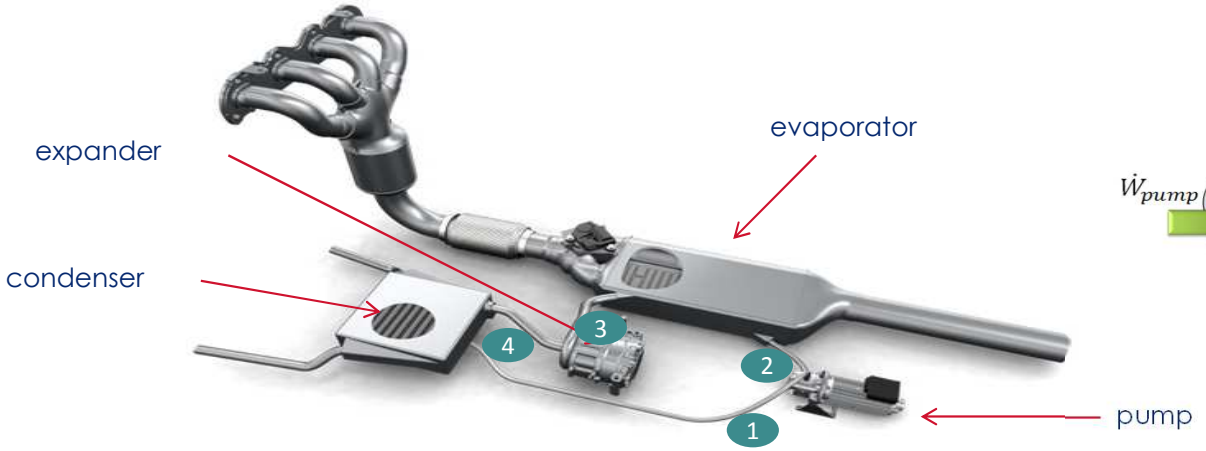
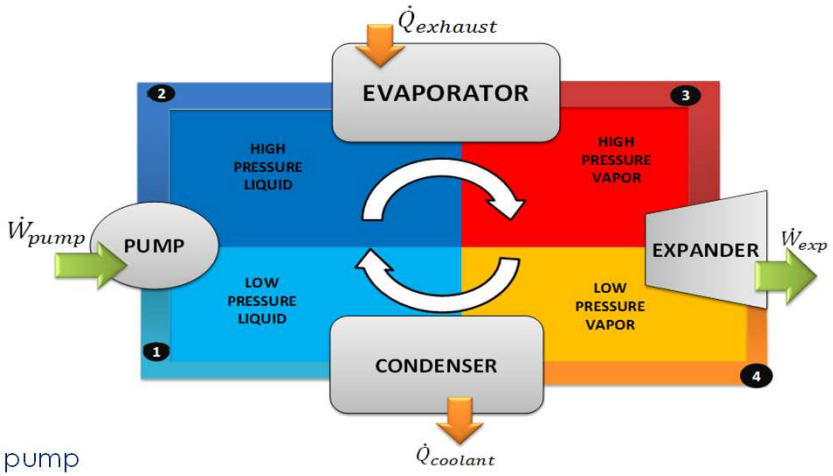
Heat to Power technologies
EHPG Rankine Cycle

EHPG: Exhaust Heat Power Generation





- **How does it work ?**
  - Thermal cycle based on Rankine process
  - Pump feeds evaporator with high pressure liquid
  - Evaporator generates high pressure vapor with exhaust heat
  - Expander expands vapor to produce mechanical work
  - Condenser turns low pressure vapor back into liquid

- **Technology constraints**
  - Maximum pressure / temperature
  - Packaging
  - System control
  - Cost vs return of investment (ROI) and system mass

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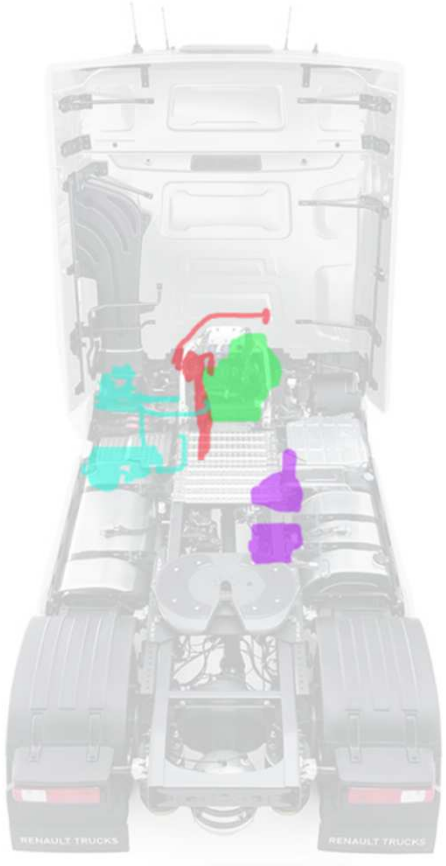
Exhaust Heat Power Generation
System Integration for 1st generation Demo Truck

EHPG Demo Truck:

- Faurecia supervised the whole system integration and developed proprietary control laws

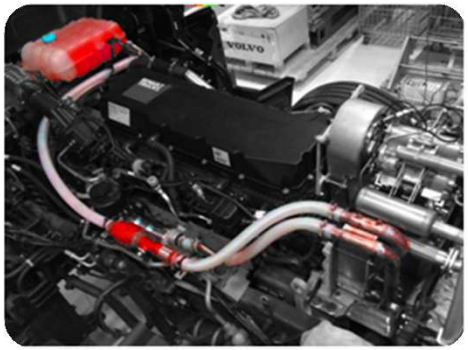
Exhaust module

Expander module



Pump module

Cooling circuit



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Conclusion & Perspectives

- **Exhaust system evolution has been a continuous process supporting internal combustion engine development**
- **Exhaust systems have gone a long way from the original gas leading function to now ensuring acoustic performance, emissions control and energy recovery functions**
- **further innovations are in progress:**
  - Active systems
  - Lightweight
  - Energy recovery
  - New emission systems for quiet and near-Zero Emissions Vehicle


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