

Smart air filtration for improved cabin air quality and energy savings in electric vehicles

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Agenda

1 Background

2 System simulation

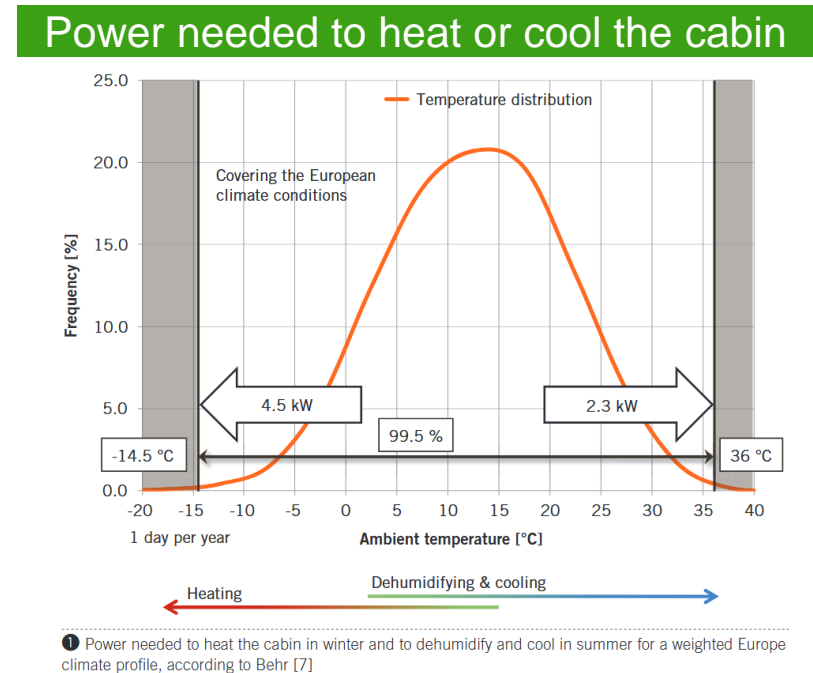
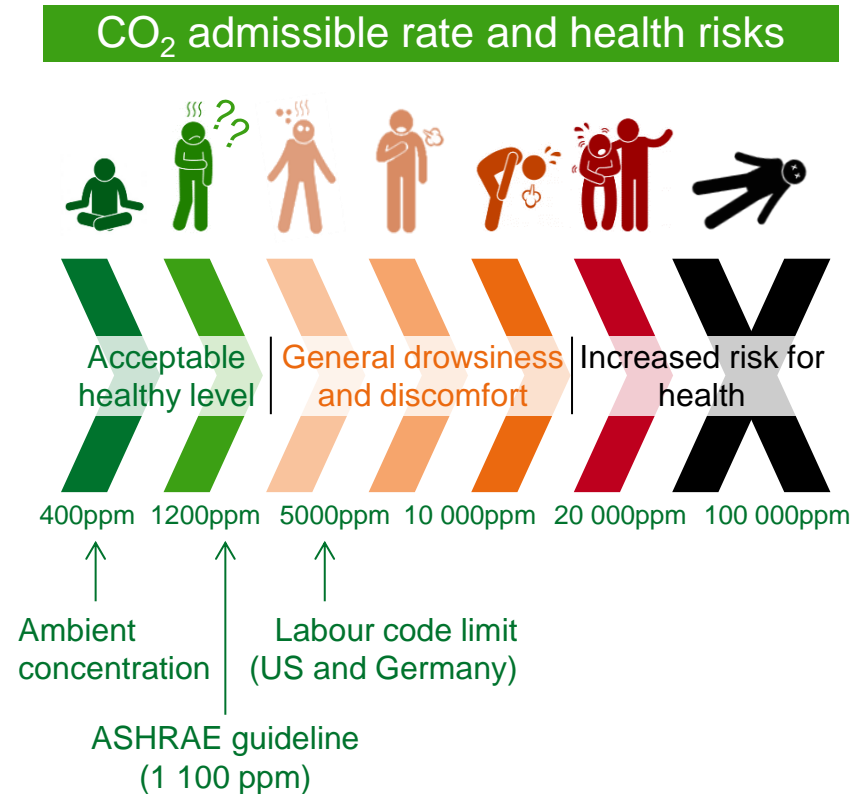
3 Tests

4 Conclusion and outlook

Introduction to Smart Cabin Air Filtration

Air pollution has to be reduced at minimal energy consumption cost

- Challenges: Air quality, thermal comfort, energy consumption.



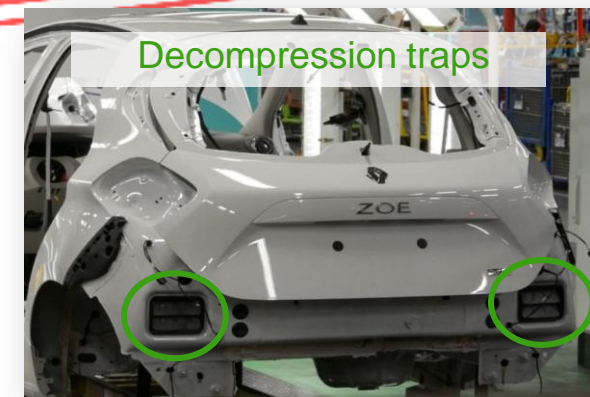
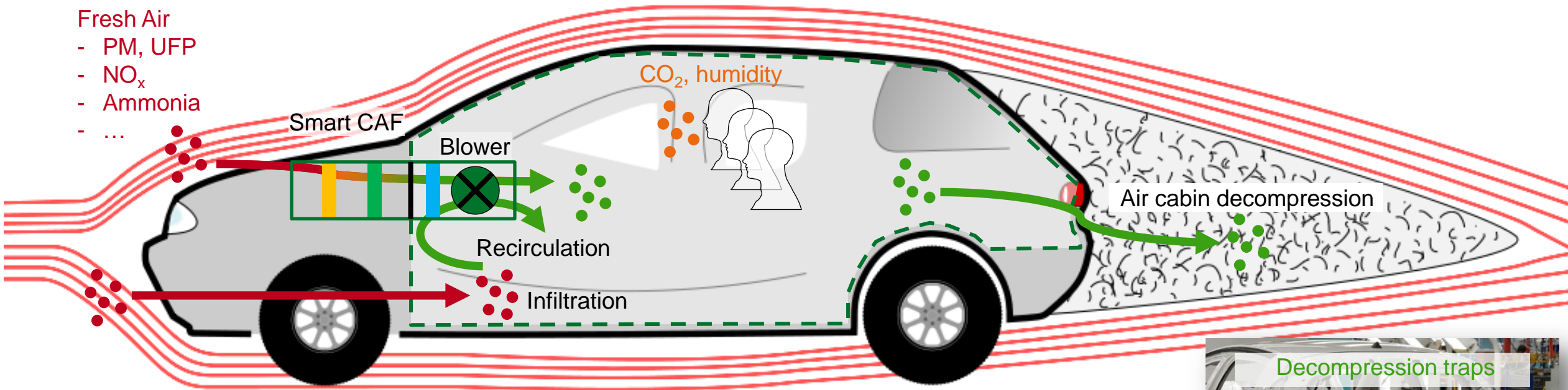
Source: Prokop G, Lewerenz P. Thermal Management Solutions for New and Old Challenges. ATZ Worldwide 2011;113(11):4-8.

Introduction to Smart Cabin Air Filtration

Overview of Air Flows in a Vehicle Cabin

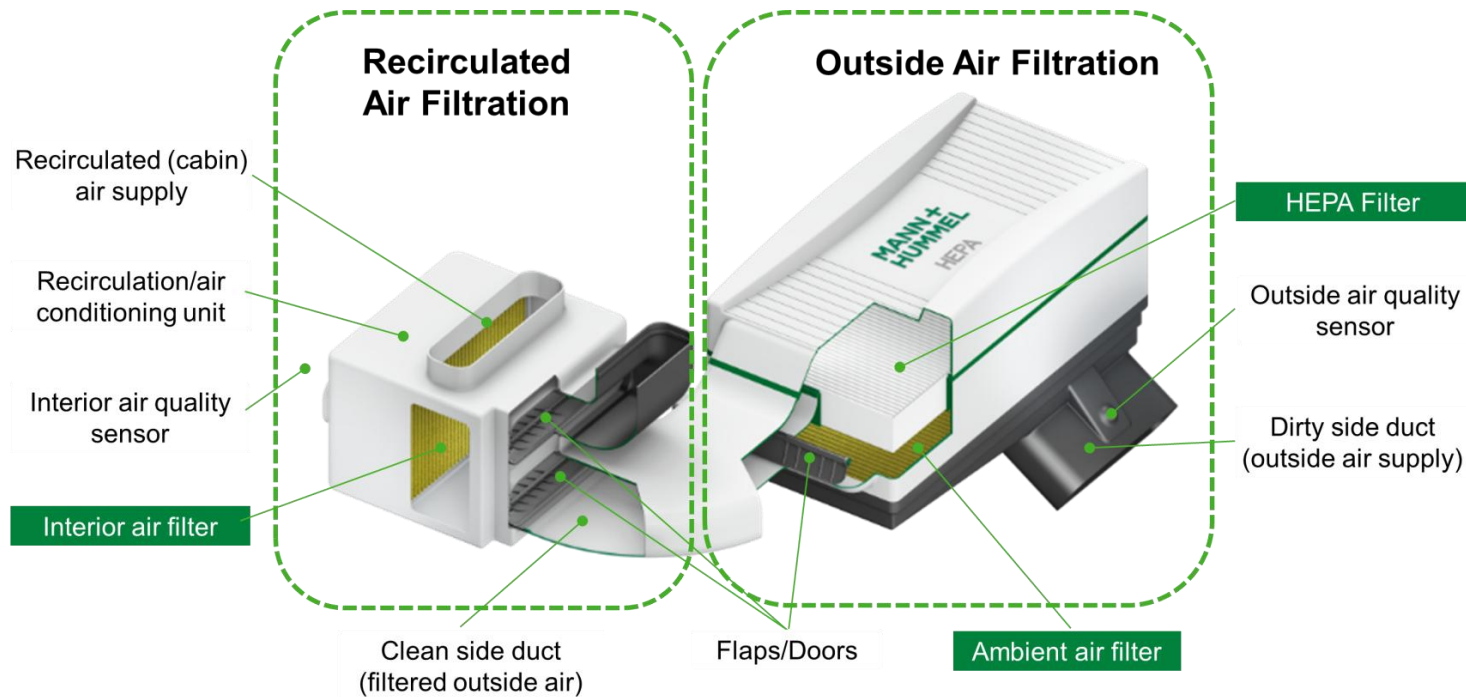
Fresh Air

- PM, UFP
- NO_x
- Ammonia
- ...



Introduction to Smart Cabin Air Filtration

What is Smart CAF ?

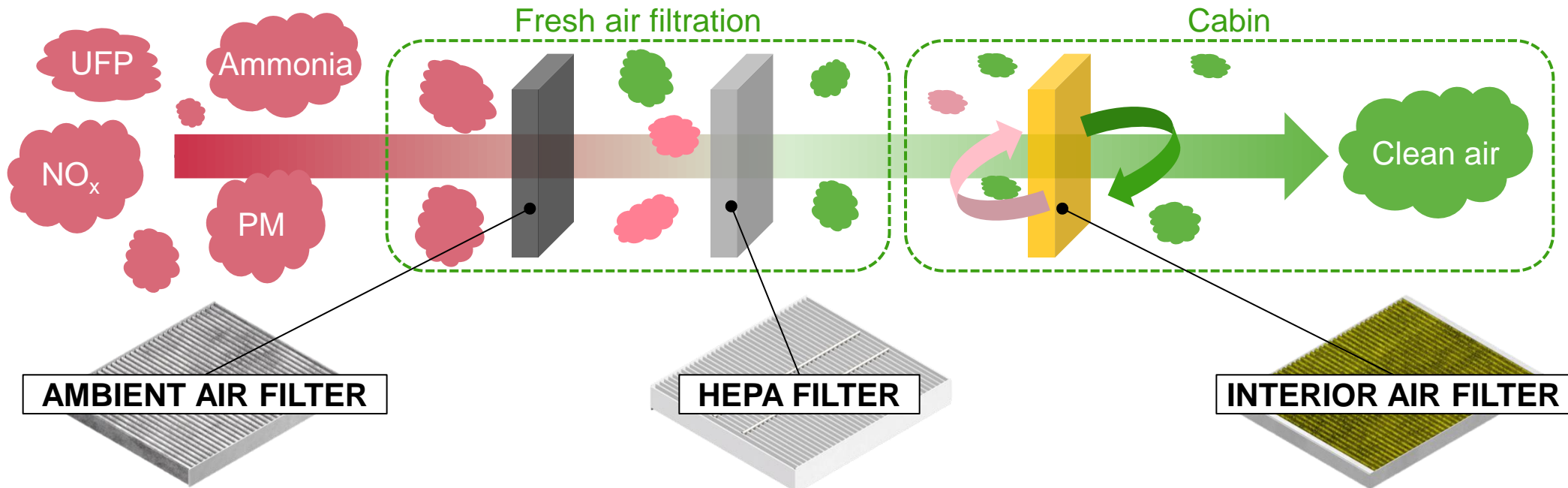


Smart Cabin Air Filter System:

- Saves energy and increases driving range
- Ensures always best air quality and maximum passenger protection
- Increases the filter lifetime

Introduction to Smart Cabin Air Filtration

Filtration technology



- High efficient filtration of fine dust particles (PM_{2.5})
- Removes harmful gases such as nitrogen dioxide (NO₂), ammonia (NH₃) and volatile organic compounds (VOC)

- HEPA Filter for PM₁ and ultra fine particles (<0.1µm)

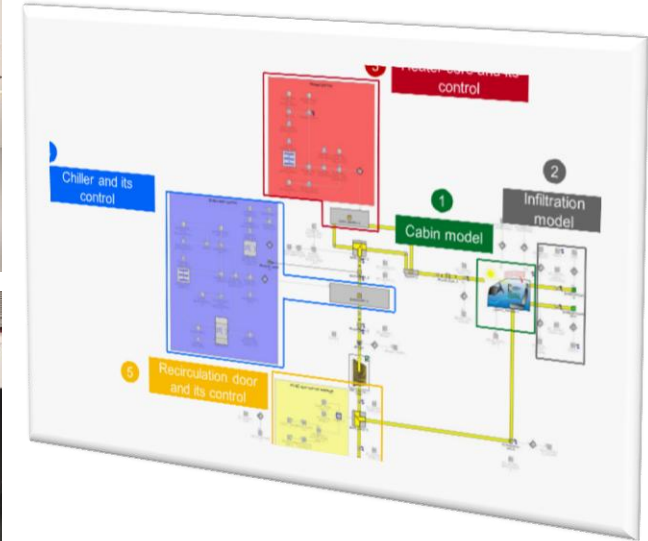
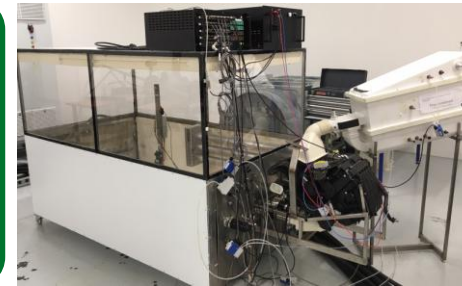
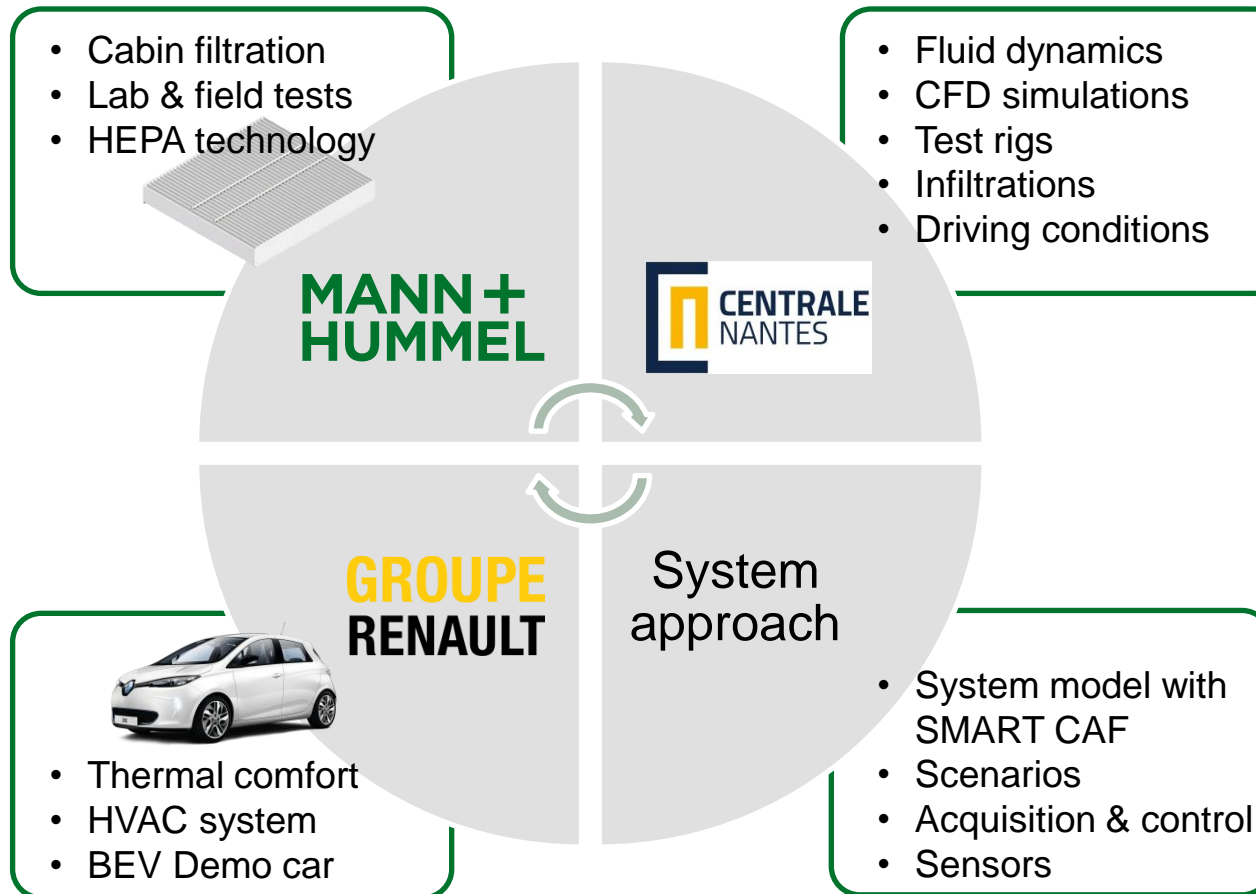
- Bio functional filter layer with anti-allergenic and antimicrobial properties
- Retains pollen and fine dust particles (PM_{2.5})
- Adsorbs harmful gases

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- 2 System simulation**
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System simulation

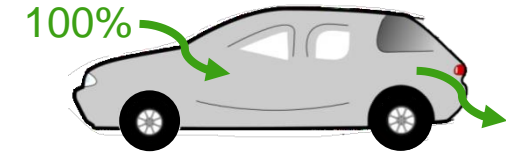
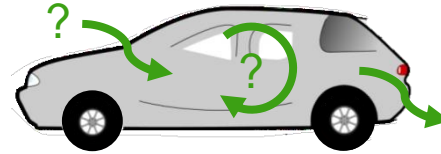
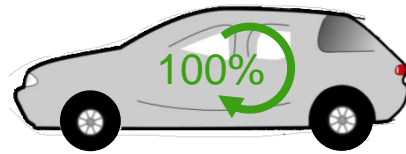
Platform for multiphysics exchanges













System simulation integrates multiphysics models with data from test rigs, to evaluate concept and algorithm optimization

System simulation

Recirculation mode or Fresh air mode ?

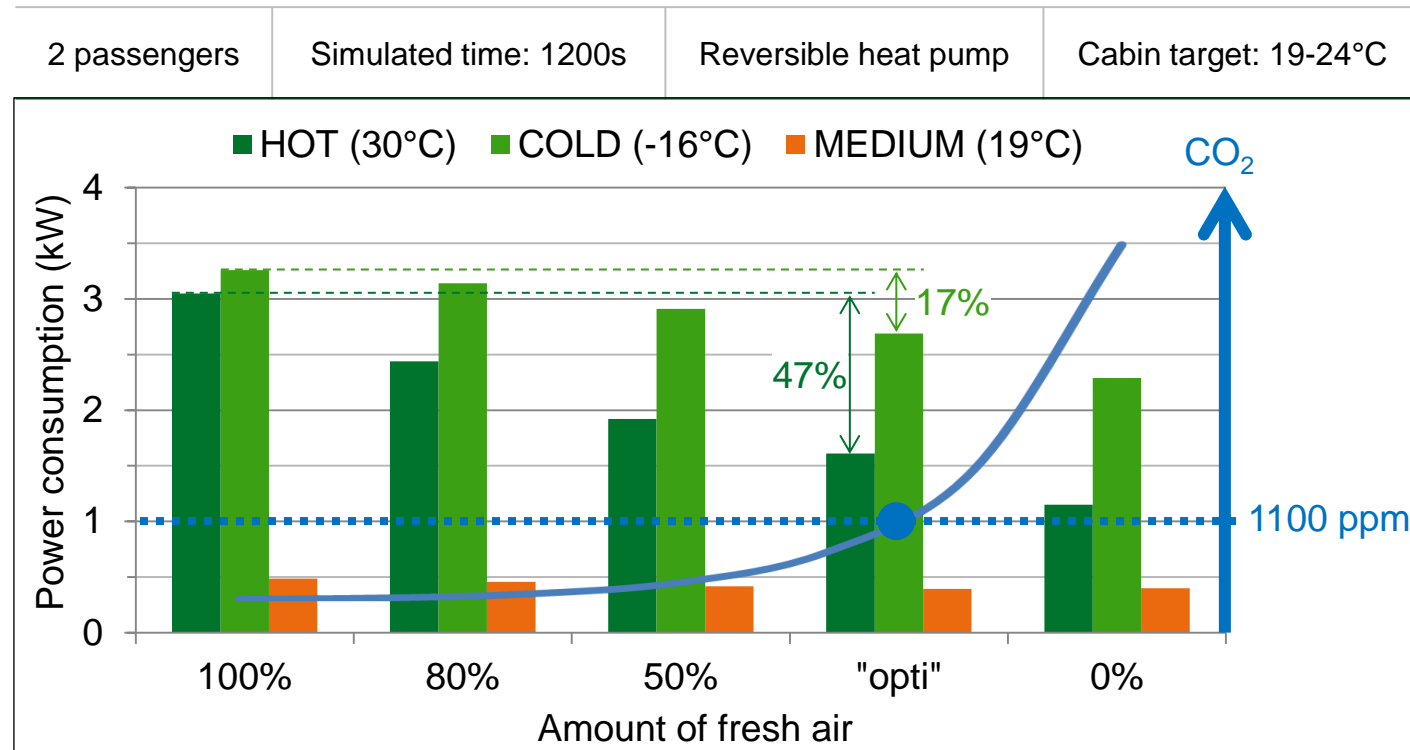


	100% Recirculation	Opti-mode	100% Fresh air
CO ₂ concentration level		Smart controlled recirculation ratio to find best trade-off depending on driving condition	
Pollutant and Particle level			
Infiltration flow rate			
Energy savings			
Filter lifetime savings			
Humidity management	It depends on ambient conditions		

100% recirculation in the HVAC system is not the optimal solution to guarantee the best air quality inside the cabin (not possible to have positive ventilation in cabin)

System simulation

Results – Recirculation rate and energy savings



Optimum amount of fresh air depending on the amount of passengers

1	13%
2	30%
3	50%
4	68%
5	84%

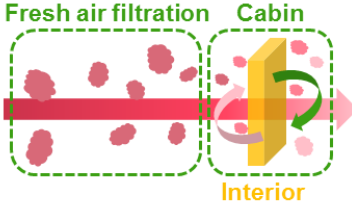
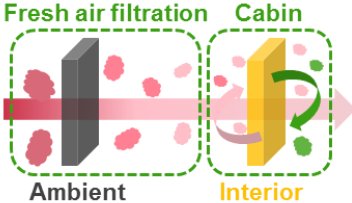
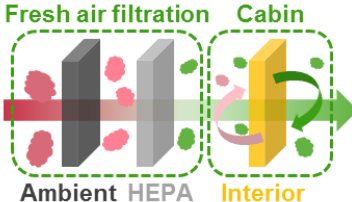
In "opti-mode" the CO₂ level is always kept in a safe and comfortable range, while simultaneously optimizing the required power for heating and cooling

MIGAUD J., LESAGE M., CHALET D., HEININGER T., BAUER B., HEINZMANN M., KRAUTNER C., KLEIN M. – Adaptive cabin air filter system for energy efficient filtration for e-vehicles – 18th Stuttgart International Symposium, Automotive and Engine Technology, Stuttgart, Germany, March 13-14, 2018

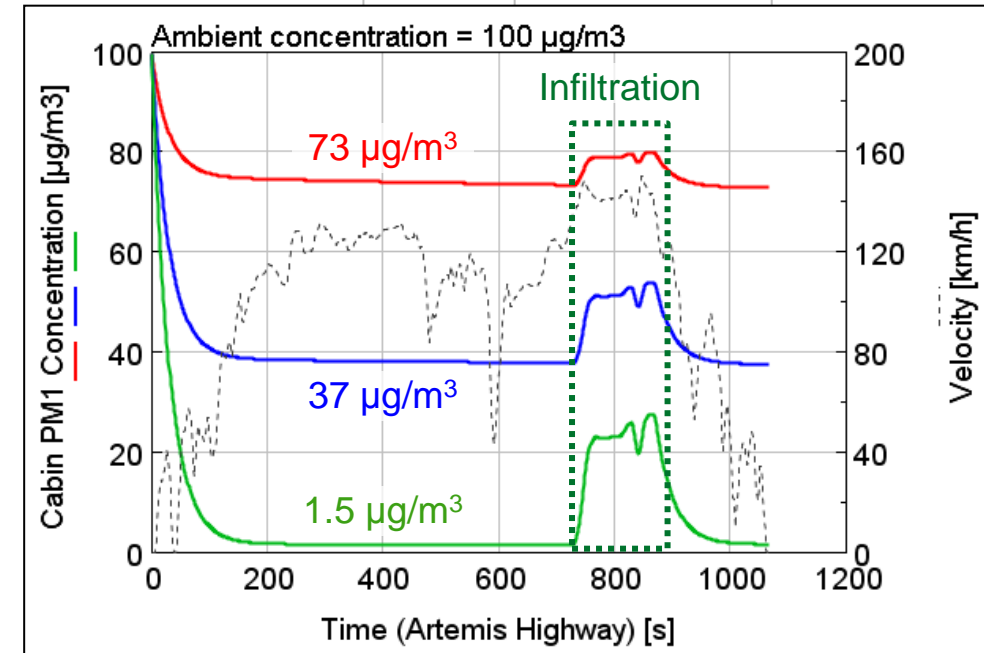
System simulation

Results – Air quality analysis (PM1)

- Three configurations are compared in the **simulation** tool to evaluate the **need for filtration** inside a vehicle.

Interior Filter		PM1 Efficiency = 27%
Interior + Ambient Filter		PM1 Efficiency = 63%
Interior + Ambient + HEPA Filter		PM1 Efficiency > 98%

Recirculation	no (0%)	Blower flow rate	300 m ³ /h
Sealing leakage	3%	Road cycle	Artemis Highway



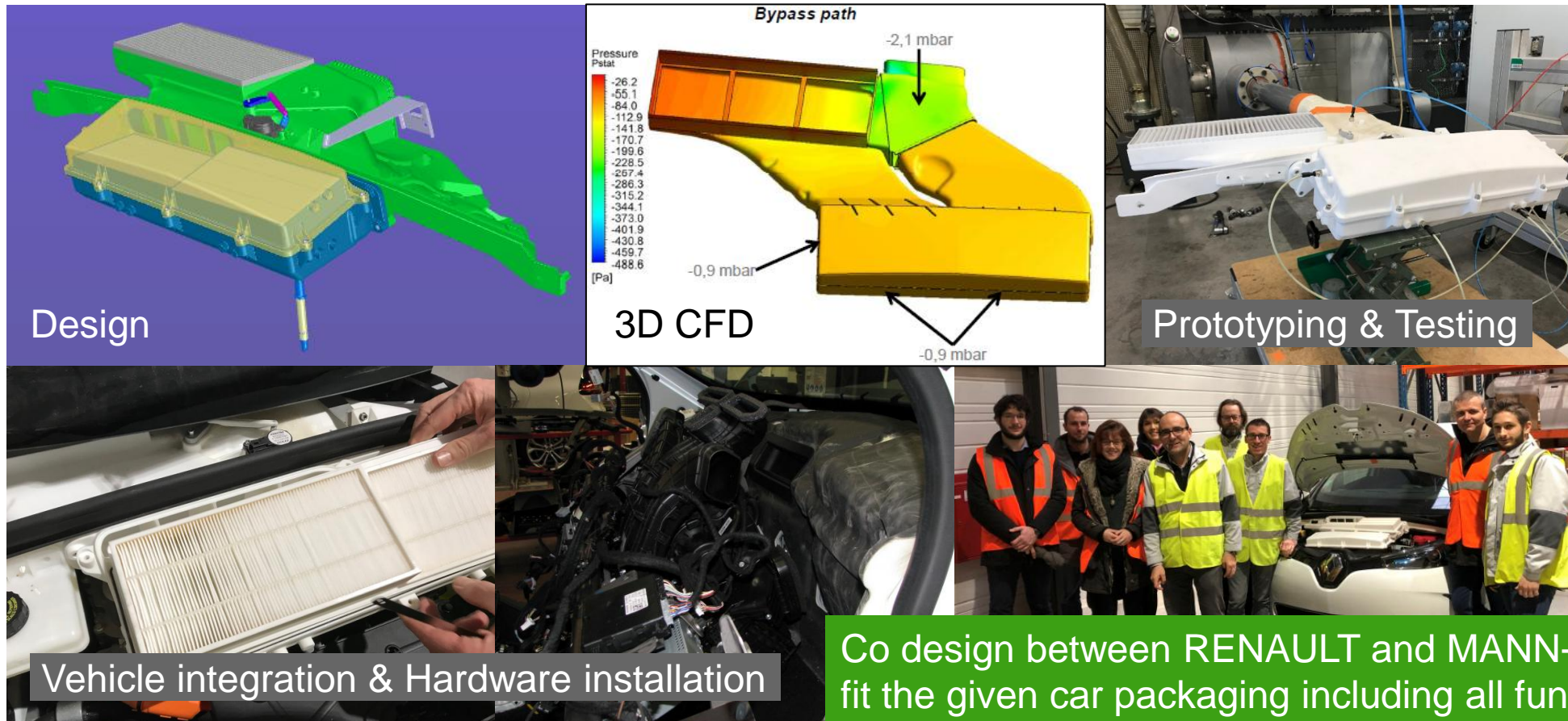
Only HEPA configuration is able to keep safe level of PM1 concentration

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Road tests with ZOE car

From design to demo car

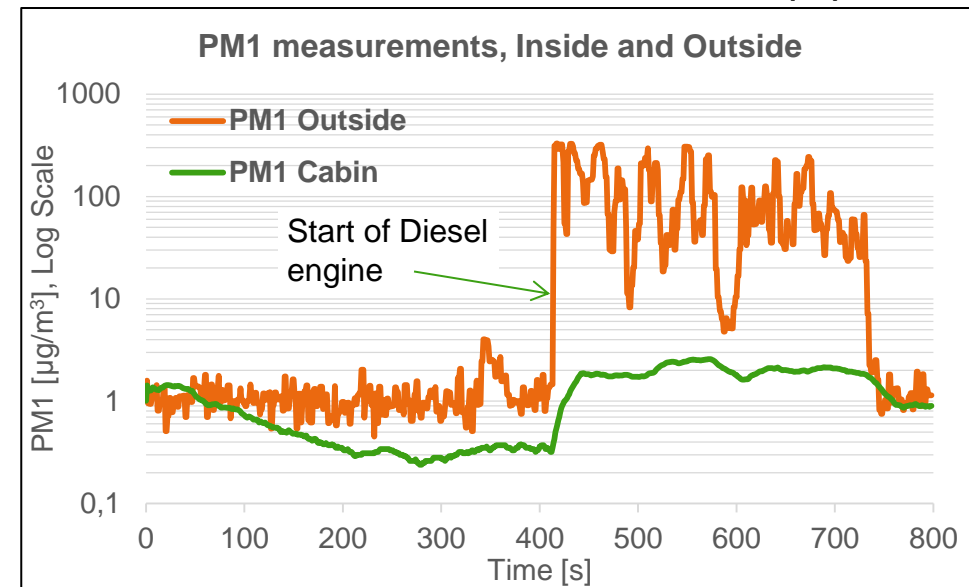


Road tests with ZOE car

Static test with the ZOE Car, Dust generation with Diesel engine



- Old Diesel vehicle used to generate particles
- Exhaust directly plugged to SMART CAF inlet
- Measurement of PM levels with lab equipment

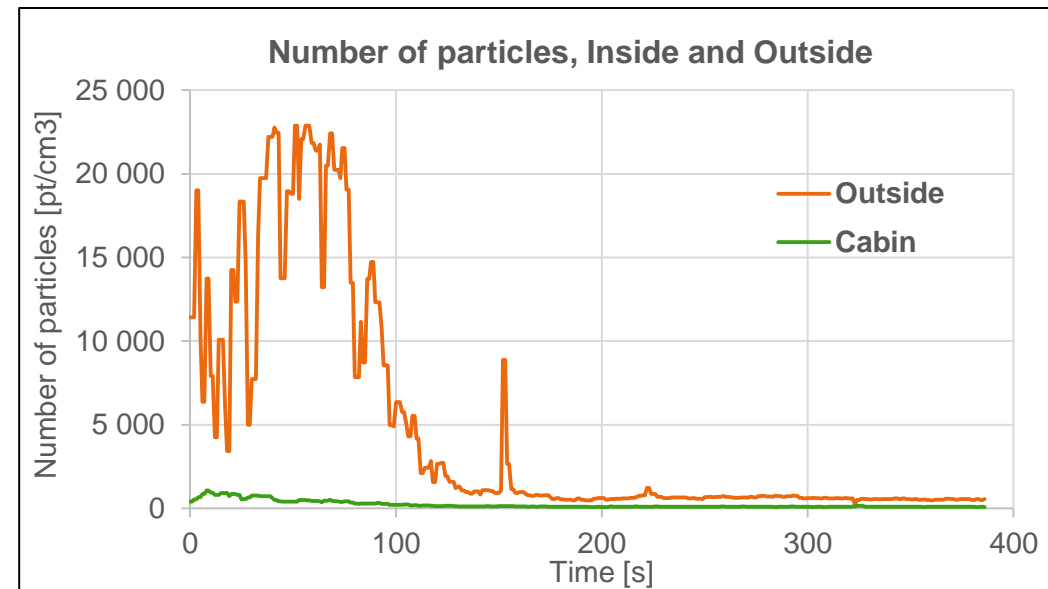


98% efficiency achieved in worst conditions for PM1 thanks to HEPA technology !

Road tests with ZOE car

Static test with the ZOE Car, Dust generation with gasoline engine

- Similar test conditions but with a gasoline engine used to generate particles (<PM1):



95% efficiency achieved in worst conditions thanks to HEPA technology !

Road tests with ZOE car

Opti mode control, new algorithm development, tests in progress

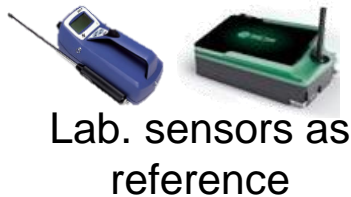
Sensors



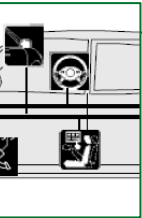
CO₂



PM



Lab. sensors as
reference

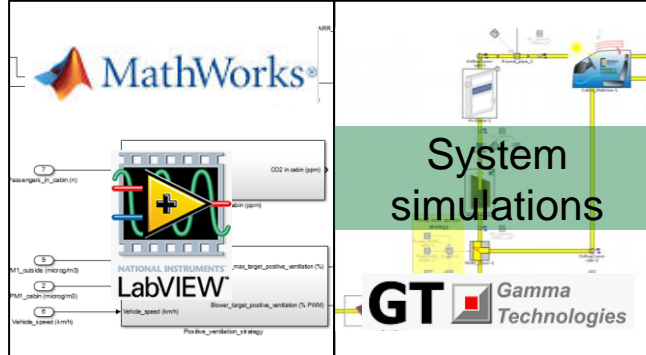


Vehicle speed /
CAN data

Optimized Algorithms

Optimum =
Best air quality
at minimum
energy cost

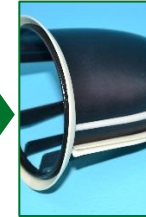
→ Impact on
BEV range



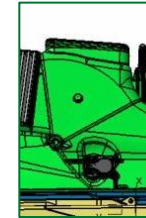
Actuators



Blower



Recirculation flap



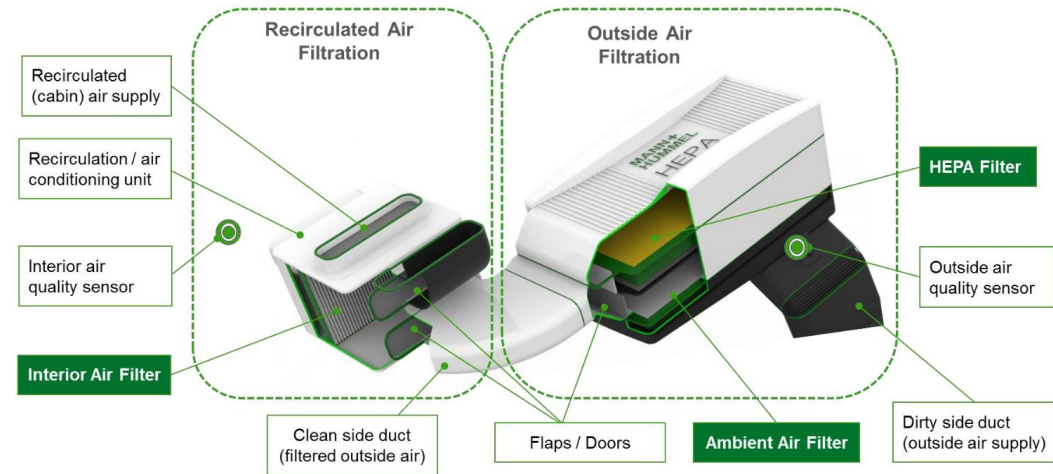
HEPA Bypass

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Conclusion and outlook

- New HEPA technology proposed reached up to 98% PM1 filtration efficiency in fresh air mode. It has been measured in a ZOE car.
- Smart Cabin air filtration will play a major role to reduce UFP ; the new concept is including new filtration technology (HEPA) and new algorithms.
- Then the new solution can guaranty the best lifetime of HEPA filter while reducing the amount of energy used for HVAC.



Thank you!