

GHG and local emission assessments for a democar running with a MtG advanced fuel, a Hybrid Powertrain and an innovative ATS

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INTRODUCTION

LCA & FUELS

DEMOCAR & RESULTS

AIR QUALITY

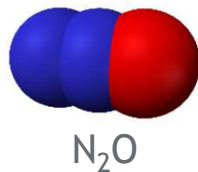
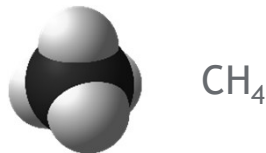
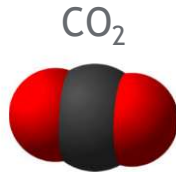
CONCLUSION



Transport sector emission challenges

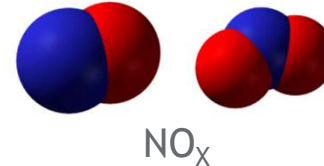
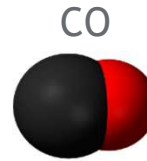
Global impact Green House Gases

- GHGs contribute to Global Warming Potential
- Mainly from anthropogenic activities: fossil energy, deforestation, and agriculture
- Low-carbon fuels to reduce transport sector contribution



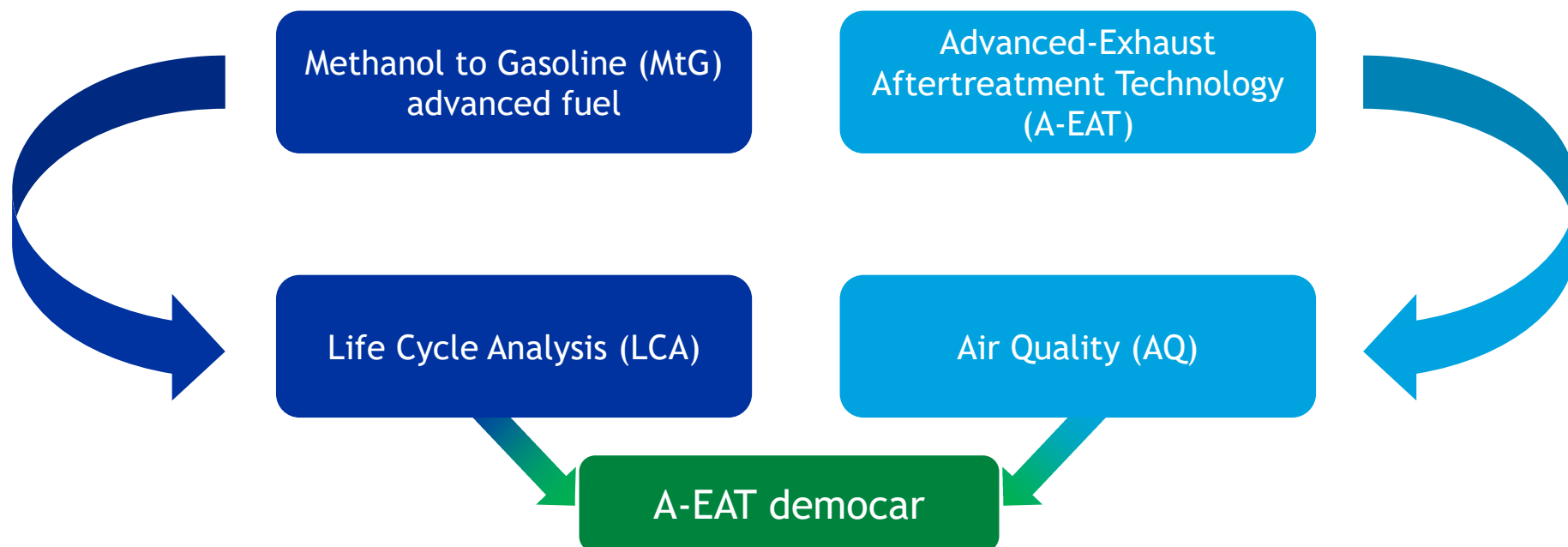
Local impact Air pollution

- Gaseous and particulates emissions are impacting local Air Quality
- Both biogenic and anthropogenic sources: agricultural, transport sector, industries ...
- Innovative after-treatment technologies to reduce tailpipe emissions



Public

Integrated development of advanced vehicle technologies



Public

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LCA motivation & setup

Evaluate both global and local impacts of different powertrains and energy production pathways

General methodology

- Software: Sphera LCA For Experts
- Foreground data: published/industry sources + BatPaC for battery manufacturing
- Background data: Sphera LCA For Experts database
- Well-to-Wheel (WtW) approach for fuels, following JEC v5
- Cradle-to-Grave (CtG) approach for vehicles



Impact categories

- Primary focus on climate change, using IPCC AR5 characterization factors over a 100-year horizon

Vehicle powertrains

- Battery Electric Vehicle (BEV)
- Fuel Cell Electric Vehicle (FCEV)
- Internal Combustion Engine (ICE)
- Hydrogen ICE (H₂-ICE)

Energy production pathways

- Conventional/fossil route: conventional gasoline, grey H₂ for FCEV and 788 gCO₂-eq/kWh for electricity
- Renewable/low-carbon route: e-gasoline with CO₂ capture, green H₂ for FCEV and 13.6 gCO₂-eq/kWh for electricity

Public

Low-carbon gasoline focus

Two reference fuels for calibration and validation test campaigns

- Certification
- High-particulate: designed to generate higher particulate emissions than standard market fuels

Development of a MtG mock-up advanced fuel for test campaigns

- E10 equivalent and EN228 compliant
- Lower aromatics content

Property	Unit	Certification	High-particulate	MtG
RON	-	97.2	97.3	96.9
MON	-	86.2	86.9	88.1
Density at 15 °C	kg/m3	0.747	0.746	0.726
DVPE at 37.8 °C	kPa	58.5	63.7	58.2
E70	%v/v	38.4	35.9	40.9
E100	%v/v	56.3	47.8	73.4
E130	%v/v	88.7	76.5	84.3
E150	%v/v	92.2	85	88.7
E170	%v/v	95.7	93.7	95.9
LHV	MJ/kg	41.41	41.57	41.87
Total aromatics	%v/v	26.8	26.3	17.9
Total olefins	%v/v	6.6	6.2	7
Ethanol	%v/v	9.2	9.1	0.3
ETBE	%v/v	0	0	19.2
sPMI v1	-	0.86	1.38	0.99

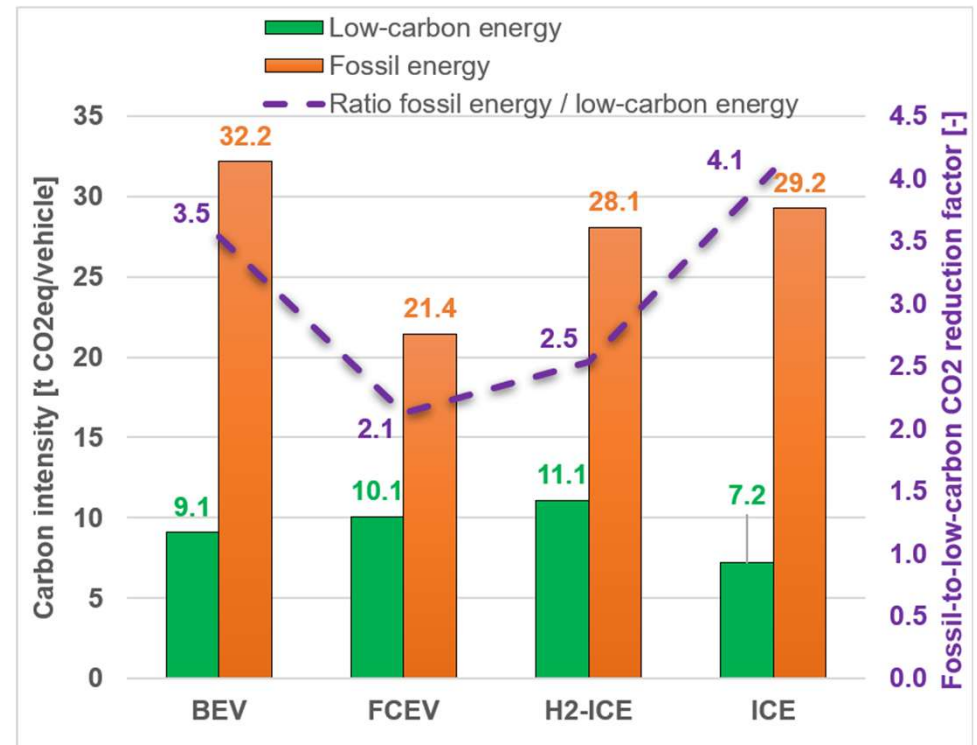
Development of a MtG mock-up advanced fuel to reduce global impact

LCA Results

Homogeneity of the carbon intensity among powertrains within the same energy category

H₂-ICE powertrain displays the highest carbon intensity using low-carbon energy due to low electrolysis and engine efficiencies, and logistics

On average, carbon intensity is three times lower using low-carbon energy than with fossil energy



Carbon intensity is more sensitive to energy source than powertrain technology

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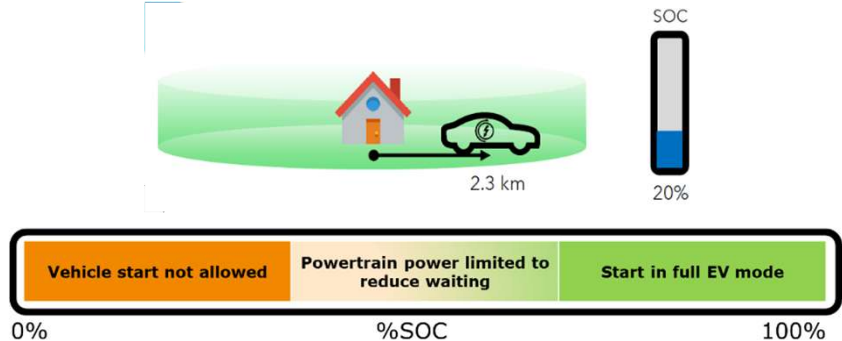
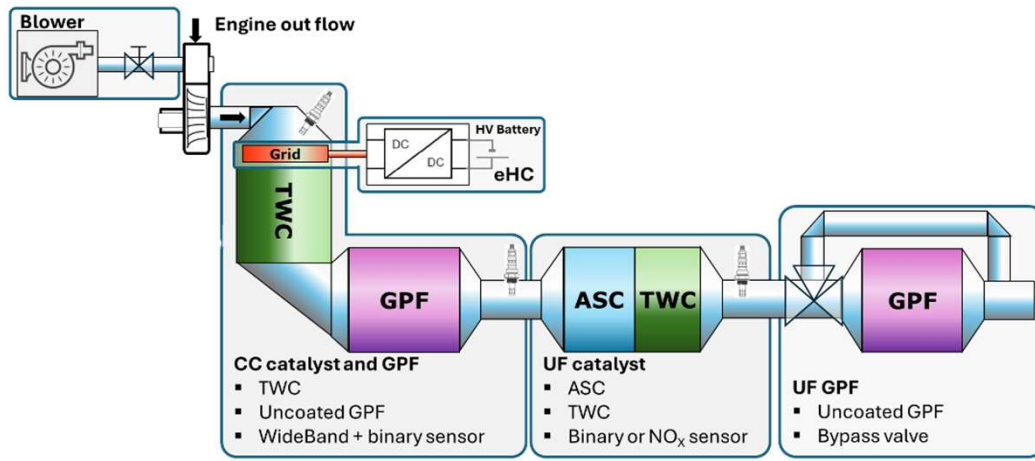
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Hardware & software vehicle setup



- Vehicle : Renault Austral E-Tech
- Powertrain : 1.2L TGD engine Euro 6 Full hybrid
- ATS modifications
 - Blower + 3 kW electrical Heated Catalyst (eHC)
 - Upgraded Close Coupled (CC) TWC + GPF
 - Under Floor (UF) catalysts : Ammonia Slip Catalyst (ASC) + TWC
 - Patented double GPF (dGPF) with bypass



- Battery State Of Charge (SOC) optimization = charge zone
 - GPS based strategy to load battery before reaching destination
- Pre-heating starting with vehicle key detection
- Priority for low emissions strategies in powertrain management
- Cold start instantaneous limitation of the ICE pollutant exhaust flow to match the first TWC treatment capacity

Dedicated ATS architecture & control strategies for lowering emissions

Test matrix and conditions

Cycle	Temperature (°C)	Fuel
CBR	-10	High particulate
RDE95	0	High particulate
WLTC	14	Certification
Beaune	35	High particulate

	Validation test matrix	Extended test matrix	Road testing
Cycles	WLTC, CBR, RDE95, Beaune	WLTC, RTS95, TfL, Artemis urban, Artemis road, N184-Poissy, FTP75	RDE
ATS ageing	Fresh and durability	Fresh, mid and durability	Durability
Ambient temperature	-10, 0, 14 & 35°C	-10, 0 & 23°C	~ 10-20°C
Initial SOC	Min	Min & max	-
Road load	Mid, high	Low, mid & high	-
Fuel	Certification and high particulate	MtG advanced fuel	MtG advanced fuel
Status	Finalized and presented	Tests performed and on-going analysis	Q4 2026

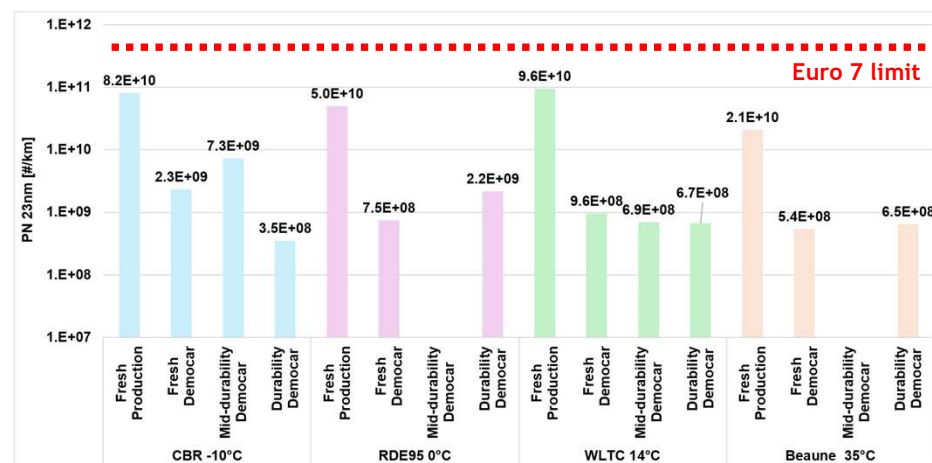
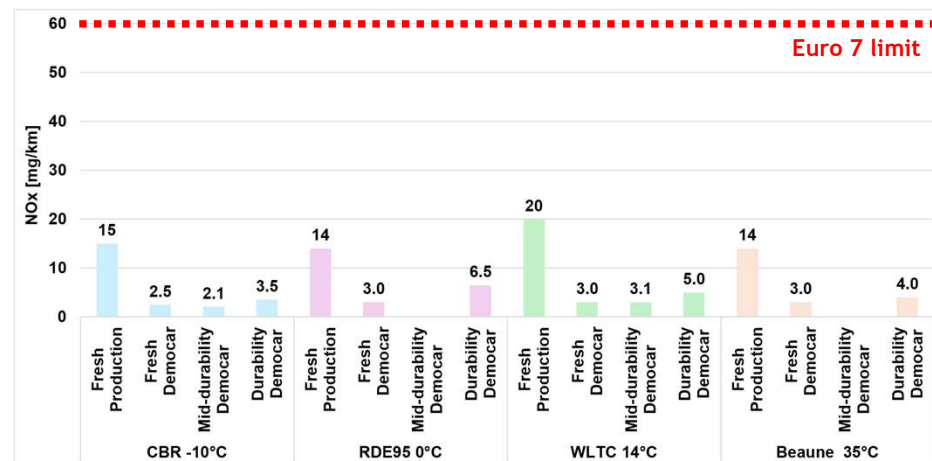
Vehicle tested in standard and severe conditions

Validation test matrix results

Emissions results over all cycles (CBR -10°C, RDE95 0°C, WLTC 14 °C, Beaune 35 °C)

Pollutant	Emission [mg/km]	Reduction NAQIV fresh / production fresh ATS	Reduction Euro 7 to NAQIV (fresh / durability ATS)
NO _x	3.6	82%	20 / 10
CO	62	92%	25 / 10
HC	3.7	94%	60 / 20
NH ₃	1.1	95%	-
N ₂ O	0	-	-
PN ₂₃	1.60E+09	98%	525 / 350

- From 82 to 98% reduction compared to the serial vehicle
- From 10 to 525 times lower emissions compared to Euro 7

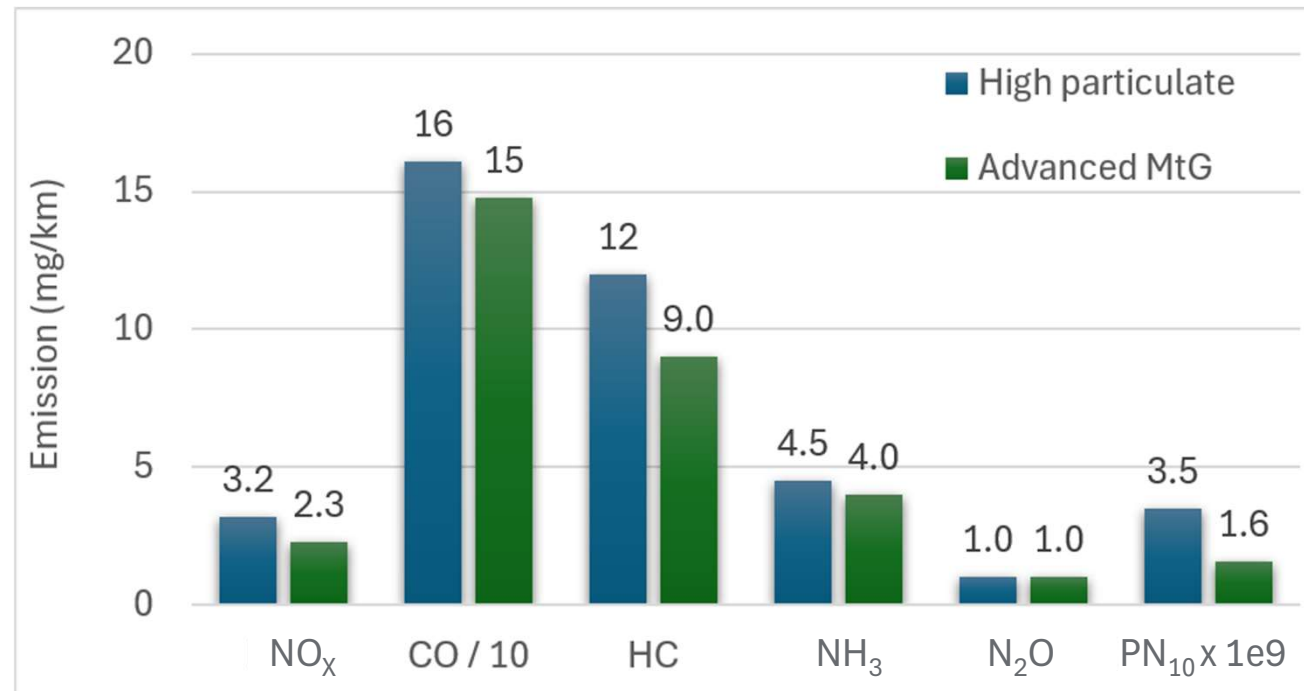


On average, more than 90% lower emissions than the production vehicle, with emission levels at least 10 times below Euro 7 limit

Advanced MtG fuel emission validation

Validation by comparison with the high particulate fuel

- Gaseous pollutants present similar to lower emission levels
- Particulates emissions are halved



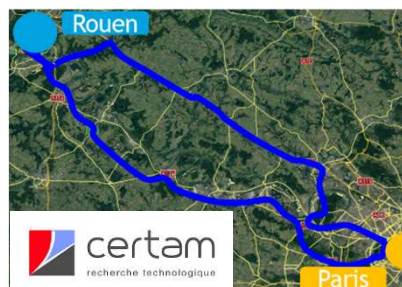
Emissions validated with advanced MtG fuel

Double GPF PN results on Peugeot 308

Rouen - Paris - Rouen cycle (275 km)

- Different road types (urban, road, highway, peripheric ...)
- Different ambient conditions (countryside, urban area, La Défense tunnel ...)

Peugeot 308 1.2 L TGD engine

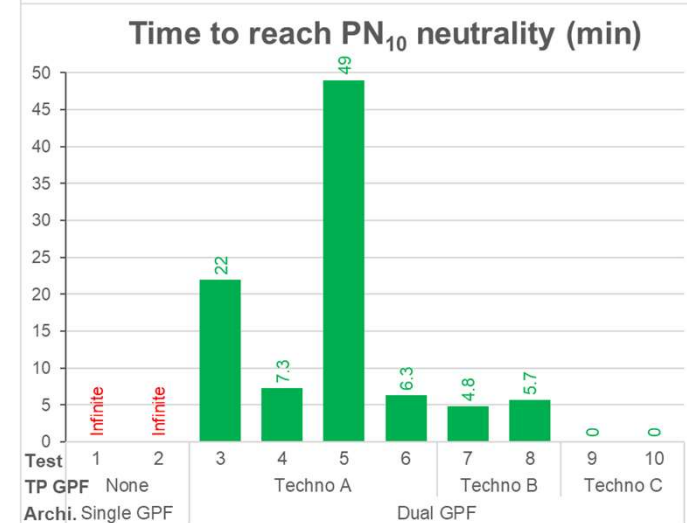
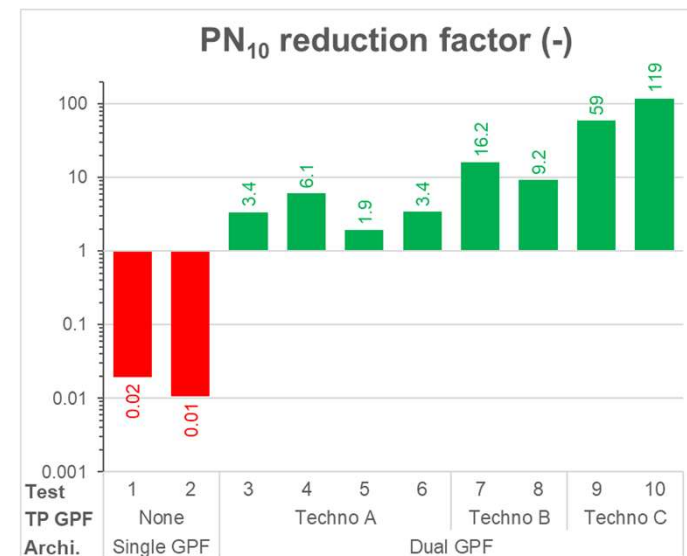


Measurements: distribution of PN measured with ELPI at ambient and tailpipe

Results

- PN reduction factor is the ratio between ambient and tailpipe exhaust PN concentrations. Techno C allows to be ~90 times lower at tailpipe compared to ambient concentration
- Cumulated tailpipe PN concentration, with Technology C, is lower compared to the ambient one from the start of the engine, while technologies A & B require more than 5 minutes

~90 times lower exhaust PN concentrations compared to the ambient with dGPF



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Air quality targets

International definition

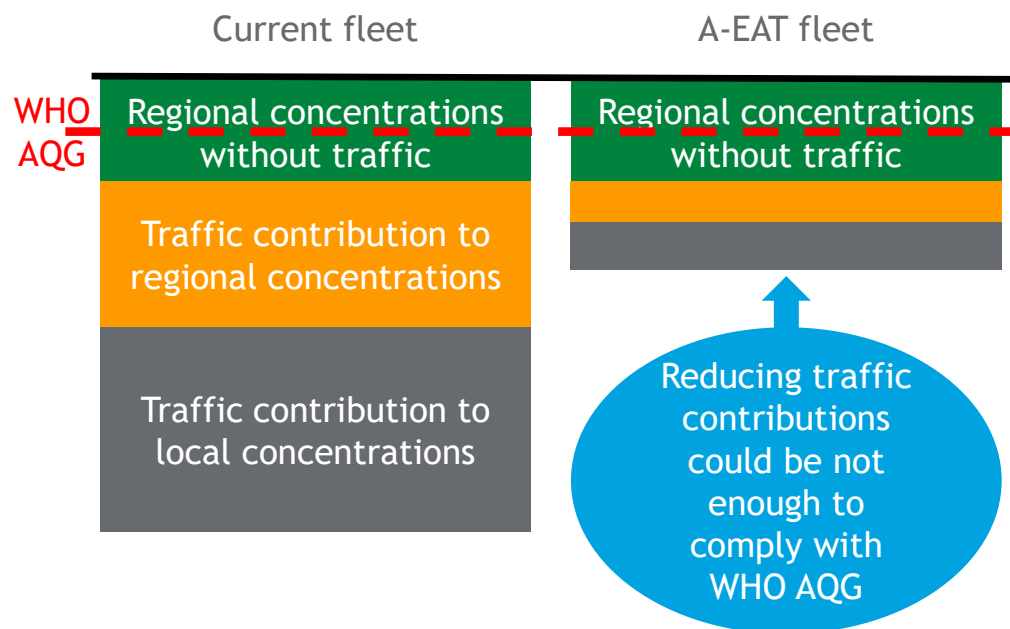
- European Union (EU) and World Health Organization (WHO)
- Based on the current scientific knowledge with “at least moderate certainty evidence for adverse health effects” (WHO)

AQ standards to reach by 2030

Concentration [µg/m³]		EU AQ Directives (last updated in 2015)	WHO AQ Guidelines (last updated in 2021)
Pollutant	Averaging period		
NO ₂	Hourly	200	200
	Annual	20	10
CO	24 hours	4 000	4 000

Multi-sectoral origins

- Emission reduction efforts across all activity sectors to comply with AQ targets



Efforts across all activity sectors needed to reach the more stringent WHO AQG

High-resolution NO₂ viewer for Europe

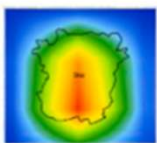


Long-distance
low-resolution
impacts of 9
non-traffic
sectors



+

Long-distance
low-resolution
impacts of
urban traffic
emissions



+

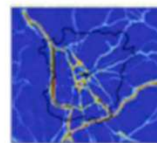
Long-distance
low-resolution
impacts of
regional traffic
emissions



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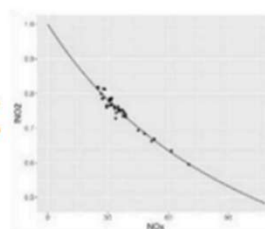
High-resolution impacts of
42 vehicle types inside the
city and all traffic outside

$$\sum_{vt=1}^{43} w_{vt} \times$$



×

Conversion from NO_x to
NO₂ using empirical
correlations

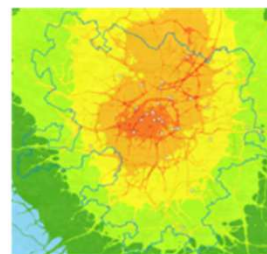


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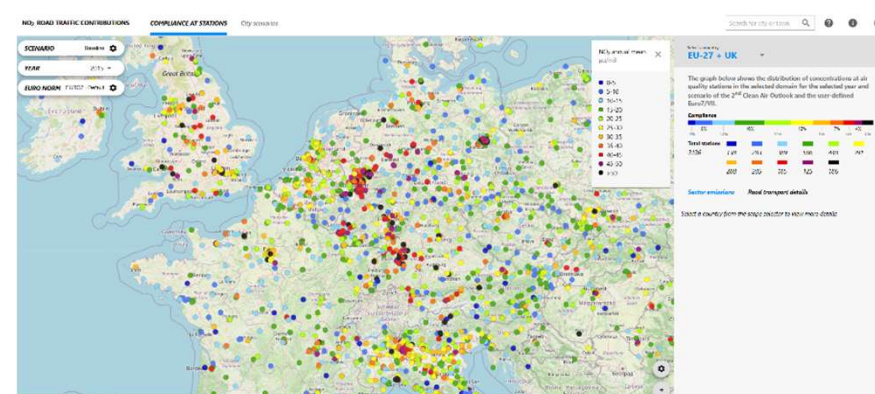


NO₂ compliance at
monitoring stations

or



NO₂ concentration
maps over cities

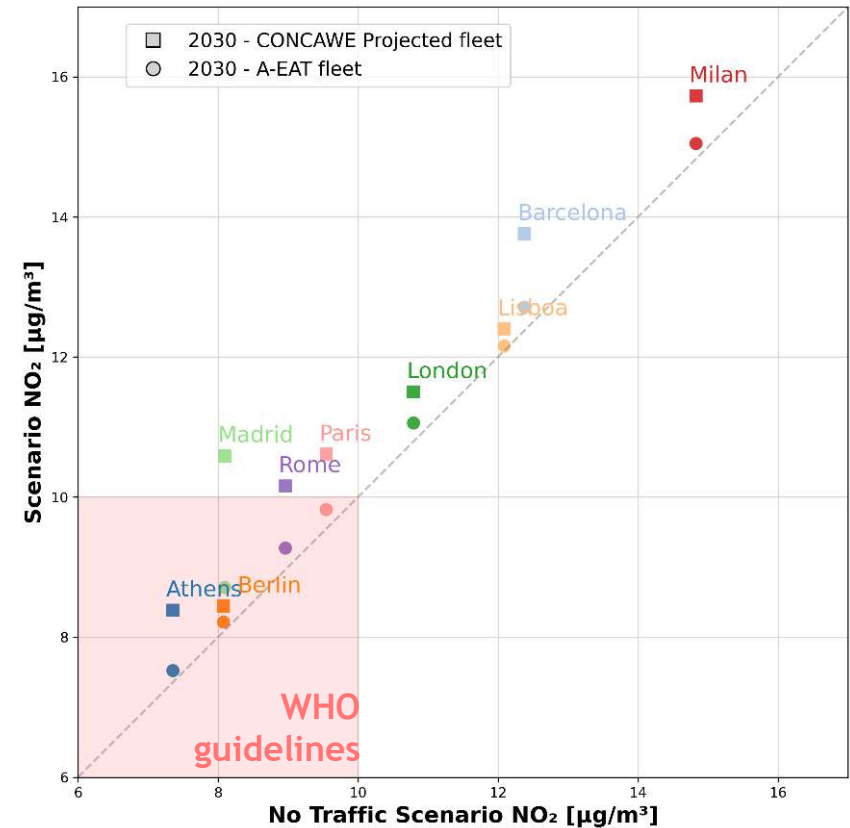


A rapid decision-making tool for estimating future NO₂ concentration across Europe

A-EAT AQ impact on major European cities

Comparison of 2030 scenarios and WHO guidelines

- For some cities, further air quality improvements require actions beyond the transport sector
- NO₂ reductions from widespread A-EAT adoption bring some cities into compliance with WHO guidelines
- NO₂ concentrations with the A-EAT fleet are close to no traffic scenario

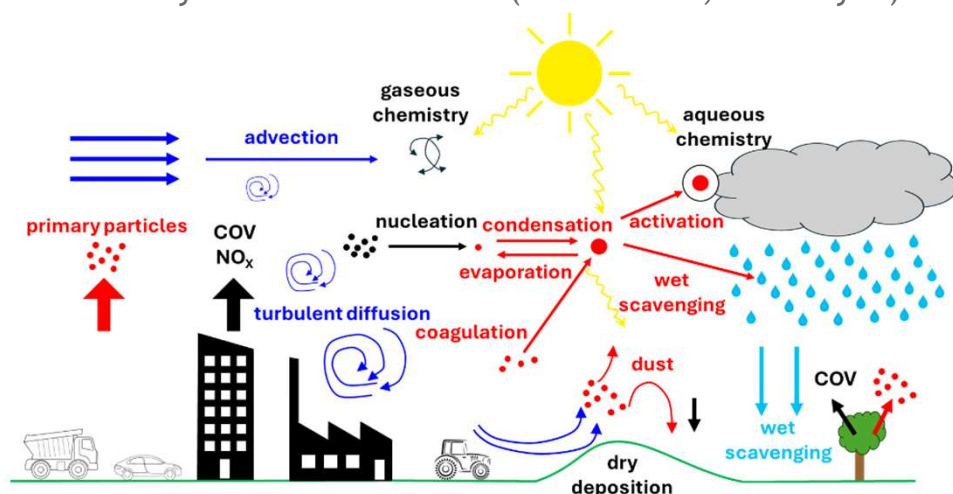


Overall benefits of A-EAT across European urban areas / cities

Physical multi-scale modelling for Paris area

Regional scale (Polair3D)

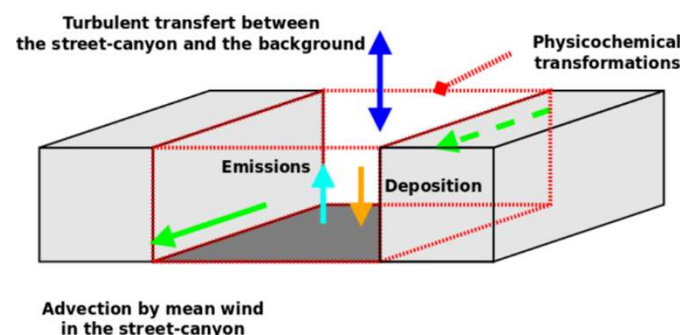
- 3D grid with a horizontal resolution of 2 km² to represent physicochemical dispersion of pollutants
- All activity sectors considered (road traffic, industry ...)



Provide background concentrations for the local scale

Local scale (MUNICH)

- Model of Urban Network of Intersecting Canyons and Highways
- Only road traffic emissions considered due to the lack of knowledge on the other sources (residential heating ...)



Provide concentrations in streets

Multi-scale modeling to capture higher concentrations of pollutants observed in streets

Emissions modeling hypothesis

Base year 2014 projected to 2030 for all sectors

- Prospective scenarios depending on the traffic fleet composition
 - Projected fleet with standard renewal rates and Euro 7 introduction
 - Full Euro 7 fleet
 - Full A-EAT fleet
- Reference simulation without traffic emissions at both scales

A-EAT emission definition

- Definition of average emission factors for Passenger Cars (PC) using test results with the A-EAT democar, under different cycle conditions
- Emission factors for other vehicle categories – LCV, HDT, buses and two-wheelers – derived from the Euro 6/VI equivalents and reductions observed for PC

PC emission factors

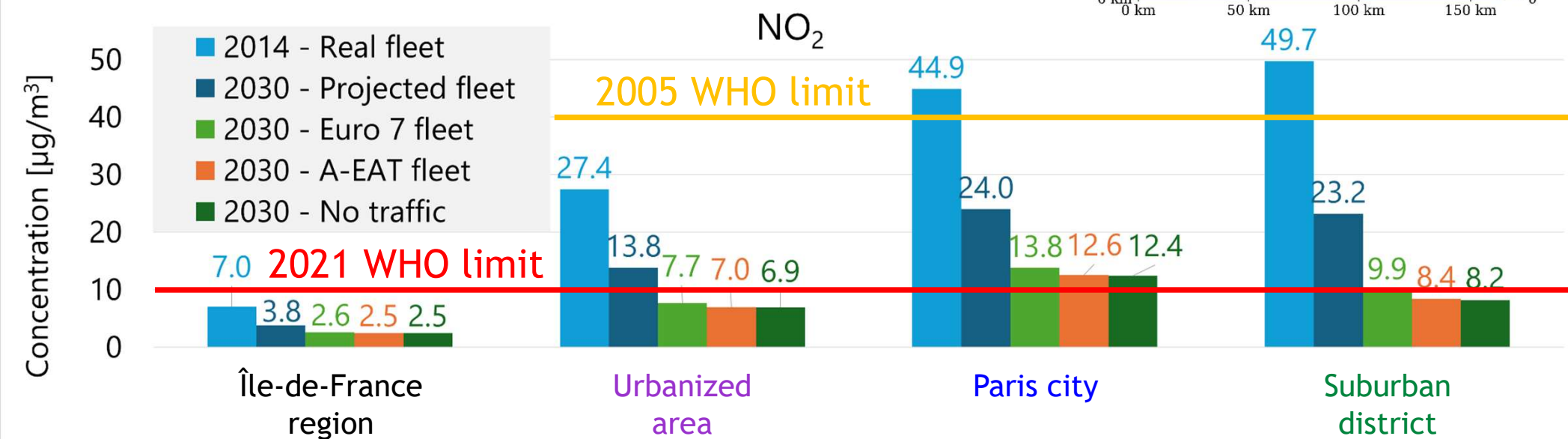
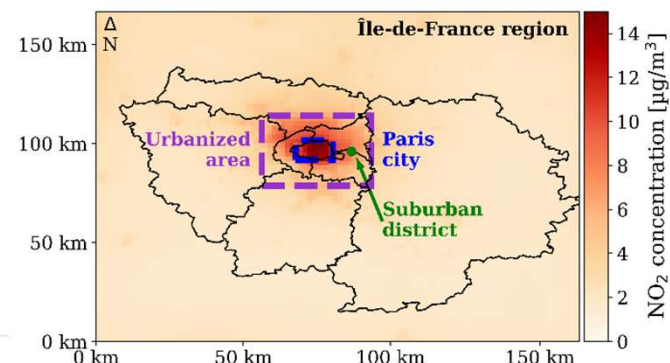
	Petrol			Diesel	
[mg/km]	A-EAT	Reduction to Euro 6		A-EAT	Reduction to Euro 6
CO	50	89%		11.9	50%
NO _x	2.5	96%		2.5	96%
VOC	5	93%		0.8	52%
NH ₃	1.3	86%		1.3	81%
PM	0.1	90%		0.1	96%

~90% emission reduction using average A-EAT fleet compared to Euro 6

Spatial domain comparison

Impact of the considered domain size and location

- Limited impact of the A-EAT fleet compared to no-traffic scenario
- Importance of the domain of interest to check compliance with WHO AQG

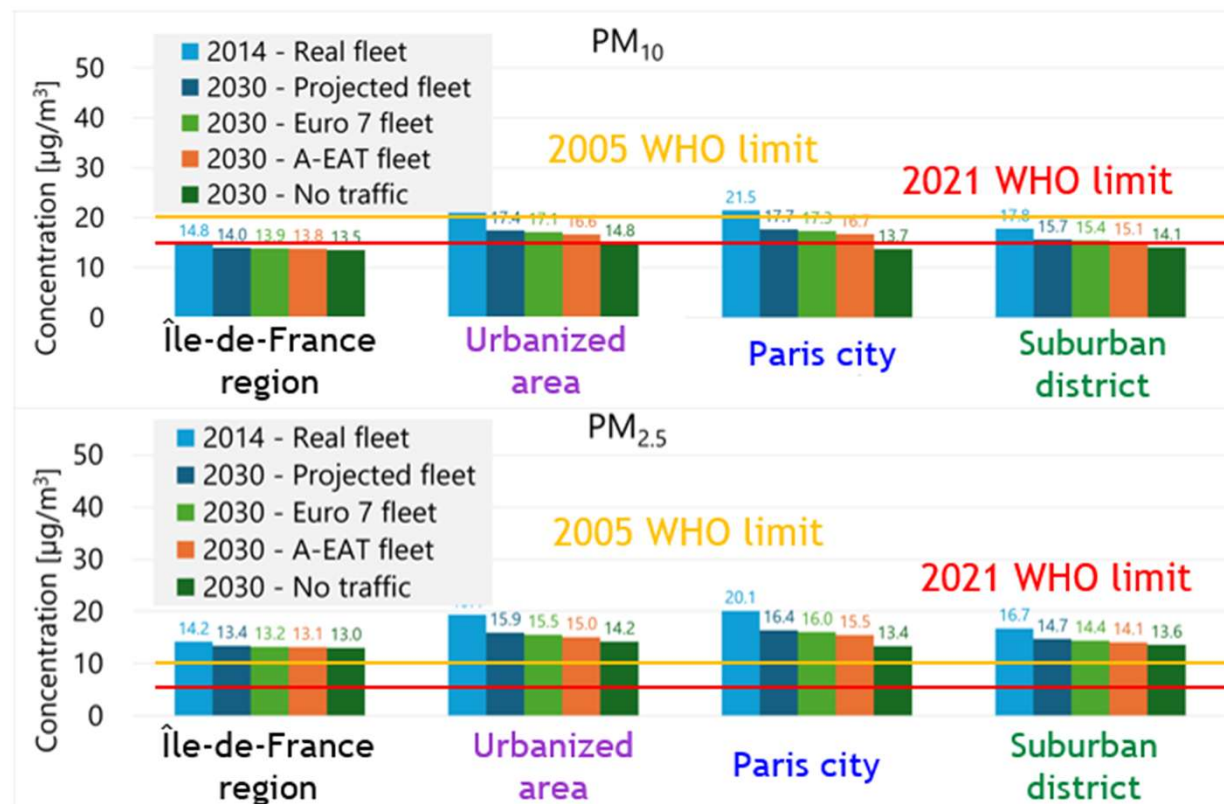


Even in the absence of traffic, some locations are exceeding WHO AQG

Particulate Matter (PM) simulation results

Impact of the A-EAT technology

- PM concentrations approach No traffic levels
- WHO PM_{10} guideline levels are within reach
- Even with no road transport, the WHO $PM_{2.5}$ guideline levels remain unattainable

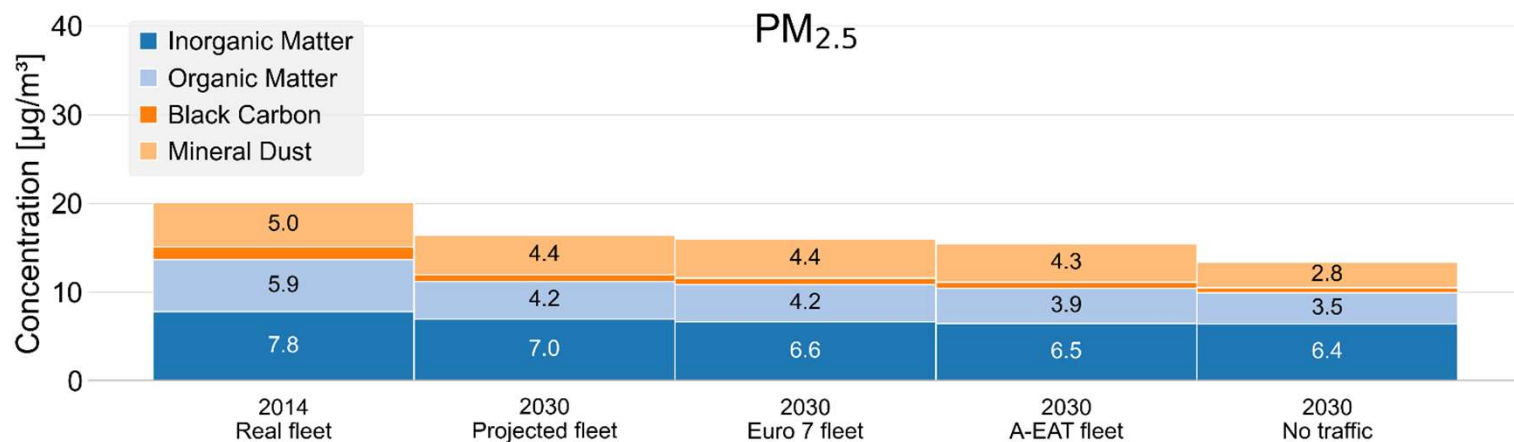


Strong influences of non-traffic sectors on PM concentrations

PM_{2.5} composition analysis

Impact of A-EAT on PM_{2.5} composition

- Inorganic and black carbon exhaust particulates are reduced to near No traffic levels
- Organic aerosol concentrations also decrease
 - Lower exhaust emissions reduce primary organic aerosol (POA)
 - Lower precursor emissions reduce secondary organic aerosol (SOA) formation
- Non-exhaust mineral dust becomes the dominant traffic-related PM source



In 2030, non-exhaust sources dominate traffic PM emissions

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Conclusion

- Our global approach combines fuels, advanced Hybrid Powertrains and ATS technologies development, supported by LCA and AQ modelling, to demonstrate achievable reductions of global and local impacts of the transport sector
- Carbon intensity is more sensitive to energy source than powertrain technology
- Advanced MtG fuel reduces carbon intensity by 3 compared to fossil counterpart
- A-EAT able to reduce by 90% the emissions for WLTC compared to the Euro 6 production vehicle
- Cold-start emission peaks nearly eliminated using eHC & control strategies
- dGPF technology shows ~90 times lower exhaust particulates concentrations compared to the ambient
- Benefits of A-EAT are consistent with both approaches across European cities
- Limited increases of NO₂ concentrations from no traffic to A-EAT fleet scenario
- PM concentrations remain above WHO AQG despite exhaust emission reduction
- Even in the absence of traffic, some locations still exceed WHO AQG requiring efforts from other sectors

Innovation becomes reality through the combined power of expertise, collaboration and determination.

Thank you for your attention .

