



Climate Action in Mobility 2018

**Towards clean vehicles –
the future of the internal combustion engine
and EU research**

27/9/2018

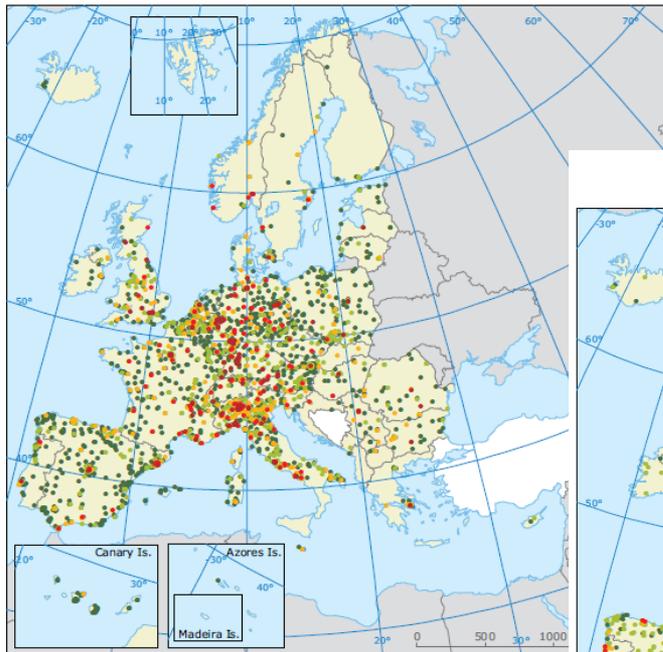
Maurizio MAGGIORE
European Commission
DG RTD H2



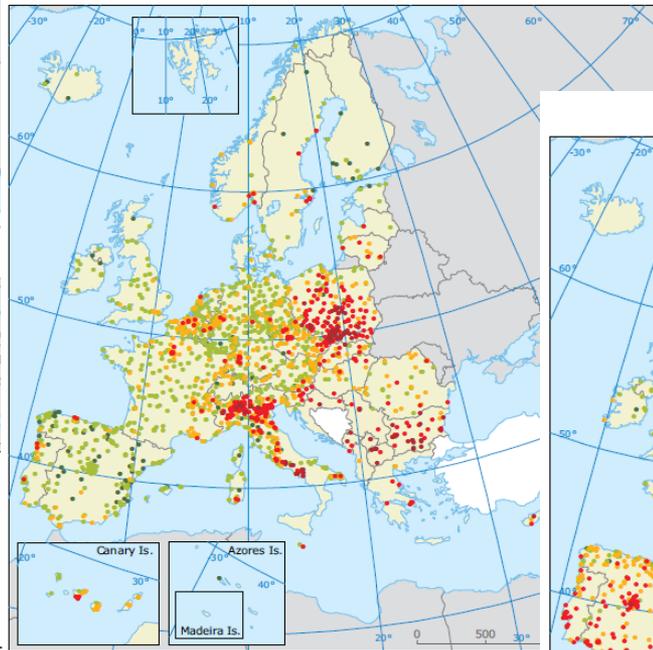
European
Commission

Pollution levels remain high in the EU, and even worse in other countries

Concentrations of NO₂ in 2013



Concentrations of PM₁₀ in 2013



Concentrations of O₃ in 2013

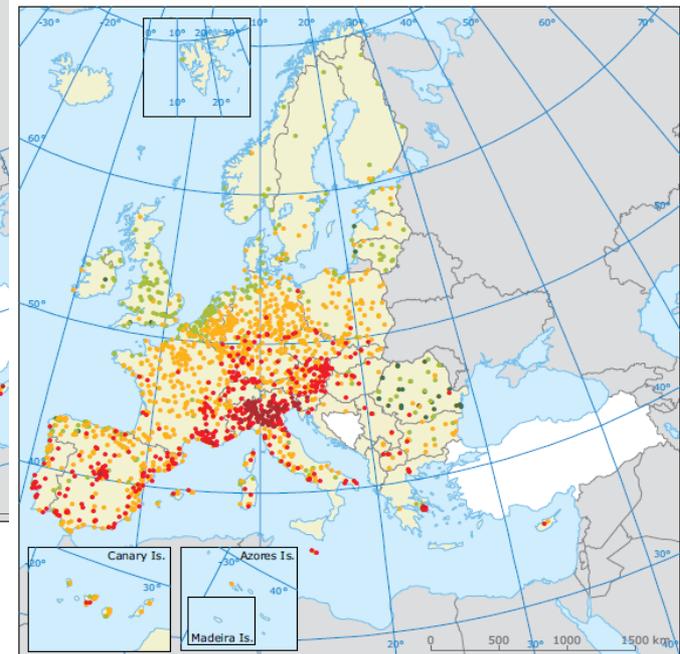


Table 9.1 Years of life lost (YLL) attributable to PM_{2.5}, O₃ and NO₂ exposure in 2012 in 40 European countries and the EU-28

Country	PM _{2.5}		O ₃		NO ₂	
	Annual mean	YLL	SOMO35	YLL	Annual mean	YLL
Total^(b)		4 804 000		215 000		828 000
EU-28^(b)		4 494 000		197 000		800 000

Premature deaths attributable to PM_{2.5}, O₃ and NO₂ exposure in 2012 in 40 European countries and the EU-28

	PM _{2.5}	O ₃	NO ₂
Total^(b)	432 000	17 000	75 000
EU-28^(b)	403 000	16 000	72 000

EU standards not as strict as WHO's

Set and enforce science based targets as proposed by WHO to protect health!

EU limits are NOT SCIENCE BASE and do NOT protect people's health

Pollutant	EU limit	% citizens Exceeding EU limit	Science based Guidelines of WHO	% citizens Exceeding WHO limit
PM ₁₀	50 µg/m ³ in 24 h	16	20 µg/m ³ a year	50
PM _{2.5}	25 µg/m ³ a year	8	10 µg/m ³ a year	85
BaP	1 µg/m ³ a year	20	0.12 ng/m ³ a year	88
NO ₂	40 µg/m ³ a year	8	40 µg/m ³ a year	8
SO ₂	125 µg/m ³ in 24 h	<1	20 µg/m ³ in 24 h	38
O ₃	120 µg/m ³ in 8 h	8	100 µg/m ³ in 8 h	96

Choking cities want solutions, fast!



Effective Euro 6 RDE¹ - an opportunity for industry

Cleaning up the fleet

- is an opportunity
 - for new vehicles with lower emissions
 - for retrofit solutions



Making it work

Not cleaning up the fleet

- is not an option
- achieving limits of Ambient Air Quality Directive is incompatible with cars that have the current (average) emission performance



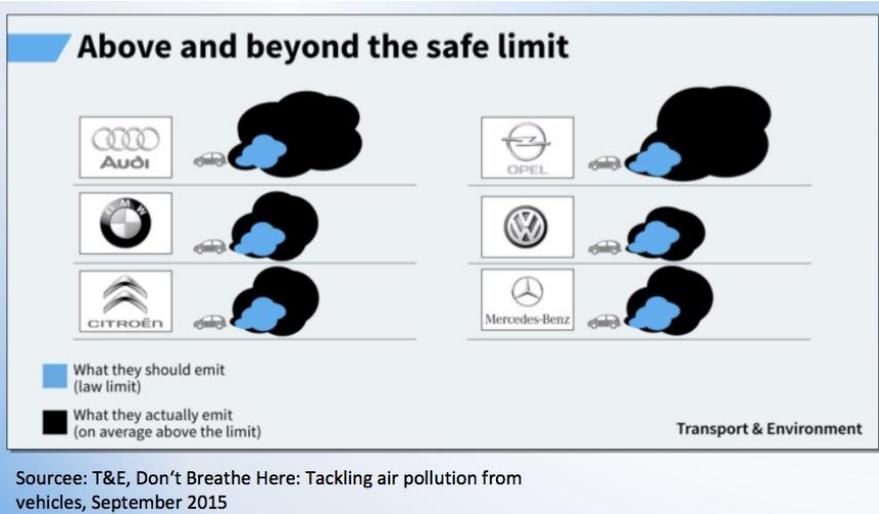
Next steps

- 19 May agreement on RDE test procedures is positive first step
- What needs to be agreed in autumn
 - **Swift introduction of RDE testing**
 - Strict conformity factors
 - Do not introduce loopholes



Pollution and cities around the world decide future engines
 No question about the need of lowering diesel car/van NO_x...

DG RTD projects had strict test requirements since many years, yet research results were not applied, prizes have even stricter test procedures and targets
 Trucks ok with warm exhausts



Source: T&E, Don't Breathe Here: Tackling air pollution from vehicles, September 2015

But NO_x (and NO₂ specifically) are not the only issue for combustion engines, other pollutants and CO₂ need to be reduced

NO_x - Emissions of two Daimler Diesel Vehicles

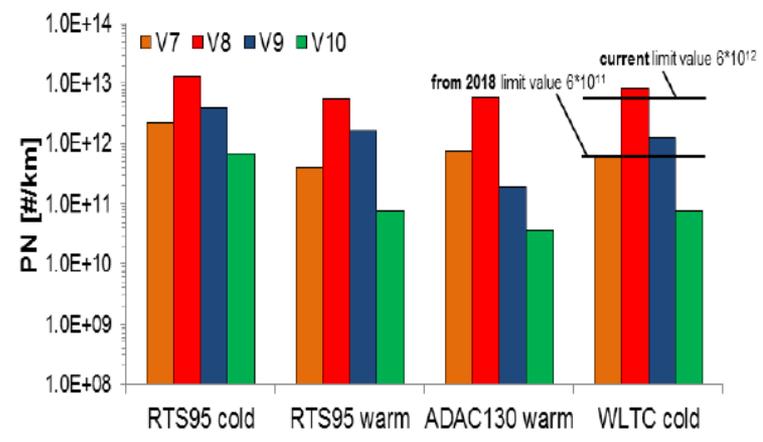
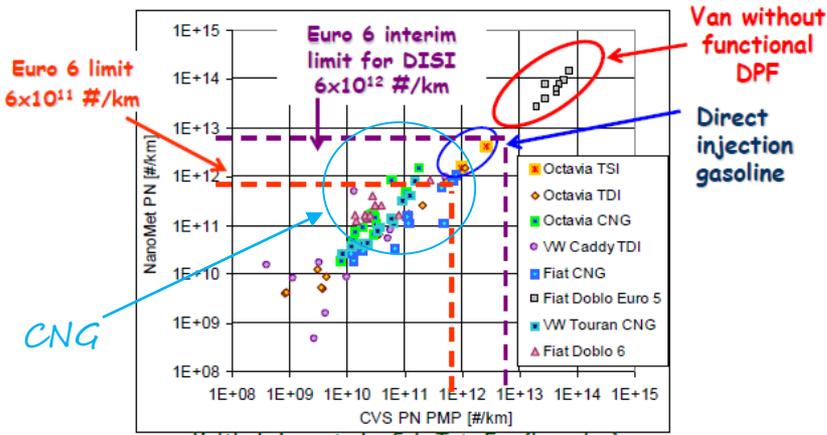


RDE works, but pollution is not solved! Cities also have particulate issues (might not be visible, in mass terms one 5µm particle equals 2.5M 20nm ones)... and it's an emerging global warming issue too

Total number of non-volatile particles (PN)



NanoMet3 - raw exhaust, relies on calculated exhaust flow and data synchronization; diffusion charger measures approximately total particle length (different principle); correlation with PN (PMP) established on diesel vehicles (EC Joint Research Center)

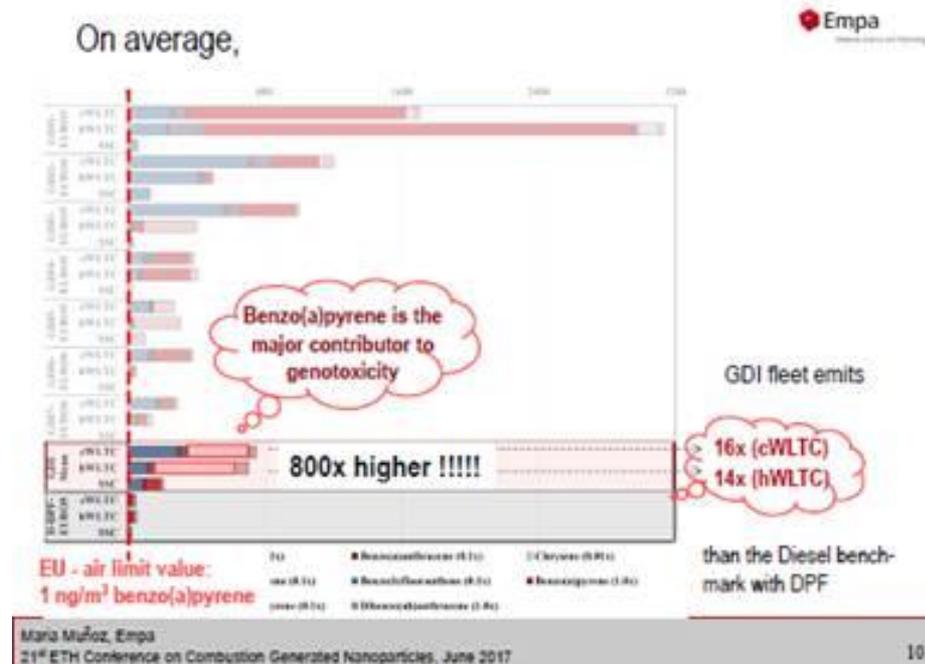


PN results in all driving cycles.

... all combustion engines contribute (also gasoline and NG MPI, ships, planes) orders of magnitude more than new diesels, all with high efficiency filters... but tampering is a huge threat

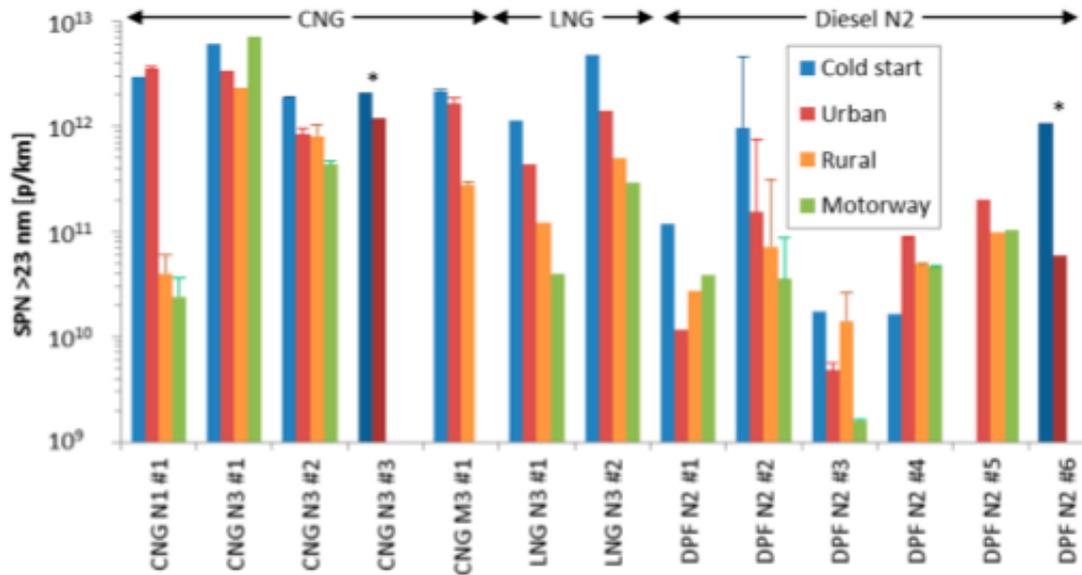
Vojtisek et al.: On-road measurement of emissions of reactive nitrogen compounds and greenhouse gases from Euro 6 diesel and natural gas vans using an on-board FTIR. ETH Conference on Combustion Generated Nanoparticles 2017 30

... and since gasoline particles (finer and with more PAH) might be more dangerous than diesel's... and jet engines emit 10nm PN

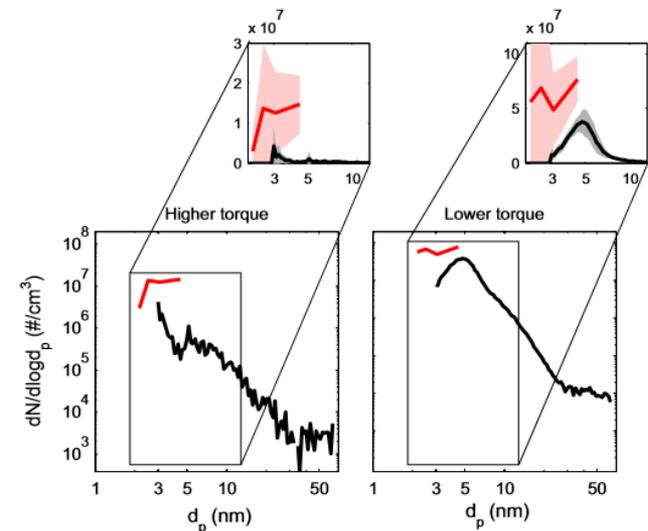


... risk-based PN limits are considered for the "Engine of the future" prize (for instance, they'll be measured down to 10nm), more later

... even natural gas, widely promoted as clean in the world, is emerging as a PN threat, with >50% of particles escaping counting due to small size (3-10nm) yet still total count higher than diesel...



J. Alanen et al. / Fuel 162 (2015) 155–161



PN limits being considered in upcoming EU regulation for HD natural gas vehicles, might be later also for cars

Currently unregulated pollutants should not be forgotten

- **NO₂** is being manipulated (higher than normal NO/NO₂ ratios) to help in trap regeneration, should be regulated separately
- **N₂O** is an extremely powerful GHG
 - TFL reported a bus emitting the equivalent of 15% of its CO₂ emissions as N₂O
 - Other buses around 5%
 - Cannot be forgotten as a GW threat
- **CH₄** with its large GW multiplier might become a problem with widespread C/LNG use in trucks and ships
- **Cyanides** and **NH₃** from SCR
- **Aldehydes** from biofuels
-

All these are covered in Horizon Prizes

- Even when AQ legislation is met, it does not mean health impact is solved
- Whatever the fuel, cities want low pollution, not only decarbonised
- Zero emissions is a need, and it's a performance standard, so technology neutral
- Combustion engine improvements cannot sufficiently reduce CO₂ across transport
- ICEs will in any case be hybridised, but they need to be clean too, it's not yet true
- Full electrification can deal with both issues, and all needed elements are available
- For long term full decarbonisation, de-fossilised fuels, e.g. e-fuels and bio, might be needed for some sectors, but they need to be ready to pay a premium
- It's an option for transitions in countries where electrification will take longer
- A joint EC/IEA workshop recently in Brussels presented some interesting material

Electro fuels to complement electrification in transports



- Direct electrification more efficient
 - Real range needs should be considered carefully
- On-the-move electrification is an option for long haul trucking
 - Eggs and chicken problem
- Battery busses, trolley-busses and tramways excellent city options
- Hydrogen fuel cell vehicles vs. synthetic gasoline/diesel fuel
- Ammonia & biofuels best options for maritime transportation
 - Can be used in existing vessels
- Hydrocarbons likely to remain needed for aviation
 - Best in volumetric and gravimetric densities
 - Hydrogen-enhanced biofuels the preferred option?

Direct electrification efficiently drives the change in transport
Electro fuels will find effective uses in transport

Cost is an issue even with optimistic assumptions

No taxes, really?
 And incentives too?
 Oil might get cheaper
 An option for world trade
 and emerging countries

EXAMPLE GERMANY

In a 100% scenario, we estimate the fuel cost for SynFuels significantly higher than for ICEs today, whereas BEVs will be lower and FCEVs are comparable and costs

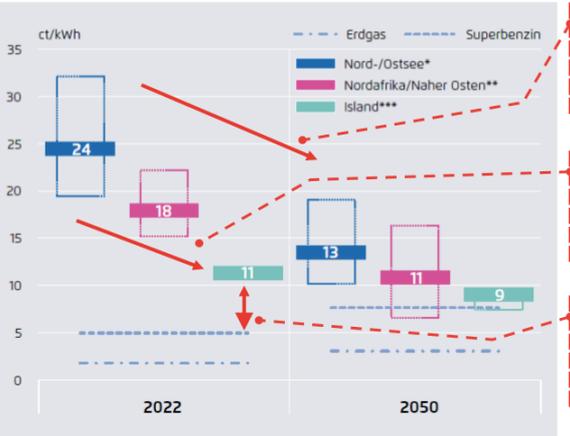
Full supply scenario for Germany: Estimation of variable costs (€/MWh_{fuel})

	Production & storage		Infrastructure		Add. price components		End user price	Fuel per 100km	
	Production	Storage	Distribution	Point of supply	Margin	Tax		Consumption	Fuel cost (€)
Electrical energy	85	7	65	33	19	64	273	~18-26 kWh	5-7
Hydrogen	170 146	3	32	9	21	45	279	~0.8-1.0 kg H ₂	7-11
SynFuel	219 193	0	50	3	27	57	357	~5.5-8L Synfuel	18-26

Sources: Strategy& research, PwC Strategy& research, Electrical energy, Fuel processing

ICE today: ~7-12€

Cost of Synthetic Fuels / Methan



Thesis 1: Costs for Synthetic fuels will decrease in future – given that there is sufficient scaling

Thesis 2: There is huge potential to optimise costs for the supply of PtX around the globe

Thesis 3: The scaling up of global PtX markets will require an adequate market framework and incentive scheme

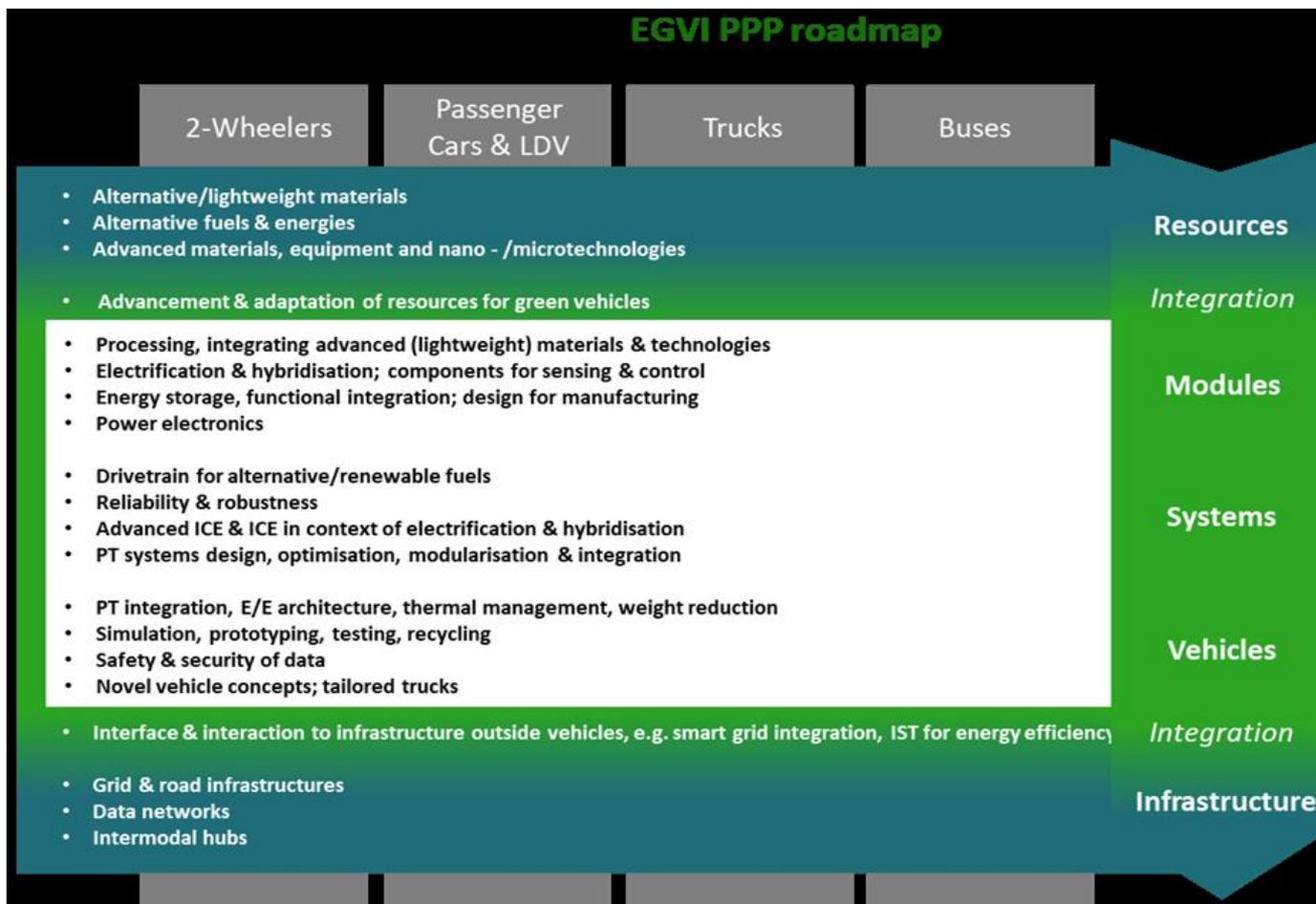
Src: Frontier Economics in: Agora Verkehrswende und Agora Energiewende (2018)

Renewables excess not enough to justify the massive investment (electrolyser...)

WHAT ARE WE DOING ABOUT IT: EU ENGINE PRIZES AND RESEARCH



Sustainable electrification is the top priority, ZERO pollutants and renewable grid...
needs large investments for competitiveness with Asian and US industry
An investment of more than 1.5B€ in electrification and HFC research



International cooperation is needed to spread clean technology

LC-GV-05-2019: InCo flagship on "Urban mobility and sustainable electrification in large urban areas in developing and emerging economies"

✓ Content

- Tools and models for policy-making, E-mobility management strategies
- Develop demonstrations and pilots in the field of electro mobility
- Twinning of EU and international projects
- Implementation concepts for scaling up, city planning and financing

✓ Policy Context

- Climate Change, New Urban Agenda, Sustainable Development Goals

✓ International Partners

- Asia (e.g. China, India), CELAC - Community of Latin American and Caribbean States (e.g. Brazil) and Africa

International Cooperation call on reducing impact of transport on air quality: around 40 proposals received

- Low-emission oriented driving, vehicle, traffic management and assistance.
- Development of holistic scoring mechanism for the environmental performance of all vehicles
- Sensing of emissions for monitoring fleet-wide on-road emissions, tampering, OBD ineffectiveness, etc
- Development of an emissions measurement system for operating vessels and assessment of AQ impact
- Measurement of pollutants emissions from aircraft in/around airports and assessment of AQ impact
- Assessment of health effects of ultrafine particles (VOCs and SVOCs) emitted from engines
- Hardening vehicle environmental protection systems against tampering

A comprehensive approach for Engine Prizes

– Prize on retrofits addresses cleaning the existing fleet

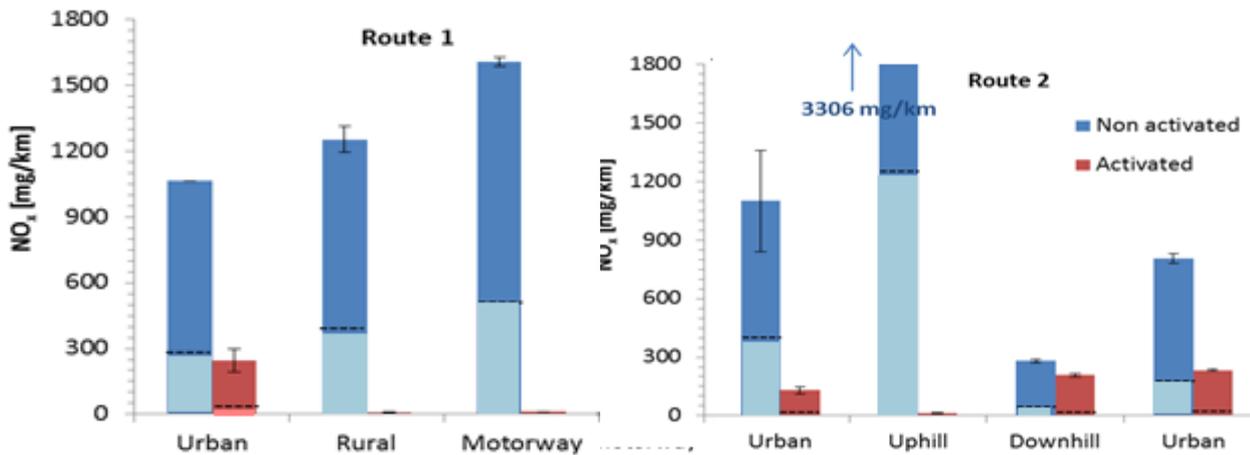
- Most dieselgate cars will be around for >10 years, some for sale (huge amount registered in August), not everybody can afford to change them
- The really clean alternative is electric, still not affordable for many
- Certification, incentives and who pays?
 - Access to the city allowed only for RDE or retrofitted
 - Lower/zero congestion/pollution charges
 - Contribution to installation costs
 - Support from OEMs
- Avoid that they end up buying an unfiltered car
- RETROFITS: A DEMOCRATIC ALTERNATIVE TO CLEAN THE FLEET FAST

– Prize on future engines

- A clean alternative to electrification if it grows slowly and decarbonised fuels happen (a safety net)
- Useful to get CLEAN hybrids, so even for the longer term
- Also looks for low "real driving" fuel consumption, i.e. decarbonisation
- Given the progress in batteries, might be overtaken by events

The Horizon Prize: Engine Retrofit for Clean Air in synthesis...

- Delivered an effective retrofit for diesel engines without modifying existing ECU: IT WORKS!
- Eliminating thermal windows would work even better
- Acceptable cost (<1500€, less than diesel devaluation or charges by some cities in one year)
- Has been checked
 - In the lab, at cold temperature and on aggressive cycles
 - in **real urban** and **rural driving** under stricter methodology than current RDE (**no vxa, more altitude gain, wider asymmetric CO2 boundaries in the normalising procedure**)
 - The winner is **cleaner** than most brand new Euro 6 cars, and **on a par** with **post 2019** ones, i.e. from **2700 down to 10 mg/km** at 130km/h (constant speed), from **>3000 mg/km** driving uphill (**1300 of NO₂**), to **<15!**



Horizon Prize

CLEANEST ENGINE
OF THE FUTURE

Aims at an engine for future hybrid powertrains for really **healthy** and **decarbonised** transport:

- if really renewable **fuels** become widely available,
- if **electric** vehicles don't become cheaper than ICE ones

A seal of excellence for the winner

An **opportunity** for industry and researchers to show EU is still the best at **real** combustion engine technology?

Deadlines³

LAUNCH OF THE CONTEST	20 April 2016
Call for applications is open on the Participant Portal All detailed information is available on the Horizon Prize website	
DEADLINE FOR REGISTRATION	20 May 2019 at 17:00:00 CET ⁴
Contestants register through the Participant Portal and by sending email to RTD_FUTURE_ENGINE_PRIZE@EC.EUROPA.EU	
CLOSING DATE FOR SUBMISSION	20 August 2019 at 17:00:00 CET ⁵
Applicants submit the application form Part A and Part B through the Participant Portal and deliver the prototype vehicle to JRC	
EVALUATION	September 2019 - March 2020
Applicant submissions are evaluated against the award criteria described in this document, and on the basis of verification testing performed by JRC	
AWARD	April-June 2020
Announcement of the Winner of the Horizon Prize for the Cleanest Engine of the Future	

3.5 M€ Prize
value





THANK YOU FOR YOUR ATTENTION

- DG RTD
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Visit our websites:

<https://ec.europa.eu/research/horizonprize/index.cfm?prize=clean-engine>

http://ec.europa.eu/research/transport/index_en.htm

<http://ec.europa.eu/research/participants/portal>