Vehicle emissions: regulatory perspective and empirical evidence

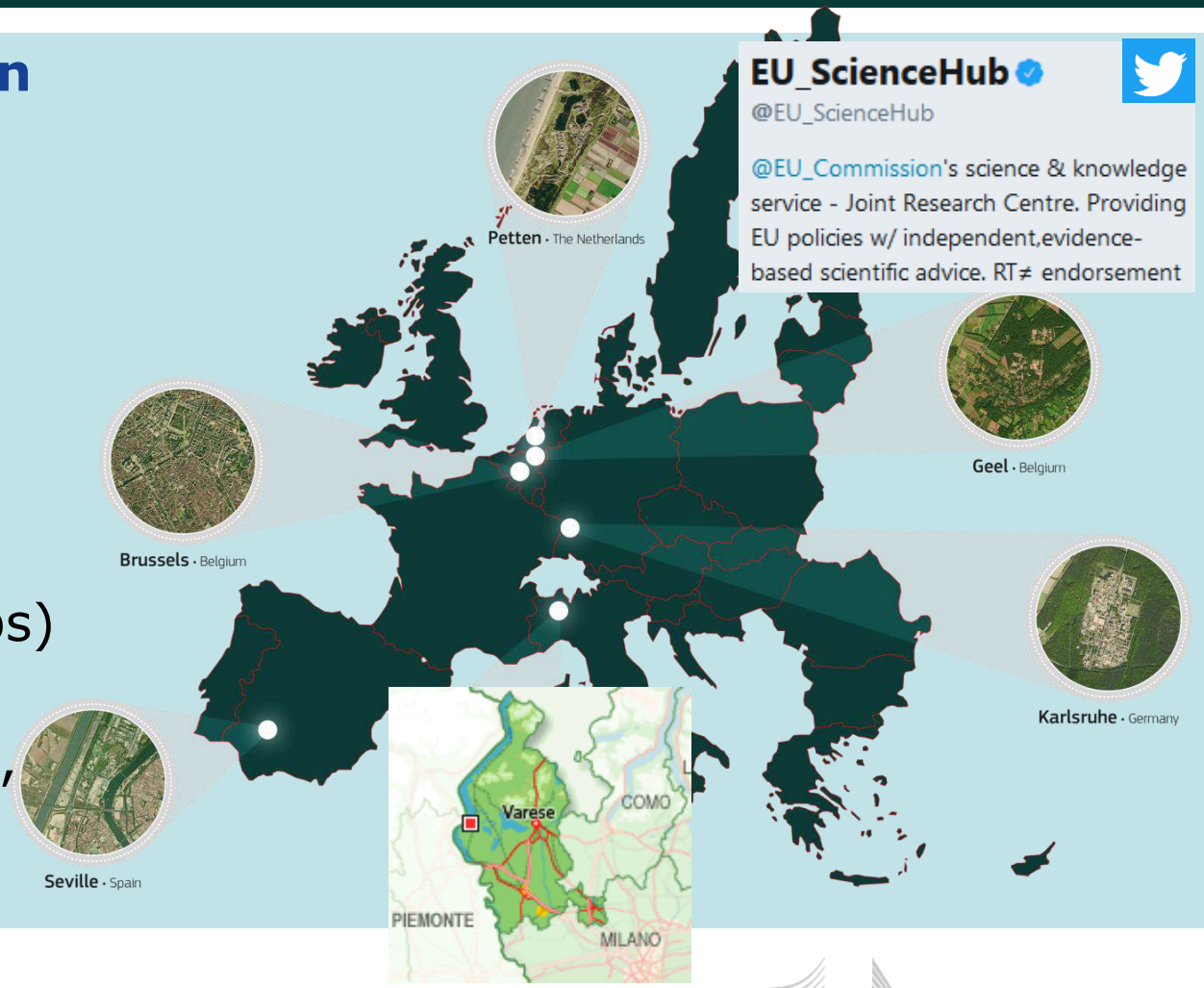
Víctor Valverde, Joint Research Center (JRC), European Commission

Storie d'aria WEBINAir Cittadini per l'aria, May 28th 2020

European Commission

The Joint Research Center at a glance

- **In-house science service of the European Commission.** Independent, evidence-based scientific and technical support for many EU policies (natural resources management, cybersecurity, migration, taxes, COVID-19 response, etc.)
- **~2730 staff** ~70% researchers, >2300 publications per year
- 42 large scale research facilities including **9 vehicle emission laboratories** (VELA labs)
- **Sustainable Transport Unit** pollutant emissions, CO_2 from road transport, alternative fuels, connected and automated mobility, vehicle safety, electric mobility, electromagnetic compatibility, etc.



[JRC Annual Report 2018.]

European Commission

Motivation

Premature deaths attributable to $PM_{2.5}$, NO_2 and O_3 exposure in the EU-28, 2016

	Population (1 000)	$PM_{2.5}$ Annual mean (a)	$PM_{2.5}$ Premature deaths (b)	NO_2 Annual mean (a)	NO_2 Premature deaths (b)	O_3 SOMO35 (a)	O_3 Premature deaths (b)
Italy	60 666	16.6	58 600	22.1	14 600	6 058	3 000
EU-28	**506 028**	**12.9**	**374 000**	**16.3**	**68 000**	**3 547**	**14 000**

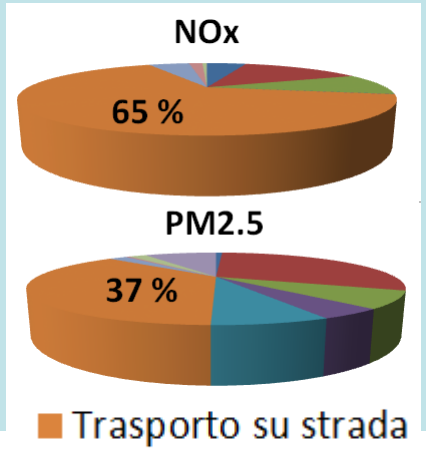
Air quality in Europe. EEA Report No 10/2019

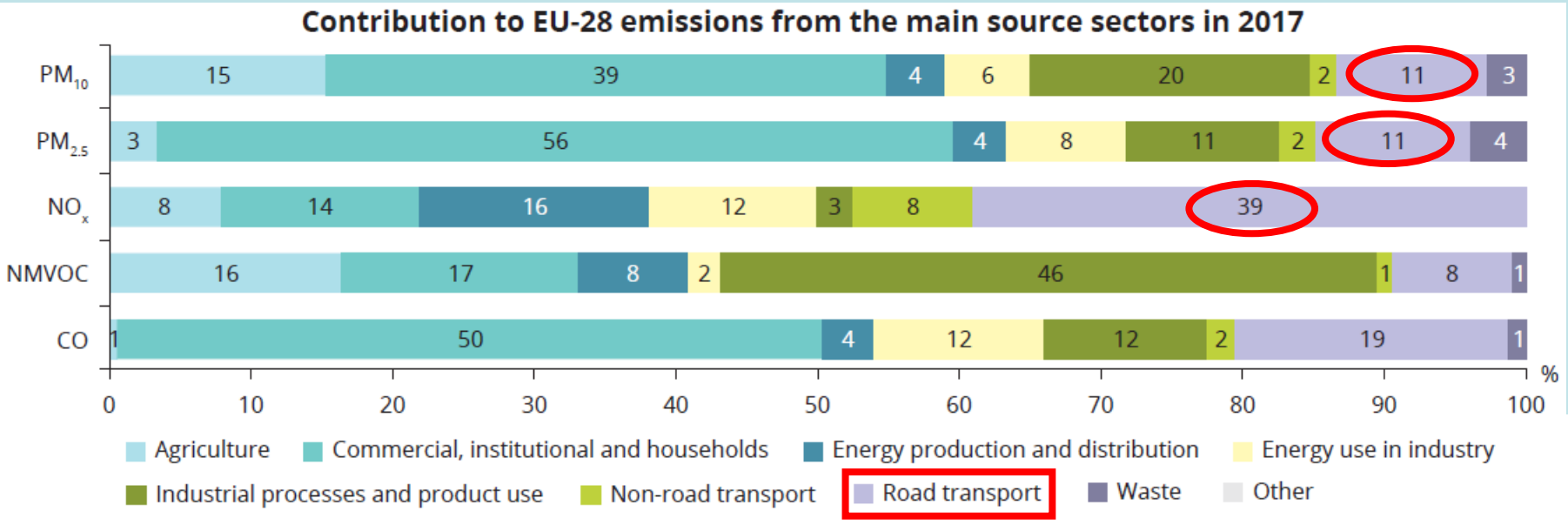
15x



Annual Accident Report 2018.

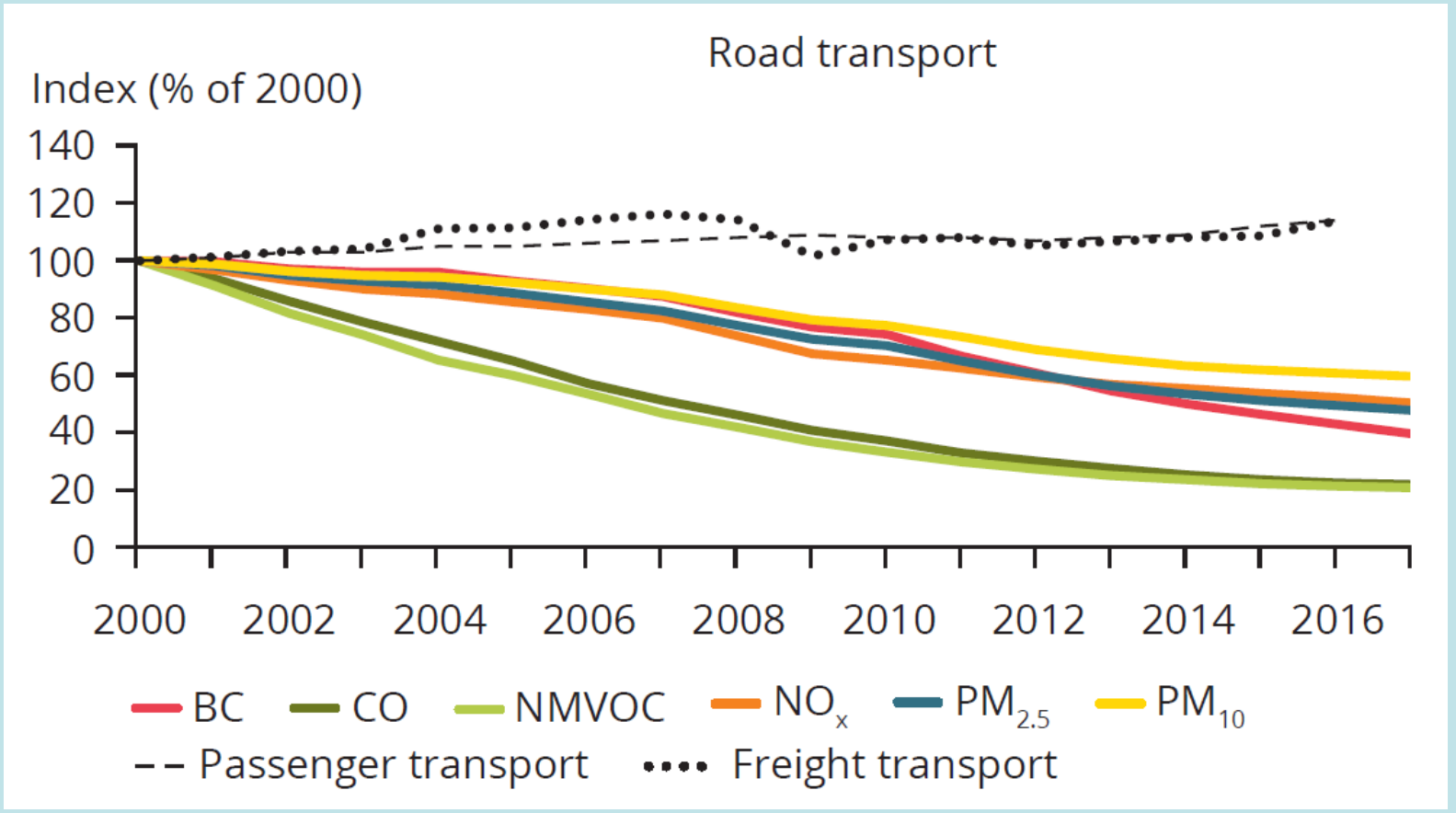
Distribuzione percentuale delle emissioni in provincia di Milano nel 2017. INEMAR - ARPA Lombardia

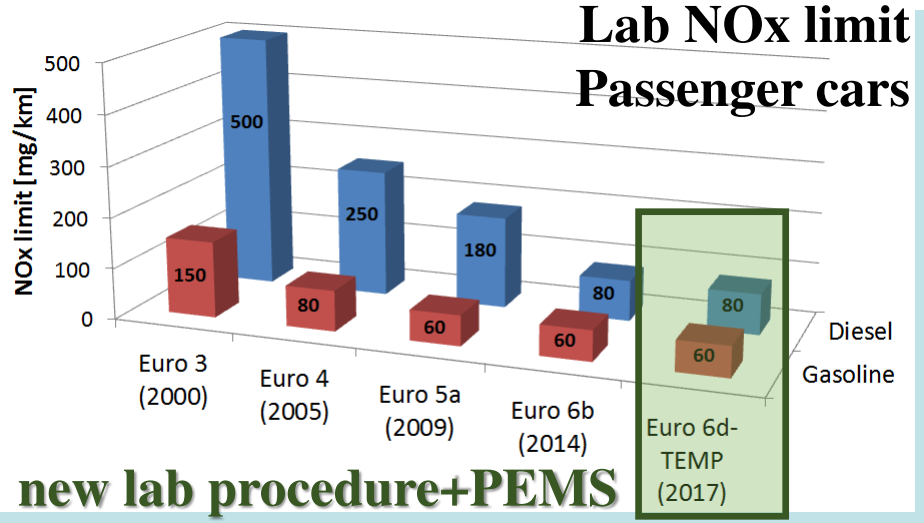


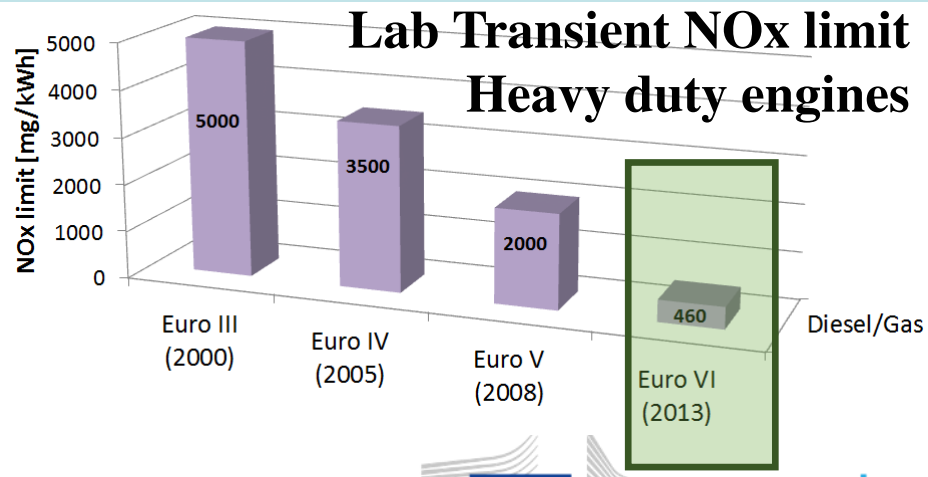


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Trends in EU-28 emissions: road transport



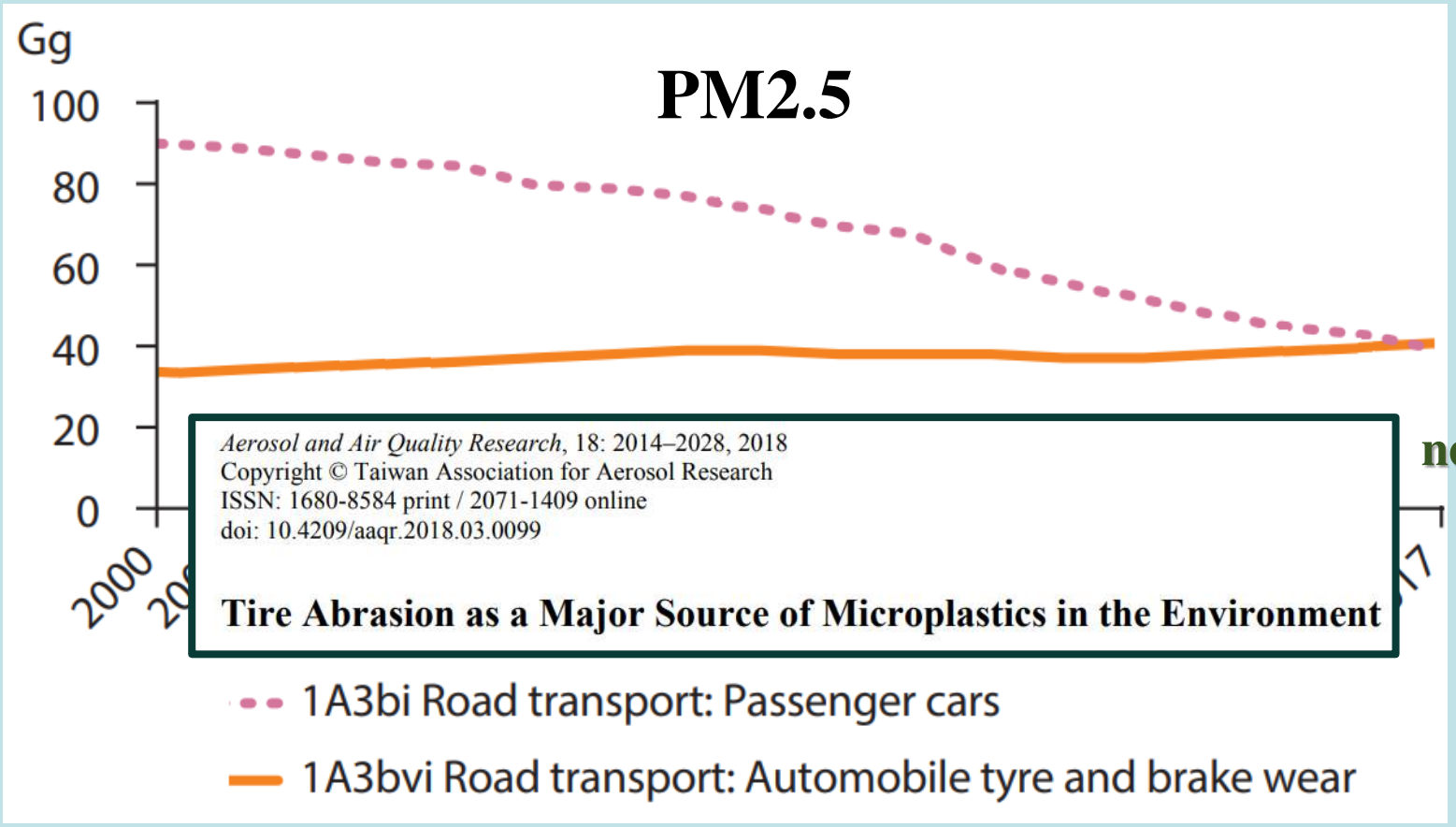




[Air quality in Europe. EEA Report No 10/2019]

European Commission

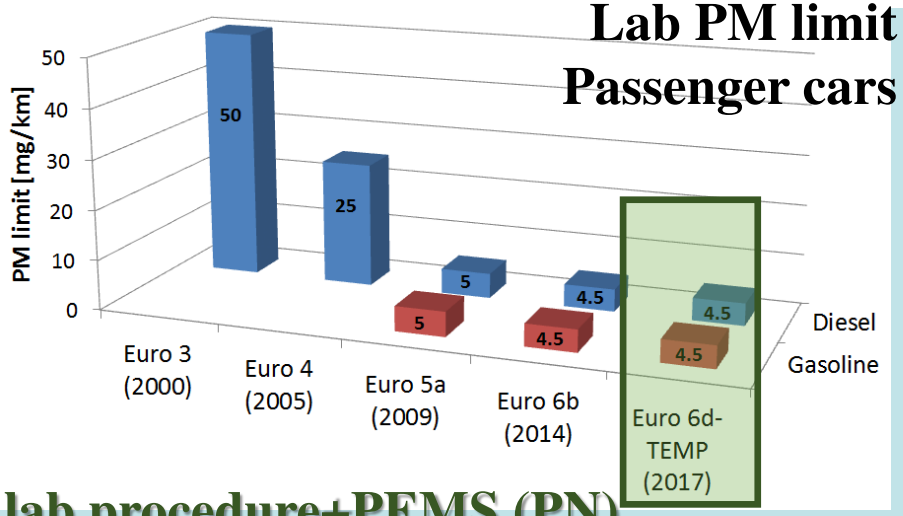
Trends in EU-28 emissions: road transport



Aerosol and Air Quality Research, 18: 2014–2028, 2018
Copyright © Taiwan Association for Aerosol Research
ISSN: 1680-8584 print / 2071-1409 online
doi: 10.4209/aaqr.2018.03.0099

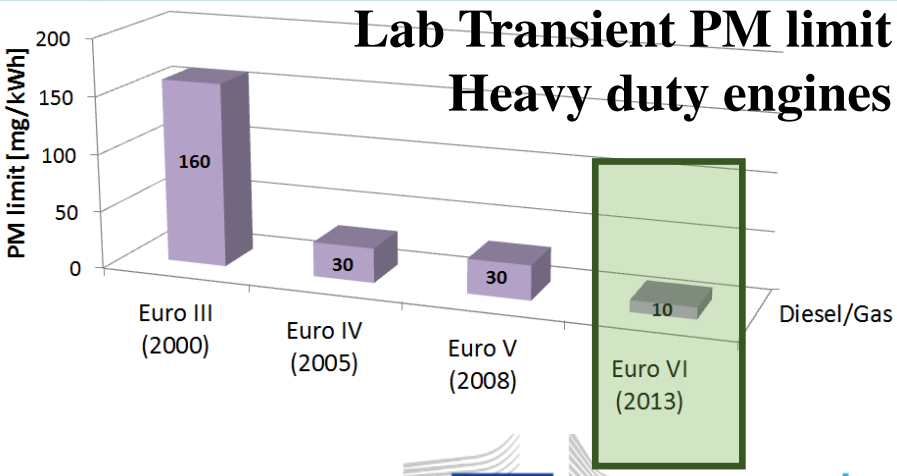
Tire Abrasion as a Major Source of Microplastics in the Environment

Lab PM limit
Passenger cars



new lab procedure+PEMS (PN)

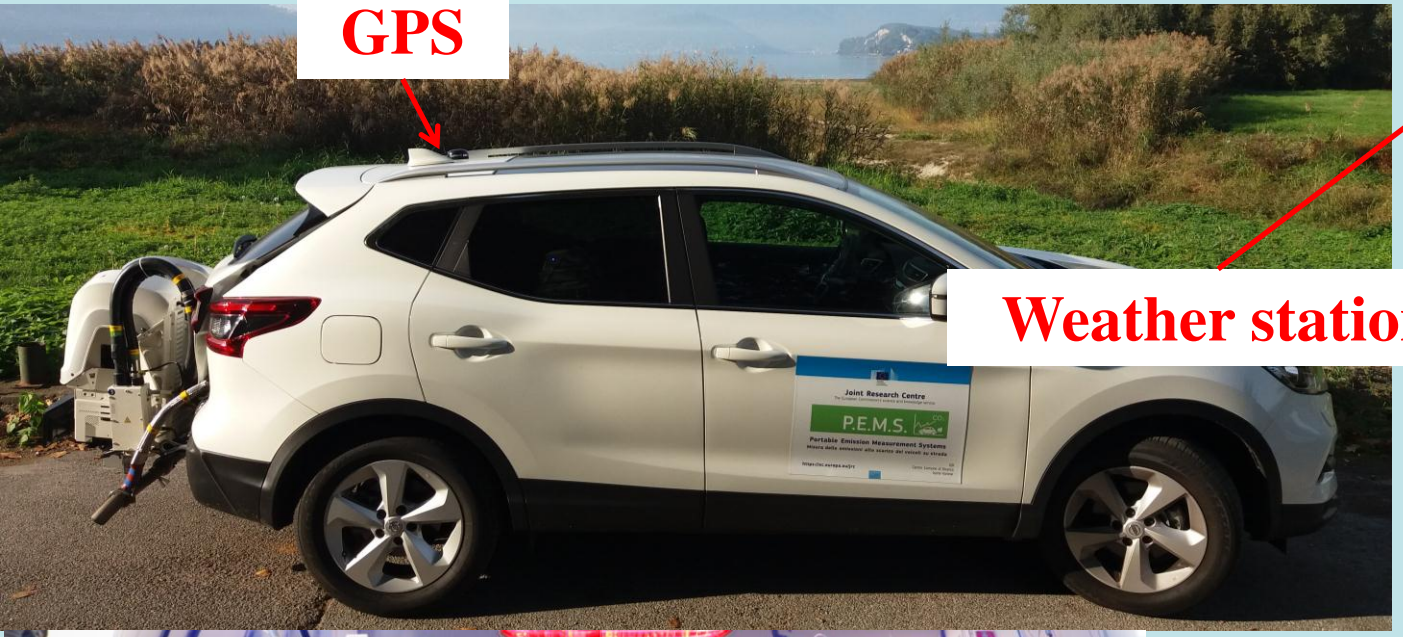
Lab Transient PM limit
Heavy duty engines

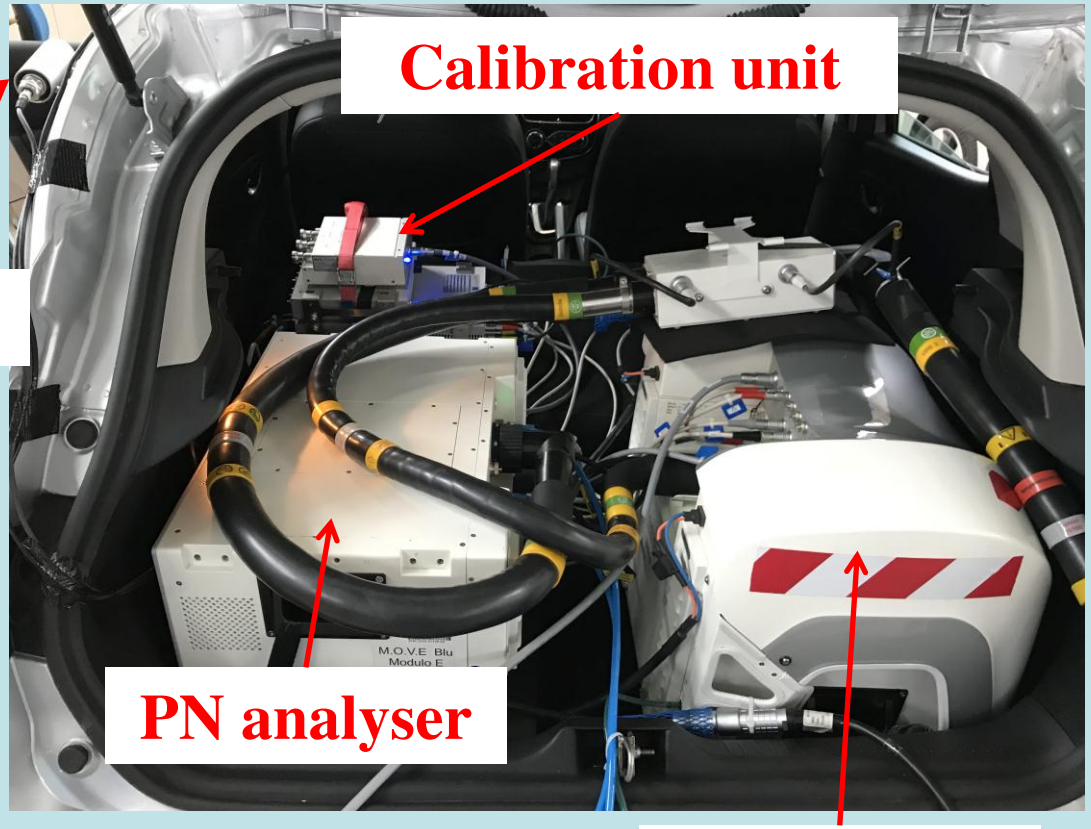


[European Union emission inventory report 1990-2017. EEA Report No 08/2019]

European Commission

Portable Emissions Measurements Systems PEMS





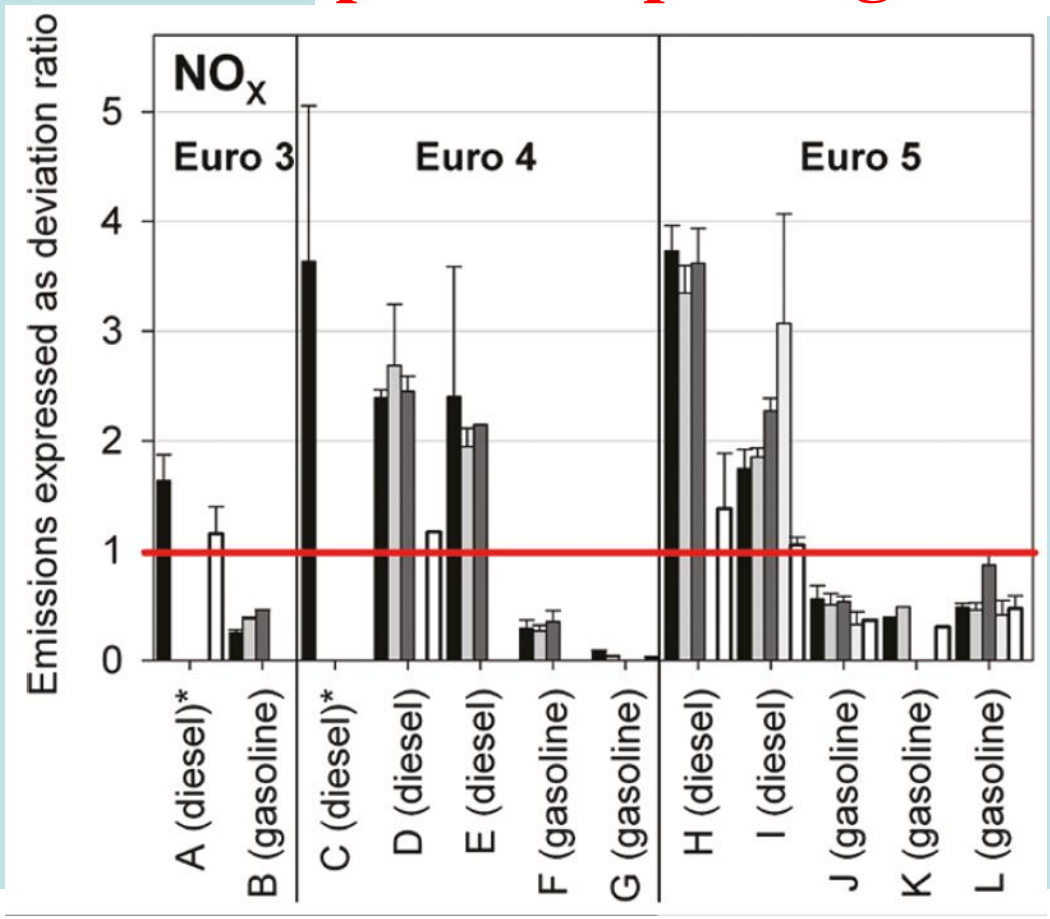


On-road testing with PEMS JRC Report 109812

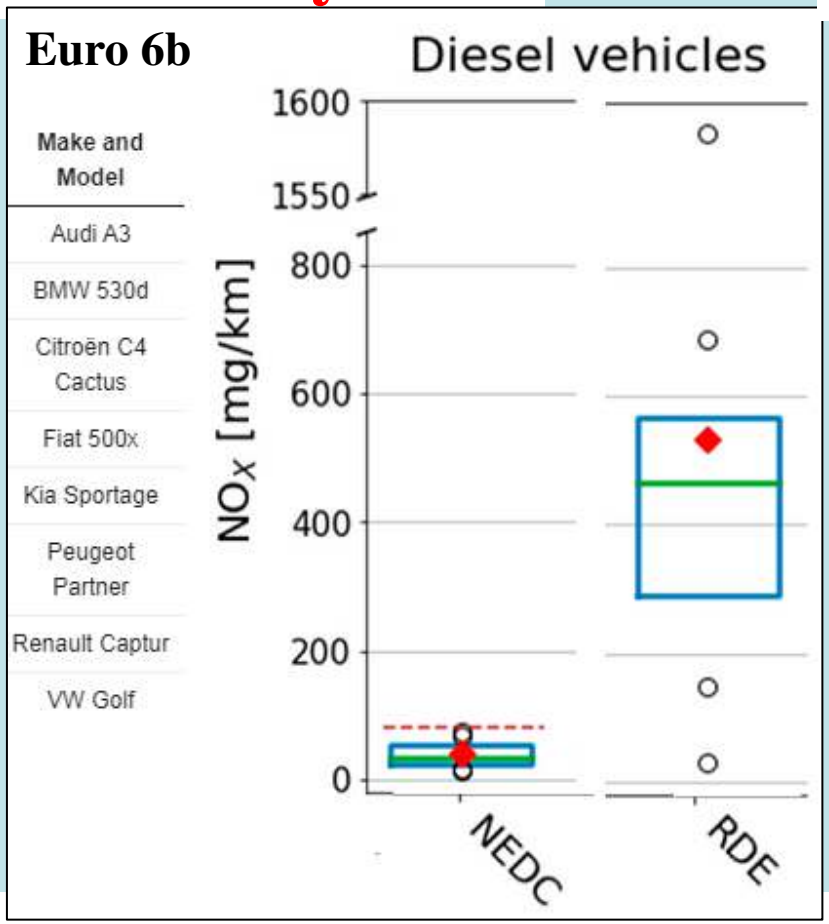
European Commission

Real life NOx emissions – PEMS

pre-RDE passenger cars tested by JRC

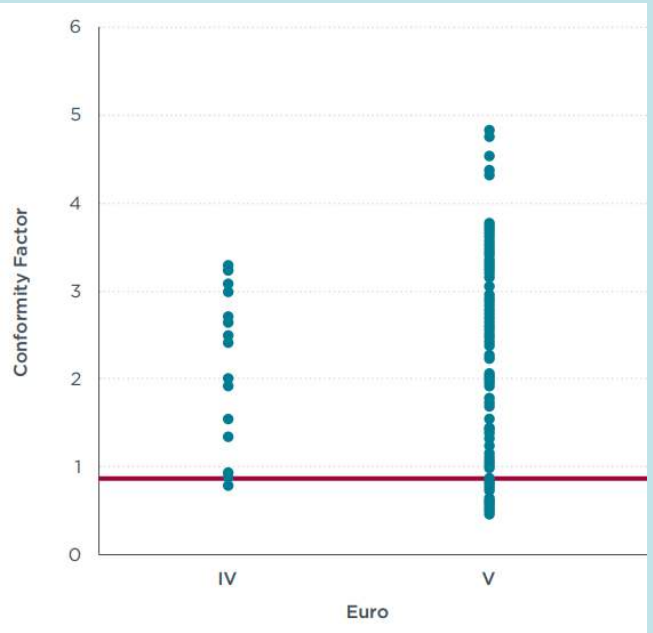


Weiss et al., 2011



Valverde et al., 2019

Heavy duty vehicles



ICCT, 2015

European Commission

Real life NOx emissions – PEMS

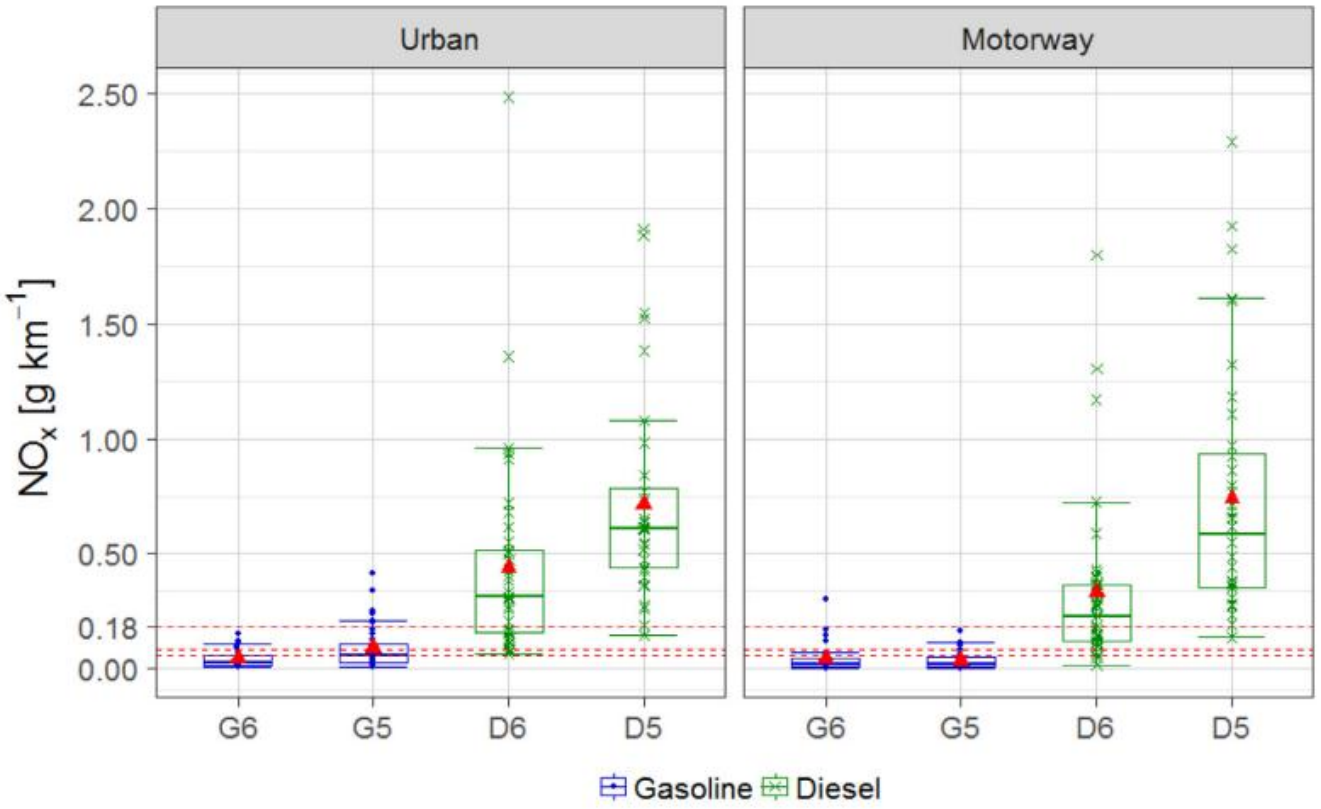


Fig. 4. Urban and motorway NO_x emissions by vehicle category (red dashed line = type approval limits, D5 limit (0.18 g km^{-1}) is labelled, below is the D6 limit (0.08 g km^{-1}) and below that gasoline limit (0.06 g km^{-1} for G5 and G6), red triangle = mean). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

37 Gasoline Euro 5 (G5),
35 Gasoline Euro 6b (G6),
36 Diesel Euro 5 (D5),
39 Diesel Euro 6b (D6),

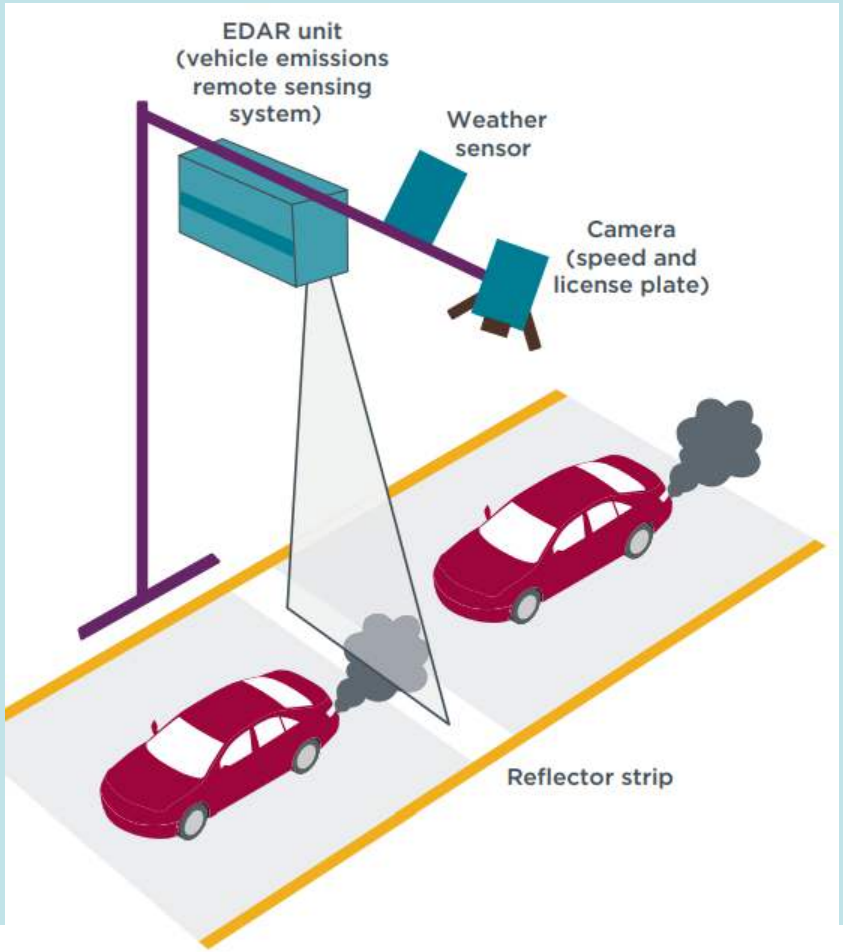
by 27 manufacturers

PEMS based

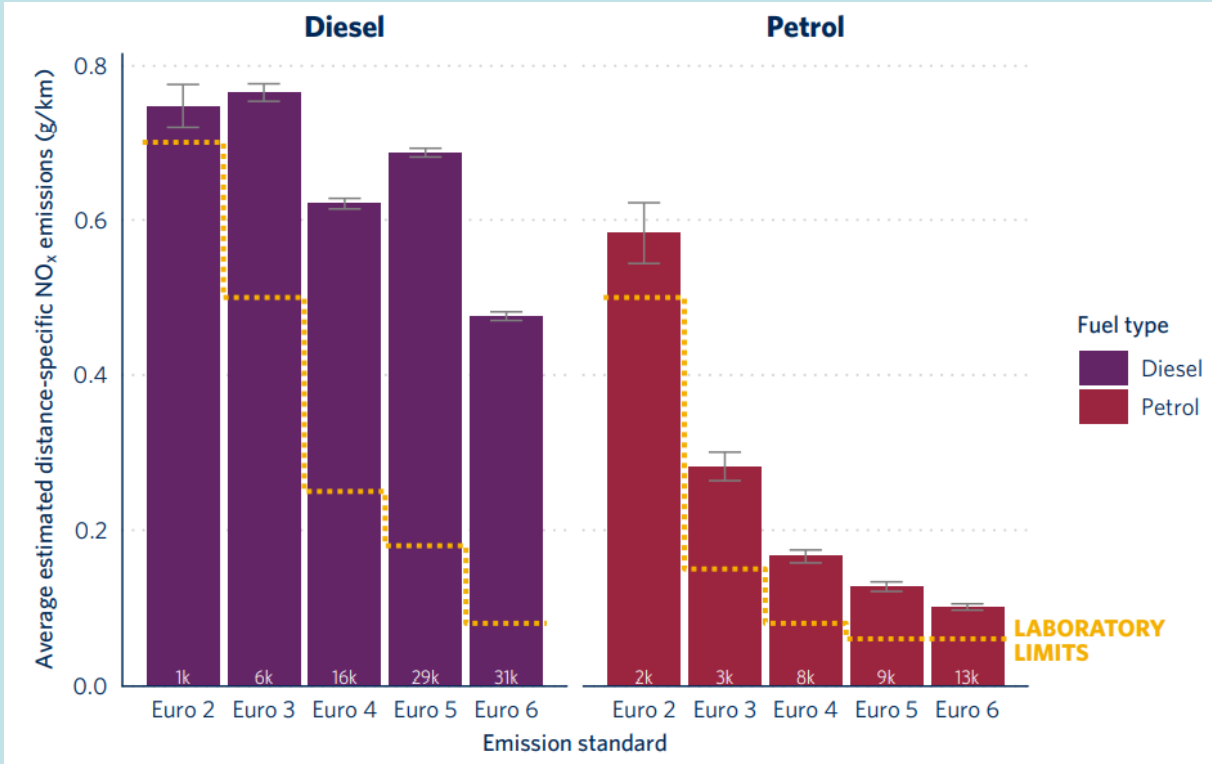
O'Driscoll et al., 2018

European Commission

Real life NOx emissions – Remote sensing



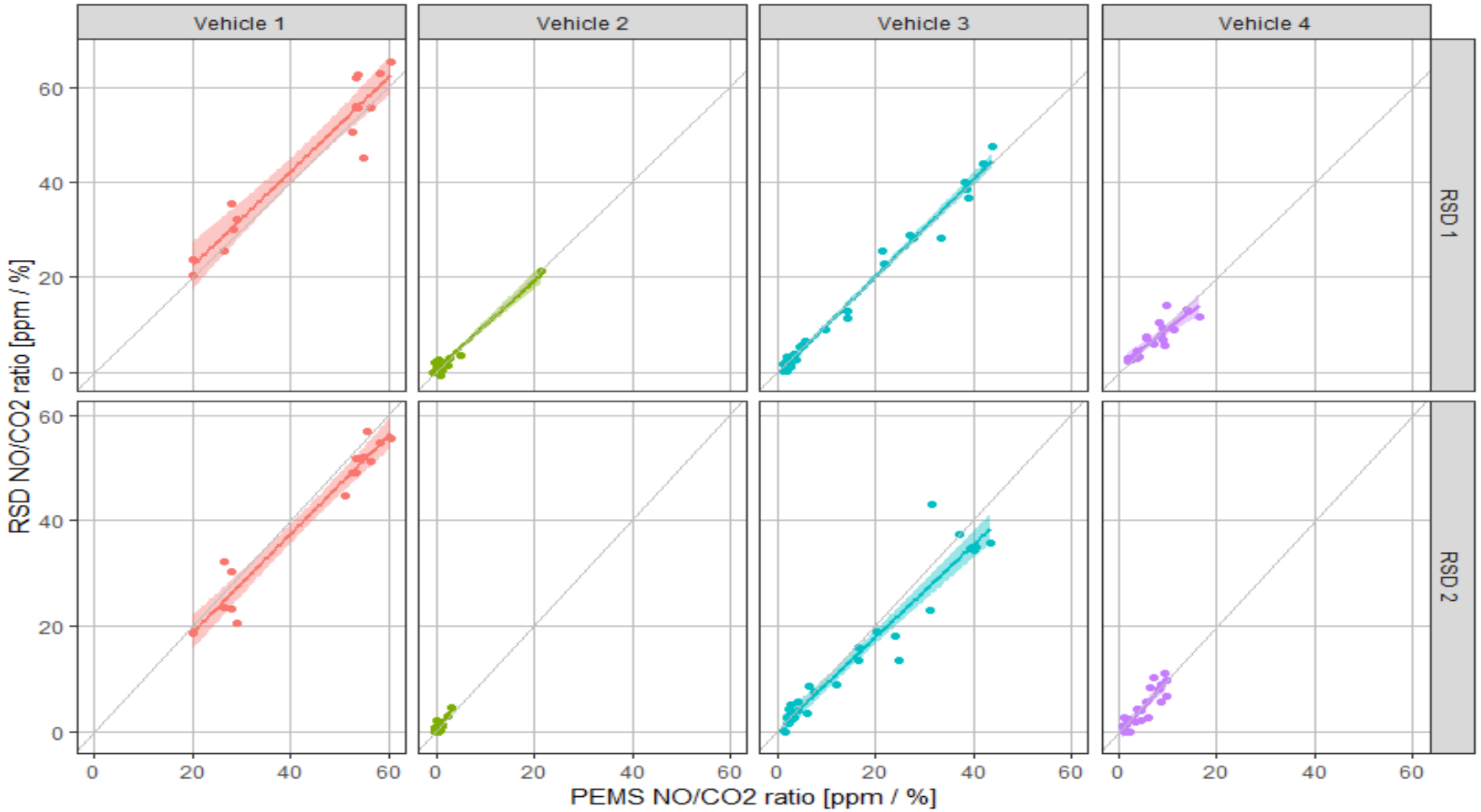
Data collected downtown Paris in summer 2018 – 180 000 vehicles



[Dallmann et al., 2019]

European Commission

Remote Sensing Devices vs PEMS



Gruening et al., 2019

European Commission

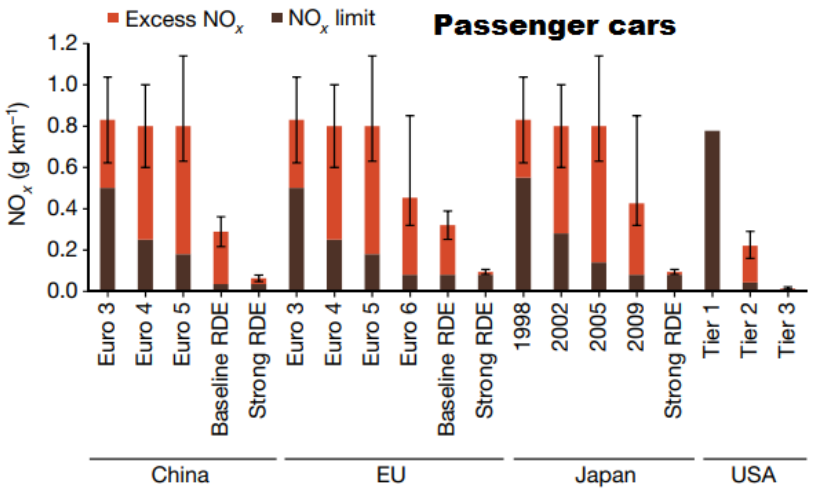
nature

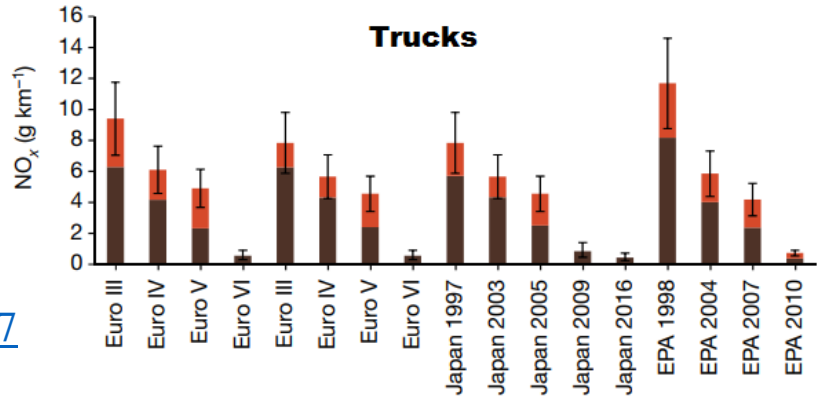
Published: 15 May 2017

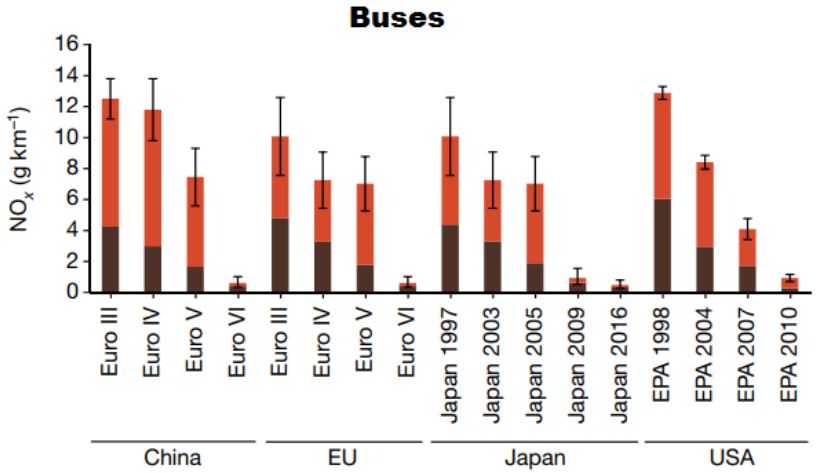
Impacts and mitigation of excess diesel-related NO_x emissions in 11 major vehicle markets

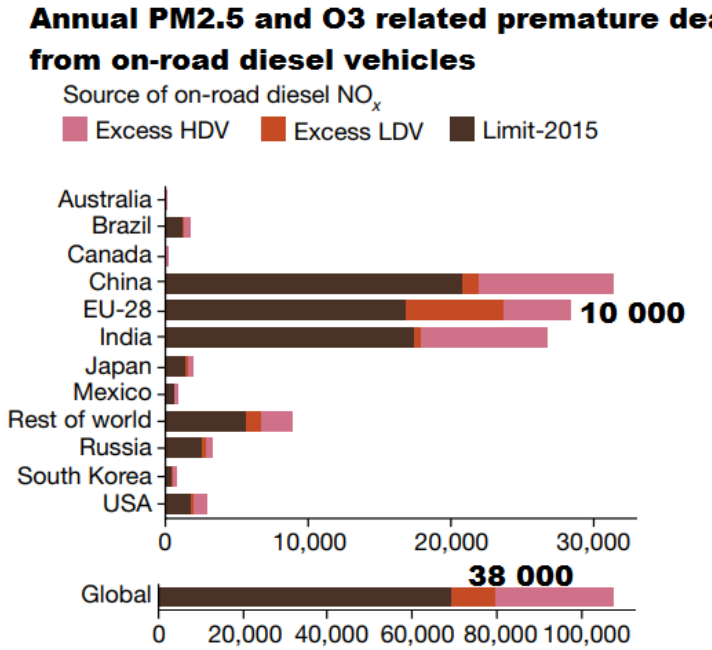
Susan C. Anenberg ✉, Joshua Miller ✉, Ray Minjares, Li Du, Daven K. Henze, Forrest Lacey, Christopher S. Malley, Lisa Emberson, Vicente Franco, Zbigniew Klimont & Chris Heyes

Nature **545**, 467–471(2017) | Cite this article



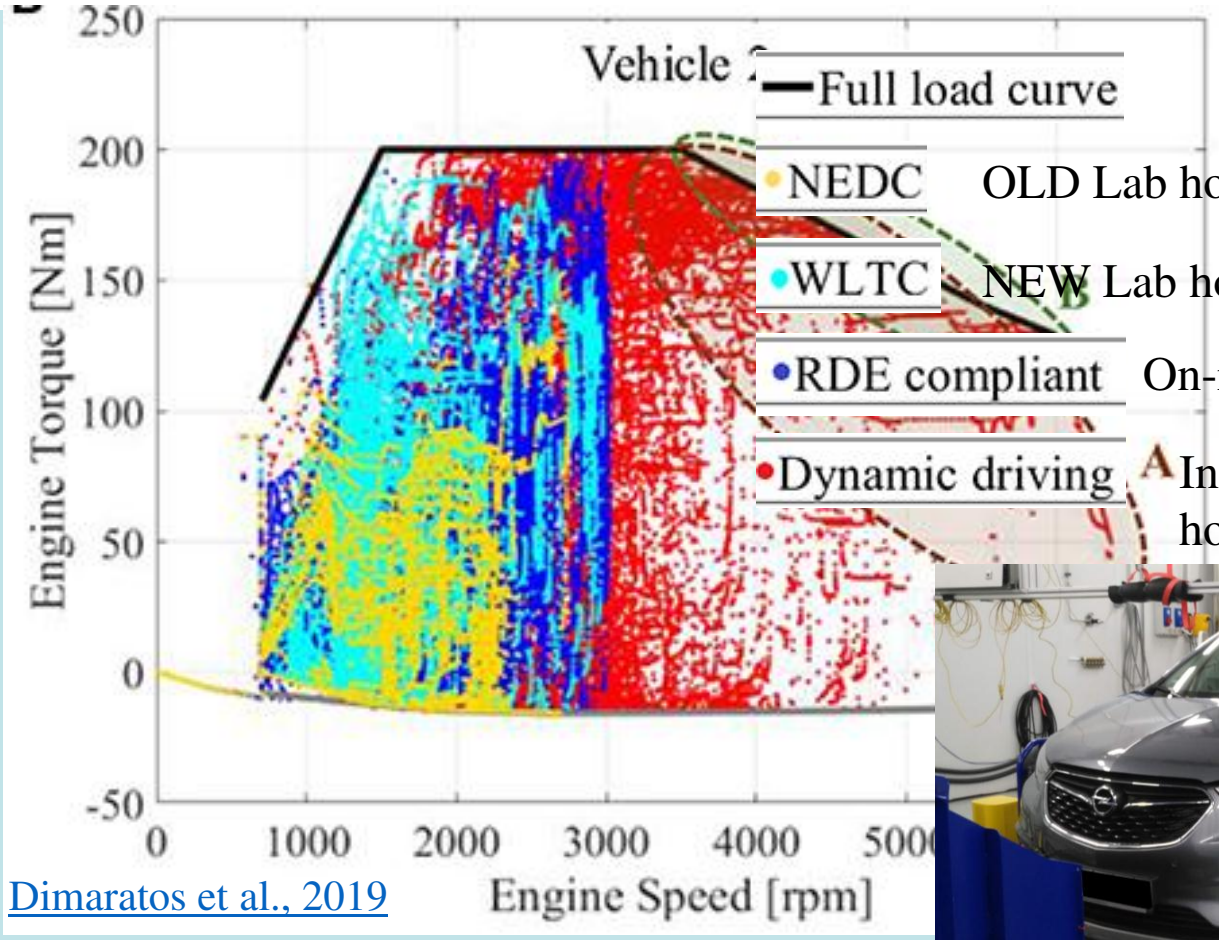






Anenberg et al., 2017

Engine operating points in different driving conditions



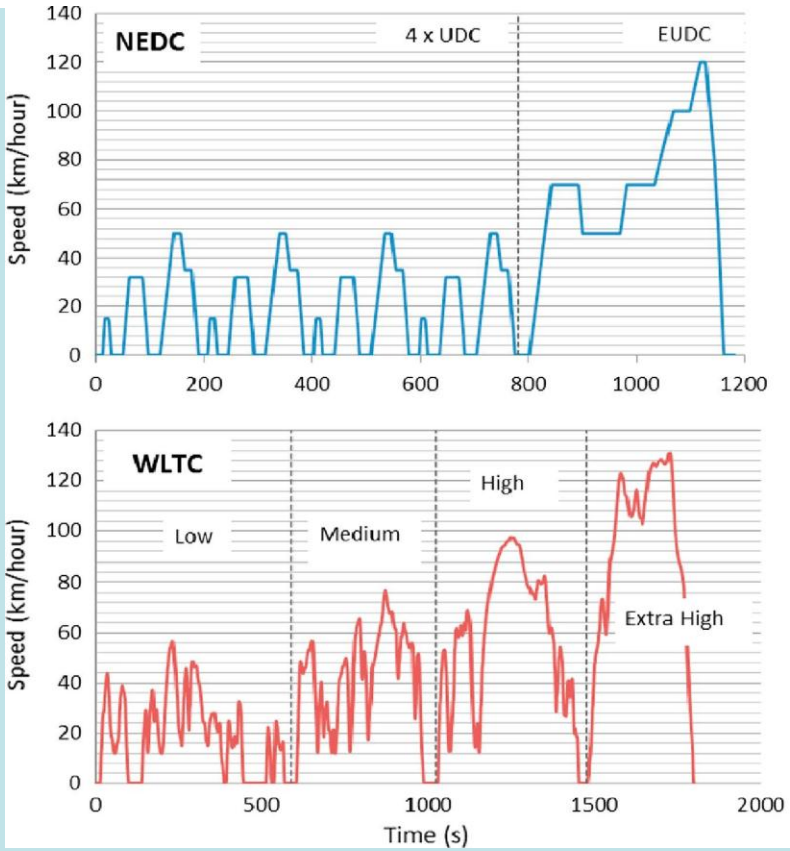
OLD Lab homologation cycle

NEW Lab homologation cycle

On-road homologation test

Invalid on-road test for homologation





Dimaratos et al., 2019

NEDC: New European Driving Cycle. Reg. 83

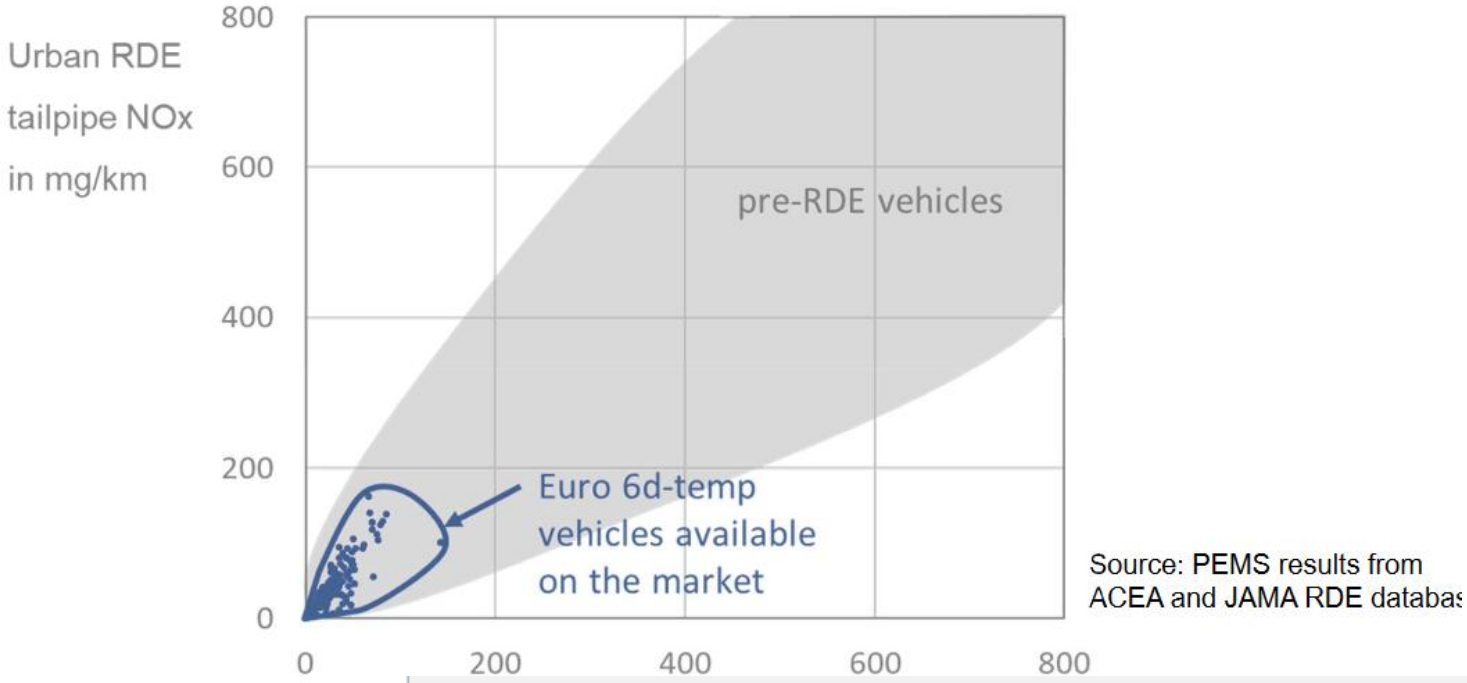
WLTP: Worldwide harmonized Light vehicles Test Procedure. Reg. 2017/1151

European Commission

Real Driving Emissions regulation (EU-RDE)

- EU regulations 2016/427, 2016/646, 2017/1154, 2018/1832
- Phasing-in: 2017-2020 (Euro 6d-TEMP)
- Not-To-Exceed principle – NOx & solid particle number (PN > 23 nm)
- PEMS based test (PEMS uncertainty > lab uncertainty → margin .43 NOx, .5 PN)
- RDE boundaries: altitude < 1300 m, ambient T -7C to 35C, urban/rural/motorway, 90-120 minutes, driving dynamics, etc.
- Type-approval (homologation)
- In-service conformity (in-use up to 5 years or 100 000 km) performed by 3rd parties

Overview RDE type-approval data



Source: PEMS results from ACEA and JAMA RDE databas

[Demuynck et al., 2019]

acea.be/publications/article/access-to-euro-6-rde-monitoring-data

To get the real driving emissions results (according to the RDE 4th Package - **EU 2018/1832 [4]**) for the PEMS test family you are searching for enter one or more of the following parameters: make, commercial name, type, variant, version or EU Type Approval number (EUTA) and you will receive the results for the PEMS test family in which your vehicle is placed.

Enter your search parameters to get the real driving emissions results.

Instructions: Please select Make & Commercial Name, and type additional information you have on the Type, Variant, Version & WVTA. Then, click [Search]

PEMS Tests Search

Search | Clear

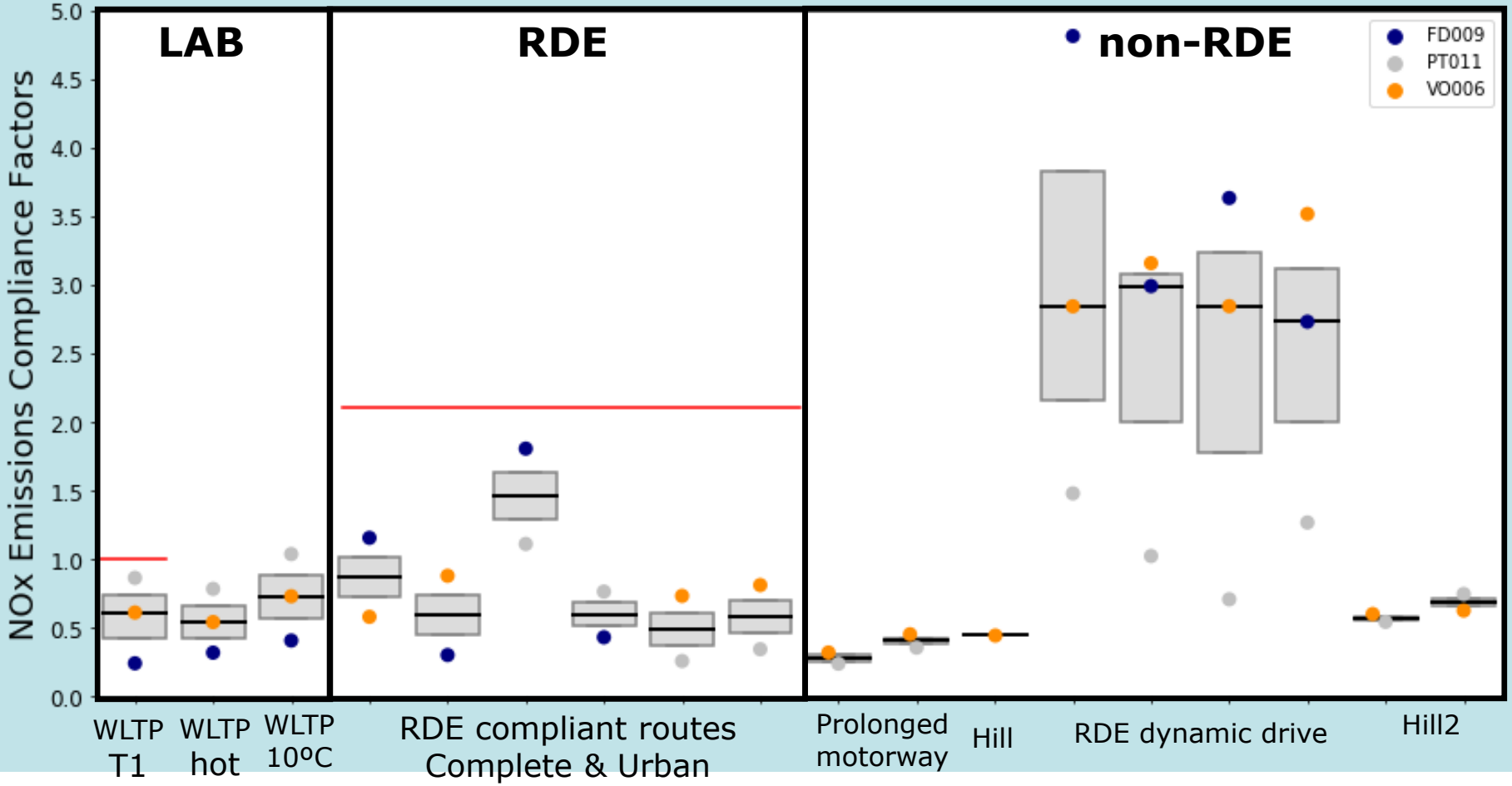
Make: JEEP
Commercial Name: RENEGADE
Type: Please type...
Variant: Please type...
Version: Please type...
WVTA: Please type...

Families
E3-1C4-16-0
E3-1C4-18-0
E3-1C4-20-0
E3-1C4-21-0

Identification of PEMS TEST FAMILY (MS-OEM-X-Y)							Technical Criteria for PEMS TEST FAMILY			PEMS test results			
PEMS TEST FAMILY	emission type	Make	commercial name	type	variant	version	WVTA	propulsion type	fuel type	NOx Total [mg/km]	PN Total [#/km]	NOx Urban [mg/km]	PN Urban [#/km]
E3-1C4-16-0	E3*715/2007*2018/1832DG*1079*00	JEEP	RENEGADE	BU	AXM11	15D	E3*2007/46*0300*24	ICE	DIESEL	11.6	2.3E+10	23.9	3.2E+10
E3-1C4-16-0	E3*715/2007*2018/1832DG*1052*00	JEEP	RENEGADE	BU	AXM1B	12D	E3*2007/46*0300*23	ICE	DIESEL	34.5	1.3E+10	59.9	2.7E+10
E3-1C4-18-0	E3*715/2007*2018/1832DG*1053*00	JEEP	RENEGADE	BU	AXR22	16D	E3*2007/46*0300*23	ICE	DIESEL	27.1	7.1E+09	45.7	9.5E+09
E3-1C4-18-0	E3*715/2007*2018/1832DG*1080*00	JEEP	RENEGADE	BU	AXR22	16E	E3*2007/46*0300*24	ICE	DIESEL	7.2	1.2E+11	21.6	1.6E+11
E3-1C4-20-0	E3*715/2007*2018/1832CG*1054*00	JEEP	RENEGADE	BU	AXN1B	13H	E3*2007/46*0300*25	ICE	PETROL	23.5	2.0E+11	19.4	3.3E+11
E3-1C4-20-0	E3*715/2007*2018/1832DG*1215*00	JEEP	RENEGADE	BU	AXN1B	13L	E3*2007/46*0300*26	ICE	PETROL	24.6	8.6E+09	36.1	6.4E+09
E3-1C4-21-0	E3*715/2007*2018/1832DG*1081*00	JEEP	RENEGADE	BU	AXP11	14C	E3*2007/46*0300*24	ICE	PETROL	20.6	4.0E+09	10.1	7.3E+09
E3-1C4-21-0	E3*715/2007*2018/1832DG*1082*00	JEEP	RENEGADE	BU	AXP22	18D	E3*2007/46*0300*24	ICE	PETROL	14.5	1.8E+11	35.9	3.0E+11

JRC testing – NOx from diesel Euro 6d-TEMP vehicles

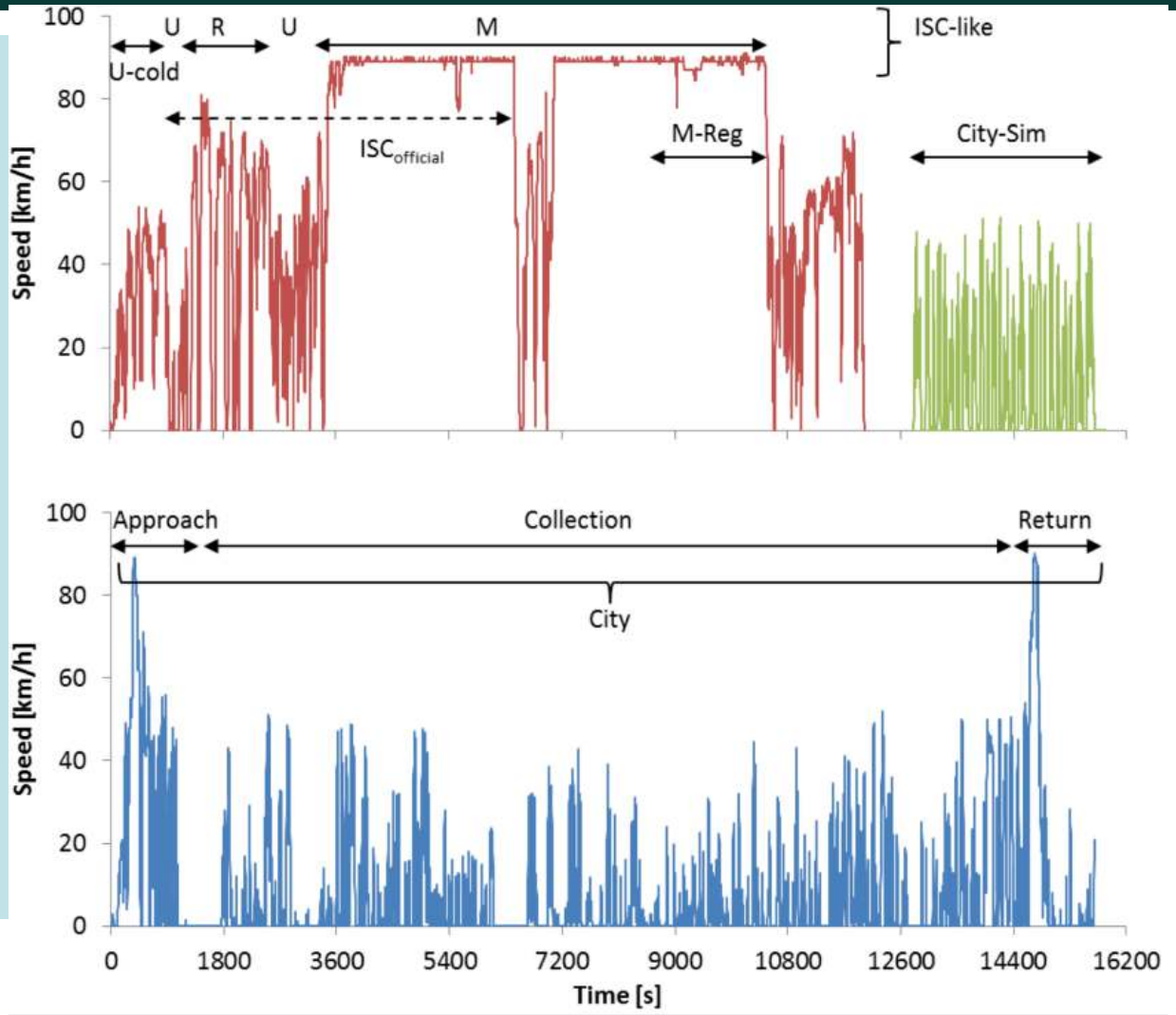
Emissions Compliance Factor = raw emissions / 80 (Type 1 limit)

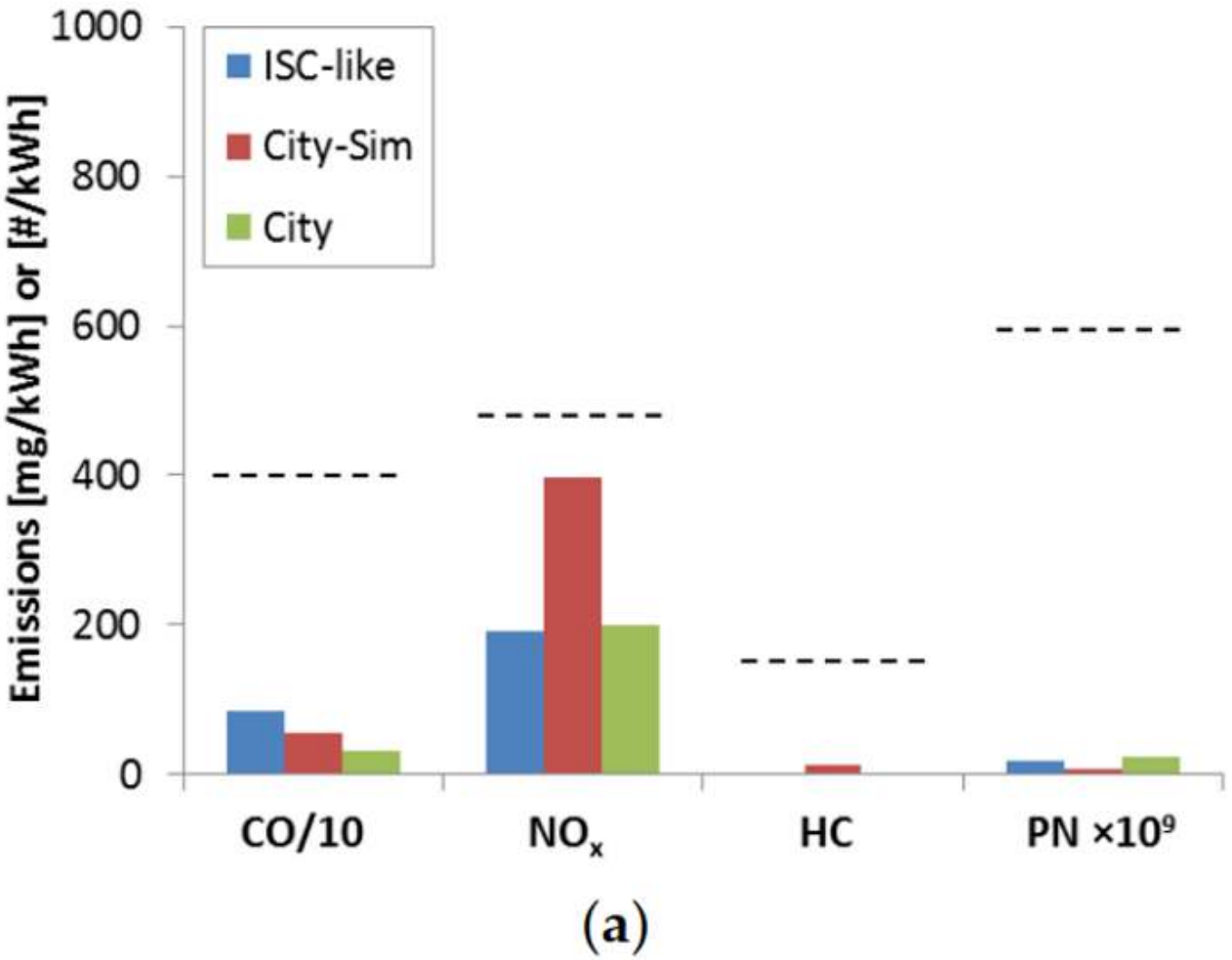


Valverde et al., 2019

European Commission

Euro VI Heavy-duty Diesel Refuse Collection Vehicle





[Giechaskiel et al., 2019]

European Commission

Enforcement of regulation





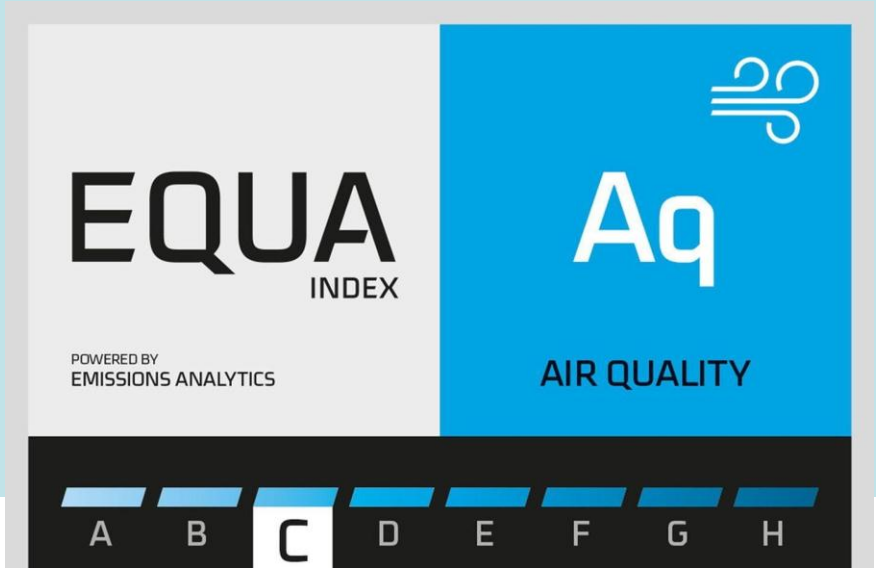
European Commission



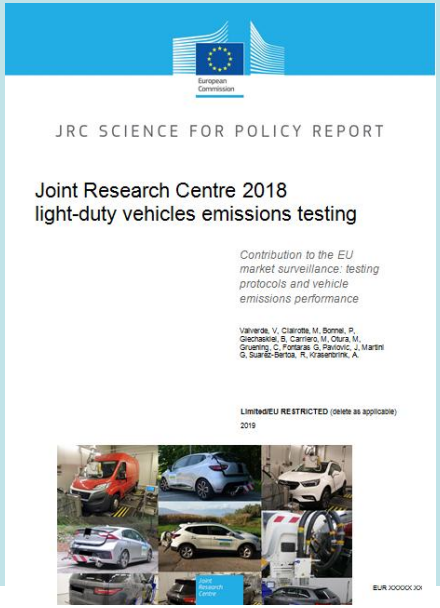
https://www.greenncap.com/



https://www.trueinitiative.org/true-rating



https://equaindex.com/



JRC publications

European Commission

Conclusions

- Strong steps ahead on performant regulations to curb criteria pollutant emissions from LDV + HDV
- 1st wave of Euro 6d-TEMP vehicles (type-approved on RDE & WLTP): large reduction of real-life emissions. Pushing the adoption of best available techniques (SCR, SCRF, ASC, GPF).
- Challenges for efficient enforcement (appropriate screening methods, adequate ISC testing, robust peer-review mechanism, tampering handling, etc.)
- post-Euro 6/VI technology neutral to cover additional pollutants (NH3, PN10, N2O, CH4, VOCs), driving conditions (-7C),

Thanks for the attention



victor.valverde-morales@ec.europa.eu

European Commission