Real-world Vehicle Emission Measurements using PEMS in Hong Kong

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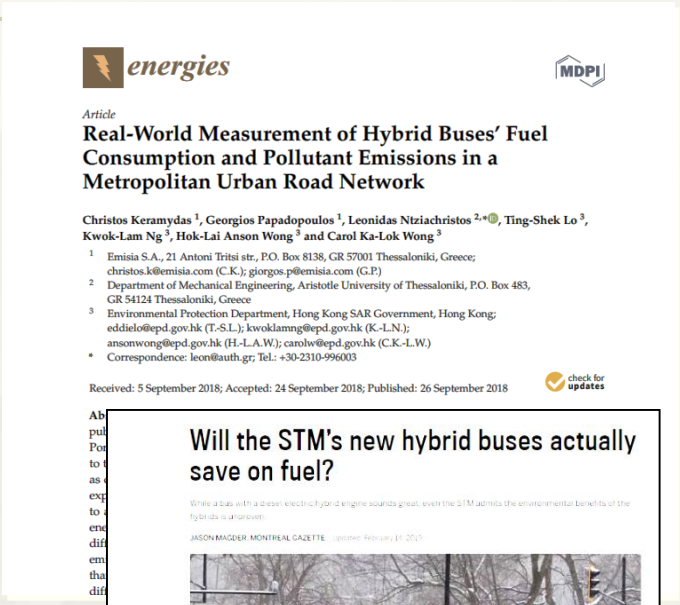
Outline

* PEMS measurement in Hong Kong
* NOx emissions from light duty diesel trucks
* LPG taxi emissions

PEMS measurement in Hong Kong

- Since 2008
- Application:
  - evaluate the vehicle emission reduction initiatives
    - e.g. program for retrofitting buses with SCR, hybrid bus program
  - update the emission factors in the vehicle emission model
    - e.g. EMFAC-HK, upgrade of current vehicle emission model
  - identify the high emitters in the vehicle fleet



energies

MDPI

Article

Real-World Measurement of Hybrid Buses' Fuel Consumption and Pollutant Emissions in a Metropolitan Urban Road Network

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check for updates

Will the STM's new hybrid buses actually save on fuel?

JASON MAGDER, MONTREAL GAZETTE

If a bus is consuming more fuel, it's also emitting more carbon dioxide. ALLEN MCINNIS / MONTREAL GAZETTE

In the next five years, more than 800 new hybrid buses will be on Montreal's streets.

The goal of the nearly $1 billion order for 820 new buses with diesel engines and electric propulsion systems is to significantly reduce the carbon footprint of the Société de transport de Montréal's dirty diesel buses. By the time they arrive in 2024, hybrid buses will make up roughly half of an enlarged STM fleet of 2,100 buses.

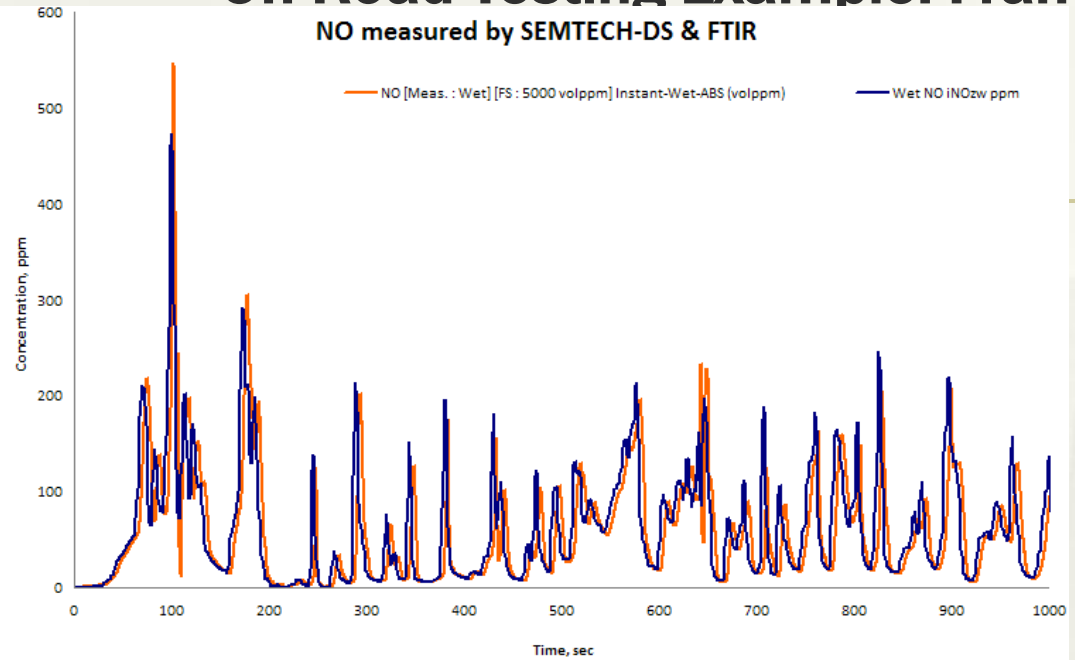
However, while a bus with a diesel-electric hybrid engine sounds like it's better for the environment, even the STM admits the environmental benefits of the city's hybrids are improved and the buses now on order may never live up to their advertised 30-per-cent savings on fuel and carbon emissions.

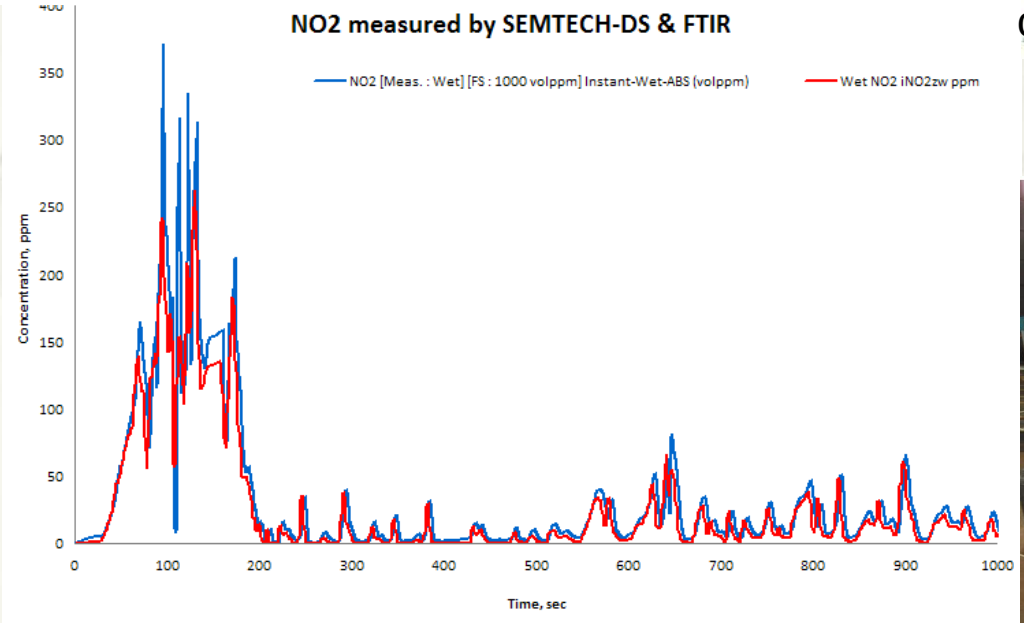
A recent study for the city of Hong Kong found hybrids consumed just six per cent less fuel on average over their fully diesel counterparts, and in certain conditions — like hills, hot weather and in heavy traffic — the hybrids were even less efficient, consuming 26 per cent more fuel. That eligible fuel savings delivered the transit association there from buying any hybrids.

Vehicles Explored up to end Feb., 2019

Vehicle Class	Fuel Type	Emission Standard							Total
		Pre-Euro	Euro I	Euro II	Euro III	Euro IV	Euro V	Euro VI	
Motorcycles	Gasoline				1				1
Cars	Gasoline			3	7	21	14	6	51
Taxis	LPG			13	6	13	13		45
Mini buses	LPG				6	4			10
	Diesel		1	1	6	2			10
Trucks <= 6.1 tons	Gasoline					4			4
	Diesel	5	4	12	25	19	29	5	99
Trucks > 6.1 tons	Diesel	4	1	4	19	17	32	2	79
Single Deck Coaches	Diesel			2	9	20	25		56
Double Deck Buses	Diesel			4	2		6	6	18
Total		9	6	39	81	100	119	19	373

On-Road Testing Example: Franchised Bus Fixed Route



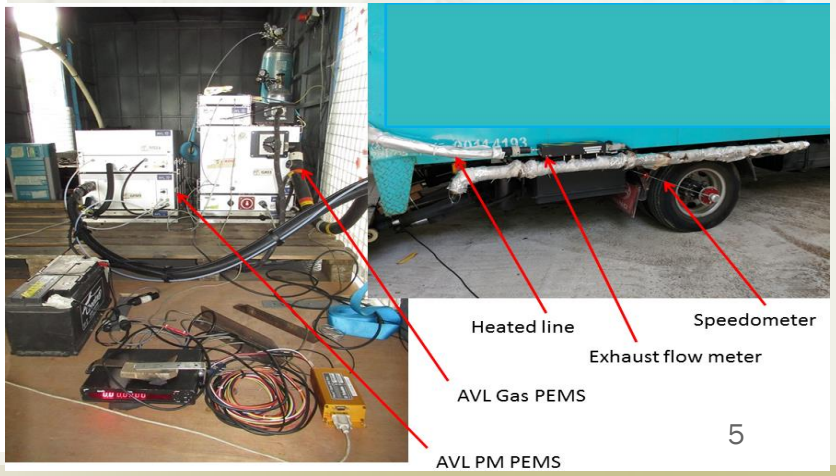


On-road testing of a SCR retrofitted Euro II bus

- Professional bus drivers following another in-service bus to simulate real-life application
- 50-60% of maximum payload
- Traffic are captured by video camera mounted in front of the bus
- Minimum target of 5 round trips

Both gaseous pollutants and PM are collected

- PEMS used – SEMTECH-DS, SAMPS, Filter System and FTIR

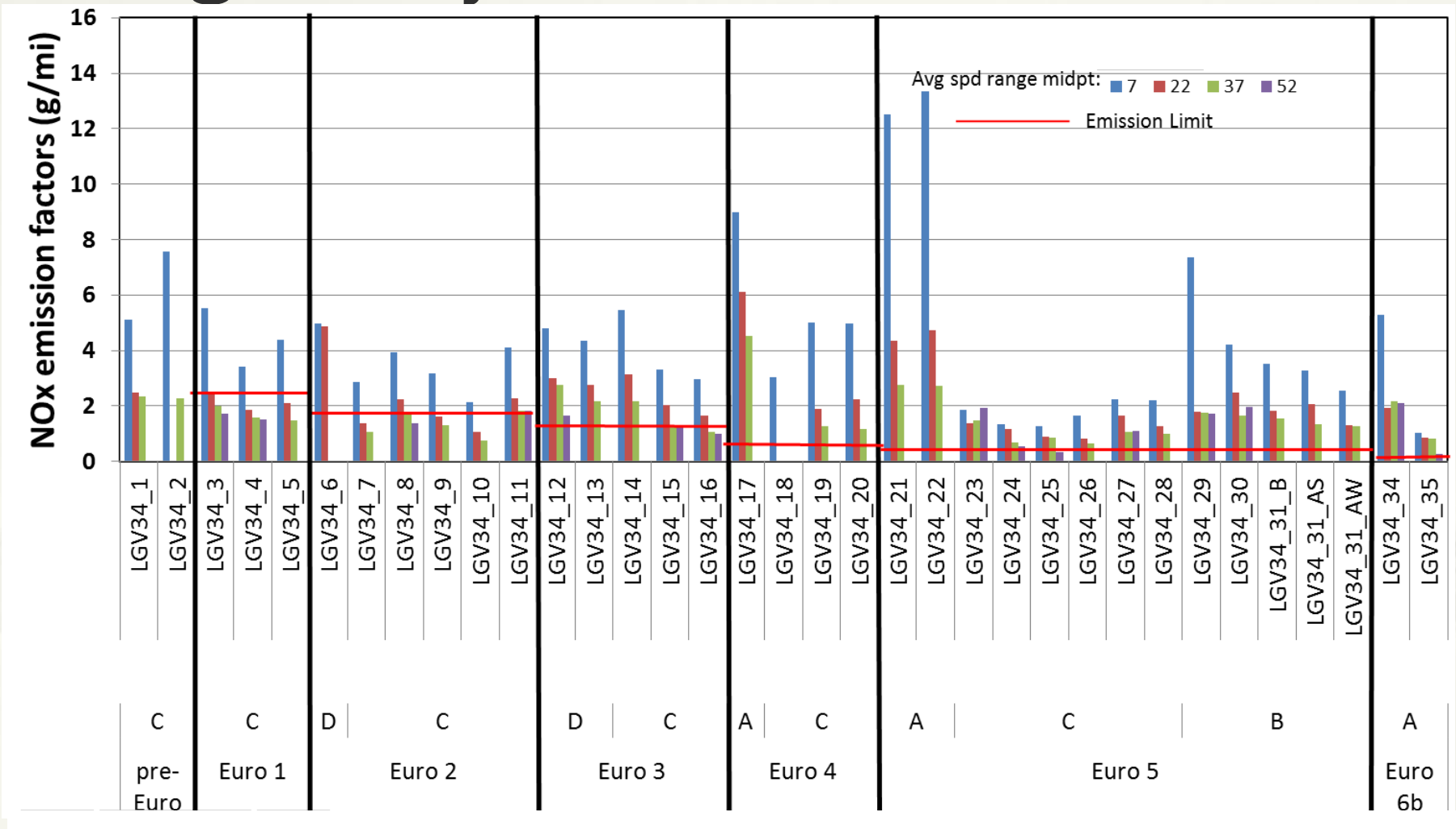


Emission data from franchised bus testing

Outline

* PEMS measurement in Hong Kong
* NOx emissions from light duty diesel trucks
* LPG taxi emissions

On-road PEMS Testing for Diesel Light Duty Trucks <=3.85 tons

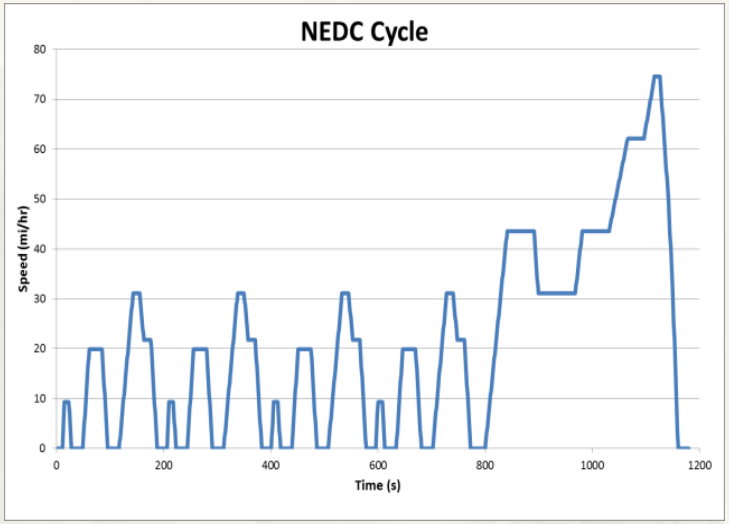


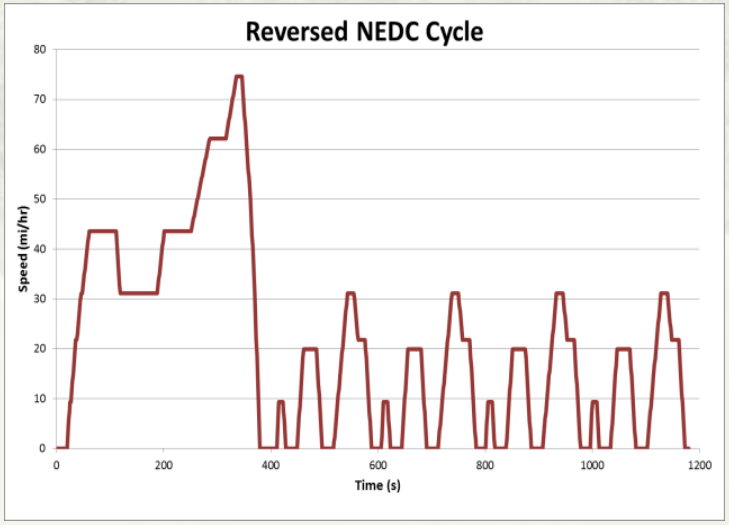
NOx Emissions from Light Duty Diesel Trucks

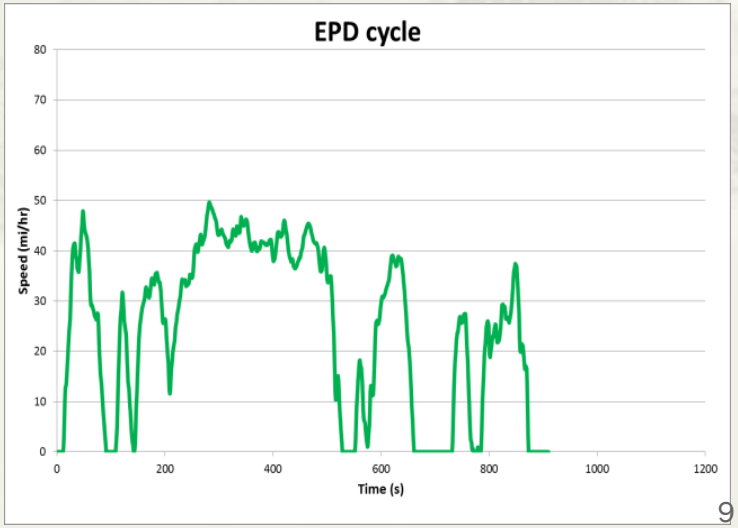
- Brand B
  - NOx emissions much higher than their corresponding emission standards
  - Some models known to be fitted with defeat device.
- Brand A
  - NOx emissions higher than Brand B
  - Compose of 15% of light duty trucks <= 3.85 tons for Euro 5 or above in Hong Kong
- Brand C
  - Lowest NOx emissions but still higher than their corresponding Euro emission limit

Different Driving Cycles

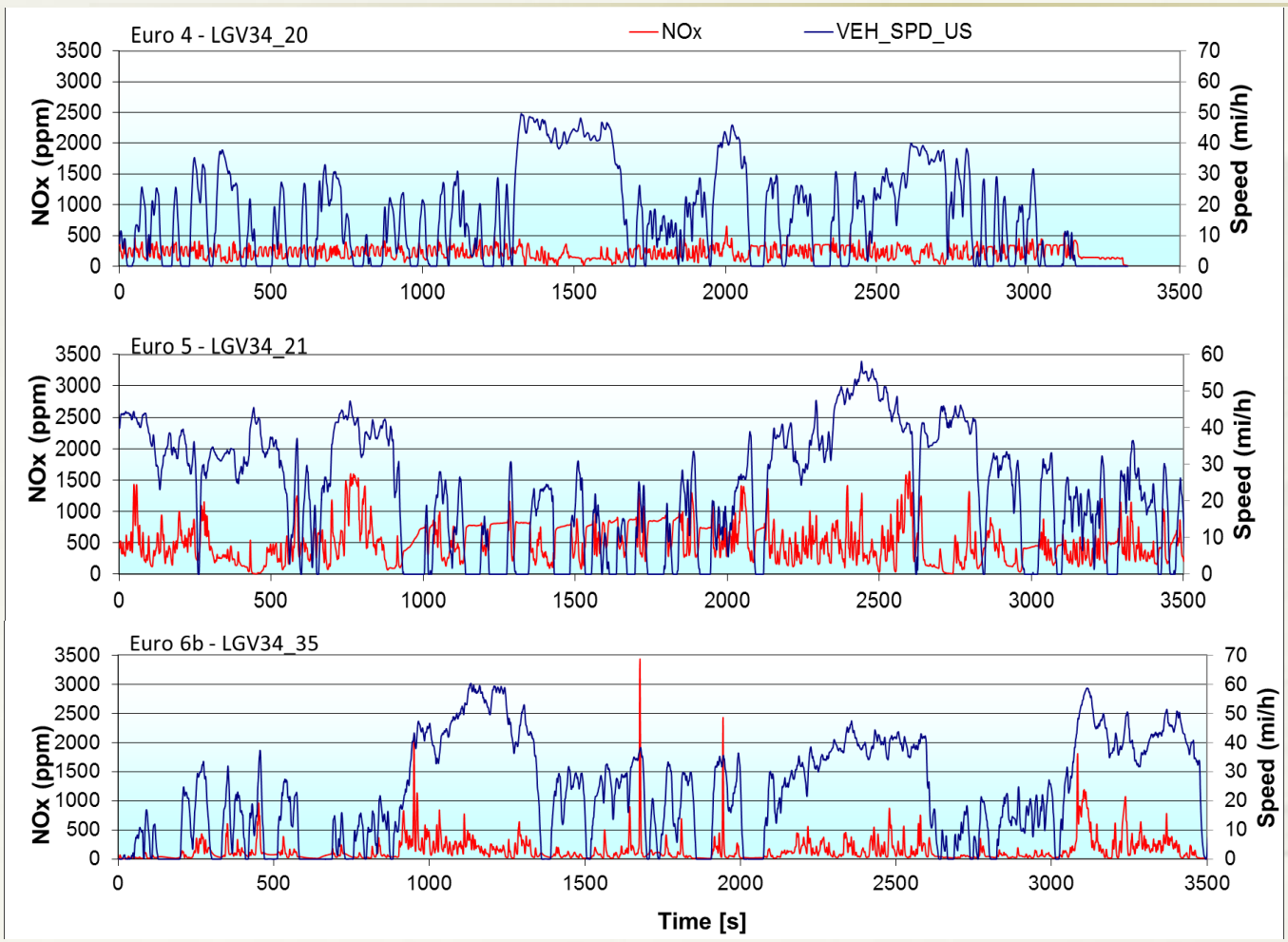
Test	Cycle	Condition
NEDC-N	NEDC	Cold
NEDC-H	NEDC	Hot
NEDC-RH	Reversed NEDC	Hot
EPD	Customized	Hot







Brand A (Road Test)



LGV34_20, Euro 4, Brand C

- Moderate NOx emissions with low peaks

LGV34_21, Euro 5, Brand A

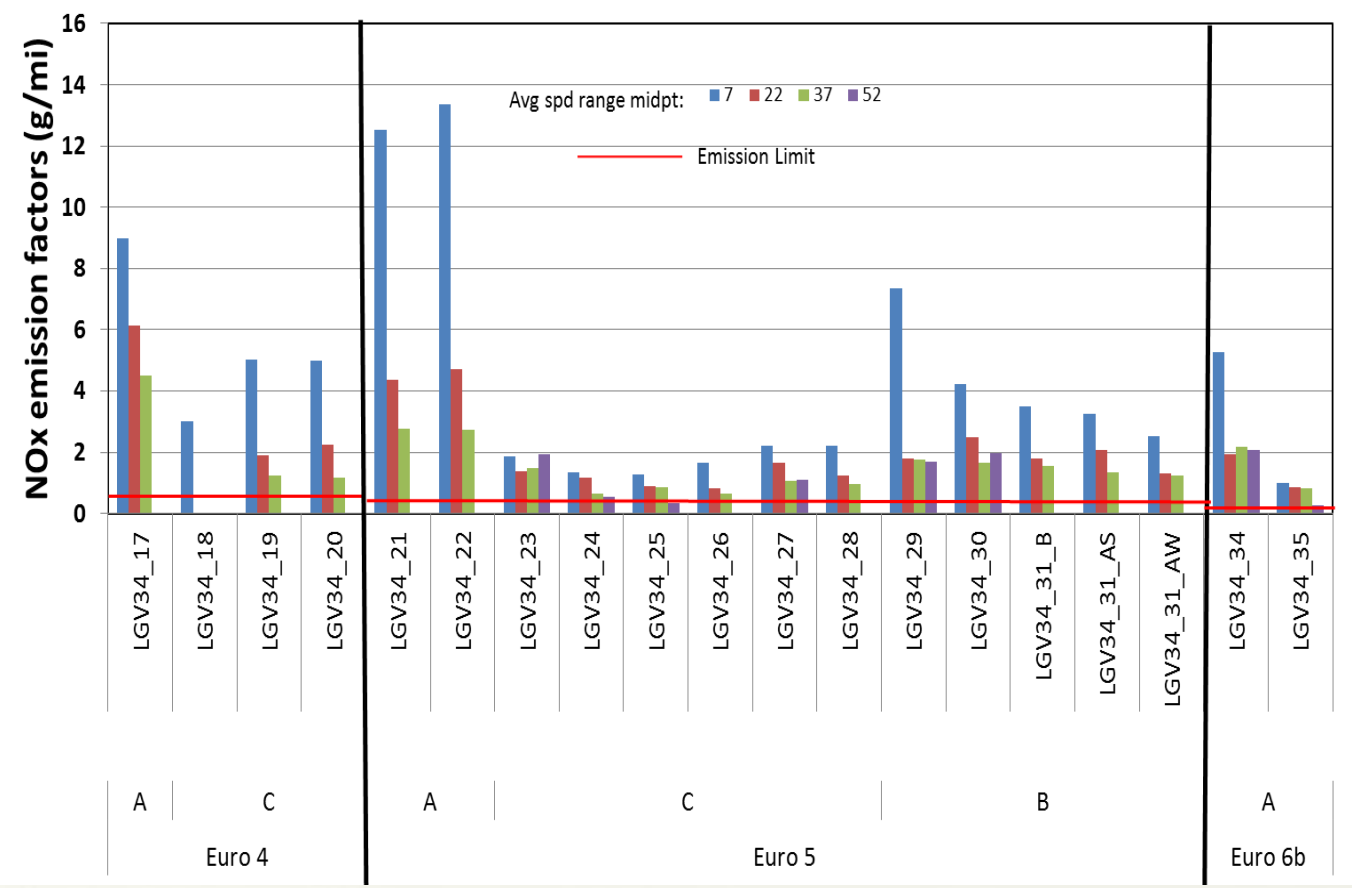
- High emissions with even higher peaks

LGV34_35, Euro 6, Brand A

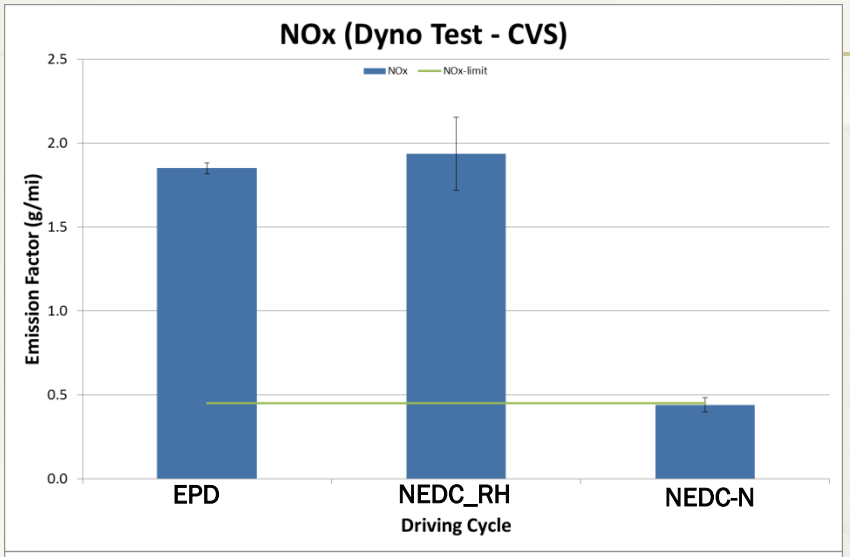
- Low NOx emissions with very high peaks

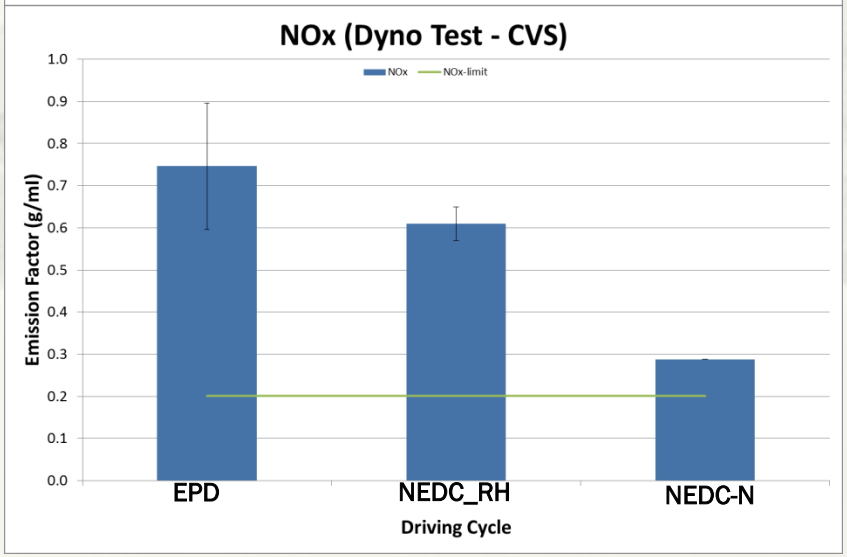
Brand A (Road Test)

- NOx emissions are higher than Brand B
- NOx emissions from Euro 5 vehicles are similar to its Euro 4
- NOx emissions from Euro 6 vehicles are lower but still higher than its emission limit



Brand A (dyno)



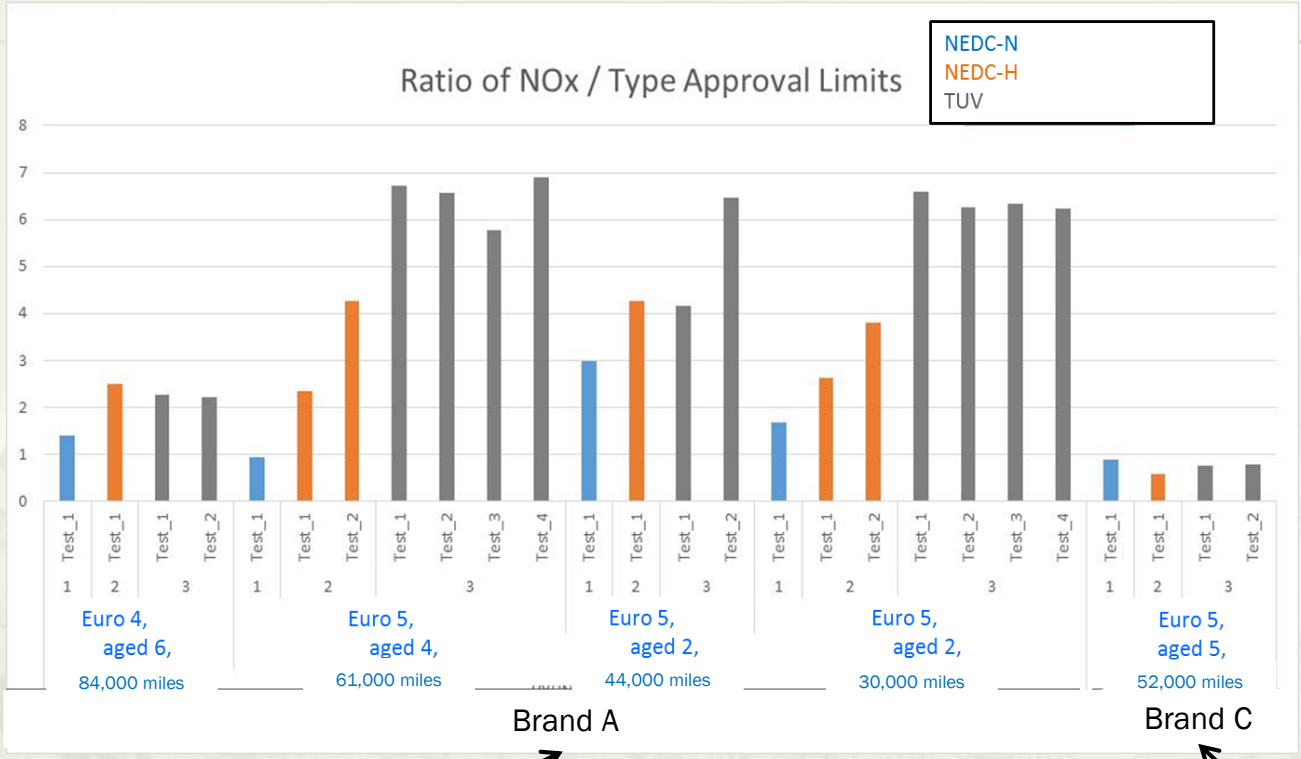


LGV34_22
Euro Std: Euro 5
Mileage: 42,369 mi
GVW: 3.55 tons
Rated power: 168 bph@3600RPM

LGV34_35
Euro Std: Euro 6b
Mileage: 806 mi
GVW: 3.52 tons
Rated power: 134 bph@3600RPM

vehicles were provided by the local dealer

Brand A (dyno)

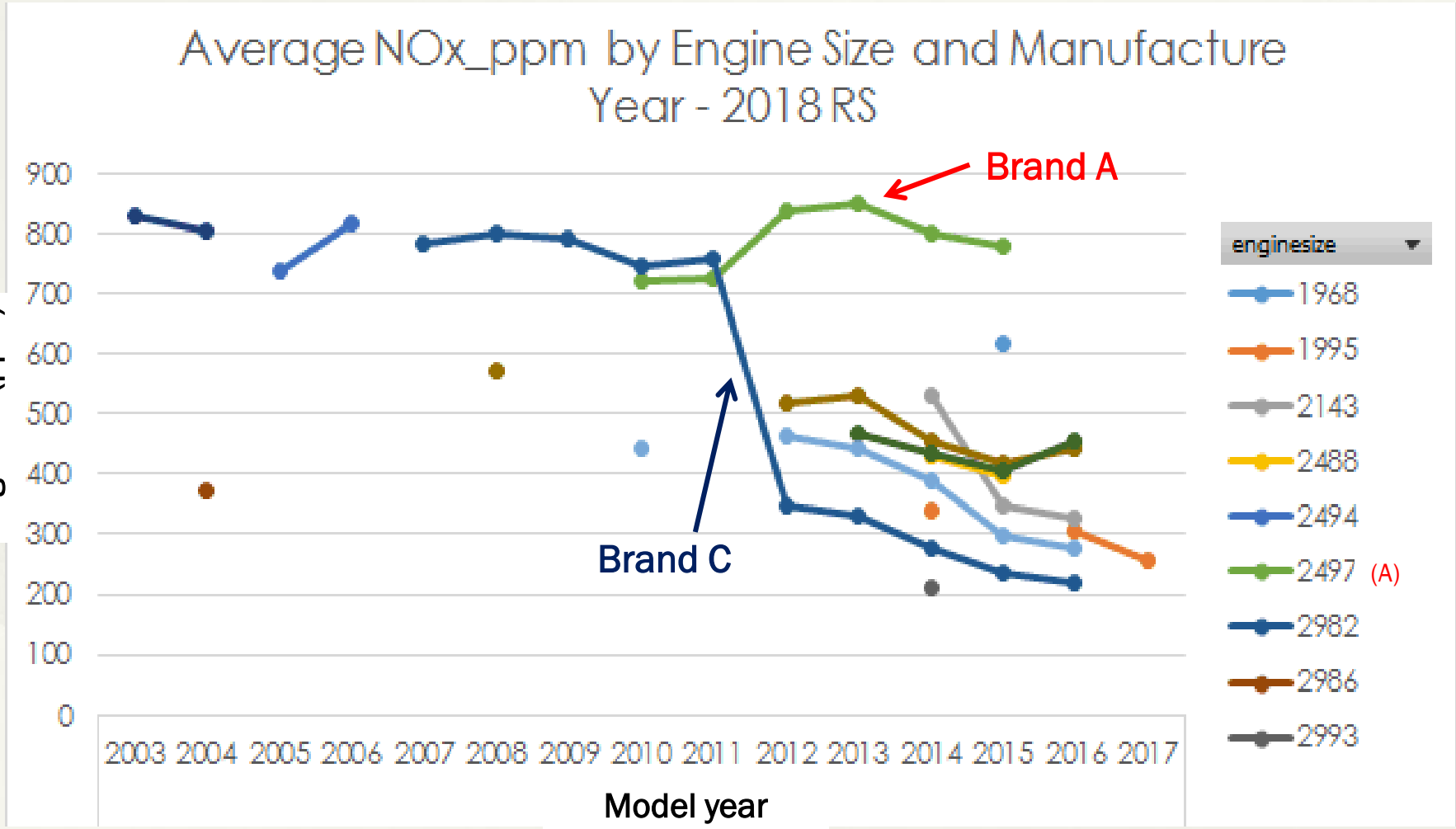


- NOx emissions in Hot NEDC are higher than Cold NEDC
- NOx emissions in customized cycle are higher than Cold NEDC and Hot NEDC

NOx emissions of all tests are similar

(vehicles are rented vehicles

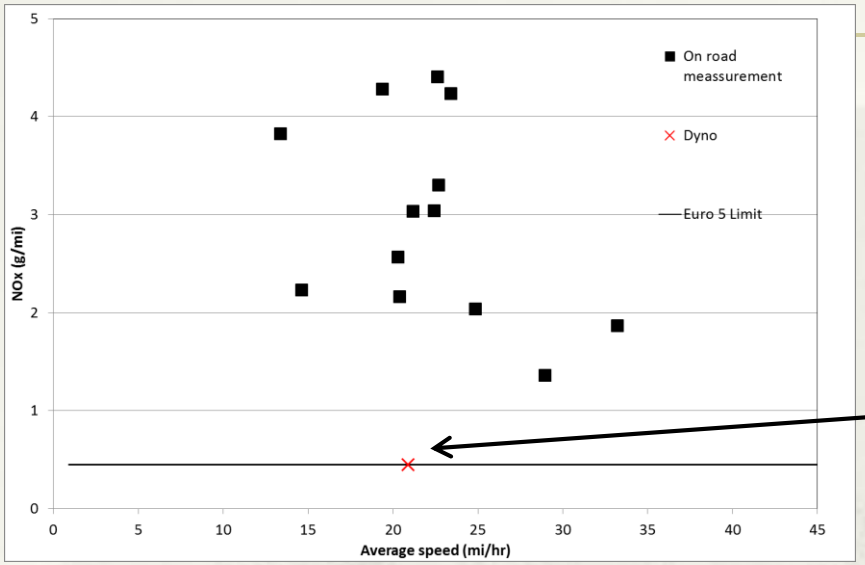
Remote Sensing NOx data for Diesel Vehicles



Brand A

- Extraordinary high NOx emissions in
  - Road test (even higher than those identified with defeat device)
  - Customized cycle tests on dyno
- For Euro 5 model, NOx emissions are about the same as the Euro 5 limit in certification tests
- For Euro 6 model, NOx emissions are about 40% higher than the Euro 6 limit in certification tests

Brand B (LGV34_29, LGV34_30)



LGV34_29

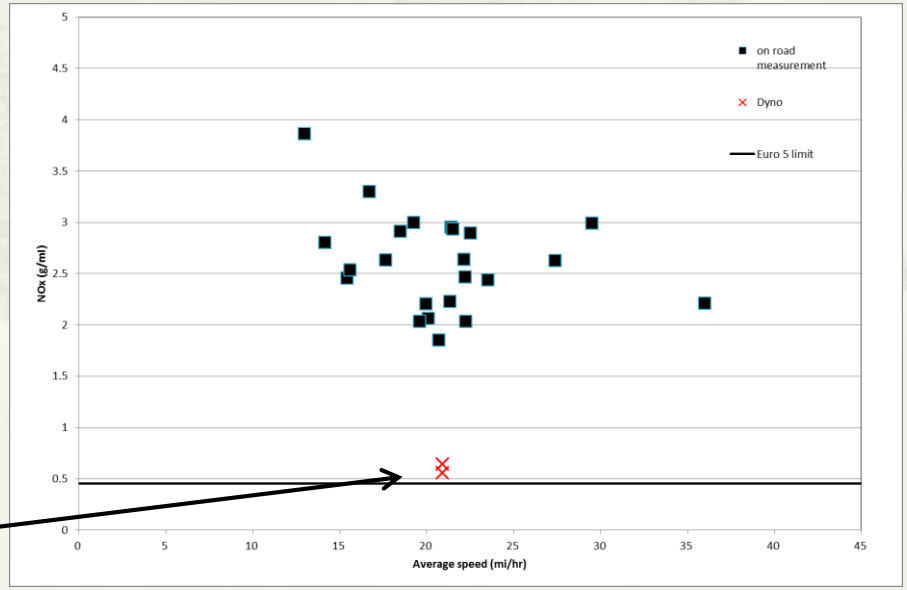
Euro Std: Euro 5

Mileage: 537 mi

GVW: 3.1 tons

Engine rated power: 177 bhp@4000RPM

vehicle NOT installed with PEMS in lab test



LGV34_30

Euro Std: Euro 5

Mileage: 52 mi

GVW: 3.1 tons

Engine rated power: 138bph@3500RPM

vehicle installed with PEMS in lab test

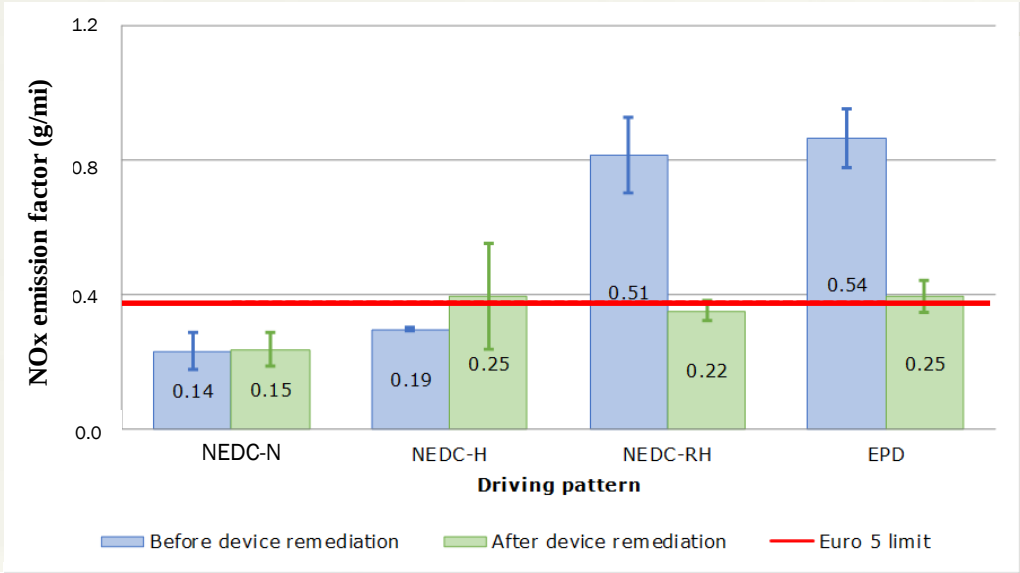
(vehicles were provided by the local dealer)

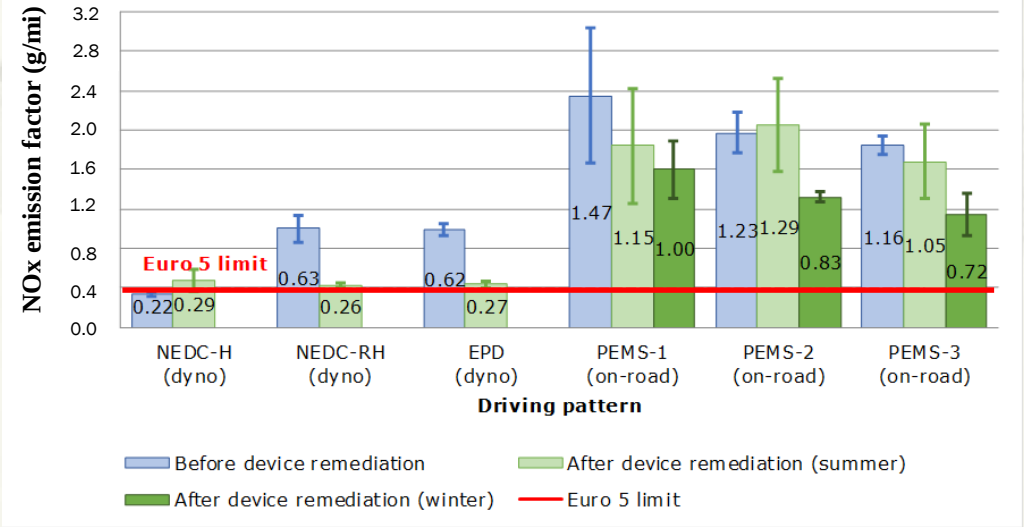
Brand B (LGV34_31)

LGV34_31_B: Before remediation (amb. temp.: 86°F & RH:71%)
LGV34_31_AS: After remediation, tested in summer (amb. temp.: 88°F & RH:61%)
LGV34_31_AW: After remediation, tested in winter (amb. temp.: 73°F & RH:42%)

Road tests:
3 different road segments are selected

Brand B (LGV34_31)





Before Remediation

- High NOx emissions in NEDC-RH, EPD cycle tests

After Remediation

- Low NOx emissions in all tests on dyno (NEDC-H is a bit higher)
- NOx Emissions in road tests are still high
- NOx Emissions in road tests in summer > winter

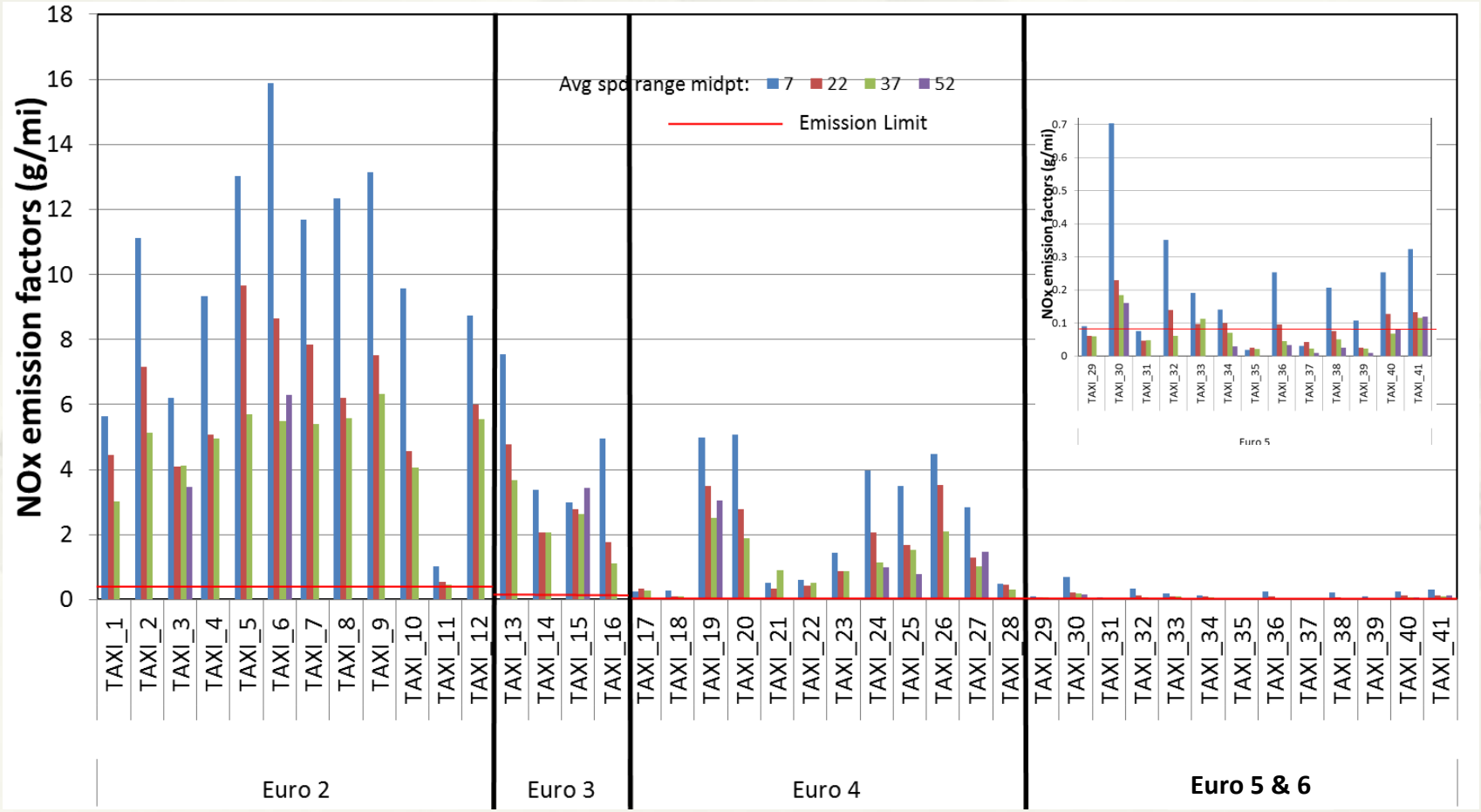
Outline

* PEMS measurements in Hong Kong
* NOx emissions from light duty diesel trucks
* LPG taxi emissions

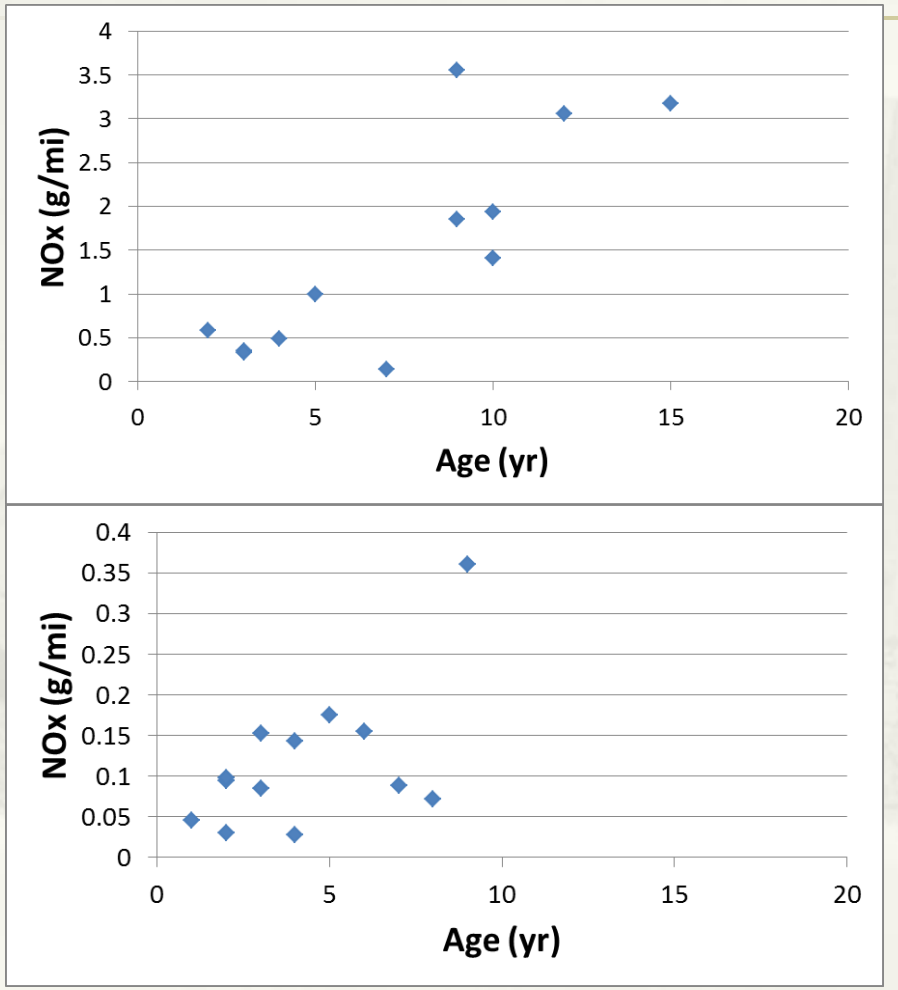
On-Road PEMS Testing for LPG taxis

Euro 5 and 6 taxis will dominate the taxi fleet in future

For PEMS tests so far, NOx emissions from Euro 5 & 6 are very low



LPG Taxi NOx emissions

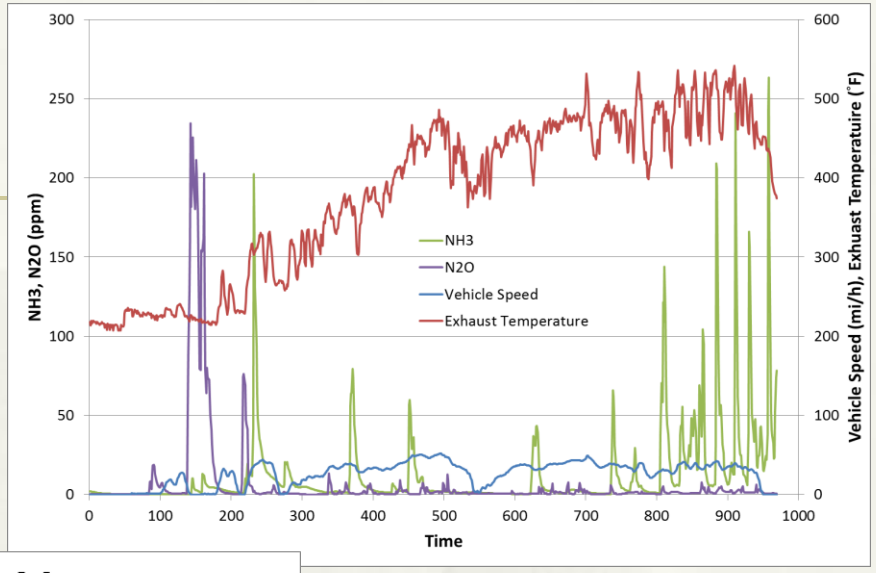


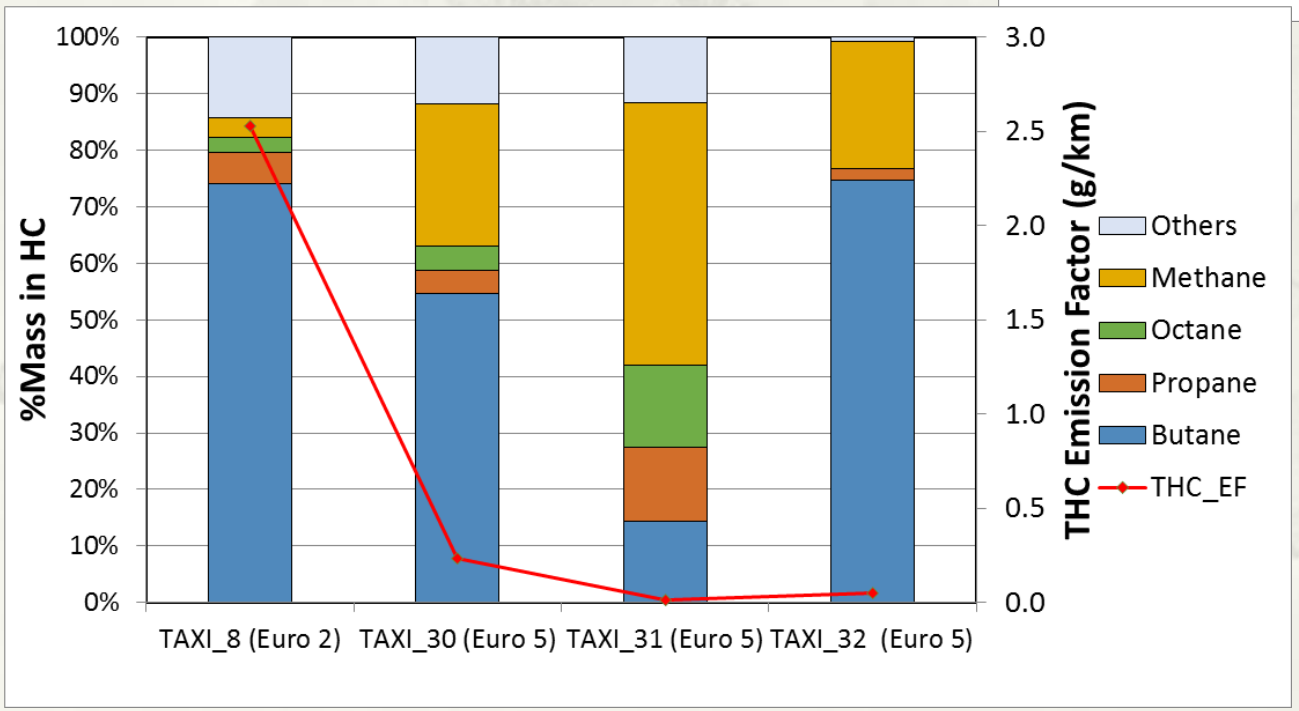
Euro 4 LPG taxis
deteriorate considerably.
Especially after Age>8

Euro 5 LPG taxis
So far no significant deterioration is observed

Taxi Emissions

Measurement using FTIR on dyno

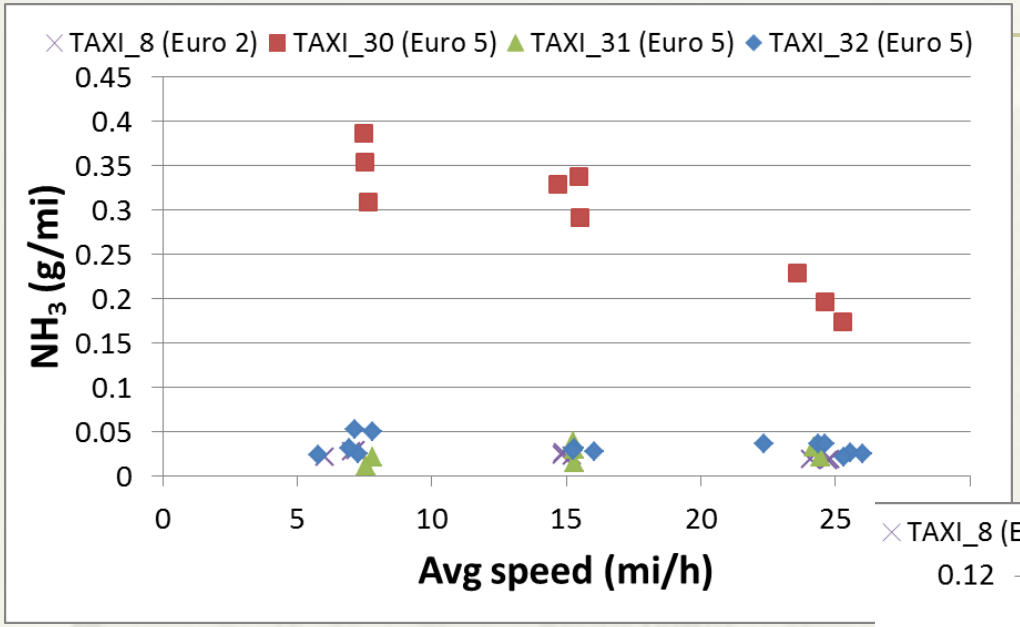




For LPG taxis (75% butane, 25% propane)

Emissions of Butane > Methane >> others HC

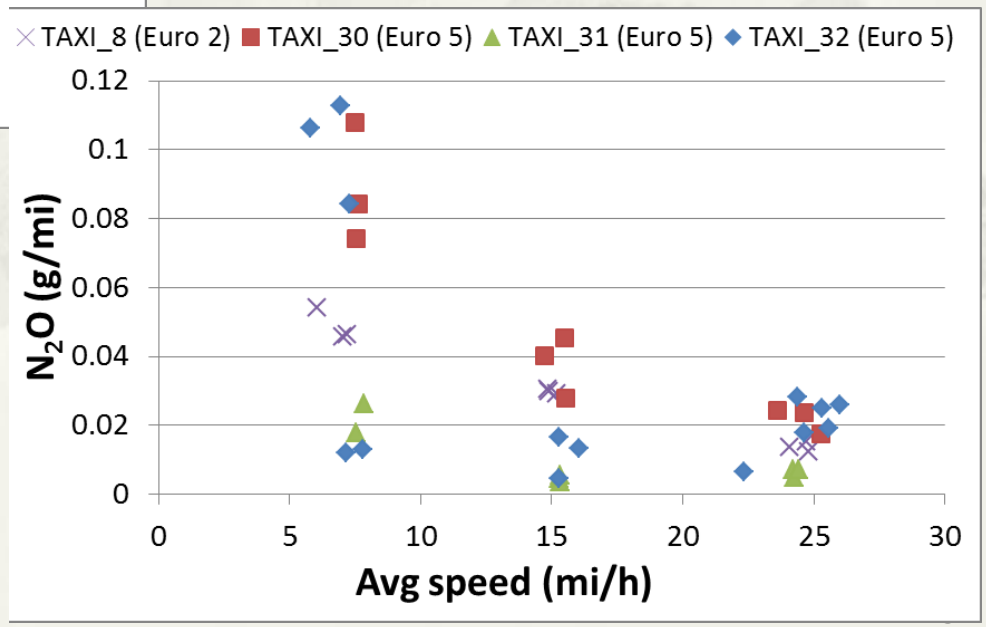
LPG Taxi: NH_3 and N_2O



NH_3 emissions are low in most cases.

One vehicle has high NH_3 emissions

N_2O emissions are low in all cases



Thank you.