



Air Pollution from vehicles

Contents



- Pollution is an unhelpful word
- Idling...?
- London Ultra Low Emission Zone
- Bus emissions
- Oxford Emissions Maps
- Recent developments in vehicles

Pollution is an unhelpful word

- An ideal combustion engine vehicle emits the following:



Pollution is an unhelpful word

- An ideal combustion engine vehicle emits the following:
 - CO_2
 - H_2O



Pollution is an unhelpful word

- A typical combustion engine vehicle emits the following:
 - CO₂
 - H₂O
 - Particulates
 - NO + NO₂
 - Unburned HydroCarbons
 - CO
 - and other “unregulated” emissions

Pollution is an unhelpful word

- A typical combustion engine vehicle emits the following:
 - CO₂
 - H₂O
 - Particulates
 - NO + NO₂
 - Unburned HydroCarbons
 - CO
 - and other “unregulated” emissions
- This is all “pollution” (depending on who asks)
- Strategies for reducing these are widely different
- Policies need to be carefully designed to consider all of these “pollutants”
- What can we do about this?

Vehicle emissions control

- A wide range of technologies are employed to control these “pollutants”
- Passive vs active
- Temperature matters
 - Ecatalysts?
 - Hybrids?
- All add cost and efficiency penalties

CO₂



Diesel	Pollutant	
Vehicle calibration	All	Active
DOC	HC, CO, NO	Passive
DPF	PM	Passive
EGR	NOx	Active
LNT	NOx	Passive
SCR	NOx	Active
Gasoline	Pollutant	
Vehicle calibration	All	Active
TWC	HC, CO, NOx	Passive
GPF	PM	Passive

Vehicle emissions control

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CO₂

Require temperature to be effective

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Idling – all bad?

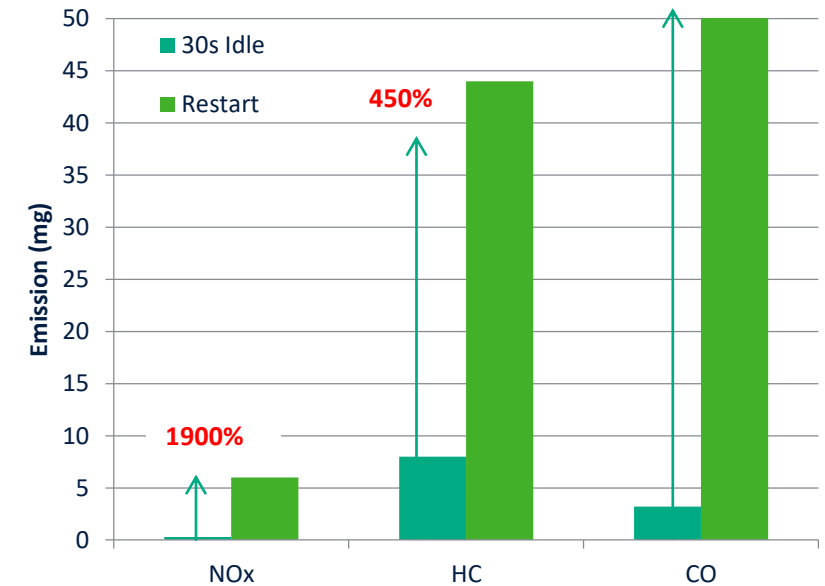
- Under all circumstances stopping a vehicle idling will reduce:
 - CO₂ ✓
 - H₂O ✓
 - Particulates
 - NO + NO₂
 - Unburned HydroCarbons
 - CO
 - and other “unregulated” emissions



2011 Ford Fusion petrol

Idling – all bad?

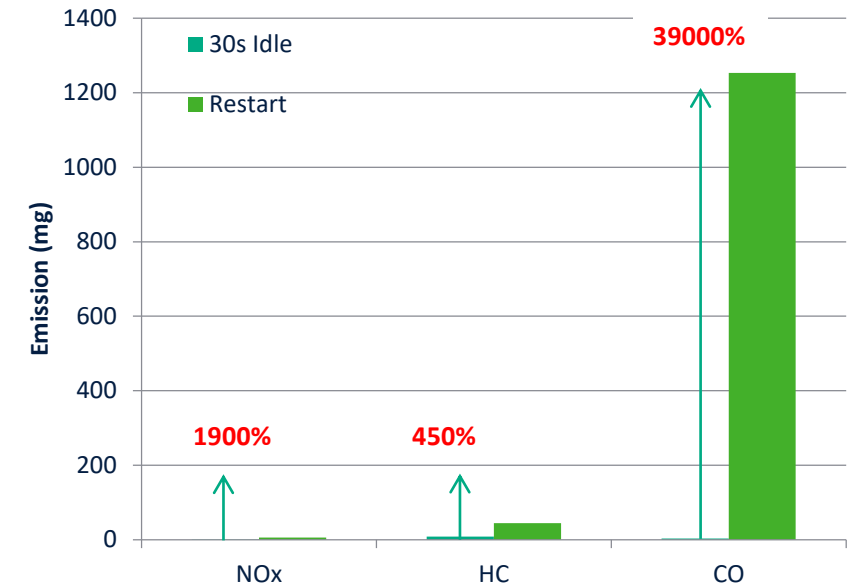
- For other pollutants:
 - Particulates
 - NO + NO₂
 - Unburned HydroCarbons
 - CO
 - and other “unregulated” emissions
- This will vary hugely depending on:
 - Vehicle
 - Vehicle (age)
 - Generally not applicable to Euro 6 +
 - Vehicle journey history
- Vehicles fitted with stop/start take this into account



	HC	NOx	CO
‘Hot’ restart	2.75 mins	10 mins	3.3 hrs
Cold restart	11.9 mins	6.3 hrs	7.7 hrs

Idling – all bad?

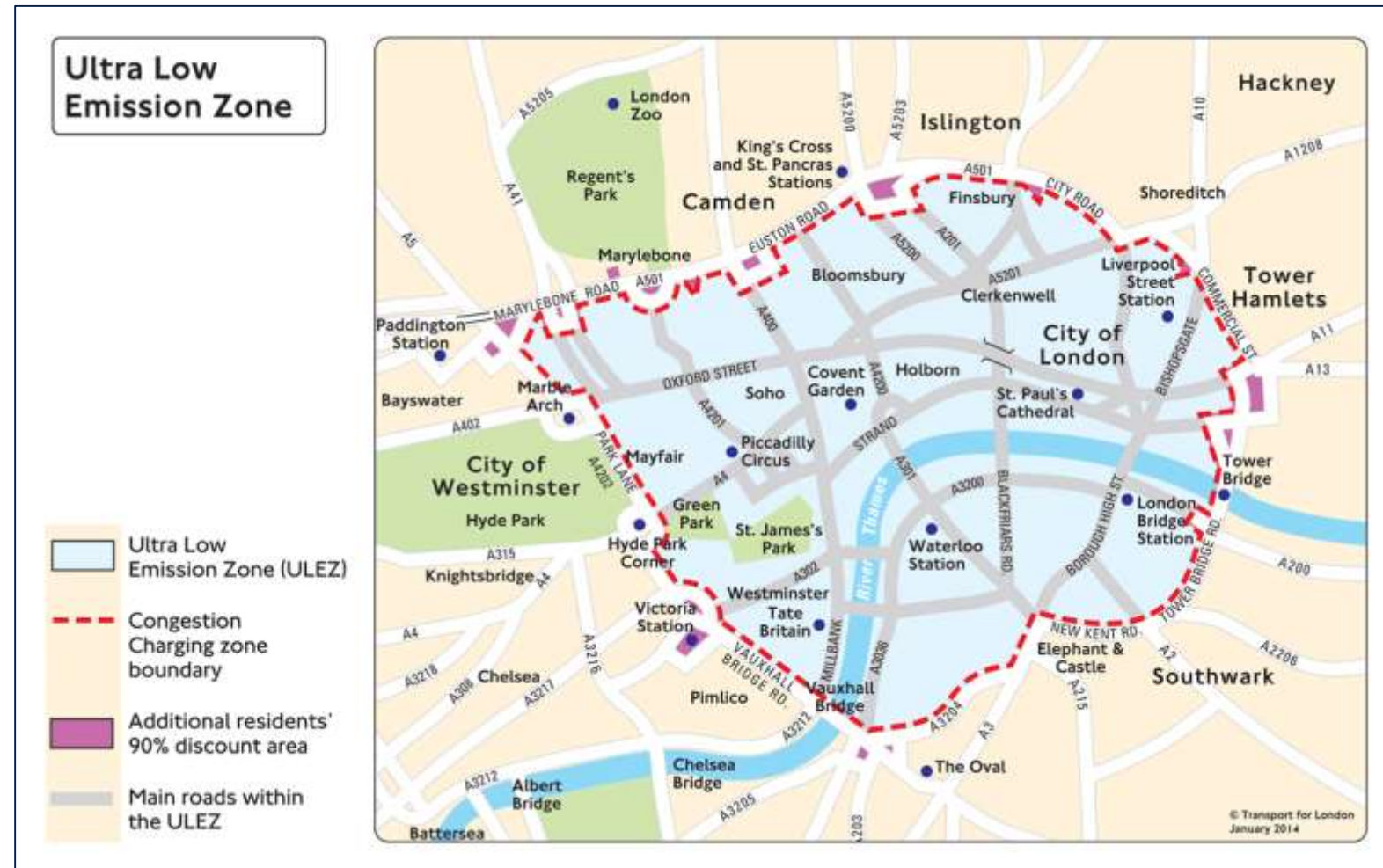
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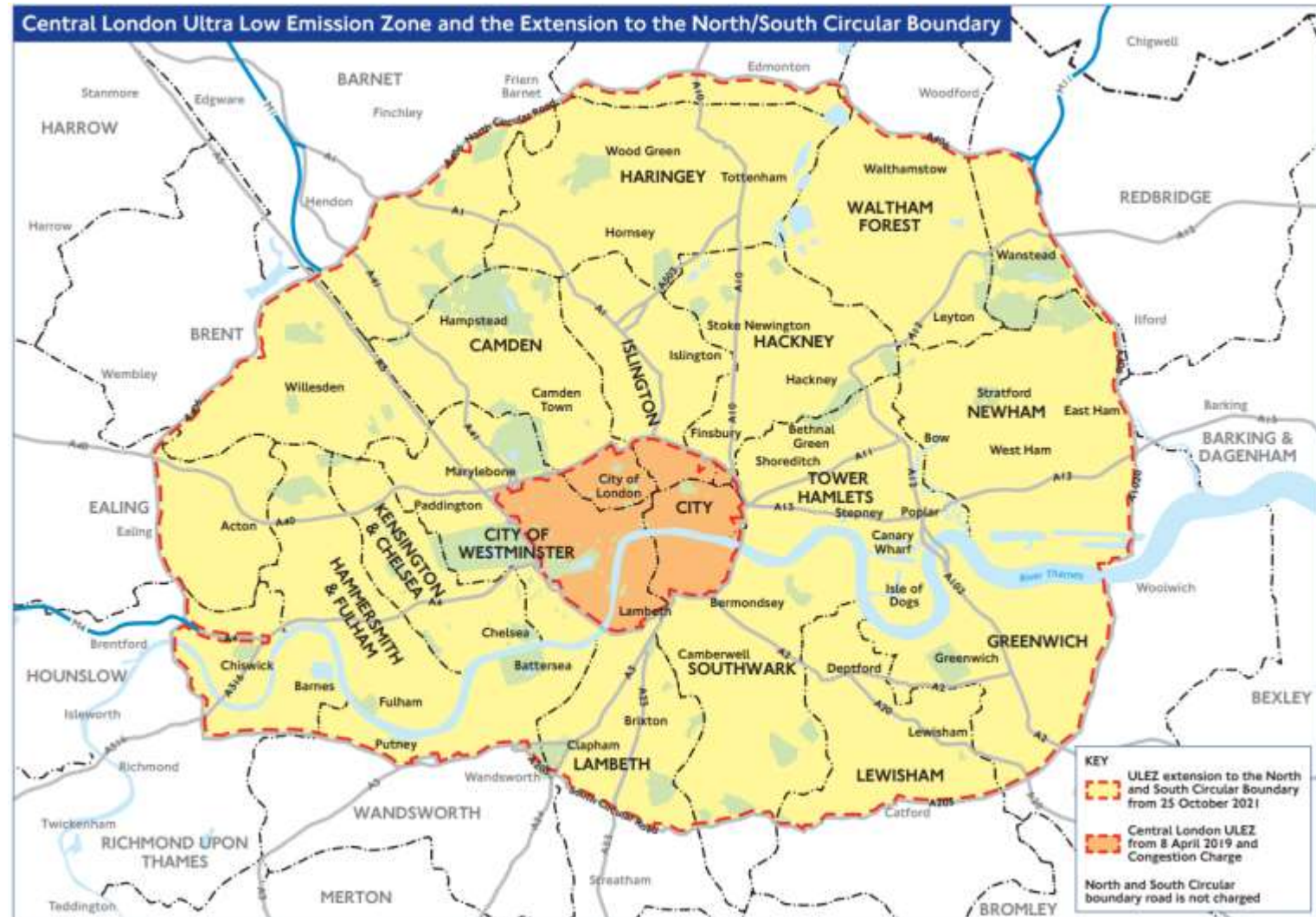
London ULEZ

- From 8 Apr 2019
- Euro 3 for motorcycles
- Euro 4 for petrol
- Euro 6 for diesel
- Euro VI for lorries & buses



London ULEZ

- From 25 Oct 2021
- Euro 3 for motorcycles
- Euro 4 for petrol
- Euro 6 for diesel
- Euro VI for lorries & buses



London ULEZ

Are these the appropriate technology levels?



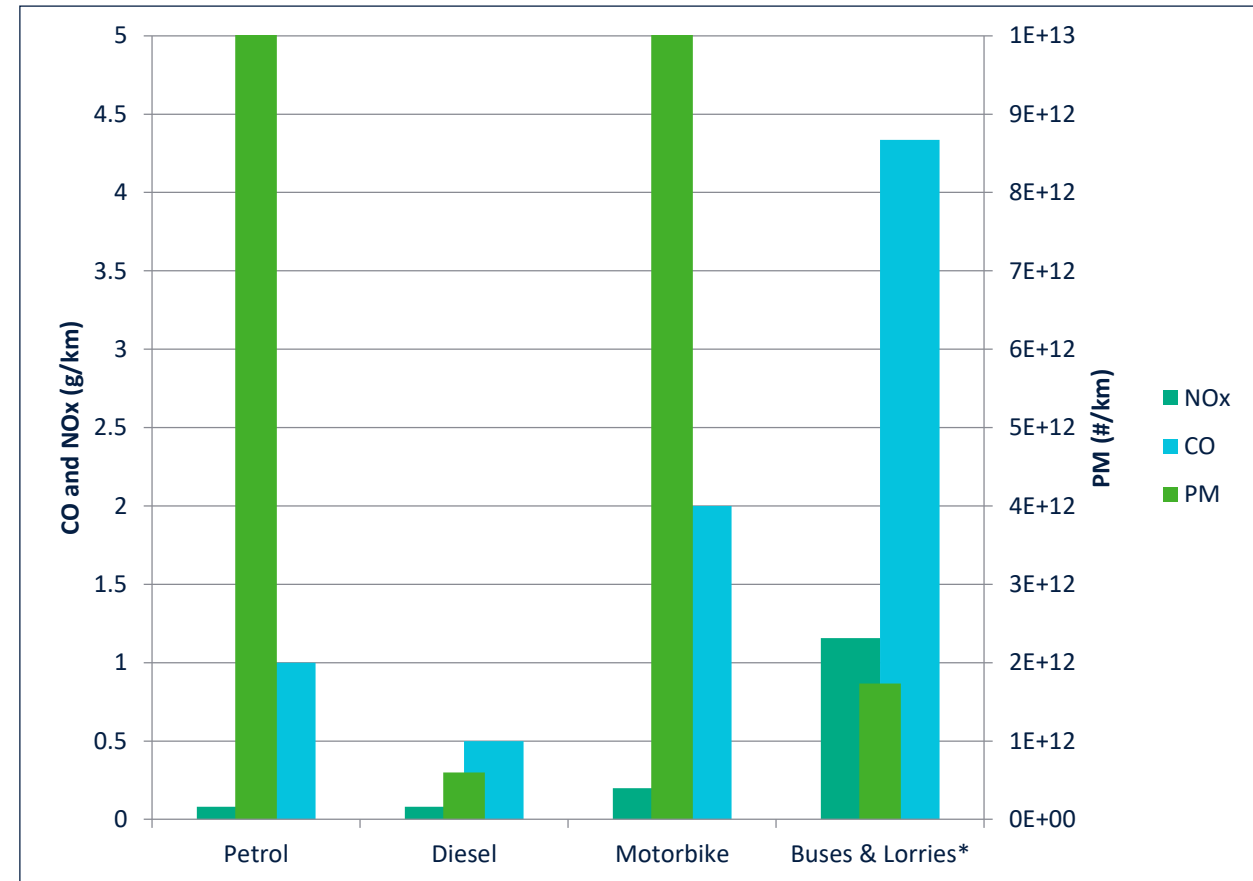
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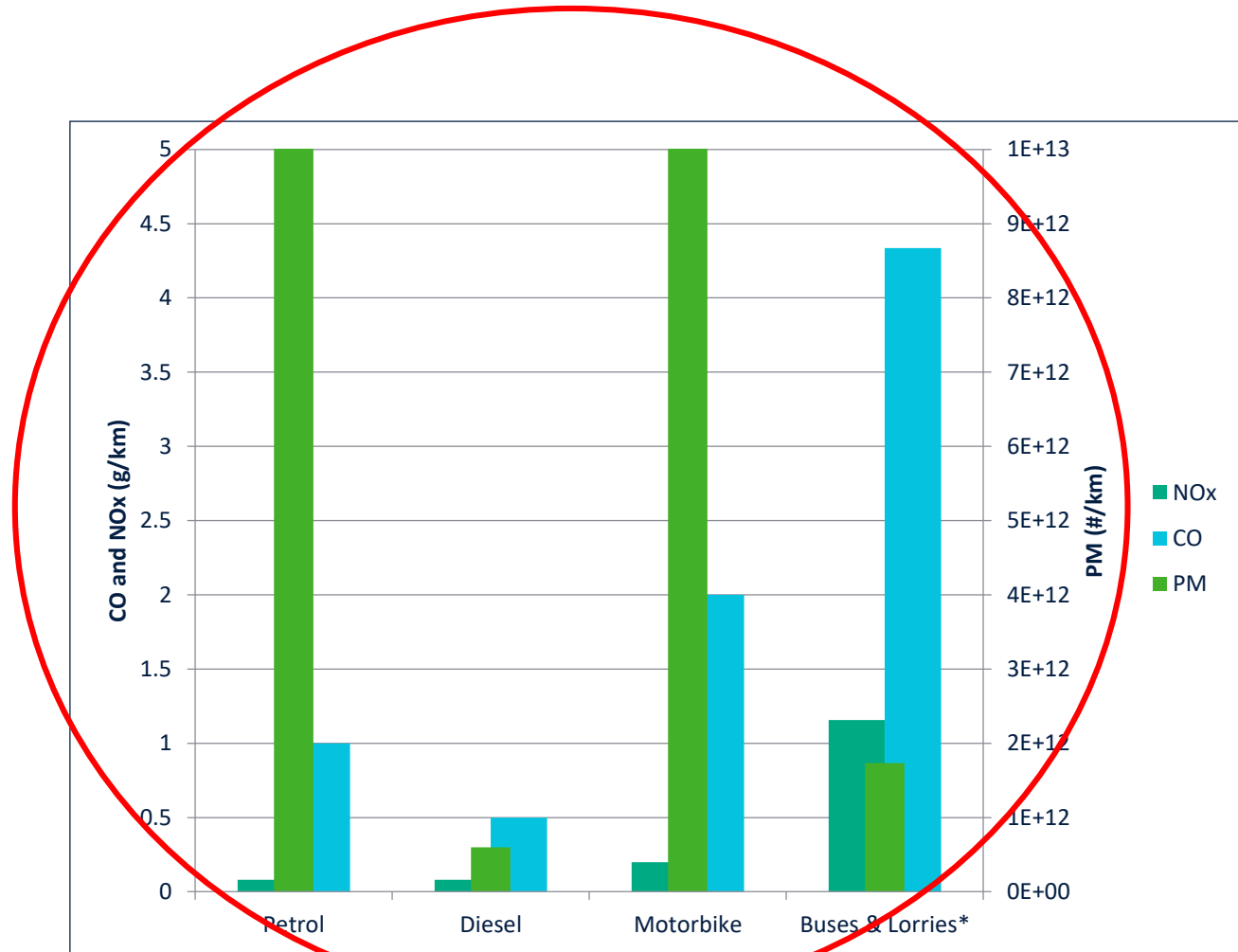


* - different measurement method, assumes Euro VI double decker bus

London ULEZ

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Can this really happen?



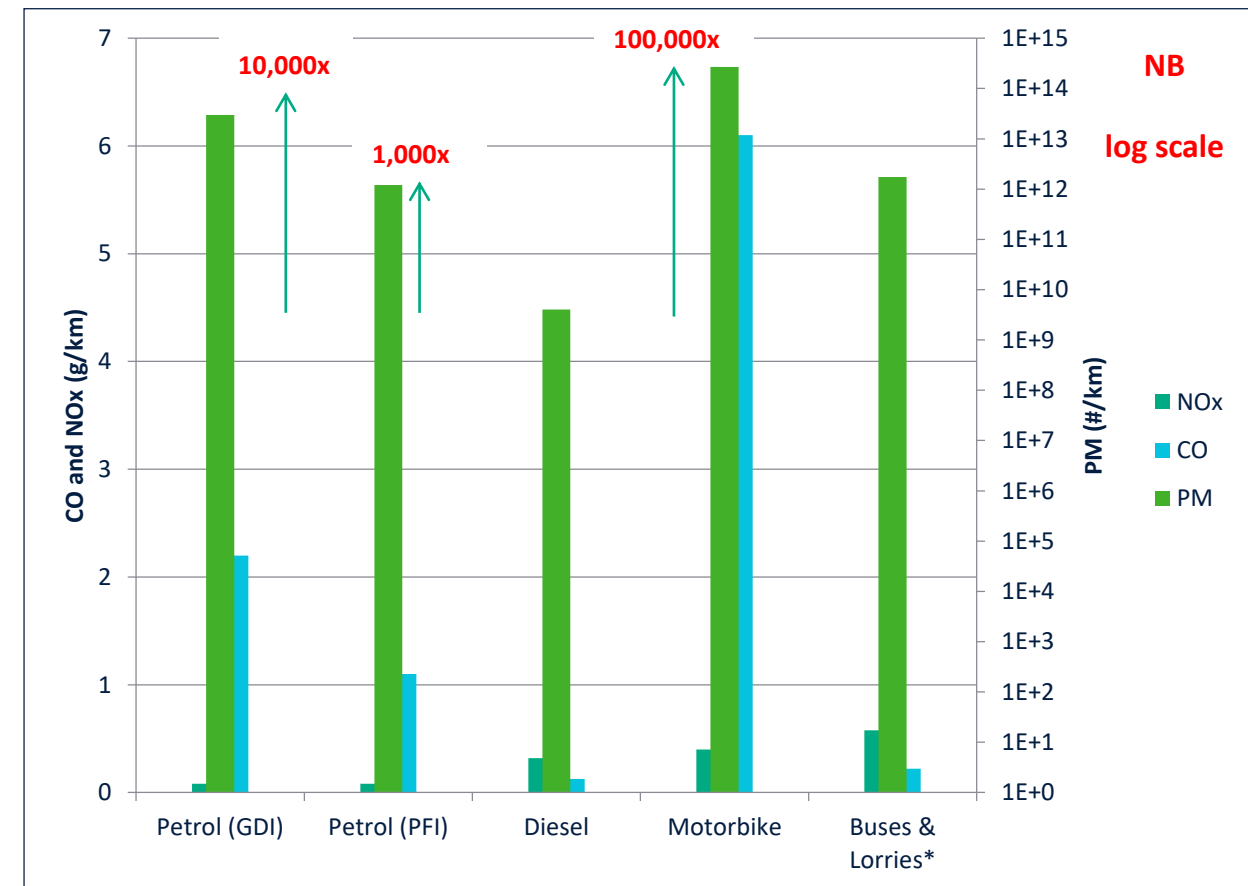
* - different measurement method, assumes Euro VI double decker bus

London ULNZ

Data from: Braisher 2010-01-0786, TFL In-service emissions performance of Euro 6/VI vehicles, <https://doi.org/10.1016/j.scitotenv.2017.11.271>, 2009-01-1841, equaindex.com, Particle Emissions of Powered Two Wheelers AECC, 2017-01-0985

- Very low levels of NOx across the vehicles
- BUT
- Unregulated particulates from Petrol and motorbikes at Euro 3/4
- Ultra Low NOx Zone?

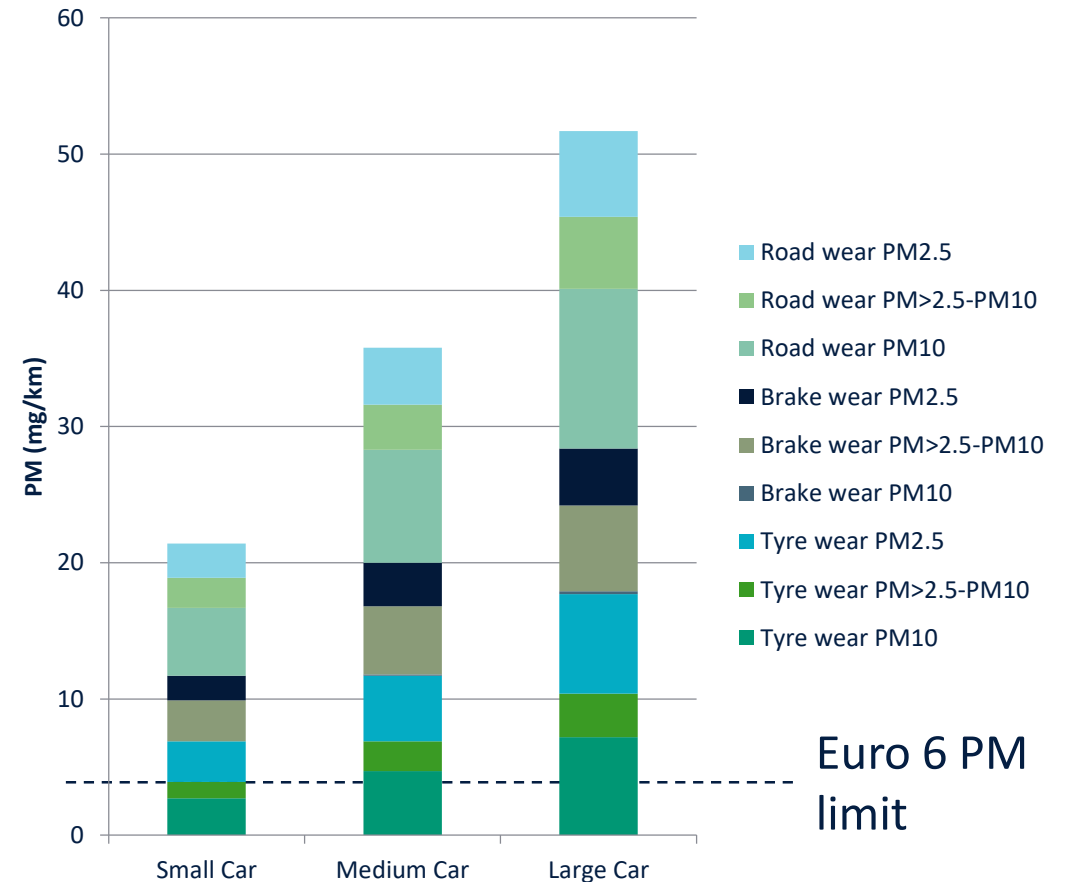
YES! – over 1000x more PN from Euro 4 petrol



* - different measurement method, assumes Euro VI double decker bus

Non-exhaust emissions

- Non-exhaust emissions are already higher than engine-out
- EVs emit PM too

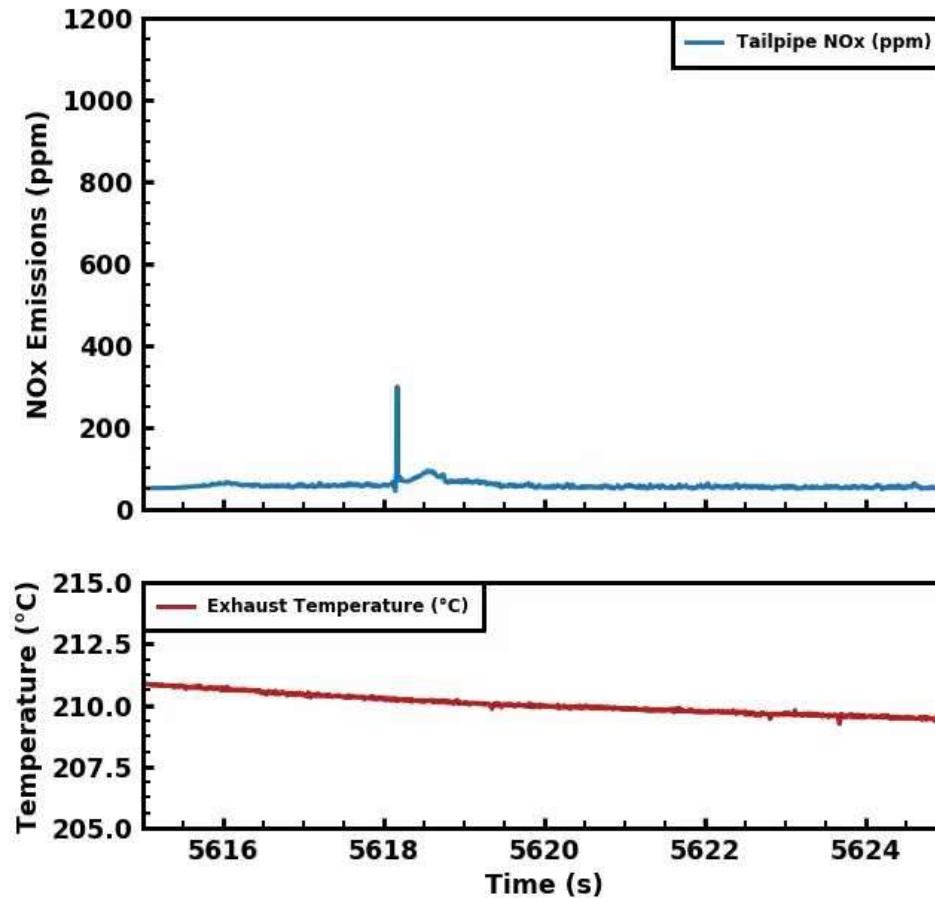


Bus emissions

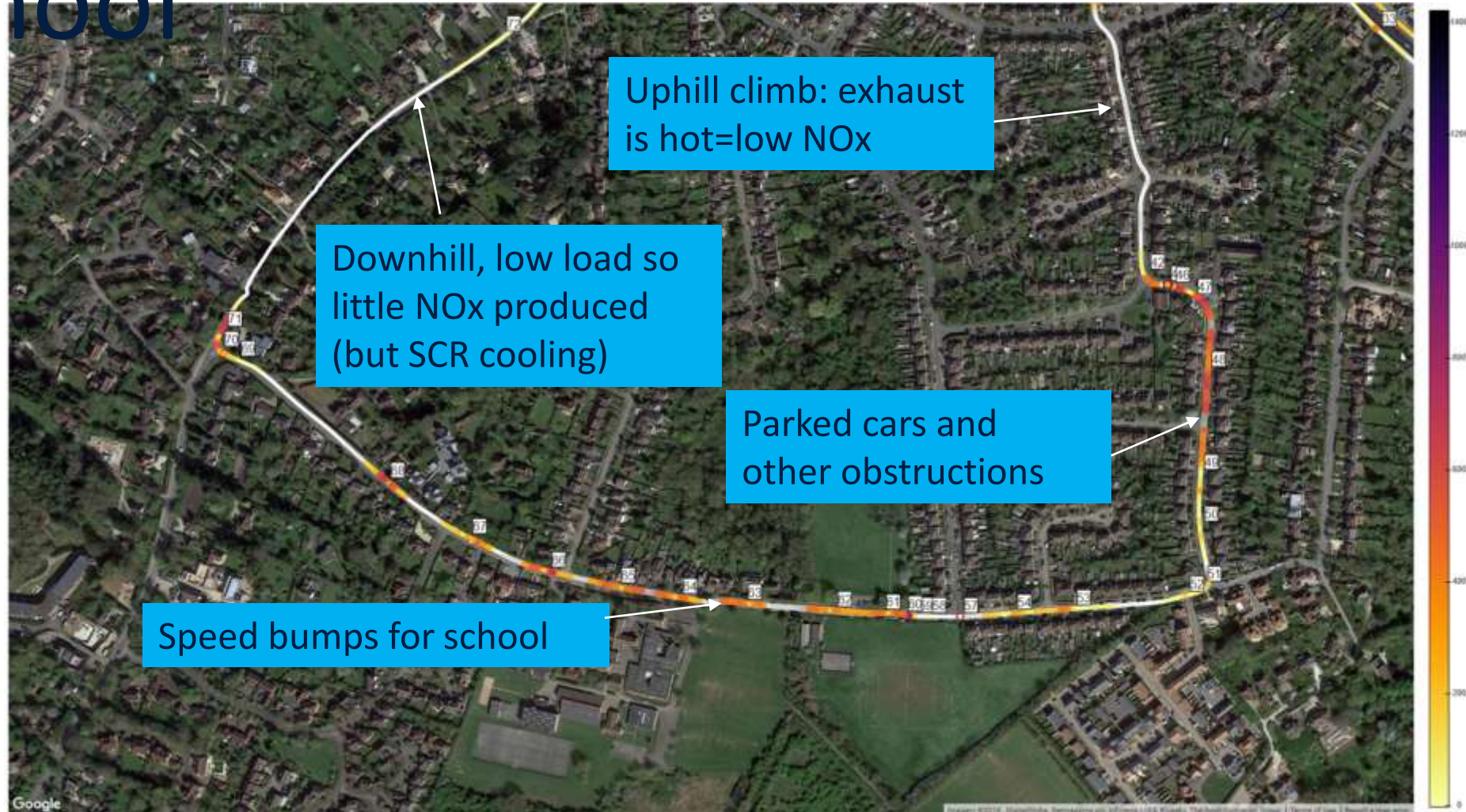
- Euro V hybrid with SCR (251,000 miles)
- Euro VI with SCR (119,000 miles)
- Euro 5 passenger car 7-seater diesel no SCR (80,000 miles)



Bus stop manoeuvre



Bus manoeuvre around school



Comparison of 3 x Eu VI Blackbird Leys



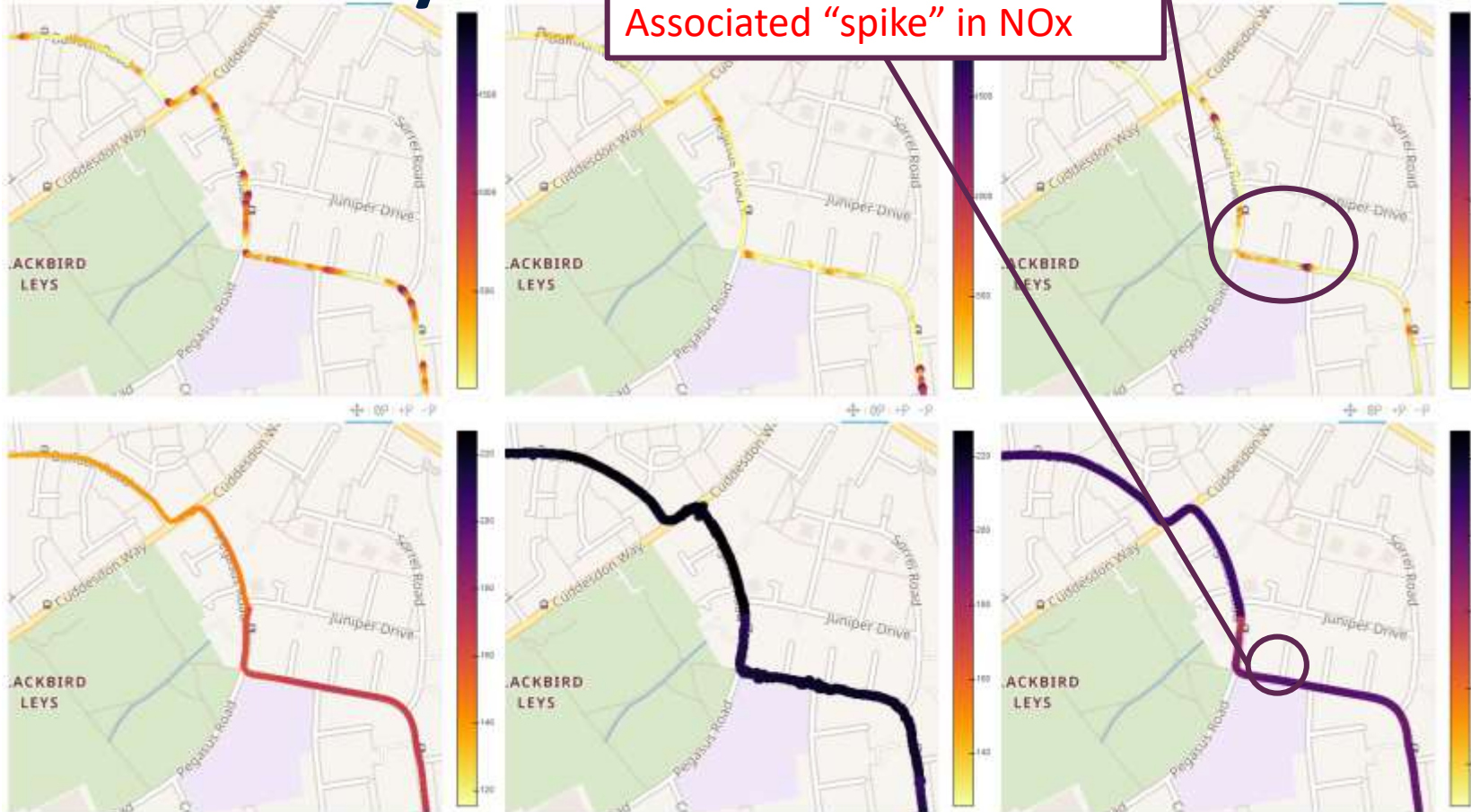
Bus stop location correlates with emissions:



Wikimedia maps
Map data © OpenStreetMap contributors

Comparison of 3 x Eu VI Blackbird Leys

Engine off stop
Catalyst cools
Associated "spike" in NO_x



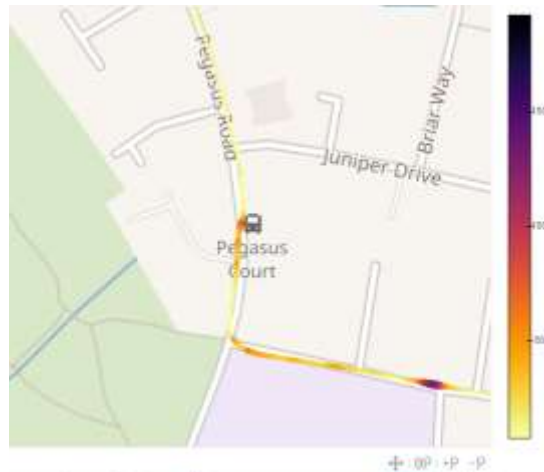
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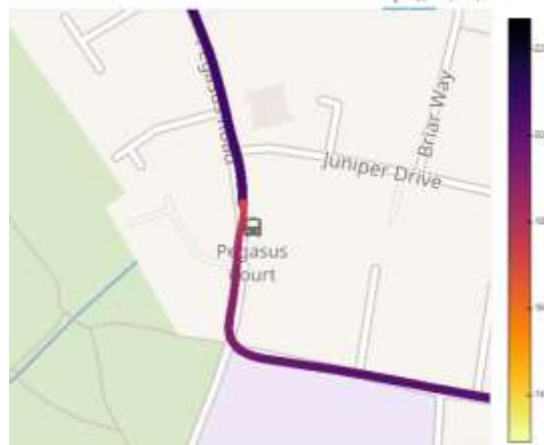
Wikimedia maps
Map data © OpenStreetMap contributors

Effects of 4-min engine switch-off Eu VI

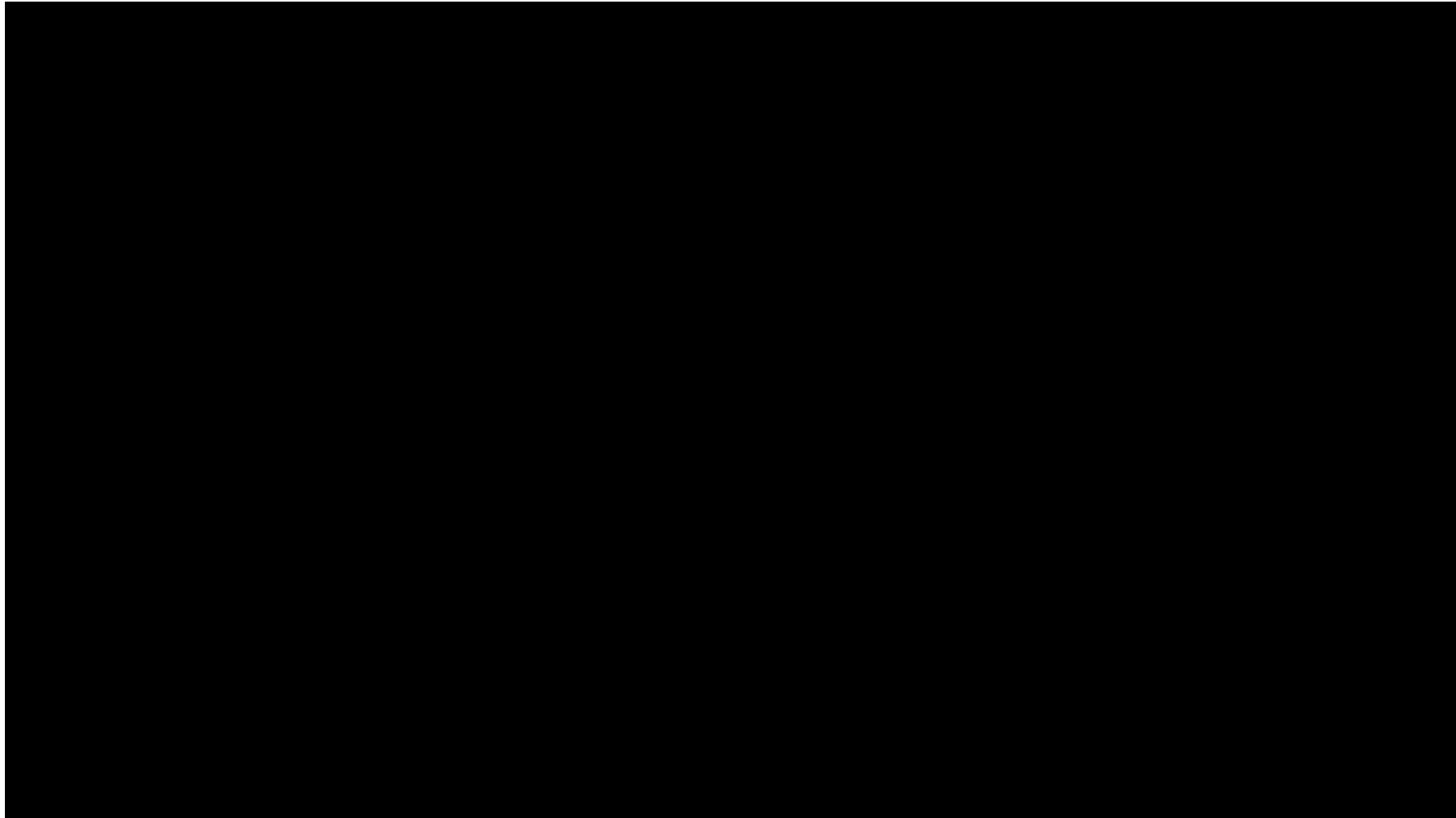
NO_x



Ex temp



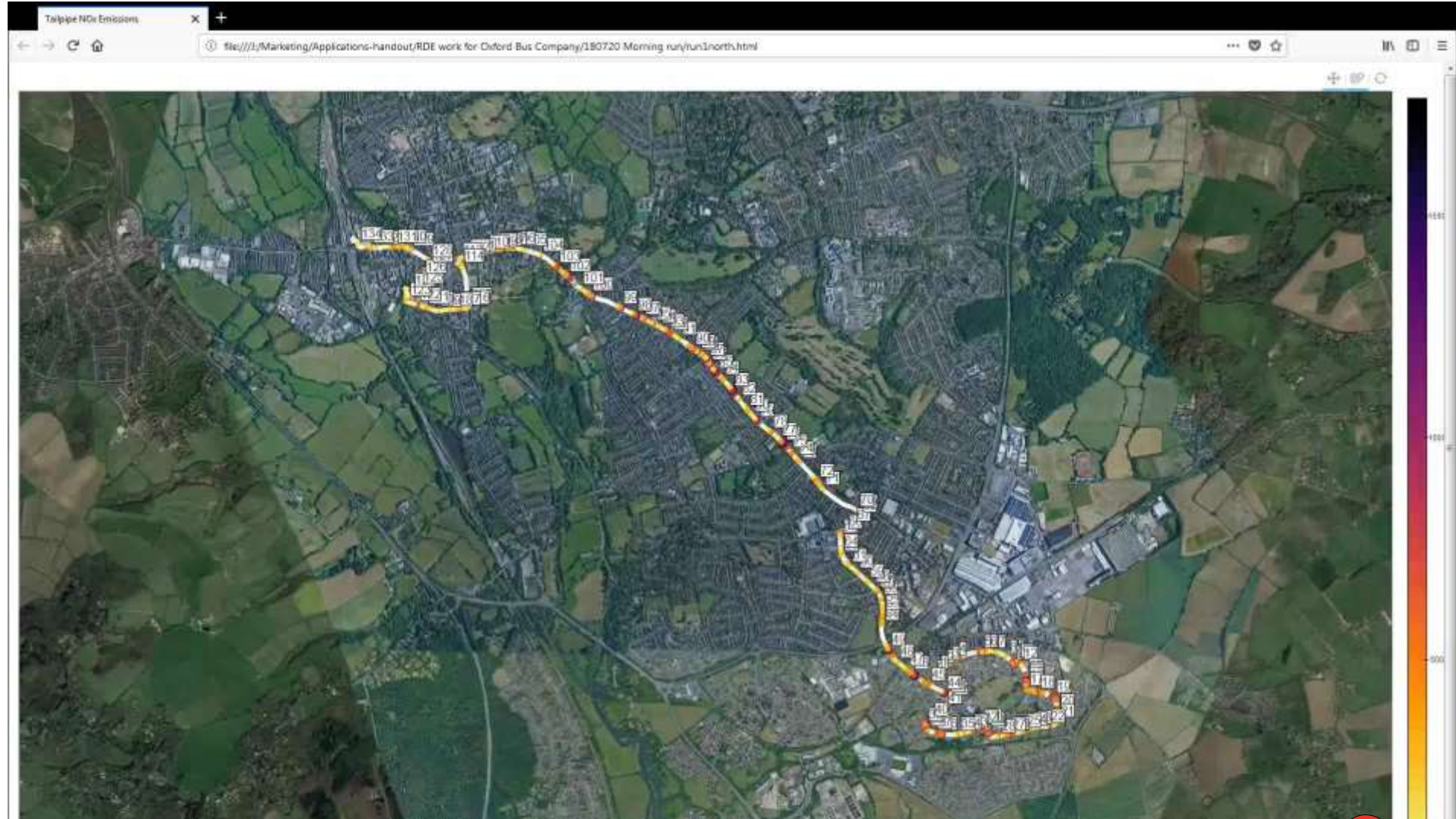
Speed bump (PHEV)



Speed bump (PHEV)

Plugin hybrid emits ~1km worth of NO_x per speed bump

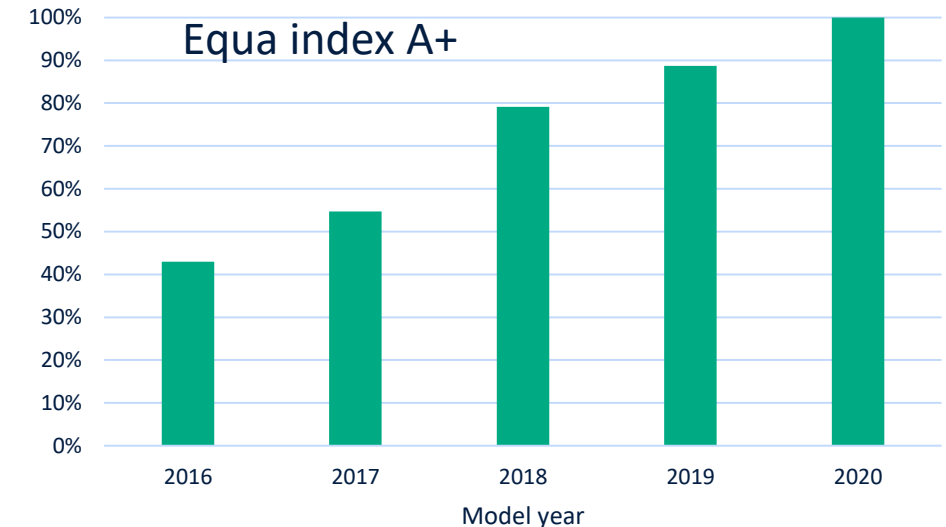
Oxford Emissions Maps



<https://oem.eng.ox.ac.uk>

Recent developments in vehicles

- This is a “solvable” problem with today’s technology
- Petrols AND DIESELS near zero local pollutants
- EQUA index
 - Nearly 90% of 2019 MY vehicles tested exceed Euro 6 gasoline RDE NOx
 - www.equaindex.com
- ADAC RDE tests (Germany)
 - Vehicles emitting zero NOx
- Euro 6d temp
- Euro 7



Car	RDE NOx (mg/km)	Car	RDE NOx (mg/km)
Audi A8 50 TDI	15	Mercedes A 180 d	40
BMW 520d Steptronic	5	Mercedes C 220 d	0
BMW 520d Touring	1	Opel Astra 1.6 D	1
BMW X2 xDrive 20d	23	Peugeot 308 SW BlueHDI 180	30
Citroen Berlingo BlueHDI 130	7	Volvo XC60 D5 AWD	56
Honda Civic 1.6 i-DTEC	101	VW Golf 1.6 TDI SCR	14
Kia Ceed 1.6 CRDi	22		

Recent developments in vehicles

- TEVVA / UPS plug-in hybrid
- 400 km range
 - 100 km electric-only
- Geo-fenced
 - Integration with CAZs / urban areas
- Same carrying capacity
- Current trial in Birmingham and Southampton



Conclusions



- **Pollution** control from vehicles is top priority
- Many current efforts focus on NO_x
- Non-exhaust emissions are a majority today
- Road layouts have substantial impact on emissions
 - Oxford Emissions Maps help understand this
- Incentivise switches to modern vehicles



Oxford Air Quality Meeting

Drawing together experts in vehicle emissions,
air quality measurement, public health, and policy



Friday 10 January 2020, 9:00am - 5:00pm
Keble College, Oxford

www.oaqm.org

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Oxford Air Quality Meeting

Thank you

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