

Road Vehicle Exhaust Emissions

Progress to date and Challenges ahead

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Overview

We are living through a period of change, in terms of knowledge, technologies, behaviour, attitudes, and legislation.

This short presentation will not attempt to provide a comprehensive and definitive overview of road vehicle exhaust emissions.

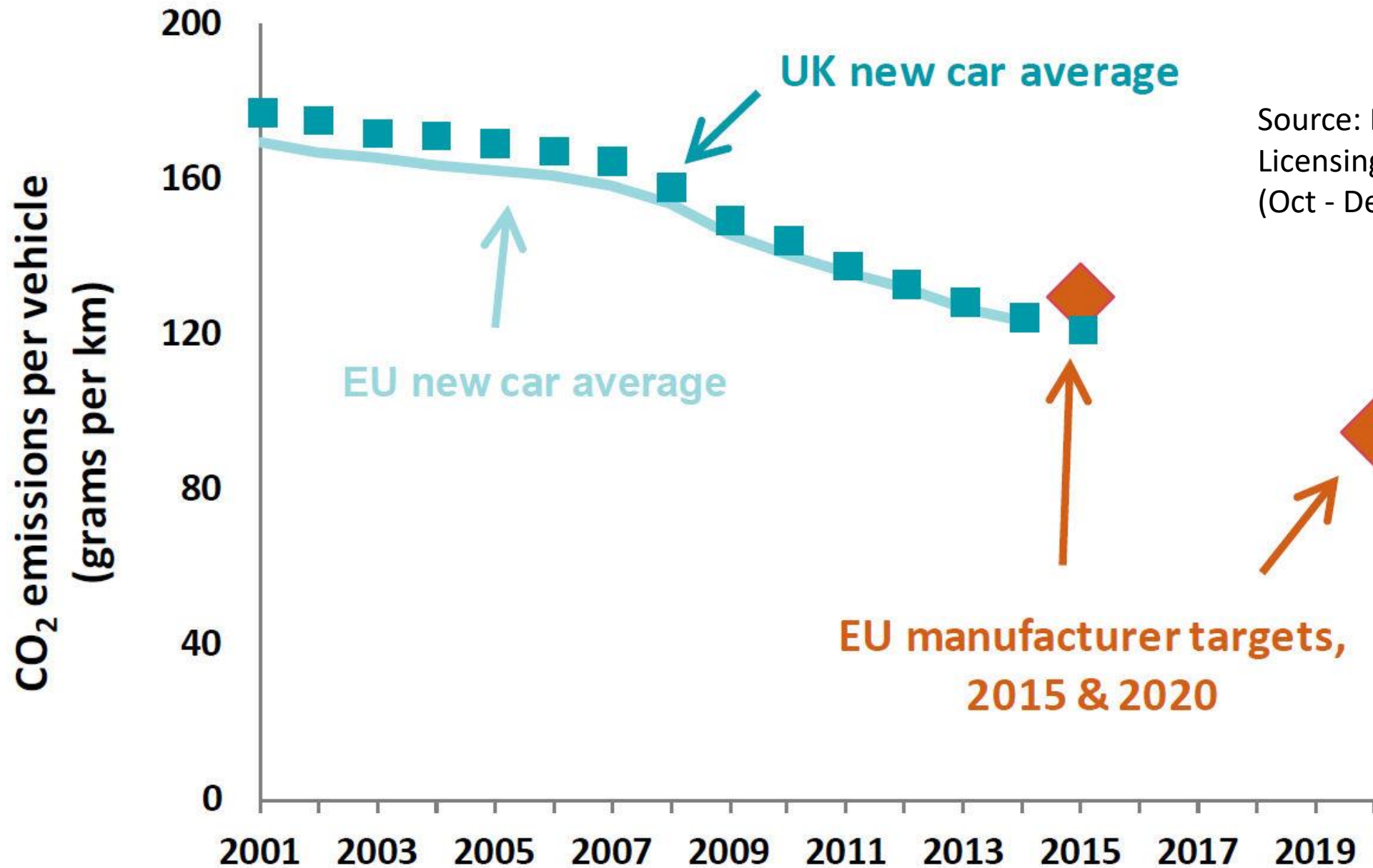
Instead, after providing some introductory context, the presentation will highlight 3 or 4 issues which I (and others) regard as worthy of ongoing attention over the next couple of years.

Certainly not exhaustive or exclusive. There are many others....

Some issues

- The ongoing primary NO₂ (f-NO₂) problem;
- Observed variability in exhaust emissions performance across vehicle manufacturers;
- Exhaust emissions from vans (N1) up to 3.5 tonnes;
- Age / mileage /maintenance related deterioration in performance of emissions control technologies;
- The legacy challenge.

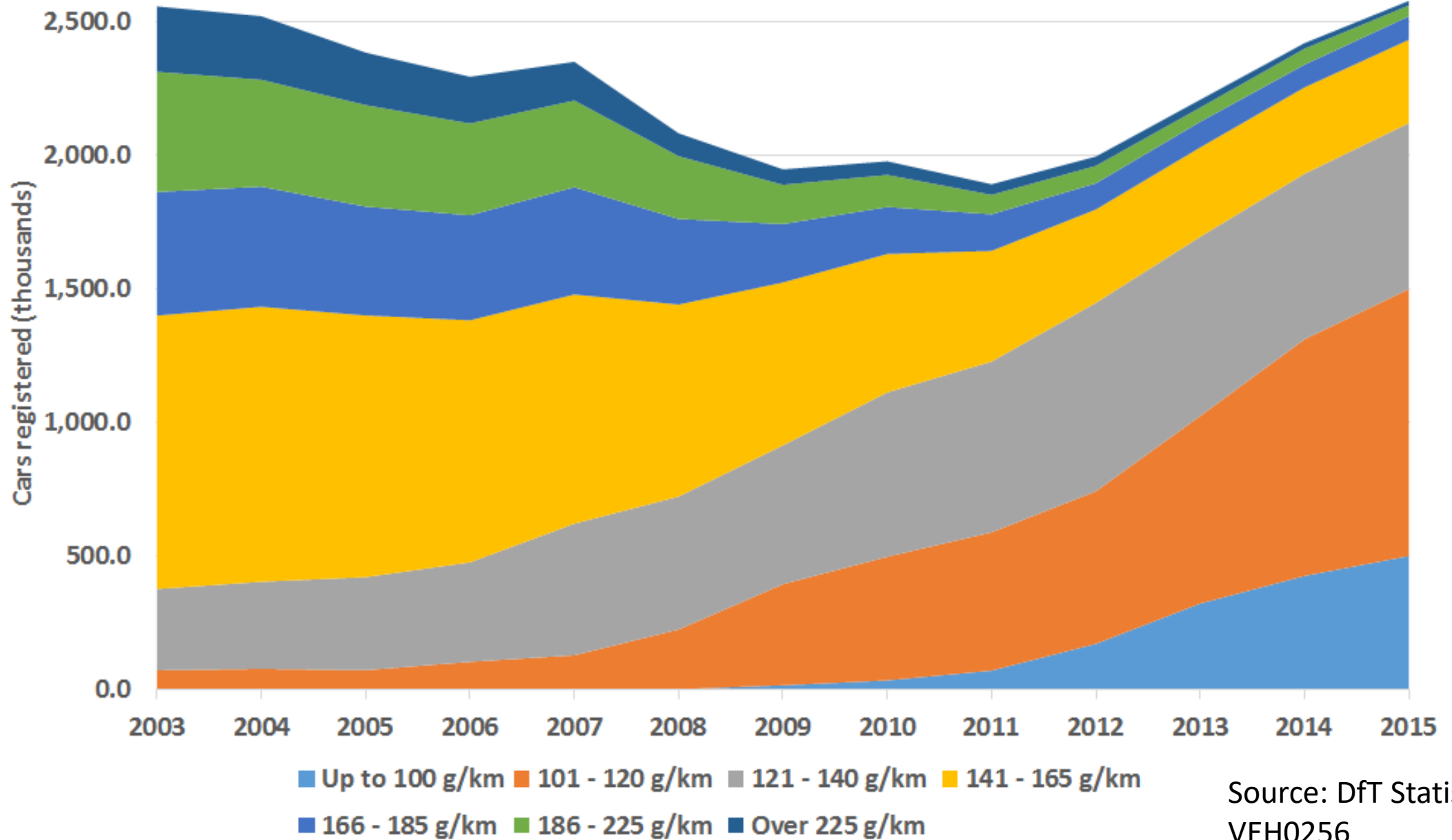
New car CO₂ emissions



Source: DfT (2016) Vehicle Licensing Statistics: Quarter 4 (Oct - Dec) 2015.

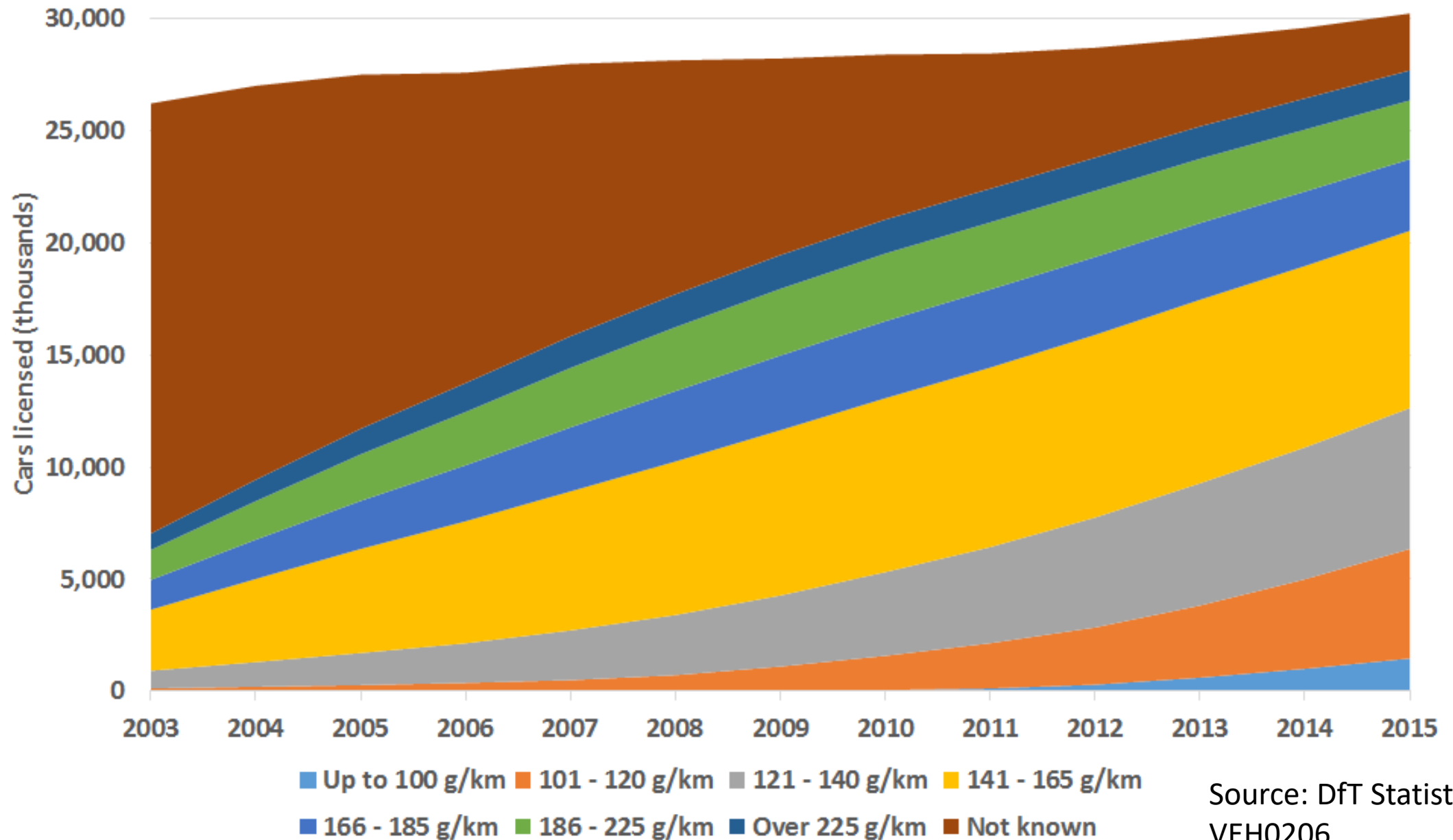
**EU manufacturer targets,
2015 & 2020**

Cars registered for the first time by CO₂ emission band



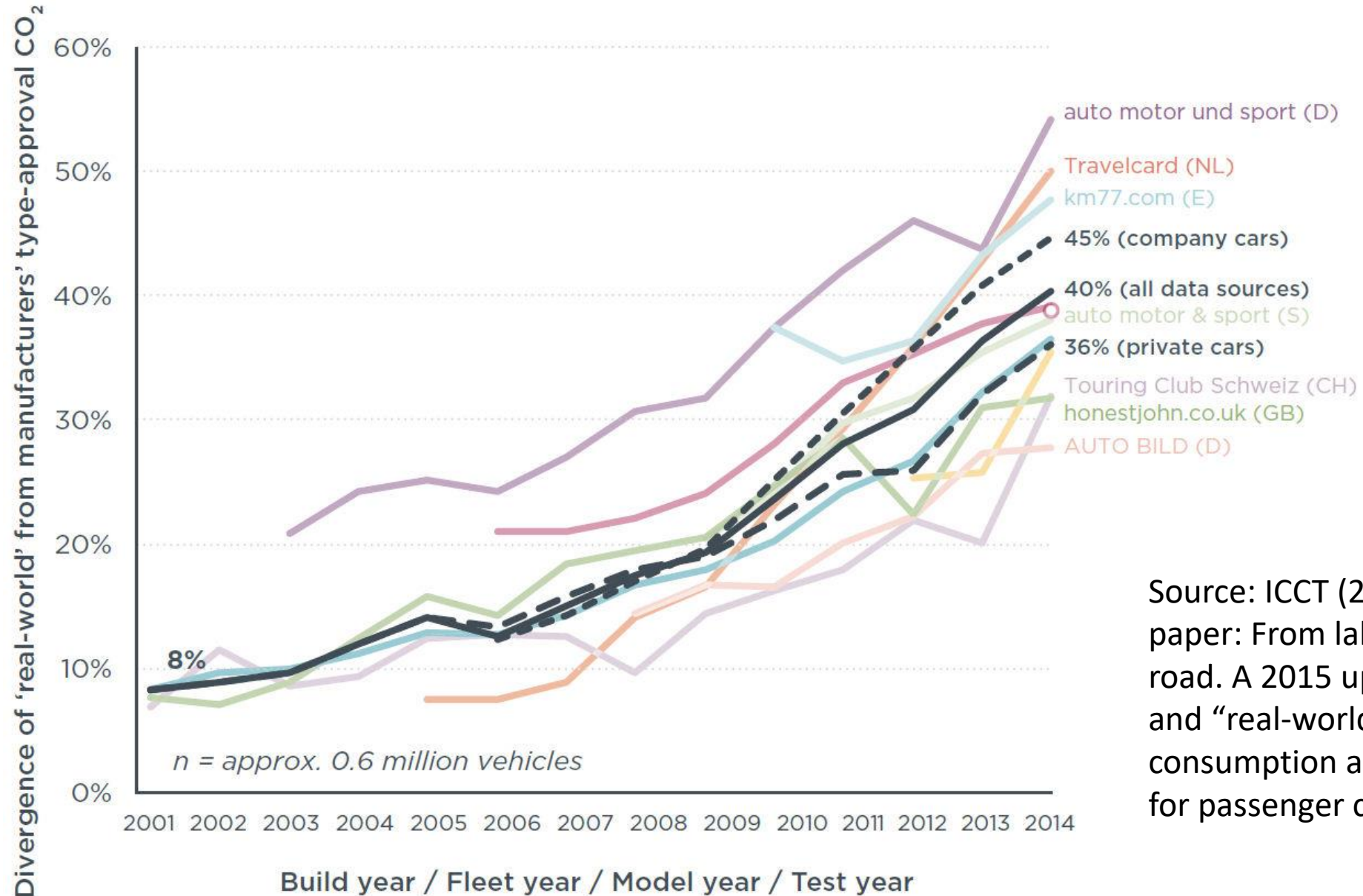
Source: DfT Statistics Table
VEH0256

Licensed cars by CO₂ emission band



Source: DfT Statistics Table
VEH0206

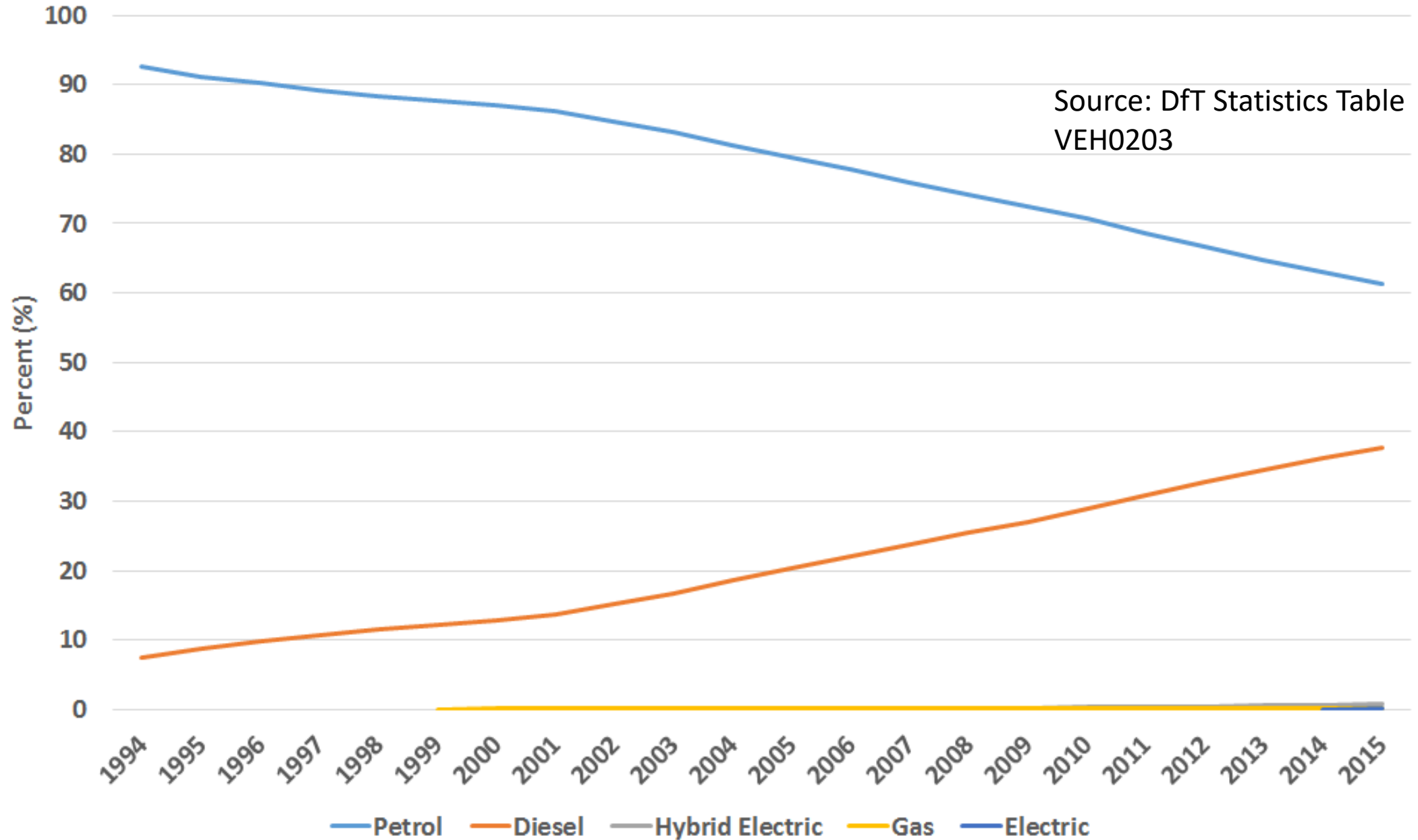
Divergence of real-world from type-approval CO₂ emissions



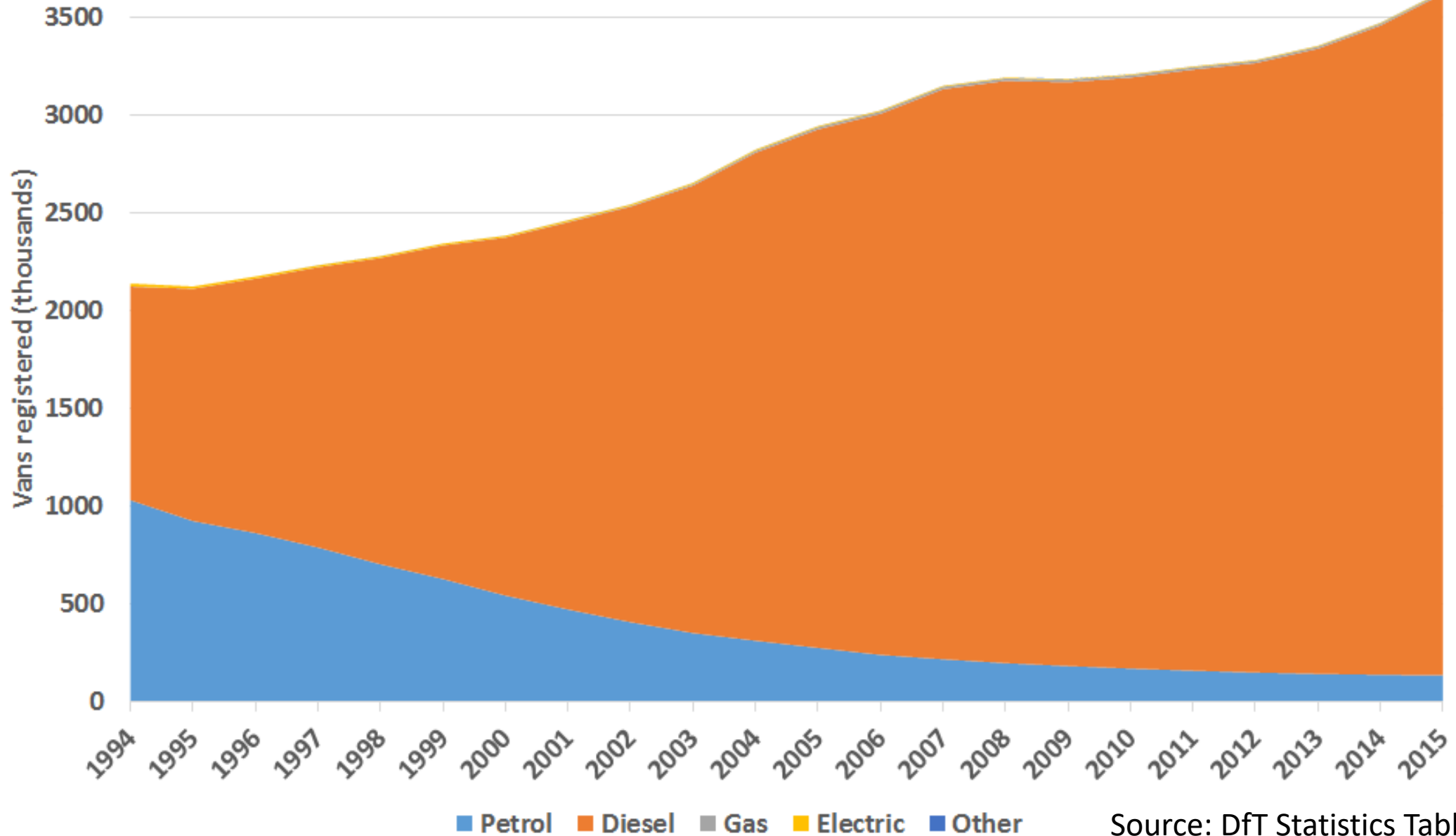
Source: ICCT (2015). White paper: From laboratory to road. A 2015 update of official and "real-world" fuel consumption and CO₂ values for passenger cars in Europe.

Cars licensed by propulsion / fuel type

Source: DfT Statistics Table
VEH0203



Licensed light goods vehicles by propulsion / fuel type



Source: DfT Statistics Table VEH0403

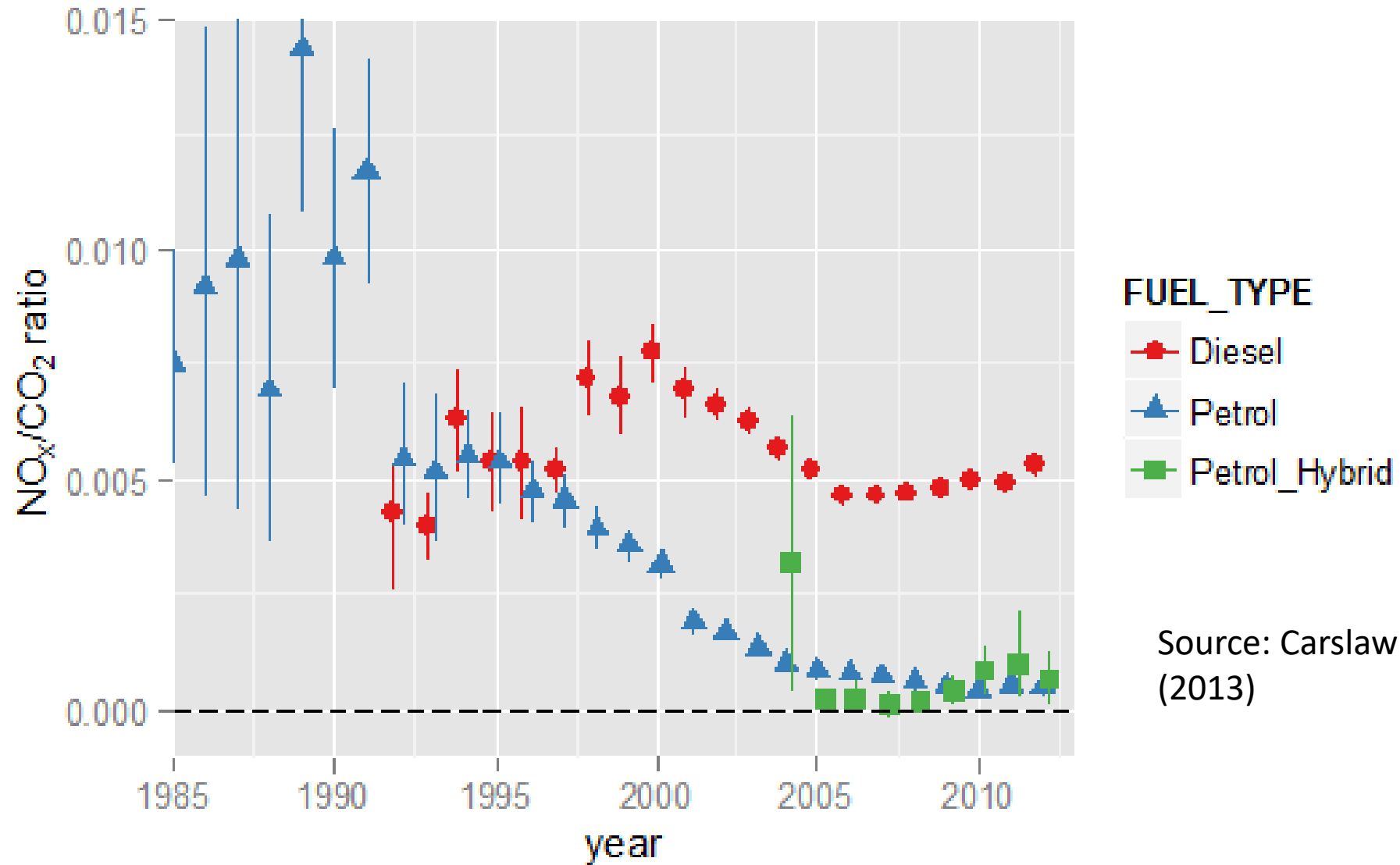
Euro 6 and Real Driving Emissions (RDE) tests (I)

- **Euro 6** emissions standard for light vehicles came into force in September 2015 for the registration and sale of passenger cars in the EU.
- NO_x limit for passenger cars and light vans reduced from **180 mg/km** at **Euro 5**, to **80 mg/km** at **Euro 6**.
- **Euro 6** emissions limits for HGV's introduced over a different timescale but are due to be fully implemented by December 2016. Reduces NO_x emissions limit from **2.0 g/kW.hr** at **Euro 5**, to **0.46 g/kW.hr** at **Euro 6**.

Euro 6 and Real Driving Emissions (RDE) tests (II)

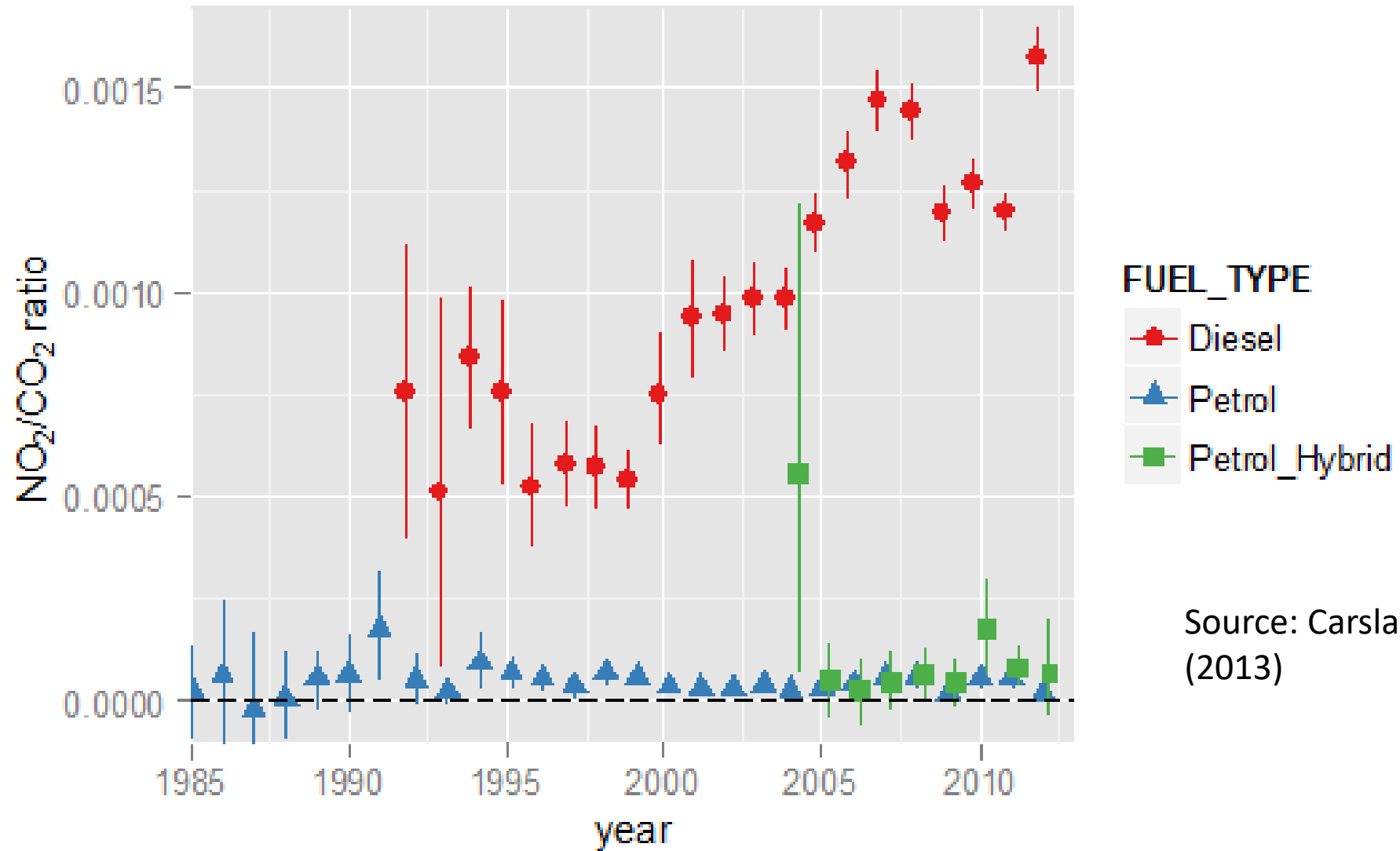
- In October 2015 the Technical Committee on Motor Vehicles and the European Commission reached agreement on the implementation of new procedures for real driving emissions (RDE) for diesel cars. Specifically, the following agreement was reached:
- Step 1: **conformity factor of 2.1** for all new model types in September 2017 and all vehicle registrations in September 2019
- Step 2: **conformity factor of 1.5** for all new model types in January 2020 and all vehicle registrations in January 2021.

Passenger cars – Total oxides of nitrogen



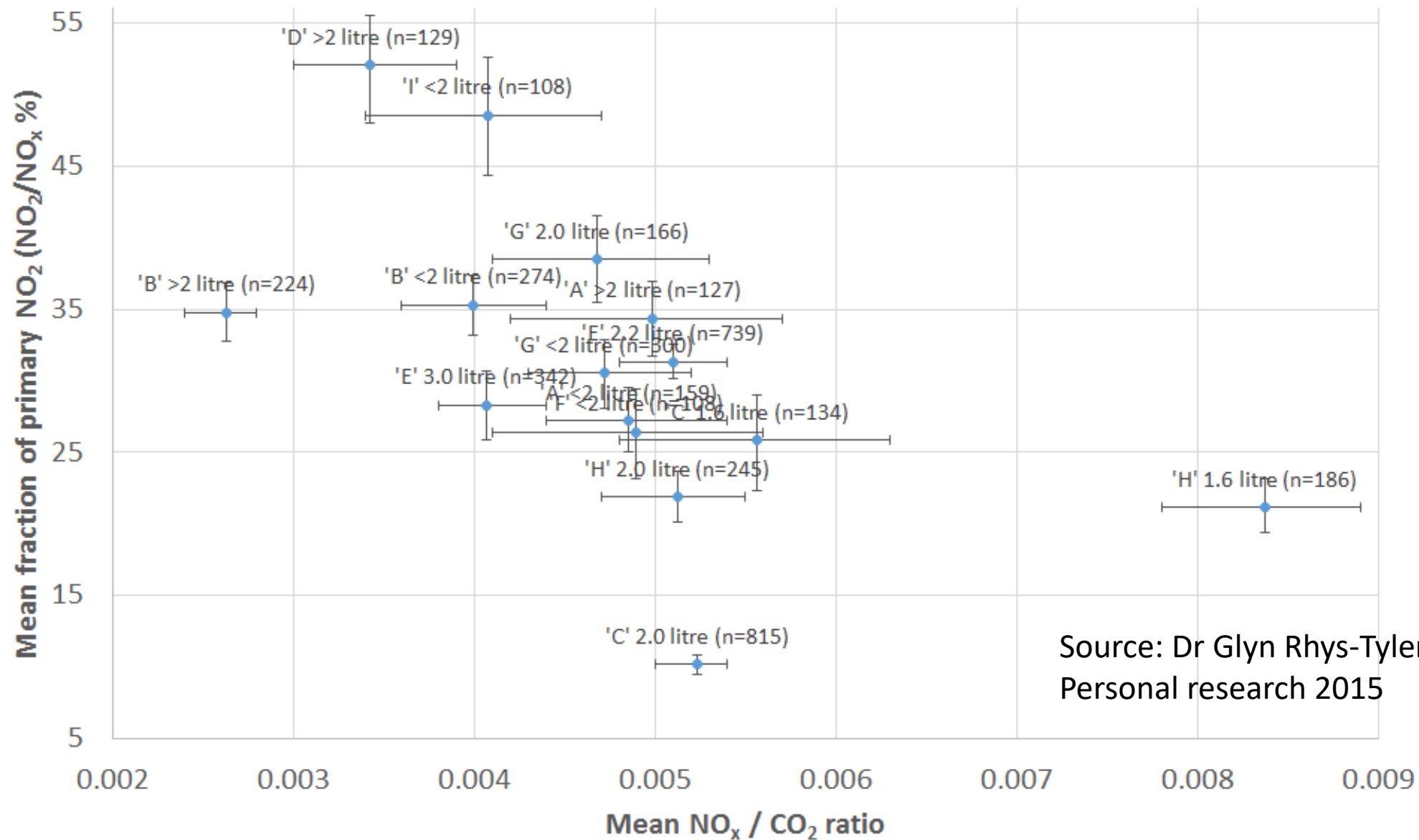
Source: Carslaw & Rhys-Tyler (2013)

Passenger cars – Nitrogen dioxide emissions



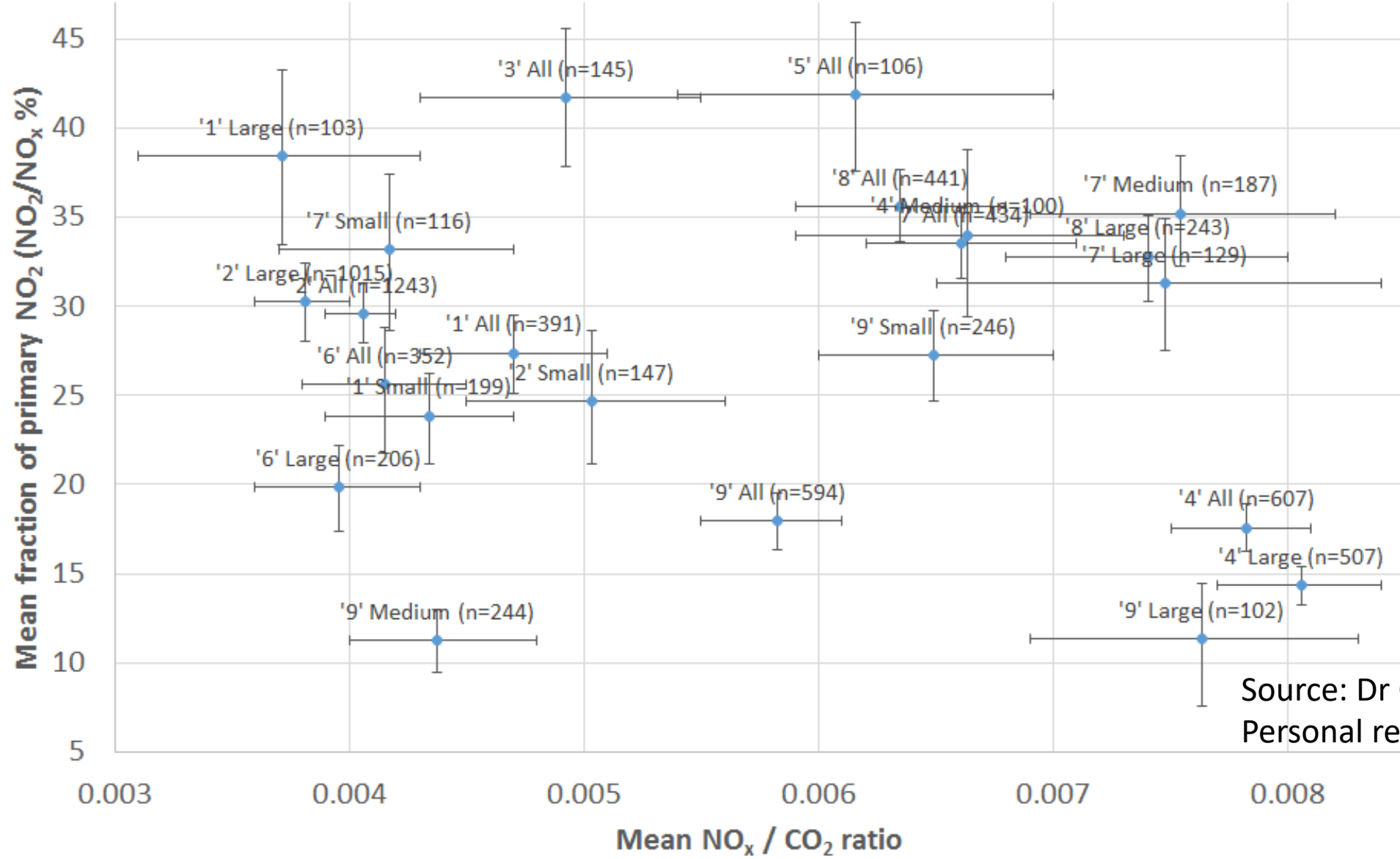
Source: Carslaw & Rhys-Tyler
(2013)

Euro 5 diesel cars observed in 2012 by manufacturer - NO_x emission ratios



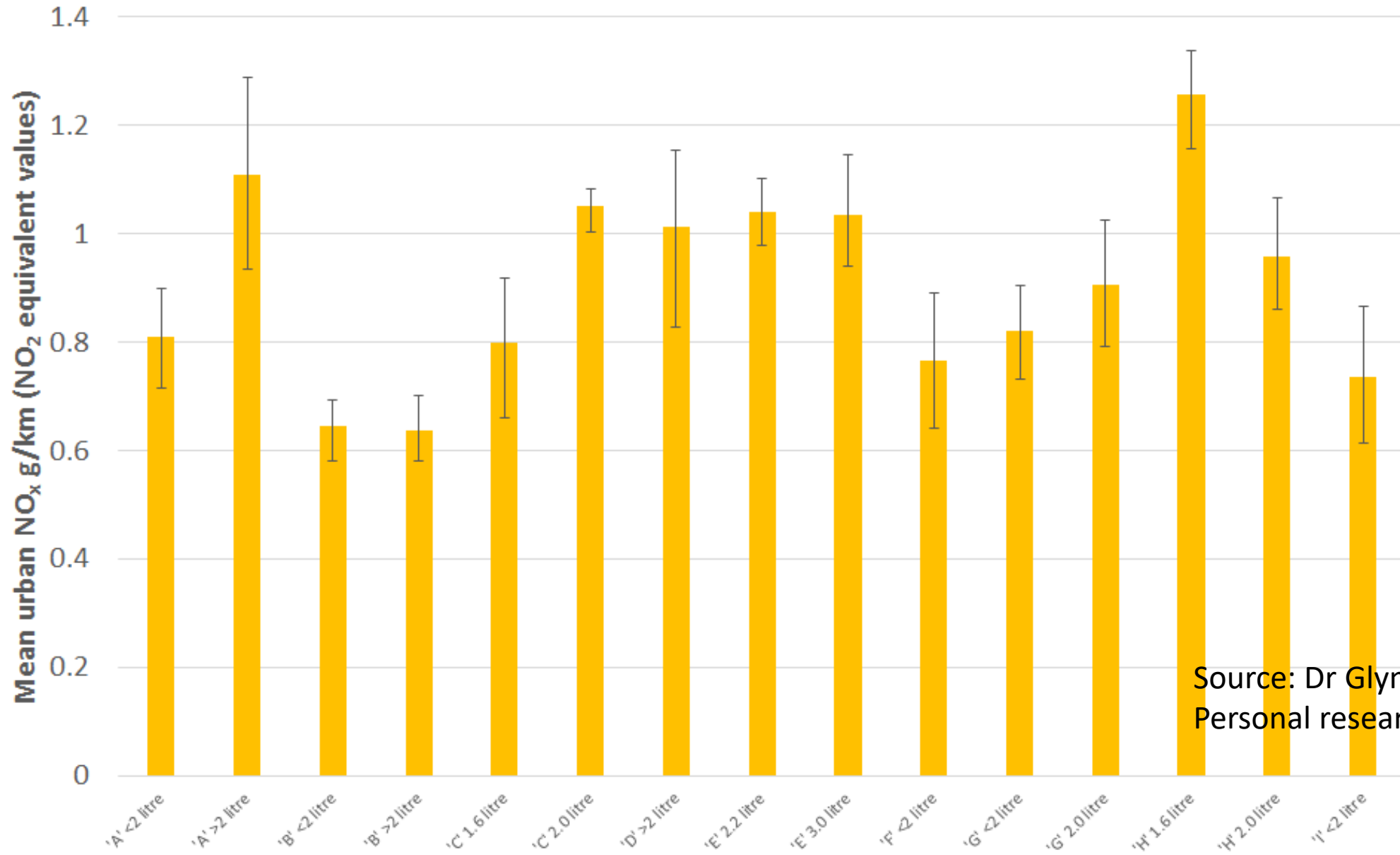
Source: Dr Glyn Rhys-Tyler –
Personal research 2015

Euro 5 diesel vans observed in 2012 by manufacturer - NO_x emission ratios



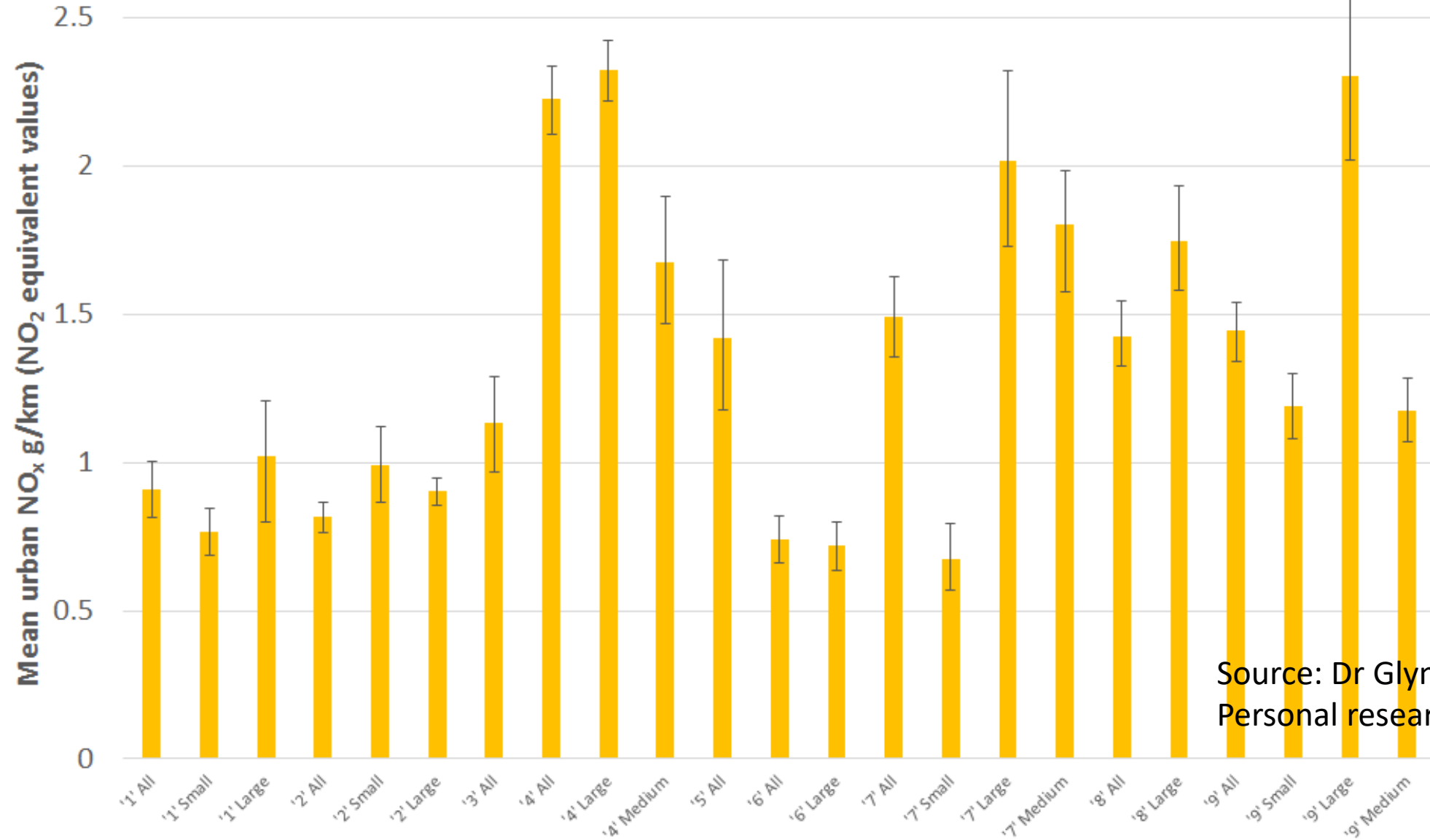
Source: Dr Glyn Rhys-Tyler –
Personal research 2015

Euro 5 diesel cars (M1) by manufacturer - Mean urban NO_x g/km



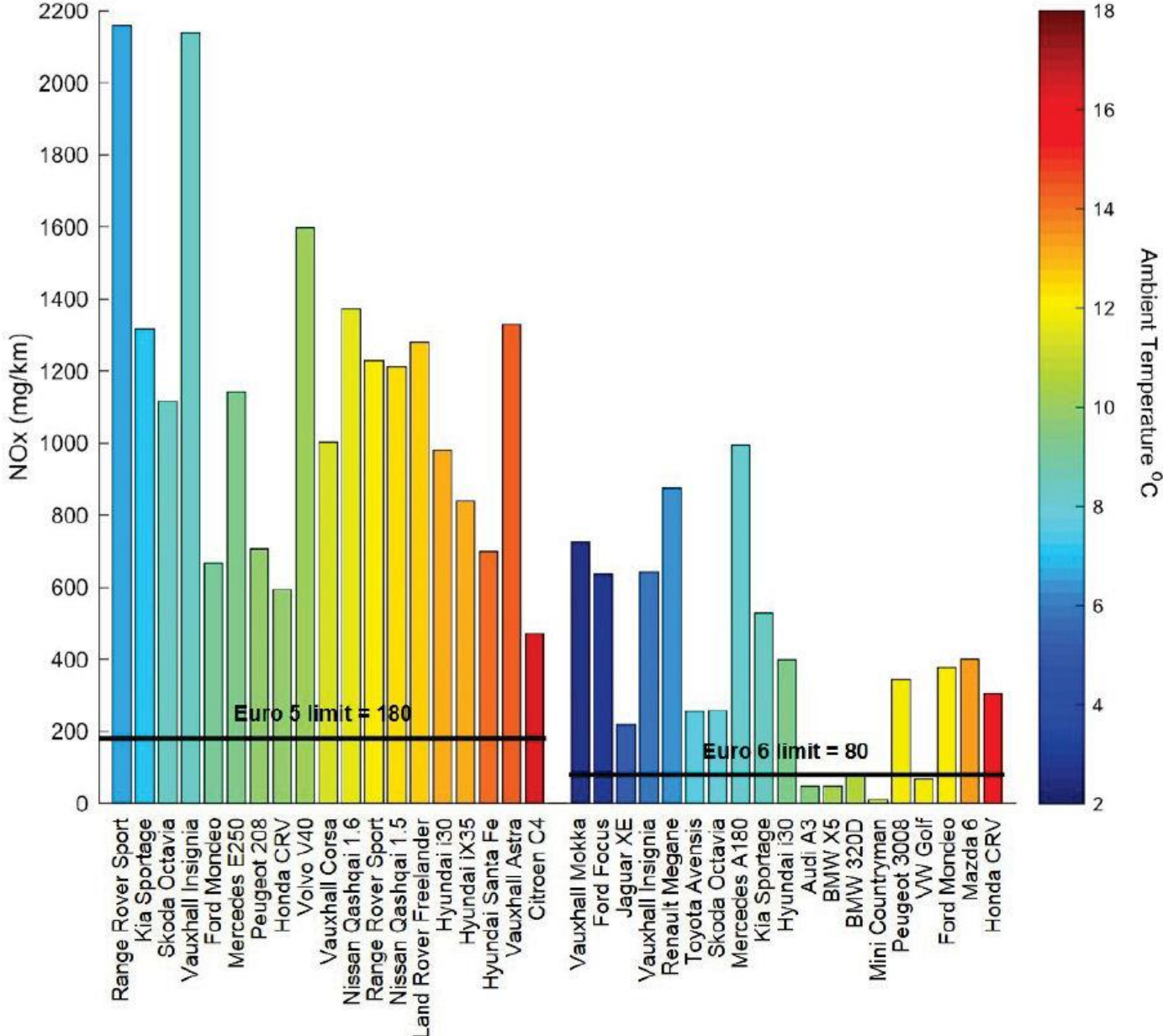
Source: Dr Glyn Rhys-Tyler –
Personal research 2015

Euro 5 diesel vans (N1) by manufacturer - Mean urban NO_x g/km



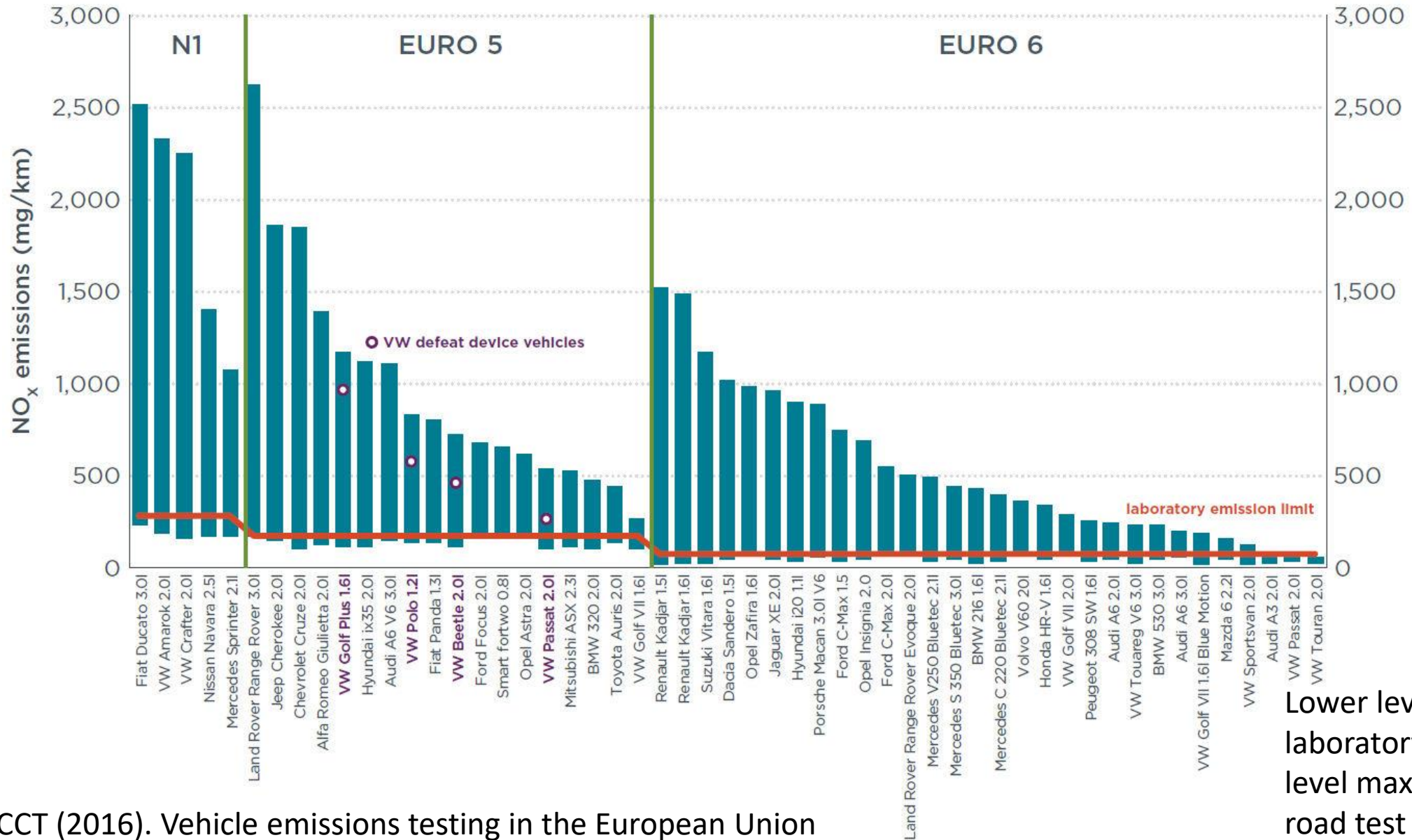
Source: Dr Glyn Rhys-Tyler –
Personal research 2015

DfT Vehicle Emissions Testing Programme 2016



Source: DfT (2016).
 Vehicle Emissions
 Testing Programme
 (Cm 9259). April 2016.

German Ministry for Transport tests (ICCT 2016)



Source: ICCT (2016). Vehicle emissions testing in the European Union

Lower level NEDC laboratory test; upper level maximum on-road test result)

Some observations:

- Euro 5 vans and Euro 6 cars in the 2014-2016 period exhibit on road emission levels twice as high as used in current models (COPERT, VERSIT+, HBEFA).
- Measured levels vary a lot for Euro 6 vehicles.
- Ongoing monitoring of emissions from vehicles under real-world conditions is desirable, following an agreed testing protocol.
- Uncertainty due to sensitivity of emissions control systems to ambient temperature.
- Limited information on how aged emission control systems of both gasoline and diesel vehicles perform.
- More information required on non-regulated pollutants, e.g. ammonia (NH₃), nitrous oxide (N₂O).

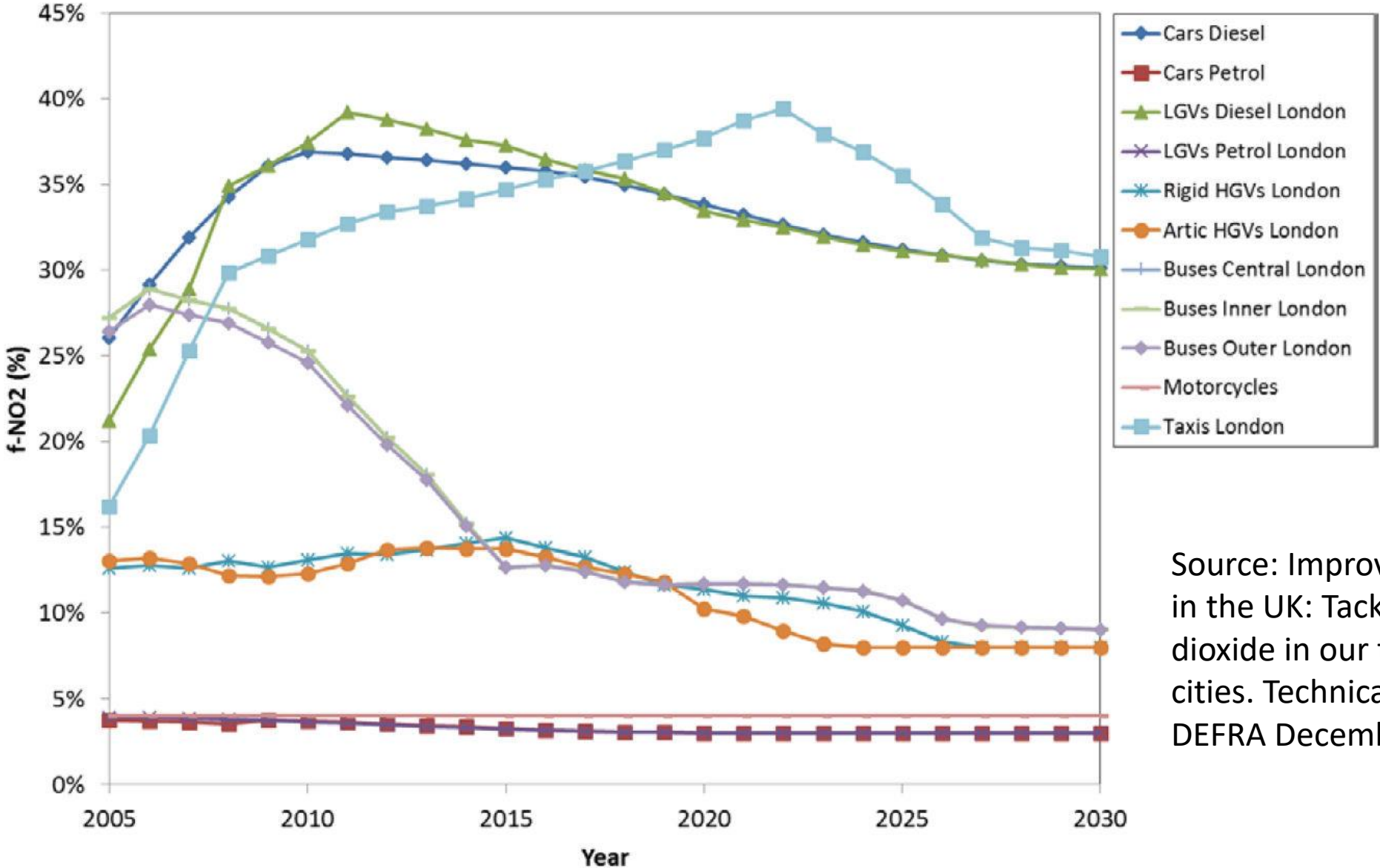
R. O'Driscoll et al. / Atmospheric Environment 145 (2016) 81-91

Some observations:

- PEMS study of 39 Euro 6 diesel vehicles.
- 2 vehicles achieved a trip average within the Euro 6 limit (80 mg NO_x/km).
- 11 vehicles within the RDE Euro 6 not-to-exceed limit (168 mg NO_x/km).
- Large variation observed between vehicles with emissions as much as 22 times the limit.
- Large variability observed in the urban performance of Euro 6 vehicles with emissions between 0.7 and 27 times the type approval limit, with an average of 5.4.
- Large variability observed in primary NO₂ emissions within each after treatment group (e.g. the highest SCR NO₂ emission was 20 times the lowest).

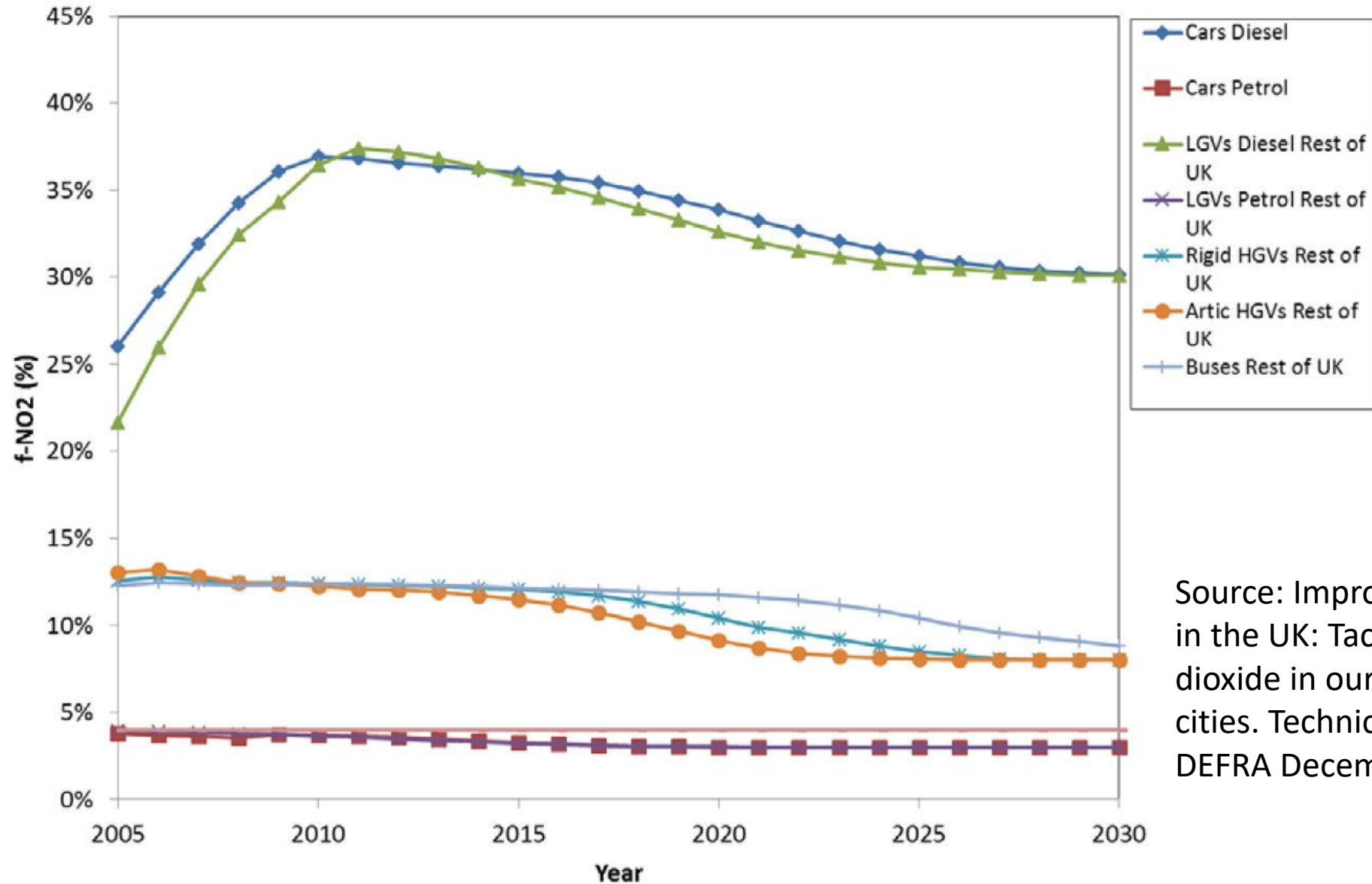
“A Portable Emissions Measurement System (PEMS) study of NO_x and primary NO₂ emissions from Euro 6 diesel passenger cars and comparison with COPERT emission factors.” © 2016 Elsevier Ltd.

DEFRA fleet average f-NO₂ projections by vehicle type - London



Source: Improving air quality in the UK: Tackling nitrogen dioxide in our towns and cities. Technical report. DEFRA December 2015

DEFRA fleet average f-NO₂ projections by vehicle type – Rest of UK



Source: Improving air quality in the UK: Tackling nitrogen dioxide in our towns and cities. Technical report. DEFRA December 2015

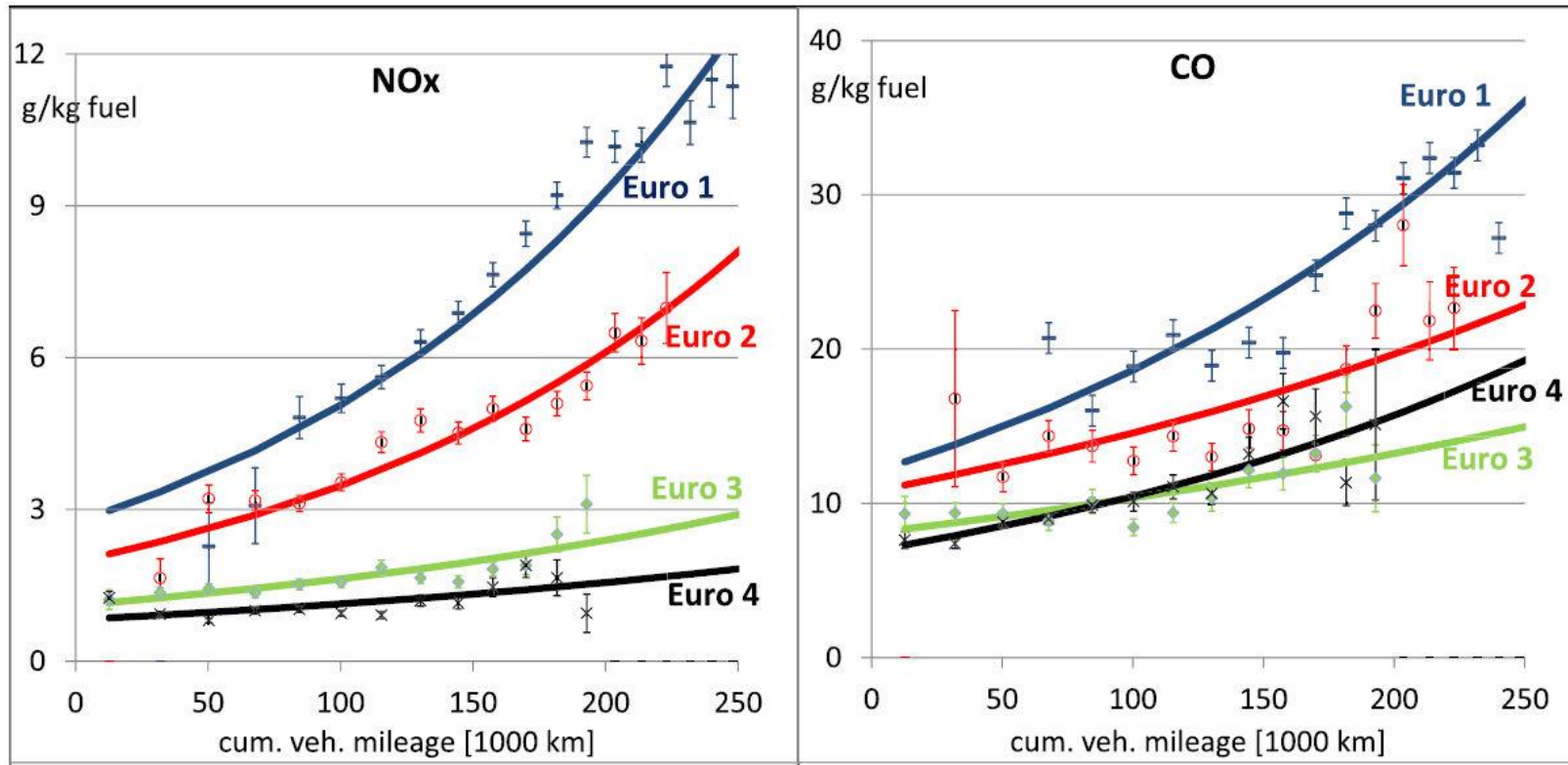
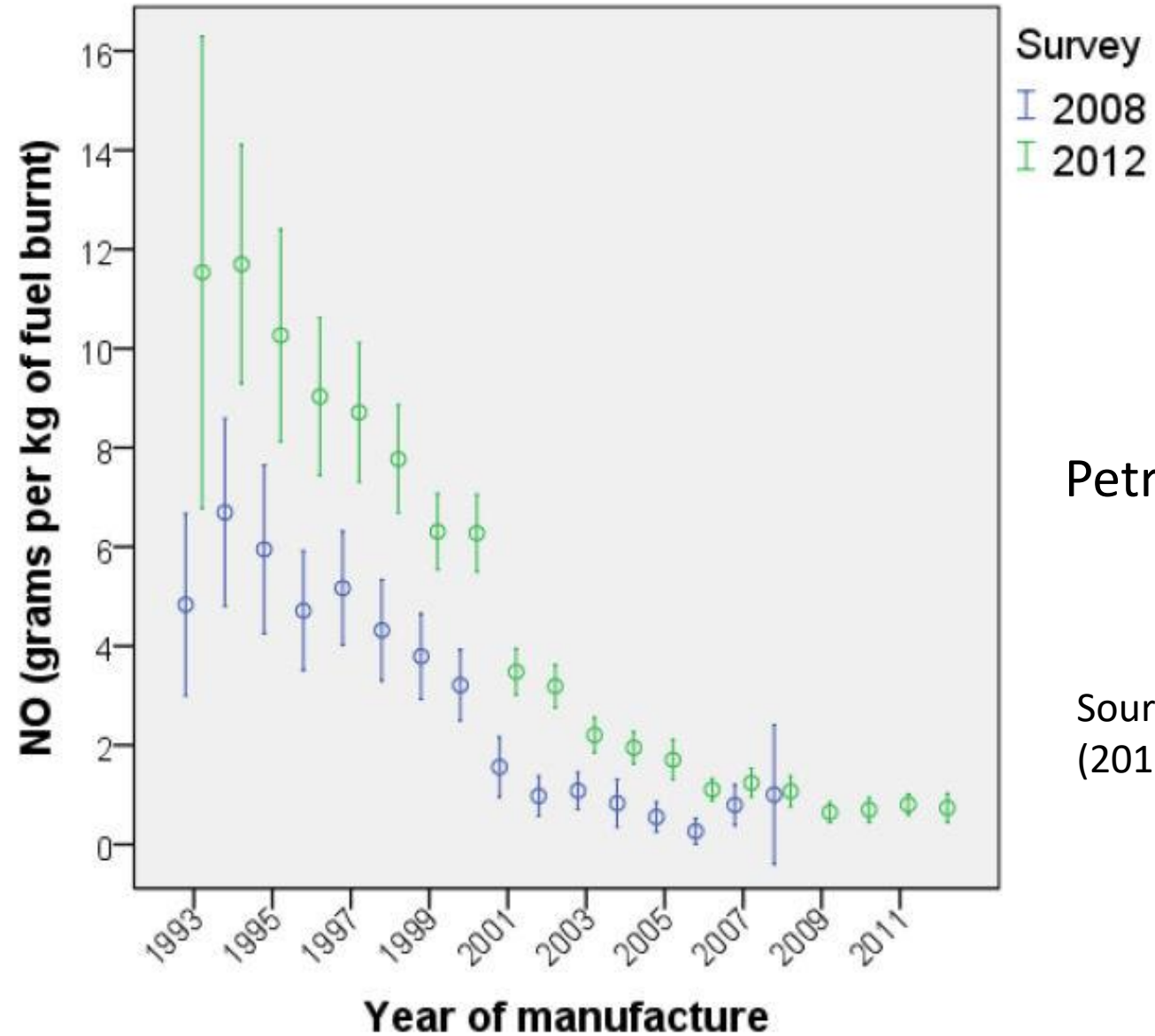


Fig. 2. Deterioration of unit emissions of gasoline passenger cars with vehicle mileage for Euro 1 to Euro 4 technologies. Each dot represents the mean value over at least 100 individual measurements; the whiskers represent the 95th confidence interval for the mean.

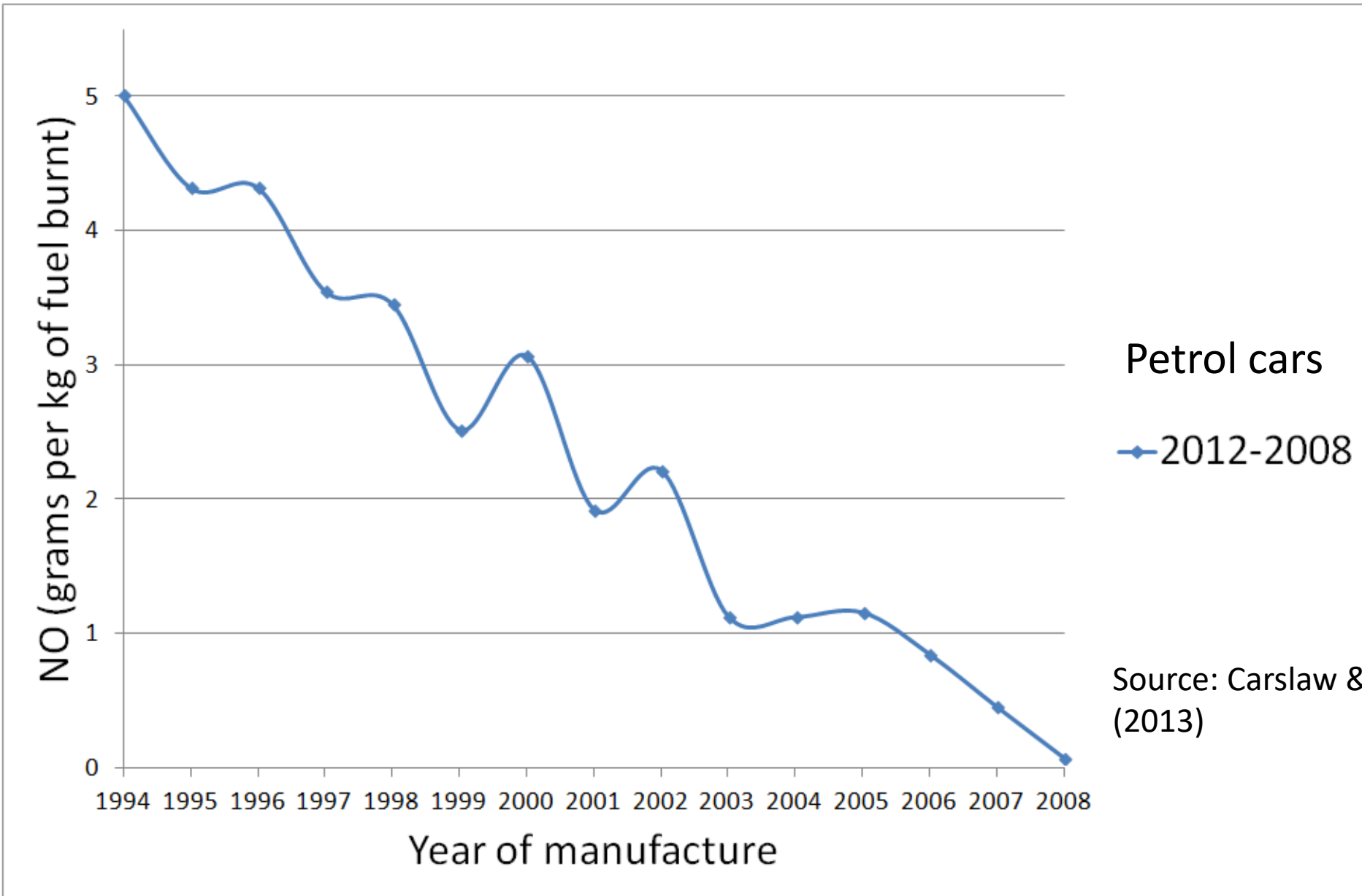
Inter-survey comparisons – 2012 vs 2008



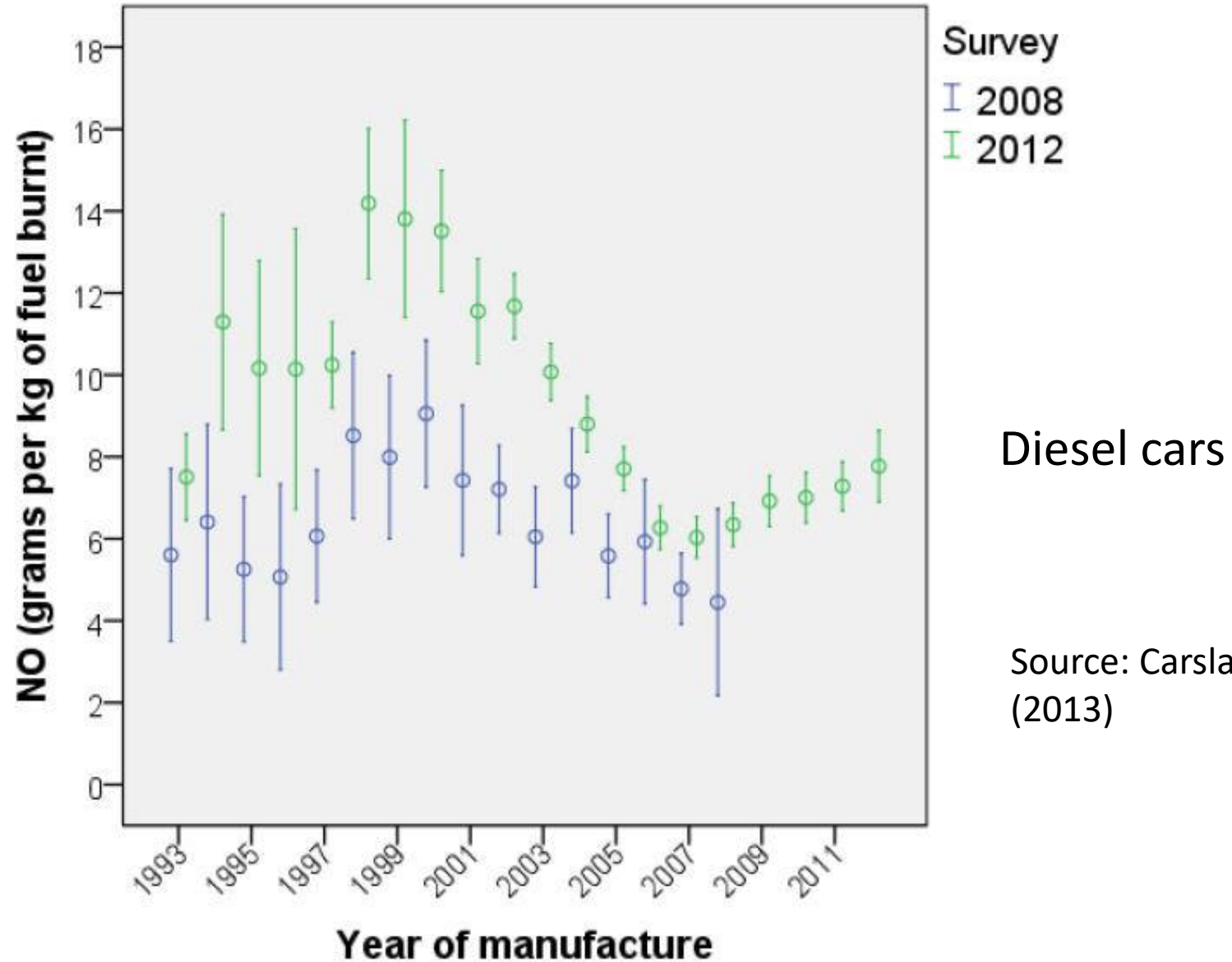
Petrol cars

Source: Carslaw & Rhys-Tyler (2013)

Inter-survey comparisons – 2012 vs 2008



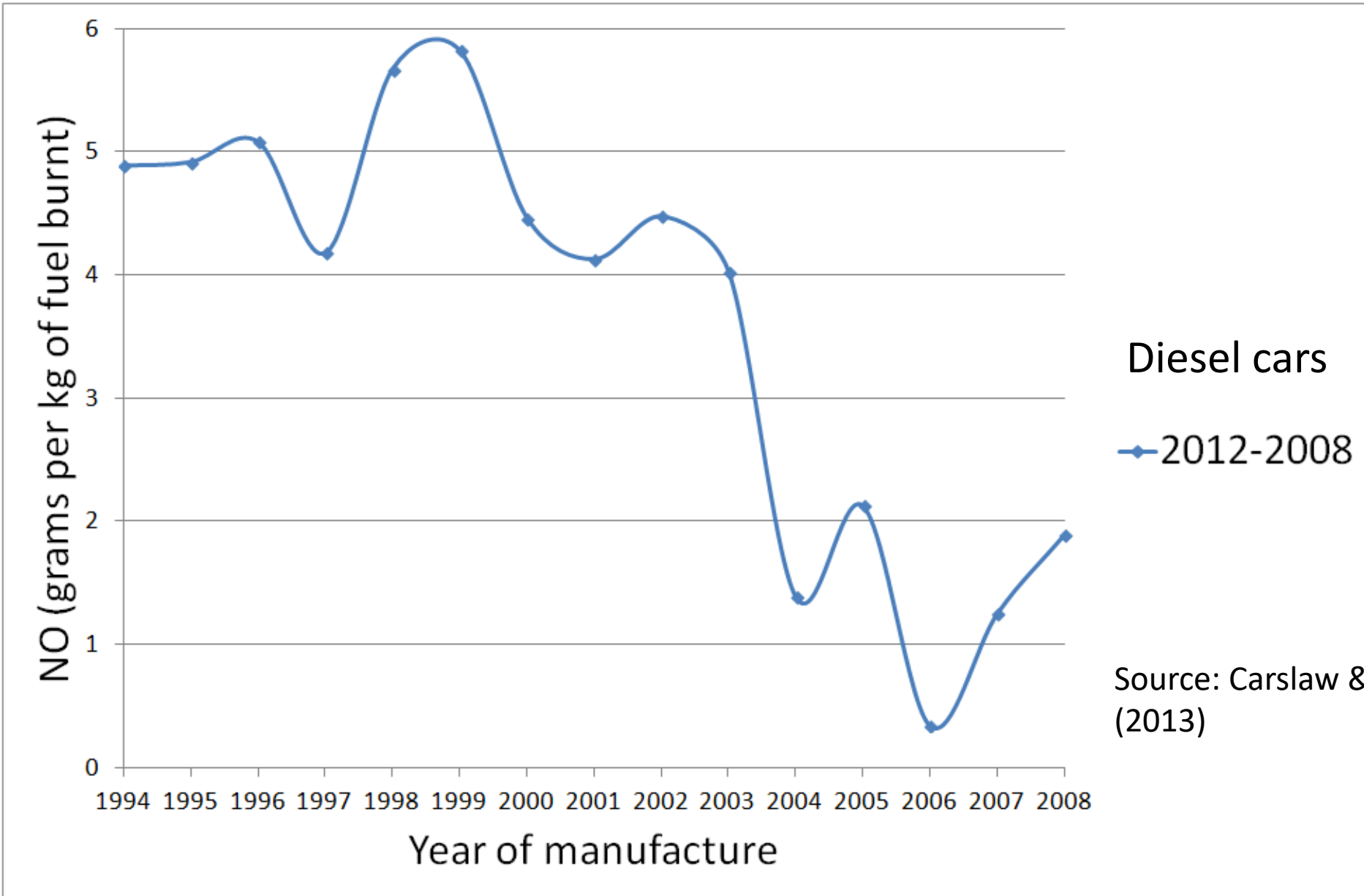
Inter-survey comparisons – 2012 vs 2008



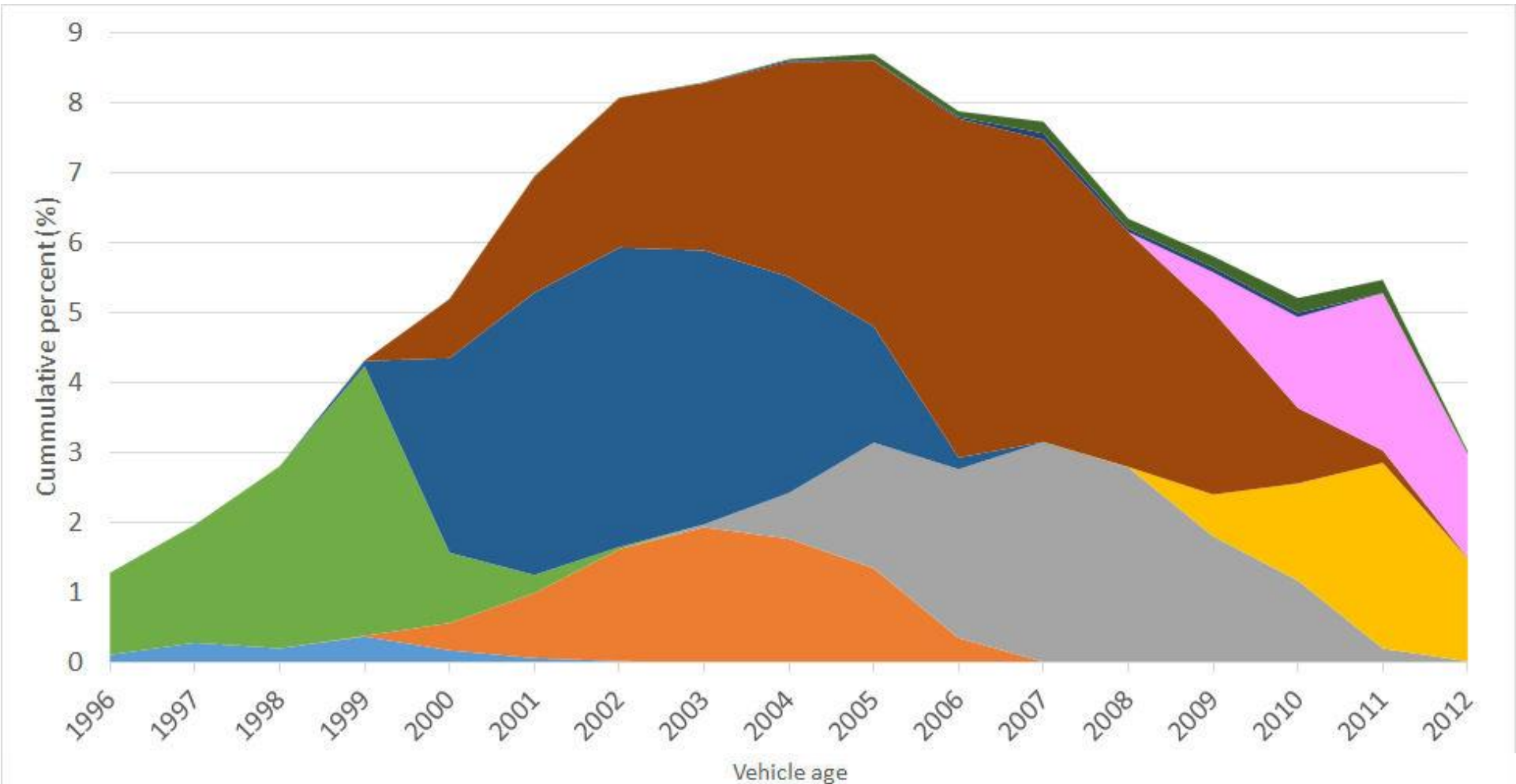
Diesel cars

Source: Carslaw & Rhys-Tyler (2013)

Inter-survey comparisons – 2012 vs 2008



Ealing passenger car fleet mix at 2012



- Diesel Euro 2
- Diesel Euro 3
- Diesel Euro 4
- Diesel Euro 5
- Diesel Euro 6
- Petrol Euro 2
- Petrol Euro 3
- Petrol Euro 4
- Petrol Euro 5
- Petrol Euro 6
- Hybrid Euro 4
- Hybrid Euro 5
- Hybrid Euro 6

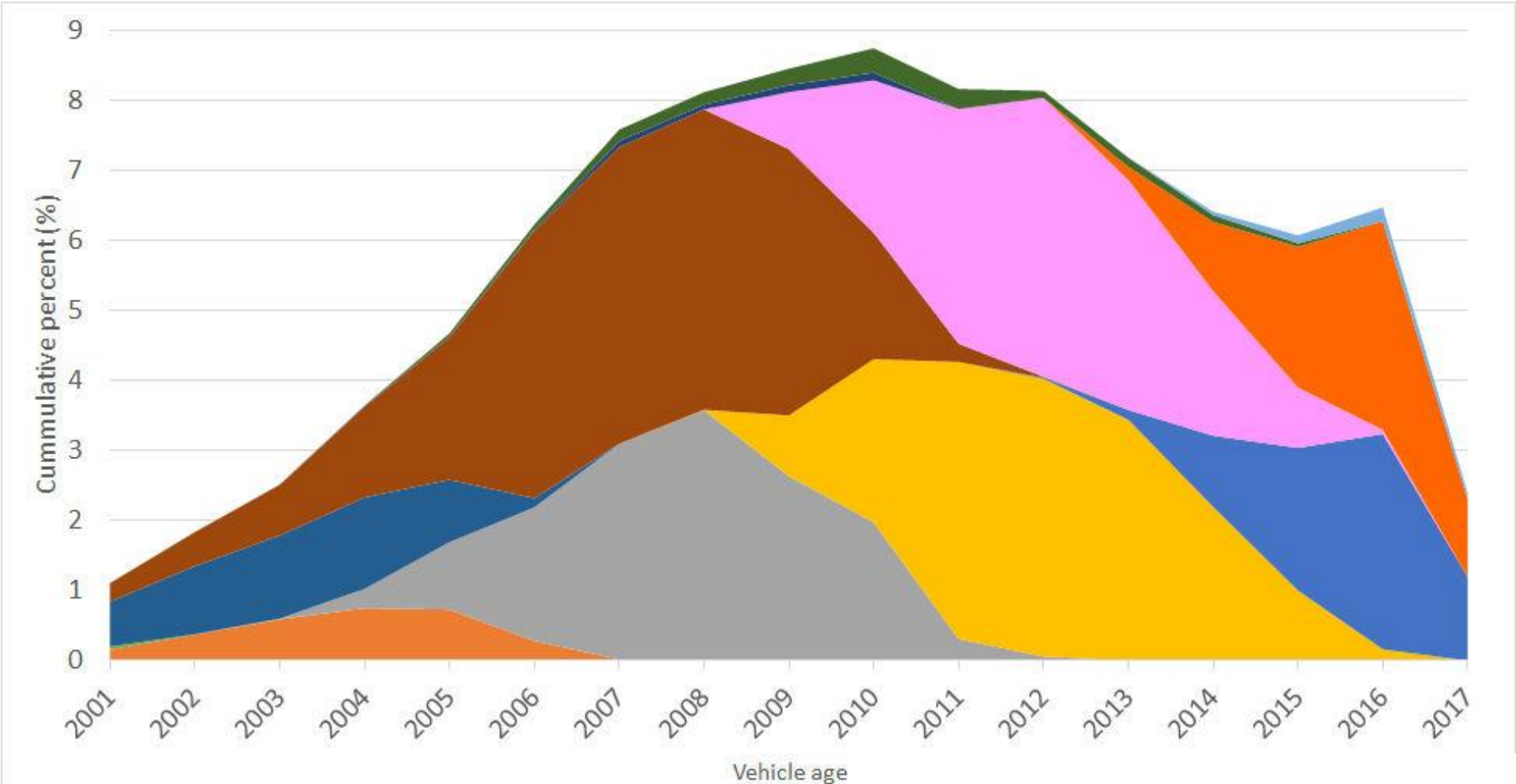
Source: Rhys-Tyler G. (2014)

Future year fleet mix assumptions

Need to be defined

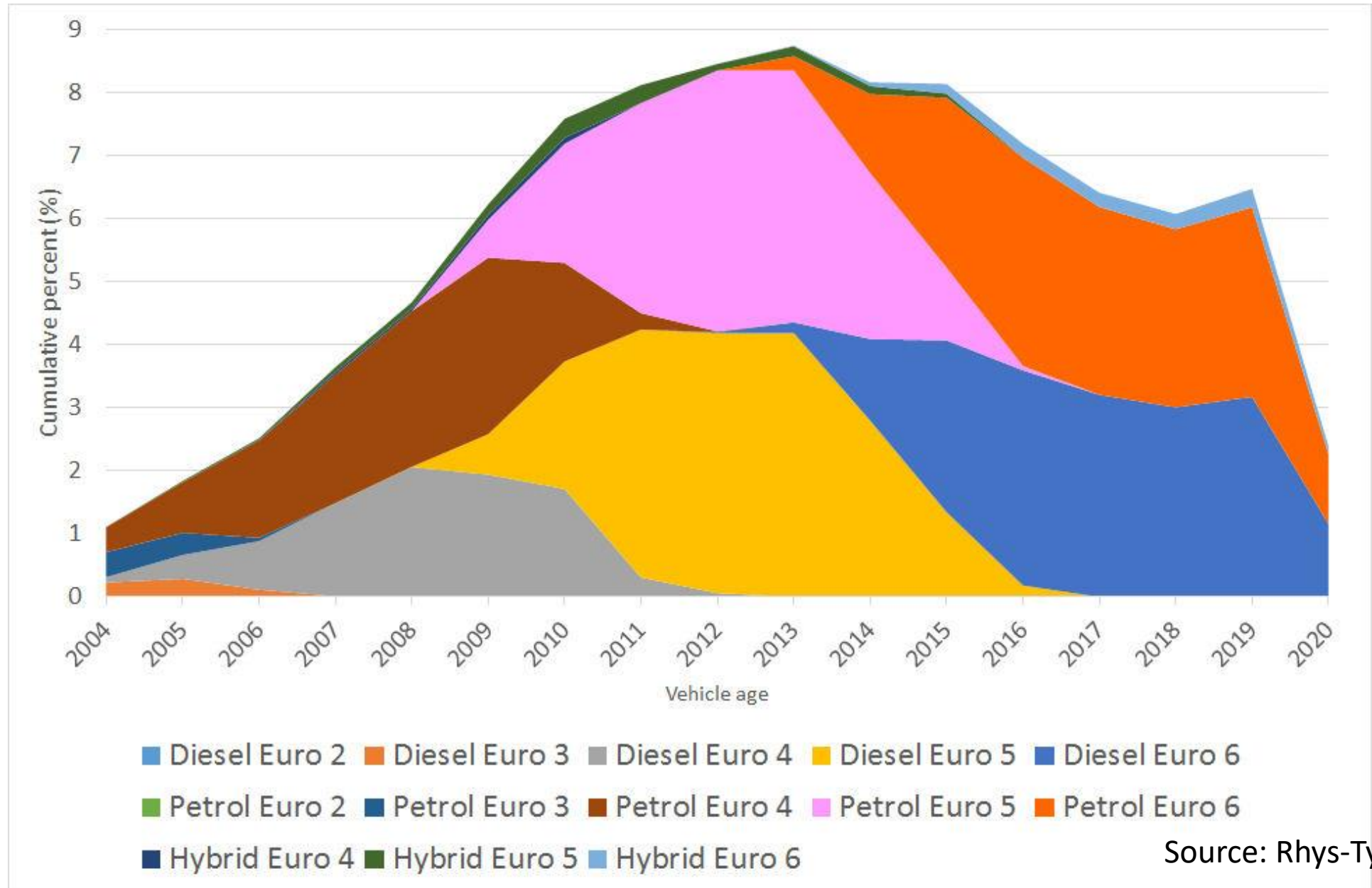
- Age profile
- Market share by fuel type
- Market share by engine capacity
- Market share by Euro emissions standard

Ealing passenger car fleet mix at 2017 – The Legacy Challenge



Source: Rhys-Tyler G. (2014)

Ealing passenger car fleet mix at 2020 – The Legacy Challenge



Source: Rhys-Tyler G. (2014)

Some issues

- The ongoing primary NO₂ (f-NO₂) problem. *Still ongoing....*
- Observed variability in exhaust emissions performance across vehicle manufacturers. *A challenge and an opportunity....*
- Exhaust emissions from vans (N1) up to 3.5 tonnes. *Deserves more attention....*
- Age / mileage / maintenance related deterioration in performance of emissions control technologies. *Significant uncertainty....*
- The legacy challenge. *Perhaps the biggest challenge....*

References

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