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Idling Action Research - Review of Emissions Data

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This report has been amended and issued as follows:

Version	Date	Description	Editor	Technical Reviewer
1.0	25/11/2020	Completion of Draft	OC / TB	CH
2.0	10/12/2020	Amendments following Client feedback	OC / TB	CH
3.0	17/12/2020	Tables 1 & 2 amended, RDE explained	TB	OC

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1 Introduction

TRL have been commissioned by City of London to undertake research into the vehicle emissions emitted whilst idling.

Across all 32 London Boroughs, campaigns have been launched to raise public awareness of the impact of idling on environmental air quality and human health. These campaigns use a combination of education, training and enforcement. Historically, the key strapline that has been used in campaigns UK-wide is that *an idling car can fill up to 150 balloons with harmful exhaust emissions every minute*. However, the reliability and applicability of this statement to the vehicles in London today has recently been called into question.

This project aims to provide an updated, evidence-based conclusion to support the upcoming anti-idling campaign planned for launch in February 2021.

Through analysis of real-world data, TRL have quantified the emissions and associated costs from idling events, taking into account NO_2, NOx, NO and CO_2 emissions from petrol and diesel cars and vans. TRL have then compared the outputs to tangible constructs so the impact of idling can be easily understood by a wide audience.

2 Research Requirements

At the project inception meeting that took place on the 19th October 2020, the following research requirements were agreed upon:

- To quantify the emissions from a typical roadside idling event for a given time period for a variety of vehicles – small cars, family estate cars and vans.
- Provide a creative, appreciable comparison to the data with multiple strapline options.
- TRL will aim to use real-world rather than laboratory testing data where possible.

3 Background to Data and Analysis Methodology

Existing data available from the Department for Transport's PEMS (Portable Emissions Measuring System) database was analysed. This data was collected from laboratory tests, track tests and real driving (RDE test – Real Driving Emissions), on normal roads under standard traffic conditions. This included:

- DfT's vehicle emissions testing programme, which was performed in 2016 as an investigation into whether vehicle manufacturers are manipulating emission tests following the VW scandal. https://www.gov.uk/government/publications/vehicle-emissions-testing-programme-conclusions
- DfT & DVSA's Vehicle Market Surveillance Unit programme results, 2018, a test programme carried out to check that new products on the UK market meet legal obligations. https://www.gov.uk/government/publications/vehicle-market-surveillance-unit-programme-results-2018

Categorising the data by vehicle type - small car, family / estate car, 4X4 / SUV car, light goods vehicle (LGV) and heavy goods vehicle (HGV) - and fuel source (petrol or diesel), TRL identified sections of the trip where the vehicle speed was less than 0.2 km per hour for 5 or more seconds. During these stops, the average exhaust flow rate and exhaust composition were calculated.

A total of 55 vehicles were analysed across the available data sets. This provided 79 data entries.

Where engine speed data was available, emissions were averaged when this was within the 600 – 1000 rpm range. This eliminates both stop-start periods and an initial engine rev prior to moving off. Where engine speed data was unavailable, vehicles with a particularly low average of CO_2 (less than 100 mg / sec) were excluded. Of those included, a 'trim average' was used where the highest and lowest values are excluded before an average is calculated to avoid any stopping and pulling away events.

In addition, based on the standard carbon balance equation (carbon intake equals carbon output) stated in various type approval regulations (e.g. UN Regulation R101), fuel consumption was determined.

The age of each specific vehicle is not available from the analysed date. However, for 29 vehicles the Euro standard is available (detailed in Appendix 1). From this, it can be inferred whether the vehicle is less than 6 years old (Euro 6), or 5 to 10 years old (Euro 5).

4 Results and Output Conversion

The following section summarises the results of the data analysis undertaken.

Throughout all figures and tables, in the cases that n/a is displayed, the data was unavailable. Petrol data has been more difficult to source as in previous studies a larger interest was placed on the operation of diesel vehicles under real driving conditions. There are currently no modern petrol HGVs and very few petrol LGVs (although some are starting to appear on the market now).

4.1 Emissions Data Results and Comparison

Figure 1 and Figure 2 present averages of vehicular emissions CO_2 and NOx across all track and RDE testing data. Diesel HGVs emit the largest amount of pollutants per minute of idling, followed by 4X4 / SUV type cars. All the analysed diesel vehicles emit over 10 g of CO_2 per minute and the average NOx emitted from all vehicle types is less than 0.1 g per minute.

Figure 1 shows the average of CO_2 emitted, by fuel and vehicle type, whilst idling for one minute.

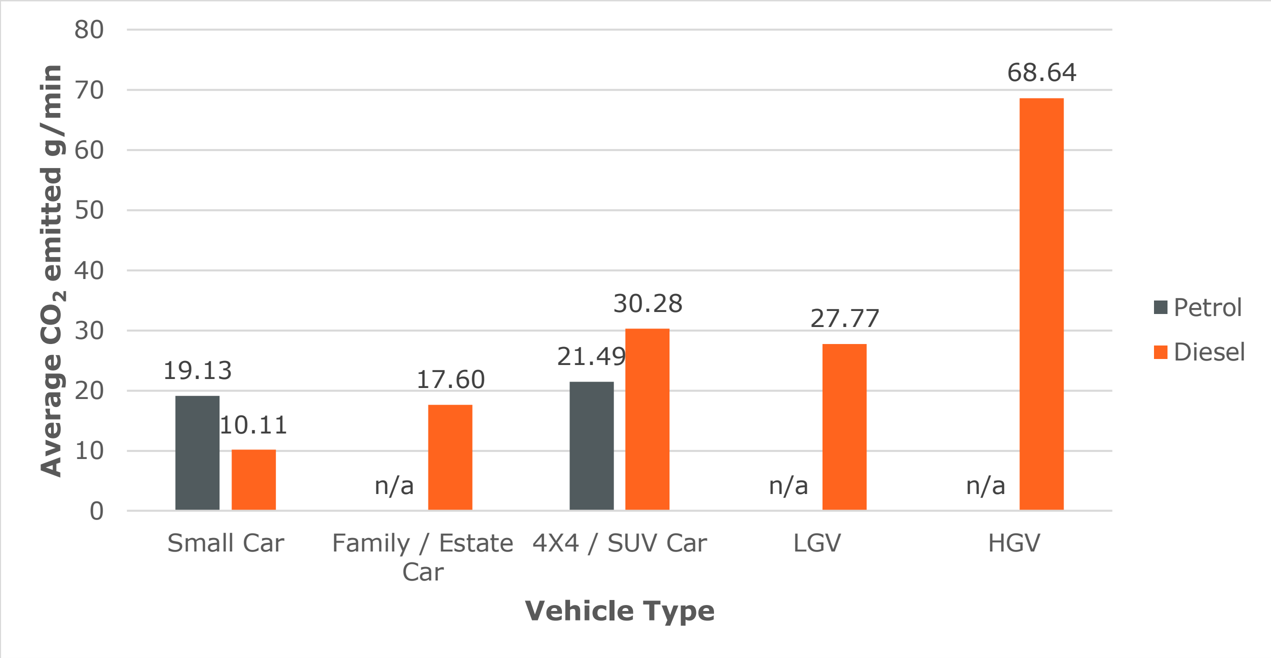
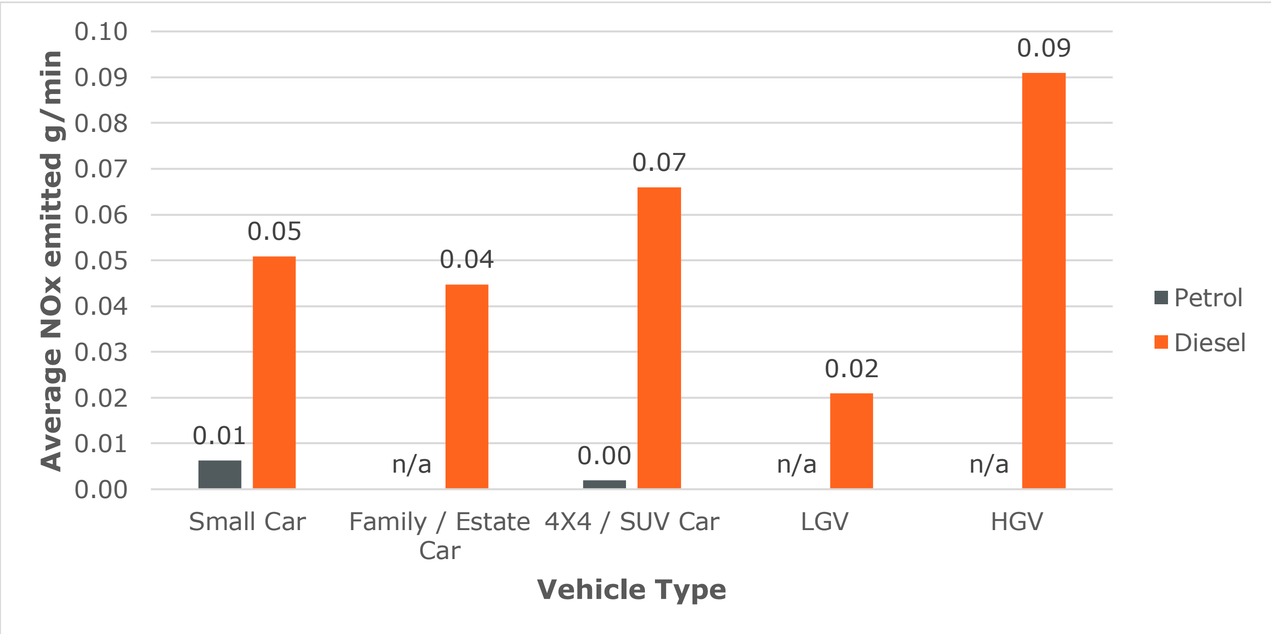


Figure 2 shows the average of NOx emitted, by fuel and vehicle type, whilst idling for one minute.



The vehicles that will be used in marketing for the upcoming campaign, as specified in the project inception meeting are:

- 2013 Škoda Citigo 1.0 Petrol
- 2010 Volkswagen Passat Bluemotion 1.6 Diesel
- 2020 Vauxhall Combo 1.5 Diesel

The average values of vehicular emissions for these cars are presented in Table 1 together with the total exhaust flow rates. This includes track, RDE and laboratory testing in order to increase the sample size and improve the reliability of the average. It is evident that all vehicle types emit only minute amounts of NOx, despite the fuel type. Petrol produces less NOx than diesel due to the lower operational temperature and pressure of the engine. However, as the diesel vehicle is under very little load at idle, the NOx emissions are likely to also be small. LGVs produce the largest amount of CO_2, 27.7g when idling for just one minute which is considerably higher than small and family / estate cars. These vehicle types produce approximately 17g of CO_2 per minute.

Table 1 presents the average emissions from equivalent vehicles to those specified for the campaign, over a one-minute idling period.

Car Make	Vehicle Type	CO_2 g/min	CO_2 litres/min	NOx g/min	NOx litres/min	Exh Flow litres/min
Škoda	Small Car	17.35	9.42	0.000	0.000	80.6
Volkswagen	Family / Estate Car	16.61	9.02	0.045	0.030	422.4
Vauxhall	LGV	27.77	15.08	0.021	0.014	421.6

The Society of Motor Manufacturers & Traders confirms the most common cars on UK roads are the Ford Fiesta, Ford Focus and Vauxhall Corsa which all fall into the small car category (SMMT, 2020).

According to the (Department for Transport, 2020), the number of licensed cars across all 32 London Boroughs totalled over 2.65 million and for LGV's over 210,000. In one day, if 50% of all cars in London idled at a set of traffic lights for just one minute, nearly 30,000 kg (exact value 29,669 kg) of CO_2 would be released. If in one day, 50% of all LGV's in London idled at a set of traffic lights for just one minute, nearly 3,000 kg (exact value 2,916 kg) of CO_2 would be released.

To give this value greater context, a UK native broadleaf tree is estimated to take up 1,000 kg of CO_2 during its full lifetime (approximately 100 years) (Imperial College, 2015). It would take 66 trees, 100 years to absorb the CO_2 released if each vehicle in London idled for just one minute.

Alternatively, for the following example – a single family / estate car idling for five minutes outside the school gates. If this car was a diesel vehicle, up to 52 litres (exact value 51.93 litres) of CO_2 may be released. For a petrol vehicle, the volume of CO_2 can exceed 27 litres (exact value 27.45 litres).

The average volume of air a child breathes in one minute is 5-6 litres (GOSH, 2012). If they are stood at the school gates for the same time period as the vehicle is idling, the child could inhale a considerable volume of this emitted CO_2.

4.1.1 Total Exhaust Emissions

In addition to analysis of the volume of specific pollutants released, available data for total exhaust emissions was collated. This was from several tests performed both on track and on public roads over a real driving emissions (RDE) test[1]. Raw data results are typically given as distance-based values (i.e. g/km, mg/km etc). The data values presented in Table 2 are time-based. This is to enable comparison to idling emissions.

Idling emissions form only a small amount of the overall exhaust emissions from a given vehicle. Events involving acceleration (when there is a higher load on the engine) are responsible for a large proportion of the total emissions.

Table 2 presents typical emission rates over an entire trip.

Vehicle type	CO_2 (g/min)		NOx (g/min)		Exhaust flow (l/min)	
	Petrol	Diesel	Petrol	Diesel	Petrol	Diesel
Small Car	119.31	129.73	0.031	0.497	421	1,248
Family/Estate Car	131.41	122.84	0.040	0.632	n/a	1,167
4X4 SUV	122.44	149.44	0.031	0.751	504	1,388
LGV	n/a	160.46	n/a	0.476	n/a	1,451

4.1.2 Effect on Air Quality

The exhaust emissions from both idling and driving will affect air quality in the local area. Normally, air quality is modelled using the passing traffic's emission rate in g/km/h however, idling emissions are a stationary source. The concentration will be dependent on airflow, number of vehicles and the volume of the sensitive area. A fictional scenario is presented below:

Idling NOx emissions rate = 0.05 g/min

NOx emission in 1 minute = 0.05 g

= 50,000 µg

Location (assuming several cars are stopped at both sides of a road within a street canyon and considering a box around each vehicle):

Width (assumed: half a typical street canyon) = 8 m

[1] RDE test is now part of the type approval procedure and is carried out on normal public roads. The test follows a route taking 90-120 minutes with almost equal amounts of urban, rural and motorway driving.

Height (typical eaves height of a 2-storey building) = 6 m

Length (1.5 times length of a typical car) = 6.75 m

Total Volume = 324 m^3

Concentration after 1 minute (assuming even distribution) = 154 $\mu g/m^3$

As this is a NOx concentration, the NO_2 fraction of 28.6% (taken from Defra's NOx to NO_2 calculator (DEFRA, 2020)) can be used. This provides a NO_2 concentration of 44.1 $\mu g/m^3$. The approach taken is simplistic, ignoring air flows, atmospheric chemistry and emissions from passing vehicles. It looks solely at a small localised 'box' and assumes homogenous mixing within this.

The UK National Air Quality objective states that NO_2 should not exceed 200 $\mu g/m^3$ (hourly mean, no more than 18 times in one calendar year) or the annual NO_2 mean should not exceed 40 $\mu g/m^3$. A concentration of 44.1 $\mu g/m^3$ measured in one minute could potentially build up to levels close to, or over these objectives.

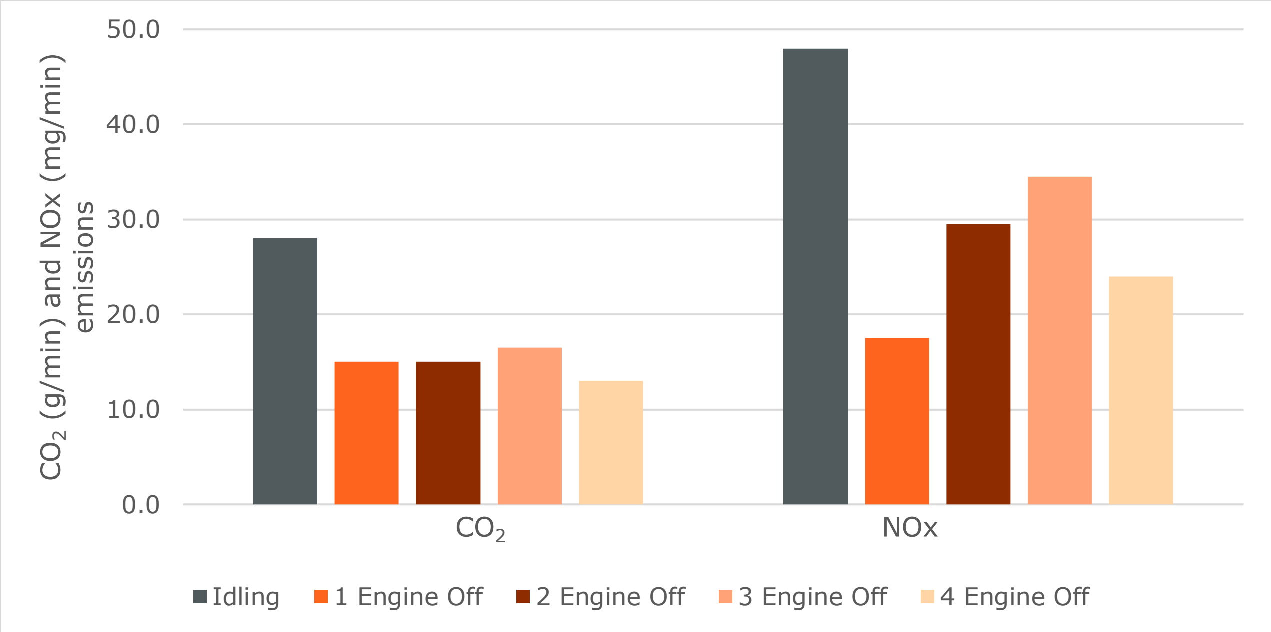
4.1.3 Engine Off Compared to Idling

There may be a greater output of emissions when restarting an engine than idling, likely due to the additional load on the engine to recharge the battery. To determine this, ideally data from the same vehicle, over the same test cycle, repeated under two conditions is required – when idling and with the engine switched off at stops.

Whilst the dataset available to TRL does not meet this requirement, some of the vehicles had auto stop-start systems. The engine of one vehicle continued running during the earlier stops in the test cycle but switched off at those later on.

This data has been extracted and reconstructed to give approximately 30 second stops, together with the initial acceleration following the stop (note: only the first few seconds after the stop have been included so that the speed traces are similar). The idling emissions shown in Figure 3 demonstrate that the first stop (with the engine running) has higher outputs of CO_2 and NOx. Although the engine should be warmed up prior to starting the test, there might have been a small amount of additional heating required to reach the temperature required before the stop-start system worked.

Figure 3 CO_2 and NOx emissions during various stops and following initial accelerations.



4.2 Fuel Consumption Data Results and Comparison

Figure 4 shows the average fuel consumption, by fuel and vehicle type, whilst idling for one minute.

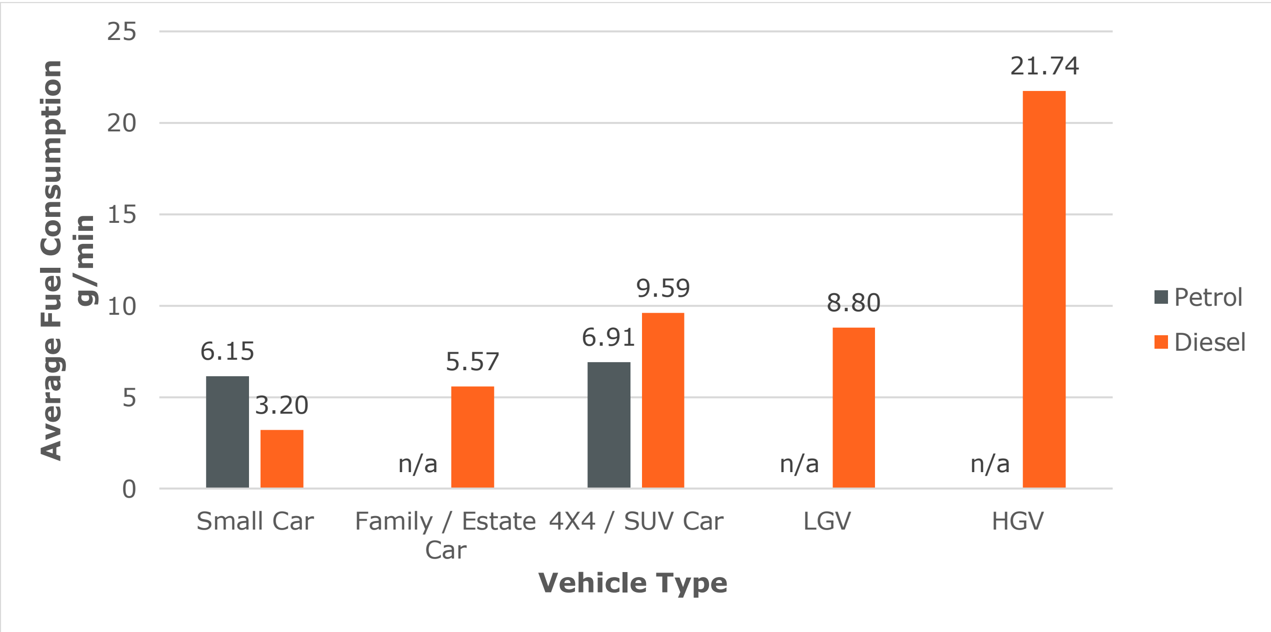


Figure 4 presents the average fuel consumption by vehicle type. Diesel fuel consumption increases as vehicle size increases, up to 21.7 g of diesel used by HGVs whilst idling for one minute.

The annual average price of petrol and diesel are 112.35 pence per litre and 117.07 pence per litre respectively, at the time of writing (Department for Business, Energy and Industrial

Strategy, 2020). Using fuel consumption and these values, the cost to the driver associated with each idling event could be determined. The costs presented in Table 3 are minute when only idling for one minute, but also presented are the costs by vehicle type for if the vehicle idles for 10 minutes each day of the academic year (190 days). All vehicles types are likely to be present around school areas e.g. cars of parents picking up or dropping off children, school buses idling at stops or vans and lorries making deliveries.

Table 3 shows the price per minute of idling by vehicle and fuel type. This is based on the average fuel consumption and annual average fuel prices. Values in 2.d.p.

Vehicle Type	Petrol		Diesel	
	Pence per minute	Cost of 10 mins for 190 days £	Pence per minute	Cost of 10 mins for 190 days £
Small Car	0.94	17.82	0.45	8.56
Family / Estate Car	n/a	n/a	0.78	14.90
4X4 / SUV	1.05	20.02	1.35	25.64
LGV	n/a	n/a	1.24	23.52
HGV	n/a	n/a	3.06	58.12

4.3 Euro 5 / Euro 6 Data Results and Comparison

A question considered at the project inception meeting was the difference between Euro 5 and Euro 6 compliant vehicles at idle. As expected, when engine size was compared with NO / NOx / NO2 emissions, Euro 6 vehicle emissions were consistently lower than those of Euro 5 (see Figure 5). Also discussed were the vehicular emissions of cars depending on their age. Although data was unavailable for the average car age specifically in London, statistics from the SMMT states the average UK car is 8 years old. As Euro 6 only became mandatory on all new cars from September 2015, many cars registered before that time might only be Euro 5. Based on this and vehicle size, an inference of emissions could be made.

Figure 5 shows the emissions of NO, NOx and NO_2 in relation to engine size, between Euro 5 and Euro 6 vehicles.

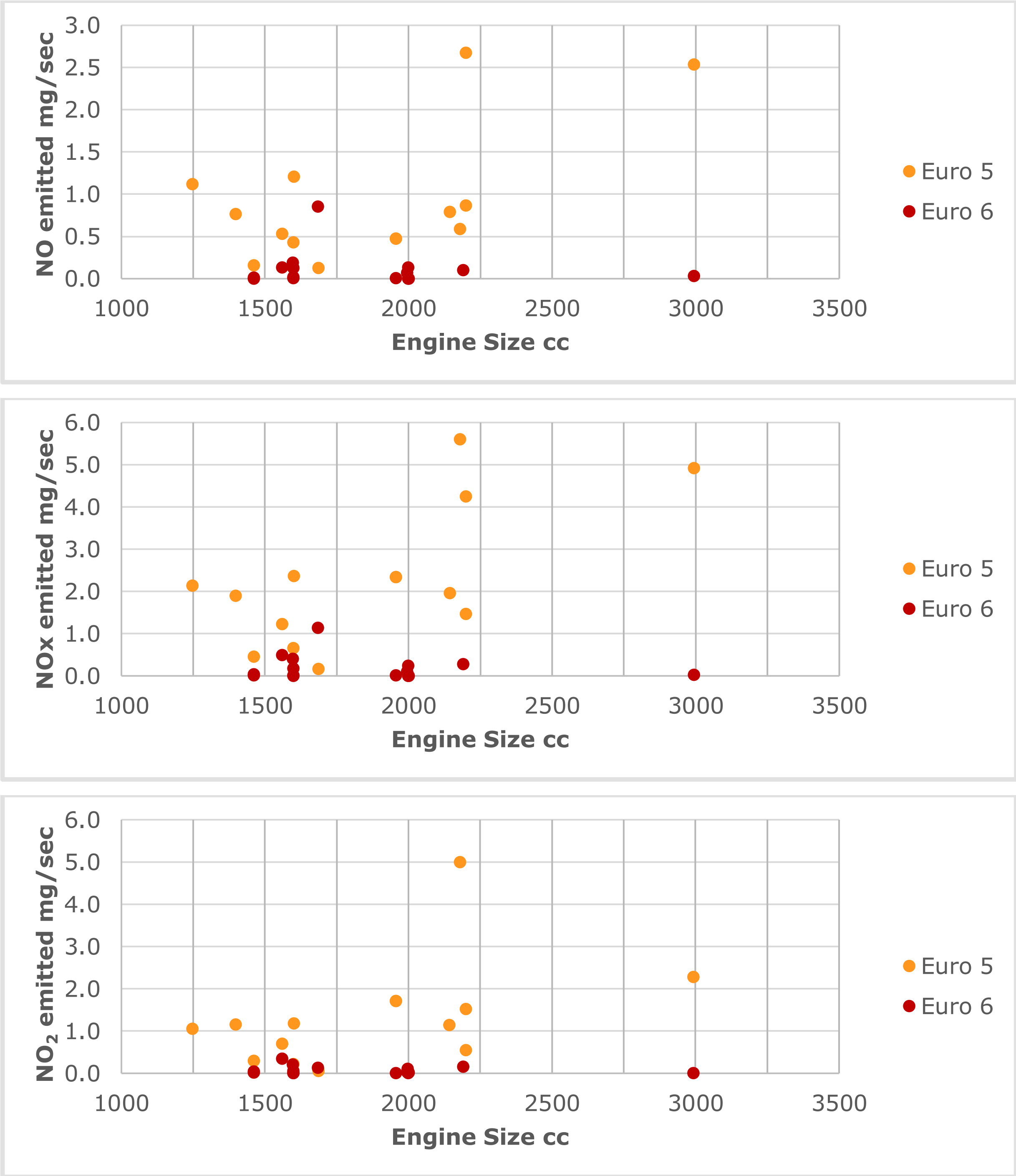
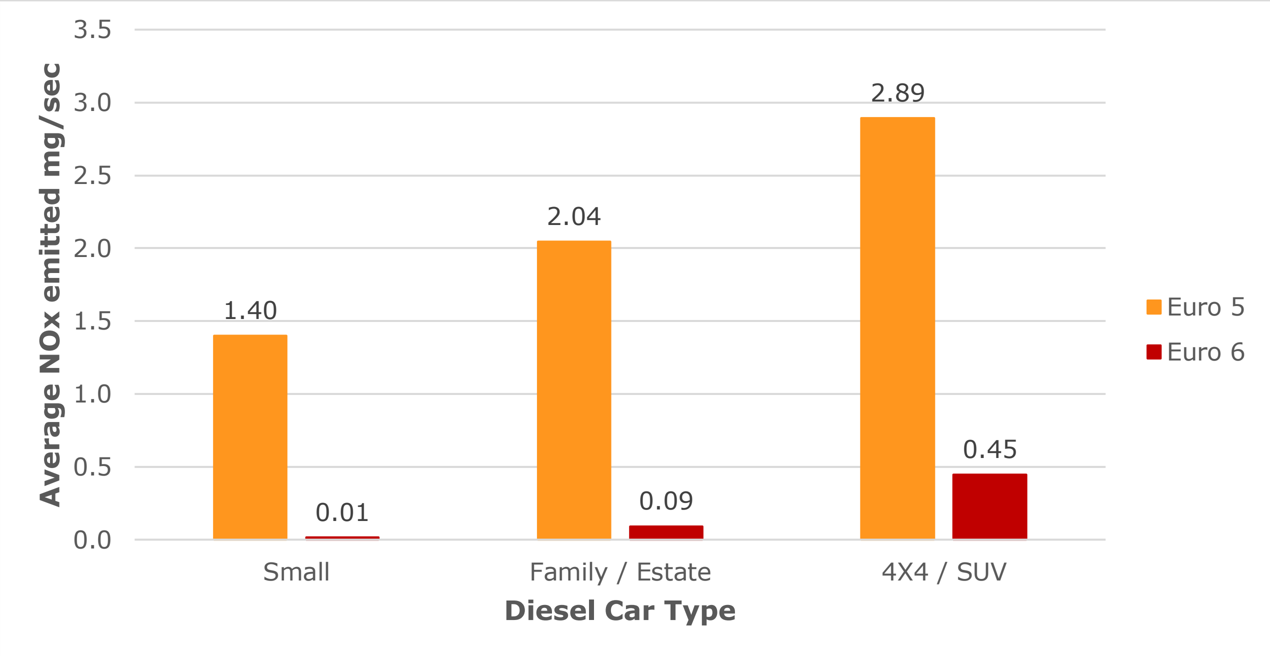


Figure 6 shows the average NOx emissions from diesel Small, Family / Estate and 4X4 / SUV cars that are either Euro 5 or Euro 6 compliant.



The final graph in this section, presented in Figure 6 shows the average NOx emissions by vehicle type, depending on whether the vehicle is Euro 5 or Euro 6 compliant. The highest emitted NOx emissions are produced by a Euro 5 4X4 or SUV at 2.89 mg per sec, or 0.17 g per minute. A Euro 6 compliant small or family / estate vehicle produces only between 0.01 and 0.09 mg of NOx per second, around 0.03 g per minute.

5 Summary

In conclusion, this report aims to summarise the key findings from a methodical analysis of RDE and track testing data for petrol and diesel vehicles.

TRL have quantified the vehicular emissions and fuel consumption associated with idling to provide an updated and evidence-based conclusion that is relevant to vehicles present in London today.

Tangible comparisons have been drawn from the value outputs so that the social, environmental and financial implications of idling can be understood by a wide audience.

6 References

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