Primary NO_2 Emission Factors for Road Vehicles

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Nitrogen oxides (NO_x) are emitted in the form of nitric oxide (NO) and nitrogen dioxide (NO_2). The fraction emitted directly as NO_2 (f-NO_2) is of particular interest for air quality modelling. Road transport is the major source of primary NO_2 emissions especially in urban areas and different vehicle types emit different proportions of NO_x as NO_2. Evidence has shown that diesel vehicles are particularly prone to high f-NO_2 values and especially those vehicles fitted with certain types of catalyst systems for controlling other pollutant emissions such as oxidation catalysts and diesel particulate filters for controlling carbon monoxide, hydrocarbons, and particulate matter. Thus, diesel vehicles meeting more recent Euro standards tend to have higher f-NO_2 values.

Values of f-NO_2 have been developed from recent real-world roadside vehicle emissions remote sensing measurements of NO_2/NO_x ratios compiled by Ricardo Energy and Environment and the University of York[1]. Factors were developed for different vehicle types and Euro standards, with the exception of buses. The f-NO_2 factors for buses were taken from the EMEP/EEA Emissions Inventory Guidebook (2019)[2] and previous roadside remote sensing studies by Carslaw et al (2016)[3]. Analysis of the Ricardo and University of York roadside vehicle remote sensing data suggests that f-NO_2 factors for Euro 3, 4 and 5 diesel cars and LGVs are lower than in the EMEP/EEA Emissions Inventory Guidebook. The f-NO_2 factors for Euro IV and V HGVs derived from roadside remote sensing are lower than in the EMEP/EEA Guidebook, while for Euro VI the remote sensing factors suggest higher factors than the EMEP/EEA Guidebook.

Values of f-NO_2 for each main vehicle type and Euro standard are provided in the spreadsheet "By Euro" tab. These figures refer to the mixing ratio of NO_2 in emitted NO_x, i.e. the volume fraction of NO_2 in the emitted NO_x

Other worksheets provide weighted values of f-NO_2 for years between 2013 and 2035. The weighting has been done in different ways for use when the user does not have detailed information on the mix of Euro standards in the fleet. The weighting of the factors are by the NO_x emissions from each detailed vehicle category.

The Primary NO_2 factors up to 2019 are based on the methodology and input data for the NO_x inventory reported in February 2021, but also factoring in improvements to the representation of traffic speeds in the road transport emissions inventory. This was based on analysis and assessment of Teletrac Navman GPS travel time data from the Department for Transport (DfT) and road level speed limit data from Basemaps.

The NO_x emissions inventory uses fleet composition and vehicle kilometre data derived from the Department for Transport (DfT) to estimate the NO_x emissions by each Euro standard. Details on the method for estimating NO_x emissions from road transport are given in the UK's official Informative Inventory Report submitted under the National Emission Ceilings Regulations (NECR, 2018) and the United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution (CLRTAP)[3]. Fleet composition uses evidence from DfT's Automatic Number Plate Recognition data (2007-2019)

on how the age and fuel mix of vehicles vary on different types of roads. The emission factors for NO_x are those derived from COPERT 5.3[5].

Primary NO_2 factors are also based on the methodology and input data for the submitted version of the Air Quality Directive 2020 compliance assessment. From 2020-2035, this was based on the latest NAEI projections on road transport NO_x emissions, as reported in March 2021 to CLRTAP[6] but also factoring in the updated basemap road speeds. The key assumptions behind the forecasts in weighted f-NO_2 factors are those that define the composition of the future vehicle fleet, future traffic activity and the corresponding NO_x and f-NO_2 factors for current and future vehicles.

The composition of the future vehicle fleet is based on figures provided by DfT in January 2021 on sales and activities of new cars and vans and on updated assumptions made by the NAEI on future sales, annual mileage and survival rates of HGVs and buses derived from analysis of past trends. Outside of London, a fleet turnover model is used to calculate the future fleet composition using vehicle survival rates derived from trends in historic licensing data. Traffic growth assumptions for each main vehicle type come from DfT (provided in January 2021) for Great Britain (GB) projected to 2035 and re-set to the 2019 base year. Fleet composition and vehicle activity forecasts for London were provided by Transport for London in January 2020.

To account for the COVID-19 impacts on road traffic for 2020, DfT's provisional road traffic estimates for GB up to the third quarter (Q3) of 2020 were used in combination with DfT's statistics on transport use by mode for the fourth quarter (Q4) of 2020. The reduction rate calculated from these two data sources between traffic in 2019 and in 2020 was applied to adjust DfT's traffic growth rate for 2020 due to the COVID-19 pandemic. The impacts from COVID-19 pandemic were not taken into account for the projections beyond 2020.

Projections are from a 2019 base year, taking into account the introduction of new vehicles up to Euro 6/VI standards. Euro 6 standards for diesel cars and LGVs are introduced in 3 stages from 2015/16 according to COPERT 5.3.

'***Fleet-avg by area_road_type'***. This sheet provides values for each main vehicle class weighted by NO_x emissions by each fuel type and Euro standard in the fleet. The different values for cars and taxis on urban, rural and motorway roads reflect the different mix of NO_x emissions coming from petrol and diesel cars on each road type. The values for different parts of London reflect the different proportions of NO_x emissions coming from diesel taxis and cars in each part of London. The different values for cars in Northern Ireland reflect the different proportions of NO_x emissions coming from diesel and petrol cars in Northern Ireland due to the different petrol/diesel car fleet in this country. The different values for LGVs, HGVs and buses for London and the rest of the UK reflect the different fleet age mix of these vehicles in London as a result of the current Low Emission Zone and Ultra Low Emission Zone introduced from 2019.

'Fleet-avg by_vehicle_fuel_type'. This sheet shows values weighted by NO_x emissions occurring from each Euro class in the mix of vehicles on all roads outside London, but provides separate values for cars and LGVs by fuel type. This should be used when the user knows the fuel mix of vehicles on the road(s) being modelled, but not the mix of Euro standards. The factors for each vehicle type are weighted by the NO_x emissions coming from the mix of Euro standards on all roads.

'Fleet-avg all_traffic'. This sheet provides the most aggregated values of f-NO_2 which can be used when the user does not know the mix of vehicles on the roads being modelled. The factors for individual vehicle types are weighted by the relative amounts of NO_x emissions occurring from the mix of vehicle types on urban, non-urban and for all UK roads combined.

These Base 2021 Projection figures are an update of the March 2020 f-NO_2 factors (PrimaryNO2 factors_NAEIBase_2020_v1.xlsx). The major reason for recalculations is because of the use of the new remote sensing factors for all vehicle types. The effect this has varies by vehicle type. For cars, for example, it leads to a significant reduction relative to the previously published values. For HGVs, it leads to a reduction in historic years but an increase in projected years because the Primary NO_2 factors for HGVs are typically lower than the previous factors for earlier Euro Standards and higher for newer Euro Standards.

Other reasons for minor recalculations include:

- The application of updated traffic speeds across all years. This generally leads to a small reduction in the Primary NO_2 factors, compared to using the speeds used previously.
- Re-setting the base year of the traffic projections to 2019. This changes the vehicle km projections for each vehicle type which in turn affects the overall contribution of each vehicle type to the NO_x emissions and therefore the weightings used to derive the f-NO_2 factors in the 'Fleet-avg all_traffic' sheet
- The use of new traffic forecasts data from DfT with information showing an increasing share of car vehicle kilometres from petrol cars relative to diesel cars. As the f-NO_2 values for petrol cars are much lower for petrol cars relative to diesel cars, this leads to a reduction in the weighted f-NO_2 value for cars for future years, especially notable from 2031-2035.

These factors will be updated annually after submission of each version of the NAEI's UK inventory figures.

References:

[1] Grange et al. (2019), "Strong Temperature Dependence for light-Duty Diesel Vehicle NOx emissions", Environ, Sci.Technol., 53, 6587-6596

[2] EMEP/EEA air pollutant emission inventory guidebook 2019.https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i/view

[3] Carslaw et al (2016). "*Have vehicle emissions of primary NO_2 peaked*?". Faraday Discuss., 2016, 189, 439

[4] UK Informative Inventory Report (1990 to 2019), Churchill et al, March 2021, https://naei.beis.gov.uk/reports/reports?report_id=1016

[5] https://www.emisia.com/utilities/copert/

[6] UK Projected emissions – March 2021
https://naei.beis.gov.uk/resources/annex_iv_projections_reporting_template_2021_GB_v1.0.xls