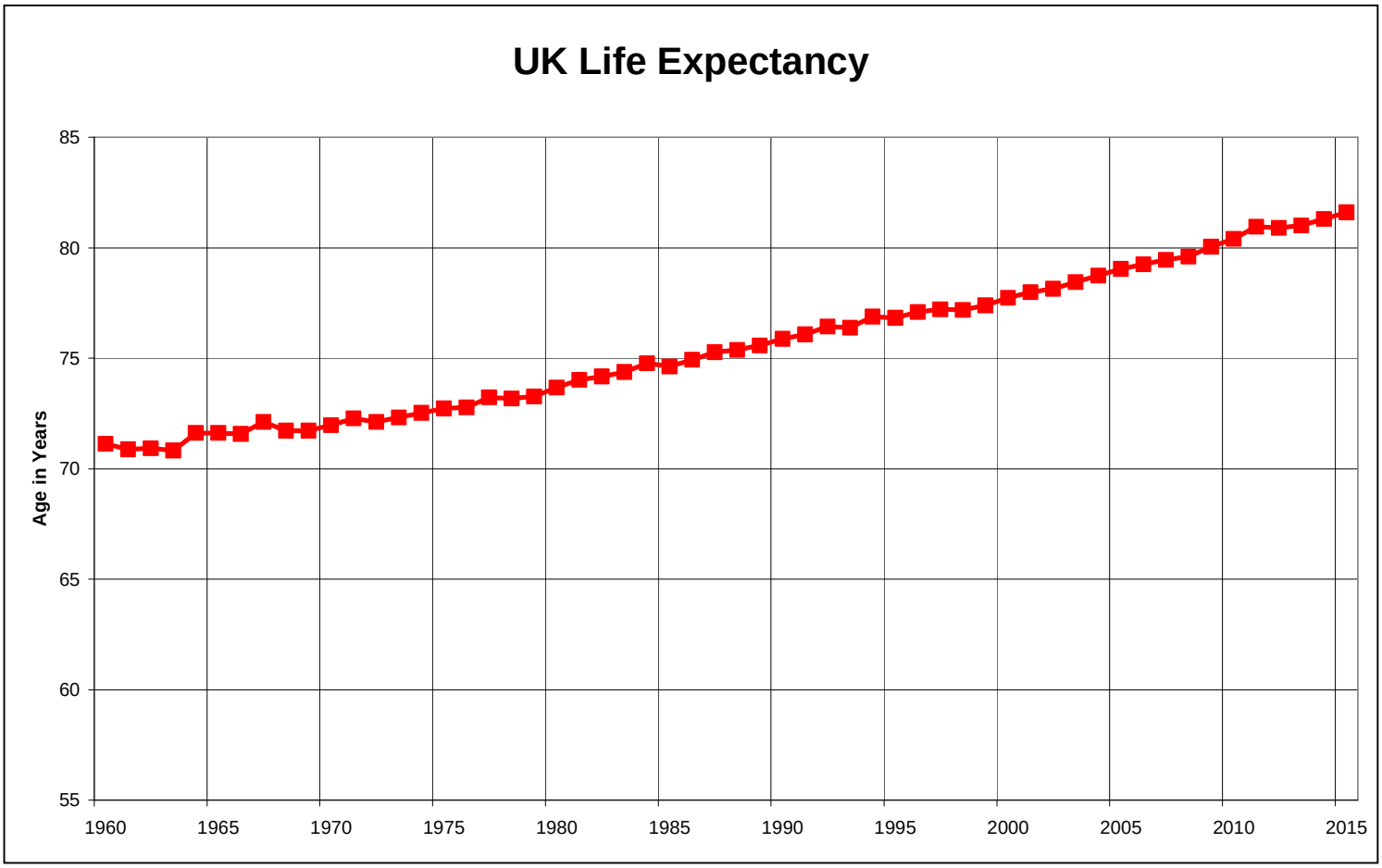
UK Air Quality

The long-term view

More than two generations



To provide some context and background to the current discussion and campaigning by many regarding the UK's air quality, it is clearly necessary to re-iterate the reality of increased life expectancy over the last six decades for people born in the UK.

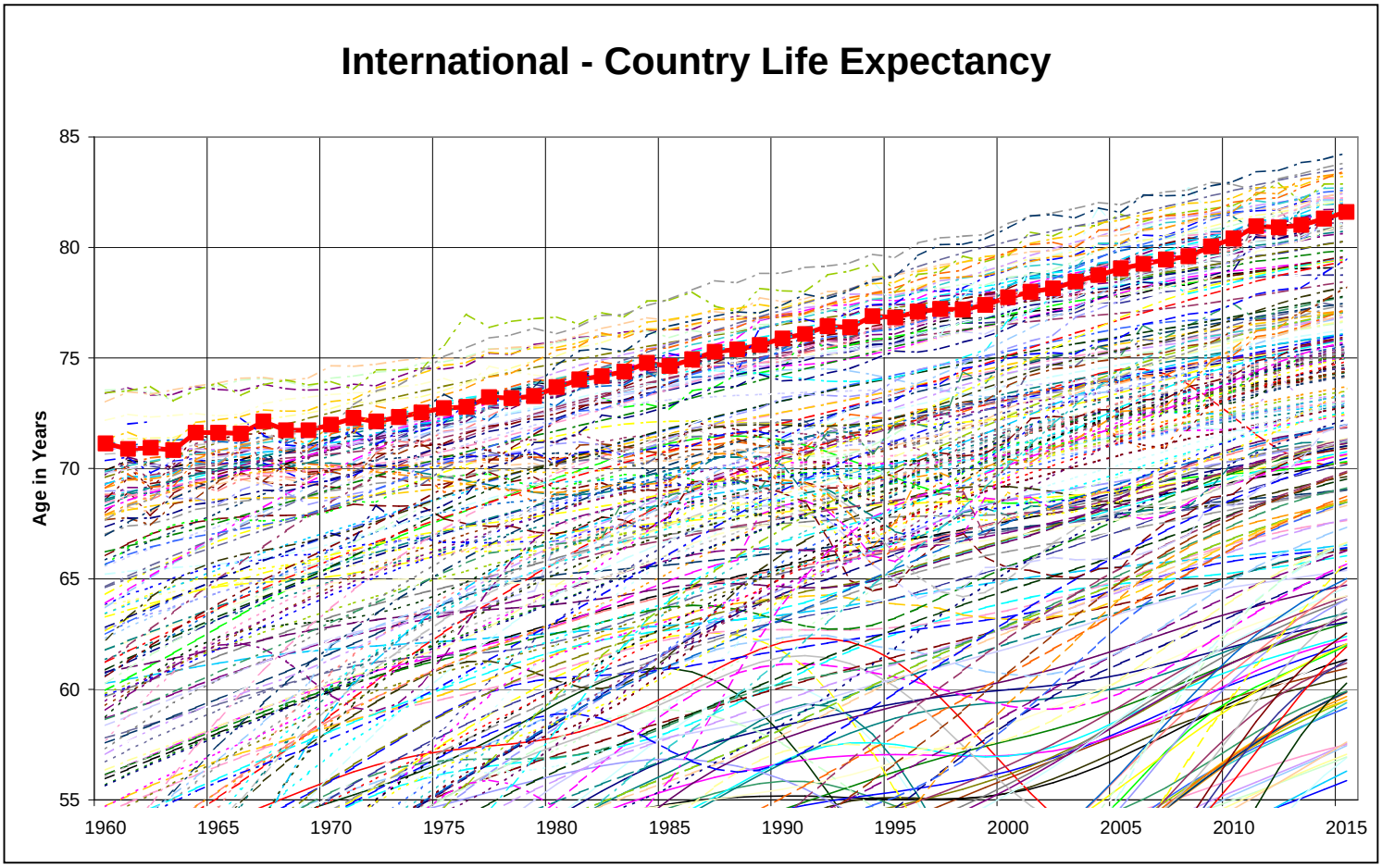
Life expectancy has increased substantially from slightly over 71 years of age in 1960, to now over 81 years of age in 2015. In just 6 decades. (So incidentally (!) has general health and wealth so improved in that time).

This increased life expectancy is plotted in the chart using figures as collated by the World Bank.

This follows the trend of the previous 100 years, from the 1840's, when life expectancy at birth was still actually only about 40 to 41 years, (as it had been, essentially, for over 200 years).

Note that there is a slight slow down in the rate of increase of calculated life expectancy since the last census of 2011, as reported by the Office of National Statistics in September 2017 (https://www.ons.gov.uk/), and picked up nationally by much of the media, but well reported by https://theconversation.com/uk in their report "Life expectancy in Britain…" published 29th November 2017, and also discussed in their earlier article "Is austerity really to blame…" published 20th July 2017.

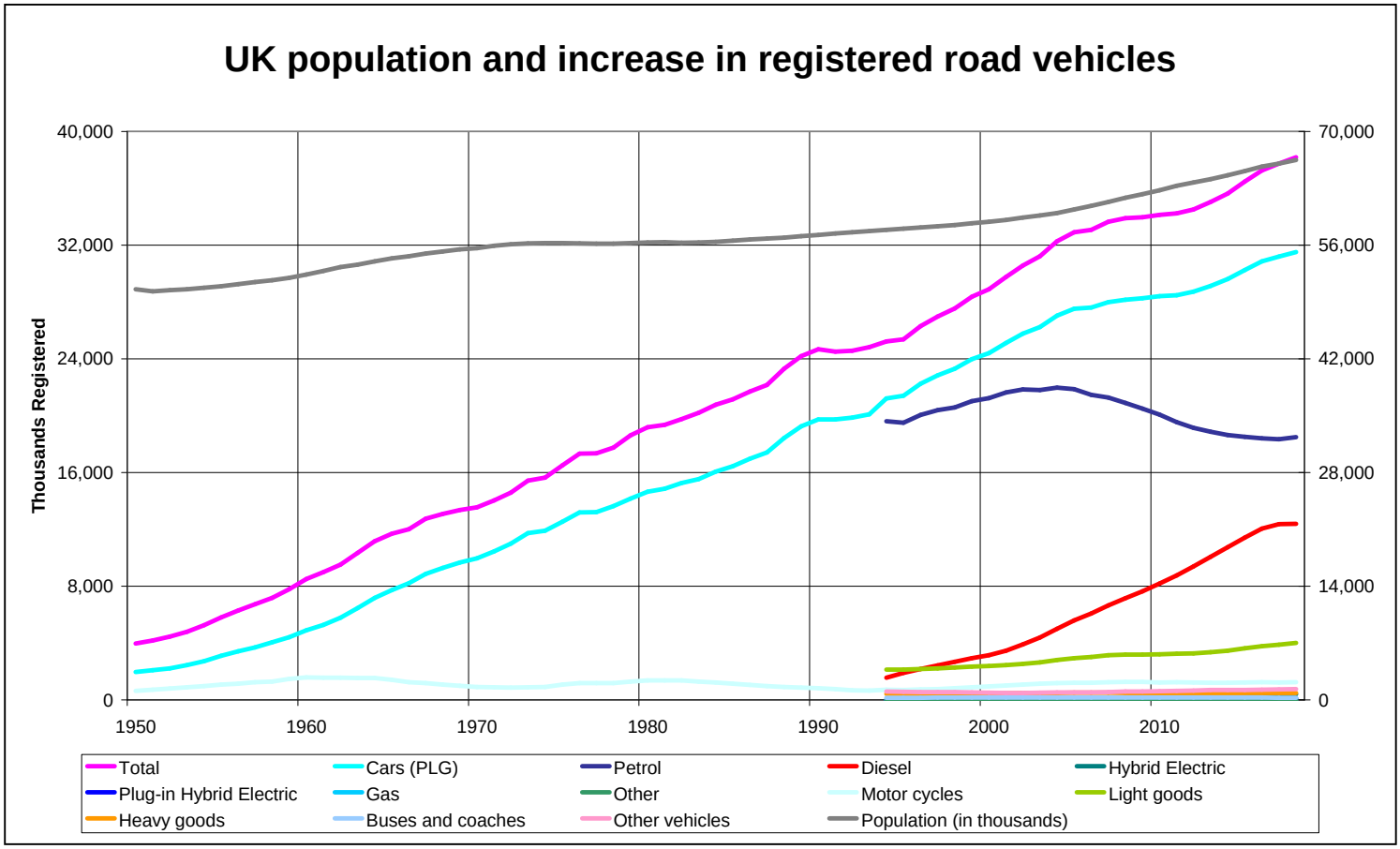
There is currently no known connection in this slowing in the rate of increase and air quality, and this is more likely a function of our ageing population and the ultimate current limits to human longevity.



In illustrating this large increase in UK life expectancy in the context of whole world's population, country by country, it becomes clear that this is a truly global improvement for almost all people. Clearly the life expectancy of the population's of some nations has overtaken the UK over the decades as well.

International wealth, the greater sharing of that wealth, combined with huge strides in hygiene and food security over the last 6 decades, and more recently medical advances, have driven this international improvement for all the people of the world (and UK).

This reality has been very well discussed and illustrated by both Hans Rosling (particularly his last book "*Factfulness*") and Stephen Pinker (in his 2018 book "*Enlightenment Now*").

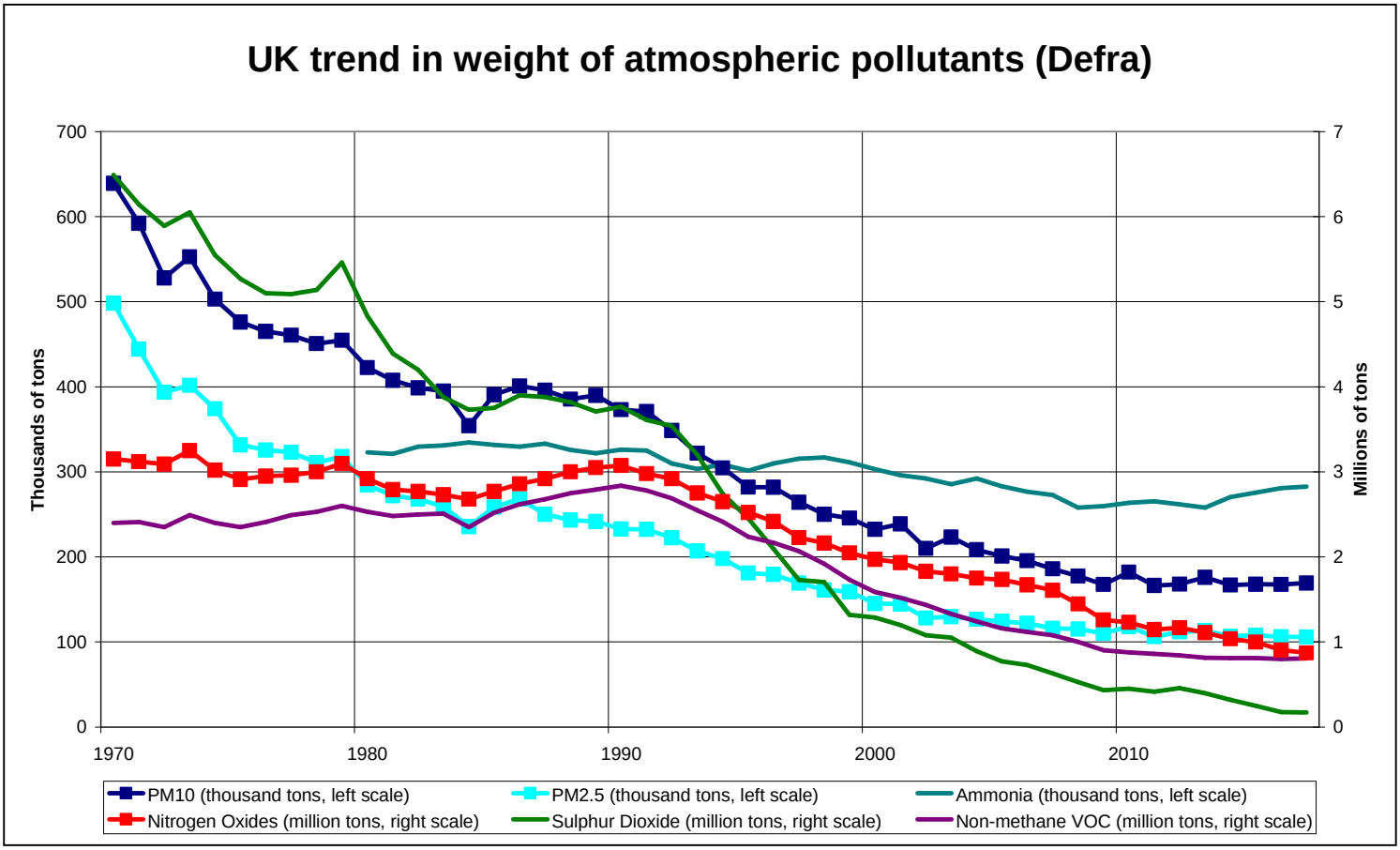


Much of the discussion around air quality in the UK (and it's detrimental effect on human health) has been directed at the use of motor vehicles, and now more recently the rise in popularity of Diesel engine powered motor vehicles.

The Department for Transport records clearly show an enourmous increase in registered cars (nearly all in private personal ownership), from slightly fewer than 2 million in 1950 to over 31 million in 2017. This is plotted in the cyan line in the chart. (All vehicles plotted in the pink line in the chart).

Noticeable in the statistics since 1994, is the large increase in Diesel fuel powered cars, growing slightly more rapidly after Government policy changes in 2001 (due to perceived issues about higher CO_2 emissions from Petrol fuelled cars).

Now more recently, thanks to the known greater emissions of Nitrogen Dioxide (NO_2) and particulates (PM10 and PM2.5) of Diesel fuelled vehicles compared to Petrol, the focus of attention has moved more on these latter emissions than the previous CO_2. This seems to indicate the current 40% fleet share of Diesel vehicles may be the peak.



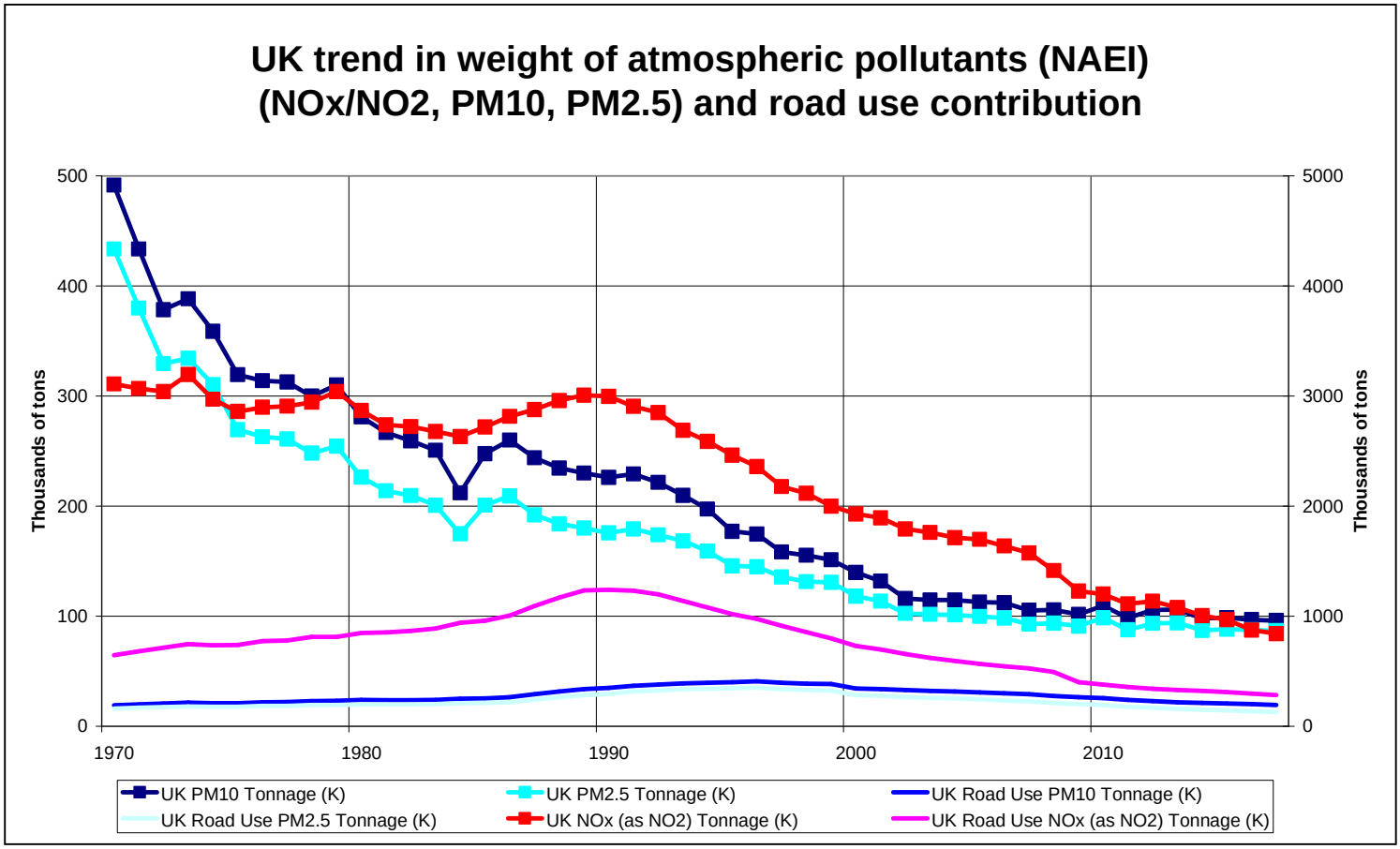
Over the time period that ownership and use of private motor vehicles has increased so dramatically, many other changes have been wrought in the UK economy and the technology used to generate the wealth people now enjoy (including ever greater fuel and emissions efficiency of those motor vehicles).

Despite the growth in ownership and use of motor vehicles, in that time, there has been a dramatic fall in all forms of pollutants released into the UK atmosphere; reaching effectively record lows in 2017/2018 (at least since the early years after the second World War and in many cases since the peak of the industrial revolution).

This huge improvement in air quality is highlighted in the chart (from data published by the Department of the Environment, Farming and Rural Affairs), in particular shown in the boldest colours, is the weight of Nitrogen Oxides (NO_x) in red, PM10's in dark blue and PM2.5's in cyan, over the last 5 decades.

Clearly the weight of all of these pollutants emitted into the atmosphere has fallen dramatically (by as much as 80% in the case of particulates).

Note the huge reduction, in that time, of reliance on the burning of coal, which also has a major contribution to particulate and Sulphur Dioxide emissions (shown in green).



By adding the contribution from road vehicle use to the picture of the overall weight of the three pollutants in question, it can also be clearly seen from the National Atmospheric Emissions Inventory database (http://naei.beis.gov.uk/) that the contribution from road vehicles (fuel burning emissions and other wear and tear emissions, such as road wear, tyre wear, brake dust etc.) is actually a relatively small part of the overall UK emissions:

34% for NO_x, 21% for PM10's and 16% for PM2.5's

It should be further understood that the contribution to road use PM10's and PM2.5's from the burning of Diesel fuel in engines is an even smaller portion of those emissions nationally (about 6% for both PM10's and PM2.5's). The other portion from tyre wear, road wear and brake dust, common to all road vehicles.

It follows inevitably that discouraging, or even eliminating Diesel powered road vehicles will actually have only a relatively small effect on UK air quality.

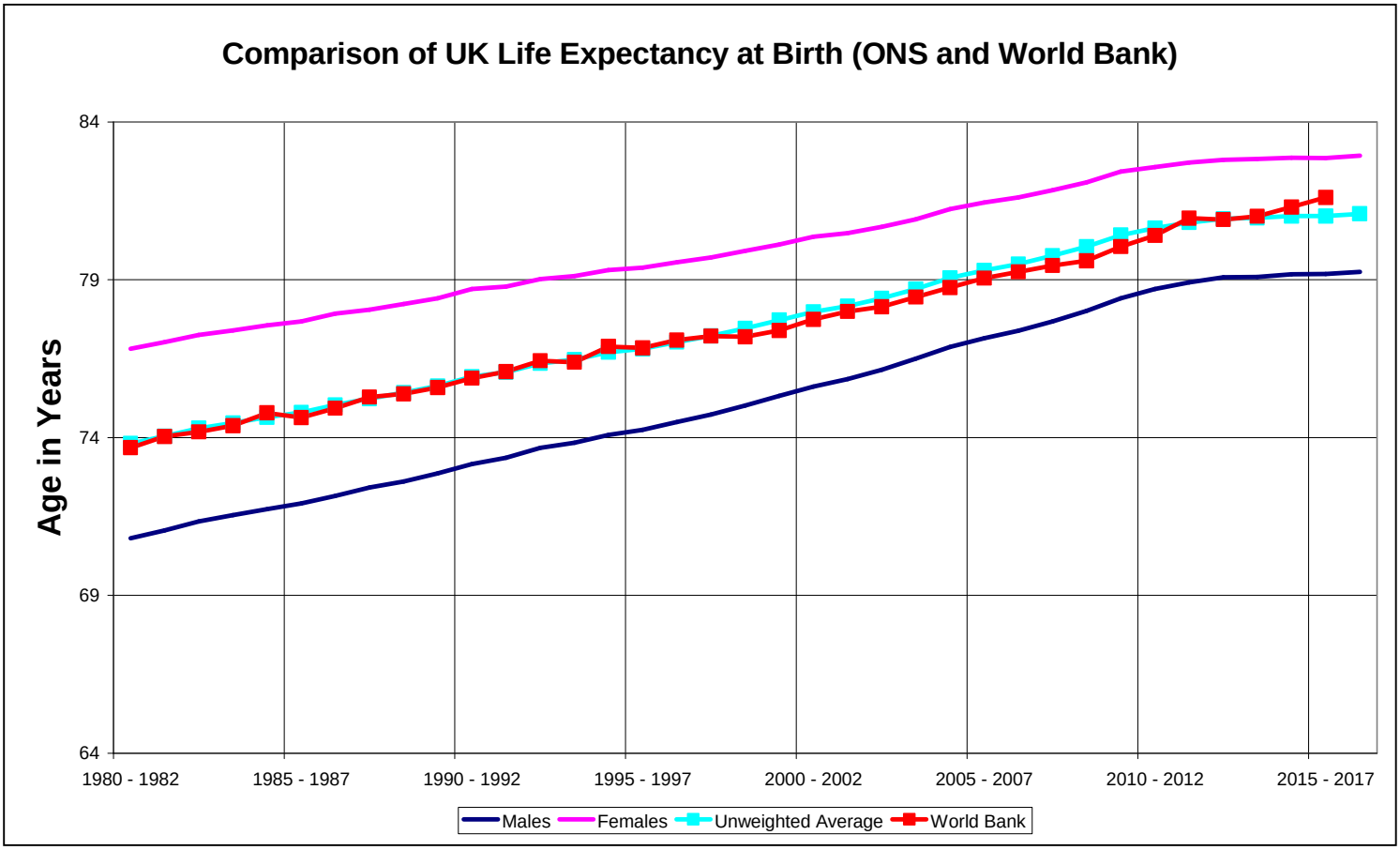
However, it must also be understood that the concentration of these three main pollutants in large cities, and in particular at or near the roadsides of the major road networks of the UK's largest city, London, the contribution from road vehicles is much higher.

This is calculated to be twice as high as the national average in some cases (Capital City Foundation https://policyexchange.org.uk/ – "Up in the Air" Howard 2015, pages 24-26).

Nevertheless even in those areas, the improvement gained from removal of fuel burning vehicle emissions would remain partial and strictly limited.

The last two decades

The 21st Century so far



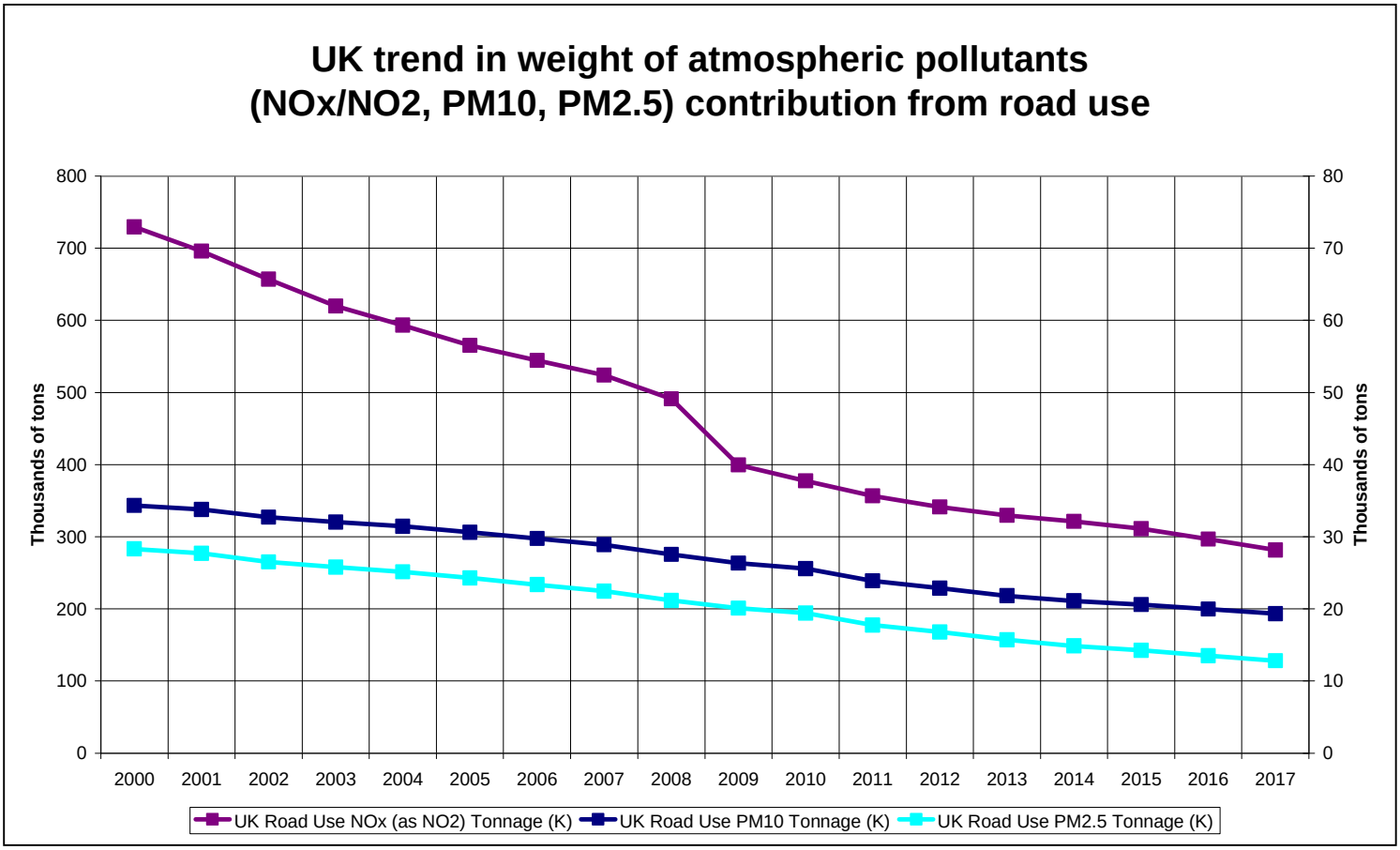
The current discussion about the issue of air quality actually concentrates heavily on the 21st century measures. This has been particularly supported by the COMEAP (2010) (PM2.5) and Royal College of Surgeons (2016) analysis of "premature deaths" caused (*aggravated (?)*) by atmospheric pollutants. This has resulted in the now infamous 40,000 per year figure in the media and public consciousness (reported by the BBC in February 2016 https://www.bbc.co.uk/news/health-35629034, following the publication of the RCS report).

In addition the analysis and estimates for London of "premature death/life years lost" offered by the Institute of Public Policy Research (https://www.ippr.org/) and Capital City Foundation are actually based upon recent relatively high rates of pollution in London in 2010 (though still much lower than most of the previous 4 or 5 decades). Since 2010, these levels have all fallen somewhat, and by some measures quite significantly.

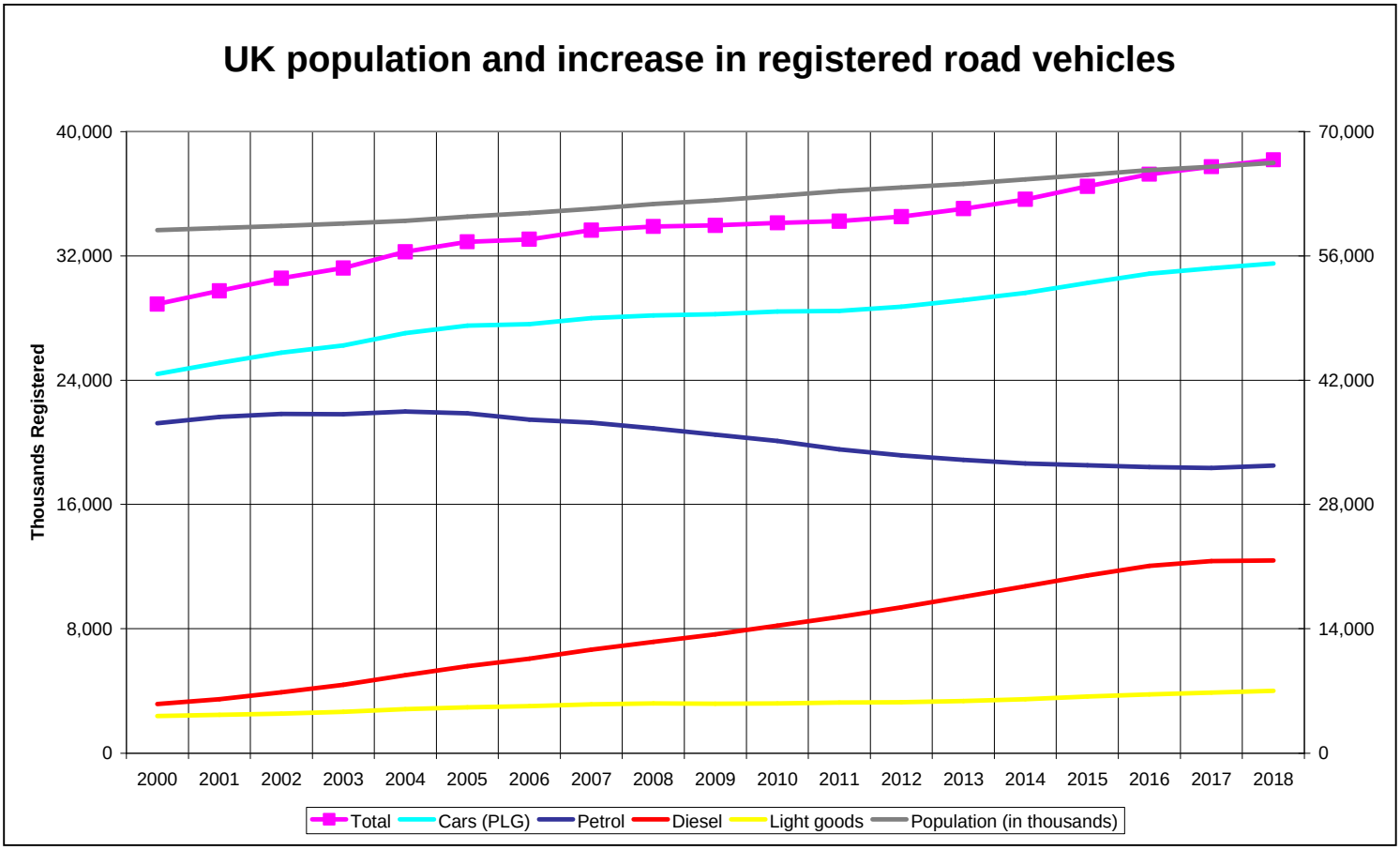
Note that there are also very large levels of uncertainty surrounding these "premature death" analyses (from perhaps as low as only 1/6 of the numbers estimated, or 6,700 per year to as high as twice the estimate, or 80,000 per year).

David Spiegelhalter of Cambridge University gave an excellent analysis of these estimates in February 2017: https://medium.com/wintoncentre/does-air-pollution-kill-40-000-each-year-people-in-the-uk-ecca96fb3a1a.

Again to set context, though, the life expectancy in the UK has continued to rise relentlessly, from a little under 78 years in 2000 to the current 81 (recent ONS (see first page)) or 81.5 years (World Bank).



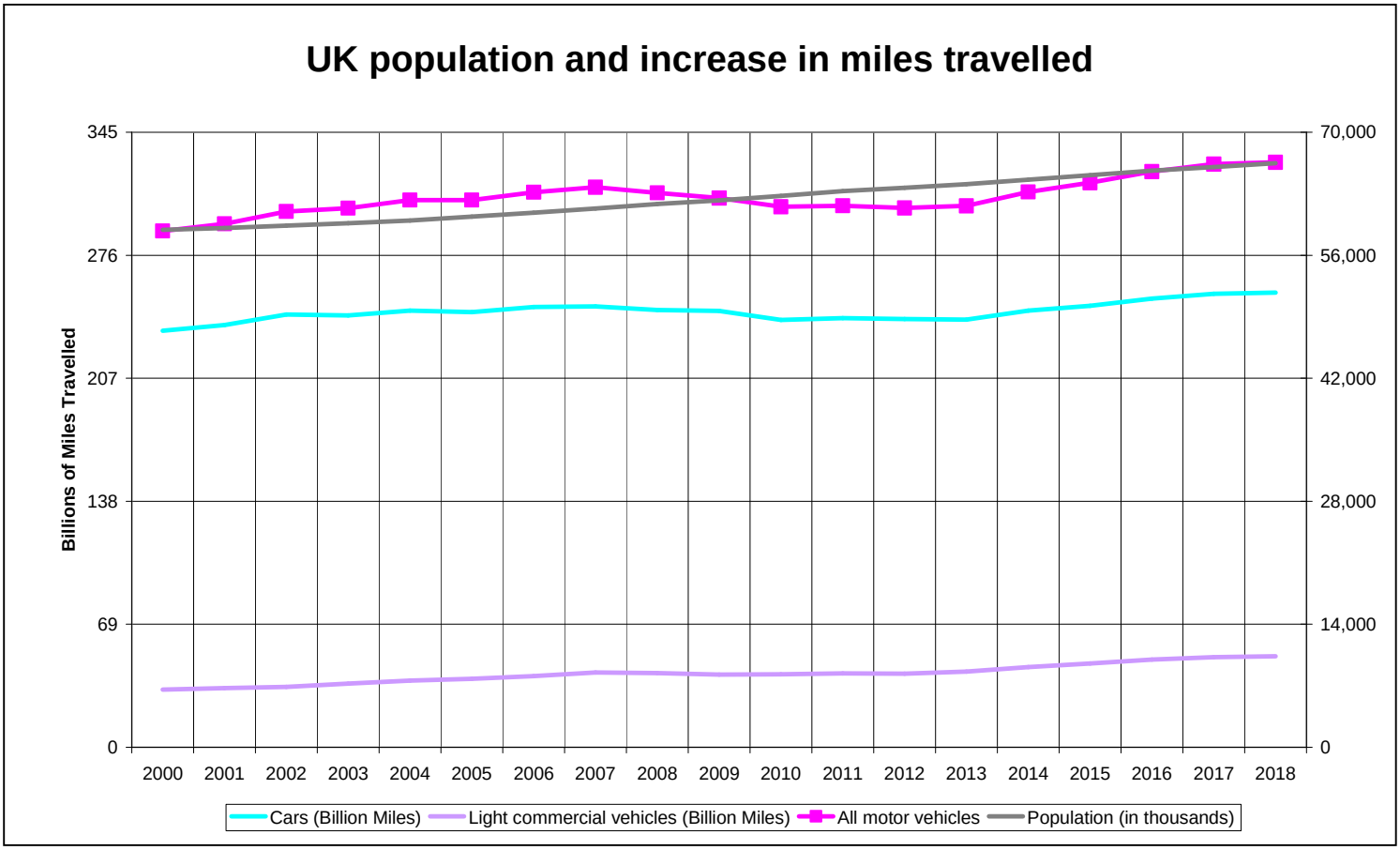
From the start of the 21st century, as life expectancy has increased, the weight of the three principal air pollutants emitted into the atmosphere in the UK, as contributed by use of motor vehicles, has relentlessly and continuously fallen at the same time.



Returning, over this time period, to the number of registered private cars and, in particular, Diesel powered private cars, shows their continued growth in popularity, in direct opposition to the reduction in emissions from road vehicle use.

There is a known recent reduction in purchase of new Diesel vehicles revealed by the flattening of the growth of the red line in the chart on the right (2016 to 2017).

Throughout 2018 further reduction in demand for Diesel vehicles are being reported, as new government policy and media reporting dissuades the motorist from buying such vehicles.

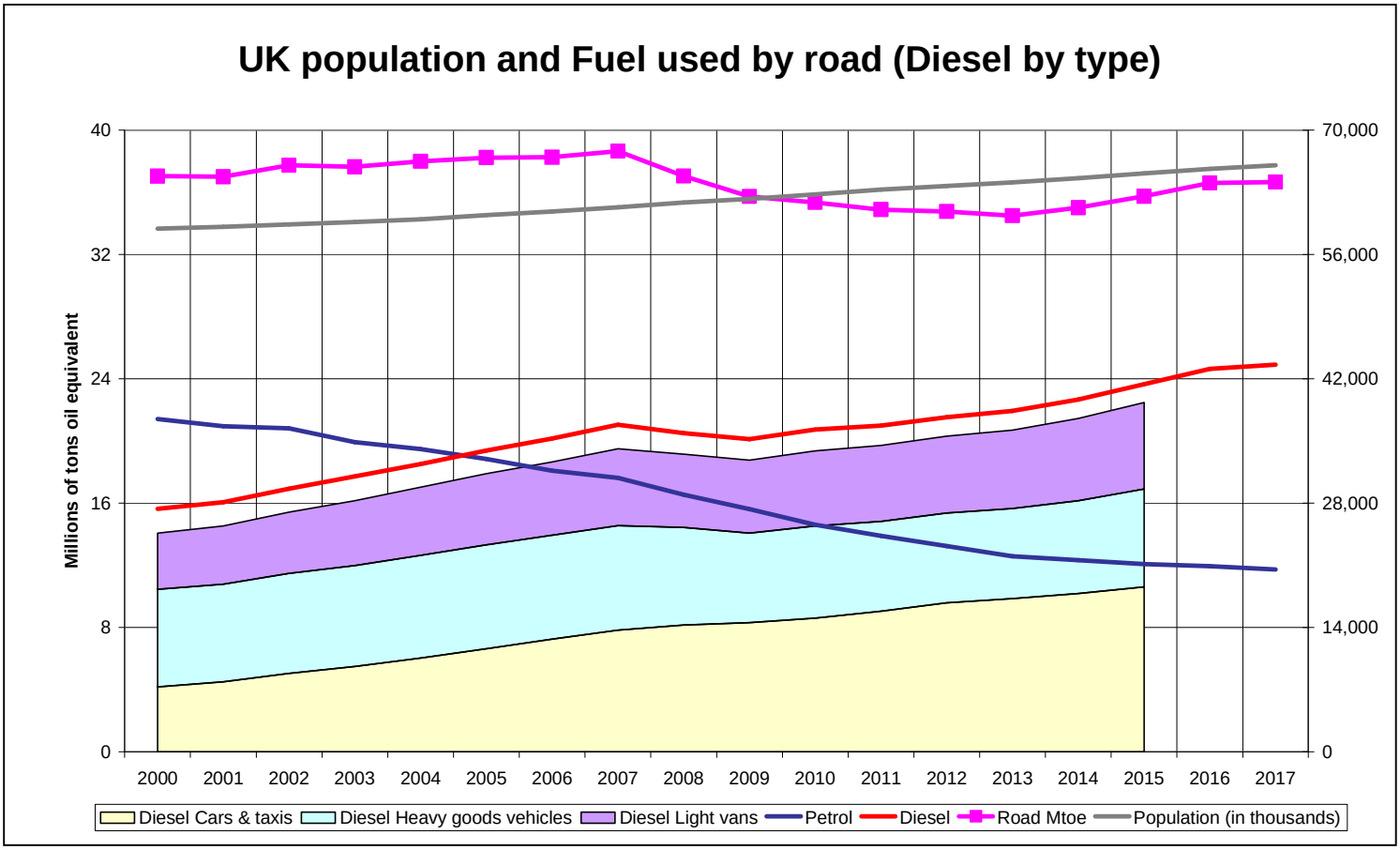


It is notable however that the annual miles travelled per person in the UK, has not actually increased over that corresponding period (see the coincidence of the 2000 and 2017 points on the chart for population in grey and miles travelled in pink).

This is calculated to slightly less than 5,000 miles per person per year.

This clearly shows that despite a small rise from the 2002 to 2008 period, and subsequent fall from 2010 to 2015, the annual miles travelled per person are remarkably stable (and therefore reduced correspondingly per private car).

Other factors may play a part in these trends, particularly the increase in home working, rather than as many daily trips to the “office”, but perhaps also the growth in relative wealth and ownership of more “cherished/leisure/hobby” vehicles.



Given the increase in the number of registered vehicles, whilst the number of miles travelled per person has remained stable, the key question that follows is what is the average road use fuel consumed per person and per mile travelled, over this same period this century.

This has shown a clear reduction from 630 tonnes per person per year to just 558 tonnes per person. This is clearly due to 11% improved fuel efficiency of motor vehicles in the national fleet over the period.

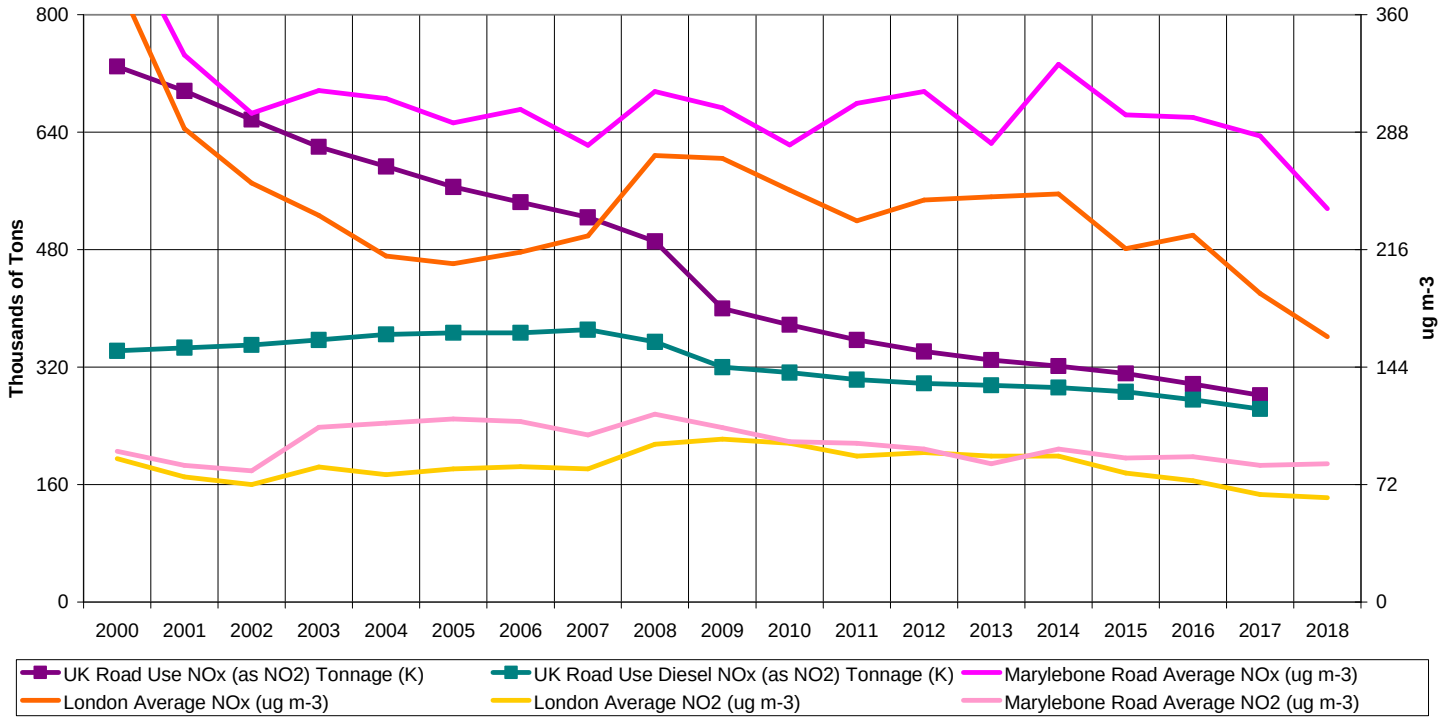
Notable however, is the steady reduction in weight of petrol consumed (in blue), compared to the growth in weight of diesel consumed (in red). **Note** the increase in diesel is clearly driven by (private) cars and taxis (the yellow block) rather than commercial vehicles.

Concentrations of

NO_x/NO_2, PM10 and PM2.5

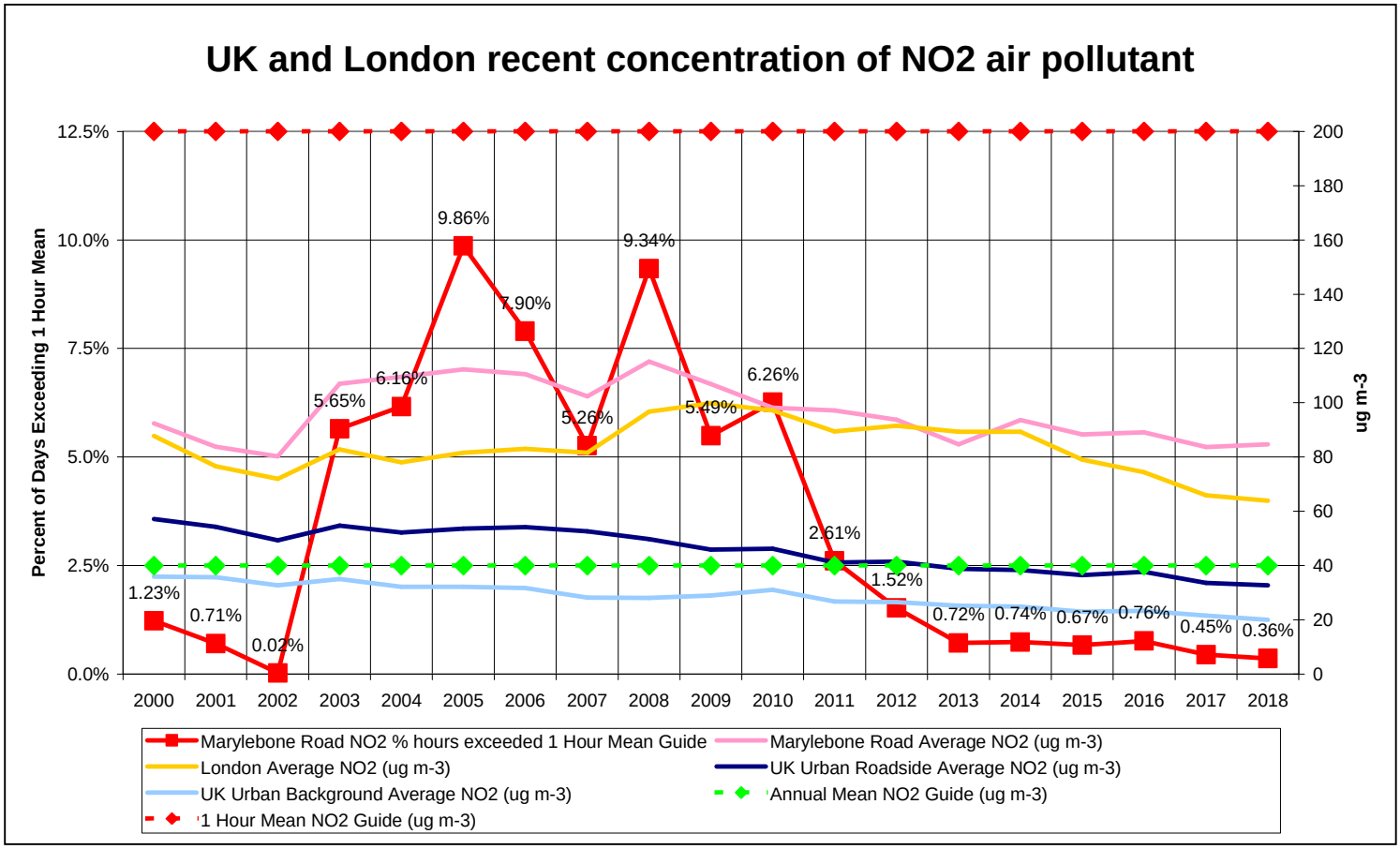
In the UK and London

UK and London recent concentration of nitrus-oxide (NOx) and nitrogen dioxide (NO2) air pollutants



Despite huge improvements nationally for all these pollutants being emitted into the atmosphere, most of the discussion has actually centred on the nation's capital city, London (supporting about 12% to 13% of the UK's resident population, and more when considering commuters).

Looking in more detail at emissions of NO_x and NO_2, (as sourced from the London Air Quality/Kings College database found at https://www.londonair.org.uk/) in London (the orange and yellow lines in the chart) and in particular one of the most polluted roads in London, the Marylebone Road in Westminster (the bright and light pink lines in the chart), does show that there has not been a corresponding reduction in concentration of NO_x and NO_2 in either London in general, or the Marylebone Road over the 21st century so far.



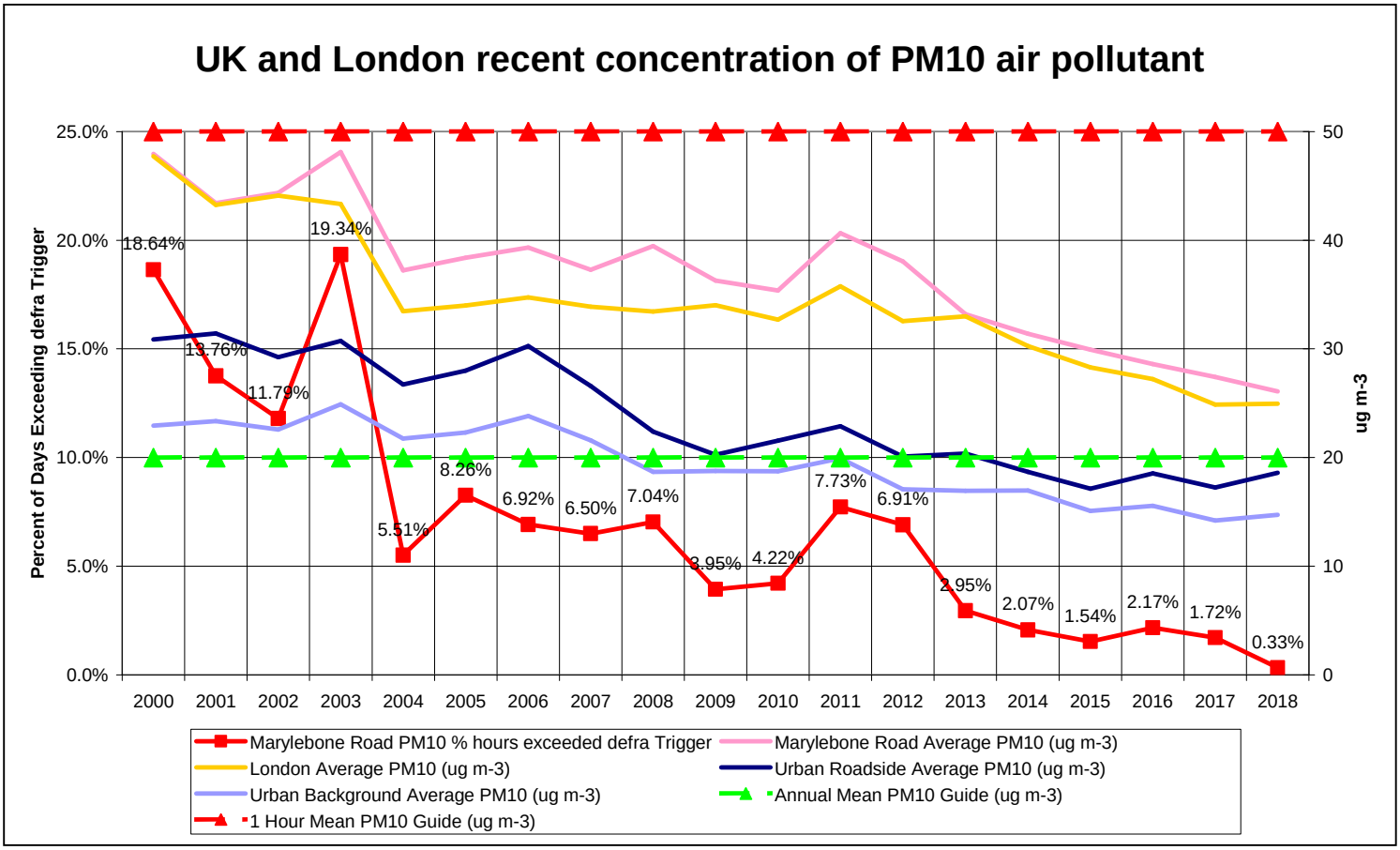
Concentrating further on the more health threatening NO_2 concentration, reveals that the urban roadside and urban background concentrations for the UK (plotted in dark and light blue, from Defra) have fallen sufficiently to say they are now generally just below the WHO guideline for annual mean concentrations of 40 ug/m-3 (micro grams per cubic metre).

However, the London average (in yellow) and, for example, the Marylebone Road (in pink) continues to be significantly above this WHO annual guideline.

However it is also shown clearly from the data that the percentage of time throughout the year that the concentration of NO_2 on the Marylebone Road has exceeded the hourly mean guideline by the WHO (200 ug/m-3) has dropped dramatically since the high levels from 2003 to 2011.

For 2017 this was actually only 0.45% of the year, or just 40 hours of the year.

It is also noted by Defra that this identical trend in number of measured intervals for "Average hours spent in 'Moderate' or higher NO2 pollution" is found nationally for UK roadside sites as well. (Reported in "Defra National Statistics Release: Air quality statistics in the UK 1987 to 2017", published 26th April 2018. See page 19.)

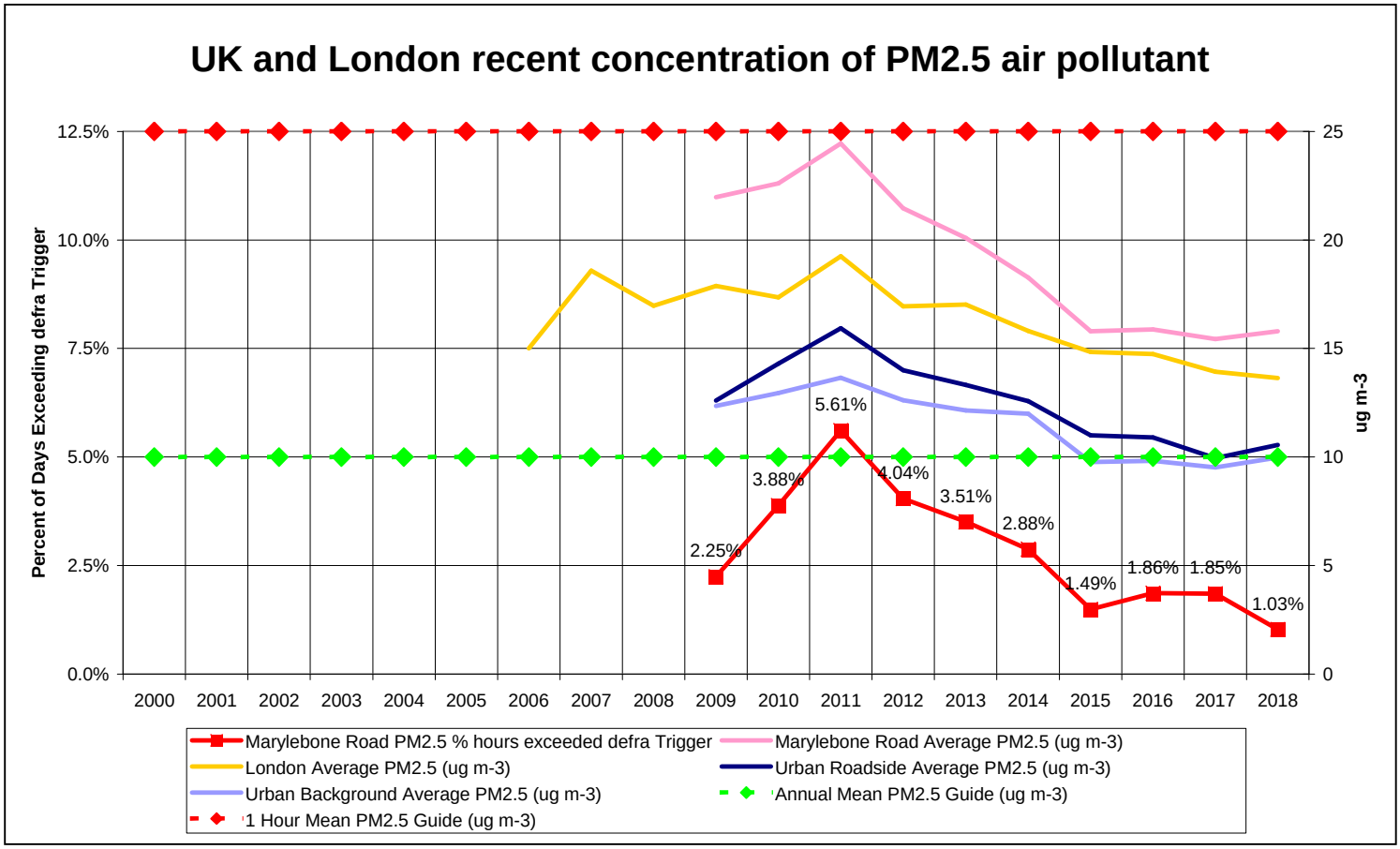


The concentration of PM10's in the urban UK, London and Marylebone Road atmosphere follow a generally similar pattern, with a more notable downward trend, and particularly showing a slightly more marked recent downward trend for London and the Marylebone Road.

However, for London, unlike the UK urban concentrations, they still clearly breach the annual mean guidelines for PM10's from the WHO (20 ug m-3).

The pattern of hours of the year exceeding the Defra hourly average guideline (68 ug m-3 for PM10's) is more noticeably down than compared to the NO_2, but is higher at 150 hours of the year.

Keep in mind the factors of Diesel fuel burning in road vehicles and it's relative contribution to this issue, plus the impact of the increased popularity of wood burning stoves throughout the UK and it is clearly reasonable to say that the removal of Diesel burning road vehicles would have only a relatively limited contribution to reducing the PM10 air concentration in London.



Unfortunately records for PM2.5's are not available for earlier years, compared to the other two pollutants (complexity of capturing concentrations will have played a part, plus possibly not understanding the importance of these far smaller particulates as a threat to health).

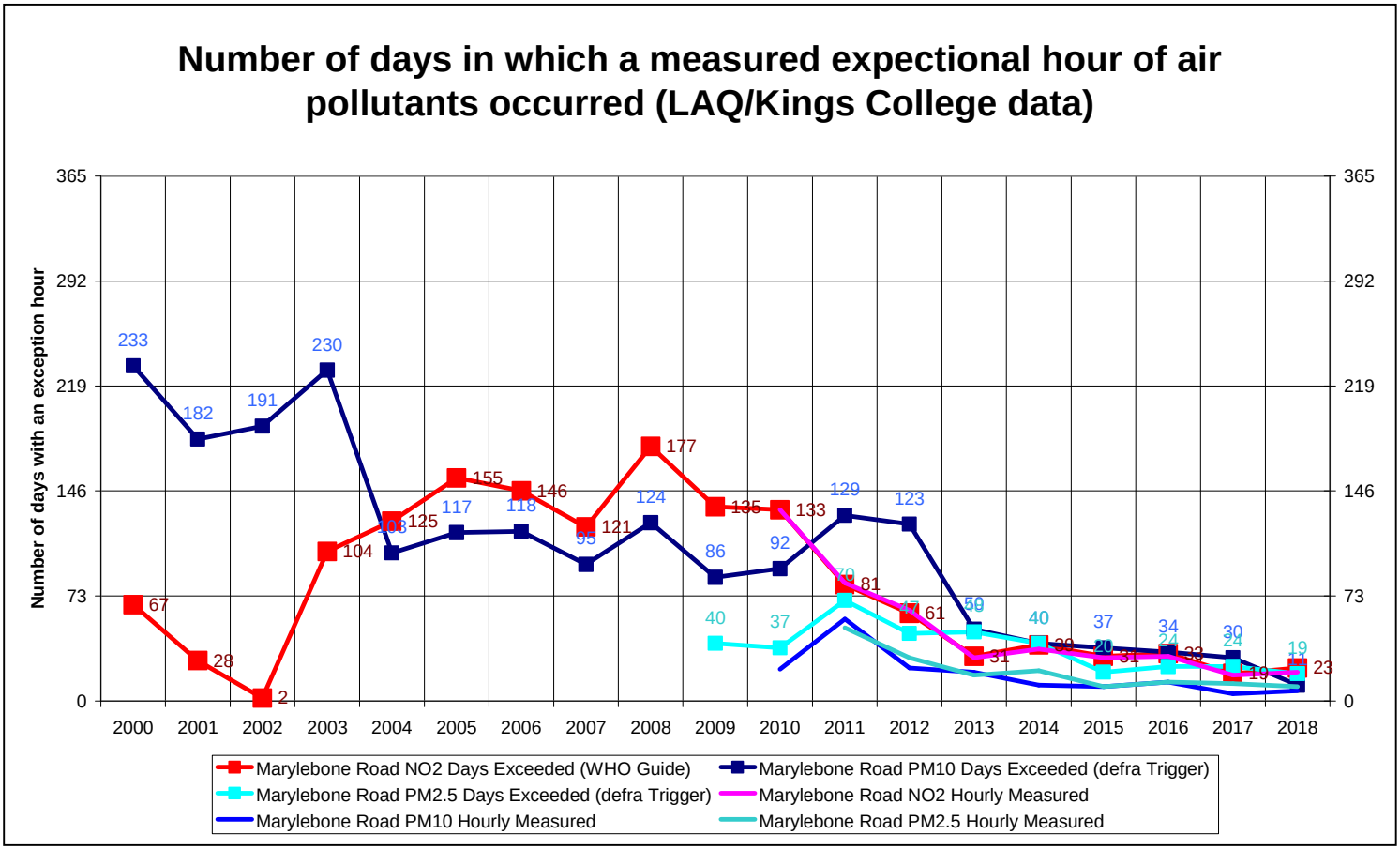
As, such reliable data is only really available for the current decade.

Again the trend does still remain downward, but this time the UK is only barely meeting the WHO annual mean guideline for PM2.5's (10 ug m-3), and London and the Marylebone Road, as with the other key pollutants break those guidelines.

Again, however the percentage of hours that have exceeded the hourly Defra trigger for PM2.5's (50 ug m-3) represents just 162 hours for the whole year for the Marylebone Road.

Again, as with PM10's, the contribution to these exceptions from the burning of Diesel fuel in road vehicles is comparatively limited and again the popularity of wood burning stoves will make a substantial contribution to keeping these concentrations higher than they might otherwise be.

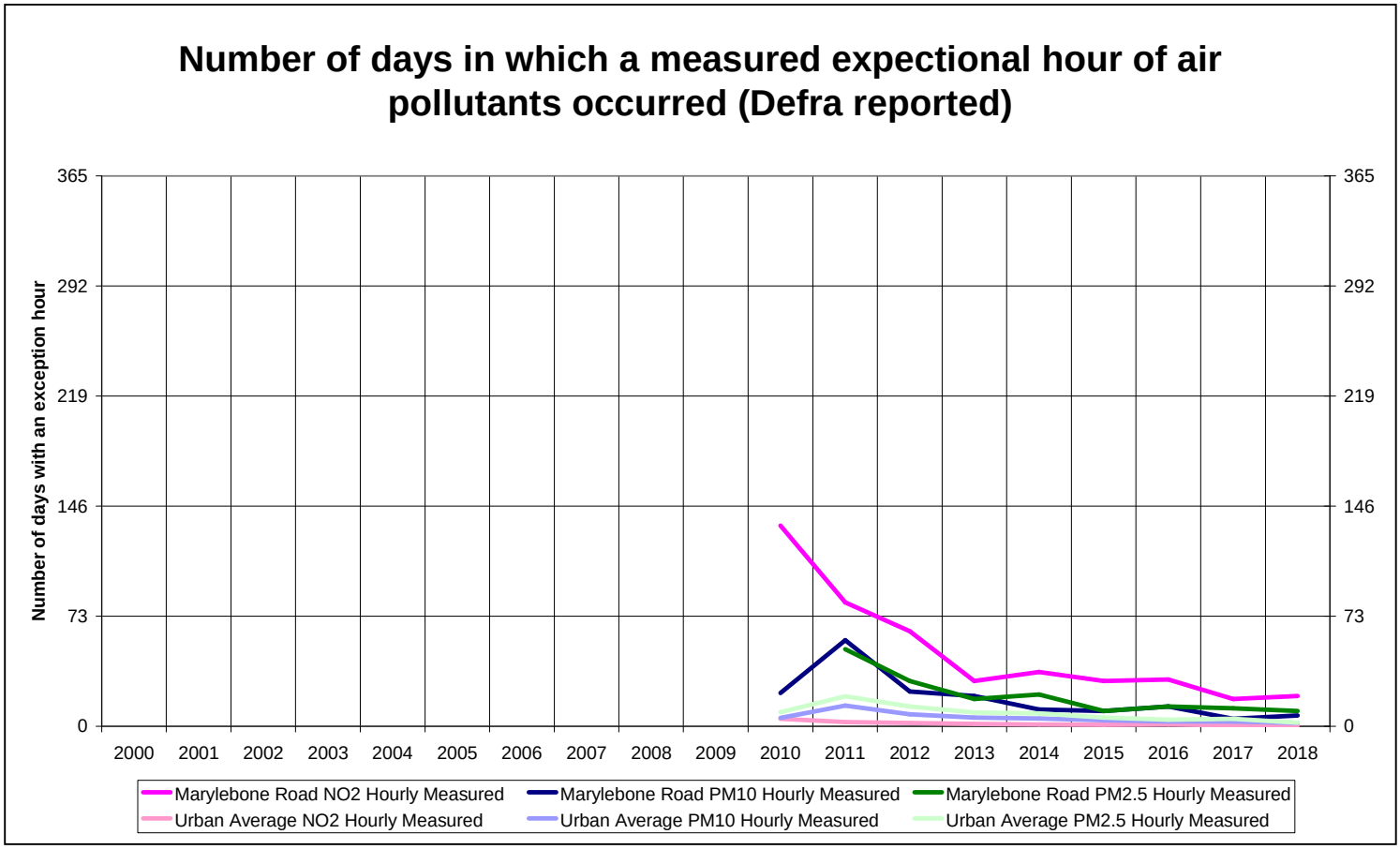
Therefore again it is fair to say that the removal of Diesel burning road vehicles from the fleet of vehicles travelling in London will only make a limited contribution to reducing the concentration of PM2.5's in the atmosphere of London and it's worst polluted roads.



Here we look at the Defra reported and London Air Quality/Kings College database for the three main pollutants for the Marylebone Road. This reveals *the fall in number of days in which an hour exceeded the Defra triggers*, now consistently much lower than before 2013.

The exception is the NO_2 low of 2002 (before the Congestion charge or Low Emissions Zone were introduced), when popularity of Diesel powered vehicles (all with much worse emission characteristics than since 2013) was already quite high.

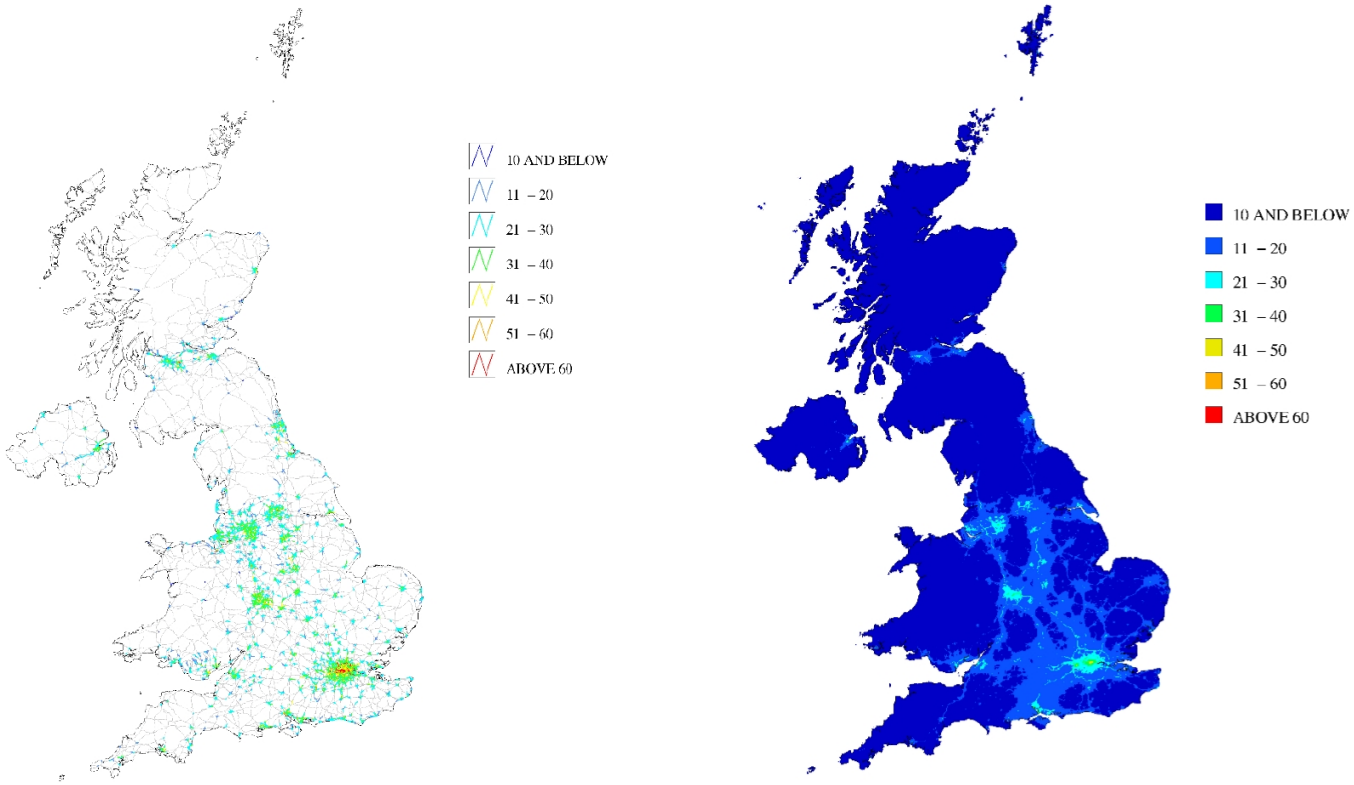
Essentially this supports all previous measures indicating a general improvement, despite a sustained London concentration that exceeds the WHO guidelines over the key period.



Comparing the Defra reported figures of number of days with exceptional hours for the three pollutants for the Marylebone Road and the UK Urban average again tends again to show a sustained drop in bad days (though the figures are not available for the whole period in question from Defra).

UK analysis of geographical concentration of NO_2, 2016

Urban major roads and annual mean background



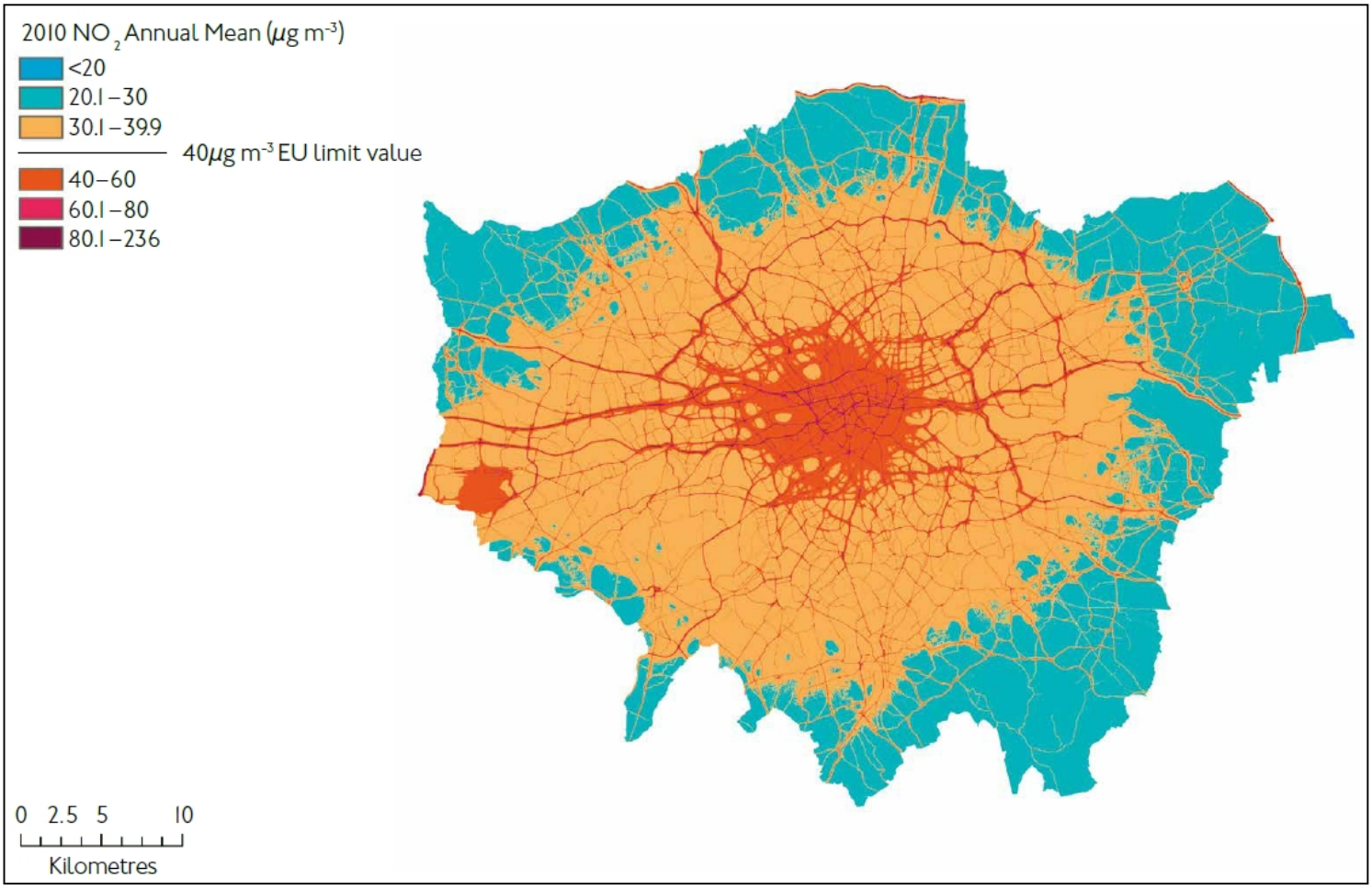
Defra have also mapped the results of it's analysis of NO_2 concentration for both UK major roads and general urban background. Colourising the results to show exceptions in yellow, orange and red. ("*Air Pollution in the UK 2016*", published September 2017, page 62)

The maps clearly support all other numeric analyses, that the area of the UK experiencing the worst air pollution is mostly London.

The remainder of the UK (with a tiny number of exceptions in other cities and very specific stretches of road) is now benefiting from generally very clean air.

In addition mapping for PM10's and PM2.5's clearly show even lower concentrations and exceptions for each pollutant than for the NO_2 shown. See Page 67 and 72 respectively.

London modelled concentration of NO_2, at recent 2010 high.



The Capital City Foundation, (https://policyexchange.org.uk/) in their report “Up in the Air. How to solve London’s Air Quality Crisis: Part 1” (published 30th November 2015) presented, on page 18, the mapped results of their modelling and analysis for 2010, clearly showing the concentrations of annual mean NO_2 in particular areas of London.

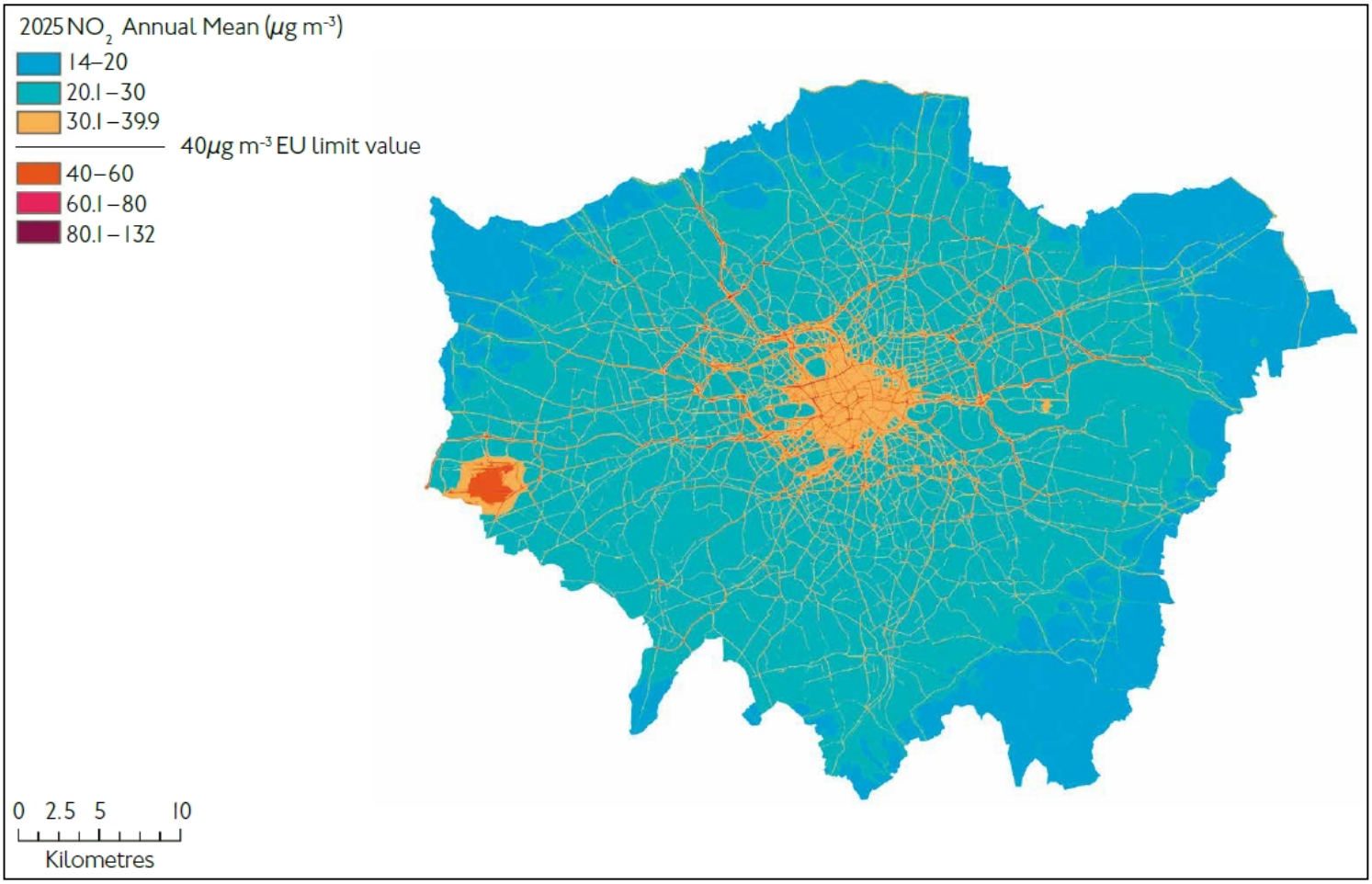
It should be noted, from this pictorial representation, that the light sandy “yellow” areas DO NOT breach WHO annual mean guidelines of 40 ug/m-3.

However, the orange, and darker pink/red areas, in central London, around major road arteries and at Heathrow airport were clearly breaching WHO guidelines during the recent high period of pollutant concentration in 2010.

Note also that the trend in concentrations has come down slightly since this report was published, and in particular the amount of time in the year with severe breaches has dropped dramatically, see page 15 of this document.

Note also the modelling of PM10’s resulted in a geographical representation with very, very limited exceptional concentrations, restricted almost entirely to major road arteries, and even then in very limited areas.

London modelled concentration of NO_2, 2025 projection based upon 2015 policies.



By adjusting the model built, to account for the effect of published policies extant and known of in 2015, the Capital City Foundation was able to project to 2025 to show the probable dramatic reduction in concentration of NO_2 in the atmosphere in London. This was shown graphically on page 27 and discussed in the section from page 26 to 32 “Air Quality Projections”.

This projection tends to indicate that even without subsequent (post 2015) government policies such as the banning of the sale of new Petrol and Diesel powered vehicles from 2040 and increase in low emissions charges from the office of the Mayor of London for the most polluting Diesel vehicles from 2019 (lower than Euro 6), that the air quality of London will see dramatic improvements to the already improved air quality reported since 2010 (and not covered by their report).