London Atmospheric Emissions Inventory 2019

Introduction

The 2019 London Atmospheric Emissions Inventory (LAEI) was published on 16 December 2021. It provides an update to the previous LAEI 2016 and a new baseline for 2019. Projections for the years 2025 and 2030 are also being produced and these will be available in spring 2022. The LAEI is produced by Transport for London and the Greater London Authority with input from project partners at Imperial College London, Aether, Ricardo, Heathrow Airport and the Port of London Authority.

The base year is 2019 and includes the impacts associated with the operation of the central London Ultra Low Emission Zone (ULEZ). It does not include the introduction of tougher standards for the Londonwide Low Emission Zone (LEZ) or ULEZ expansion as these were not yet operational[1]. However, any pre-compliance that may have been taken by vehicle owners would be reflected in fleet composition data for vehicles – for example, TfL bus preparation for the tougher LEZ standards. It is important to note that all the air quality improvements referred to in this summary pre-date the COVID-19 pandemic.

The data from the LAEI is publicly available on the London Data Store and is used as an evidence base for air quality policy work.

The comprehensive data set includes:

- Emissions trends
- Concentration maps for 2019 for NO_2, PM_{10} and $PM_{2.5}$
- Proportion of roads exceeding the NO_2 legal limit
- Population exposure data for NO_2 and $PM_{2.5}$
- Air pollution exposure at schools, care homes and hospitals
- Emissions by pollutant and source, split by London Zone and by borough
- Updated back projections for 2013 and 2016

Legal limits and World Health Organization (WHO) recommended guidelines

This summary refers to both legal limits and World Health Organization recommended guidelines.

In 2021 the WHO updated its recommended guidelines for air pollutants. For $PM_{2.5}$ it tightened the recommended annual average guideline to 5µgm^{-3}, while retaining 10µgm^{-3} as an interim guideline which the Mayor has committed to meet by 2030 (the legal annual average limit is 25µgm^{-3}). For nitrogen dioxide (NO_2) the WHO tightened the recommended annual average guideline to 10µgm^{-3} (the previous WHO guideline was 40µgm^{-3} which is also the legal annual average limit). These changes underscore that, despite the significant progress made, accelerated additional action is needed to protect human health. Delivering this action will require the Government to work with the Mayor and provide further powers and resources. The Mayor continues to make the case for these.

The Government is currently in the process of preparing secondary legislation following passage of the Environment Act to amend existing legally binding air quality limits. The Mayor has made the case for these to be aligned with the new interim WHO recommended guidelines, which are based on the best available health evidence. These reflect the overwhelming weight of evidence about the devastating health impacts of air pollution – even at low levels. This summary provides supporting evidence for the WHO guidelines to

[1] The tougher standards for the Londonwide LEZ were enforced from 1 March 2021 and the ULEZ was expanded on 25 October 2021.

be adopted. For example, $PM_{2.5}$ concentrations are much lower than Government modelling assessments had previously suggested.

Comparison with previous analysis published for 2019

In October 2020, City Hall published an initial assessment of London's air quality in 2019. The modelling for this was undertaken by King's College London (now Imperial) and was based on the London Atmospheric Emissions Inventory (LAEI) 2016, alongside a new MER2019 (Mayor's Evaluation Report) snapshot model for 2019. It is important to note that the MER2019 was not a full LAEI model, but rather a "snapshot" based on data from the latter half of 2019. Due to the time required to compile the input datasets the full data for 2019 was not yet available. This meant that some input data for MER2019 had been scaled from previous years. In addition, some of the monitoring data against which the MER2019 is validated was still provisional. This meant the MER2019 results had greater uncertainty than usual LAEI modelling.

With the updated LAEI 2019 we now have a more complete understanding of emissions and concentrations for 2019. Therefore, while the MER2019 and LAEI 2019 analysis are very similar, there have been some minor changes in results. For example, the number of state primary and secondary schools which are estimated to be located in areas which exceed legal pollution limits is now estimated to be 20 rather than 14. Nonetheless the scale of improvement – a 96% reduction from 450 schools in 2016 – remains significant.

Key findings

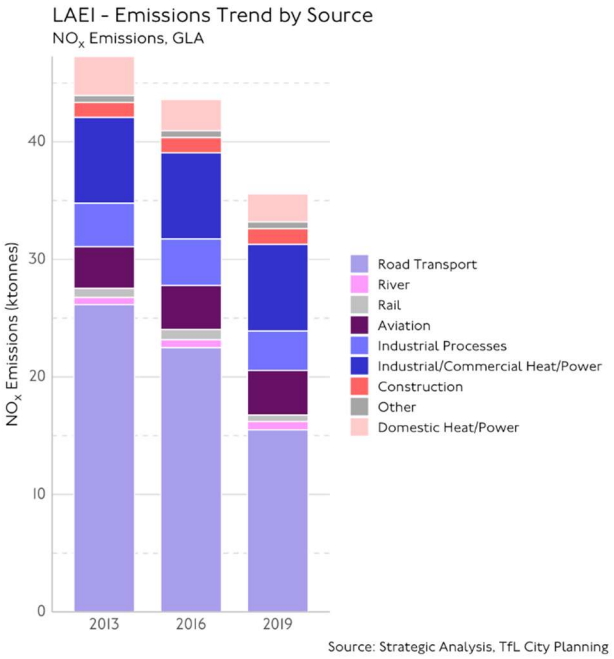
Emissions Trends

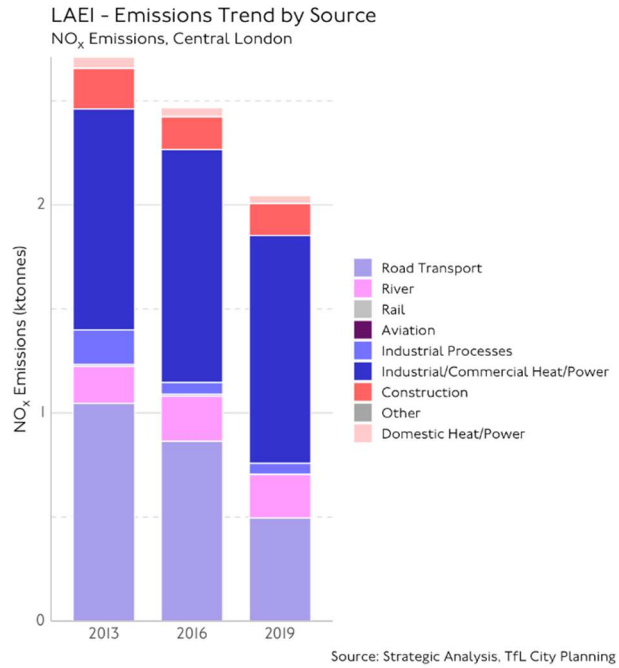
Since 2013, there has been a significant reduction in total NO_x emissions across the whole of London and also in central London. The charts below show the trend in NO_x emissions per source. Compared to 2016, total NO_x emissions have reduced by 18% in Greater London, and 17% in central London. The largest reduction in (tonnes of) NO_x emissions is from road transport in both Greater London and central London, as shown in the graphs below. Road transport NO_x emissions reduced by 31% across London, and 43% in central London, reflecting the impact of the central London ULEZ.

The pace of reductions notably accelerated from 2016.[2] Between 2013 and 2016, the change in road transport emissions in Greater London was a reduction of 14%, therefore the rate of reduction has more than doubled between 2016 and 2019. A comparison against UK emissions reductions[3] show that nationally, road transport NO_x emissions reduced by 10% between 2016 and 2019, far slower than the reductions achieved in London.

[2] A separate study by King's College London looking at the overall rate of improvement in NO_2 levels across London before 2016 found that if the trend of inaction seen between 2010 and 2016 continued, it would take 193 years to reach legal compliance. However, further modelling undertaken for City Hall by King's College London suggests the Mayor's far-reaching policies would reduce this significantly, meaning London's air would be within legal pollution limits for NO_2 by 2025. This report shows we are on track to meet this target.

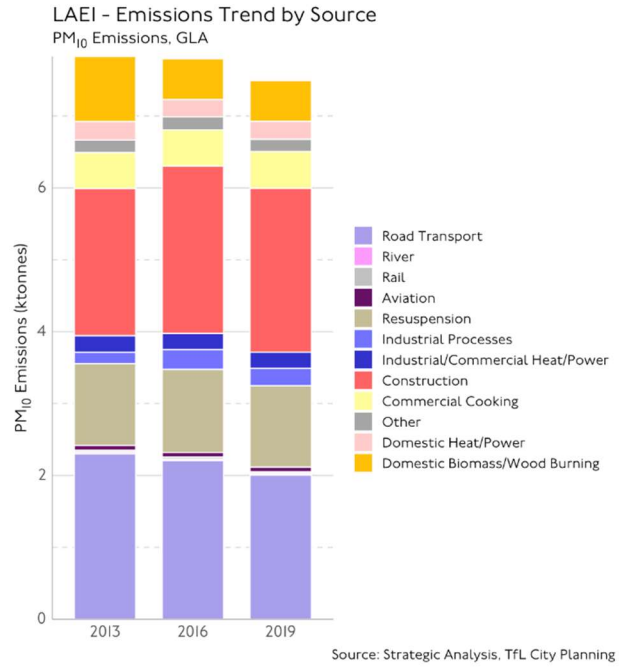
[3] 'Emissions of air pollutants in the UK, 1970 to 2019'. https://www.gov.uk/government/statistical-data-sets/env01-emissions-of-air-pollutants

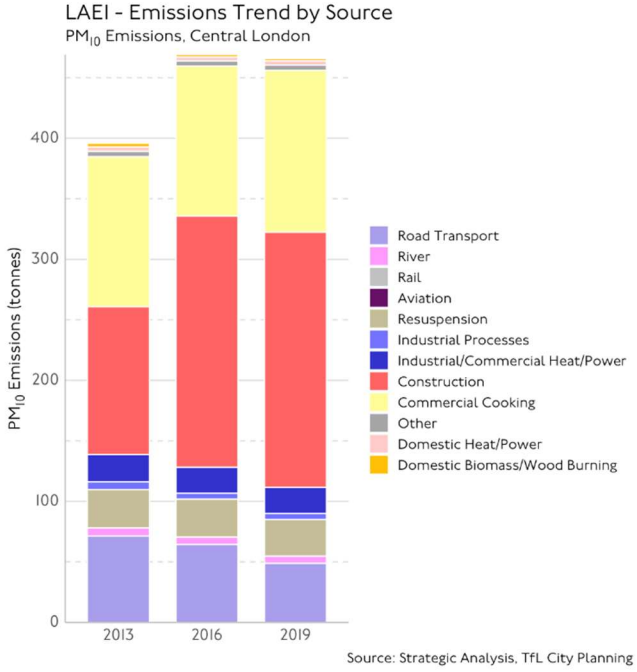




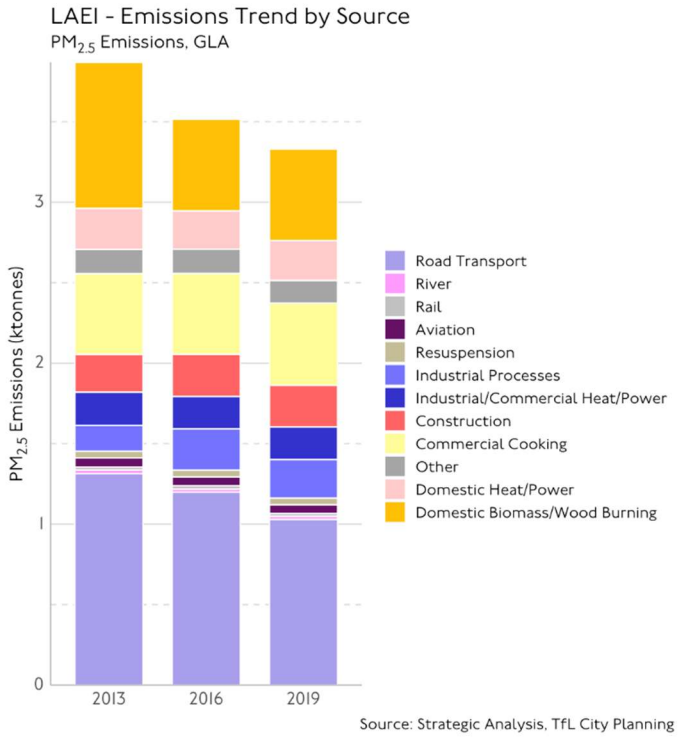
Compared to 2016, total PM_{10} emissions have reduced by 4% in Greater London, and 0.5% in central London[4]. The largest reduction in PM_{10} emissions is from road transport in both Greater London and central London, as shown in the graphs below. Road transport PM_{10} emissions reduced by 9% across London, and 23% in central London, again due to the impact of the central London ULEZ. Between 2013 and 2016, the change in road transport PM_{10} emissions in Greater London was a reduction of 4%, which shows that (as for NO_x) the rate of reduction has more than doubled between 2016 and 2019.

[4] Note that the increase in PM_{10} in between 2013 and 2016, particularly visible in central London, was due to a significant increase in national emission factors to estimate PM_{10} from the construction sector. However, this source of PM is subject to particularly significant uncertainties.

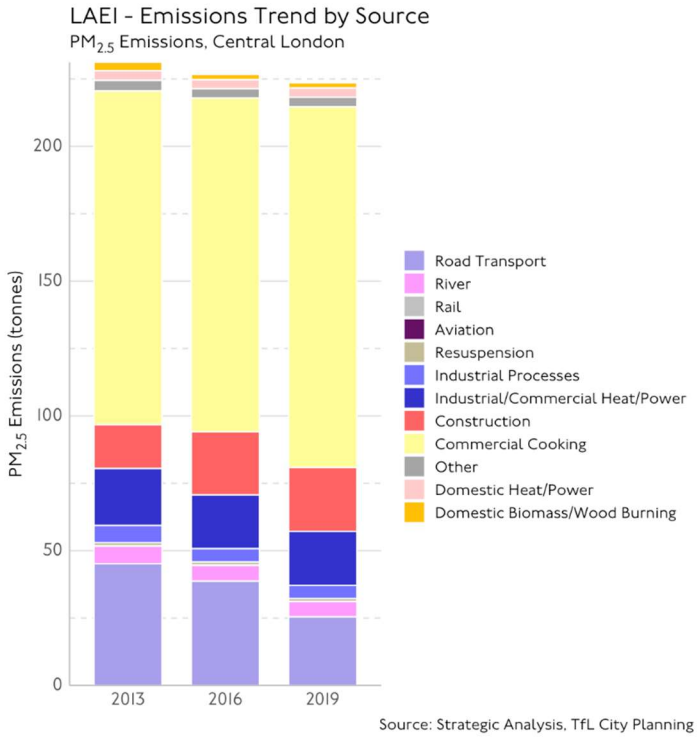




$PM_{2.5}$ emissions have gradually reduced since 2013 across London. Compared to 2016, total $PM_{2.5}$ emissions have reduced by 5% in Greater London, and 1% in central London. The largest reduction of $PM_{2.5}$ emissions is from road transport in both Greater London and central London, as shown in the graphs below. Road transport $PM_{2.5}$ emissions reduced by 14% across London, and 36% in central London. However, little change was seen in other sources. This underlines once again why it is so essential that the Mayor has additional powers to tackle non-road transport sources of pollution, including from buildings, construction, wood burning, commercial cooking and the river.



Source: Strategic Analysis, TfL City Planning

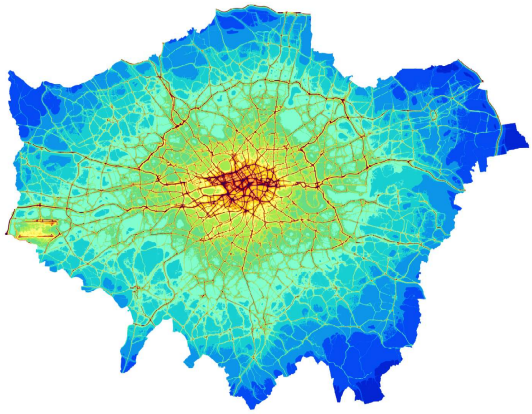


Source: Strategic Analysis, TfL City Planning

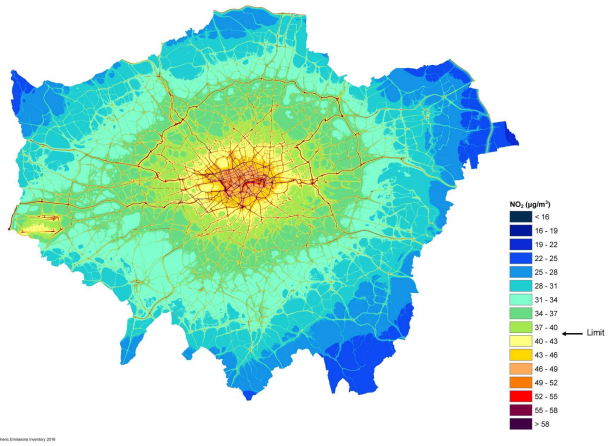
Concentration Maps

The 2019 LAEI provides modelled concentration maps for NO_2, PM_{10} and $PM_{2.5}$. Previous LAEI maps from 2013 and 2016 are provided for comparison.

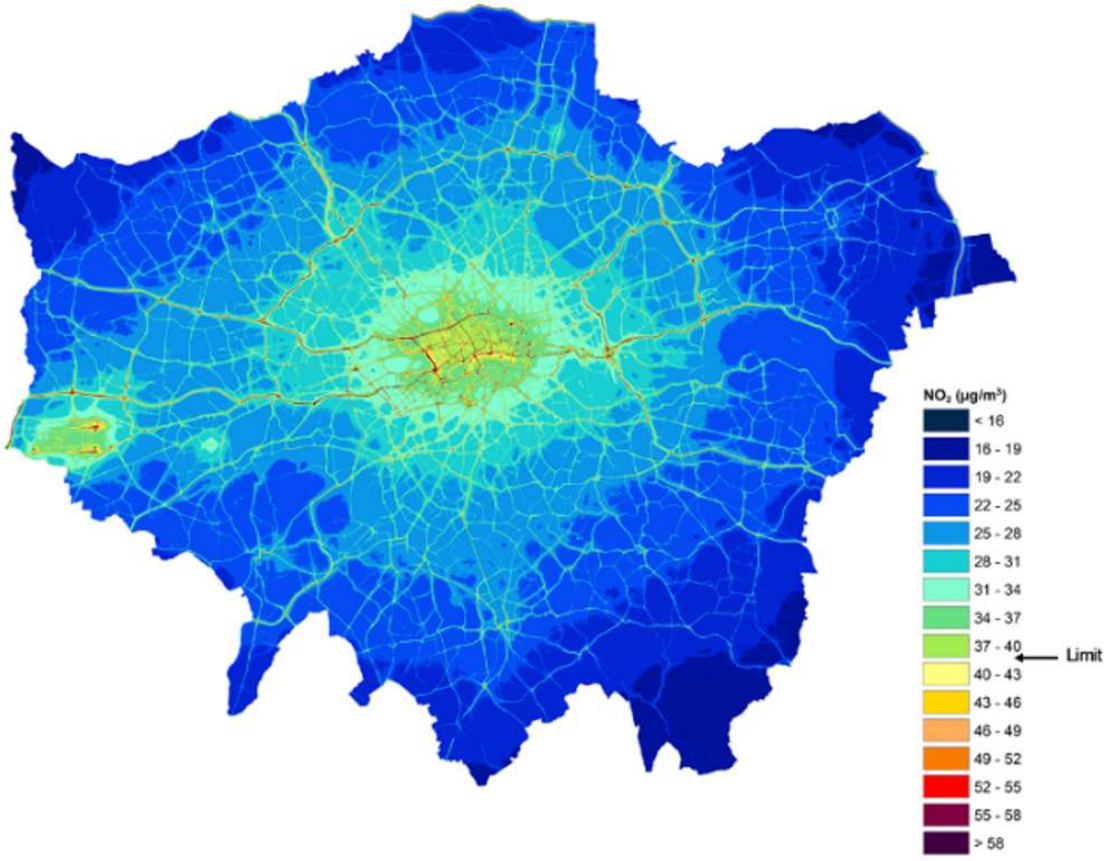
NO_2 Concentrations 2013



NO_2 Concentrations 2016

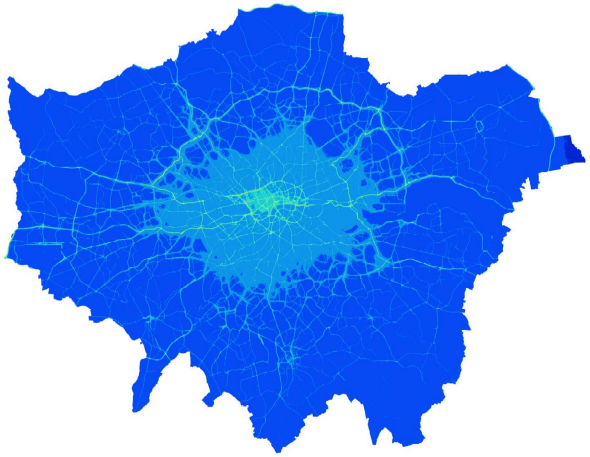


NO_2 Concentrations 2019

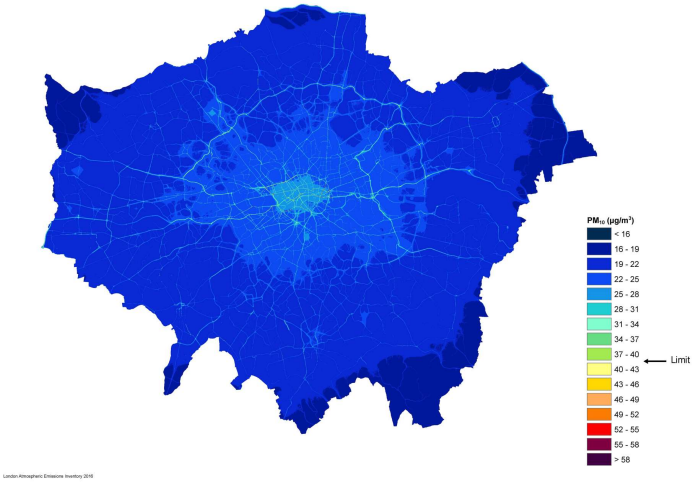


The NO_2 concentration maps show a significant reduction in concentrations across the whole of Greater London from 2016 to 2019 with the majority of the area meeting the legal limit for NO_2 in 2019. These improvements will continue with the recent expansion of the Ultra Low Emission Zone up to the North and South Circular roads on 25 October 2021. Average concentrations of NO_2 are approximately 22% lower than in 2016.

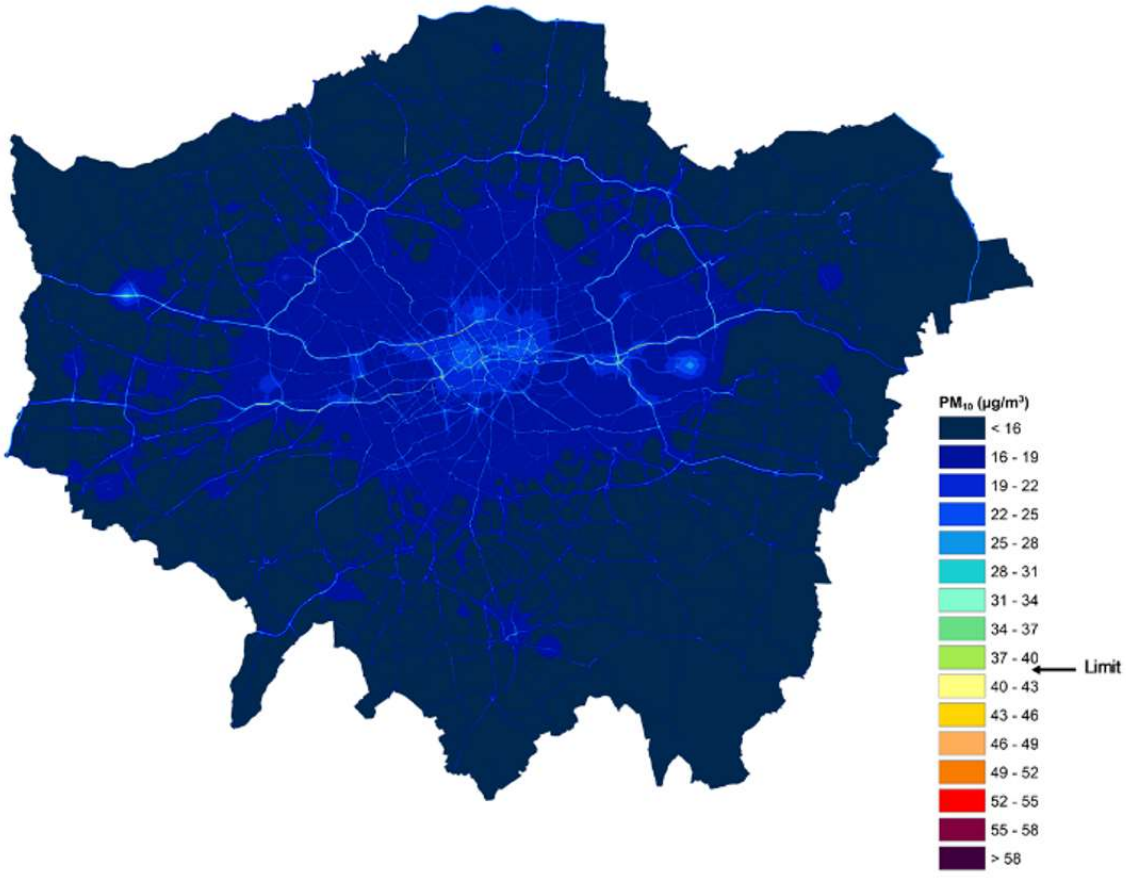
PM_{10} Concentrations 2013



PM_{10} Concentrations 2016

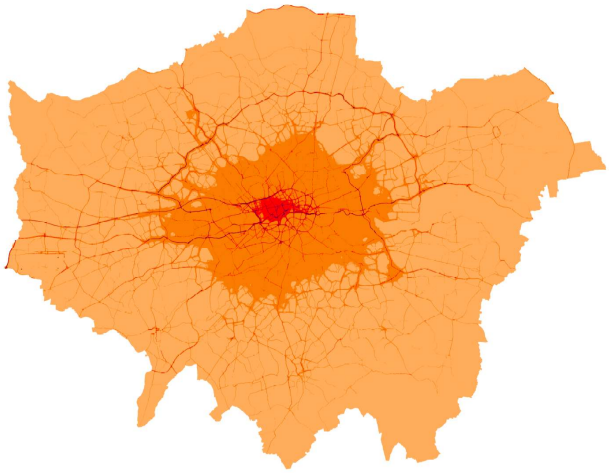


PM_{10} Concentrations 2019

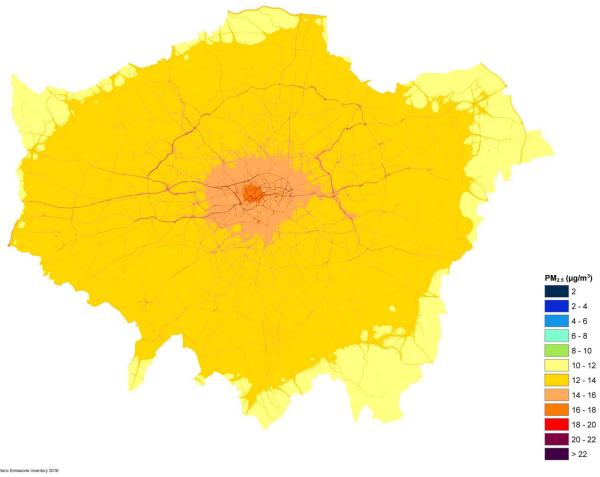


The PM_{10} concentration maps show that the whole of Greater London has experienced reductions in PM_{10} concentrations from 2016 to 2019 with large areas of outer London now in the lowest category on the map for 2019. In addition to local reductions in emissions, PM_{10} is a transboundary pollutant which is influenced by background concentrations and meteorology. Average concentrations of PM_{10} are approximately 24% lower than in 2016.

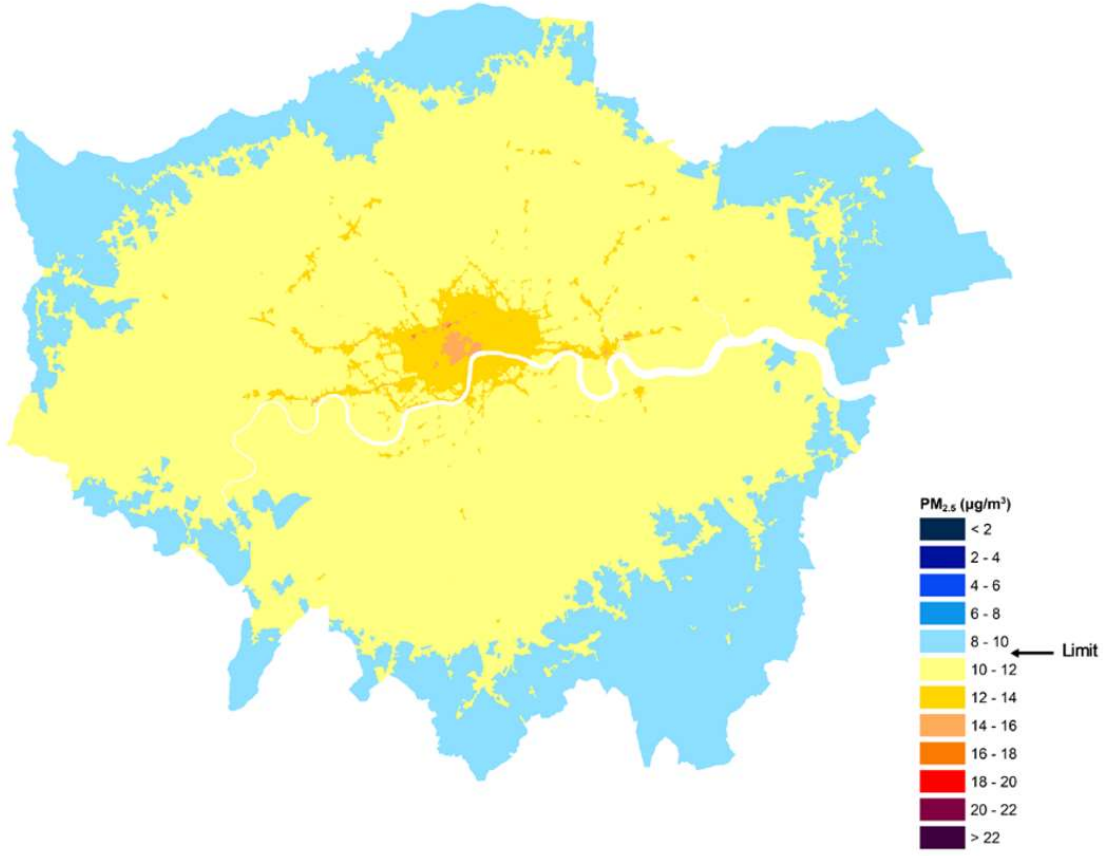
$PM_{2.5}$ Concentrations 2013



$PM_{2.5}$ Concentrations 2016



$PM_{2.5}$ Concentrations 2019



The $PM_{2.5}$ concentration maps show that there was a reduction in $PM_{2.5}$ across the whole of the city with many parts of outer London meeting the WHO interim guideline of 10µgm^{-3} for the first time in 2019. Average concentrations of $PM_{2.5}$ are approximately 19% lower than in 2016 – this includes background and roadside locations. In addition to local reductions in emissions, $PM_{2.5}$ is a transboundary pollutant which is influenced by background concentrations and meteorology.

Major roads meeting legal limits

The proportion of major road lengths[5] exceeding the legal limit for annual mean NO_2 of 40 μgm^{-3} has been assessed estimated based on analysis of concentrations along the edge of roads at approximately 4m distance.[6]

A weighted average along the distance of each road link is used as the concentration varies alongside roads depending on traffic flows and geography, including road width and dispersive characteristics such as tall street canyons and road type. This method presents a reasonably conservative estimate of how compliance against limit values is being achieved in London. It should be noted it is Defra who undertake the formal assessment of compliance; however, this provides a useful way of comparing progress.

- In 2019, 84% of major road lengths in London meet the legal limit for NO_2, this is compared to 46% of major roads lengths in 2016.
- In central London, no major road lengths met the legal limit for NO_2 in 2016, this has improved substantially, and it is estimated that 27% of major road lengths meet the limit value in 2019.

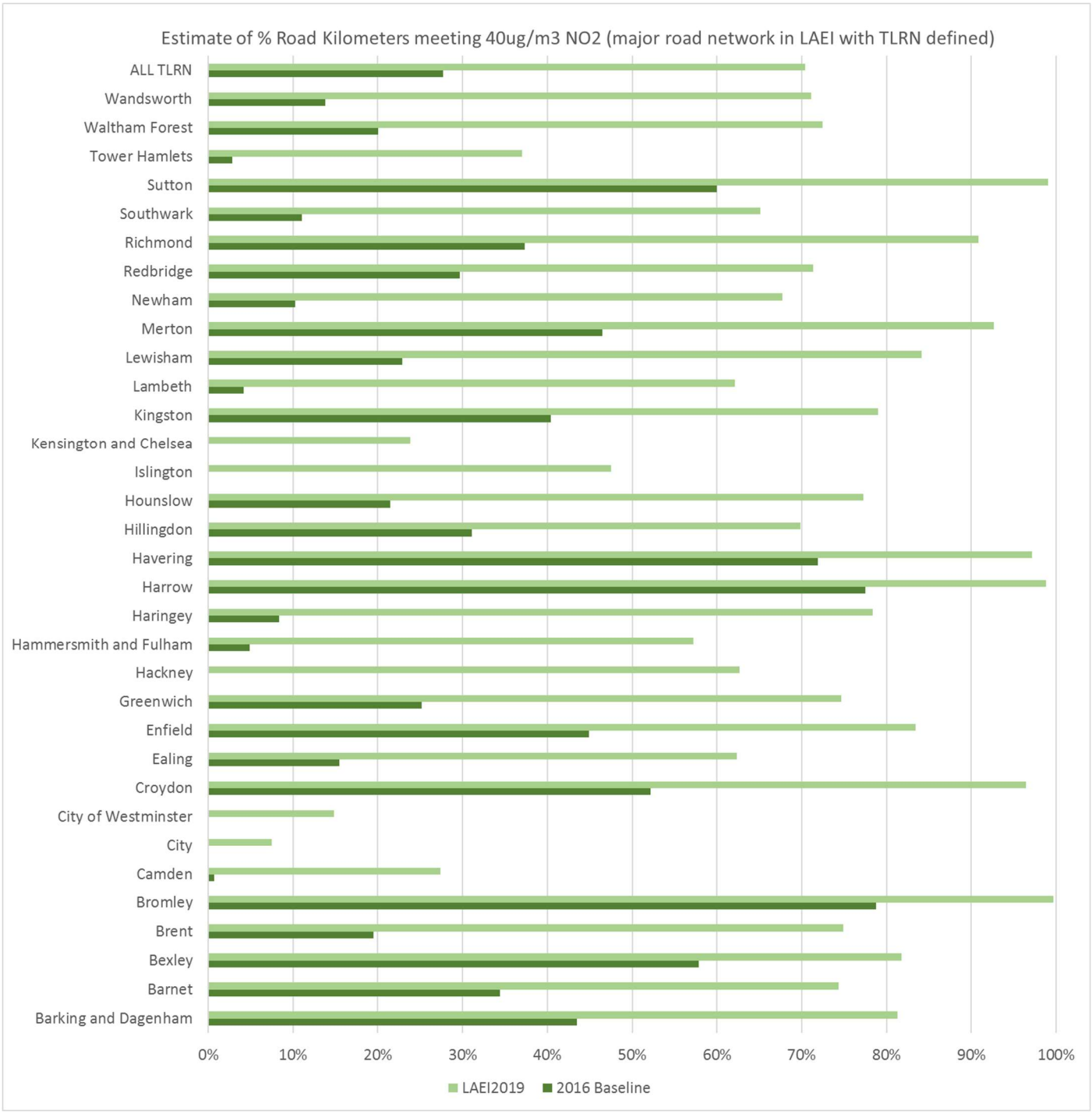
	Exceeding Central	Meeting Central	Exceeding Inner Zone	Meeting Inner Zone	Exceeding Outer Zone	Meeting Outer Zone	Exceeding GLA	Meeting GLA
LAEI 2016	100%	0%	89%	11%	36%	64%	54%	46%
LAEI 2019	73%	27%	26%	74%	8%	92%	16%	84%

Transport for London Road Network (TLRN) or London's 'red routes'

London's red routes form a network of major roads that make up 5% of the roads but carry up to 30% of the city's traffic. In 2016 it was estimated that 29% of the TLRN met the legal limit for NO_2 based on average concentrations at 4m distance. Based on the LAEI 2019 this has increased to 70% of the TLRN. The graph below shows the estimated proportion of TLRN roads exceeding limit values by borough.

[5] Major roads are road links in the LAEI which are assigned traffic flows based on TfL strategic transport models and exclude minor roads and most smaller residential roads across London where there is much lower risk of exceeding the legal limits for NO_2 concentrations.

[6] This provides a similar approach to the national assessment of compliance. Moreover, it can be replicated when new LAEI concentrations become available providing a consistent way of indicating the changes in modelled roadside concentrations.


Estimate of % Road Kilometers meeting 40ug/m3 NO2 (major road network in LAEI with TLRN defined)
ALL TLRN
Wandsworth
Waltham Forest
Tower Hamlets
Sutton
Southwark
Richmond
Redbridge
Newham
Merton
Lewisham
Lambeth
Kingston
Kensington and Chelsea
Islington
Hounslow
Hillingdon
Havering
Harrow
Haringey
Hammersmith and Fulham
Hackney
Greenwich
Enfield
Ealing
Croydon
City of Westminster
City
Camden
Bromley
Brent
Bexley
Barnet
Barking and Dagenham
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
LAEI2019
2016 Baseline

Population exposure

The population exposure data shows that there have been significant reductions in the number of Londoners living in areas of high pollution.

NO_2

- Over 2 million Londoners were living in areas exceeding legal limits for NO_2 in 2016, this has reduced to 174,000 in 2019.
- Over a quarter of those living in central London still live in areas with illegal pollution levels, but overall levels are reduced.
- Average concentrations of NO_2 are approximately 22% lower than in 2016. This includes background and roadside locations because the population estimates are based on average concentrations across census output areas which include all modelled concentrations in that area based on 20m spaced dispersion modelling.
- However, it should be remembered that nowhere in London meets the WHO recommended annual average guideline target for NO_2 of 10μgm^{-3}.

$PM_{2.5}$

- Everyone in London has benefited from improvements in air quality. In particular, nearly 1.2 million Londoners live in areas meeting the WHO interim guideline of 10 μgm^{-3} in 2019. Previously this was estimated to be no Londoners living in areas meeting this target in 2016. Modelled Londonwide average $PM_{2.5}$ concentrations were 2.5μgm^{-3} lower than in 2016 with an average of 10.8μgm^{-3} in 2019 compared to 13.3μgm^{-3} in 2016. However, all Londoners still live in areas above the newly recommended WHO guideline of 5μgm^{-3}.
- Average concentrations of $PM_{2.5}$ are approximately 19% lower than in 2016 - this includes background and roadside locations.
- All Londoners living in areas meeting the 10μgm^{-3} $PM_{2.5}$ interim guideline are in outer London, where there have historically been lower levels of pollution.

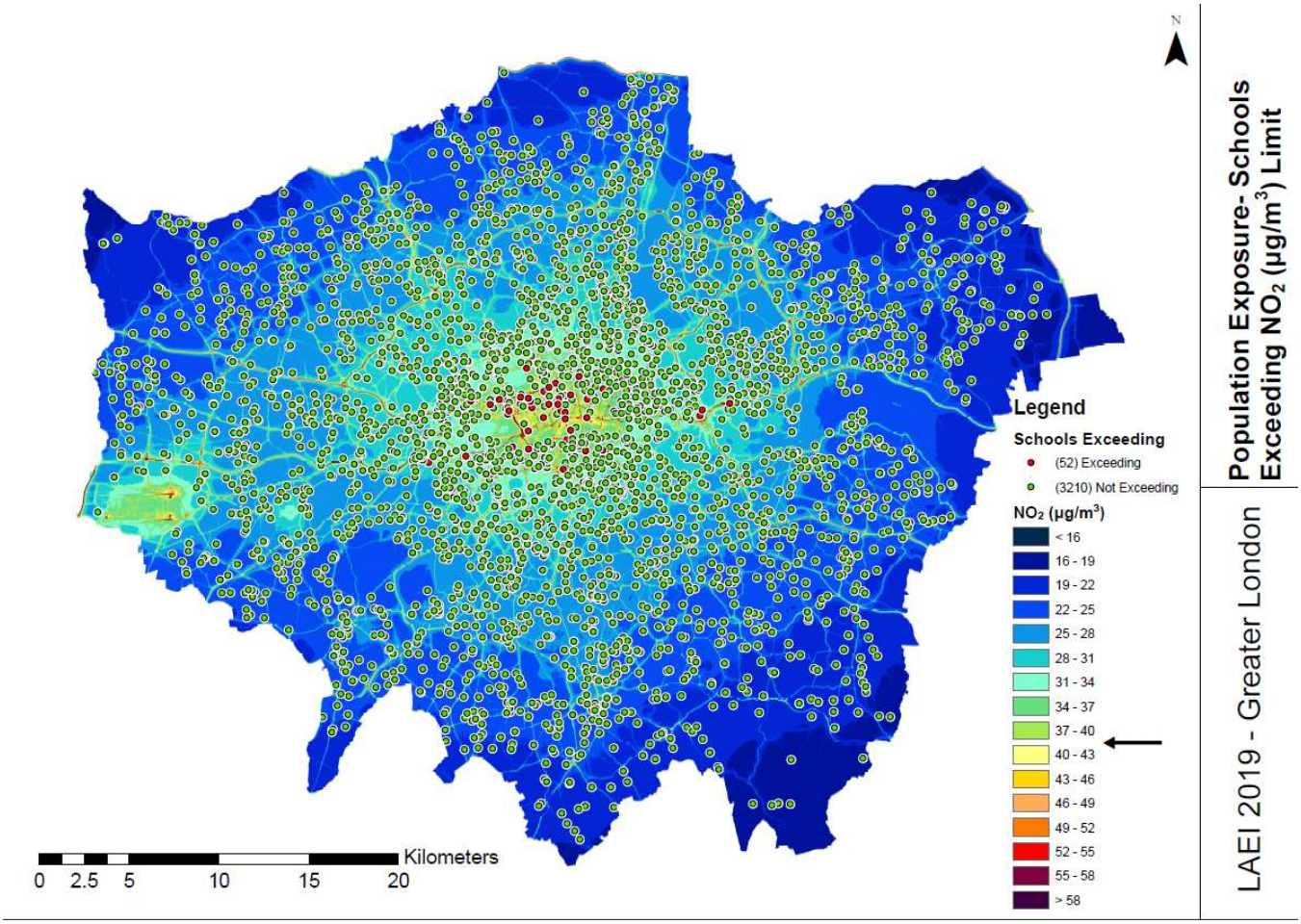
Schools

Analysis on NO_2 concentration data shows that the following number of each type of educational facilities are in areas of NO_2 exceedance of the legal limit in 2019. The NO_2 concentration has been calculated as an average within a 150m buffer of each educational establishment. Analysis shows that of 3,262 education establishments assessed, 52 (1.6%) are in areas exceeding legal limits for NO_2. Analysis shows that of 2,258 state primary and secondary schools, 20 (0.9%) are in areas exceeding legal limits for NO_2. The analysis of $PM_{2.5}$ concentrations (based on 150m buffer) indicates that 88% of schools (2,883 establishments) are in areas exceeding the WHO interim guideline of 10μgm^{-3} with all exceeding the WHO guideline of 5μgm^{-3}.

As explained in the introduction, earlier analysis for 2019 had suggested that only 14 state primary and secondary schools were exceeding rather than the 20 now reported. The reason for the variation is because all schools still exceeding are now very close to the legal limit (40μgm^{-3}), which means very small changes in concentrations as we have updated our modelling can result in a school being classified as located in an area which is either exceeding or compliant with legal limits.[7]

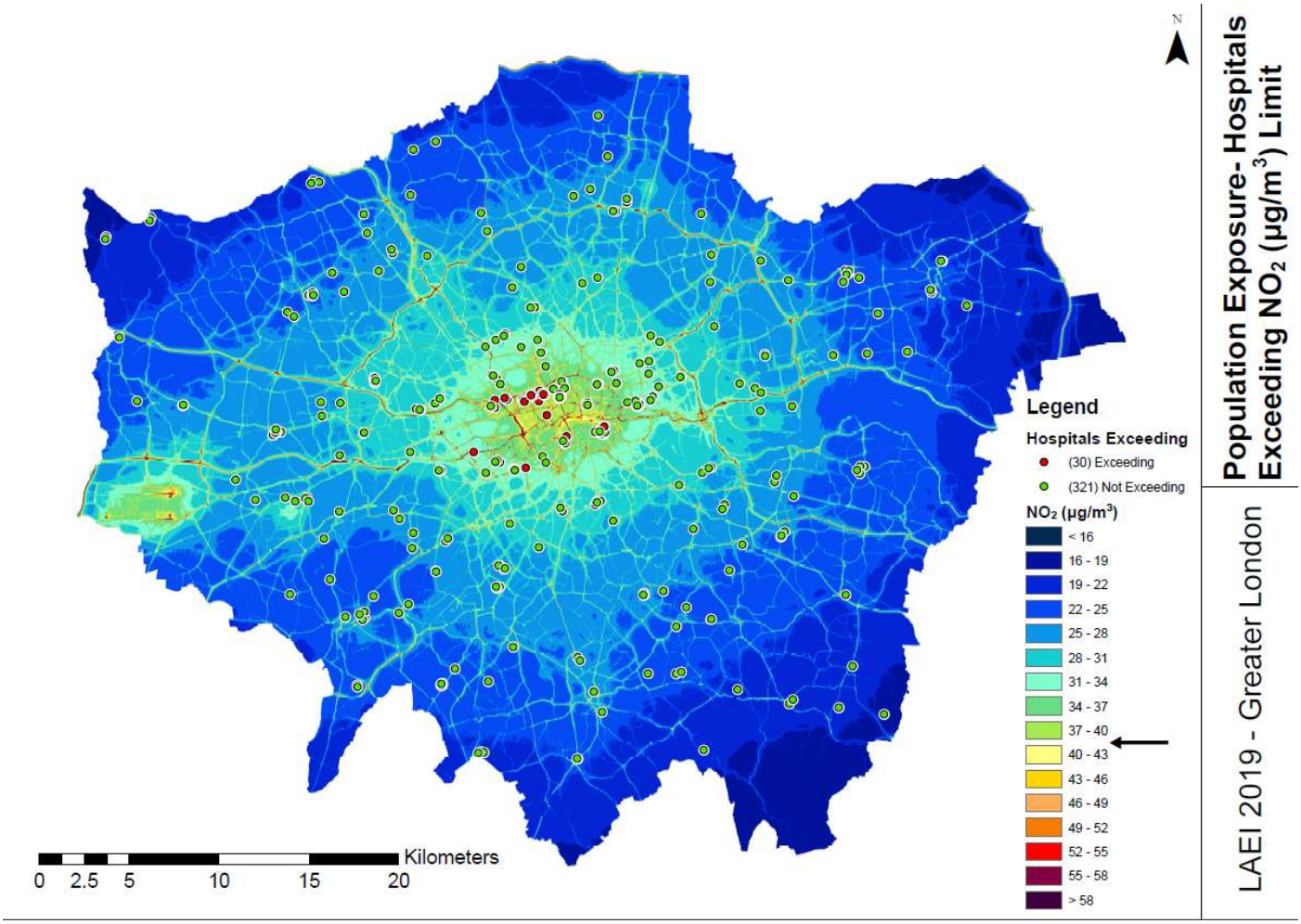
[7] It should also be noted that for some schools which modelling indicates exceed the legal limit by a small margin, boroughs have provided diffusion tube data for 2019 which is within the legal limit. In addition, the Londonwide modelling does not take into account some local level traffic changes, which may also contribute to differences between measurements and modelling. Both modelled and measured air pollution data have an associated uncertainty, and both provide valid results. Both modelled and measurement data are used when prioritising schools to receive assistance from the London Schools Pollution Helpdesk.

Establishment Type	Number	Number exceeding NO2 2019	% Exceeding Type	Number exceeding PM2.5 2019	% Exceeding Type
Nursery	79	0	0.0%	79	100.0%
Primary	1798	15	0.8%	1578	87.8%
Secondary	460	5	1.1%	382	83.0%
16 plus	46	2	4.3%	43	93.5%
Community Special School	79	0	0.0%	72	91.1%
Higher Education Institutions	37	8	21.6%	34	91.9%
Other Independent School	485	18	3.7%	451	93.0%
Other Independent Special School	60	1	1.7%	54	90.0%
Pupil Referral Unit	36	0	0.0%	32	88.9%
Other	182	3	1.6%	158	86.8%
Total	**3262**	**52**	**1.6%**	**2883**	**88.4%**



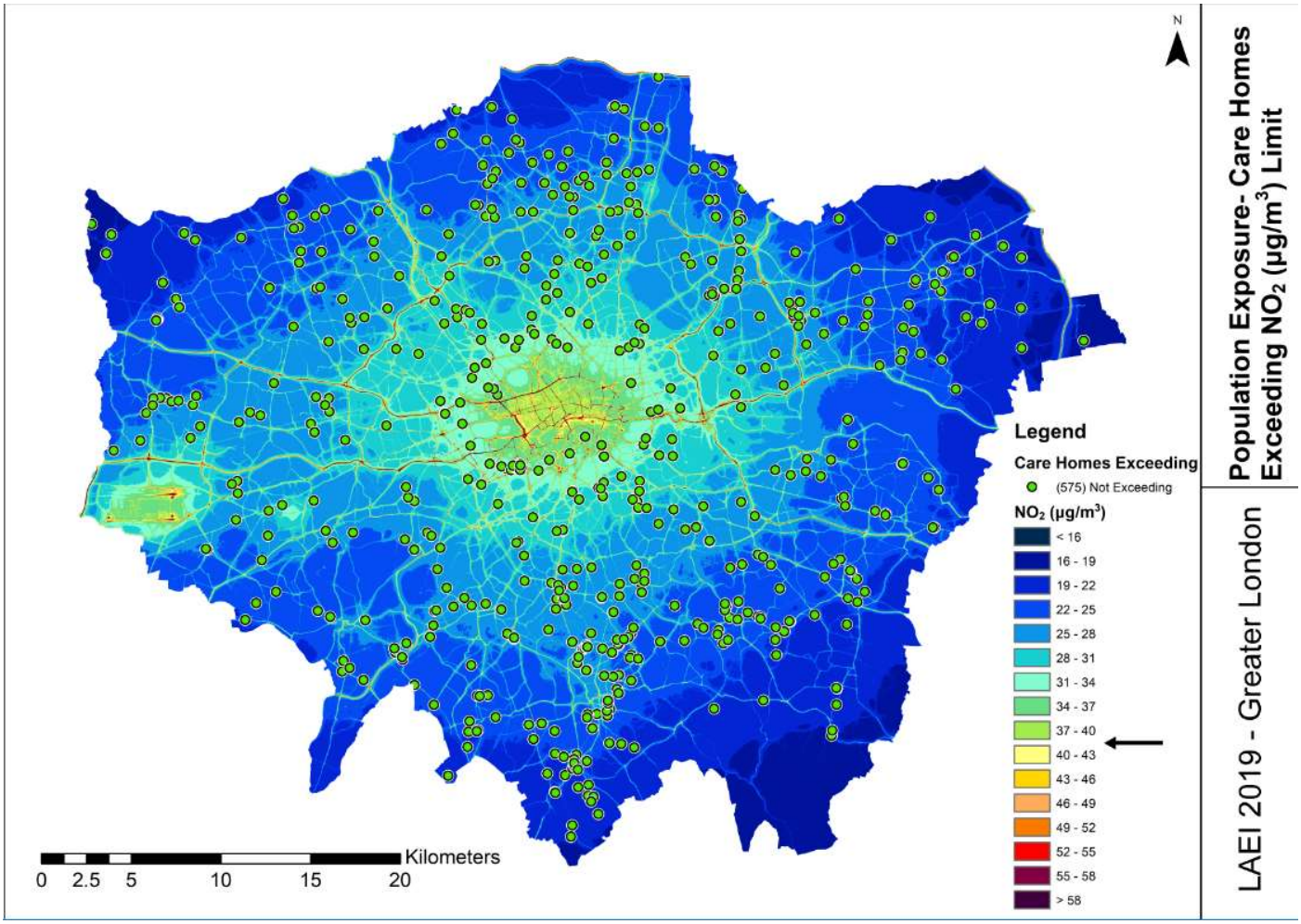
Hospitals

Of an estimated 291 hospitals it is estimated that 26 (9%) of these are in locations where the average NO_2 concentration was above the legal limit for NO_2 in 2019. 295 (91%) of these facilities were in areas exceeding the WHO interim $PM_{2.5}$ guideline of 10µgm^{-3} and all were in areas exceeding the WHO $PM_{2.5}$ guideline of 5µgm^{-3}.


N
Legend
Hospitals Exceeding
(30) Exceeding
(321) Not Exceeding
NO2 (µg/m3)
< 16
16 - 19
19 - 22
22 - 25
25 - 28
28 - 31
31 - 34
34 - 37
37 - 40
40 - 43
43 - 46
46 - 49
49 - 52
52 - 55
55 - 58
> 58
Kilometers
0 2.5 5 10 15 20
Population Exposure- Hospitals Exceeding NO2 (µg/m3) Limit
LAEI 2019 - Greater London

Care Homes

Of an estimated 322 care homes, none are in locations where the average NO_2 concentration was above the legal limit in 2019. 281 (87%) of these facilities are in areas exceeding the WHO interim $PM_{2.5}$ guideline of 10µgm^{-3} and all are in areas exceeding the WHO $PM_{2.5}$ guideline of 5µgm^{-3}.



Emissions data

The LAEI provides a breakdown of pollutant emissions by source, for 1km grid square resolution. The summaries below show that, in 2019, the largest contributing source for NOx and $PM_{2.5}$ emissions is from road transport at 44% and 31% respectively.

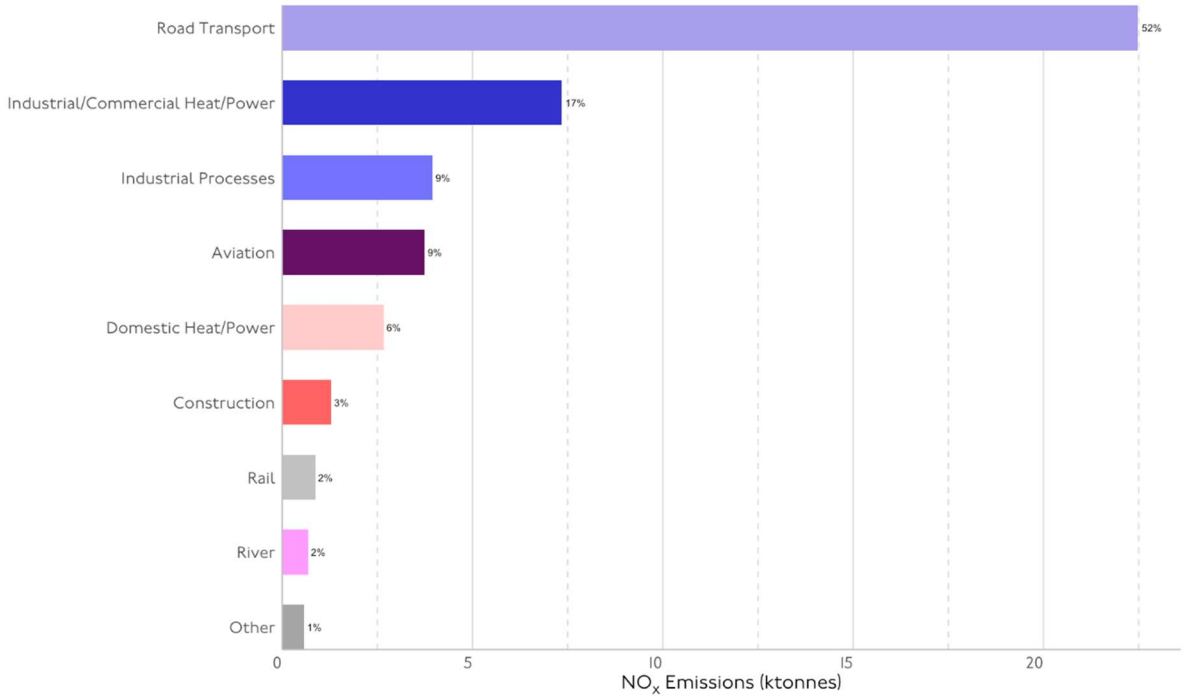
For PM_{10} the largest is construction at 30%, closely followed by road transport at 27%. The $PM_{2.5}$ chart also shows that domestic biomass/wood burning is a significant contributor at 17% of total emissions.

The contribution by source from 2016 is also provided for comparison. It shows a similar source apportionment compared to 2019, although the road transport NOx contribution reduced notably (52% in 2016 vs. 44% in 2019), whilst the contribution of industrial/commercial heat and power combustion sources increased (from 17% in 2016 to 21% in 2019).

Whilst the Mayor, working with boroughs, has put in place some programmes and policies which are having an effect (e.g. the Non Road Mobile Machinery Low Emission Zone), this data shows why it is so essential that the Mayor has additional powers to tackle non-road transport sources of pollution, including from buildings, construction, wood burning, commercial cooking and the river.

LAEI - Emissions by Source

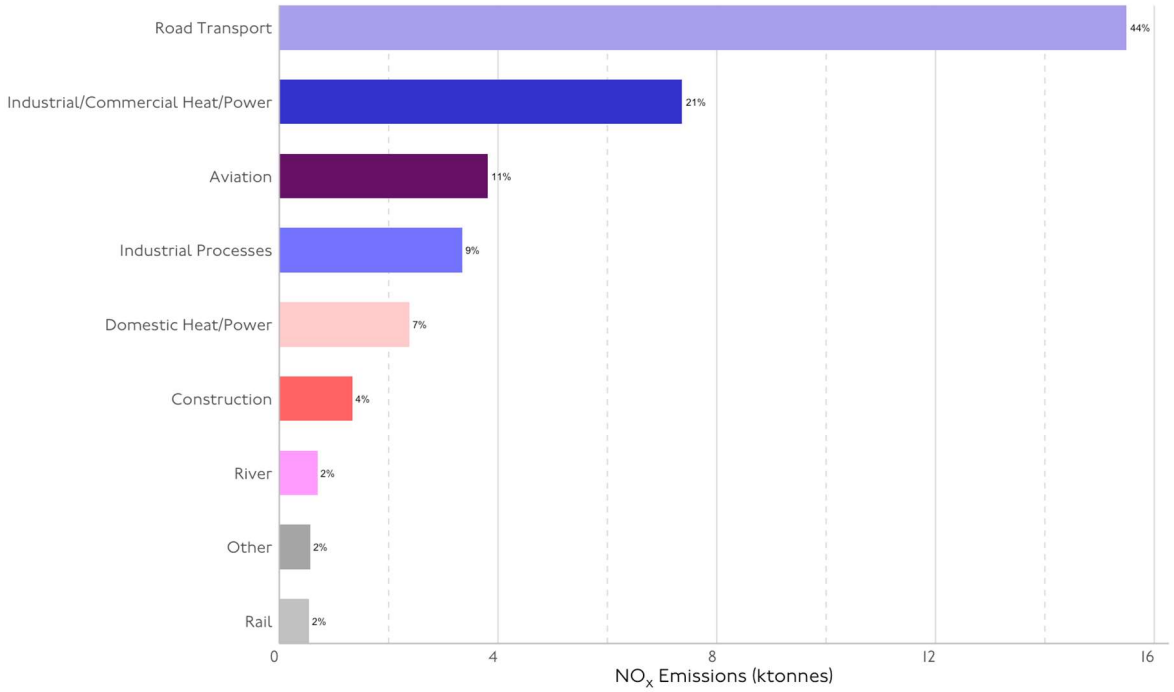
NO_x Emissions, GLA, 2016



Source: Strategic Analysis, TfL City Planning

LAEI - Emissions by Source

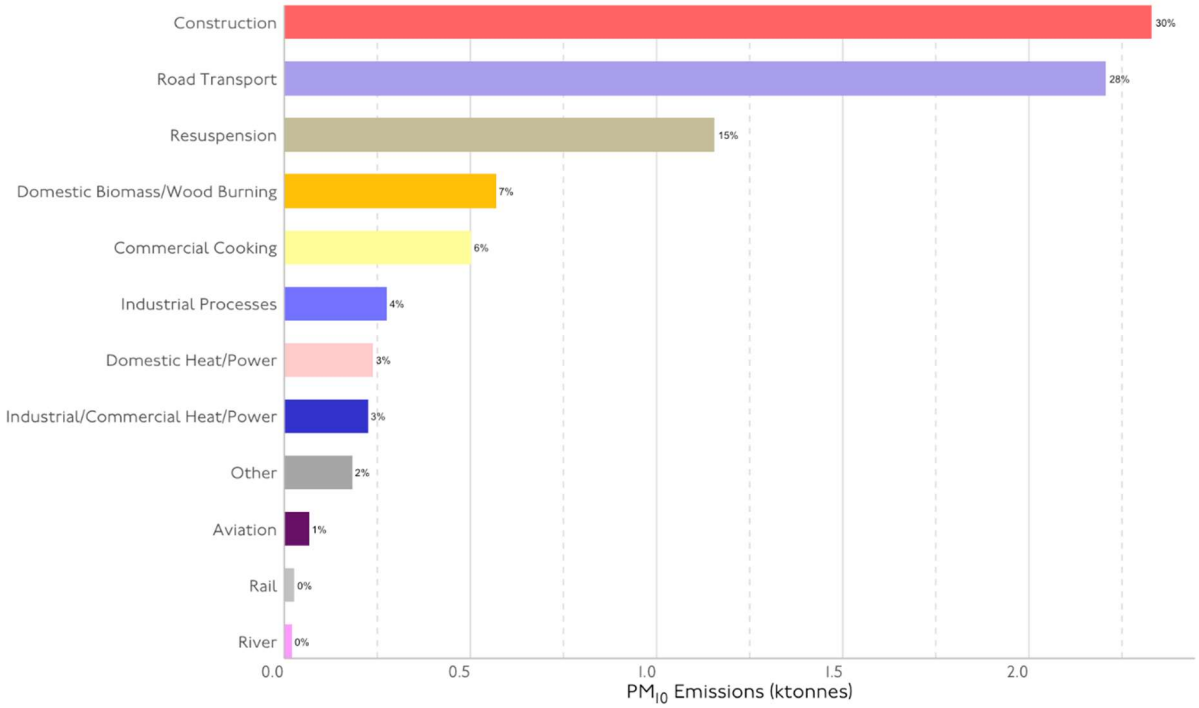
NO_x Emissions, GLA, 2019



Source: Strategic Analysis, TfL City Planning

LAEI - Emissions by Source

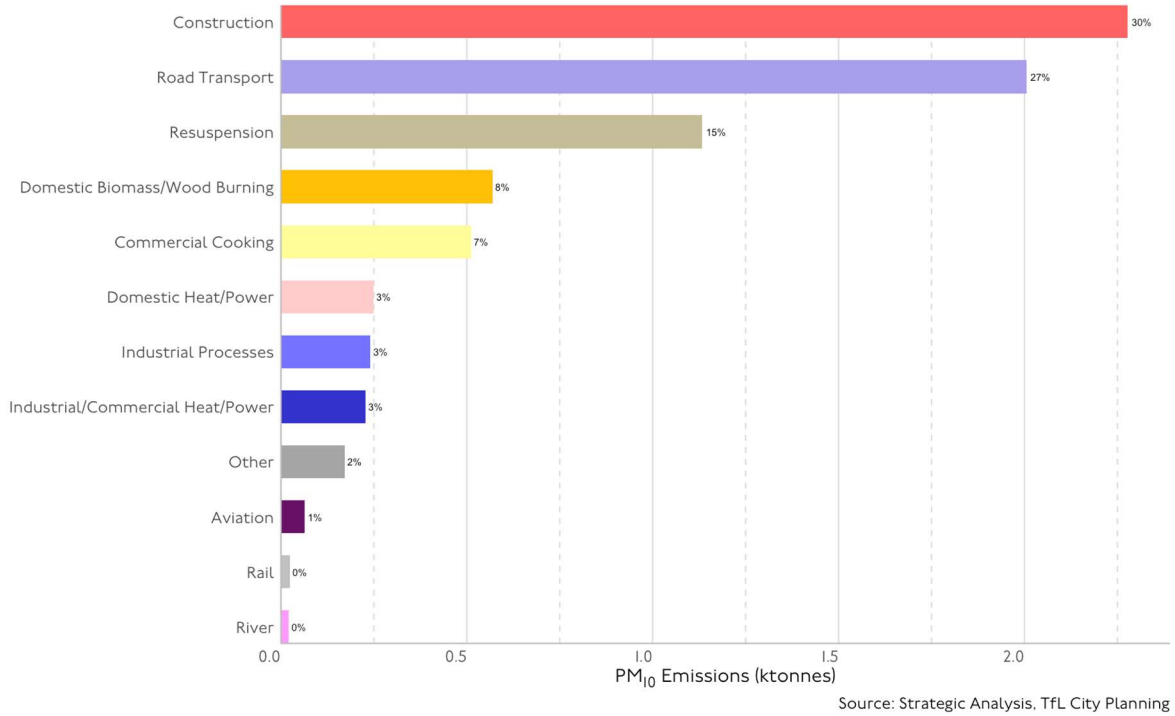
PM_{10} Emissions, GLA, 2016



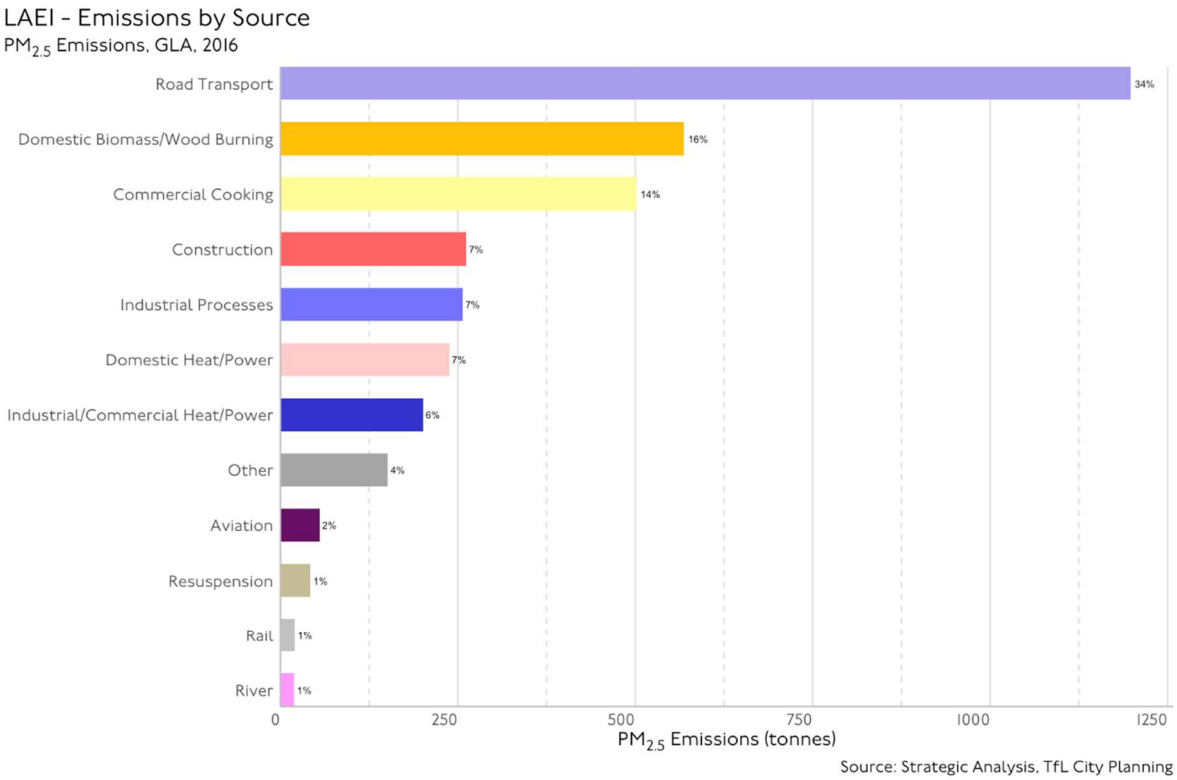
Source: Strategic Analysis, TfL City Planning

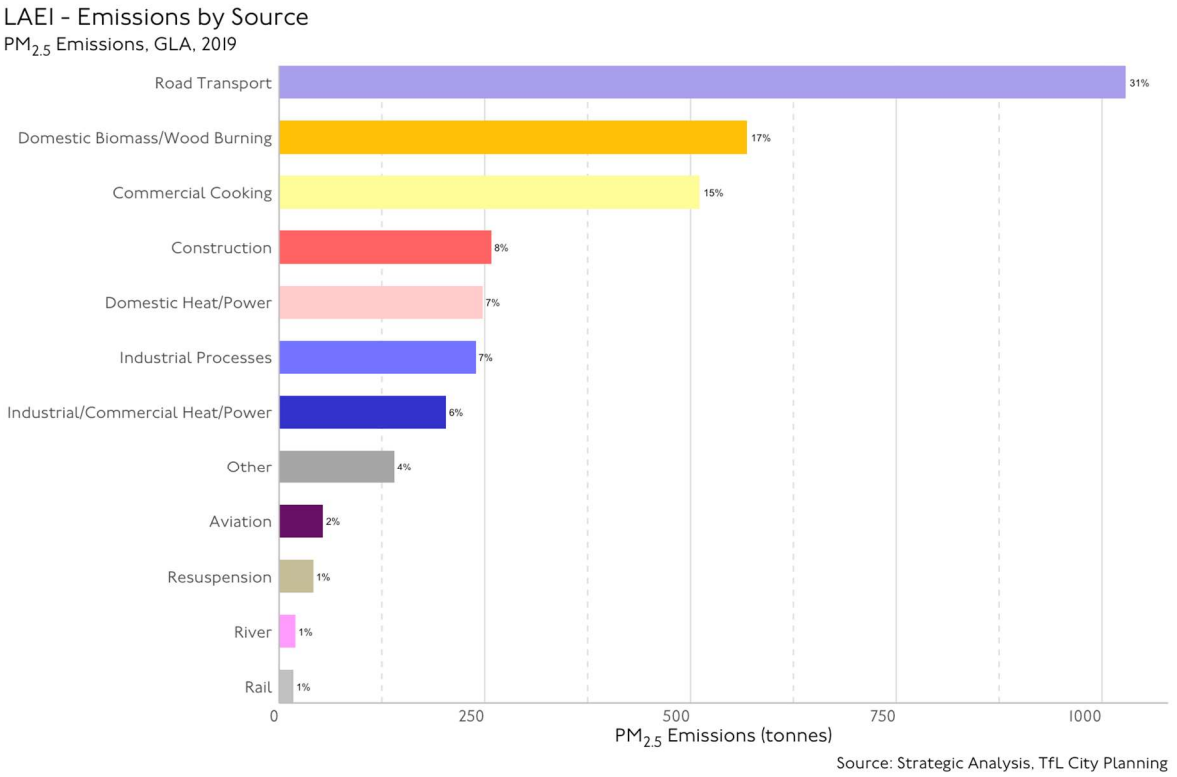
LAEI - Emissions by Source

PM_{10} Emissions, GLA, 2019



Source: Strategic Analysis, TfL City Planning





LAEI 2019 Forecast Data

The LAEI 2019 will also include projections for the years 2025 and 2030, with concentration maps and emissions data for NO_2, PM_{10} and $PM_{2.5}$. This dataset will be available in spring 2022. The data will be available on the London Data Store once finalised.