18th International Conference on
Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes
9-12 October 2017, Bologna, Italy

POLICIES FOR LONDON NITROGEN DIOXIDE (NO_2) COMPLIANCE

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Abstract: Over one tenth of the UK population live in London and since London's air pollution concentrations are predicted to exceed legal NO_2 limits until at least 2030 (DEFRA, 2015), London requires a bold combination of policies to tackle its air pollution problems. Road transport is the most significant source of NO_X emissions in London with diesel vehicles the greatest contributor (TfL and GLA, 2013/2016). The current air pollution challenge, primarily caused by a shift from petrol to diesel vehicles over the last 15 years, needs to be recognised and reversed. Our study in partnership with Policy Exchange (PX), the Institute for Public Policy Research (IPPR) and Greenpeace (GP) builds on the Greater London Authority (GLA) implementation of the Ultra Low Emission Zone (ULEZ) in 2020 (TfL, 2014). Our ambitious air quality strategy proposes a comprehensive package of measures focusing on road transport policies such as phasing out diesel cars in inner London, moving toward more sustainable road transport alternatives, restricting the most polluting vehicles entering London, cleaning up taxi and bus fleets, promoting electric vehicles and car clubs. The proposed policies (the scenario) result in large reductions in NO_X emissions (45%) across London, relative to the projected outcome of the ULEZ (TfL, 2014) from the previous administration (the baseline). Our modelling results suggest significant improvement bringing nearly the whole of London into compliance with legal NO_2 limits by 2025 and decreasing NO_2 concentration levels below 20 μgm^{-3} from 16% in the baseline to nearly 36% in the scenario. This is important since there are still health impacts below the 40 μgm^{-3} limit value. However, some key hotspots of pollution, on major roads, still remain non-compliant and will need additional localised targeted actions. These air quality improvements are projected to have a pronounced positive effect upon health outcomes in the capital. Life expectancy for all Londoners born in 2025 is predicted to improve by 1.6 months. We estimate a gain of up to 1.4 million life-years over a lifetime across the population of Greater London, leading to an estimated annualised economic benefit of up to £800 million, relative to the baseline.

Key words: London Air Pollution, Road Transport Strategy, Dispersion Modelling, Health Impact, Cost Benefit

INTRODUCTION

The legal NO_2 limit value of 40 μgm^{-3} came into force in 2010 (EC, 2016) and, whilst transposed into UK law, will remain in force post Brexit, unless repealed by the British government. Policies and technology have failed to bring NO_2 below the legal limits in London (Beevers et al, 2016) and other cities accross the UK and Europe. Reduced lung function growth, increased symptoms of bronchitis in asthmatic children (WHO, 2016), low birth weight (COMEAP, 2015a) and reduced life expectancy have been associated with long-term exposure to NO_2. There is therefore a legal obligation to decrease NO_2 concentration as well as to tackle air pollution to protect public health, with London's poor NO_2 air quality disproportionately affecting the most vulnerable people arround schools (Howard, 2015), nurseries (Laville et al, 2017) and hospitals (Castres et al, 2017). Walton et al (2015) have estimated that over 9,000 Londoners died prematurely from long-term exposure to air pollution in 2010 and that NO_2 was responsible for up to two thirds of this figure. Dieselisation of the UK fleet over the last 15 years has been prioritised by successive British Governments, with road transport responsible for half of London's total NO_X emissions in 2010 (TfL and GLA, 2013) and diesel cars and vans predicted to make up 70% of London's total road transport NO_X emissions by 2025 (Howard et al, 2016). Tackling road emissions is essential and this study has set out a roadmap of policies that can be implemented now and in the near future toward reaching both compliance and to achieve the lowest, healthiest NO_2 levels possible.

METHODOLOGY

London Air Quality model

In short, KCLurban is a dispersion modelling system based on Atmospheric Dispersion Modelling System (ADMS), which incorporates hourly meteorological measurements, empirically derived NO-NO_2-O_3 and emissions from the London Atmospheric Emissions Inventory (LAEI) (TfL and GLA, 2013). NO_2 annual average concentrations in 2010 were modelled at a resolution of 20x20m using an approach described in detail elsewhere (Beevers et al, 2013). In 2010, the model performed well at roadside and background locations all over London when validated against 87 NO_2 concentration measurements showing low normalised mean bias (-4.8%) and high correlation coefficient (r = 0.88).

Baseline

2025 baseline modelling of NO_2 annual average concentrations (Figure 1a) was based upon the previous London administration's 2020 ULEZ plan (TfL, 2014) such that all vehicles driving in central London from 2020 meet emission standards Euro 4 (petrol) and Euro 6 (diesel) including additional requirements for TfL buses (mix of hybrid and zero emission), taxis and Private Hire Vehicles (10 years old age limit from 2020 and zero emission capable for all new taxis/PHVs from 2018). We acknowledge that the new mayor's air quality strategy (GLA, 2017) is currently under development, but as yet unpublished.

Policy strategy scenario

In partnership with PX (Howard et al, 2015/2016), IPPR (Laybourn-Langton et al, 2016) and GP, we derived a number of targeted policies for London, the UK and the EU. The strategies put forward were mostly focused on reducing NO_X and primary NO_2 emissions but mindful of other pollutants such as PM and CO_2. Our 2025 scenario builds on the 2025 baseline and the following set of assumptions:

- Traffic change: 5% traffic reduction relative to the baseline was applied to all vehicles inside London's inner area (defined as the area inside the North and South circular roads)
- Better Conformity Factor (CF) for diesel cars: CF of 1.5 (0.12 gkm^{-1}) for new Euro6 (and hybrids) bought between 2018 and 2020 and CF of 1 (0.08 gkm^{-1}) afterwards
- Diesel cars phasing out: from 57% (baseline) to 5% diesel cars in Inner area by 2025 (97% of diesel cars assumed a CF of 1) and from 53% (baseline) to 29% in the rest of London (between North/South circulars and M25); i.e. the cars' dieselification trend data for the period 2005 to 2015 (~3% average towards diesel per year) was reversed from 2017 onwards to 2025
- Petrol cars: 15% hybrid and 1.25% LPG across all of London
- Electric cars: 6% inside Inner area and 2.8% in the rest of London
- Diesel vans: from 98% (baseline) to 75% in all London
- Petrol/Electric vans: remaining 25% split between 12.5% petrol and 12.5% electric in all London
- Zero-Emissions Capable (ZEC) taxis: 100% ZEC taxis everywhere in London by 2025
- London transport (LT) buses: Zero emissions LT buses in the Congestion charging Zone (CCZ) and a mixture of Euro6/Euro6 hybrid/Zero emissions in the rest of London
- Domestic and commercial gas: reduction of domestic gas by 20% from 4,025 to 3,236 tonnes and commecial gas by 7% from 3,374 to 3,129 tonnes in 2025

Health and economic impact assessment

For the health impacts analysis, the methodology for assessing the relative risks associated with air pollution was consistent with previous studies from Walton et al (2015), following COMEAP (2010) and WHO (2013) recommendations, but also acknowledging that at the time of writing COMEAP was in the process of issuing new NO_2 health impact guidelines, having recently released an interim statement (COMEAP, 2015b) and a refined recommendation letter (DEFRA and DfT, 2017).

The calculation of health impacts (in life years) started in 2010 and fed in changes in the size and age structure of the population from year to year. The projected future trends in pollution was undertaken by comparing our baseline and scenario in 2025 in which the projected improvements in NO_2 concentrations from 2010 to 2025 were calculated, then sustained for a lifetime to 2129, including new birth cohorts.

Life years lost were valued and annualised using values recommended in DEFRA (2013) guidance, updated to 2014 prices. Values for future life years lost were increased at 2% per annum, then discounted using the declining discount rate scheme in the HMT (Her Majesty's Treasury, 2011) Green Book.

RESULTS

Emissions impact

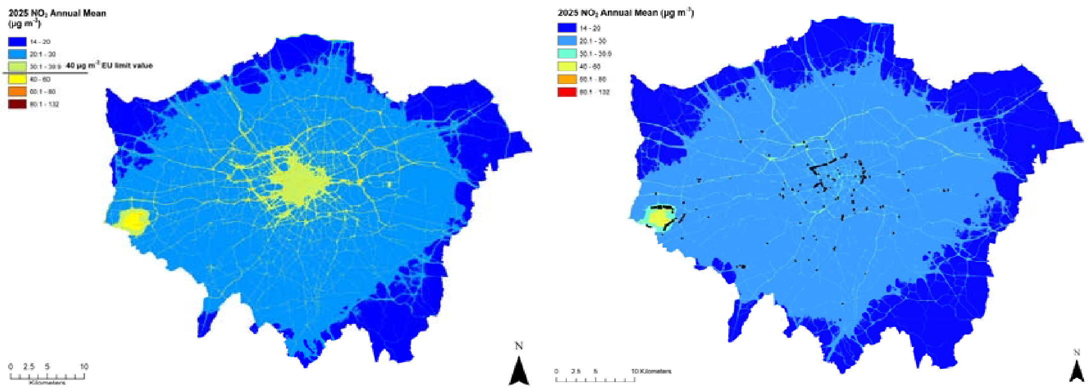
Building on 2025 baseline, our scenario resulted in impressive NO_X (45%) and primary NO_2 (56%) emissions reductions (Table 1) and more modest but non-trivial emissions reductions of CO_2 by 7% and PM by 2% in the Greater London area. The most impactful policy on NO_X reduction is the phasing out of diesel vehicles toward cleaner cars, taxis and buses. Tighter emissions standards are also very important while the other measures have a much less significant effect. In the Greater London area, 81% of the scenario's total NO_X emissions reduction stems from diesel cars while in the central area only, the main NO_X emissions reduction relate to diesel cars (46%), taxis (26%) and buses (26%).

Table 1. Greater London Area road transport emissions (tonnes per annum) in 2025 – baseline vs scenario in 2025

Pollutant	Baseline	Scenario	Reduction
NO_X	9,124	4,983	45%
NO_2	2,533	1,109	56%
PM_{10}	3,033	2,970	2%
$PM_{2.5}$	970	947	2%
CO_2	6,227,303	5,787,405	7%

Air quality impact

The 2025 baseline (Figure 1a) shows that NO_2 concentrations still exceed the legal limit near major roads accross London. By contrast, the 2025 scenario (Figure 1b) almost eliminated exceedences of the NO_2 limit value, with dots marked in black where the model still predicted an exceedence (note, we have been careful not to choose exceedence locations that are within roads/railway lines or airport sites, using a 'mask'). A few areas have been identified as having roads still at risk of exceeding the limit value (e.g. Marylebone Road, Euston Road, Edgware Road and Brompton Road), suggesting that more localised targeted actions in these locations would be required for full compliance. Table 2 shows that the areas of London with NO_2 concentrations lower than 20 μgm^{-3} increased from 16% in the 2025 baseline to 36% in the scenario. This is important since there are still health impacts below the 40 μgm^{-3} limit value.



(a) (b)

Figure 1. Annual average NO_2 forecast concentrations (μgm^{-3}) in 2025: (a) baseline and (b) strategy scenario

Table 2. NO_2 concentrations ranges ($\mu g\ m^{-3}$) as proportion of the Greater London area

NO_2 concentrations	2010 Baseline	2020 Baseline	2025 Baseline	2025 Scenario
<20 μgm^{-3}	0%	5.7%	15.6%	35.67%
20-40 μgm^{-3}	87.3%	92.8%	83.8%	64.29%
40+ μgm^{-3}	12.7%	1.5%	0.6%	0.04%

Health and economic impact

Life-expectancy – The average loss of life expectancy from birth (table 3) has been calculated by assuming exposure to 2025 concentrations for a lifetime, for those born in 2025. If NO_2 levels from 2025 scenario improve as expected, there would be a gain in life expectancy of up to 1.7 months for males and up to 1.5 months for females across all Londoners, when compared with the 2025 base case.

Life years (LY) – Table 3 gives the preferred metric of total LY saved over time as a result of the improvement in NO_2 concentrations due to the 2025 scenario, estimated to be up to 1.4 million life years gained across the Greater London population. For context, the total life years lived for the whole London population, followed up for 120 years, including new birth cohorts, is 1.17 billion LY.
Economic impact (EI) – Table 3 provides an estimate of the annualised monetary benefit of NO_2 improvements due to the 2025 scenario, estimated to be up to £800 million (at 2014 prices).

Table 3. Average loss of life-expectancy, total life years saved and annualised economic impact

Scenario	**Impact on life expectancy (born in 2025)**		**Impact of the improvement in concentration**	
	Males	**Females**	**LY lost**	**Annualised EI**
2025 baseline	Up to -12.5 months*	Up to -11.4 months*	Up to 12.2 million*	Up to £7.1 billion*
2025 scenario	Up to -10.8 months*	Up to -9.9 months*	Up to 10.8 million*	Up to £6.3 billion*

*Up to a maximum value assuming NO_2 is responsible for all the effect and a 30% overlap with $PM_{2.5}$.

CONCLUSION AND DISCUSSION

Our scenario may not deliver full NO_2 compliance across London but it delivered significant progress towards the achievement of the NO_2 air quality limit. Most importantly, the proposed assumptions resulted in considerable NO_2 concentration reductions, down to healthier levels in all parts of London. We found the most effective strategies to be the switch away from diesel and tighter emissions standards. We advocate a combination of policy changes at local level (a ban of diesel vehicles in city centre), UK (the upward trajectory of diesel vehicle's market share must be reversed) and EU level (tighten emissions standard).

People want to live in healthy areas and companies want to invest in areas where people want to live. A recent overall air quality ranking puts London behind other European cities such as Paris and Berlin, and with levels of NO_2 comparable to those of cities such as Shanghai and Beijing (AMEC, 2014). In the context of Brexit, London must increase its attractiveness by tackling its air quality problems. In fact, electric and hybrid vehicles are still a very small proportion of the fleet, even by 2025. The technology is here but past policies, such as a massive shift towards diesel and, periods of inaction have failed Londoners. Walton (2015), PX (Howard et al, 2015/2016) and IPPR (Laybourn-Langton et al, 2016) publications have generated high media attention; a better understanding of the health impacts of air pollution and air quality issues have now risen up the political agenda. There is a demand from the general public to act now and as a result the new London administration is drafting a new and ambitious strategy (GLA, 2017). Policies at London level need to be complemented by immediate action at UK and EU scale. The UK supreme court has ordered the UK government to bring down NO_2 to within legal limits as soon as possible (Client Earth, 2016). Waiting decades for actions or for others to come up with a plan would be unacceptable. In light of the evidence that no exposure is safe, the UK must grasp the oportunity and lead to reduce pollution to negligible levels. Such a policy package must not be limited to but could include phasing out the most polluting vehicles as a priority, shifting all diesel vehicles in favour of the cleanest available alternative, introducing diesel scrappage schemes, accelerating fiscal incentives and rollout of EV, increasing the number of smart charging systems, reducing vehicle kilometers driven, increasing freight consolidation, providing better public transport and sustainable alternatives (walking and cycling), introducing tougher laws and regulations on vehicle manufacturers, accelerating development of new technologies such as regenerative braking, promoting eco-driving and maximising reduction in air pollution from climate change and energy strategy (Williams et al, 2017).

ACKNOWLEDGEMENTS

The authors would like to acknowledge the GLA and TfL, who fund, develop and maintain the LAEI. We would also like to thank Richard Howard at PX, Laurie Laybourn-Langton and Harry Quilter-Pinner at IPPR, Barbara Stoll and Areeba Hamid at GP and Heather Walton at King's College London.

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