

FINAL REPORT

LETHAL & ILLEGAL

SOLVING LONDON'S
AIR POLLUTION
CRISIS



Laurie Laybourn-Langton,
Harry Quilter-Pinner
and Helen Ho

November 2016
© IPPR 2016

ABOUT IPPR

IPPR, the Institute for Public Policy Research, is the UK's leading progressive thinktank. We are an independent charitable organisation with more than 40 staff members, paid interns and visiting fellows. Our main office is in London, with IPPR North, IPPR's dedicated thinktank for the North of England, operating out of offices in Manchester and Newcastle, and IPPR Scotland, our dedicated thinktank for Scotland, based in Edinburgh.

Our purpose is to conduct and promote research into, and the education of the public in, the economic, social and political sciences, science and technology, the voluntary sector and social enterprise, public services, and industry and commerce.

IPPR
4th Floor
14 Buckingham Street
London WC2N 6DF
T: +44 (0)20 7470 6100
E: info@ippr.org
www.ippr.org
Registered charity no. 800065

This paper was first published in November 2016. © 2016
The contents and opinions in this paper are the authors' only.

SUPPORTED BY

GREENPEACE

BOLD IDEAS
for CHANGE

CONTENTS

Summary	3
Foreword	6
1. Introduction	8
2. Air pollution: the problem.....	10
Nitrogen dioxide and particulate matter	10
Sources of air pollution	13
Air pollution from other sources	18
Congestion	18
Summary	19
3. The failure of road transport air pollution policy.....	20
London’s record.....	20
The new mayor’s plans	22
Leaving the European Union	23
4. London transport policies to bring air pollution within ‘acceptable levels’	24
Transitioning away from a polluted London.....	24
Phase 1 – building for compliance (2016–2020)	27
Phase 2 – phasing out diesel (2020–2025)	32
Beyond 2025 – the future of mobility in London.....	34
5. EU and national policy	37
European policy	37
National policy	38
6. Conclusion.....	41
Summary of recommendations	42
References	44
Annex	49

ABOUT THE AUTHORS

Laurie Laybourn-Langton is a research fellow at IPPR.

Harry Quilter-Pinner is a researcher at IPPR.

Helen Ho is an intern at IPPR.

ACKNOWLEDGMENTS

The authors would like to thank all those who contributed to this report. Particular thanks must go to Barbara Stoll, Areeba Hamid and others at Greenpeace for their sponsorship, support and input. At King's College London, we would like to thank Gregor Stewart, David Dajnak, Sean Beevers and others, who conducted the modelling in this paper and whose patient input was greatly appreciated. Thanks must also go to experts from Transport for London, the Greater London Authority and Venn Chesterton.

At IPPR, we would like to thank Michael Jacobs and Jimmy Aldridge.

Any mistakes in this report are the authors' own.

Download

This document is available to download as a free PDF and in other formats at:

<http://www.ippr.org/publications/lethal-and-illegal-solving-londons-air-pollution-crisis>

Citation

If you are using this document in your own writing, our preferred citation is:

Laybourn-Langton L, Quilter-Pinner H and Ho H (2016) *Lethal and Illegal: Solving London's air pollution crisis*, IPPR. <http://www.ippr.org/publications/lethal-and-illegal-solving-londons-air-pollution-crisis>

Permission to share

This document is published under a creative commons licence:
Attribution-NonCommercial-NoDerivs 2.0 UK

<http://creativecommons.org/licenses/by-nc-nd/2.0/uk/>

For commercial use, please contact info@ippr.org



SUMMARY

60-SECOND SUMMARY

Air pollution levels in London exceed legal and World Health Organisation (WHO) limits for NO₂, and WHO limits for particulate matter. In 2010, for example, these pollutants caused a range of health problems in the capital that are estimated to have shortened lives by 140,743 years – the equivalent of up to 9,400 deaths, and representing an economic cost of up to £3.7 billion. Poor air quality in London is causing a public health problem of the highest order: air pollution is the second most significant factor in determining health, after smoking. If London is to continue to flourish and prosper as a global city it must tackle this air pollution crisis.

The principal driver of air pollution in London is road transport and, within that, diesel vehicles. Nearly 40 per cent of all NO_x emissions within London come from diesel vehicles, and unless this is explicitly tackled it will be impossible to cleanse London's air. New modelling by King's College London commissioned for this report estimates that policies bringing the level of diesel cars in inner London down to 5 per cent of the fleet, and increasing cleaner alternatives across other vehicle types, would bring 99.96 per cent of London into compliance with legal levels on NO₂. The central conclusion of this report is therefore that London must progressively phase-out diesel vehicles over the next decade and beyond in order to reduce air pollution levels down to legal and ultimately healthier levels.

This transition will take time, but there is much that the mayor can do now. This report presents a strategy for this mayoral term and the next.

Within the mayor's current term, new policies to reduce air pollution should focus on increases in regulation and road charging, and tax reforms. Investment should then be channelled into sustainable alternatives, including shared transport, and support programmes for those groups most affected during the transition. Beyond 2020, our strategy recommends increases in the extent of road pricing in order to reduce the use of petrol vehicles and road miles.

These measures are likely to have a significant positive impact on London's economy and carbon emissions, as well as on public health. Other global cities such as Paris, Berlin and Delhi are taking radical action to clean their air – it is time for London to do the same.

KEY FINDINGS

- London is breaking legal and WHO limits for NO₂, and WHO limits for particulate matter. Under the existing policy regime the capital is not expected to reach compliance with the legal limits on NO₂ until 2025 or beyond. No level of air pollution exposure is safe.
- Most air pollution in London is caused by road transport, of which diesel vehicles are the most polluting, emitting about 40 per cent of the capital's total NO_x emissions and a similar proportion for PM10.

As such, many diesel vehicles will need to be progressively phased out in order to bring air pollution to within acceptable levels. In the near term, this means legal limits; in the longer run, it will mean reducing emissions down to negligible levels.

- Modelling undertaken by King's College London for this report estimates that policies that would bring the levels of diesel cars down to 5 per cent in inner London, and drive a move towards cleaner alternatives across other vehicle types, would bring 99.96 per cent of London into compliance with legal levels on NO₂.
- These improvements in air quality would result in an estimated gain of up to 1.4 million life-years over a lifetime across the population of Greater London, providing an estimated annualised economic benefit of up to £800 million (see the annex).
- Policies to achieve the reduction of air pollution to acceptable levels will impact millions of those who live, work and travel within and out of London, so significant investment is required in policies to support those groups most affected and to provide alternative and sustainable transport options. Policies must send clear messages to vehicle manufacturers, and the mayor will need to work in concert with other cities and central government.
- Policy at the London level needs to be complemented by action at a nation and European Union scale. Air pollution and road transport manufacture, use and ownership do not respect borders, while the UK's departure from the EU means that legislation on air pollution limits could be repealed and standards reduced.

RECOMMENDATIONS FOR LONDON GOVERNMENT

Phase 1 (2016–2020)

- The mayor should extend the ultra low emissions zone (ULEZ) and accelerate its implementation, including by:
 - extending the ULEZ up to the north and south circular roads, bringing implementation forward to 2019
 - ensuring that diesel cars below the Euro 6 standard and petrol cars below the Euro 4 standard are charged a fee per day if they enter the zone
 - increasing the pollution standard on LGVs within the LEZ so they must meet Euro 5, from the current requirement of Euro 3
 - increasing the pollution standard on HGVs and coaches within the LEZ to Euro 6, from the current requirement of Euro 4
- Transport for London should procure only hybrid or zero emissions buses from 2018 and increase the emissions standard on TfL buses to Euro 6 within the expanded ULEZ.
- Central government should devolve vehicle excise duty to the London level.
- The mayor should require all newly licensed private hire vehicles to be zero-emissions capable from 2018.
- The mayor should call on central government to provide a diesel scrappage scheme.

- Transport for London should determine any temporary exemptions and discounts for those most adversely affected by the expanded ULEZ.
- The mayor should include a plan for the expansion of the car share market in his new transport strategy.

Phase 2 (2020–2025)

The mayor should:

- ensure that all Euro 6 diesel cars are charged within the expanded ULEZ by 2025, announce the plan to charge all diesel cars in the expanded ULEZ as soon as possible
- increase the pollution standard on LGVs within the LEZ so that they must meet Euro 6 by 2025
- ensure that all buses are zero emissions within central London, and on major routes where air pollution levels are particularly acute
- implement a ban on all diesel taxis across London in 2025
- introduce an emissions charge on all non-zero-emissions cars across inner London by 2025
- consider introducing a zero emission zone across central London from 2025
- mandate TfL to investigate the potential for a smart charging system and an integrated road pricing scheme in London
- ensure the revenues raised by road charging are reinvested into the public transport network and other alternative, sustainable transport options.

OTHER RECOMMENDATIONS

Influencing EU policy

- The mayor should work with other city mayors around Europe to argue for implementation date of the conformity factors to be brought forward, eventually introducing a conformity factor of 1 by 2021.

National policy

The government should:

- introduce a new Clean Air Act that targets air pollution, including nitrogen oxides and particulate matter
- introduce a diesel scrappage scheme
- progressively reform the VED regime to disincentivise diesel cars relative to petrol.

The Department for Transport should:

- convene all relevant departments to ensure the transport analysis guidance accurately reflects the cost of air pollution within its appraisal process.

FOREWORD

There is now overwhelming evidence that both long-term and short-term exposure to small particles and gases from fossil-fuel derived air pollution have major adverse consequences on health. The fact that this is an invisible and odourless killer – unlike the great smogs of the 1950s – has meant that we have been sleepwalking into a health crisis that has already claimed thousands of lives.

Thankfully, perceptions are changing, due to the accumulation of epidemiological evidence, the persistence of campaigners and a growing media debate. In London, this is beginning to translate into concerted political action to begin dealing with the problem. But, as this report outlines, there is still much further to go.

Diesel fumes are responsible for over 40 per cent of harmful nitrogen dioxide (NO₂) emissions in London – a city with the unfavourable distinction of having the highest NO₂ levels in Europe. Diesel vehicles were promoted because historically they emitted less carbon dioxide (CO₂) than petrol – even though the evidence that diesel engines emit more NO₂ pollution was well known at the time. This report, and the scientific modelling that it is based on, shows the unacceptable, and now unnecessary, consequences of this policy. In order to bring down dangerous NO₂ levels, the recent upward trajectory of diesel's market share must be reversed.

So what can we do to make sure that children born today will not grow up breathing air that both damages their lung growth and sets them on a path for increased risk of long-term lung and cardiovascular disease and cancer?

First, we need continued public pressure on politicians – and this report, by highlighting the actions that will make a real difference to London's air pollution, provides an excellent toolkit.

Second, we need academics to calculate the full economic cost of air pollution, taking into account the fact that exposure significantly increases risk factors for disease and onset disease over the life-course.

Third, we must tackle the causes of modern air pollution at their roots, and with equality foremost in our minds – otherwise we risk simply displacing the problem. We must move away from the diesel engine, and indeed the internal combustion engine, as quickly as possible. It is inexplicable why taxation remains structured to encourage diesel cars, especially when diesel cars are now producing as much CO₂ as their petrol counterparts. The motor industry and the emissions testing regime must be brought into check, and no longer allowed to produce car after car that emits far more toxins than the legal limits allow. And the fact that the most deprived portion of our population is exposed to the highest levels of traffic-derived pollution means that, if this country is serious

about reducing health inequalities, the improvement of those people's health should be the benchmark by which this and future governments are eventually judged.

Eight out of 10 people in the UK now live in cities, with some 12.5 per cent of the UK population living in the capital. Cities of the future will continue to grow. The biggest challenge facing governments at national and local levels is, therefore, to ensure that these cities are liveable. Cleaning up the air is an urgent and necessary step. We have the technology, and the benefits of moving away from diesel and fossil-fuel vehicles to health, to the economy, and to the climate will be significant. All we need is the political courage to do so.

Professor Jonathan Grigg FRCPCH

Professor of Paediatric Respiratory and Environmental Medicine

Professor Chris Griffiths FRCP FRCGP

Professor of Primary Care and Co-Director, Asthma UK Centre for Applied Research

Professor Stephen T Holgate CBE, FMedSci

Special Adviser to the Royal College of Physicians

1. INTRODUCTION

*'I asked him whether there was a great fire anywhere?
For the streets were so full of dense brown smoke that
scarcely anything was to be seen.*

"O dear no, miss," he said. "This is a London particular."

Charles Dickens, *Bleak House* (1853)

Pollution in many parts of the UK remains at illegally high levels, and has a lethal effect upon human health. Across the country, the annual mortality burden of outdoor air pollution is equivalent to approximately 40,000 deaths, representing an economic cost to society and the economy of over £20 billion a year (RCP 2016). Globally, air pollution accounts for around 1 in 10 deaths (WB & IHME 2016). This is a public health emergency of the highest order.

London has become a central focus for understanding air pollution and its effects, efforts to combat the problem, and the subsequent failure to do so. Air pollutants in the capital cause a range of health problems that are estimated to have shortened lives by 140,743 years – the equivalent of up to 9,416 deaths – and to represent an economic cost of up to £3.7 billion in 2010 alone (Walton et al 2015). As a result, the UK has been threatened with fines and legal action (EC 2010a, PA 2016), and London has seen its position in liveability rankings drop behind major global cities, such as Berlin and Paris, which have already phased out many polluting vehicles (Collinson 2016). In turn, successive mayors have introduced a slew of measures designed to reduce air pollution levels. These policies have failed to bring London's air pollution below legal levels, and it is predicted that the capital will not reach compliance with these levels before 2025.

The largest contributor to air pollution in London is road transport. Diesel vehicles are the greatest single source of some air pollutants, including around 40 per cent of nitrogen dioxide emitted in the capital (LEAC 2015). It will not be possible to address the air pollution crisis in London without tackling this principal source of the problem. This report will set out the role of transport in London's air pollution problem, its scale and effects, the efforts taken to highlight and combat it, and show the level of action required to ensure London reaches acceptable levels of air pollution.¹ Its central conclusion is that achieving compliance is contingent on the accelerated phase-out of the diesel engine across inner London and that this should therefore be the priority of air quality policy. It will provide a suite of immediate policies and long-run ambition to make this happen. Chapter 2 begins by looking at the causes and effects of air pollution in London, with chapter 3 reviewing the efforts made by mayors to understand and

¹ This report builds on a discussion paper – *Lethal and illegal: London's air pollution crisis* – that we published in July 2016 (Quilter-Pinner and Laybourn-Langton 2016).

overcome them. Chapter 4 uses new modelling results to illustrate the scale of ambition required. Here we provide policy recommendations, and consider the socioeconomic and health impacts of these policies. Chapter 5 considers national and international policy responses, while chapter 6 concludes by providing a summary of our recommendations.

2. AIR POLLUTION: THE PROBLEM

Air pollution exposure is one of the most severe public health problems in the world. Around 1 in 10 of total deaths worldwide are attributable to air pollution – over six times the number of deaths from malaria and more than four times those caused by HIV/AIDS (WB & IHME 2016). The economic cost of forgone labour resulting from these deaths is estimated at US\$225 billion a year.

NITROGEN DIOXIDE AND PARTICULATE MATTER

Many particulates and gases are classed as air pollutants.² In this report, we shall focus on nitrogen dioxide (NO₂) and particulate matter (PM) because both have particularly high concentrations and quantified public health impacts in the UK (Defra 2015a). NO₂ is a gas and part of the oxides of nitrogen (NO_x) compounds family. NO₂ can be directly produced through combustion, while other sources include the oxidation of nitric oxide (NO) in the air (RCP 2016). The levels of nitrogen oxides measured at roadside points throughout UK cities are also highly correlated with the concentration of particles in the air.

Particulate matter is the complex mixture of minute particles and liquid droplets suspended in air. Concentrations of particulate matter refer to the amount of particles of certain aerodynamic diameters. PM10 refers to particles that are generally less than 10 micrometres (µm) in diameter, while PM2.5, a subsection of PM10, refers to those less than 2.5 µm in diameter. PM can include carbon, oxides and salts of metals, ammonium nitrate and ammonium sulphate, and some organic materials, like fragments of soil.

Health impacts

The differentiation between PM10 and PM2.5 is important from a public health perspective because particles less than 10 cubic micrometres (10µm) in diameter often bypass filtration in the nose and can enter the lungs; indeed, ultra-fine particles of <0.1 µm in diameter, which are included in the PM2.5 measure as a small part by mass, are able to pass into blood circulation. PM2.5 is considered a greater risk to public health, particularly in terms of mortality and the results of long-term exposure, than the coarser range of PM10 (2.5–10 µm) as it penetrates deeper into the lung (WHO 2013a). To make matters worse, throughout most locations in Europe PM2.5 accounts for around 50–70 per cent of PM10 (ibid). Both short- and long-term exposure to PM10 and PM2.5 cause respiratory and cardiovascular morbidity, including the aggravation of asthma and respiratory symptoms, and mortality from cardiovascular and respiratory diseases and lung cancer, while exposure in the womb is linked to low birth weight (RCP 2016).

² For a list of the major air pollutants affecting health outcomes in the UK see RCP 2016.

NO₂ is also associated with a number of negative health outcomes. Exposure can increase the chance of respiratory problems, decreased lung function, and increase the change of respiratory infections (COMEAP 2015a). Long-term exposure to NO₂ is associated with respiratory infections in childhood and low birth weight (EPA 2016). The Committee on the Medical Effects of Air Pollutants (COMEAP) has estimated that 29,000 ‘equivalent’ deaths are caused annually from exposure to PM2.5 in the UK (COMEAP 2010) – a figure which increases to 40,000 when considering the related effects of NO₂ (RCP 2016). In London, Transport for London (TfL) and the Greater London authority (GLA) commissioned King’s College London (KCL) to study the morbidity and mortality burden, and the associated economic costs, of PM2.5 and NO₂ (Walton et al 2015). In doing so, KCL estimated that the mortality burden of PM2.5 in 2010 was 52,630 life-years lost, or the equivalent of 3,537 deaths, while that for NO₂ was estimated at 88,113 life-years lost, or the equivalent of 5,879 deaths. As such, the total mortality burden in 2010 of PM2.5 and NO₂ is estimated to have been up to 140,734 life-years lost, or the equivalent of up to 9,416 deaths (ibid).³ Furthermore, in 2010, short-term exposure to both pollutants in London was associated with 1,990 hospital admissions for respiratory problems resulting from PM2.5 and 420 from NO₂, and 740 admissions for cardiovascular ailments associated with PM2.5. It is estimated that all these health effects imposed an economic cost of between £1.4 billion and £3.7 billion (ibid).

Air pollution regulations

The large negative health effects of PM and NO₂ have led the WHO to define air quality ‘guideline values’ for concentrations of both pollutants, as set out in table 2.1 (WHO 2005).

TABLE 2.1

World Health Organisation and European Commission air pollution concentration limits

Pollutant name	Averaging period	Limit	Permitted exceedances		WHO ‘safe limits’ guidelines
			(per year)	Deadline	
NO ₂	1 hour	200 µg/m ³	18	Jan 2010	As per EU values
	1 year	40 µg/m ³	N/A	Jan 2010	As per EU values
PM10	1 day	50 µg/m ³	35	Jan 2005 (extended Jan 2011)	As per EU values
	1 year	40 µg/m ³	N/A	Jan 2005	20 µg/m ³
PM2.5	1 year	25 µg/m ³	N/A	Jan 2015	10 µg/m ³
	1 year	20 µg/m ³	N/A	Jan 2020	10 µg/m ³

Source: European Commission, ‘Air Quality – Existing Legislation’ (EC 2016)

Notes: concentration limits are expressed either in the form of an annual average concentration or as a restriction on the number of ‘exceedances’ over shorter time periods in a whole zone.

Crucially, in the case of PM, the WHO has cautioned that, because health impacts are still found at very low concentrations, ‘no threshold has been identified below which no damage to health is observed’ (WHO 2014). This warning is reiterated by the Royal College of Physicians, which has concluded that only a small fraction of the UK deaths from PM2.5

³ However, it was noted by the study’s authors that some of this effect may be due to other traffic pollutants.

relate to exposure to concentrations in excess of legal limits and that ‘there is no evidence for a threshold for exposure at the population level’ (RCP 2016). In light of this evidence, it may be desirable to reduce air pollution to negligible levels. However, many important industries and technologies that contribute towards air pollution levels are both important economic activities in their own right and key enablers of other economic activity. Road transport, for example, is a major contributor to the UK’s air pollution, but the automotive industry turns over around £69.5 billion a year and provides the means by which large amounts of economic activity is made possible (SMMT 2016). As such, guideline levels are decided by considering socioeconomic practicality alongside health outcomes, though it must be noted that the shift to a sustainable vehicle fleet, using hybrid and electric engines, offers an opportunity for manufacturers.

In the UK, these guideline values are enshrined in law through the Air Quality (Standards) Regulations 2010 – a transposition of the EU’s Ambient Air Quality Directive 2010, which first translated the values into law for member states. Equivalent regulations exist in Scotland, Wales and Northern Ireland. As such, any area within the UK that breaches these limits is breaking both UK and, currently, EU law. It is important to note, nevertheless, that European PM concentration limits do not all meet the WHO’s guideline levels, as table 2.1 shows.⁴

London is currently failing to meet both EU guidelines on NO₂ concentrations and WHO guidelines on PM concentrations.

- NO₂ concentrations at roadside locations in inner London have remained largely static since the early 2000s. Around 12.5 per cent of the total area of London – including central London – remains above the legal limit of 40 µg/m³, with variation across the city. For example, the average NO₂ concentration at Oxford Street in the 12 months to August 2015 was more than 150 µg/m³, almost four times the legal limit (Howard 2015) – some of the highest readings in the world, and, possibly, in the history of air pollution (Carslaw 2014).
- Levels of PM10 and PM2.5 have improved over the same period and now sit within legal limits. However, as previously mentioned, this is one of the few areas where EU and UK law does not reflect the guideline levels set by the WHO. In total, 88 per cent of the total area of London has PM10 levels above the WHO limits (Howard 2015).

Furthermore, the impacts of air pollution fall disproportionately on children. Nearly 25 per cent of school children in the capital are exposed to levels of air pollution that break legal and health limits by virtue of their school being located next to roads with high concentrations (Howard 2015). Furthermore, air pollution exposure is proportionally higher for deprived groups and black communities (Vaughan 2016). Alongside the health burden, high levels of air pollution undermine London’s standing in the world. A recent ranking put London 15th out of 36 major global cities in terms of overall air quality, behind other European cities such as Stockholm, Vienna and Berlin, and with levels of NO₂ comparable to those of cities such as Shanghai and Beijing (AMEC 2014).

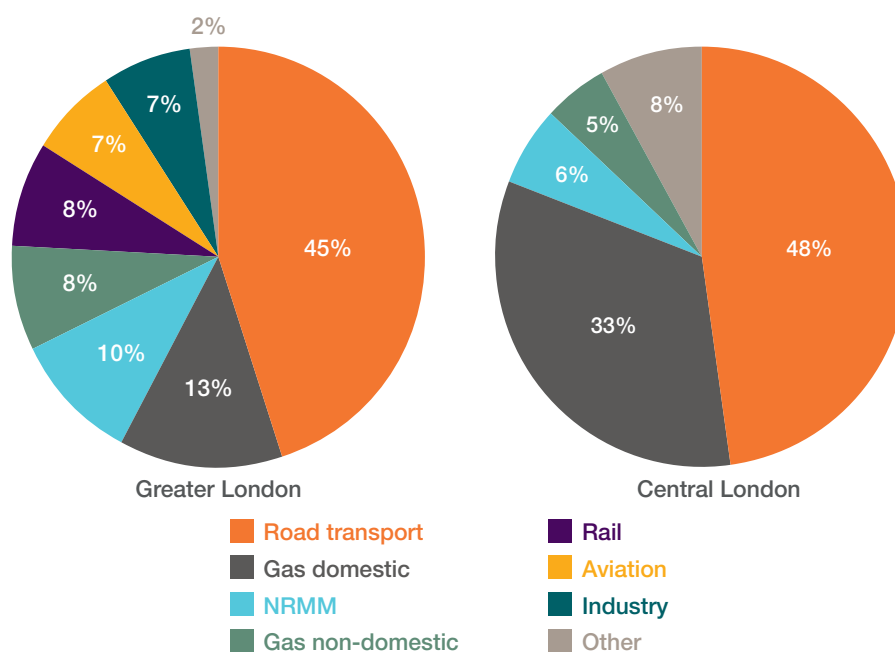
⁴ We refer to ‘legal limits’ as those EU concentration limits currently enshrined in UK law, and ‘WHO levels’ as those concentration limits for PM that differ from the EU concentration limits.

SOURCES OF AIR POLLUTION

London's air quality is affected by polluting emissions occurring within and outside the capital. In particular, particles measuring between 0.1 µm and 1 µm in diameter can remain suspended for weeks and so can be transported long distances. Around 75 per cent of PM pollution in Greater London is estimated to come from sources beyond its borders (Howard 2015), with transboundary PM2.5 making the largest contribution to that pollutant's mortality impact (Walton et al 2015). On the other hand, only 18 per cent of London's ambient NO₂ comes from outside the city (Howard 2015), and so the largest mortality contribution for NO₂ comes from sources within London (Walton et al 2015). In order to effectively tackle the problem, therefore, interventions are required at both national and London levels. While the principal focus of this paper is the action that can be taken in London, some of the major interventions required at a national and EU level are discussed in chapter 5. Within London, the largest source of NO_x and PM10 emissions is road transport (see figures 2.1 and 2.2). Other sources include domestic and non-domestic gas, rail, aviation, and non-road mobile machinery such as cranes and generators. Figures 2.3 and 2.4, and table 2.2, show that not only are diesel vehicles the greatest contributors to road transport air pollution in London, they are, in the case of NO_x, the greatest single source of this air pollution. As such, the remainder of this report, and the policy recommendations detailed in chapters 4 and 5, concentrate on road transport and, within that, diesel vehicles.

FIGURE 2.1

The largest share of NO_x emissions comes from road transport in greater London (left) and central London (right)
NO_x emissions by source (%), 2010

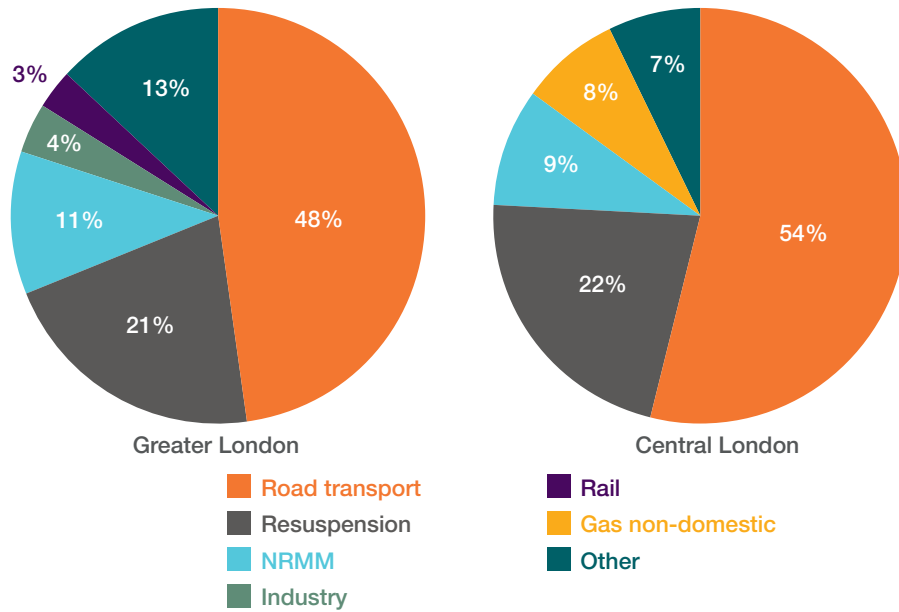


Source: Interim update to GLA, 'London Atmospheric Emissions Inventory 2010' (GLA 2010)
 *Note: 'NRMM' = 'non-road mobile machinery'.

FIGURE 2.2

The largest share of PM10 emissions comes from road transport in greater London (left) and central London (right)

PM10 emissions by source (%), 2010



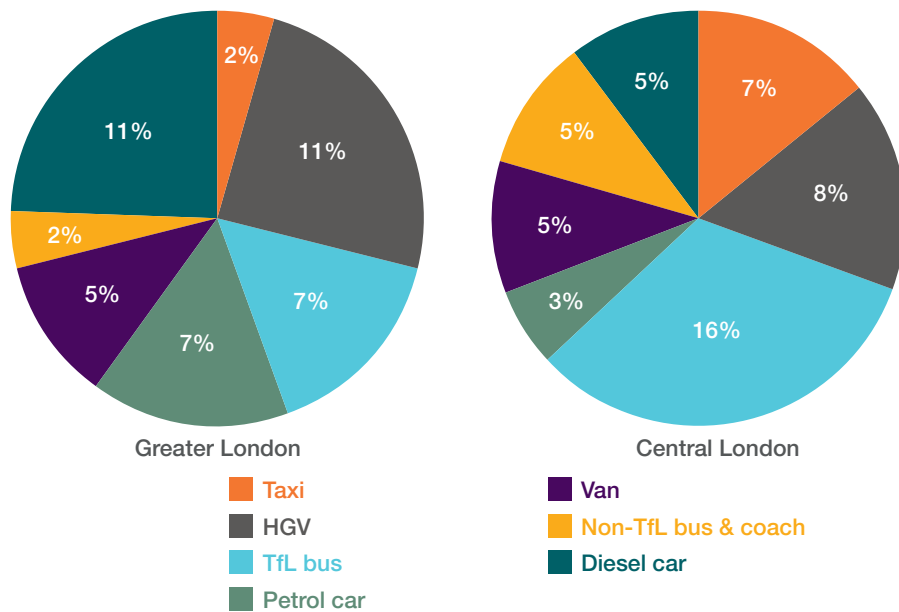
Source: Interim update to GLA, 'London Atmospheric Emissions Inventory 2010' (GLA 2010)

*Note: 'NRMM' = 'non-road mobile machinery'.

FIGURE 2.3

NO_x emissions from road transport are caused by a number of vehicles across greater London (left) and central London (right)

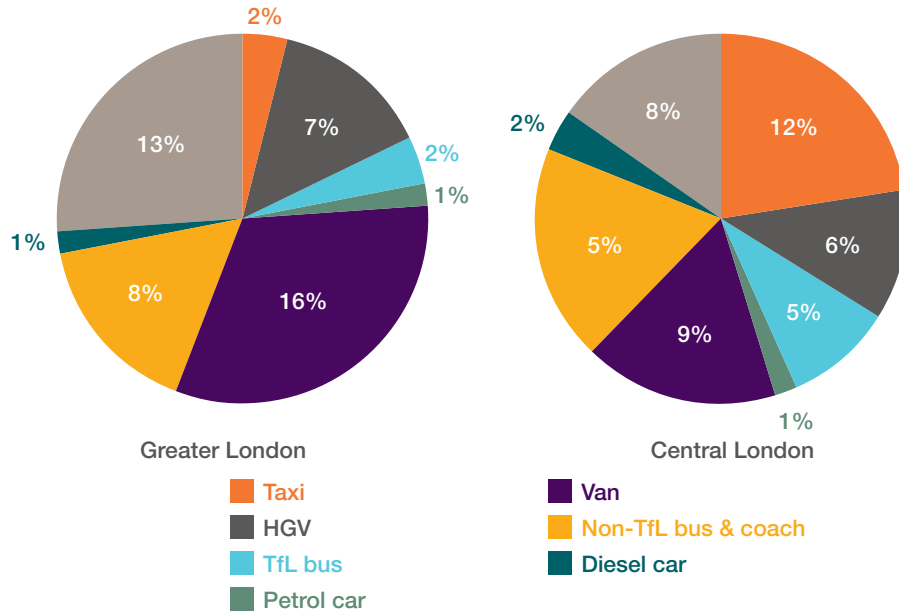
Road transport NO_x emissions by source, 2010



Source: Interim update to GLA, 'London Atmospheric Emissions Inventory 2010' (GLA 2010)

FIGURE 2.4

PM emissions from road transport are caused by a number of vehicles across greater London (left) and central London (right)
PM10 emissions by source, 2010



Source: Interim update to GLA, 'London Atmospheric Emissions Inventory 2010' (GLA 2010)

TABLE 2.2

Fuel sources of public and private road vehicles, 2015

	Petrol	Diesel	Cleaner alternatives	Contribution to NO _x emissions in central London
TfL Bus (central London)	0%	89%	11%	14.2%
Taxi	0%	100%	0%	7%
Private car and private hire vehicles	42%	57%	1%	2.9%
Light goods vehicles	2%	97%	1%	4.9%
Heavy goods vehicles	0%	100%	0	8%
Total diesel contribution (ex. non-TFL bus)				37%

Source: Provided by TfL in correspondence with IPPR, January 2016, and author's calculations
 Note: PM10 from road transport is caused by exhaust (40%), brakes (50%) and tyre wear (10%) (Howard 2015).

Diesel vehicles and air pollution

The greatest contributors to air pollution in London are diesel vehicles, causing at least 37 per cent of NO_x emissions in central London (see table 2.2). The London assembly environment committee puts the figure for the whole of London at about 40 per cent, with a broadly similar

proportion of PM10 (LAEC 2015). As such, the fleet of diesel vehicles in the capital is a major threat to the health of Londoners. In recent years, an understanding of the negative health effects of diesel exhaust has become widespread, with, in particular, the WHO's International Agency for Research on Cancer classifying diesel engine exhaust as carcinogenic to humans (group 1), alongside over 100 other substances, mixtures and exposure circumstances that cause cancers (IARC 2012).

In contrast, petrol engines are much less of a problem for air quality. The mandatory use of catalytic converters in petrol cars since 1992 has reduced the amount of NO₂ emitted by 95 per cent (RCP 2016). Conversely, significant improvements have not been made by the emissions technology used in diesels, with the proportion of NO₂ in diesel engines having actually increased (Carslaw and Rhys-Tyler 2013). The disparity between petrol and diesel is highlighted by the Euro emissions standards, as set out in table 2.3, with petrol cars having emitted less NO_x than diesel cars since 1996. Indeed, the levels of NO₂ directly emitted by Euro 5 diesel cars is nearly 310 times greater than that from Euro 5 petrol cars (Howard et al 2016).

TABLE 2.3
Euro emissions standards

Pollutant name/Emissions standard (introductory year)	Petrol car		Diesel car	
	NO _x	PM10	NO _x	PM10
Euro 1 (1992)	0.97	—	0.97	0.140
Euro 2 (1996)	0.50	—	0.70	0.080
Euro 3 (2000)	0.15	—	0.50	0.050
Euro 4 (2005)	0.08	—	0.25	0.025
Euro 5 (2009)	0.06	0.005	0.18	0.005
Euro 6 (2014)	0.06	0.005	0.08	0.005

Source: Transport & Environment, *Don't Breathe Here* (Transport & Environment 2015)
Note: Figures are for grams of pollutant per km.

The proportion of diesel vehicles in the UK road transport fleet has been increasing. In the case of cars, the number of diesels has increased from 1.6 million, or 7 per cent of the fleet, in 1994 to more than 10.7 million today – over 36 per cent of the total fleet (DfT 2016). This rise is the result of incentives introduced by the UK government and the European Union, who sought to reduce transport-related CO₂ emissions. In 2005, when the incentives were introduced, the average diesel vehicle emitted 5–10 per cent less CO₂ than a petrol alternative (EC 2013). The decision to incentivise diesel was made in relative ignorance of both the levels of air pollution caused by diesel exhaust, made worse by the inaccuracies of laboratory testing procedures. Therefore, the slow progress on reducing NO₂ and PM levels throughout urban environments in the UK is the result of the rise of the diesel engine across the road transport fleet. In addition, as discussed below, the CO₂ saving of diesel relative to petrol vehicles has now been eroded, removing any rationale for incentivising diesel vehicles.

The failure of the Euro standards

The inaccuracies of laboratory testing procedures have hindered progress on improving air quality. There is evidence that these tests significantly underestimate the amount of pollution cars actually produce when driving in real-world conditions, meaning that Euro emissions standards are inaccurate and so are not an effective barrier against illegal levels of air pollution, particularly for diesel cars. For example, some studies have shown that Euro 6 diesels produce between 2.5 and 7 times, or even 10 times, the published standard when driven on the road (Weiss et al 2011, Transport & Environment 2016). A recent study of Euro 6 diesel cars by the International Council on Clean Transportation (ICCT) has confirmed that most laboratory tests do not conform with real-world driving conditions – all 32 vehicles tested met the Euro 6 NO_x limit in the current testing procedure, while only 10 met the same limit in a more realistic test (ICCT 2015a).

In response, the European Commission has established the Real Driving Emissions working group to oversee the introduction of on-road testing for new diesel cars. ‘Conformity factors’ will regulate the extent to which vehicles can produce higher levels of emissions in real-world conditions over laboratory testing. The conformity factor will be set at 2.1 for new cars from September 2017 and all new vehicles from September 2019 – that is, they may exceed the Euro 6 standard by 2.1 times in real-world tests. The conformity factor will then be tightened to 1.5 for new cars by January 2020 and all new vehicles by 2021 (EC 2015). The level of conformity factor has been decided by weighing the health benefits of reduced air pollution against the potential negative effects upon industries and economies of the pace of change required.

In addition, the effectiveness of the Euro standards system has also been called into question due to its focus on vehicle exhaust, and by the use of ‘cheat devices’. PM10 pollution from road transport is caused by exhaust (40 per cent), brakes (50 per cent) and tyre wear (10 per cent), and so it may be that as much as 60 per cent of the PM air pollution problem is missed by the standards (Howard 2015). Meanwhile, the Volkswagen (VW) emissions scandal, which was exposed in September 2015, revealed that VW cars were fitted with illegal ‘defeat’ devices to falsify results during laboratory tests. Globally, this amounts to around 11 million cars that require ‘re-correcting’, including as many as 1.2 million in the UK, or more than 10 per cent of the country’s diesel car fleet (Hotten 2015).

Incentivising diesel

The last Labour government (2005–2010), motivated by a desire to reduce CO₂ emissions in order to tackle climate change, favoured diesel over petrol vehicles in the rates of both vehicle excise duty (VED) and company car tax. At the same time, EU CO₂ emissions targets incentivised diesel vehicle manufacturing through the 1998 agreement between the European Commission and the European Automobile Manufacturers Association, which sought to achieve a target of 140g CO₂/km for the average of new cars sold in the EU by 2008 (EC 1998). Together, these policies contributed significantly to a re-composition of the UK’s vehicle fleet, with diesel cars now making up over 50 per cent

of all new cars sold and over 36 per cent of the total car fleet, up from around 8 per cent in 1994 (DfT 2016). The light goods vehicle (LGV) fleet has gone from a 51 per cent diesel composition in 1994 to 96 per cent in 2014 (ibid).

This is a particularly European problem – Japan, for example, has reduced CO₂ emissions to a greater extent, and at a greater pace, than Europe through investment in petrol engine technology (Cames and Helmers 2013). While European CO₂ emissions from new registered cars fell from over 180g CO₂/km in 1995 to between 140 and 150g CO₂/km in 2009, emissions in Japan fell from a similar starting point to between 120 and 130g CO₂/km over the same period, mainly as a result of an increase in petrol hybrids (EC 2013).

The contrast between road transport climate change policies across countries serves to illustrate the trade-off that formerly existed between action on CO₂ and that to minimise air pollution. In the case of UK policy, it is clear that reductions in CO₂ came at the large cost of a significant increase in air pollution. However, the gap between the average CO₂ fuel efficiency of new petrol and diesel cars has now closed, to 122.6 g CO₂/km for petrol and 119.2 g CO₂/km for diesel (EEA 2016). Indeed, some studies have suggested that CO₂ emissions for diesel may be worse than petrol due to the higher exhaust levels of black carbon (Helmers 2016). As such, the need to trade off between air pollution and action on CO₂ is fast becoming unnecessary. This process is further accelerating with the rise of low- and zero-carbon alternatives such as hybrid and other zero-emission capable technologies.

AIR POLLUTION FROM OTHER SOURCES

This report focuses on road transport because of the scale of its contribution towards London's air pollution. As discussed above, there are other sources for this pollution. Modelling of future pollution trends, including policies approved during the mayoralty of Boris Johnson (discussed in the next chapter), point towards a steep rise in the contribution of aviation and non-road mobile machinery (Jacobs 2014a). Furthermore, Policy Exchange has pointed out that forecast increases in decentralised energy sources throughout London, many of which may be fossil-fuel based, could increase local NO_x emissions (Howard 2015). Indeed, energy policies that promote non-renewable decentralised energy could run the risk of going the way of previous road transport policies and reduce CO₂ at the cost of increases in air pollution. Though beyond the scope of this report, action must be taken in all of these areas, alongside that for road transportation, as part of the integration of environmental outcomes across the mayor's new spatial and energy policies, as set out by IPPR in the report *London: Global Green City* (Laybourn-Langton 2016).

CONGESTION

London's road transport also negatively impacts the capital's economy through rising congestion. Assuming that no policies are put in place to manage increased demand, it is estimated that total passenger vehicle miles travelled will increase by 43 per cent between 2013 and 2030

(CEBR 2014) – which is more than most other major cities around the world – and that every five years the transport system will need to cater for more than a million extra trips per day (TfL 2014a). It is estimated that the resulting congestion will decrease average road speeds, from 21mph today – already one of the lowest speeds in a major city – to around 16mph by 2030, with speeds in central London significantly lower still. Slower speeds mean greater delays and unpredictability in journey times, leading to higher economic costs – from an estimated £5.99 billion in 2013 to over £10 billion in 2030 (CEBR 2014).

SUMMARY

London is suffering from a persistent air pollution problem, which has considerable negative health and economic impacts. Road transport and the diesel engine in particular are at the heart of this problem, and so subsequent action will have to target these sources. We now turn to the efforts taken by mayors to date, and the failure of these policies to combat the air pollution problem.

3.

THE FAILURE OF ROAD TRANSPORT AIR POLLUTION POLICY

To date, no governing authority in the UK has taken sufficient responsibility for bringing air pollution levels to within legal limits. Modelling by the Department for the Environment, Food and Rural Affairs (Defra) has shown that, without significant policy changes, most of the UK would remain in breach of legal limits into 2025 and beyond, with London not reaching compliance with legal limits until 2030 (Defra 2015b). The projected failure to achieve compliance resulted in the European Court of Justice (ECJ) ruling in 2015 that the UK must ensure it has plans to reach legal limits as soon as possible, and requiring all member state courts to take any measures necessary to ensure compliance (ECJRC 2015). This process followed the legal case brought against the UK government by ClientEarth, which challenged Defra on the failure to protect the health of citizens from the harmful outcomes of air pollution. The two legal processes are separate but closely related. The UK's continued failure to comply with the law has led to the threat of fines from the ECJ, upon recommendation by the European Commission. These fines could be handed down from the UK government to local government, including to the GLA and the London boroughs.

Consequently, in 2015 the UK supreme court ordered the government to introduce measures within the national action plan for NO₂ to meet compliance across air pollution zones in the shortest time possible (UKSC 2015). To meet this requirement, Defra has produced a new plan for improving air quality in the UK, including the introduction of 'clean air zones' in which the most-polluting vehicles will be charged. These will come into force in Birmingham, Leeds, Nottingham, Derby and Southampton by 2020 (Defra 2015c). While bringing forward the date of compliance for UK cities, Defra estimates that NO₂ will not reach legal limits until 2020 – with London's compliance only being brought forward five years to 2025. These timescales do not suggest that compliance is set to be reached within the shortest time possible. This has led some environmental groups to conclude that the plans are inadequate. They also argue that the responsibility for compliance has been passed to local authorities without the devolution of the resources and powers necessary to achieve this end (Birkett 2015).

LONDON'S RECORD

At the London level, progress has been slow: the capital is the only area in the UK that is still forecast to fail to achieve compliance before 2025 under the new Defra plans. Furthermore, this forecast is disputed by many air quality groups, as the new air quality plans fail to provide

any new measures for tackling air pollution in London above those already proposed by the previous mayor of London. There are also concerns about the emissions factors used in the modelling given that many Euro 6 diesel cars currently fail to meet the limits, as described in chapter 2 (Leake 2016).

The incoming mayor inherits two main policies that help to reduce air pollution – the low emissions zone (LEZ) and the planned ultra low emissions zone (ULEZ). The LEZ was introduced during the mayoralty of Ken Livingstone and operates across the whole of Greater London. From January 2012, the LEZ has levied a charge on the most-polluting vehicles: lorries, buses and coaches below the Euro 4 emissions standard, and vans, minibuses and ambulances below Euro 3 (TfL 2016a). It operates 24 hours a day, 365 days a year. Number plate-reading cameras police the zone, and eligible vehicles not paying the charge are fined. Recent evidence points to the ineffectiveness of the LEZ in reducing ambient air pollution levels, particularly those of NO_x, as a result of implementation delays, a focus on PM over NO_x emissions, and the failure of the Euro standards to constrain NO_x emissions, leading to the conclusion that more robust measures are needed to reduce traffic emissions (Wood et al 2015).

The ULEZ, approved during the administration of Boris Johnson, is not due to come into force until September 2020. The ULEZ, which will cover the current congestion charge zone of central London,⁵ will levy a charge on vehicles that do not meet the Euro 6 emissions standard for diesel, and Euro 4 for petrol (and Euro 3 for motorcycles). The charge will be £12.50 for cars, vans and motorcycles, £100 for HGVs, buses and coaches. Fines will be levied on eligible vehicles not paying the charge. At the same time newly registered taxis will be required to meet these standards by 2018, and new buses by 2020.

The ULEZ is projected to at least halve emissions of NO_x and PM10 from vehicle exhausts, primarily in central London. Because the majority of traffic entering the ULEZ will come from outside the zone,⁶ reducing this flow is expected to produce significant reductions in the number of people living in areas of poor air quality: by 74 per cent in central London, 51 per cent in inner London and 43 per cent in outer London (TfL 2015a). This will be due to an increased replacement rate of high-emissions vehicles and a reduction in the total number of car journeys within the zone, which are predicted to fall by 5 per cent by 2025 (Jacobs 2014a). Critically, however, the ULEZ will not immediately bring London into compliance with legal limits – it will only bring forward the expected date of compliance, to 2025 (TfL 2015b). Furthermore, diesel cars are forecast to grow as a source of NO_x emissions under the planned ULEZ, from 11 per cent across Greater London in 2010, to 50 per cent by 2025 (Howard et al 2016).

5 That is, it will cover the same area as the congestion charge zone (CCZ), which covers approximately 22 km² in central London, where congestion is most acute. Introduced in 2003, the scheme has led to small decreases in air pollution, being too small to have produced major improvements (Kelly et al 2011).

6 96 per cent of ULEZ traffic is expected to originate outside the zone (Kelly et al 2011).

THE NEW MAYOR'S PLANS

A growing understanding of the health impacts of air pollution has seen the issue rise up the political agenda. Air pollution is now of major concern to Londoners, with one poll showing that 51 per cent of those polled were extremely or very concerned about air pollution levels (Quilter-Pinner and Laybourn-Langton 2016), while another showed that air pollution is ranked by the public as the top priority for the mayor, ahead of better public transport or improved access to healthcare (WSP-PB 2016).

Accordingly, London's new mayor, Sadiq Khan, has chosen to make the improvement of air quality one of his highest priorities. In early July 2016 he launched a consultation on new measures to address air pollution, including the creation of a new vehicle charging zone across London. The consultation period comprises a three-part process that will conclude with a full statutory consultation in 2017 and could include the following measures.

- Introducing a new emissions surcharge (dubbed the 'T charge') from 2017 for all vehicles with pre-Euro 4 emissions standards entering central London. This will be an extra £10 per day on top of the existing congestion charge. A 90 per cent discount will be available to residents living within the CCZ.
- Bringing the implementation of the central London ULEZ forward by one year to 2019.
- Expanding the ULEZ beyond central London – up to the north and south circular roads – in September 2020:
 - all cars and vans to meet Euro 6 diesel standards, or Euro 4, for petrol – a charge of up to £12.50 a day if they do not meet these standards
 - London-wide buses, coaches and HGVs to meet Euro 4 diesel standards – a £100 charge a day if they do not meet these standards
 - from 2018, all new licensed taxis must be zero-emissions capable – that is, they must be able to travel at least 30 miles and produce no air pollutants – a fund will be available to help taxi drivers buy new cleaner vehicles
 - from 2018, all private hire vehicles (PHVs) must meet Euro 6 emissions standards; from January 2020, all manufactured PHVs must be zero-emissions capable, with a minimum zero emissions range of 10 miles; as a result, the entire taxi and PHV fleet will be made up of zero-emissions capable vehicles by 2033.
- Develop a detailed proposal for a national diesel scrappage scheme.
- Action on the bus fleet:
 - introduce 1,700 hybrid buses by the end of 2016, and provide 3,000 double-decker hybrid buses and 300 zero emissions single-decker buses in central London by 2020
 - buy only hybrid or zero emissions double-decker buses from 2018
 - retrofit older buses to reduce emissions
 - pioneer new clean technology buses (for example hydrogen, electric).
- Implement clean bus corridors, bringing cleaner buses to the dirtiest routes.

There is strong support for these measures among those Londoners who responded to the first stage of the consultation. The consultation garnered over 15,000 responses and arrived at the following findings.

- Ninety per cent of respondents thought central London had a problem with air pollution, and 68 per cent thought their local high street had poor air quality.
- There was 79 per cent support for the bringing forward of the ULEZ implementation to 2019, while 70 per cent thought the ULEZ boundary should be extended up to the north and south circular roads. Seventy per cent thought the ULEZ should extend across all London for light vehicles, while 87 per cent thought a London-wide extension should apply to heavy vehicles.
- The emissions surcharge was supported by 81 per cent, while the call to central government for a diesel scrappage scheme was supported by 77 per cent (GLA 2016a).

LEAVING THE EUROPEAN UNION

The UK's expected exit from the European Union could significantly reduce the pressure on the UK government to cut concentration levels. Although the Air Quality (Standards) Regulations 2010 will remain in law they will not automatically be tightened should the EU revise its concentration limits to more closely align with WHO guidelines (in the case of PM). If the UK remains a member of the European Economic Area (EEA) EU air pollution law will still apply, although enforcement will be weaker as there is no threat of fines within the EEA. If it does not, the UK government would no longer be liable to fines by the European Commission, could repeal its current air pollution regulations, and would not be required to meet new air pollution regulations with higher ambition. This would significantly reduce the incentive for governments to introduce compliance policies.

As with all areas of public policy, air quality regulation is greatly affected by the uncertainty over the future relationship of the UK with the EU. That uncertainty could remain for some time. This strengthens the case for taking action to address air pollution at the city level. The mayor of London has sufficient powers in place to make substantial progress and this report focuses on how those powers can best be employed. Our examination of EU and national policy, including the proposal for a new Clean Air Act to enshrine air pollution regulations in UK law, is set out in chapter 5.

4.

LONDON TRANSPORT POLICIES TO BRING AIR POLLUTION WITHIN 'ACCEPTABLE LEVELS'

The objective of air quality policy in London should be to achieve acceptable levels of NO₂ and PM pollution in the capital so as to reduce the negative effects of those pollutants. This chapter discusses what needs to be done to achieve acceptable levels. Measures to this end should weigh the resultant benefits against the costs of action. In discussing these measures, and weighing the benefits and costs, we shall use two definitions of 'acceptable levels':

- the first is compliance with legal limits
- the second is to reduce pollution to as close to negligible levels as possible, in light of the evidence that no exposure is safe, as discussed in chapter 2.

This chapter will propose a suite of transport policy measures that seek to achieve the first definition of 'acceptable levels', detail the benefits of doing so and weigh them against the costs of action, and discuss the ameliorative options available to reduce these costs. It will then provide a longer-run vision for London's transport in a world in which large parts of London experience little to no air pollution emissions from vehicles, and technological change – primarily in digital technology – is likely to have changed how transport services are delivered and consumed. Chapter 5 will then turn to the national and international policy implications of these shifts.

TRANSITIONING AWAY FROM A POLLUTED LONDON

As we discussed in two previous reports – *London: Global green city* (Layborn-Langton 2016) and *Lethal and illegal* (Quilter-Pinner and Laybourn-Langton 2016) – two fundamental shifts in road usage are needed to reduce air pollution and other related problems, including congestion.

1. A move away from petrol and diesel fuels towards greener and cleaner alternatives for private and public vehicles.
2. A continuation of the modal shift away from private motorised vehicle use and towards walking, cycling and public transport.

These shifts require large and sustained investment in London's public transport, cycling and walking infrastructure. However, though necessary, investment in sustainable transport will not on its own ensure

that London's transport system contributes fully towards reducing air pollution. As such, transport policy targeting air pollution has focused on extending road pricing across London, to charge road users for their contribution to the problem. As chapter 3 showed, these proposals, along with those to stimulate investment in sustainable transport, enjoy large levels of public support across London.

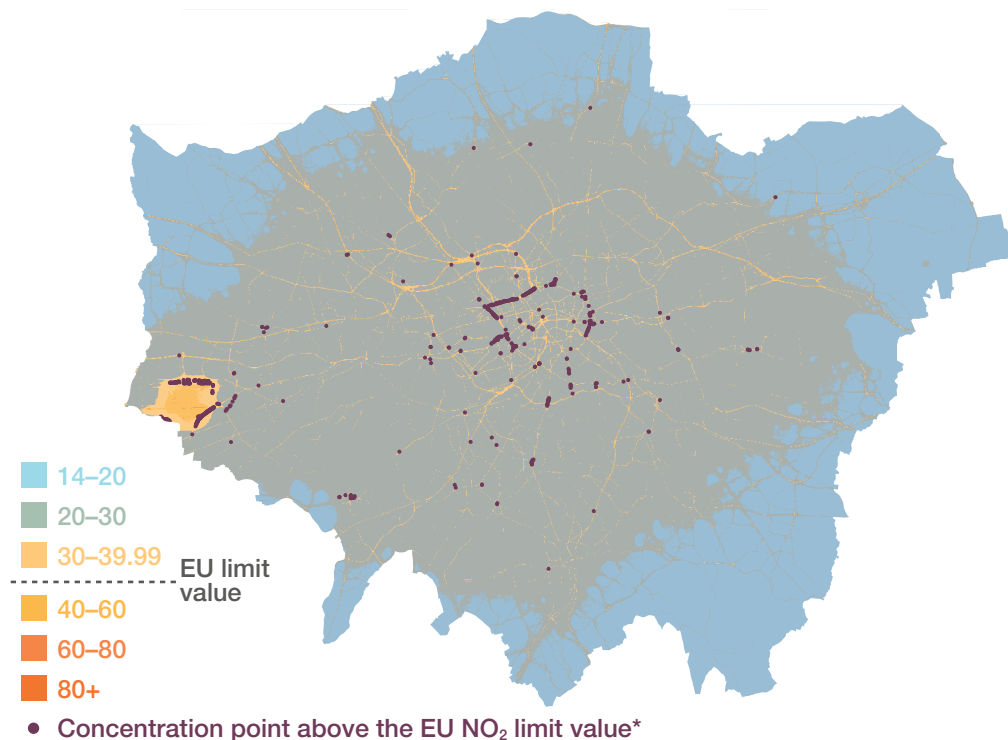
Previous modelling by King's College London's Environmental Research Group, commissioned by IPPR, has shown the scale of the problem and therefore the level of ambition required of policy (Quilter-Pinner and Laybourn-Langton 2016). This modelling showed that even if the capital were to return to the lowest recorded level of diesel car ownership in the UK – at around 10 per cent of the car fleet (as it was in 1995) – from its current position of 57 per cent of cars, London would still not be compliant with legal levels of air pollution in 2025.

For this report, we commissioned King's College London to model the impact of an even more ambitious scenario on air pollution in London (the assumptions of which can be found in the annex). This scenario assumes that a number of policies – including a ULEZ extended up to the north and south circular roads – would drive the petrol:diesel split for cars from 57:42 today to 5:95 by 2025 within inner London, with 15 per cent of petrol cars becoming hybrids and 6 per cent being electric within that area. Of those diesels remaining, nearly all would adhere to the Euro 6c standards (the real-world compliant variants of Euro 6, with conformity factors of 1.5 and 1). Similar trends, towards the highest emissions standards, or towards zero-emissions capability, are seen across all other transport types. This is a world in which the road transport fleet in London has nearly transitioned away from diesel cars – the heart of the air pollution problem – towards petrol, and, in turn, is beginning to transition to hybrid, electric and other zero emissions alternatives.

This scenario is projected to result in large reductions in NO_x and NO₂ emissions across all of London, with a 45 per cent reduction in NO_x and a 56 per cent reduction in NO₂ concentrations relative to the projected outcome of the policy programme of the Johnson administration (the base case). Both PM10 and PM2.5 are projected to be reduced by 2 per cent and CO₂ emissions by 7 per cent. These reductions would bring nearly the whole of Greater London into compliance with legal NO₂ limits, to 99.96 per cent. This is a large improvement on the approximately 87.5 per cent of Greater London that reached compliance in 2010. Furthermore, the area of Greater London experiencing NO₂ emission levels below 20 µg/m³ increases from 15.6 per cent in the base case to nearly 36 per cent. Some key hotspots of pollution, on major roads, are still projected to remain non-compliant, as the map in figure 4.2 illustrates. These include Marylebone Road, Euston Road, Edgware Road and Brompton Road. The greatest contributors to NO_x emissions on these roads become petrol cars, diesel LGVs, TfL buses, coaches and rigid goods vehicles. Additional localised policy solutions will be needed to reach compliance in these areas.

FIGURE 4.2

A near total phase out of diesel cars in inner London, and a move toward more sustainable alternatives across other road transport, brings nearly all of London into compliance with legal limits of NO₂ concentrations
NO₂ forecast concentrations (µg/m³) in 2025



Source: courtesy of King's College London

*Note: excludes points on roads and railways, and within Heathrow airport site.

These large reductions are projected to have a large positive effect upon health outcomes in the capital. Life expectancy for males and females born in 2025 is projected to improve by 1.7 months and 1.5 months respectively, relative to those outcomes from the base case. In total, the reduction in NO₂ emissions resulting from these policies would result in a gain of up to 1.4 million life-years over a lifetime across the population of Greater London, providing an estimated annualised economic benefit of up to £800 million, relative to the base case.⁷

Policies to achieve the required shift in the vehicle fleet

As the KCL modelling shows, any suite of policies to significantly reduce the impact of road transport on air pollution must necessarily result in large changes to the makeup of the vehicle fleet in London. This transition would be extremely difficult to achieve in one term. Below, we provide a suite of policies for a 'two term plus' strategy, which gives a roadmap of this ambition over two phases that may help deliver this transformation in road usage.

⁷ These values are expressed as maximums due to the fact that some of the effect could be due to other traffic pollutants. Furthermore, there are other health outcomes associated with NO₂ that have not been quantified here, although mortality outcomes usually dominate assessments of economic benefits. Please see the annex for a full discussion of the health impacts analysis.

Phase 1 covers the current mayoral term (from 2016 up to 2020) and details policies for all major vehicle types that would set the foundation for dramatic reductions in road transport air pollution levels in the next 10 years. These policies build on those recommended in *London: Global green city*, much of which has become part of the mayor's consultation on air pollution policies, and look to build towards the first definition of acceptable levels – compliance with legal levels. Phase 2 covers the years from 2020 to 2025, including the next mayoral term (2020–2024), and provides policies that seek to build a foundation on which road transport air pollution emissions can be reduced towards negligible levels as London heads towards 2030, bridging the gap between both definitions of acceptable levels.

PHASE 1 – BUILDING FOR COMPLIANCE (2016–2020)

In seeking to achieve compliance in the shortest timescale possible, we recommend the **extension of the ultra low emissions zone on an accelerated timescale**. Specifically, we recommend that the mayor of London pursues the most ambitious version of his current proposal.

- Extend the ultra low emissions zone up to the north and south circular roads, bringing implementation forward to 2019 (as per the mayor's current proposals).
- Diesel cars below the Euro 6 standard should be charged a fee per day if they enter the zone, along with petrol cars below the Euro 4 standard (as per the current mayor's proposals).
- Increase the Euro standard for charges on LGVs within the expanded ULEZ so they must meet Euro 5, from the current requirement of Euro 3.
- Increase the Euro standard for charges on HGVs and coaches within the LEZ Euro 6, from the current requirement of Euro 4 (as per the current mayor's proposals).

Buses

Unlike with cars, the mayor has greater direct influence over London's bus fleet and so can actively drive air pollution reductions. As discussed in chapter 2, TfL buses are a major contributor to air pollution, particularly in central London, and so mayoral policy should also focus on a rapid transition to a zero-emissions capable fleet. As such, we recommend that **Transport for London should procure only hybrid or zero emissions buses from 2018**, and increase the emissions standard on TfL buses to Euro 6 within the expanded ULEZ, as per the current mayor's proposals.

This would require large-scale investment in a dedicated bus charging network to ensure the larger incidence of electric and hydrogen buses in the fleet can be supported. Such investment would impose a non-trivial fiscal burden on TfL, and so the mayor would have to balance the benefits of air pollution and CO₂ reductions and the economic benefit of investment against the budgetary cost and the fact that Euro 6 double-decker buses are able to reliably reduce emissions. Although beyond the scope of this report, such investment could be part of a wider programme of fiscal devolution for London, allowing the capital to make self-determined investment in infrastructure deemed critical to supporting its economic and population growth, and improving health outcomes (LFC 2013).

Vehicle excise duty

One area of fiscal policy in particular has attracted calls for devolution (GLA 2016c). The vehicle excise duty (VED) charged to London-registered vehicles is currently consolidated by central government into general tax revenue and, from 2020, will be used for investment in the national strategic road network. According to the GLA, none of the approximately £500 million raised per annum in London is invested in the capital's road network (ibid). Therefore, we recommend that the mayor **call on central government to devolve vehicle excise duty to the London level**, ensuring that the city retains its share of the proceeds for investment in transport infrastructure and other mobility schemes. Monitoring procedures would have to be assured and it is likely that VED would have to be linked to the address through which a vehicle is registered. The GLA should then use these powers to reverse the incentive to purchase diesel over petrol vehicles.

Taxis and private hire vehicles

The mayor can exercise a large amount of control over the standards of the taxi and private hire vehicle (PHV) markets in London through licensing regulation. The London taxi market is set to be transformed with the release of the first zero-emissions capable taxi in 2018, and to ensure the rapid move away from the domination of diesel within the taxi fleet, a requirement exists for all newly licensed taxis to be zero-emissions capable from 2018, with a minimum zero emissions range of 30 miles. In a bid to accelerate the move to a zero-emissions capable taxi fleet, the mayor is set to introduce a scrappage scheme for the oldest taxis from 2017, and TfL will need to invest in the rapid charging infrastructure to ensure that those zero-emissions capable taxis entering the fleet are provided with charging facilities (TfL 2016b).

Alongside taxis, PHVs are a key means of private travel within London. The number of PHVs has grown from around 63,000 in 2015 to over 80,000 in 2016, increasing congestion and vehicle emissions (DfT 2015a, TfL 2016b). In comparison, the number of taxis has remained relatively stable, at around 22,000 (DfT 2015a). Though PHVs will be regulated as cars within the expanded ULEZ, it is our view that the transition to a zero emissions fleet should keep pace with the changes in the taxi market, particularly as PHV operators and owners have many replacement options when seeking to procure cars that are either compliant with standards or zero-emissions capable. Therefore, we recommend that the mayor **require all newly licensed private hire vehicles to be zero-emissions capable from 2018**, with a minimum zero emissions range of 30 miles.

Socioeconomic costs

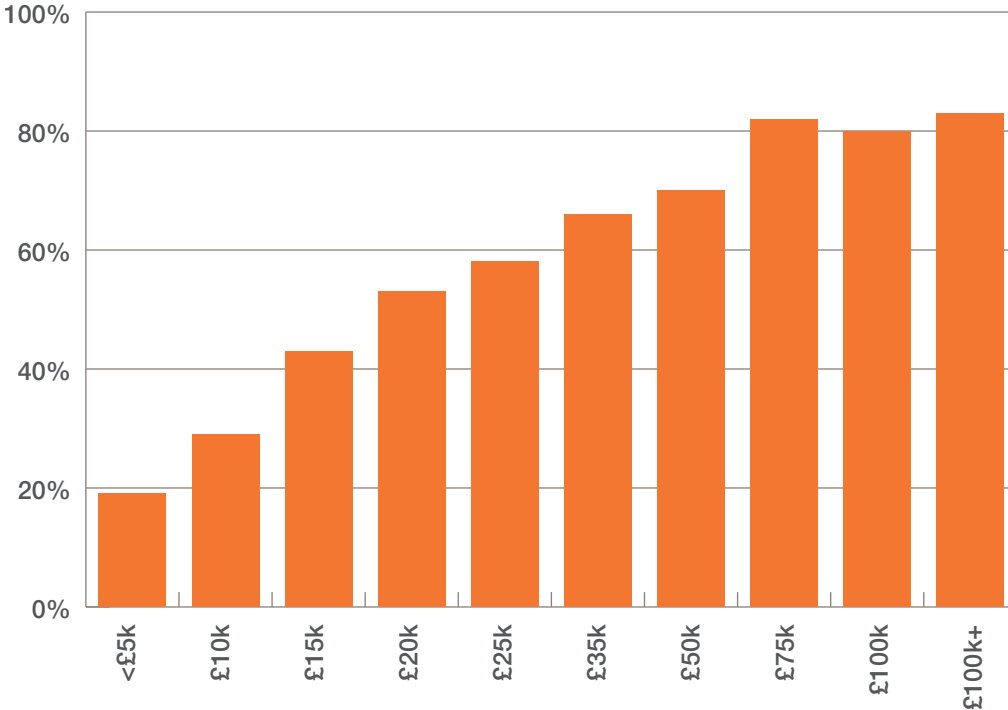
The implications of an expanded ULEZ are significant. It will affect a large number of people, including the more than 3 million who live in inner London, and the millions more who travel into the zone each day. Using data from TfL's London travel demand survey, which captures information on the travel behaviour of households in London, we estimate that 46 per cent of car journeys would be affected by the expanded ULEZ.⁸

⁸ Of this, 2 per cent of journeys are in central London, 10 per cent in inner London, 5 per cent between central and inner London, 6 per cent between central and outer London, and 23 per cent between inner and outer London (TfL 2011). Data is from 2009/10.

Half of these journeys, or 23 per cent of total car journeys, are between inner and outer London. As such, the transition will be challenging, imposing costs on drivers and business, but also positive, boosting socioeconomic outcomes through improved health and lower congestion. As such, an implementation process is required that ensures this transition is both efficient and equitable, minimising regressive outcomes and providing support to those interests experiencing the largest effects. The main groups who are likely to experience the greatest cost are car drivers and businesses operating LGVs and HGVs within the zone.

In the case of car use, an expanded ULEZ will impose costs on households who own and drive a car. These costs will be regressive, as those on lower incomes will inevitably pay a higher proportion of their income if they travel within the zone. As table 4.1 shows, most households, on average, make around four to six trips per week by car, with car use increasing with income. However, those on the lowest incomes – an equivalised household income of less than £10,000 – use cars significantly less than other incomes bands, at just under two trips per week. Furthermore, car ownership decreases significantly with household income, see figure 4.1.

FIGURE 4.1
Lower-income households are less likely to own a car
Percentage of households with car access, by income, London residents, 2011/12



Source: TfL, 'How many cars are there in London and who owns them?' (TfL 2012)
 Note: Household income is before tax.

TABLE 4.1**Projected cost of the expanded ULEZ per year by income**

Household income group	Car trips made per week
<£10k	1.82
£10—£20k	3.92
£20—£35k	4.69
£35—£50k	5.46
£50—£75k	5.74
£75k+	5.88

Source: TfL 2011, and authors' calculations.

Alternative options for impacted households are limited. TfL estimates the minimum cost of compliance for a car to be between £500 and £10,000, with the highest price being the cost of buying the oldest compliant car if the current car is worth nothing, and the lowest price taking into account the ability to buy a compliant petrol vehicle of a similar age (TfL 2014b). Depending on the age of the current vehicle, it may be cheaper for some households to purchase a compliant vehicle instead of incurring the expanded ULEZ fee. Nevertheless, for lower-income households, investing in a compliant vehicle or paying the charge may not be feasible. As such, there is large scope for the mayor to provide car users with support in reducing the cost of reaching compliance.

There are three ways in which the cost of travel for car users and owners can be reduced.

- The first is time. The cost of compliance depends on the speed of implementation of the expanded ULEZ and the associated vehicle standards, which increase in phase 2. The longer the notice periods given to households, the lower the costs. This is because they will anyway be replacing their vehicles, as an increasing number of vehicles move towards replacement age, and because the cost of compliant vehicles will fall as more enter the market. Therefore, there is a trade-off between health impacts (the earlier the better) and acceptable cost (the later the implementation the better). It is our view that the implementation of the expanded ULEZ in 2019, and the increase in standards thereafter, as described in phase 2, is the correct balance between these two factors, as long as alternative transport investments occur and policies are introduced to support those who experience greatest cost.
- The second means of reducing transport costs, and one of these supporting policies, is for the mayor to provide temporary discounts or exemptions on the charge over a 'sunset period'. To this end, we recommend the mayor should ask **TfL to determine any interim exemptions and discounts for those most adversely affected by the expanded ULEZ**. Above all, TfL should ensure that cost reductions are time-limited and do not substantially reduce the impact of the road charging policies.
- The third way is to directly reduce the cost of compliance through cash support to car users and owners who wish to purchase a compliant

vehicle. Accordingly, we recommend that the mayor continue to call on **central government to provide a diesel scrappage scheme** that incorporates a facility by which households are provided with support in reaching the costs of compliance. The scheme could provide a cash payment linked to the purchase of a compliant, or zero-emissions capable vehicle. The scheme would have to be time limited and should be targeted at lower-income households. Furthermore, vehicles could be exchanged for access to other sustainable transport use, including public transport and walking and cycling and car clubs, encouraging the modal shift away from private vehicle ownership.

Heavy goods vehicles (HGVs)

In the case of HGVs, roughly 80,000 trips were made each day into and out of inner London in 2010 (Allen et al 2014). Approximately two-thirds of these trips are made by the 14,000 HGVs that enter almost daily (Jacobs 2014b). The non-compliant charge for a HGV within the LEZ is £200 a day and the cost of a compliant HGV is estimated to range from £3,000–16,000, depending on the age of the current vehicle (TfL 2014b). Based on registered fleet composition, it is estimated that 95 per cent of fleet operators with more than 10 HGVs registered (accounting for 90 per cent of HGVs registered) may be able to reallocate vehicles to ensure that only compliant vehicles enter the expanded ULEZ (Jacobs 2014b). For smaller fleet operators, it is estimated that this falls to around 75 per cent. Accordingly, we anticipate that the expanded ULEZ will not have a significant impact on HGV operators given the flexibility that exists within fleets. That said, a cost for compliance is still imposed and HGVs have fewer alternative fuel technologies at their disposal, as the vehicles are particularly weight and space constrained and diesel is an energy dense fuel. As such, we recommend that the mayor **mandate TfL to review the state of the HGV fleet and provide temporary discounts or exemptions** to the LEZ charges if reaching compliance places too onerous a cost on businesses. The fleet would have to be reviewed regularly according to the emergence of alternative fuel options and other technologies. The absence of alternative fuel options cannot be used as a justification for a delay in action on reducing air pollution and procurement decisions should be educated by the fact that any ‘bridge fuels’, such as liquid petroleum gas (LPG), still produce air pollution and CO₂ emissions.

Light goods vehicles (LGVs)

A similar situation can be found with the LGV fleet, though there is more scope for alternative technologies to be developed and adopted in the coming years. In 2010, almost 300,000 LGV trips were made each day into and out of inner London, and almost 12 million trips into and out of central London (Allen et al 2014). There are 200,000 LGVs registered in London, with two-thirds expected to enter or travel within the expanded ULEZ on a weekly basis. Ownership is broadly split between companies (10 per cent), small businesses (40 per cent) and private owners (50 per cent) and, as such, LGVs play an important part in all sectors of London’s economy. LGV owners may find it particularly hard to reach compliance due to the cost of vehicle replacement and the lack of alternative fuel technologies that are currently available. However, it is our understanding that there is greater scope for LGVs to either retrofit or transition to alternative fuel options, such as LPG or electric vehicles.

Therefore, we recommend that the mayor take the same approach to LGVs as HGVs and **mandate TfL to review the state of the LGV fleet and provide temporary discounts or exemptions** to the LEZ charges if reaching compliance places too onerous a cost on businesses, with regular reviews.

PHASE 2 – PHASING OUT DIESEL (2020–2025)

Phase 1 provides policies that can be implemented in the current mayoral term to build a basis for reaching compliance with legal limits on air pollution in London, and details the support and investment needed to minimise the costs of transition. Phase 2 covers the years up to 2025, including the next mayoral term, and its policies are intended to ensure that London has essentially reached compliance by 2025, and is set thereafter to go beyond legal compliance, into the second definition of acceptable levels of air pollution – that is, to reduce pollution to as close to negligible levels as possible.

As the next mayoral term approaches its end, the expanded ULEZ implemented by 2019 would be embedded within London’s transport policies, and its effects would be to change the composition, and emissions, of the road transport fleet. Greater changes are required, however, to build towards compliance, including the accelerated phase-out of diesel vehicles, which contribute most to air pollution. Diesel vehicles, even those at the Euro 6 standard, are too polluting, as chapter 2 explains and as previous modelling has shown (Quilter-Pinner and Laybourn-Langton 2016). Accordingly, the current mayor, and whoever is incumbent beyond 2020, should **set the 10-year goal of phasing out almost all diesel vehicles in London**, sending a clear message to manufacturers. This should be amplified by working in concert with central government and other cities in the UK and abroad. The ongoing phasing-out of diesel vehicles would, primarily, push NO₂ concentrations towards compliance. However, though reductions in PM would likely result, as much as 60 per cent of road transport PM emissions come from non-exhaust sources, such as tyre wear and brakes, which can only be minimised through reductions in traffic (Howard 2015). As such, we also recommend that the mayor **focus transport policy in phase 2 on a reduction in vehicle miles**. Such a focus would also have a significant impact on reducing congestion and CO₂ emissions from road transport. Reductions in CO₂ are particularly important in light of the requirement for London to almost completely decarbonise by the middle of the century as part of the global effort to reduce net greenhouse gas emissions to zero beyond 2050, as set out in the Paris agreement on climate change concluded in December 2015.

To accelerate the phase-out of diesel, we recommend that the mayor **ensures all Euro 6 diesel cars are included within the expanded ULEZ by 2025**. Such a policy would affect nearly all cars on the road today and those vehicles manufactured thereafter. Therefore, the mayor should **announce the plan to include all diesel cars in the expanded ULEZ as soon as possible** in phase 1 to provide forewarning for drivers and manufacturers.

Furthermore, alongside policies to reduce car emissions, the mayor should increase the emissions standards facing vans, buses and taxis across London in an effort to push air pollution levels towards compliance. Specifically, we recommend that the mayor:

- **increase the Euro standard on LGVs within the expanded ULEZ so they must meet Euro 6 by 2025**
- **ensure all buses should be zero emissions within central London and on major routes where air pollution levels are particularly acute**
- **implement a ban on all diesel taxis across London in 2025** – this ban must be announced before 2018 to provide adequate forewarning to those purchasing new taxis before the zero-emissions capability requirement given in phase 1 binds. Furthermore, it would ensure the more rapid uptake of zero-emissions capable taxis in phase 1, as drivers would know that, by 2025, all taxis purchased in 2013 would be banned.

In the case of reducing vehicle miles, we recommend the mayor **introduce an emissions charge on all non-zero-emissions cars across inner London by 2025**. It is our view that this charge should seek to reduce traffic miles by 5 per cent per year, driving a modal shift away from vehicles using the internal combustion engine and towards sustainable transport means. It would be the responsibility of TfL to set the level of charge required to meet this goal. Indeed, the task can only be properly undertaken by TfL, which alone possesses the necessary resources, modelling capability and expertise to assess, develop and implement an expanded emissions charge across inner London. An overall reduction in vehicle use would boost economic and health outcomes not just through a reduction in air pollution, CO₂ emissions and congestion, but also through an increase in physical activity, changes in working practices, and improvements in the wider urban environment (Tainio et al 2016).

Finally, to complement the reduction in vehicle miles and to build towards a future in which road transport emissions are reduced to negligible levels, we recommend that the mayor should consider the **introduction of a zero emissions zone (ZEE) across central London from 2025**. The ZEE would ensure direct that NO₂ and PM emissions are reduced to a minimum in the centre of London, eliminating the transboundary effects upon the rest of London. Implementation of the zone would have to be carefully considered. Even after nearly 10 years of technological change spurred by the aforementioned policies, replacement options may still be limited and present too high a cost to households, businesses and other sectional interests who operate within central London. As such, exemptions must be made available for vehicles with constrained replacement options, particularly LGVs, HGVs and coaches – a process which should be reviewed by TfL.

Investment in alternative transport options

The introduction, administration and enforcement of these policies would be costly for TfL. Road users would need to be well informed – well in advance of the implementation timeline – of the actions required on their part, of the existing and planned transport alternatives, and, crucially, of how revenues would be reinvested. Alongside this, adequate

monitoring and compliance mechanisms should be put in place, such as personalised accounts that provide drivers with a central, online platform for charging costs and enable a seamless means of payment. These could allow for charging schedules based on vehicle type and journey, with charging levied via number plate recognition by an extended camera network. Though these measures would be costly, extending emissions charging across inner London, in particular, is likely to raise significant revenues, which TfL could use to pay for the introduction of schemes and invest in alternative, sustainable transport and support schemes for drivers and businesses, such as those detailed above. In addition, future revenues could also be used to compensate for the loss of TfL's general grant from central government.

Indeed, the provision of alternative, sustainable transport options is integral to the success of such a scheme, and will, in turn, benefit from it, as road-pricing revenues are reinvested and congestion is alleviated. History provides a good guide here: the greatest cost incurred in establishing the CCZ lay in upgrading the public transport network (TfL 2005), but since then around 80 per cent of the resultant revenues have been invested in the bus network alone (ESMAP 2011). As such, the **revenues raised by road charging should be reinvested into the public transport network and alternative, sustainable transport options**, particularly in those areas within inner London where coverage is lower.

TfL's network remains the most resource-efficient means of moving London's population, particularly at peak times. Cycling investment is also providing clear gains, with the number of cyclists having tripled since 2000 (TfL 2015c). This investment should continue, with a renewed emphasis on safety, including further investigation of the scope for segregated routes and cycle bridges. Meanwhile, electric vehicles (EV) and car sharing schemes can reduce emissions and congestion (CCC 2015). The mayor should ensure the rollout of EV and the required charging infrastructure are given top priority, and **include a plan for the expansion of the car share market in the new mayor's transport strategy** as part of a drive to facilitate a modal shift in London.

BEYOND 2025 – THE FUTURE OF MOBILITY IN LONDON⁹

The sum effect of the policies detailed in phases 1 and 2 are likely to push levels of air pollution in London towards compliance with legal levels, and lay the foundations for a future in which the capital can reduce air pollution to negligible levels. In doing so, the composition of London's road transport fleet will change dramatically, from diesel to petrol and then from petrol to zero emissions alternatives.

As discussed, road charging is the main mechanism through which this change will occur. New techniques offer ways of making road charging more efficient and targeted. Foremost among them should be a 'smart charging' system, along the lines of the electronic road pricing system used in Singapore.

9 IPPR will release a briefing paper on the future of mobility in London in the coming months.

Smart charging places the monitoring and enforcement mechanisms of road pricing schemes into the vehicle itself, through a smartphone or other device, collecting real-time data on location and basing pricing decisions on a vehicle specification linked to a road user's payment account with TfL. Such a system would allow the variable charging of road pricing zones, allowing TfL to more efficiently drive reductions in air pollution and congestion when they reach intolerable levels through the price mechanism. Furthermore, it would reduce the costs of enforcement and monitoring both through almost eradicating the potential for abuse of the system and minimising the number of cameras and other monitoring equipment needed. Smart charging would also allow the targeting of key groups eligible for support in bearing the costs of road pricing, particularly if charging were to become variable based upon driving conditions. Finally, smart charging would provide the means by which TfL could integrate all the existing and planned road pricing schemes into one holistic charging regime, reducing costs of administration through economies of scale and improving ease of use for road users.

Therefore, we recommend that the mayor **mandate TfL to investigate the potential for a smart charging system and an integrated road pricing scheme in London**, with the objective of implementing both after 2025. This would ensure that road users more accurately cover the cost to society of the congestion, air pollution and CO₂ emissions they cause. A number of challenges to successful implementation exist, and would need to be carefully considered by the mayor and TfL with the input of all communities within London. There are a number of forms a smart charging system could take – from charging schedules that change quarterly, to those that occur in real-time. Different systems present a range of technical and privacy issues, among others. The success of a smart charging scheme depends on satisfactory answers to these challenges, and TfL is best placed to explore the possible set of future solutions.

Road pricing will also ensure transport behaviours move from private vehicle ownership and use to more sustainable and shared alternatives. Indeed, these changes are already occurring, albeit slowly.

The digital revolution has precipitated an increase in app-based mobility platforms that are disrupting existing markets, and are transitioning the idea of mobility from that of the ownership of vehicles to the consumption of transport services. In the case of the taxi and PHV markets, Uber has already irrevocably altered the status quo, providing on-demand PHV services through its app and mobilising over 25,000 drivers (Titcomb 2016). It is yet to be seen if the rise of Uber will reduce car ownership and use, or, conversely, increase emissions and congestion, at least in the short run. Furthermore, there are concerns around the effect upon market incumbents, and the loss of jobs in particular, and how much government should intervene to actively ensure equality of access and opportunity in the taxi and PHV market.

In the private car market, car share companies, such as Zipcar and DriveNow, are already having a tangible effect upon ownership and usage behaviour, with each London car club vehicle removing over 10 cars in 2015/16 and having an average occupancy of 2.5 people (compared to the

average private use of 1.6 people per car) (Carplus 2016). Alongside the more efficient use of the vehicle fleet, London's car club vehicles produce 30 per cent less CO₂ than the average car, and reduce a user's carbon footprint by 49 per cent. Furthermore, car club users are more likely to cycle and use public transport.

These changes presage a future in which car ownership has dramatically declined and mobility is seen as a service. Indeed, mobility as a service (MaaS) platforms, that aggregate all available transport options and provide central payment and subscription options, are already being tested. Foremost among them is 'Whim', a MaaS app developed in Finland, which builds on the functionality already provided by apps such as Citymapper and Google Maps by providing monthly subscription packages for all transport options based upon the user's mobility needs (MaaS Global 2016).

The disruption digital technology is bringing to transport markets is likely to continue and accelerate. With it comes enormous potential to reduce pollution and congestion from road transport as ownership and usage declines. As such, measures to reduce air pollution, and other negative transport outcomes, should be developed in tandem with those looking at the future of mobility.

5. EU AND NATIONAL POLICY

While there is much that London can do to tackle air pollution on its own, action is required at both a national and EU level to ensure air pollution is brought to within acceptable levels. There are a number of reasons for this.

1. The UK imports many of its vehicles, with a negative trade balance in cars, many of which come from the EU (Rhodes and Sear 2015). As such, EU policy on vehicle manufacturing has, and will continue to have, a direct effect upon UK air quality, irrespective of the country's exit from the EU.
2. London is affected by transboundary air pollution, caused by emissions from sources outside of the capital and blown in by prevailing winds. Action within the city's borders must therefore be complemented with action on air pollution outside of London.
3. The large-scale action on air pollution recommended in chapter 4 would inevitably lead to the export of the most-polluting vehicles out of London, through the secondhand market, and into those areas with an air pollution problem that do not have the same policies as in the capital.
4. The result of the referendum on the UK's EU membership presents an opportunity for central government to go beyond EU limit values on air pollution. There is a very strong case for the UK to take this opportunity.

EUROPEAN POLICY

The UK imports a large number of vehicles from the EU, while the automotive industry exports the majority of its vehicles back the other way, and so those vehicles manufactured and sold in the UK will have to meet the same standards as those in the EU single market (SMMT 2016). As such, EU policy will remain a major driver of local air pollution levels in London irrespective of the UK's exit from the EU, determining the proportions and air quality performance of diesel, petrol, hybrid and electric vehicles. It does this in two main ways.

1. Through laws and regulations on vehicle manufacturers that enforce emissions standards in new vehicles, and the testing regimes under which these standards are set and vehicle performance measured.
2. Through the Ambient Air Quality and National Emissions Ceilings Directives, which set limits on local air pollution concentration levels with which member states have to comply.

The former requires vehicle manufacturers to directly reduce emissions through improving the air quality performance of existing technologies, or switching to new ones. As discussed in chapter 2, the latter requires

EU member states to introduce policies to reduce air pollution, such as through vehicles tax rates and local clean air zones. In turn, these policies further incentivise manufacturers to produce cleaner vehicles that are compliant with limit values. The EU will be able to use at least the first of these levers to drive further progress in air pollution in London even if the UK leaves the EU. Its ability to use the second lever is highly uncertain, and dependent on the trading agreement made between the EU and the UK, as discussed below.

In the case of emissions standards for vehicle manufacturers, action could be taken by the EU to improve testing regimes and ensure greater conformity with existing standards. These efforts would help combat the failures of the existing laboratory testing regimes, and are already in train with the introduction of the new on-road 'real driving emissions' test in 2019, as described in chapter 2. As it stands, the conformity factor by which vehicles must adhere to the Euro standards – the factor by which real-world emissions can differ from laboratory tests – will be 2.1 for those sold from 2019, falling to 1.5 from 2021.

The public health literature points to any levels of air pollution being unsafe, and so all sections of society have an obligation to reduce emission levels (see chapter 2). Furthermore, much of the failure to reduce air pollution in London has been driven by vehicles that do not conform to Euro standards. Therefore, we recommend that **the mayor of London work with other city mayors around Europe to argue for the implementation date of the conformity factors to be brought forward, eventually introducing a conformity factor of 1 by 2021**. This would likely drive vehicle manufacturers to either deliver on promises of cleaner diesel fuels or shift production and sales towards alternative petrol, gas, electric or hybrid alternatives.

NATIONAL POLICY

Prior to air quality legislation being underpinned by EU law, the UK's air quality standards were not binding, and so could only guide decisions around regulation (IEEP 2016). As discussed in chapter 3, if the UK were to remain a member of the European Economic Area (EEA) then the EU air quality legislation would still apply, though the UK would lose its right to vote on or shape legislation. If the UK did not enter the EEA, then the UK could alter or repeal this legislation. This would mean there would be no legal recourse through the European Court of Justice and so there would be no judicial means of upholding those EU regulations that have been transposed into UK law, presenting, as the Institute for European Environmental Policy has concluded, a 'significant risk to the health of UK citizens in major urban areas where meeting EU standards is currently a problem' (IEEP 2016).

This is a non-trivial risk, considering the potential effects upon morbidity and mortality, and so the UK government should provide assurance that action on air pollution will not be affected by the decision to leave the EU. Indeed, leaving the EU presents an opportunity to go further on air pollution by passing new legislation to secure existing limit values and provide guidance on increased ambition to citizens, local authorities and industry. Accordingly, campaigners and the mayor of London have called

for a new Clean Air Act to protect and accelerate action on air pollution across London and the UK (ClientEarth 2016, GLA 2016b). We join these calls and recommend that **central government introduces a new Clean Air Act that targets air pollution, including nitrogen oxides and particulate matter**. In particular, the Act would focus on:

- the retention of air pollution limits under the EU Ambient Air Quality Directive and the enhancement of these limits through the adoption of the World Health Organisation’s revised guidelines on particulate matter
- the guarantee of the right to access courts to enforce these provisions, in accordance with the Aarhus convention
- a national plan for introducing clean air zones that phase out diesel vehicles and accelerate a modal shift towards zero emissions transport and sustainable alternatives, such as cycling and walking
- support for manufacturers and local authorities in accelerating the rollout of electric vehicles, including a clear timetable for the delivery of reliable charging networks in towns and cities and continued investment in research and development of electric highways.

As discussed in chapter 2, as part of its existing efforts to reduce CO₂ emissions, the UK government has promoted diesel vehicles through tax incentives, particularly those in vehicle excise duty (VED). The tax rate was changed in 2001 and, within three years, diesel cars had increased to 33 per cent of new cars bought – up from 7.4 per cent in 1994 (DfT 2015b). Diesel cars now comprise nearly 38 per cent of the national fleet, a proportion that has been roughly increasing at the same rate each year since the tax rate changes (DfT 2016). As such, the current VED regime is continuing to promote vehicles that have a disproportionately high contribution to air pollution. In order to reverse this trend, we recommend that **central government progressively reforms the VED regime to disincentivise diesel cars relative to petrol**.

Behavioural modelling would be needed to establish the size of the differential required but to achieve a significant decline in diesel sales and use it would likely have to be substantial. National VED reform should be sought regardless, but in order to reach compliance in areas with acute air quality problems, the government could devolve VED rates to urban centres so that they could go further and faster, as recommended for London in chapter 4. Indeed, the creation of mayoralities for city regions in the north of England and the devolution agenda around the northern powerhouse present an opportunity for VED devolution to become part of the political debate around air pollution. However, the practical implications of devolution, including the questions around where vehicles must be registered and how systems will be enforced, require more investigation before VED devolution can become a viable policy nationwide.

Furthermore, as discussed in the previous chapter, central government must support cities, such as London, in reducing the cost incurred by households of reaching compliance for a diesel car, or switching to alternative, sustainable forms of transport. Accordingly, central government should **introduce a national diesel scrappage scheme**.

The scheme should not only provide a cash payment linked to the purchase of a compliant vehicle, but encourage the modal shift away from private ownership by offering incentives to use public transport and car clubs, or cycle and walk.

Finally, the National Audit Office (NAO) – in its investigation into the role of the Department for Transport (DfT) in ensuring environmental objectives are met across transport policy – has raised questions over the department’s appraisal process (NAO 2016). In particular, the NAO concluded that the appraisal process was weighted towards transport efficiency and that some stakeholders are viewing the ‘department’s engagement with the environment as being focused on mitigation of impacts, rather than as a system which considers the environment to be sufficient reason to prevent a project going ahead at all, or as a justification for intervention’ (ibid). This is partly because environmental issues, and their fiscal implications, fall under the purview of other departments, particularly Defra and the Treasury. In response, the environmental audit committee has called for greater interdepartmental cooperation, singling out the DfT as being particularly well suited to act as an intermediary (EAC 2016). Therefore, we recommend that **the Department for Transport should convene all relevant departments to ensure that the transport analysis guidance accurately reflects the cost of air pollution within its appraisal process.**

6. CONCLUSION

It is only recently that awareness of London's air pollution problem has reached critical mass. The capital's air is both illegal and lethal, breaking legal limits enshrined in UK law and contributing to the equivalent of up to 9,416 deaths in 2010 alone.

This pollution is predominantly caused by road transport and, within that, the diesel engine. Previous actions have failed to control this problem, and partial solutions will ensure this failure continues. This report argues that London's air pollution problem will only be solved if diesel vehicles are increasingly phased out across London. Similar measures are set to be implemented in other major European cities. There is much the mayor of London can do to achieve this objective. Modelling commissioned for this report has estimated that the near total phase-out of diesel cars in inner London, and the move towards more sustainable alternatives for other vehicles, would bring nearly all of London into compliance with legal limits on NO₂ and, accordingly, increase lives by a total of up to 1.4 million life-years, providing an annualised economic benefit of up to £800 million.

We have provided a suite of policies to be enacted over the next 10 years that seek to achieve this outcome. These policies might be hard to achieve in one term alone, and so we have detailed a 'two term plus' strategy that aims to push London beyond compliance, towards ever healthier air, in the years beyond 2025. Political ambition can make a large difference to the health of London's population and economy.

Such a transition would affect millions of Londoners and is likely to have a non-trivial effect upon low-income groups and some businesses. We have proposed a number of policies designed to ensure support is given to affected groups, and it is our view that the benefit of action – in terms of improved health outcomes and reductions in congestion and CO₂ – is likely to outweigh the costs of increased charges for road users. Furthermore, we provide a number of policies that would lay the foundation for London to go beyond compliance and towards negligible levels of air pollution as we approach 2030. These policies are summarised at the end of this chapter.

While these actions would result in a major reduction in London's air pollution, complementary action is required by central government. National policy must drive progress on air pollution in London because neither air pollution nor road transport use and ownership respect borders. Effective intervention in one area, such as London, will export the problem elsewhere through secondhand vehicle markets, and so action on air pollution must, ultimately, be *national* action on air pollution. We have suggested a number of policies at the EU and national level, including, in particular, a new Clean Air Act that would drive greater

ambition throughout the UK and ensure any risk to action on air pollution from the country exiting the EU is minimised. IPPR will continue its work in this area.

Regardless of the actions of national and EU governments, the mayor of London is presented with a unique political opportunity to implement the measures needed to bring the capital's air pollution down to acceptable levels, and ensure all Londoners reap the rewards of improved health, social and economic outcomes. London has been here before, having been blighted by air pollution crises during periods of growth throughout its history. Each time it has risen to the challenge.

SUMMARY OF RECOMMENDATIONS

London government – Phase 1 (2016–2020)

- The mayor should extend the ultra low emissions zone (ULEZ) and accelerate its implementation, including by:
 - extending the ULEZ up to the north and south circular roads, bringing implementation forward to 2019
 - ensuring that diesel cars below the Euro 6 standard and petrol cars below the Euro 4 standard are charged a fee per day if they enter the zone
 - increasing the pollution standard on LGVs within the LEZ so they must meet Euro 5, from the current requirement of Euro 3
 - increasing the pollution standard on HGVs and coaches within the LEZ to Euro 6, from the current requirement of Euro 4.
- Transport for London should procure only hybrid or zero emissions buses from 2018 and increase the emissions standard on TfL buses to Euro 6 within the expanded ULEZ.
- Central government should devolve vehicle excise duty to the London level.
- The mayor should require all newly licensed private hire vehicles to be zero-emissions capable from 2018.
- The mayor should call on central government to provide a diesel scrappage scheme.
- Transport for London should determine any temporary exemptions and discounts for those most adversely affected by the expanded ULEZ.
- The mayor should include a plan for the expansion of the car share market in his new transport strategy.

London government – Phase 2 (2020–2025)

The mayor should:

- ensure that all Euro 6 diesel cars are charged within the expanded ULEZ by 2025, announce the plan to charge all diesel cars in the expanded ULEZ as soon as possible
- increase the pollution standard on LGVs within the LEZ so that they must meet Euro 6 by 2025
- ensure that all buses are zero emissions within central London, and on major routes where air pollution levels are particularly acute
- implement a ban on all diesel taxis across London in 2025

- introduce an emissions charge on all non-zero-emissions cars across inner London by 2025
- consider introducing a zero emission zone across central London from 2025
- mandate TfL to investigate the potential for a smart charging system and an integrated road pricing scheme in London
- ensure the revenues raised by road charging are reinvested into the public transport network and other alternative, sustainable transport options.

Influencing EU policy

- The mayor should work with other city mayors around Europe to argue for implementation date of the conformity factors to be brought forward, eventually introducing a conformity factor of 1 by 2021.

National policy

The government should:

- introduce a new Clean Air Act that targets air pollution, including nitrogen oxides and particulate matter
- introduce a diesel scrappage scheme
- progressively reform the VED regime to disincentivise diesel cars relative to petrol.

The Department for Transport should:

- convene all relevant departments to ensure the transport analysis guidance accurately reflects the cost of air pollution within its appraisal process.

REFERENCES

- Allen J, Browne M, Woodburn A (2014) *London Freight Data Report: 2014 Update*, University of Westminster. <http://content.tfl.gov.uk/london-freight-data-report-2014.pdf>
- AMEC (2014) *Comparison of Air Quality in London with a Number of World and European Cities*. https://www.london.gov.uk/sites/default/files/comparison_of_air_quality_in_world_cities_study_final.pdf
- Bailey D (2016) 'What does Brexit mean for the UK's automotive industry?', online newsletter, *The UK in a Changing Europe*, 25 July 2016. <http://ukandeu.ac.uk/what-does-brexit-mean-for-the-uks-automotive-industry/>
- Bell ML, Davis DL and Fletcher T (2004) 'A Retrospective Assessment of Mortality from the London Smog Episode of 1952: The Role of Influenza and Pollution', *Environmental Health Perspectives* 112: 6–8. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1241789/pdf/ehp0112-000006.pdf>
- Birkett S (2015) 'Defra NO₂ consultation: "Plan for plans by others" is inadequate', webpage, Clean Air in London. <http://cleanair.london/sources/defra-buries-consultation-on-diesel-ban-in-cities-minutes-before-corbyn-announcement/>
- Cames M and Helmers E (2013) 'Critical evaluation of the European diesel car boom – global comparison, environmental effects and various national strategies', *Environmental Sciences Europe* 2013 25:15. <https://enveurope.springeropen.com/articles/10.1186/2190-4715-25-15>
- Car Club Coalition [CCC] (2015) *A Car Club Strategy for London: Growing car clubs to support London's transport future*. <http://content.tfl.gov.uk/tfl-car-club-strategy.pdf>
- Carplus (2016) *Car clubs in London: changing the way Londoners travel*. <http://www.carplus.org.uk/wp-content/uploads/2016/04/Carplus-Annual-Survey-of-Car-Clubs-in-London-A4-AW.pdf>
- Carlaw D (2014) 'Recent findings from comprehensive vehicle emission remote sensing measurements', presentation to Frontiers in Air Quality Science, 23–24 June 2014. http://www.londonair.org.uk/london/asp/LAQNSeminar/pdf/June2014/David_Carlaw_Recent_findings_from_comprehensive_vehicle_emission_remote_sensing_measurements.pdf
- Carlaw D C, Rhys-Tyler G (2013) 'New insights from comprehensive on-road measurements of NO_x, NO₂ and NH₃ from vehicle emission remote sensing in London, UK', *Atmospheric Environment* 81: 339–347. <http://www.sciencedirect.com/science/article/pii/S1352231013007140>
- Centre for Economics and Business Research [CEBR] (2014) *The future economic and environmental costs of gridlock in 2030*. http://inrix.com/wp-content/uploads/2015/08/Whitepaper_Cebr-Cost-of-Congestion.pdf
- ClientEarth (2016) 'ClientEarth calls for a new Clean Air Act', webpage, 4 July 2016. <http://www.clientearth.org/clientearth-calls-new-clean-air-act-tackle-air-pollution/>
- Collinson P (2016) 'Vienna named world's top city for quality of life', *Guardian*, 23 February 2015. <https://www.theguardian.com/business/2016/feb/23/vienna-named-worlds-top-city-for-quality-of-life>
- Committee on the Medical Effects of Air Pollutants [COMEAP] (2010) *The Mortality Effects of Long-Term Exposure to Particulate Air Pollution in the United Kingdom*, Public Health England. <https://www.gov.uk/government/publications/comeap-mortality-effects-of-long-term-exposure-to-particulate-air-pollution-in-the-uk>
- Committee on the Medical Effects of Air Pollutants [COMEAP] (2015a) *Statement on the evidence for the effects of nitrogen dioxide on health*, Public Health England. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/411756/COMEAP_The_evidence_for_the_effects_of_nitrogen_dioxide.pdf

- Committee on the Medical Effects of Air Pollutants [COMEAP] (2015b) 'Interim statement on quantifying the association of long-term average concentrations of nitrogen dioxide and mortality', Public Health England. <https://www.gov.uk/government/publications/nitrogen-dioxide-interim-view-on-long-term-average-concentrations-and-mortality>
- Department for Environment, Food and Rural Affairs [Defra] (2015a) *Air Pollution in the UK 2014*. https://uk-air.defra.gov.uk/library/annualreport/viewonline?year=2014_issue_1
- Department for Environment, Food and Rural Affairs [Defra] (2015b) *Improving air quality in the UK – Tackling nitrogen dioxide in our towns and cities*. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/486636/aq-plan-2015-overview-document.pdf
- Department for Environment, Food and Rural Affairs [Defra] (2015c) 'Improving air quality in cities', news release, 17 December 2015. <https://www.gov.uk/government/news/improving-air-quality-in-cities>
- Department for Transport [DfT] (2015a) 'Taxi and Private Hire Vehicle Statistics: England 2015', statistical release, 25 August 2015. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/456733/taxi-private-hire-vehicles-statistics-2015.pdf
- Department for Transport [DfT] (2015b) 'Vehicle Licensing Statistics: Quarter 4 (Oct–Dec) 2014', statistical release, 9 April 2015. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/421337/vls-2014.pdf
- Department for Transport [DfT] (2016) 'Vehicle Licensing Statistics: Quarter 4 (Oct - Dec) 2015', statistical release, 14 April 2016.
- Dickens C (1853) *Bleak House*. Reprint, Wordsworth Editions, 1993.
- Energy Sector Management Assistance Program [ESMAP] (2011) *Good Practices in City Energy Efficiency: London, United Kingdom – Congestion Charges for Urban Transport*, World Bank. <https://www.esmap.org/sites/esmap.org/files/London%20Final%20edited.pdf>
- Environmental Protection Agency [EPA] (US) (2016) *Integrated Science Assessment for Oxides of Nitrogen – Health Criteria, 2016 Final Report*, Washington D.C. <https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=310879>
- European Commission [EC] (1998) 'Commission and ACEA agree on CO₂ emissions from cars', press release, 29 July 1998. http://europa.eu/rapid/press-release_IP-98-734_en.htm?locale=en
- European Commission [EC] (2010a) 'Air quality: Commission sends final warning to UK over levels of fine particle pollution', press release, 3 June 2010. http://europa.eu/rapid/press-release_IP-10-687_en.pdf
- European Commission [EC] (2010b) 'Commission welcomes Member States' agreement on robust testing of air pollution emissions by cars', press release, 28 October 2015. http://europa.eu/rapid/press-release_IP-15-5945_en.htm
- European Commission [EC] (2013) 'Diesel cars' climate impacts not as beneficial as believed, scientists conclude', *Science for Environmental Policy*, news alert, 5 December 2013. http://ec.europa.eu/environment/integration/research/newsalert/pdf/353na4_en.pdf
- European Commission [EC] (2015) 'Commission welcomes Member States' agreement on robust testing of air pollution emissions by cars', press release, 28 October 2015. http://europa.eu/rapid/press-release_IP-15-5945_en.htm
- European Commission [EC] (2016) 'Air Quality – Existing Legislation', webpage. http://ec.europa.eu/environment/air/quality/legislation/existing_leg.htm
- European Commission Joint Research Centre [ECJRC] (2015) 'Mandate and Scope – RDE Task Force on Uncertainty Evaluation', presentation, 1 October 2015. [https://circabc.europa.eu/webdav/CircaBC/GROW/wltp/Library/meetings/RDELVDV%20meetings%202015%20-151001%20-%20RDE-LDV_Uncertainty_evaluation%20\(audio_web\)/Introduction.pdf](https://circabc.europa.eu/webdav/CircaBC/GROW/wltp/Library/meetings/RDELVDV%20meetings%202015%20-151001%20-%20RDE-LDV_Uncertainty_evaluation%20(audio_web)/Introduction.pdf)
- European Environment Agency [EEA] (2016) *Reported CO₂ emissions from new cars continue to fall*. <http://www.eea.europa.eu/highlights/reported-co2-emissions-from-new>
- Goulding T (2016) 'UK among EU nations 'watering down' air quality proposals', *Air Quality News*, 21 June 2016. <http://www.airqualitynews.com/2016/06/21/uk-among-eu-nations-watering-air-quality-proposals/>

- Greater London Authority [GLA] (2010) 'London Atmospheric Emissions Inventory 2010', dataset. <http://data.london.gov.uk/dataset/london-atmospheric-emissionsinventory-2010>
- Greater London Authority [GLA] (2014) *London Infrastructure Plan 2050, a consultation*. <https://www.london.gov.uk/what-we-do/business-and-economy/better-infrastructure/london-infrastructure-plan-2050>
- Greater London Authority [GLA] (2015a) 'Interim London Energy and Greenhouse Gas Inventory (LEGGI) 2013', statistical release, 6 July 2015. <http://data.london.gov.uk/dataset/interim-leggi--2013>
- Greater London Authority [GLA] (2016a) 'Results of the Clean Air Consultation', webpage, 13 September 2016. <http://talklondon.london.gov.uk/blogs/talk-london-team/results-clean-air-consultation>
- Greater London Authority [GLA] (2016b) 'Sadiq Khan unveils action plan to battle London's toxic air', webpage, 5 July 2016. <https://www.london.gov.uk/press-releases/mayoral/mayor-unveils-action-plan-to-battle-toxic-air>
- Greater London Authority [GLA] (2016c) 'Mayor calls for new measures to secure the success of London's roads', press release, 4 February 2016. <https://www.london.gov.uk/press-releases/mayoral/mayor-calls-for-new-road-improvement-measures>
- Helmets E (2016) 'Does the European diesel car boom mitigate global warming', briefing paper, Green Budget Europe, February 2016. http://green-budget.eu/wp-content/uploads/2016-02-17_Helmets_European-diesel-car-bias-makes-climate-worse1.pdf
- Hotten R (2015) 'Volkswagen: The scandal explained', BBC, 10 December 2015. <http://www.bbc.co.uk/news/business-34324772>
- House of Commons Environmental Audit Committee [EAC] (2016) *Sustainability in the Department for Transport: Third Report of Session 2016-17*, House of Commons. <http://www.publications.parliament.uk/pa/cm201617/cmselect/cmenvaud/184/184.pdf>
- Howard R (2015) *Up in the Air: How to Solve London's Air Quality Crisis: Part 1*, Policy Exchange. <https://policyexchange.org.uk/publication/up-in-the-air-how-to-solve-londons-air-quality-crisis-part-1/>
- Howard R, Beevers S and Dajnak D (2016) *Up in the Air: How to Solve London's Air Quality Crisis: Part 2*, Policy Exchange. <https://policyexchange.org.uk/wp-content/uploads/2016/09/up-in-the-air-part-2.pdf>
- Institute for European Environmental Policy [IEEP] (2016) *The potential policy and environmental consequences for the UK of a departure from the European Union*, March 2016. http://www.ieep.eu/assets/2000/IEEP_Brexit_2016.pdf
- International Agency for Research on Cancer [IARC] (2012) *IARC: diesel engine exhaust carcinogenic*, WHO press release no 213, 12 June 2012. https://www.iarc.fr/en/media-centre/pr/2012/pdfs/pr213_E.pdf
- International Council on Clean Transportation [ICCT] (2015a) *NO_x control technologies for Euro 6 diesel passenger cars*. <http://www.theicct.org/nox-control-technologies-euro-6-diesel-passenger-cars>
- International Council on Clean Transportation [ICCT] (2015b) *European Vehicle Market Statistics – Pocketbook 2015/16*. http://www.theicct.org/sites/default/files/publications/ICCT_EU-pocketbook_2015.pdf
- Jacobs (2014a) *Ultra Low Emission Zone Integrated Impact Assessment – Environmental Assessment*. https://consultations.tfl.gov.uk/environment/ultra-low-emission-zone/supporting_documents/ULEZ%20IIA_EA_FINAL.pdf
- Jacobs () *Ultra Low Emission Zone Integrated Impact Assessment – Economics and Business Impact Assessment*. https://consultations.tfl.gov.uk/environment/ultra-low-emission-zone/user_uploads/ulez-ia_ebia_final.pdf
- Laybourn-Langton L (2016) *London: Global green city*, IPPR. <http://www.ippr.org/publications/london-global-green-city>
- Leake J (2016) 'Clean air pledge based on tests of five cars', the *Times*, 22 May 2016. <http://www.thetimes.co.uk/article/clean-air-pledge-based-on-tests-of-five-cars-9bq8p7qj9>
- London Assembly Environment Committee [LAEC] (2015) *Driving away from diesel: reducing air pollution from diesel vehicles*, Greater London Authority. <https://www.london.gov.uk/sites/default/files/Driving%20Away%20from%20Diesel%20final%20report.pdf>

- London Finance Commission [LFC] (2013) *Raising the capital: the report of the London Finance Commission*. https://www.london.gov.uk/sites/default/files/gla_migrate_files_destination/Raising%20the%20capital_0.pdf
- MaaS Global (2016) 'Whim is ready to go!', webpage. <http://maas.global/our-solutions/>
- Met Office (2015) 'The Great Smog of 1952', web page, 20 April 2015. <http://www.metoffice.gov.uk/learning/learn-about-the-weather/weather-phenomena/case-studies/great-smog>
- Murphy J (2015) 'London pollution: 50 worst spots in UK for air filth are ALL in the capital', *Evening Standard*, 5 March 2015. <http://www.standard.co.uk/news/london/london-pollution-shame-laid-bare-the-uks-50-worst-spots-for-air-filth-are-all-in-the-capital-10087611.html>
- National Audit Office [NAO] (2016) *Departmental Sustainability Overview: the Department for Transport*. <https://www.nao.org.uk/wp-content/uploads/2016/04/DFT-sustainability-overview-briefing-for-EAC.pdf>
- Press Association [PA] (2016) 'UK government told to take action on air pollution or face legal challenge', *Guardian*, 1 March 2016. <https://www.theguardian.com/environment/2016/mar/01/government-told-to-take-action-on-air-pollution-or-face-legal-challenge>
- Quilter-Pinner H and Laybourn-Langton L (2016) *Lethal and illegal: London's air pollution crisis*, IPPR. <http://www.ippr.org/publications/lethal-and-illegal-londons-air-pollution-crisis>
- Rhodes C and Sear D (2015) *The motor industry: statistics and policy*, briefing paper no 00611, House of Commons Library. <http://researchbriefings.files.parliament.uk/documents/SN00611/SN00611.pdf>
- Royal College of Physicians [RCP] (2016) *Every breath we take: the lifelong impact of air pollution*, report of a working party. <https://www.rcplondon.ac.uk/projects/outputs/every-breath-we-take-lifelong-impact-air-pollution>
- Society of Motor Manufacturers and Traders [SMMT] (2016) *SMMT Motor Industry Facts 2016*. <http://www.smmt.co.uk/2016/05/motor-industry-facts-2016/>
- Tainio M, de Nazelle A J, Götschi T, Kahlmeier S, Rojas-Rueda D, Nieuwenhuijse, M J, de Sá TH, Kelly P and Woodcock J (2016) 'Can air pollution negate the health benefits of cycling and walking?', *Preventive Medicine*, 87: 233–236. <http://dx.doi.org/10.1016/j.ypmed.2016.02.002>
- Te Brake WH (1975) 'Air Pollution and Fuel Crises in Preindustrial London, 1250-1650', *Technology and Culture* 16(3): 337–359. <http://infinitiesque.net/articles/2012/Environmental%20History/3103030.pdf>
- Titcomb J (2016) 'Majority of Uber drivers in London work part time, study says', *Daily Telegraph*, 2 June 2016. <http://www.telegraph.co.uk/technology/2016/06/02/majority-of-uber-drivers-in-london-work-part-time-study-says/>
- Transport & Environment (2015) *Don't Breathe Here*. https://www.transportenvironment.org/sites/te/files/publications/Dont_Breathe_Here_report_FINAL.pdf
- Transport & Environment (2016) *Dieselgate: Who? What? How?*. https://www.transportenvironment.org/sites/te/files/2016_09_Dieselgate_report_who_what_how_FINAL_0.pdf
- Transport for London [TfL] (2005) *Central London Congestion Charging Impacts monitoring: Third Annual Report*. <http://web.archive.org/web/20140224074429/http://www.tfl.gov.uk/assets/downloads/ThirdAnnualReportFinal.pdf>
- Transport for London [TfL] (2011) *Travel in London, Supplementary Report: London Travel Demand Survey (LTDS)*. <http://content.tfl.gov.uk/london-travel-demand-survey.pdf>
- Transport for London [TfL] (2012) 'How many cars are there in London and who owns them?', technical note 12, Roads Task Force. <http://content.tfl.gov.uk/technical-note-12-how-many-cars-are-there-in-london.pdf>
- Transport for London [TfL] (2014a) 'London's Road Modernisation Plan', webpage. <https://tfl.gov.uk/travel-information/improvements-and-projects/whats-the-plan>
- Transport for London [TfL] (2014b) *Ultra Low Emission Zone consultation – supplementary information*. https://consultations.tfl.gov.uk/environment/ultra-low-emission-zone/user_uploads/ulez-supplementary-information---final-291014.pdf

- Transport for London [TfL] (2015a) *Ultra Low Emission Zone: Report to the Mayor*. https://consultations.tfl.gov.uk/environment/ultra-low-emission-zone/user_uploads/ulez-consultation-report-to-the-mayor.pdf
- Transport for London [TfL] (2015b) *Ultra Low Emission Zone (ULEZ) Portfolio*. <http://content.tfl.gov.uk/board-20151217-pt1-item12-ulez.pdf>
- Transport for London [TfL] (2015c) *Travel in London*, Report 8. <https://tfl.gov.uk/corporate/publications-and-reports/travel-in-london-reports>
- Transport for London [TfL] (2016a) 'Your views: how can we clean up our air?', webpage. <https://www.london.gov.uk/what-we-do/environment/pollution-and-air-quality/your-views-how-can-we-clean-our-air-1>
- Transport for London [TfL] (2016b) *Taxi and Private Hire Action Plan 2016*. <http://content.tfl.gov.uk/taxi-and-private-hire-action-plan-2016.pdf>
- UK Supreme Court [UKSC] (2015) 'R (on the application of ClientEarth) (Appellant) v Secretary of State for the Environment, Food and Rural Affairs (Respondent) [2015] UKSC 28 - On appeal from [2012] EWCA Civ 897', press summary, 29 April 2015. <https://www.supremecourt.uk/cases/docs/uksc-2012-0179-press-summary.pdf>
- Vaughan A (2016) 'London's black communities disproportionately exposed to air pollution – study', *Guardian*, 10 October 2016. <https://www.theguardian.com/environment/2016/oct/10/londons-black-communities-disproportionately-exposed-to-air-pollution-study>
- Walton H, Dajnak D, Beevers S, Williams M, Watkiss P and Hunt A (2015) *Understanding the Health Impacts of Air Pollution in London*, King's College London. https://www.london.gov.uk/sites/default/files/hiaainlondon_kingsreport_14072015_final.pdf
- Weiss M, Bonnel P, Hummel R, Manfredi U, Colombo R, Lanappe G, Le Lijour P and Sculati M (2011) *Analyzing On-Road Emissions of Light-Duty Vehicles with Portable Emission Measurement Systems (PEMS)*, JRC Scientific and Technical Reports. http://ec.europa.eu/clima/policies/transport/vehicles/docs/2011_pems_jrc_62639_en.pdf
- Wood H, Marlin N, Mudway I S, Bremner SA, Cross L, Dundas I, Grieve A, Grigg J, Jamaludin J B, Kelly F J, Lee T, Sheikh A, Walton R and Griffiths C J (2015) 'Effects of Air Pollution and the Introduction of the London Low Emission Zone on the Prevalence of Respiratory and Allergic Symptoms in Schoolchildren in East London: A Sequential Cross-Sectional Study', *PLoS ONE*, 10(8): e0109121. <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0109121>
- World Bank and Institute for Health Metrics and Evaluation [WB & IHME] (2016) *The Cost of Air Pollution: Strengthening the Economic Case for Action*. License: Creative Commons Attribution CC BY 3.0 IGO. <https://openknowledge.worldbank.org/bitstream/handle/10986/25013/108141.pdf>
- World Health Organisation [WHO] (2005) *WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide – global update 2005*. http://apps.who.int/iris/bitstream/10665/69477/1/WHO_SDE_PHE_OEH_06.02_eng.pdf
- World Health Organisation [WHO] (2013a) *Health Effects of Particulate Matter*. http://www.euro.who.int/_data/assets/pdf_file/0006/189051/Health-effects-of-particulate-matter-final-Eng.pdf
- World Health Organisation [WHO] (2013b) *Health risks of air pollution in Europe – HRAPIE project Recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone and nitrogen dioxide*. http://www.euro.who.int/_data/assets/pdf_file/0006/238956/Health-risks-of-air-pollution-in-Europe-HRAPIE-project,-Recommendations-for-concentrationresponse-functions-for-costbenefit-analysis-of-particulate-matter,-ozone-and-nitrogen-dioxide.pdf
- World Health Organisation [WHO] (2014) 'Ambient (outdoor) air quality and health', webpage, March 2014. <http://www.who.int/mediacentre/factsheets/fs313/en/>
- WSP | Parsons Brinckerhoff [WSP-PB] (2016) 'Improving the capital's air is Londoners' most important sustainability priority', press release, 3 March 2016. <http://www.wsp-pb.com/en/WSP-UK/Who-we-are/Newsroom/News-releases/2016/1/Improving-the-capitals-air-is-Londoners-most-important-sustainability-priority/>

ANNEX

BACKGROUND

This modelling scenario builds upon the GLA and TfL's 2025 base case, which is based upon the revised London Atmospheric Emissions Inventory 2010 (LAEI 2010).

TRAFFIC

A 5 per cent reduction relative to the base case was applied to all vehicles (motorcycle, taxi, car, bus and coach, LGVs, rigid HGVs, articulated HGVs and electric or hybrid vehicles) between the congestion charge zone and the north and south circular roads, including the inner ring road and the north and south circular itself, with no traffic changes assumed outside of this area. The traffic decrease in future years is assumed to result in an increase in speed, which varies by location and time of day; this is summarised in the LAEI 2010 documentation, and is expressed as the percentage speed reduction per 1 per cent traffic increase (GLA 2010).

PETROL:DIESEL SPLIT

Cars

For non-electric cars, a split of 95:5 petrol:diesel was assumed in central and inner London (that is, the expanded ULEZ). Outside of this area, this split was 71:29.

To calculate the petrol:diesel split in the outer and external areas, the trend in the petrol:diesel ratio between 2005 and 2015 (a period during which there was a rise in diesel vehicles) was first calculated, using LAEI 2010 figures. This trend was then reversed from 2017 onwards, producing a number that could be used in 2025 for these areas.

Vans

Of vans, 75 per cent were assumed to be diesel, with the remaining 25 per cent split evenly between petrol and electric. This split was applied in all locations, reflecting an LEZ-wide type policy.

EMISSIONS FACTORS

Diesel cars

It was assumed that all new Euro 6 and Euro 6 hybrids in each location from 2018 to 2020 are Euro 6C12 (NO_x Conformity Factor [CF] = 1.5) and Euro 6C12 hybrid respectively. It was also assumed that all new Euro 6 and Euro 6 hybrids in each location from 2020 to 2025 have a conformity factor of 1.

FLEET COMPOSITION: PROPORTIONS BY TECHNOLOGY

Cars

Working from the base case, and on top of the Euro 6c assumptions listed in the emissions factors section, it was assumed that 97 per cent of diesel cars would be Euro 6c by 2025. The Euro 6c diesel cars added as a result of this policy were assumed to have a conformity factor of 1. The resulting fleet composition was used throughout the new ULEZ area including central and inner London.

Petrol cars were set to be 15 per cent hybrid in all locations with the proportion of full to plug-in hybrid the same as in the base case. LPG cars were also included as part of the petrol car fleet, giving a 1.25 per cent contribution to the total fleet in each location. These policies, applied on top of the 2025 base case, resulted in a CCZ fleet composition for petrol cars, which was used throughout the new ULEZ area.

Electric cars

It was assumed that 6 per cent of cars would be EVs throughout the new ULEZ area by 2025 and 2.8 per cent outside of this area.

LGVs

LGVs used the 2025 base case assumptions for diesel and petrol fleet composition for the CCZ throughout the new ULEZ area.

Cars and LGVs

In the absence of further information on spillover effect outside of inner London, other than the policies mentioned elsewhere, no additional changes were made to the fleet compositions in these areas.

Taxis

It was assumed that all taxis (black cabs) in all locations would be zero-emissions capable (ZEC).

LT buses

In the CCZ, it was assumed that all LT buses had zero emissions. In the rest of London, it was assumed that all LT buses were Euro 6, Euro 6 hybrid or had zero emissions. Changes to the 2025 base case were made by replacing existing vehicles with the equivalent cleaner technology vehicles, for example in the CCZ, making Euro 6 double-decker into zero emissions double-decker, and outside of the CCZ making Euro 5 double-decker hybrid into Euro 6 double-decker hybrid.

HGVs and coaches

The same was assumed as in the 2025 base case.

ADDITIONAL GAS ASSUMPTIONS

In the 2025 base case, the total NO_x from domestic gas was 4,025 tonnes (1,398 in central/inner London and 2,627 in outer London) and the total NO_x from commercial gas was 3,374 tonnes (1,709 in central/inner and 1,665 in outer). This scenario assumed a change of domestic gas in central, inner and outer London and commercial gas in central and inner London only, as table A.1 shows.

TABLE A.1

Change in total NO_x (tonnes per annum) from domestic and commercial gas relative to our 2025 base case scenario

	Central & inner London	Outer London	Total
Domestic gas	-380	-409	-789
Commercial gas	-245	-	-245

HEALTH IMPACTS ANALYSIS

The methodology for assessing the health impacts associated with air pollution was consistent with previous studies (Walton et al 2015), following COMEAP (COMEAP 2010) and World Health Organisation (WHO 2013b) recommendations, but also acknowledging that COMEAP is in the process of issuing new NO₂ health impact guidelines, having recently released an interim statement on the subject (COMEAP 2015b). This suggested a lower concentration-response function and noted uncertainty in whether a 30 per cent overlap with PM2.5 was a reasonable figure, although it was retained on an interim basis. The final COMEAP report is not yet published. Different results would be likely to be obtained using the (as yet unknown) forthcoming recommendations from the full report on nitrogen dioxide from COMEAP.

It should be noted that NO₂ is very closely correlated with other traffic pollutants, which could account for part of the results. Results are thus expressed up to a maximum, assuming that NO₂ rather than other traffic pollutants is responsible for all of the effect. The results already assume a 30 per cent overlap with PM2.5. If the policies examined here were to only affect NO₂ concentrations, the results could be more of an overestimate than for policies reducing traffic pollution in general. However, aside from the traffic pollutants reflected by modelling of PM2.5, changes in other traffic pollutants were not modelled. The health impacts calculated on the basis of changes in NO₂ concentrations may be reflecting changes in these other pollutants as well.

Other health outcomes associated with nitrogen dioxide were not quantified. Some of these have less uncertainty (for example, respiratory hospital admissions), although mortality outcomes usually dominate assessments of economic benefits.