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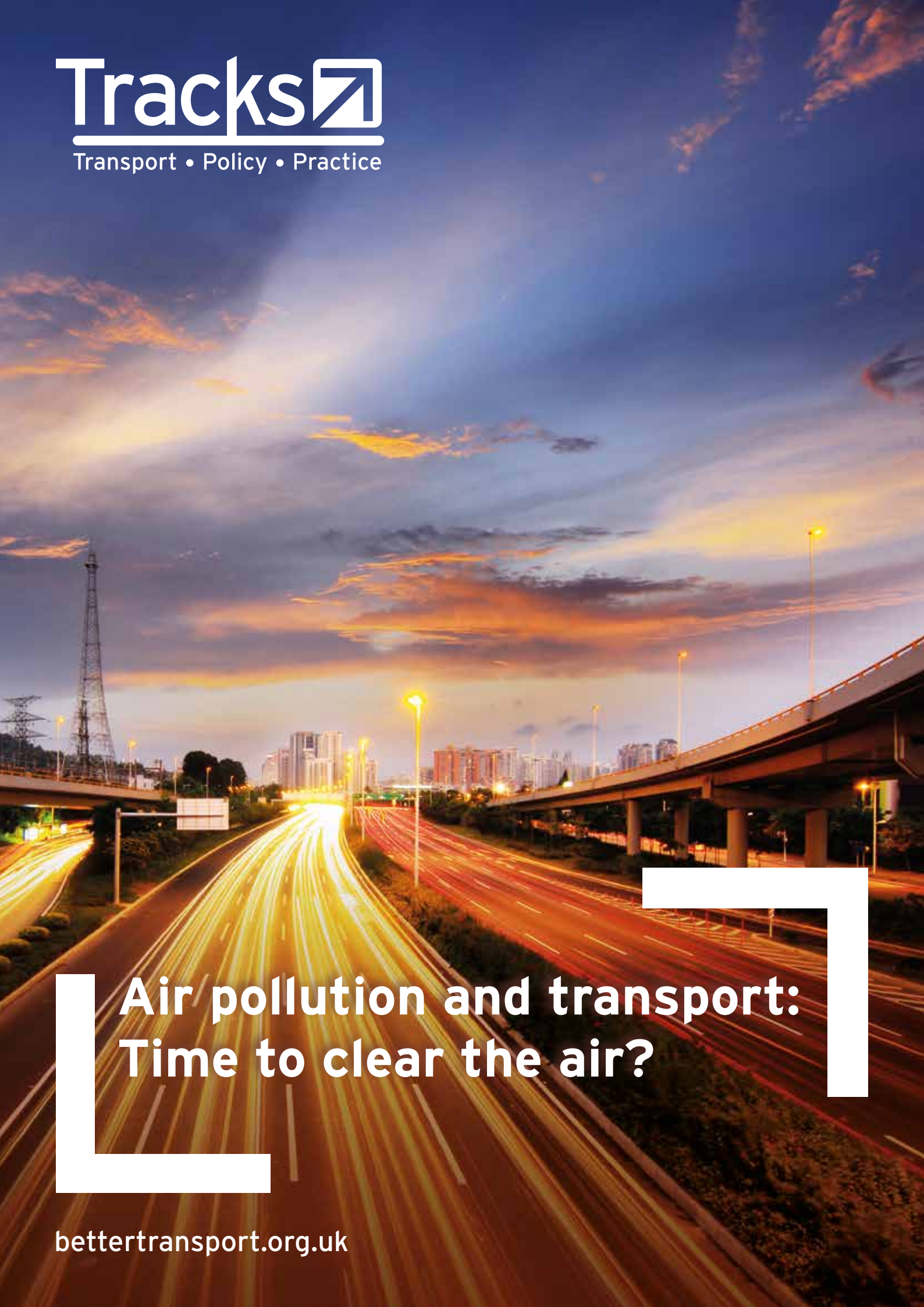

Air pollution and transport: Time to clear the air?

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Contents

Executive summary

UK air quality standards are effectively EU standards – these are legally binding and the UK has been in breach of these in many of its air quality zones since 2010. The UK is now subject to legal action from the European Commission for not complying with the standards and also in the UK from legal judgements for not having a sufficiently robust response. This has placed greater pressure on UK government to take urgent action.

The continued non-compliance with EU air quality standards in the UK is leading to an estimated 40,000 premature deaths a year. The sooner action is taken to improve air quality, the fewer premature deaths there will be in the next few years.

EU emission standards for vehicles have been successively tightened - at least as measured on the test cycle. However, particularly for diesel cars and vans, this has not delivered equivalent reductions in the real world for various reasons. This is now being addressed through the introduction at the EU level of real world testing, although this will not yet deliver the emissions reductions originally foreseen for the Euro 6 standard.

In spite of Brexit, it is likely that the UK will continue to apply the EU's air quality limit values and the Euro-emission standards for vehicles. Weakening the former, and introducing a parallel scheme to the latter, would be politically difficult and would incur unnecessary administrative and implementation costs.

In any case, the UK will continue to be a member of the World Health Organisation (WHO). In order to protect human health, the WHO has additional guidelines, for example for particulate emissions (PM) that recommend that air quality limit values be reduced to beyond the current EU/UK standards. WHO's air quality guidelines are currently under review, and so might recommend even lower limits for some air pollutants.

Local road transport is the main contributor to roadside nitrogen oxides (NOx) emissions and hence to nitrogen dioxide (NO_2) pollution exposure in many towns and cities. Diesel cars contribute significantly more to these emissions than petrol cars. This, coupled with the fact that most vans, HGVs and buses also use diesel and also contribute to roadside NOx emissions, means that in order to reduce roadside NO_2, it is necessary to reduce NOx from diesel engines.

The electrification of cars in particular is gaining momentum, but sales are still small in relation to internal combustion engine (ICE) vehicles, and so this will only help to solve the air quality problem in the longer-term across the board, although measures could be taken to accelerate this trend at local level. Alternatives are also emerging for HGVs and buses, but newer diesel models are relatively clean already in terms of NOx and particulates.

Existing measures to reduce the CO_2 emissions of cars and vans, and future measures on lorries and buses, will contribute to reducing the emission of pollutants from road transport vehicles as they (will increasingly) stimulate the development of electric and other low emission vehicles. The potential benefits of electric bicycles in terms of replacing car journeys are not yet being realised to a significant extent in the UK.

Amending the transport tax system to penalise diesel vehicles is a measure that could have an impact in the medium-term, but which will not be sufficient to address the immediate air quality problems of the existing vehicle fleet.

A general diesel scrappage scheme would be expensive and would risk being a blunt instrument, as many diesel vehicles have little impact on air quality in towns and cities.

While the Government has proposed a framework for Clean Air Zones (CAZs), for many local authorities these might be an expensive option to address what is, in a purely legal context, likely to be a relatively short-term problem with nitrogen dioxide emissions in many cases. However, a CAZ might be worthwhile in a broader context in which such a framework can be used to deliver other benefits to cities, including cleaner and quieter urban centres and lower carbon emissions, as well as to meet WHO's current guidelines for levels of PM, and any potential revised guidelines for other pollutants. There is a range of other, more targeted local measures that local authorities might consider in order to remove the most polluting diesel vehicles from the roads.

Recommendations

- Local authority measures need to target the sources of NOx emissions from transport, in order to consider how to remove the most polluting diesel vehicles from their most polluted roads and urban centres
- A particular focus should be on older buses, taxis and delivery trucks, as these are generally more polluting and are used intensively. The retrofitting of older buses in particular is a potential way of reducing emissions. However, as the cost of electric batteries continues to fall, electric or hybrid buses might be the preferred options in a few years' time
- Measures on bus need to be delivered in such a way as to ensure the continued competitiveness of bus against private motorised travel, otherwise intervention on air quality grounds could inadvertently discourage sustainable travel and thereby prove counterproductive.
- Diesel cars and vans pose more of a challenge. Introducing disincentives could lead diesel car owners to replace these with petrol cars. For vans the situation is a lot less clear-cut, as there are fewer technological alternatives
- Existing policy mechanisms to ensure the development, purchase and use of vehicles that emit less CO_2 need to be continued, particularly after Brexit, in order to ensure that the development of electric vehicles – and other low emission vehicles – continues
- National government should consider changes to the VED and/or company car tax to take account of the fact that the emission limit values for NOx for diesel cars are less stringent than those of petrol cars and that real-world emissions have been far higher, and will probably continue to be higher
- National government should consider supporting targeted local scrappage schemes in order to remove the most polluting buses, taxis and delivery trucks from the roads in and around CAZs and stimulate the market for low and zero emission vehicles in these categories

- Local authorities should consider the following measures:
  - For buses: Reaching agreement with bus operators to use less polluting buses on specific routes/at specific locations (via a Local Enterprise Zone (LEZ) or the powers under the Bus Services Act 2017 to enter into enhanced partnerships or to franchise local bus services). Ideally the aim should be to retire the oldest buses and retrofit or upgrade the newer ones, and avoid merely transferring air quality problems to other routes or areas. Where buses (or bus services) are procured, it is important to ensure that the vehicles procured (or the vehicles to be used in the service procured) are low emission vehicles. Whichever course of action is agreed, care is required to ensure that the competitiveness of buses as against car travel is not damaged, as any shift from bus to car is likely to exacerbate the air quality problems. This will probably require a mix of public sector support for retrofit and bus priority measures
  - For taxis: Integrate emissions conditions in licensing arrangements; ban older, more polluting vehicles from being used as taxis
  - For trucks and diesel vans: Consider promoting and enabling (i.e. through planning) freight consolidation centres that can use electric vehicles, or even cargo bicycles, for last mile delivery; for the services that it procures – such as waste collection, postal and courier services, etc. – ensure that the procurement procedure and conditions promote the use of less polluting vehicles
  - For diesel cars: Reflect the higher emissions of these vehicles in parking charges and permits; engage with major employers and other organisations with existing extensive car parks to reduce the number of spaces and promote alternative modes of travel; consider developing park and ride locations to reduce the number of visitors driving into urban centres
  - More generally, take measures to improve the infrastructure and the conditions for public transport, cycling and walking; ensure that the infrastructure for these modes is well integrated and provide coherent networks
  - Promote and support the development of car clubs, and more generally promote alternatives to car use alongside the potential imposition of CAZs.

1. Introduction

Air quality in the UK has once again become an important part of the political agenda; indeed, it is arguably the highest profile environmental issue at the present time. This is due in large part to the high profile legal challenges, both within the UK and by the European Commission, reflecting the ongoing failure of the UK to meet its legal commitments to provide clean air to the legislated standards for its citizens. As a result, human health is not yet protected from the impacts of air pollution to the level that is legally required, which, it has been estimated, results in 40,000 premature deaths every year, as well as to increased costs in public health and to the National Health Service.

The failure of the UK, and many other European countries, to meet their legal commitments with respect to air pollution is in spite of the introduction of increasingly more stringent emission standards for the major sources of air pollutants, including for road transport vehicles, over the last 25 years. These emission standards were set to enable air quality limit values to be met, but this was on the assumption that real world emissions would fall in line with the tighter standards.

The aim of this report is to set out in more detail, the issues with, and potential solutions for, the current air quality problems in the UK. It complements another Tracks report on transport and carbon reduction. Although the environmental focus of the two reports is different, in practice similar measures are discussed in both reports, as many of the measures that would contribute to reducing the emission of air pollutants also reduce transport's greenhouse gas emissions, and vice versa.

Section 2 of this report provides more detail on the ongoing problems of air pollution. It highlights the role of road transport in particular, summarises the health impacts associated with the main air pollutants and provides an overview of the air quality policy framework. Section 3 provides more detail on the reasons why air quality problems still persist, and projects how the situation might change in the coming years. Section 4 sets out the UK policy response.

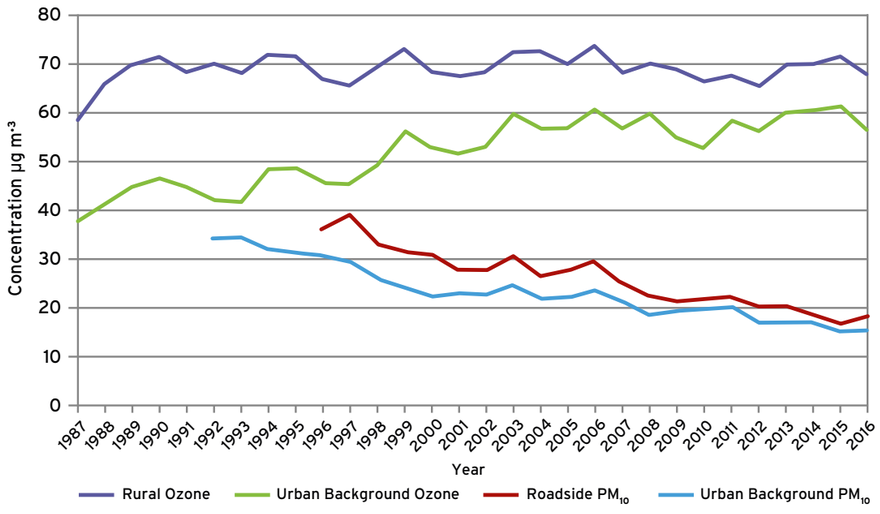
Sections 5 to 7 are forward looking. In Section 5, the emissions of different vehicle types are compared, particularly in the context of their potential compliance with the proposed UK Clean Air Zone (CAZ) framework. The role of different alternative fuels in improving air quality is also discussed. Section 6 reviews additional action that might be undertaken at the national, or EU level, while Section 7 looks at what other measures local authorities might consider to reduce air pollution locally. Section 8 concludes the report with some recommendations.

2. Why are we concerned about air pollution?

2.1 Air pollution in the UK: State of play

While there has been much progress in terms of reducing air pollution in the UK over the years, this has not been sufficient to deliver air quality that does not adversely affect human health. In the last decade, persistent problems have remained, as demonstrated in Figure 1 and Figure 2. The former demonstrates that while annual concentrations of large particulate matter (PM_{10}) have declined, ozone remains a problem, and indeed is becoming a greater problem in urban areas.

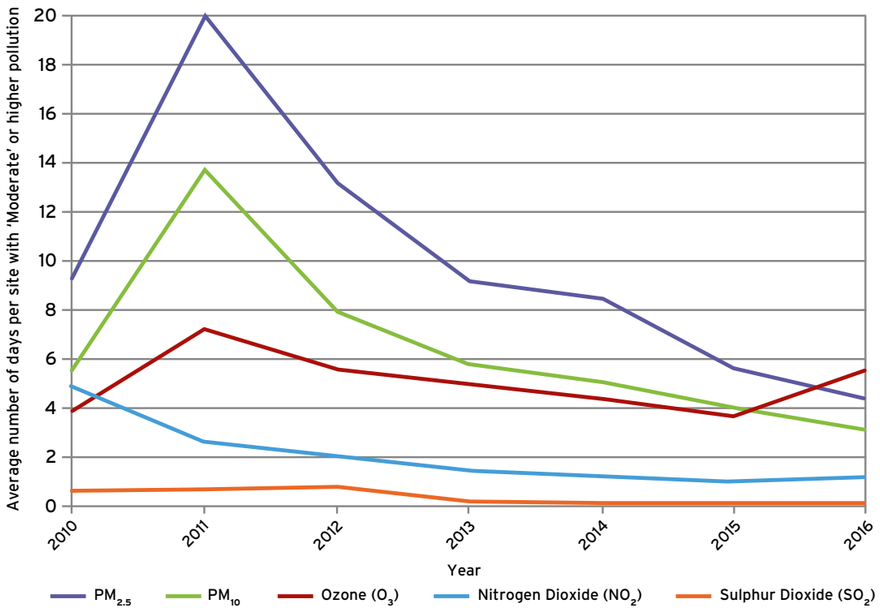
Figure 1: Annual concentrations of PM_{10} and ozone in the UK, 1987 to 2016 (No data capture threshold pre-2013, 75% from 2013 onwards)



Source: Defra (2017)

Figure 2 underlines that sulphur dioxide is no longer a significant contributory factor to air pollution in the UK, whereas nitrogen dioxide (NO_2), PM_{10}, small particulate matter ($PM_{2.5}$) and ozone remain concerns. While the average number of days on UK monitoring sites experience 'moderate' or 'high' levels of pollutions for these pollutants is declining, the rate of improvement has tailed off in recent years. It is also important to recognise that as these are average figures across all urban monitoring sites in the UK, some locations will experience many more days of 'moderate' or 'high' pollution than implied by Figure 2. Other sources also indicate that roadside monitoring sites are the main sources of concern.

Figure 2: Average number of days when levels of ozone, particulate matter, nitrogen dioxide and sulphur dioxide were moderate or higher at urban sites in the UK, 2010-2016



Source: Defra (2017)

The improvements in air quality have not been sufficient for the UK to meet its legal responsibilities with respect to air pollution. The air quality limit values currently applicable in the UK are those set by EU Directive 2008/50 (see below) and should have been met by 2010. However, in 2010 the UK did not meet the Directive's requirements for NO_2 in the vast majority of the UK's zones and agglomerations. At the time, the UK did not expect 16 (out of 43) of these zones and agglomerations to be able to meet the requirements of the Directive before 2015, which was the maximum extension to the original deadline that was allowed by the Directive. The European Environment estimated that in 2012, nearly 20 per cent of the UK population was exposed to NO_2 levels above legal limits (see Table 1).

Table 1: UK urban population exposed to air pollutant concentrations above the EU air quality objectives (2010-2012)

	EU reference value	Exposure estimate (%)		
		2010	2011	2012
PM_{10}	Day (50 µg/m³)	0.0	2.4	0.0
Ozone	8-hour (120 µg/m³)	0.0	0.0	0.0
NO_2	Year (40 µg/m³)	26.0	23.2	18.9

Source: EEA (2014)

The UK submitted air quality plans for these 16 areas to the European Commission to demonstrate that the limits would be met as soon as possible. However, the advocacy group ClientEarth brought a claim for judicial review of these plans. In response, the UK Supreme Court ruled in 2013 that the UK was in breach of Article 13 of the Directive, i.e. that which required the levels of certain pollutants, including NO_2, to be limited to the values set in the Directive.[5] After further guidance from the Court of Justice of the European Union (commonly referred to as the ECJ), in 2015 the Supreme Court ordered the UK Government to submit new plans to the EU by the end of that year.[6] The Government published its initial approach for addressing NOx emissions in December 2015,[7] which was followed, after further legal action[8] and a consultation, by a revised 'Detailed Plan' in July 2017[9] (see Section 4).

In the meantime, in 2014 the European Commission launched legal proceedings against the UK for its failure to reduce NO_2 emissions.[10] The Commission has subsequently sent a final warning to the UK, as well as to Germany, France, Spain and Italy, for continued breaches of NO_2 limit values. The UK is not the worst offender; while the legal action against the UK relates to the 16 areas mentioned above, the action against France relates to 19 zones, while that against Germany covers 28 zones. In all, the Commission is currently taking action against 12 Member States for breaching NO_2 limit values.[11] This emphasises that it is not only the UK that is experiencing current air quality problems.

As a result of the continuing issues, the Guardian reports that a UN special rapporteur on human rights related to toxic waste has added to the criticism of UK policy.[12] "Air pollution continues to plague the UK," he said. "I am alarmed that despite repeated judicial instruction, the UK government continues to flout its duty to ensure adequate air quality and protect the rights to life and health of its citizens. It has violated its obligations."

The remainder of this section outlines the contribution of road transport to the existing air quality problems, provides some more information on the health impacts of the main pollutants and provides an overview of the air quality policy framework.

2.2 Air pollution and road transport

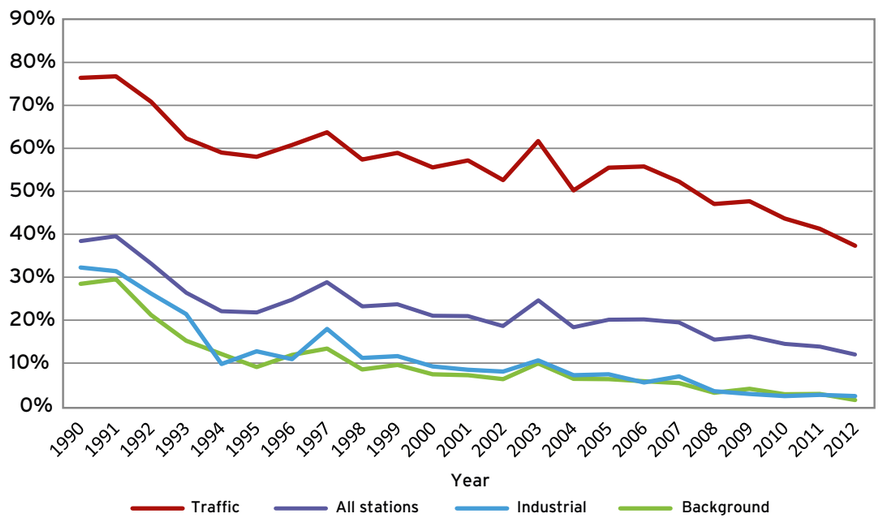
The distinctive role of transport in air pollution

Air pollution arises from many sources, including factories and power stations burning fossil fuels; other chemical processes; some agricultural practices; domestic cooking and heating; natural processes including dust storms; and transport. This report focuses on the latter, and particularly on road transport vehicles and other machinery powered by internal combustion engines (ICEs).

Because of its ubiquity and proximity to human habitations and public spaces, road traffic remains a major contributor to many or most of our air quality problems and contributes an ever-growing share. For example it produces 80 per cent of the particulates in central London and 46 per cent of all the nitrogen oxide emissions in Greater London.[13] These values are likely to be fairly typical of other large towns and cities across the UK, and remain the case in spite of the efforts to curb emissions from new vehicles by tighter legislation (see Section 2.4). From the perspective of the impact of air quality on human health, emissions in urban areas are more important, as this is where population is highest and densest, so it is where exposure to air pollution will cause the most health issues.

Data from the European Environment Agency (EEA) database of air pollution illustrates the impact of traffic on overall air pollution, in particular in terms of NOx as NO_2 in Figure 3 on page 10.

Figure 3: Nitrogen dioxide: % of EU monitoring stations exceeding allowed annual average



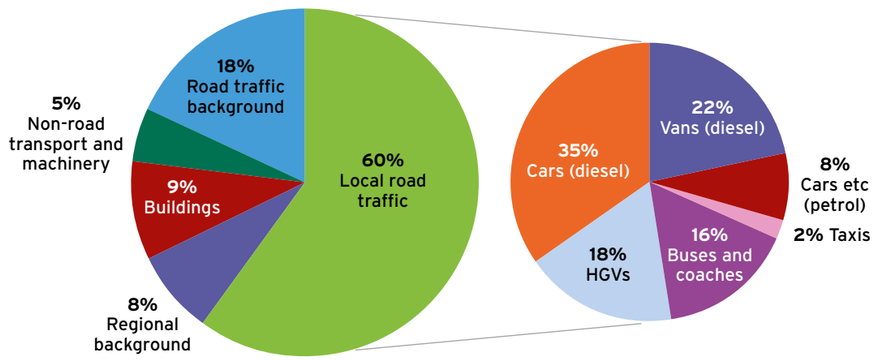
Source: EEA

As Figure 3 illustrates, it is a very divergent story for NO_2 across Europe. Background and industrial stations have improved steadily over time, and exceedances have now almost been eliminated. This is largely the result of the improved environmental regulation of industry and the shift away from coal to renewables for electricity production. The result of this success is that road transport is in most areas now the main cause of air quality problems concerning NO_2. Exceedances at traffic stations start from a much higher level and have improved fairly steadily but only slowly since the mid-1990s. In 1990 around three quarters of all traffic stations registered exceedances, but more than one in three stations are still not attaining the annual average limit value. This is one of the main reasons for the air quality problems that we still face today. A similar story is evident in many different cities around the EU, both large and small.

Road traffic pollution in the UK

The Society of Motor Manufacturers and Traders, in defence of diesel cars in particular, frequently claims that diesel cars account for 'only 11 per cent' of traffic NOx pollution.[14] This statistic is derived from Transport for London's Transport Emissions Roadmap of 2014.[15] However, this estimate dates back to data from 2010 when diesel cars were fewer and their real emissions were less well understood than now; it is also as a share of all transport emissions including rail and air; and it is for London, which has the largest congestion charging zone in the world and Europe's busiest airport. In all these respects, therefore, this cannot be regarded as an up to date or representative estimate for UK urban areas. Instead, the government's 2017 NOx Plan includes the up-to-date estimates presented in Figure 4.[16]

Figure 4: UK average roadside NOx concentration apportioned by source, 2015



This shows that 60 per cent of roadside NOx is attributable to local road traffic and a further 18 per cent to road traffic further afield. Of this, over a third is now attributable to diesel cars, making it difficult to bring about substantial air quality improvements without tackling emissions from diesel cars in particular. In addition to diesel cars, other diesel vehicles including vans, HGVs, buses and coaches, each make a substantial contribution.

In addition to NOx emissions, the other main local air quality issue related to transport is due to particulates. Although these are not currently the cause of any legal action, as the UK is compliant with existing EU standards for PM (see Table 1), WHO Guidelines suggest these standards should be lower in order to protect human health fully (see Section 2.4). This pollutant source is more complex than NO_2, as explained in Box 1 on page 12.

Other sources of air pollution

As argued in Box 1, it is likely that road transport is a major source of the relevant pollutants in many areas suffering from serious air quality problems. However, it is not the only one, and a number of other major sources will need to be taken into account if relevant. These include:

- Other major industrial point sources, such as major chemical works, steelworks or power stations. These will be regulated for the relevant emissions, but they can still be significant
- Non-road mobile machinery can also be important, for example on construction sites. Large boilers or generators can also be significant. These are subject to less stringent emission standards to those for road vehicles
- Major airports or seaports can also make a very significant contribution to local pollution if located nearby. For example, it appears that shipping emissions from both ocean liners and cargo shipping are a key consideration in Southampton, while aviation and airside activities make Heathrow a major factor in west London's air quality issues.

Other sources of pollution may be much more diffuse and much more distant, but a local authority on its own can do little about these. Ultimately, it is not possible to fully determine the relevant contribution of different sources and the best ways to tackle them without undertaking local air quality modelling, and most authorities thinking of setting up a CAZ will need to do this at some point to inform their decision making (see Section 4.2).

Box 1: Road vehicles and particulates

Particulates come in many shapes and sizes, and from many different sources. Some of these are far distant and cannot really be controlled; others arise closer to home, and for these some abatement is possible.

Professor Frank Kelly who chairs the government's advisory body on air pollution (COMEAP) has recently highlighted the dangers of particulate pollution, and stated in a recent article in the Guardian newspaper that even electric vehicles are "not the complete answer to poor air quality".[17] This is undeniably true, and clearly we need broader sustainability solutions in our cities if we are to do more than substituting traffic jams of electric vehicles for traffic jams of diesels.

On the other hand, it is not true to say that electric vehicles will not help to reduce particulate pollution. Particulates for conventional road vehicles come from four main sources:

- primary and secondary particles from vehicle exhaust
- dust generated from discs and brake pads during vehicle braking
- tyre wear
- road wear and resuspended road dust from traffic.

Substituting an electric vehicle for an internal combustion engined one essentially eliminates the first of these four sources, and this is important not least because exhaust particulates can carry many hazardous chemicals on their surfaces and penetrate deep into the lungs. Diesel exhaust is also carcinogenic, and there are no known safe limits for the concentration of ultrafine particles. And of course, electric vehicles eliminate all the other harmful exhaust gases at the point of use, including NOx.

Electric vehicles will be much better in terms of brake wear as well, since they are generally fitted with regenerative braking that reduces or avoids the need for conventional mechanical braking except in emergencies. Regenerative braking is particularly effective in this respect in urban stop-start driving.

It is quite true that electric vehicles are not much different from others in terms of tyre and road wear, but only a dramatic reduction in traffic can currently tackle these particular problems.

2.3 Sources and health impacts of air pollution

Nitrogen Oxides (NOx)

Sources: NOx can be formed in any high-temperature combustion process, but primarily in vehicle engines and power plants. NOx, comprising mainly nitric oxide or nitrogen monoxide (NO) and nitrogen dioxide (NO_2), is formed through the chemical combination of nitrogen and oxygen from the air drawn into the cylinders of an engine. For most sources only a small proportion of emissions are primary NO_2, but for diesel engines NO_2 typically makes up the larger part of the NOx emitted. Road vehicles typically account for a substantial share of roadside NOx.

Health Impacts: NO is not a primary pollutant in that it is not directly harmful to human health, but it oxidises in the air to form more NO_2, which is. Both NO and NO_2 are free radicals, so are highly reactive with other compounds in the air.

Scientific evidence links short-term NO_2 exposures to adverse respiratory effects including airway inflammation in healthy people, and increased respiratory symptoms in people with asthma or other pre-existing respiratory problems. NOx in the air also reacts with ammonia, moisture, and other compounds to form very small particles (see below).

Nitrogen Oxides (NOx)

Sources: PM consists of particles suspended in the air. Sea salt, black carbon from combustion, dust and condensed particles from certain chemicals can all be classed as PM. During ICE operation, the combination of unburnt carbon particles with condensed heavy fractions of hydrocarbons and sulphates originating from sulphur in the fuel give rise to particulate matter (PM) in vehicle exhaust. Black carbon particles are particularly associated with diesel engines, and these may have other harmful compounds adsorbed onto their surfaces. Wear on brake pads, clutches and tyres is also significant sources of particulates.

The smallest particles are of greatest concern, and are measured as PM_{10} (diameter less than 10 micrometres) and $PM_{2.5}$ (less than 2.5 micrometres). Although power plants and road transport are major sources of primary particulates, the majority of the PM_{10} particles in Europe's air are secondary particles, created from the emissions of other pollutant gases such as NOx, sulphates and ammonia. Smaller particles are particularly affected by wind conditions and can travel hundreds of kilometres, so reduction of PM concentration must be a coordinated effort between local, national and transboundary emission sources.

Health Impacts: Small particles penetrate deeply into sensitive parts of the lungs and can cause or worsen respiratory disease, such as emphysema and bronchitis, and can aggravate existing heart disease, leading to increased hospital admissions and even premature death. The PM component of air pollution is also most closely associated with increased incidence of cancer, especially lung cancer, and in 2012, the International Agency for Research on Cancer (IARC) reclassified diesel engine exhaust as carcinogenic to humans. There is little evidence to suggest a safe threshold for particulates, and indeed effects can be detected at little more than background concentrations, especially for $PM_{2.5}$.

2.4 The policy framework for air quality in Europe

The WHO Guidelines

The WHO has the remit of assessing the emerging evidence on the adverse health effects of air pollution, and of establishing safe levels that countries should aim to achieve. These are set out in the WHO Guidelines, which state that air of an acceptable quality is a fundamental human right.

On the basis of the available evidence, the WHO recommends guideline values both for the maximum safe concentration of each pollutant, and the duration of safe exposure. A chemical may cause acute, damaging effects after peak exposure for a short period, or irreversible or incapacitating effects after prolonged exposure to lower concentrations – or both. Hence, an averaging time as short as an hour or less may be specified for acute pollution, or typically an annual average level to reflect prolonged exposure.

EU air quality legislation

The WHO Guidelines are only a guide, so have no legal force. In order to provide the latter, the EU has set mandatory limit values that require its Member States, including the UK, to meet limits for certain pollutants through its Ambient Air Quality Framework Directive.[18]

In most cases, the limit values set at EU level follow the WHO guide values, but as they are mandatory they are set at levels that are deemed to be achievable without excessive cost or effort on the part of the Member States. In a few cases this results in EU limits that are less stringent than those set out by the WHO, or to the specification of interim targets or indicative guide values rather than strict limits. The main limits for relevant pollutants are summarised in Table 2 below. In some cases, too, a limited number of exceedances of the limit may also be allowed.

As can be seen from the numbers in brackets in Table 2, the annual limit values for PM in the WHO Guidelines are significantly stricter than the current EU limit values. WHO has proposed these values because these are the values above which cardiopulmonary and lung cancer mortality increases. WHO is in the process of updating its air quality guidelines, which will cover inter alia PM_{10}, $PM_{2.5}$ and NO_2, based on recent scientific evidence.[19] This underlines that meeting the EU limit values for PM in particular is only a step in the right direction to protecting our health from air pollution, not the end point.

Table 2: Summary of EU limit values

Pollutant	Concentration	Averaging period	Legal nature	Permitted exceedences each year
Fine particles ($PM_{2.5}$)	25 ↔g/m3 (10)**	1 year	Target value entered into force 01.01.2010 Limit value entered into force 01.01.2015	n/a
Nitrogen dioxide (NO_2)	200 ↔g/m3	1 hour	Limit value entered into force 01.01.2010	18
	40 ↔g/m3	1 year	Limit value entered into force 01.01.2010*	n/a
PM_{10}	50 ↔g/m3	24 hours	Limit value entered into force 01.01.2005	35
	40 ↔g/m3 (20)**	1 year	Limit value entered into force 01.01.2005	n/a

*Under Directive 2008/50/EC the Member States can apply for an extension of up to five years (i.e. maximum up to 2015) in a specific zone. The request is subject to assessment by the Commission. In such cases within the time extension period the limit value applies at the level of the limit value plus an agreed maximum margin of tolerance.

** Figures in brackets are WHO Guideline values where these differ from EU standards.

Source: European Commission

The EU air quality monitoring network

In order to establish whether EU limit values are being met across the EU, the Member States have been required to designate a network of monitoring stations with equipment designed to continuously measure the levels of all the main pollutants, including those for which limits have been set. There are now over 2,500 stations in the network, although the exact number varies from year to year and for different pollutants.

Stations are categorised into three types, according to their location and hence the pollution sources that they measure:

- **Background** stations can be in urban, suburban or rural areas; they are located away from major sources of emissions in order to indicate the general level of pollution in an area or country
- **Industrial** stations are located close to major emitters in the form of industrial areas or major point sources such as power stations
- **Traffic** sources are located close to busy roads where vehicle emissions are at their highest.

The results of this monitoring are reported to the EEA, which produces regular reports on progress in cleaning up our air.[20]

EU vehicle emissions standards

In order to bring about improvements in our air quality, emission limits are imposed on the most important sources of emissions of a particular pollutant. Increasingly sophisticated monitoring and modelling exercises are undertaken to evaluate which sources of pollution are the most important, and how much their maximum or average emissions can be required to be reduced in order to improve air quality in the most efficient and cost-effective way possible (see below).

For most of the common pollutants, emission limits are typically imposed in some or all of the following main sources:

- Power stations
- Other large industrial plants
- Cars and vans
- Heavy duty vehicle engines, i.e. engines used in trucks and buses.

Cars and vans have been regulated by a steady sequence of tightening limit values, from Euro 1 beginning in 1991, through to Euro 6 which is coming in to force in stages from 2014. These Euro standards limit all the main pollutants from vehicle exhausts – including nitrogen oxides and particulates. These are summarised (in a slightly simplified format) in Table 3 below.

Table 3: EU Emission Standards for Passenger Cars

Euro Stage	Year of entry into force for new models*	CO	HC	HC+NOx	NOx	PM	PN
		1 year					number/km
Compression Ignition (Diesel)							
Euro 1	1992	2.72	-	0.97	-	0.14	-
Euro 2	1996	1.0	-	0.7	-	0.08	-
Euro 3	2000	0.64	-	0.56	0.50	0.05	-
Euro 4	2005	0.50	-	0.30	0.25	0.025	-
Euro 5a	2009	0.50	-	0.23	0.18	0.005	-
Euro 5b	2011	0.50	-	0.23	0.18	0.005	6.0÷1011
Euro 6	2014	0.50	-	0.17	0.08	0.005	6.0÷1011
Positive Ignition (Petrol/Gasoline, LPG, CNG, etc)							
Euro	1992	2.72	-	0.97	-	-	-
Euro 2	1996	2.2	-	0.5	-	-	-
Euro 3	2000	2.30	0.20	-	0.15	-	-
Euro 4	2005	1.0	0.10	-	0.08	-	-
Euro 5	2009	1.0	0.10	-	0.06	0.005a	-
Euro 6	2014	1.0	0.10	-	0.06	0.005a	6.0÷1011 a

Notes:

* models already in production must comply typically around one year later

a applicable only to direct injection petrol engines

As Table 2 illustrates, light duty petrol and diesel engines are each subject to separate and sometimes different limits that are slowly converging, reflecting the technical potential for emissions reductions. This has involved some trade-offs; for example diesel vehicles have more stringent CO standards but are allowed higher NOx emissions. For both engine types and for all the compounds regulated, emissions limits have tightened considerably over more than two decades of EU vehicle emissions regulation. For example, the diesel car limit for particulates has fallen from 0.14g/km to 0.005g/km (a reduction of 96 per cent).

While the emission limit values for cars and vans are referred to as Euro 1 to Euro 6 and apply directly to whole vehicles as shown above, different emission standards have been developed for heavy duty vehicles (HDVs), i.e. trucks, buses and coaches. The Euro emissions standards for HDVs apply to the engine, not the vehicle, as regulating HDVs would be challenging owing to their size, and because these vehicles are often manufactured to specifications provided by a particular customer. Hence, HDV Euro emission standards are referred to differently, i.e. as Euro I to Euro VI.

Linking emissions to air quality – the EU air quality strategy

All of the above form essential components of the European air quality management system: but how do we know that the limits we set on emissions are sufficient to meet the air quality targets that we set?

The European Economic Community (EEC as it then was) first legislated on vehicle emission limits in Directive 70/220/EEC, but the first major milestones were Directive 91/441/EEC that effectively required catalytic converters on all new petrol cars, and Directive 94/12/EC that set second stage limits (Euro 2) and separate limits for diesel cars. These early measures were however hotly contested by the motor industry, and subsequently a more integrated and holistic approach was developed under the two Auto Oil Programmes and the subsequent Clean Air for Europe (CAFE) initiative which culminated in the 2008 air quality Directive. These sought to set subsequent standards on the basis of the most cost-effective approach to meeting air quality standards across Europe through new limits on a range of sectors, including motor vehicles. This was therefore was a deliberative process whereby future emissions limits were meant to be linked to attainment of the air quality objectives.

In particular, CAFE envisaged a 60 per cent reduction in NOx emissions by 2020 relative to the year 2000, and a 59 per cent reduction in primary $PM_{2.5}$. This objective in turn gave rise to the new Regulation in 2007 that set the standards for Euro 5 and Euro 6 for cars and vans, requiring in particular significant cuts in NOx and PM emissions. For example, the Euro 5 limit represented an 80 per cent cut in the $PM_{2.5}$ standard relative to Euro 4 for diesels; while Euro 6 required a 68 per cent cut in diesel NOx from Euro 4.

Hence the failure of these emission limits (especially diesel light duty NOx) to bring about the substantial cuts in emissions needed, as discussed in Section 3 below, can be directly related to the persistent exceedances of air quality standards that we face. It is clear from this discussion that the regulation of the sources of air pollution, and the air quality standards themselves, have been heavily reliant on EU legislation, a fact that is unlikely to change even after Brexit (see Box 2).

SECTION 2
Why are we concerned
about air pollution?

Box 2: The likely impact of Brexit on UK air quality

As with many other aspects of Brexit, the impacts on air quality are still far from clear at the time of writing. One possibility is that there will be no change, e.g. if relevant EU legislation continues to apply in the UK, either as a result of the agreement with the EU or as a result of the choice of the UK Government. Alternatively, the UK could be free to draft new legislation on air quality, which could be weaker, or stronger, than that currently in place.

In order to consider the potential impact in more detail, it is useful to identify how different pieces of legislation may be affected by Brexit. Essentially, the most important pieces of EU legislation in this context are those that set emissions standards (i.e. Euro 5, etc.) from road transport vehicles (and other sources), and the air quality legislation that sets limits on the amount of various pollutants allowable in the air that we breathe, as set out above.

Vehicle emission limits

Depending on the UK's subsequent relationship with the EU's single market, it might be possible for the UK Government not to continue to apply the EU's emissions standards relating to road transport vehicles. However, in spite of Brexit, the UK's vehicle market will remain part of the broader European market into which global manufacturers sell their products. From a manufacturer's perspective, the development of different emissions standards in different countries is not desirable, as it means that this aspect of their vehicles would need to be designed according to different national rules, which would increase their costs. Given the uncertainty around the implications of Brexit more generally, it is unlikely that the UK car industry would be in favour of introducing different emissions standards in the UK. From an administrative perspective, setting new emissions standards would require a lot of additional work in policy development and enforcement, which is effectively unnecessary as a result of the existing standards. It would also be politically difficult for the UK to be seen to weaken emissions standards for the home market. Hence, it appears unlikely that the UK would implement a different approach to setting vehicle emissions standards, even if it was completely free to do so.

Air quality standards

On the other hand, the air quality problem is not going to go away as a result of Brexit. If the UK chose not to apply existing EU air quality standards as a result of Brexit, and not to replace these with stronger standards, an immediate legal problem might disappear, but the public health problem would remain. As with weakening emissions standards, it would be politically very difficult for one of the subsequent Brexit actions to be the easing up of action to improve air quality, unless the political landscape were to change significantly. A UK outside of the EU could also in principle set more stringent standards than those of the EU; but in light of our difficulties in even meeting the latter, this seems unlikely.

Consequently, it is difficult to foresee circumstances in which vehicle emissions or air quality legislation would change significantly as a result of Brexit. Alternatively, Brexit could be seen as an opportunity to strengthen the UK's approach to air quality, which would make the measures outlined below even more important. Administrative details may also need to change, but this should be a relatively minor issue.

3. Why is there still a problem?

Given all of the policy action that has been targeted at reducing air pollutant emissions from its various sources, it is worth setting out why this has not been successful in delivering clean air. This is the subject of this section. It concludes by projecting how the current situation might change in the coming years.

3.1 The discrepancy between test cycle and real world emissions for cars and vans

The emission limits for cars and vans that were outlined in Section 2 are applied through a test procedure designed to force manufacturers to produce new vehicles that are increasingly cleaner by meeting ever-tighter limit values. Euro standards for cars set limit values for the so-called regulated pollutants (including NOx and particulates) that must not be exceeded in a chassis dynamometer test using the so-called New European Driving Cycle (NEDC) test procedure. This procedure is standardised to a high degree in its driving conditions, speed profile, ambient conditions etc. and is run on a laboratory test bed known as a chassis dynamometer.

A major problem, though, is that this test cycle is now very old and does not reflect modern driving conditions. It is also very stylised and does not even pretend to replicate real driving conditions. It covers a distance of just over 11 km in 1,180 seconds (just under 20 minutes) at an average speed of 34 km/h (around 21mph). The test cycle is characterised by low accelerations and a rather low engine load as compared to real-world driving behaviour: the vehicle is stationary for 24 per cent of the entire test and decelerating for a further 16 per cent.

As a result, it is very easy to adjust a modern engine such that it performs very well (i.e. with low emissions) under the test conditions, but much less well on the road in real driving conditions. As emission limit values have grown ever tighter, car manufacturers have become ever more adept at manipulating the test cycle and certain flexibilities in the testing procedures that are laid down, resulting in a growing 'gap' between test results and real world emissions. As a result the expected benefits of tighter standards have not been fully realised, and it is in NOx emissions from diesel cars that this gap appears largest and of the most acute concern.

There appears to be not such a marked 'gap' between test results and real world emissions for HDVs. The technology in the engines used in these vehicles works effectively to deliver the anticipated level of emissions reductions under real world conditions, and the improvements over time (at least where NOx and particulates are concerned) appear to be very substantial. Consequently, Euro VI HDVs can be considered to be significantly less polluting that Euro V or earlier heavy duty vehicles.

3.2 Cycle beating and defeat devices

The 'tricks of the trade' used by the manufacturers to massage their test results have been widely described elsewhere.[21] While some of these are dubious, they arguably only bend the rules, as the existing rules are very flexible anyway.

Then in September 2015, the United States Environmental Protection Agency (EPA) and the California Air Resources Board filed two separate complaints against Volkswagen for the illegal sale of vehicles and engines equipped with defeat devices that enable the cars to operate under two emission control regimes. One regime would recognise when the vehicle was undergoing certification test procedures and would produce emissions compliant with US standards. Outside of testing conditions the device would switch to conditions that optimise other performance characteristics (e.g. power and performance) while producing higher emissions, violating EPA emission standards for nitrogen oxides.

This use of a 'defeat device' is clearly illegal under both US and EU law, and VW duly received an extremely heavy fine in the US. Since then there has been mounting evidence that other EU carmakers have used similar tactics to meet emissions limits. The results of German, French and UK official investigations showed huge discrepancies between lab and real-world emissions for all of the models tested, although no manufacturers have yet been prosecuted in Europe. Several civil court actions have been initiated, however.

3.4 Action being taken to address these issues

The old NEDC test cycle is now being replaced with the new World Light Duty Test Cycle and Protocol (WLTC/WLTP). This is a more realistic test cycle that will be harder to manipulate through engine tuning, while the revised protocol has removed some, but not all, of the flexibilities that have allowed carmakers to game the system. In addition, a Real Driving Emissions Directive (RDE) is introducing new on-road tests that seek to ensure that the gap between real world NOx emissions and the test standards is being reduced (see Section 6.1 for more detail).

Taken together these changes will go some way to reduce the NOx 'gap' for diesel cars and vans. However, it is worth emphasising that these changes are not yet fully operational. Consequently, while some new diesel cars will already meet the more stringent standards now referred to as Euro 6c, most of the cars being sold at the time of writing are no cleaner than those from previous years. It is therefore a mistake to suppose that all Euro 6 diesels are now clean, as most are not. It is however not easy to distinguish between those that are genuinely low NOx and those that are not.

Changes to diesel taxation for first year VED and company car taxation have been introduced in the November 2017 budget. These will seek to 'nudge' new car buyers towards the cleanest new diesels available, but it remains to be seen if the tax differential is large enough to have a significant effect.

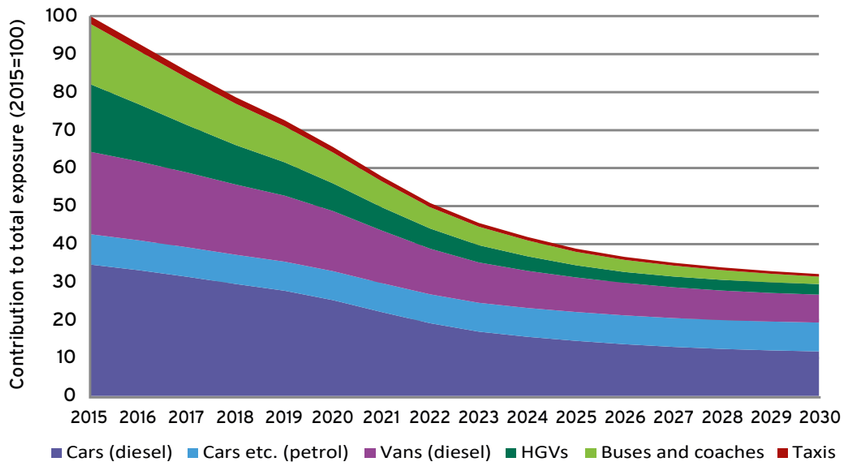
For the future, it will also be possible to deploy new remote sensing equipment to detect vehicle emissions in real time and hence to detect non-compliant ones on the basis of their actual emissions rather than their age, type and emissions standard only.[22] As yet this equipment is not widely deployed, but in the next few years it will become an invaluable additional tool in enforcing clean air legislation.

3.5 The baseline

Figure 5 below gives an outline indication of how exposure to NO_2 in urban areas from road transport sources might develop in future years. It does this by applying changes in future emissions per vehicle class to the expected stock turnover over time, and then apportioning this to each vehicle class as in Figure 4 on page 11. As such it can only be a very approximate indication, as the relationship between NOx emissions and NO_2 air quality is nonlinear, and will in any case vary from place to place according to the mix and conditions of traffic, local weather, topography, etc.

It does however offer some confirmation of the government conclusion that NOx emissions will fall, although it is less certain how fast and how much this will help to improve the air quality situation in individual local authorities. In reality, much will depend upon the future composition of the vehicle stock, the rate of turnover, and the extent to which predicted reductions in real-world emissions are actually delivered on the road.

Figure 5: Indicative chart of likely future trajectory of NO_2 exposure from road vehicles



Source:
Own calculations

There are also several specific caveats that should be raised at the outset:

- For the sake of simplicity, it was assumed in this model that the vehicle stock in each category would remain stable over time, whereas in fact, for cars in particular, there has been a steady increase in the vehicle stock over time. In effect, we simply do not collectively scrap as many cars as we purchase new. Amongst other things this is attributable to the growing population, increasing GDP, and a ready supply of second-hand cars that are still reliable but fairly cheap on account of their age. In some areas, older cars may be a significant confounding factor in attempts to tackle air quality, although on average old cars are driven very small annual mileages compared to newer ones
- Equally, it was assumed that total vehicle mileage would remain broadly stable over the calculation period, whereas in fact it has risen year on year for most of its recent history and on some scenarios is forecast to grow further. Clearly growing amounts of traffic could in part counteract any benefits from improving emissions at the level of the individual vehicle; although in practice this will be very largely a function of how traffic is managed within an individual CAZ
- This simplified model is relatively optimistic about the rate of stock turnover and average emissions from future vehicles: in practice improvement may well be slower than this, and is in any case likely to vary from place to place
- On the positive side, these estimates are based purely on fleets of ICE vehicles; in practice, electrification is likely to reduce emissions further, especially for cars and taxis.

Caveats aside, it seems fairly clear that total road traffic emissions should have reduced very substantially by 2030, or even 2025. This reflects the fact that all major classes of road vehicle are delivering (or at least will soon begin to deliver) substantial improvements in real average emissions of NOx on the roads. Total emissions might reduce by as much as one third by 2020 relative to 2015, and perhaps two thirds by 2030, but this is not quickly enough to obviate the need for local measures over and above the baseline in some cases at least.

It can be seen that some of the biggest gains in the early years will come from heavy duty vehicles (buses, coaches and trucks) owing to the very substantial reductions delivered under Euro VI which are now coming through the fleets. Light duty diesels (cars and vans) however contribute a larger share to the total pollution load, and in the baseline case will take significantly longer to abate. Petrol cars are the most numerous class of vehicles in this diagram, and although they have delivered substantial reductions in the 1990s and beyond, not much further improvement is currently anticipated.

Of course, while this shows that things will improve, and probably that most areas outside London at least would come into compliance eventually even with baseline measures and currently agreed national actions, it gives no guide as to when any particular area will come into compliance, or whether any individual local authority will need to declare a CAZ in the interim. It also omits the wider environmental and health benefits that a CAZ can bring (see below). There are also benefits in reducing carbon dioxide emissions from road transport, and these would often be co-benefits of efforts to improve air quality.[23]

4. What is the UK's response? The UK's air quality strategy

In the middle of 2017, there was much press coverage of the Government having updated the UK Air Quality Strategy. Strictly speaking this is not accurate, in that an update of the strategy is currently envisaged for next year (2018). There have however been two related and relevant documents published in 2017, and these are outlined below.

4.1 The UK plan for tackling roadside nitrogen dioxide concentrations

A new plan for tackling roadside NOx concentrations was published in July 2017, in response to the judicial ruling that existing plans were inadequate (see Section 2.1). It is not therefore a full strategy, but the plan required to rectify the UK's widespread violations of the annual mean NO_2 limit as set out in EU and UK law. This version was produced at some speed in order to meet the timetable specified in the judgement.

Outline of the key components of the UK plan

The 2017 plan is subtitled 'detailed plan'; and although it does contain a great deal of detail on some points, in many respects it falls far short of being a plan.

The introduction outlines the list of existing government financial commitments amounting to £2.7 billion that are dedicated to national programmes which directly or indirectly support cleaner vehicles. These are important to note, as some of these can be directly channelled into local schemes. Those listed are:

- Promotion of ultra low emission vehicles (ULEVs), including nearly £100 million for electrical charging infrastructure and the Plug In Car and Van Schemes
- The National Productivity Investment Fund which includes £100 million for new buses and bus retrofits, and £50 million for a Plug In Taxi programme
- An Air Quality Grant scheme has already supported some local authorities in improving air quality – although much more funding is now envisaged (see below)
- A Green Bus Fund to help bus companies and local authorities in England to procure over 1,200 new low carbon buses
- The Clean Bus Technology Fund and Clean Vehicle Technology Fund that have financed the retrofit of almost 3,000 of the oldest vehicles, most of which were buses
- The new Cycling and Walking Investment Strategy which identifies up to £1.2 billion which may be invested in cycling and walking schemes from 2016-2021
- The Road Investment Strategy includes £100 million for an Air Quality Fund available through to 2021 for Highways England to help improve air quality on its national road network – which could be particularly helpful to some authorities.

Some of these measures have their origins in the low carbon agenda, e.g. those measures incentivising electric and plug-in vehicles, but would also contribute substantially to reducing air pollutant emissions. Later in the document, it is made clear that the Government will also supply a £255 million Implementation Fund to support local authorities in preparing and implementing their plans. Beyond this there will also be a further Clean Air Fund available to local authorities who bring forward proposals for packages of measures to improve air quality in their area.

The nature and purpose of a Clean Air Zone

The UK Plan as published in July 2017 is focussed more or less exclusively on the question of roadside NOx, and the need in response to legal rulings to achieve compliance as quickly as possible. In this respect, arguably its main focus is on the introduction of Clean Air Zones or CAZs (see Box 3). As a result of the focus on CAZs, it does not pay much attention to other aspects which are relevant to a local authority thinking about setting up a CAZ. These include, in particular:

- Any consideration of the wider health benefits of going beyond the statutory limit value (see Section 2.4)
- Any substantial consideration of the co-benefits in terms of reduced particulates that would be likely to accompany all NOx reduction measures, and which would bring significant health benefits insofar as there is no known safe level of particulates
- Any consideration of the potentially much wider environmental and health benefits, including those resulting from lower carbon emissions and lower levels of noise, that could accompany either cleaning up of the vehicle fleet or better traffic management in urban areas – although the CAZ Framework (see Section 4.2) does reflect these considerations to an extent.

In the circumstances this is perhaps not surprising, but it is to be hoped that the updated Strategy (slated for 2018) will remedy some of these deficiencies and help to develop a more holistic approach for local authorities to follow.

Box 3: Clean Air Zones

The Department for Food and Rural Affairs (DEFRA) and The Department for Transport (DfT)'s CAZ framework document defines a CAZ as an area 'where targeted action is taken to improve air quality' and where resources are prioritised and coordinated to deliver health and economic benefits. They can address different pollutants, including NOx and PM, and should ensure 'ongoing and sustainable' improvements to decouple local growth from air pollution. The focus is on immediate action, with a long-term aim of accelerating the transition to a low emission economy.

In a practical sense, restrictions are placed on certain specified vehicles, depending on the scale of the problem, and so the vehicle coverage needed to reduce air pollution to legal levels (see Table 4 in Section 4.2 below). A CAZ can be charging or non-charging. In the former, some older, more polluting vehicles would be charged to enter the CAZ, which would act as a disincentive for these vehicles to enter the zone. For non-charging CAZs, the focus would be on introducing other measures to reduce emissions by restricting the access of non-compliant vehicles, including planning, traffic management, vehicle procurement and fleet management.

The Government's NO_2 modelling

A large part of the Plan (and its accompanying technical report) is taken up with a major modelling exercise to estimate levels of exceedance at the roadside on the principal road network across the country, and their health and social impacts.

The final version of the plan (from July 2017) does not contain a great deal of detail on the modelling that was undertaken, but much more information was included in the draft Plan (from May 2017) and its attendant Technical Report. This information was extremely detailed and no attempt is made to reproduce or summarise it here. However, several key points are worthy of note:

- The new modelling makes use of the COPERT5 vehicle emissions methodology, which realistically reflects current understanding of real-world emissions, and thereby rectifies one of the principal criticisms of earlier projections
- The modelling is quite detailed and seems to make all reasonable efforts to produce a realistic assessment of the likely state of non-compliance in future years across the UK – at least within the limitations outlined below.

There are nonetheless a number of key uncertainties and reservations that need to be borne in mind:

- As the report itself makes clear, there remain a substantial number of uncertainties and potential sources of inaccuracy in the modelling
- Although the modelling is quite detailed, it is still based around a model of approximately 9,000 substantial road links; of course this is a significant number but does not produce a very fine grain when spread across the entire country, and does not by any means reflect the totality of road traffic or pollution in any given area
- The modelling has as its basis compliance with the limit value in 2021, so is not a good indicator of compliance or non-compliance in intermediate years.

As a consequence, an indication of nonattainment (or indeed attainment) in a given year should not be considered as any more than a first indicator of the level of total nonattainment nor its duration within a given urban agglomeration. Wider local evidence including monitoring and detailed modelling data will be required in order to determine with any certainty where a CAZ or other action is actually required at a local level. It is noteworthy that the Air Quality Management Resource Centre at The University of the West of England (UWE) in Bristol has expressed scepticism in its initial response to the plan that this presents a complete picture, given that only 17 towns and cities are highlighted with projected to need urgent action, as against the more than 260 local authorities with one or more Air Quality Management Areas (AQMAs) already declared with respect to NO_2. They conclude that this approach significantly underestimates the scale and likely persistence of the problem.[25]

They further state their surprise and concern that the probable widespread spatial delineation of NO_2 exceedances, and their relationship to the modelling presented, is not incorporated into the new national plan. This is clearly thus far a major omission that will hamper most local authorities in making a first assessment of if, far less how, they need to respond.

Possible policy actions for a CAZ

Section 7.3 of the Government's roadside NOx Plan usefully summarises the additional national actions that are envisaged in support of local authority action and CAZs. These can be summarised as:

- Implementing more stringent emissions testing regimes for new vehicle type approval
- Support for low emissions freight through improvements in vehicles, fuels and logistics
- Roadside checks for heavy goods vehicles
- Additional funding to accelerate the uptake of low emission buses and the targeted retrofitting scheme
- The new plug-in taxi scheme and charging infrastructure, projected to facilitate the introduction of 23,000 ultra low emission taxis nationally
- Hydrogen vehicles and infrastructure
- Various consultations in new powers on supporting measures
- New emission standards for non road mobile machinery and measures to tackle NOx from medium-sized combustion plants and generators.

Again, there would also be benefits in terms of carbon emission reduction on other co-benefits from many of these measures. Section 7.4.1 of the Plan then outlines the action be taken by local authorities, with the principal focus on England, although it should not be very different in the devolved administrations.

The nature of local measures to be taken – to charge or not to charge?

The UK plan is quite definite that a charging CAZ is the best solution to tackling the NO_2 problem. In many ways this is correct in that charging offers the greatest flexibility for users faced with a newly imposed CAZ.

In principle, a private motorist living close to a CAZ and faced with the prospect of having to drive into it has a range of options with which to respond. Broadly speaking these are as follows:

- **Abandon the trip:** if a journey was not too important a user could decide not to make the trip at all or to do something different instead to achieve an equivalent or similar outcome
- **Reroute:** if the planned destination were on the far side of the CAZ but outside of it, they could simply reroute to avoid the controlled zone
- **Change mode:** depending on the nature of the journey, it may be possible to make it by an alternative mode such as public transport, walking or cycling
- **Change the timing:** if the controlled zone only operated during business hours, for example, it might be possible to make a trip outside the controlled hours
- **Change the vehicle:** if a motorist has a vehicle which is non-compliant with the terms of the controlled zone and they make frequent trips into the zone, they may well decide to exchange their current vehicle for a compliant one – although switching from a diesel to an equivalent petrol car is now considerably more expensive than it would have been even a year ago
- **Pay the charge:** if all other alternatives prove unattractive and a trip into the CAZ is sufficiently important, there is still the option of paying the charge to enter the zone, either regularly or on a one-off basis.

This list is mainly to make the point that, for a private motorist in particular, even if they have a non-compliant vehicle, there are a range of options available to them in response to the establishment of a controlled zone. Most of these are available to most motorists for most of the time, depending on the circumstances. The key difference is that a charging zone always allows the trip to be made in a non-compliant vehicle provided that the charge is paid. This represents an extra degree of flexibility, albeit one of several, in using a charging zone rather than some other form of controls or incentives.

As against this, setting up a charging zone is a relatively complex undertaking and might not be considered either possible or necessary given the resources available and/or the scale of the problem. For example, if it were judged that controls on buses, coaches and taxis would be sufficient to deal with the problem, then other powers are available that could be employed more quickly and cheaply, and probably to greater effect, than a charging system and it would seem perverse to be charging the sort of vehicles that should be part of the solution rather than part of the problem. Equally, if it were judged that improvements could be made by, for example, closing certain roads to certain types of traffic, allowing convenient public parking spaces to be used only by compliant vehicles, etc., then this would almost certainly be quicker and much easier to achieve than setting up a charging zone for many or most local authorities. Of these options only an outright ban threatens serious disruption to most trip choices. Such measures are also much more scalable and can be extended as necessary to achieve the desired results, while learning from good or bad outcomes and best practice along the way. Arguably, a charging zone does not add much to these benefits in quite a number of circumstances.

The other measures mentioned in the plan seem rather randomly chosen and not those likely to have the greatest impact on air quality:

- It is usually a good idea to make street improvements and to adjust traffic lights in such a way as to improve traffic flow. In general, any measure that encourages smooth traffic flow and discourages rapid acceleration or braking will be good for air quality. Such measures should have some beneficial effect on the level of emissions, and would also bring other benefits. If it has not been possible to make these improvements in the past, then the new clean air fund discussed below might present a useful opportunity to include such measures in a proposed new package of improvements
- Although not explicitly mentioned by the Plan, the idea has been raised elsewhere of removing speed humps as a key means to improve air quality; this seems particularly bizarre. It is true that fierce braking followed by rapid acceleration does have an adverse effect on vehicle emissions, but a well-designed speed hump should not have a significant adverse effect on traffic flow, in which case it follows that its removal would not do a great deal of good. Also, all speed humps were presumably put in for a reason, probably for improved safety, so it is likely that the benefits that flow from this in terms of slowing down drivers will outweigh any possible gain in terms of air quality. The Parliamentary Advisory Council for Transport Safety (PACTS) has urged caution on this suggestion from Government, and Transport NGOs have been particularly scathing,[26] stressing that "Removing speed control measures such as speed bumps from local streets would be at best an expensive diversion from addressing air quality and at worst a dangerous and retrograde measure. Local councils and the communities they serve have introduced speed control measures to make streets safer [...]".

SECTION 4
What is the UK's response?
The UK's air quality strategy

The timing and priority of measures to be enacted

Aside from London, the five cities named in the draft plan (Southampton, Derby, Nottingham, Leeds and Birmingham) are highlighted for priority action, however a much longer list of authorities are expected to take some form of action at least to assess the options. In its earlier plan, the Government stated that the five named cities would have to implement a CAZ. In in the first three of these, the CAZ will have to cover buses, coaches, trucks and taxis, while those of Leeds and Birmingham will also have to cover vans, in addition to other local measures. In each case, only Euro 6/VI vehicles will be allowed to enter the CAZ free of charge, with the exception being petrol vans as these will only have to comply with the Euro 4 emissions standard. There would be no restrictions on cars operating in any city. Other cities wishing to introduce a CAZ will be able to do so on a voluntary basis, under which vehicles would not be charged, as a tool to raise awareness and target local action.[27]

It is envisaged that local authorities in non-compliance will submit plans for CAZs or other appropriate measures in early 2018. Government will then review these draft plans with a view to their being finalised by the end of 2018. It is expected that zones will be established on the ground probably during 2019 for priority cities, and perhaps 2020 for others.

As against this, the Government's modelling suggests that most of the major roads modelled would come into compliance with the NO_2 target by around 2022 or 2023 even without further action by local authorities. Indeed, it suggests that by 2024 all but three of the country's 43 air quality reporting zones would be in compliance with the existing standards without further measures. In reality it seems that this modelling might be overoptimistic, for example of the speed of progress towards cleaner vehicles, and in reality local modelling will probably be required to ascertain whether the whole of a locality will be in compliance by any given date.

The plan is also clear that any actions implemented by local authorities should be withdrawn as soon as compliance is achieved. This raises the prospect that, in many cases, local measures might only be in operation for a matter of three or four years. This is an odd prospect, and raises the question of whether sophisticated or in-depth measures could be cost justified for such a short implementation period. As against this, there are a number of reasons why it might make sense for a local authority to set up a clear, long-term framework for delivering improvements in air quality, either through a CAZ or other measures.

First, if local authorities did implement a thoroughgoing and effective CAZ (or alternative set of local traffic measures), they might well find that the enormous co-benefits of tackling air quality (such as greater use of sustainable modes of transport, reduced urban space devoted to parking, cleaner and quieter city centres, and other opportunities for improvements to the public realm, as well as a reduction in carbon emissions) would justify its continuation beyond the point where the immediate, legal target of NO_2 compliance has been met. This possibility is not discussed in the plan, however.

Second, as underlined in Section 2, delivering compliance with existing air quality standards will not protect people from the full adverse impacts of poor air quality, as the WHO's guidelines for particulate matter are more stringent than the existing air quality standards (and even these do not afford full protection from adverse health effects). Where vehicle exhaust is concerned, NOx and particulate emissions will continue to arise together, so setting up a CAZ and keeping it in place in the longer-term could therefore act to deliver further air quality improvements that are needed beyond existing standards. It is also worth noting again that WHO Guidelines are currently under review, and this process could give rise to further reductions in the limit values of some air pollutants.

Finally, waiting for compliance with existing standards to occur without additional action means that more people will die from air pollution than would be the case if action is taken earlier. In order to reduce the cumulative number of premature deaths from air pollution, it is necessary to take action as early as possible. This point applies to carbon dioxide emissions as well and is developed in the parallel Tracks report.[28]

4.2 Clean Air Zone Framework: Principles for setting up Clean Air Zones in England

The CAZ class framework

The central feature of the CAZ framework[29] is the establishment of the series of classes of zone based on the depth of measures required and hence the extent of the vehicle types requiring to be covered by the actions taken. These are summarised in a concise format in Table 4 below.

Table 4: Summary of vehicle classes for CAZs

Vehicle type	CAZ class coverage				Minimum Euro standard for compliance
	A	B	C	D	
Buses and coaches	✓	✓	✓	✓	Euro VI
Taxis and PHVs	✓	✓	✓	✓	Euro 6
HGVs		✓	✓	✓	Euro VI
All vans and minibuses			✓	✓	Euro 6
Cars (petrol)				✓	Euro 4
Cars (diesel)				✓	Euro 6
Motorcycles and mopeds (optional)				✓	Euro 3

Essentially this proposes, quite reasonably, that the number of vehicle classes to be included in CAZ coverage should escalate according to the intensity of the measures deemed to be required to meet the air quality targets. This is broadly sensible, in that there is no doubt that the first target (class A) should be local buses and coaches, taxis and other private hire vehicles as legacy fleets have an intensive impact on local air quality, are relatively few in number, and the most modern diesel buses (or of course electric or hybrid buses) deliver a very substantial reduction in emissions. But measures need to ensure that the competitiveness of bus travel versus car use is not damaged, as any shift from bus to car will almost certainly exacerbate the air quality problem. This will likely require a mix of public sector support for retrofit or replacement and bus priority measures.

It is worth bearing in mind, however, that if only these vehicles are to be targeted, there are already a range of other powers and remedies readily available to local authorities that might be implemented instead of a CAZ. These are discussed in greater detail below, and include using the bus partnerships and the possibility of franchising bus services, as well as using taxi and private hire licensing, to incentivise or mandate low emission vehicles (see Section 7).

SECTION 4
What is the UK's response?
The UK's air quality strategy

Beyond this it becomes more difficult, but certainly the next target group (class B) should be HGVs in that they are still relatively few in number, and the older vehicles have a high potential to pollute as explained above. Replacing older trucks with compliant ones could be challenging for some operators, but major 'high street names' could be expected to cooperate in using cleaner and newer trucks in CAZs. However it would have to be borne in mind that HGVs are extremely expensive and are not replaced readily or often, so a degree of negotiation and an agreed timetable for phase-in may be needed. Retrofit is also an option for HGVs of intermediate age (say, Euro IV or V) and is both effective and considerably cheaper than replacement.

Vans and minibuses (class C) are judged to be the next best target if necessary. Certainly they are likely to be considerably less numerous than cars (class D), but as explained in Section 5.1, technical solutions for cleaning up the van fleet are quite limited. Also, a sole trader or SME that either delivers into or works inside a CAZ will have relatively few options but to pay up or accept other consequences, depending on the type of zone established.

Cars are likely to constitute the most numerous class of vehicles entering the zone, and this presents its own difficulties in dealing with them. However, as explained above, some motorists at least will have a range of alternatives available to them to avoid bringing a non-compliant car into the zone. The majority of diesel cars will be non-compliant in the first instance, but most petrol cars will be compliant, so the possibility of switching cars remains available in the final analysis.

The right-hand column of Table 4 indicates the minimum compliant Euro standards suggested for each class of vehicles. These are broadly sensible and fairly robust minima, and it should not be too difficult to set up administrative systems to establish the Euro class of any vehicle seeking to enter the zone.

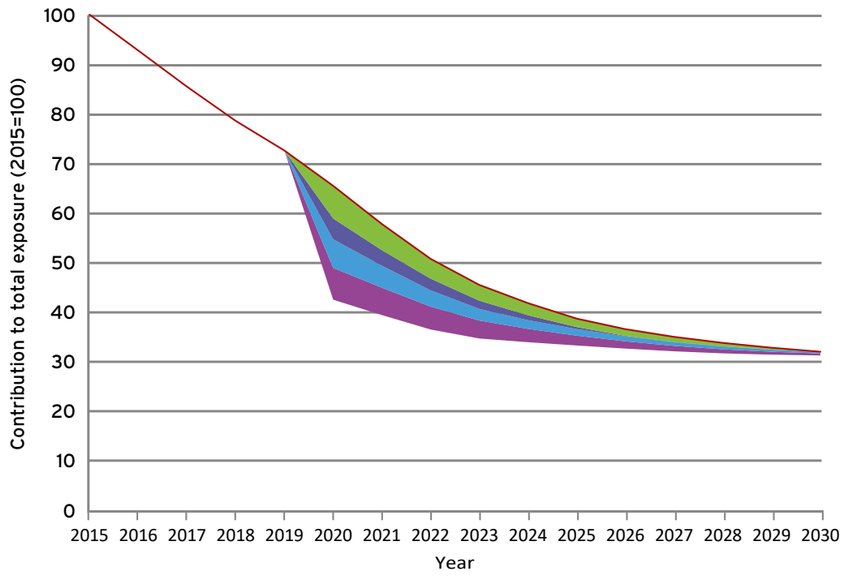
The main proviso to be raised here is that the proposed standards suggest that all diesel cars and vans meeting Euro 6 standards should be deemed compliant. In fact, as discussed above, most of those sold so far are still quite polluting. As against this, it would not be practicable to ban all diesel vans, for example, and setting the limit at Euro 6 only should at least have the effect of targeting the majority of the most polluting vehicles and reducing their numbers inside the zone.

The possible impact of setting up the different CAZ classes

Having modelled the impact of stock turnover on future road vehicle emissions (see Section 3.5), it was also possible to produce an indicative and generalised simulation of the likely impact in terms of emissions reductions from each of the four classes as CAZ in turn. To do this, the proportionate responses for non-compliant vehicle drivers set out in Table 3.3 of the Technical Report of the final NO_2 Plan were applied. This made it possible to estimate the impact of the CAZ measures on the proportion of non-compliant vehicles either entering the zone, upgrading to a compliant vehicle, or taking alternative action from 2020 onwards. The results are shown in Figure 6 on page 30.

From this it can be seen that each successive tranche of vehicles for each class adds a distinctive 'wedge' of extra abatement below the baseline. This is most significant in the early years of introduction and then tapers off towards 2030 as the measures imposed are subject to diminishing returns as increasing proportions of vehicles are compliant even in the baseline case. However, each wedge consistently reduces local emissions from what they otherwise might be over a period of a decade, giving some indication of

Figure 6: Incremental emissions savings from each vehicle class



Source:
Own calculations

the number of premature deaths or illnesses prevented. In this respect, Figure 7 (page 34) emphases the final point made at the end of the previous section, i.e. that early action to reduce air pollutant emissions will reduce the total cumulative number of premature deaths, as well as non-fatal medical conditions, compared to the situation in which no additional action was taken to improve air pollutants.

The class A tranche for buses and taxis is the largest in both initial magnitude and duration, firmly supporting the view that this should be the first priority in almost any circumstances (subject to the points made already about ensuring buses can contribute to modal shift) and that they can have a significant impact in sensitive areas where a CAZ has been established. On average, HGVs add a great deal less to the total abatement, but this might not be the case if a CAZ were to include a major through road, for example. In contrast, classes C and D bringing in vans and cars respectively are of a similar magnitude and only slightly smaller in each case than class A. In the latter cases, this reflects the enduring importance of non-compliant light diesels in delaying necessary improvements in air quality, and equally the likelihood that these will need to be tackled if a substantial improvement in air quality is required.

As before, this modelling should not be taken as anything other than indicative, in that it is generalised and carried out at a very high level, and will not therefore reflect the circumstances of vehicle stock composition or traffic conditions in any given local area. It does however suggest that the imposition of a CAZ could make a substantial contribution to bringing forward emissions reductions and hence improvements in NO_2 air quality. It also suggests that time is of the essence: any delay in setting up a zone and its attendant measures would be the subject of diminishing returns and would be likely to delay conformity with the NO_2 target.

Note also that several of the assumptions used in this simple exercise are quite conservative in nature:

- The reductions reflect only the difference between an average non-compliant and an average compliant ICE vehicle in each category. Any switch to electrification would result in proportionately larger improvements. This could be significant for some pollutants in particular in classes A, C and D
- This model assumes that all drivers of non-compliant diesel cars who switch will switch to a compliant diesel. In reality many may switch to a compliant petrol car instead, almost certainly resulting in a greater reduction in NOx emissions
- As in the Technical Report, we modelled a charging CAZ with significant numbers of non-compliant car and van drivers opting to pay the charge and continue to use the zone. If other methods were used to exclude non-compliant vehicles more completely, then the emissions reductions would be greater, particularly in classes C and D.

Further considerations

The introduction to the framework states that measures taken should accelerate the transition to a low emission economy, and hence that the improvements made should be ongoing and sustainable. It further indicates that local authorities may wish to go beyond the measures deemed essential for meeting the immediate objective of air quality compliance. This seems rather at odds with the approach suggested in the NO_2 Plan, however.

Section 2 of the framework also sets out a number of general approaches to be taken. This is useful in setting out some of the dimensions of the considerations that will need to be taken into account in developing a CAZ, but is rather short on concrete detail.

Section 3 of the framework covers a number of requirements to be taken into account when considering imposing access restrictions to CAZs. This section contains a lot of practical and useful information, although it appears far from comprehensive.

Whatever measures are to be applied as part of a CAZ, they are likely to cause particular difficulties or hardships for some users and residents within the area. Therefore, some mitigation measures will be an important component of zone design. The government guidance covers this in some detail. However some particular considerations should be highlighted, including:

- For buses, a 15 year average operational life means new vehicle investment will not be able to respond fast enough without major additional costs incurred, so a mix of public sector supported retrofit and scrappage incentives are the best means of expediting adaptation
- Agreed 'sunset periods' could be agreed to allow temporary derogations for problematic vehicles – e.g. for residents within the CAZ or users of older vans. These could give some selected users longer to adapt, leaving them to change vehicle until more compliant vehicles become available both new and second hand
- Charge reductions or special permits can be made available to residents in the CAZ
- Public transport free passes or discounted season tickets; or free car club membership, could be offered as incentives for users to relinquish a non-compliant vehicle.

4.3 Conclusions on Clean Air Zones

Where should a Clean Air Zone be set up?

Ultimately, there is nothing in either the CAZ Guidance or the NO_2 Plan that gives much help in deciding on whether or where to establish a zone. As explained above, the modelling of principal road lengths undertaken for the NO_2 plan gives a good indication that a CAZ will be needed where roads are found to be in exceedance, but a lack of exceedances on main roads should not be taken as a guarantee that the CAZ or other action is not needed, especially where an AQMA has already been set up.

Equally, the road lengths that have been found to be in exceedance do not necessarily give a good guide as to the size or shape of zone that will be needed. Only local monitoring and modelling will help resolve this, but most local authorities will need further help (probably from outside experts) with this. The Government has indicated that funds will be available to provide this help.

A Clean Air Fund

The November 2017 Budget announced that a Clean Air Fund will be established over and above the monies already announced and allocated. This is to be funded to the tune of £220 million from the new taxes on diesel cars announced in the Budget. This is smaller than anticipated but could be an opportunity for local authorities to bid for new money for packages of measures that will benefit both air quality and at the same time the traffic and public realm conditions of town centres.

5. What technological options exist to clean up local traffic?

This section briefly sets out the relative 'real world' emissions of different vehicle classes and ages, as well as the potential role of alternative fuels in reducing air pollutant emissions. The former is important to understand, as the figures are sometimes surprising and even counterintuitive. The values presented in Sections 5.1 and 5.2 are only rough averages, and individual vehicles may vary from the average in either direction. They are however now based on a sound body of 'real world' test results and the body of independent expert opinion, so they are a much better guide to the true position than, say, the legislated emission limits.

For each class of vehicle, there is a graphic indicating what share of the total fleet is made up of this class of vehicle, and what share of these should be deemed compliant using the Government's suggested criteria in its latest NOx plan (see Table 4 in Section 4.2). This is based on the national vehicle fleet in 2016 so is only an initial indication of the composition of traffic in any given local area. The shares of compliant vehicles will also increase over time. It should however give an idea of the magnitude of the task in tackling emissions from any particular part of the vehicle fleet.

This section focuses primarily on emissions from conventional internal combustion engined (ICE) vehicles. These still make up by far the largest share of vehicles on the road. However, these should be seen alongside the developing market for electric vehicles (EVs) which offer a dramatic improvement in air quality and other environmental considerations. See Box 4 below for the dramatic upsurge in the prospects for EVs. Section 5.3 discusses EVs and other alternatively-fuelled vehicles in more detail.

Box 4: The prospects for electrification

Any plans to improve air quality in the UK should go hand in hand with the developing prospects for the electrification of road transport, as this is becoming a major opportunity to improve the urban environment (in terms of air quality, greenhouse gases, noise, etc.).

The electric car was invented in the 1830s – long before the internal combustion engine – but the heavy weight and poor performance of the batteries prevented electric vehicles from becoming the dominant car technology in the 20th century. Instead the internal combustion engine took over the road, and it was only towards the end of the century that a rapid advance in high-powered battery technology led in turn to massive advances in modern electric vehicle (EV) technology.

So electric vehicles have been a long time coming, but in the last few years there are clear signs that they are now ready to take a major share of the market. These include the number of new EV and plug-in hybrid models expected and planned; new battery manufacturing plants now expected in Europe; rapidly falling battery costs; developments in renewable electricity generation capacity; and the spread of battery recharging infrastructure across Europe. Together these represent the key components of a healthy and self-sustaining electric vehicle industry and market in Europe.

Box 4: The prospects for electrification (contd.)

By 2016, there were 34 EV models on the European market across the main car segments, and this is expected to increase dramatically in the coming years. Sales in recent years have grown exponentially. Additional mainstream manufacturers are also entering the market with both pure EVs and plug-in hybrid versions of existing popular models. Recently both Volvo and Jaguar Land Rover have announced that they will sell only cars with an electric motor by the end of the decade, and others will surely follow. The 2017 Frankfurt Motor Show was conspicuous for the number of new electric models and concept cars on show. This is in part a response to the adverse public reaction to the 'dieselgate' scandal, and in part to the imminent arrival of the Tesla 3 (a high specification but mainstream EV which is expected to challenge conventional ICEs more fundamentally than any EVs have so far). In September 2017, the entrepreneur James Dyson also announced that his company will also produce an EV for 2020 that is "radically different" from current models. It will probably not be cheap, but it may be a further game-changer.

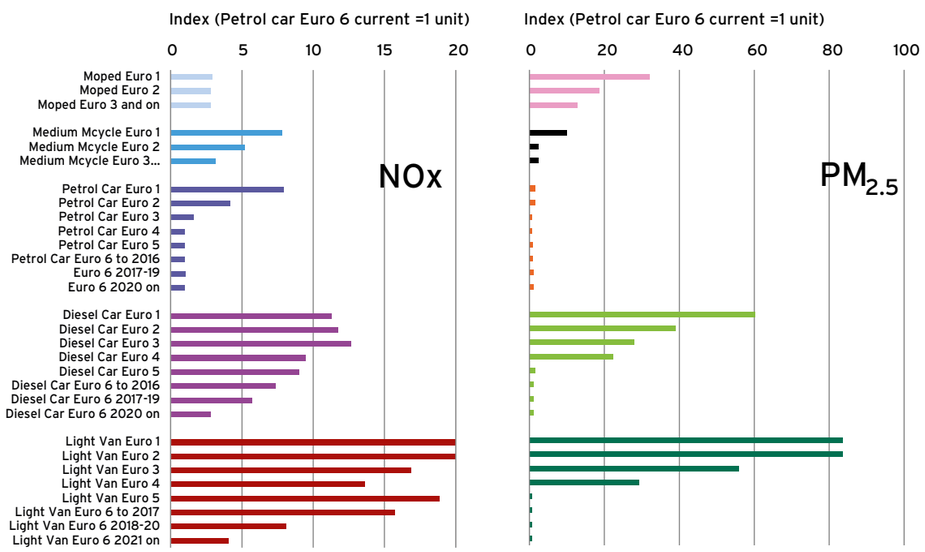
The same trend is evident to a lesser extent for light vans, but they are becoming more common and more models are available.

Pure EVs give no exhaust emissions at the point of use, and most hybrids have this capability for part of a journey as well. Hence any measures that encourage the substitution of older vehicles, especially diesels, with EVs can make an important contribution to improved air quality. Central London is expected to have the first zero emissions zone (ZEZ) in the UK by 2025 (although Oxford is currently proposing to take initial steps towards a ZEZ in 2020).

5.1 Light duty vehicles

As Figure 7 demonstrates, different categories of light vehicles can vary enormously according to both type and age or Euro standard.

Figure 7: Typical emissions of light duty vehicles by type and Euro standard



Source:
CORINAIR v5 Tier 2[30]

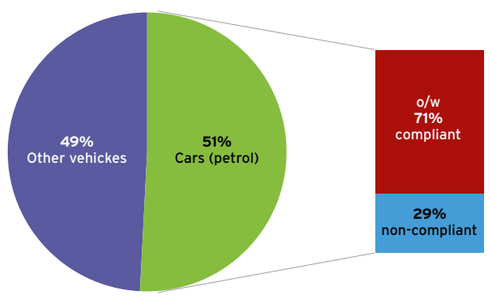
Petrol cars

It can be seen from Figure 7 that newer petrol cars (Euro 4 onwards) are by far the cleanest of the categories shown for both NOx and PM. This shows that catalytic converters and other modern aftertreatment for petrol cars are generally quite effective.

As Figure 8 illustrates, petrol cars make up more than half of all the vehicles on the roads, although they tend to driven less far each year and are older on average than the diesel cars. However, owing to the improved emissions controls of recent years, over 70 per cent are already compliant with proposed standards for a CAZ.

Hence the many petrol cars of less than 11 years old offer a ready and realistic replacement for very old petrol cars or their diesel equivalents from an air quality perspective. As box 4 shows, electric and hybrid-electric alternatives are now becoming increasingly common and competitive as well.

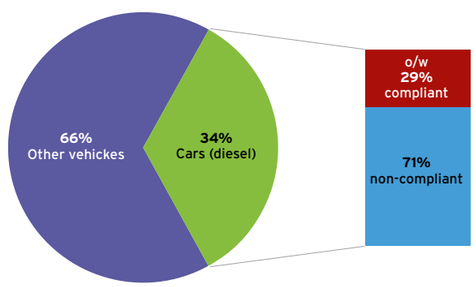
Figure 8: Share of total fleet and compliance with CAZs (petrol cars)



Diesel cars

In contrast, diesel cars are in most cases markedly worse than their petrol equivalents. Those certified to Euro 4 or earlier are typically about an order of magnitude worse than a petrol equivalent for NOx, and even more so for particulates. Newer diesel cars (Euro 6) are considerably better in terms of PM as they are now fitted with particulate traps, but for NOx they still lag far behind petrol, with current models (Euro 5 and 6) still mostly at least five times higher than an equivalent petrol car. Only the new Euro 6c standard (not in force until 2020) will bring them anywhere close to parity when tougher tests begin to ensure that real world emissions come close to the legislated limit value.

Figure 9: Share of total fleet and compliance with CAZs (diesel cars)



Diesel cars make up only about a third of all vehicles on the roads, but they tend to be newer and used more extensively than their petrol equivalents. Figure 9 indicates that nearly 30 per cent (the newer ones) are compliant with a putative CAZ, but this is only on the official suggestion that all Euro 6 cars should be deemed compliant. If, as argued

above, the majority of those already on the road are regarded as non-compliant, then the compliance rate falls to well below 10 per cent. However, this will improve with time as cleaner diesels enter the car fleet from now on. Hence it is clear that, with still nearly half of the newer cars on the road being diesels, it will be difficult to design an effective CAZ without including some measures to discourage or exclude diesel cars, at least those prior to Euro 6.

Taxis and private hire vehicles

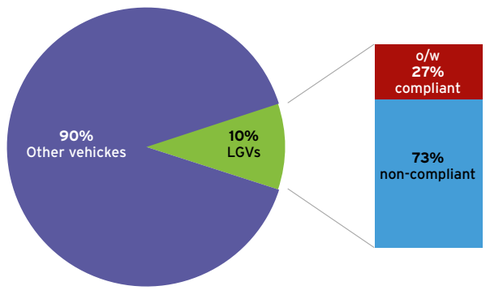
Like buses, these tend to operate primarily in town centres and are an essential component of urban transport systems. However they too are usually diesel fuelled and some are quite old, so they can be a large part of the problem in a CAZ. It is therefore essential that they be tackled as part of any substantive local plan.

Fortunately there are good options emerging for new taxis with either hybrid or all-electric models becoming available, but retrofits of existing vehicles remain problematic. Many hybrids can also operate in an all-electric mode so it should be possible to demand that they do so inside a CAZ. Fortunately some hybrid petrol cars (most obviously the Toyota Prius) have become popular as taxis and PHVs owing to their good fuel economy, so these should be encouraged and incentivised. A staged approach that progressively excludes the oldest diesel taxis from a CAZ is likely to be needed.

Light vans

These are becoming an increasing component of total traffic as shopping and delivery patterns change. However they are still almost exclusively diesels, and typically emit even higher levels of pollution than diesel cars. As with cars, only the future Euro 6c standard will offer substantial NOx improvements from 2021, and unlike with cars, petrol equivalents are increasingly rare.

Figure 10: Share of total fleet and compliance with CAZs (light vans)



Vans are numerically by far the most common vehicle type on our roads after cars, and account for about one vehicle in ten. As with diesel cars, however, the majority would be non-compliant with a CAZ (see Figure 10).

For new purchases a few electric and hybrid models are now becoming available, but the choice is still very limited and will not meet all the range of needs from the many specialist and varied applications for which this vehicle class is used. Nonetheless more options are becoming available right up to the 7.5 tonne threshold so they should be considered, and Government offers purchase incentives under the plug-in vehicle scheme. Also, an electric vehicle may be quite viable for some operating regimes (e.g. local deliveries, maintenance work) and could make a major difference to local air quality.

Retrofit options are however few and challenging. Hence this class of vehicle remains arguably the most problematic and challenging from an air quality management perspective, and a staged approach is likely to be needed.

SECTION 5
What technological options exist
to clean up local traffic?

Motorbikes, mopeds etc

The Government's latest draft air quality strategy tends to dismiss the contribution of two- and three-wheelers on the grounds that they are relatively few in number. This is generally the case, but in spite of their small size their specific emissions on a passenger kilometre basis can be very high, as they have little or no abatement compared to larger vehicles. Mopeds in particular emit several times as much NOx as a new petrol car, and more than ten times as much fine particulate, even from newer models. Larger motorbikes can be even worse, and although both NOx and particulate emissions are improved in the later Euro classes, they still amount to the equivalent of about three modern petrol cars.

It is therefore worth considering whether they might make a substantial contribution to local pollution in particular circumstances. Note that electric mopeds and motorbikes are available and work well, but are not yet common in the UK.

Category L vehicles and e-bikes

Motorbikes and other two-wheelers are part of a wider group known as Category L, but the latter also includes a proliferating range of novel forms of light vehicles with two, three or four wheels.

Some of the largest in class are four-wheelers (heavy quadricycles in Category L7) up to 400 kg in weight (or 550 kg for vehicles intended for carrying goods). Above this they are classed as cars or vans. Category L is divided into a range of subcategories, delimited in most cases by the number of wheels and an upper limit on engine power, vehicle weight or maximum speed, or some combination of all three. Typically they have seating for one or two passengers (including the driver), but in some cases there can be three or more. Seats may be straddleable (as on a motorbike) or non-straddle (i.e. more like a car seat).

Some are 'open to the elements' like a traditional scooter or motorbike, but increasing numbers now have some form of canopy that provides a degree of protection from the weather, and to some extent from impacts in the event of an accident. The largest quadricycles can have several seats and a full body shell that resembles a small car – and there are also now some very modern and sophisticated ones (increasingly referred to as 'nanocars') that can easily be mistaken for a very small car.

Most vehicles in Category L are designed primarily as lightweight passenger vehicles, but a few are intended to carry goods, and these are now developing to offer important new applications for local deliveries and maintenance in urban areas. For example, they are becoming popular in park management, and Deutsche Post in Germany is developing a large network of small purpose-built electric vans to distribute post and parcels.

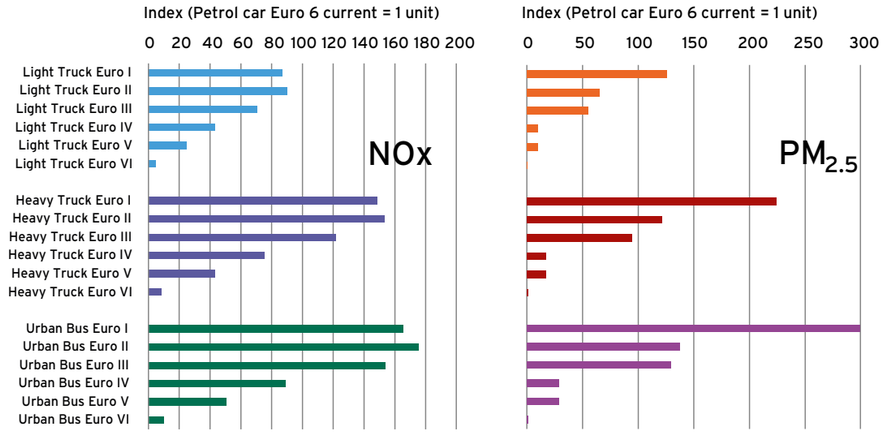
Many of these subcategories are becoming increasingly popular around the world, as they offer a substantial part of the functionality of a fully-fledged car or light van, but at a much lower cost and with a far smaller footprint. Electric versions are also becoming increasingly widespread and popular. Owing to their light weight and light duty cycles, these small vehicles are easy to build with electric power units, and do not have the same price premium as larger EVs. These offer huge environmental benefits in comparison to conventional two-wheelers in terms of CO_2, air quality and noise.

Category L specifically excludes electrically-assisted pedal cycles (EAPCs or e-bikes) and kick-scooters, self-balancing vehicles such as Segways, and electric mobility scooters intended for use by mobility-impaired people. The electric versions of these vehicles are now commonly available, either to substitute for human 'pedal power' or to supplement it for greater speed, longer journeys, or extra help with steep hills. These are becoming very common across Europe, particularly in Germany and the Netherlands, but less so as yet in the UK. They can nonetheless offer useful benefits in an ultra-low emission zone.

5.2 Heavy duty vehicles

As Figure 11 below demonstrates, different categories of heavy vehicles can also vary enormously according primarily to their age and Euro standard. It is also worth noting the scale on each chart in Figure 12. In short, older heavy diesels pollute a great deal more than light diesels, but the newest ones do not. Another plus side is that heavy diesels are far less numerous that light ones.

Figure 11: Typical emissions of heavy duty vehicles by main type and Euro standard



Source:
CORINAIR v5 Tier 2

Trucks or HGVs

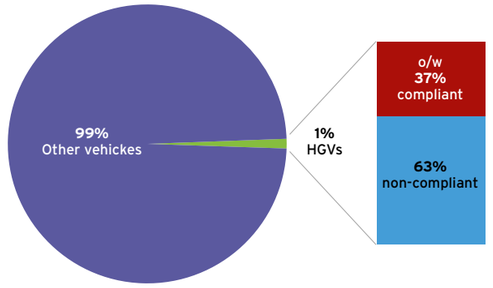
Figure 11 gives the figures for both a light/medium truck (typically a rigid vehicle of 7.5-16 tonnes GVW) and a large truck (typically articulated and of over 32 tonnes GVW). Unsurprisingly the larger emits more pollution than the smaller one but generally by less than a factor of two. In either case it can be seen that the oldest classes (Euro I and II) are a great deal worse than the newer ones, and these get gradually better in later Euro classes. It is equally clear that the newer ones (especially Euro VI) are a great deal cleaner on average than the earlier models owing to much improved aftertreatment systems being required. These latest systems appear to work well in most real driving conditions, as well as on the test bench. Indeed, a modern diesel truck emits only a few times more pollution than a petrol car, and is on a par with a single modern diesel car and cleaner than an old one.

HGVs make up only about one per cent of all vehicles on the roads (see Figure 12), but they tend to be used very intensively and are expensive to buy or upgrade. Nonetheless over a third would already be compliant with a CAZ owing to the steadily improving emissions standards, but it would be important to try to exclude at least the oldest ones (say, at least ten years old), but the newest can be regarded as quite compatible with good air quality management.

A number of firms are now using battery-electric technology on relatively large vans and smaller trucks where loads are not heavy and distances are limited to a defined urban delivery circuit of up to about 100 miles, for example. Already, too, hybrid trucks (with or without plug-ins) are becoming more common as a means of reducing fuel consumption. Some municipal applications, such as refuse collection vehicles, also appear promising and are of course particularly relevant to the local authority/CAZ context, although refrigerated trucks are more challenging (see Box 5). In September 2017 Tesla announced that it would be launching an all-electric mid-range truck by the end of 2018. It expected that it will have a range of 200 to 300 miles; so this will be of little use for long-haul freight but could be ideal for urban delivery applications.

Retrofit options are also likely to be viable for newer trucks (probably Euro IV or V), owing to their large size and high residual value. Electric and hybrid versions are also becoming available for some smaller trucks, and again these may be suitable and highly desirable for local deliveries, for example. For more discussion on options for reducing emissions from HGVs, see the parallel Tracks report on transport and carbon emissions.[31]

Figure 12: Share of total fleet and compliance with CAZs (HGVs)



Box 4: Red diesel and refrigeration

Another point to be aware of is the implications of refrigerated trucks carrying foodstuffs, etc. These have separate motors to run the refrigeration, and these are not regulated as tightly as road diesels. They may also be on for long periods of time to keep produce cool. These generally run on red diesel, which is a cheaper diesel not used for road transport fuel, and which is considerably dirtier than road diesel. As a result, they can produce substantial amounts of pollution.

To counter this problem comprehensively will require national or EU-level action. However, if a firm delivers chilled produce regularly into a CAZ, it may be possible to encourage them to switch these units to a more sustainable source of power, or at least a cleaner diesel. It is also worth noting that some manufacturers are beginning to develop refrigeration technologies that are a lot cleaner than those which run on diesel.[32] Hence, there is scope for local authority action to reduce refrigeration emissions.

Buses and coaches

Buses are important in controlling air quality because they typically operate extensively and intensively in urban areas, and by definition, they also tend to operate very close to the mass of people on the streets. Older buses can be very polluting indeed and at least comparable to a large HGV in terms of both NOx and particulates, but in comparison new (Euro VI) buses offer very substantial emissions benefits and are not much more polluting than a single car.

Fortunately buses are very few in number compared to other classes of vehicle so it is possible to make an important difference through relatively targeted interventions. Also, local authorities can in principle exert influence through charging, franchising and licensing arrangements. Nonetheless the bus fleet is quite old on average, so fewer than one in four buses, coaches and minibuses is typically compliant at the time of writing

(see Figure 13 – but it is probably even fewer for public service buses). It will therefore be important to apply a mix of retiring legacy buses, retrofit where technically feasible, and replacement/upgrade to improve the performance of the fleet overall. Overall, these measures will need to ensure that the cost-competitiveness of buses relative to car travel is not damaged, as any shift from bus to car will probably exacerbate the air quality problem. As noted already, this will require a mix of public sector support for retrofit and bus priority measures.

For new buses, a range of much more environmentally friendly options are now available, from all electric, various configurations of hybrid and through to Euro VI diesel. Note also that as with trucks, all new (Euro VI) buses are a great deal cleaner than older ones from an air quality perspective, and are even cleaner than many new diesel cars and still much cheaper than the electric alternatives.

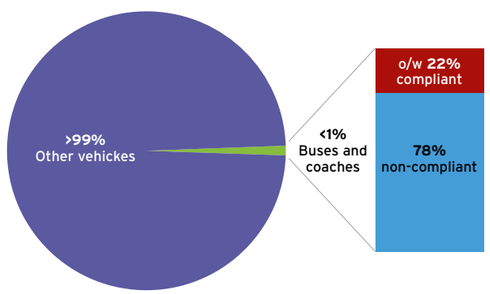
For the oldest buses, aside from scrappage little can be done apart from discouraging their use in urban centres, and/or encouraging their displacement to other less sensitive areas. Accelerated bus scrappage and renewal schemes are now becoming a real possibility as well at either local or national levels, and could bring valuable air quality benefits across the country. For newer buses (say, Euro IV and V), the options to retrofit them with more modern pollution control can also render their operation acceptable in urban centres for some years to come. For legacy Euro IIIs which will not otherwise be replaced by new vehicles, retrofit and/or engine replacement may still be options depending on engine condition. These options where feasible are still far cheaper than buying a new bus.

Note that the Clean Vehicle Retrofit Accreditation Scheme (CVRAS) is a robust new certification scheme run by the Energy Saving Trust and Low Carbon Vehicle Partnership for manufacturers of retrofit emissions reduction technology. This will facilitate CAZ compliance of existing fleet vehicles. Eventually this will cover retrofits to all classes of heavy diesel, but its first priority is buses. This certification scheme is designed specifically to support the operation of CAZs.

Recently the LowCVP has published an evaluation of earlier bus retrofit programmes, analysing vehicle test data before and after retrofit and when in service. The key findings of the Evaluation Report were:[33]

- The highest NOx emission reductions (80 per cent – 100 per cent) were from retrofit SCR aftertreatment and diesel bus engine conversion to an electric powertrain
- Moderate NOx emission reductions (25 per cent – 29 per cent) were achieved by retrofit of thermal management and flywheel hybrid technologies
- Only very minor NOx reductions (3 per cent – 6 per cent) were achieved by mild hybrid, hybrid assist and dual fuel CNG conversions.

Figure 13: Share of total fleet and compliance with CAZs (buses and coaches)



Given the relatively small size of the bus fleet and the positive options for upgrade of the emissions performance of the more modern buses, there is now a real prospect of bringing the total fleet up to modern standards if the funding is made available.

5.3 The impact of alternative fuels

There are various potential alternative fuels and energy sources that are discussed in the context of their potential contribution to reducing CO_2 emissions from transport. Some, such as electricity and hydrogen, require fundamental changes to the design of vehicles and their engines, whereas others, such gases and biofuels, require varying degrees of changes to existing petrol and diesel technologies. The air quality benefits of some of these alternative fuels and energy sources are clear, while the impact of others on air quality is less clear.

Vehicles powered completely by electricity and hydrogen have decisive air quality benefits in urban areas, as they emit no exhaust pollutants when in use.[34] Similarly hybrids, which can be powered by electricity or an internal combustion engine, have the potential to contribute to improvements in air quality, as long as their electric mode is used in polluted areas. Some hybrids have an 'electric only' mode, and this could be encouraged or mandated within CAZs. As a result, the purchase and use of vehicles using electricity and hydrogen are being encouraged by various different pieces of legislation, as discussed below. Battery costs are falling dramatically so we can expect more EVs in most vehicle classes, although double decker electric buses are still about half as expensive again as a conventional Euro VI diesel bus, with only relatively small additional benefits in terms of emissions reductions alone.

However, the air quality benefits, particularly in terms of reduced NOx emissions, which is the most serious issue as noted above, is less clear for other alternative fuels. A report by Ricardo Energy & Environment suggested that while vehicles using natural gas (or biogas) have the potential to deliver reductions in emissions of SO2 and PM, they would have less impact on NOx emissions. The report concluded that the greatest reduction from using gas would come from replacing diesel cars and vans with compressed natural gas (CNG) cars and vans, as this would deliver NOx reductions. On the other hand, the report concluded that there would be no benefit in terms of reducing NOx emissions from switching trucks or buses to CNG or biomethane.[35] These findings are similar to those of an earlier report undertaken for the Dutch government.[36]

With respect to biofuels, a third of London buses use a blend of diesel that contains 20 per cent biofuels, so called 'B20'. B20 has largely been introduced as a result of its impact on reducing CO_2 emissions. A trial concluded that there was insufficient evidence to promote B20 or higher blends of biofuels as having air quality benefits. Other studies have concluded that the emission of some air pollutants decline as biofuel blends increase, although the impact on NOx emissions is less clear, as these can actually increase with the use of some biofuels.

Consequently, while measures to promote electric and hydrogen vehicles for their potential benefits for climate change will also bring air quality benefits, with gas and biofuels, in particular, the benefits for air quality (in particular NO_2) are less clear cut (as are in many cases their benefits on reducing CO_2 emissions). Consequently, it is questionable whether policy attention should be given to promoting gas and biofuels for road transport, particularly for cars, in order to deliver climate and air quality goals given the much more decisive benefits of electrification. There may however be some merit in retrofitting some large diesels (most obviously buses), but adding NOx aftertreatment is likely to be more effective than converting to gaseous fuels for air quality purposes.

6. What else might be undertaken at the national level to improve air quality?

As described in Section 4, within the UK, the current air quality policy framework contains various elements, including CAZs and financial support. This section explores what else might be done at the national level to improve air quality. This includes more stringent emission standards, action on CO_2 emissions and amendments to the transport tax framework. Note that the companion Tracks report on greenhouse gases (referred to in the Introduction) also contains many policy proposals (e.g. on modal shift) that would also be relevant to improving air quality.

6.1 More stringent emission standards

As discussed in Section 3, the EU's Euro emissions standards have played a major role in reducing air pollutant emissions from vehicles, even though recent standards for cars and vans have not delivered the anticipated emissions reductions in practice. In order to address the discrepancy between emissions as measured on the test cycle and real world emissions, an agreement has been reached at the European level on the introduction of real driving emission (RDE) tests for Euro 6 standards, i.e. the standards for cars and vans. The RDE standards will be introduced in a staged approach from September 2017 and will be applicable to all new cars by September 2019, with all new vans being covered one year later.

However, new cars and vans will not, at least initially, have to meet the actual Euro 6 standards on the road as a result of the new RDE tests. From 1 September 2017, i.e. when the RDE tests are first applied, new vehicles will still be allowed to exceed the Euro 6 NOx emission levels under the RDE by 110 per cent. After a further two years, this level will drop to 50 per cent,[37] i.e. by September 2022 for the largest vans.[38] As the RDE element of the Euro 6 standards will not be fully implemented until 2022, it is unlikely that a further Euro 7 standard will be introduced in the next decade. However, there have been calls on the European Commission to develop proposals for Euro 7 standards, including from a committee of the French Senate[39] and from Transport and Environment,[40] both of which argued that the same standards should apply to both diesel and petrol cars under any new Euro standard. The French Government has subsequently committed itself to arguing for an ambitious Euro 7 standard.[41]

As noted above, the most recent Euro VI emission standards for trucks and buses are delivering real world reductions in pollutant emissions. Trucks and buses using Euro VI engines have been estimated to have NOx emissions of at most one third to one quarter that delivered by the previous best Euro standard.[42] Additionally, work is ongoing to develop CO_2 standards for lorries, while the possibility of a zero emission target for urban buses will also be explored.[43] These various initiatives are likely to continue to encourage vehicle manufacturers to keep developing electric cars, vans and buses, which clearly have the potential to bring air quality benefits in cities.

Euro 4 emission standards for motorcycles, and other L-category vehicles, will be in place for all new vehicles from January 2018, with Euro 5 standards for these vehicles coming into force three years later. The NOx emission limit values for petrol-powered motorcycles under Euro 5 will be amount to a 60 per cent reduction compared to Euro 3 values.[44]

6.2 Action on transport's CO_2 emissions

In spite of there being no short-term prospect of a Euro 7 emissions standard for cars and vans, **EU legislation on transport CO_2 emissions** will drive the uptake of cleaner vehicles, particularly electric vehicles. Currently, the average CO_2 emissions from all new cars in the EU will have to be no more than 130 gCO_2/km in 2021. The European Commission is committed to proposing further standards for cars and vans for the post-2021 period and work is ongoing on these, as well as on a similar framework for trucks and buses. The implication of these future frameworks on the UK remains unclear, as a result of Brexit. However, even if these policies were no longer directly applicable in the UK, vehicles sold in the UK would probably still benefit from the improvements in fuel consumption that manufacturers have implemented to comply with EU legislation. Furthermore, given the UK's commitments under its own Climate Change Act, it is likely that a UK policy framework would be developed to ensure that the fuel efficiency of vehicles continues to improve, in the event that the EU legislation no longer applies to the UK.

In the summer of 2017, two EU Member States, France and the UK, signalled their intention to set longer-term targets. While the UK has announced that it will work to bring an end to the sale of new conventional diesel and petrol cars by 2040, the French ban appears to go further as it plans to end the sale of cars that emit greenhouse gases by 2040.[45] On the side of the manufacturers, as noted in box 4 above, Volvo has also announced that from 2019 it will no longer launch any new conventional petrol or diesel models,[46] while Jaguar Land Rover has announced that all its new vehicles will be at least a mild hybrid (which does not need to be plugged in) from 2020.[47]

There are also a series of national measures aimed at promoting ultra-low emission vehicles (ULEVs), which will have benefits for both CO_2 and air pollutant emissions. ULEVs include electric vehicles and hydrogen fuel cell vehicles, which do not emit any air pollutants when in use, and plug-in hybrid vehicles, which emit no air pollutants when used in their electric mode. As with the UK's approach to air quality outlined above, financial support is an important element of such policies, particularly the plug-in grants, which provide grants to purchasers of specified zero emission vehicles, which have an electric range above a specified level. In 2017, the maximum grant available was £4,500 for cars, £8,000 for vans and £1,500 for motorcycles and mopeds.[48] The Government has also provided financial support for the installation of charging infrastructure, as well as to develop and trial low carbon trucks, to support the purchase of ultra-low emission taxis (and associated infrastructure) and to support cities more generally in the uptake of ULEVs. In order to promote the purchase of ULEVs, the Government and manufacturers in the UK have launched a joint awareness campaign, called Go Ultra Low.

6.3 Taxes and incentives

The various taxes on the use and purchase of vehicles also have a potentially important role to play in improving the environmental performance of road transport. Fuel duty has previously been differentiated in order to speed up the introduction of cleaner fuels, e.g. ultra low sulphur petrol and diesel in the 2000s. Such requirements for cleaner transport fuels have previously been linked to more stringent Euro emissions standards. As noted above, more stringent emissions standards are unlikely in the short term. Higher rates of fuel duty in general would have an impact on transport levels, but from the perspective of air quality this would be a relatively blunt instrument, as the high rates that would probably be needed to have a significant impact in air pollution hot spots would be politically very difficult. In this respect, more targeted restrictions are more appropriate (as discussed above).

In the UK, various vehicle taxes have been amended to reflect a vehicle's CO_2 emissions and these have been credited with supporting the improvements in fuel efficiency that have been seen in the UK car fleet in the last decade. Vehicle excise duty (VED) and the tax benefits linked to company car ownership and use have all been graduated according to a new car's CO_2 emissions. Prior to April 2017, annual VED was graduated by a car's CO_2 emissions, although the rates were different for the first year of registration (lower for low emitting cars, higher for high emitting cars). Since April 2017, only first year VED is graduated, but the graduation is steeper than was previously the case.

In light of the success of such graduated taxation to address climate concerns, a similar approach might be considered for air pollutants. For this reason, a recent report from University College London (UCL) proposed the introduction of a 'supplementary NOx registration tax' to be implemented nationally for new diesel cars. The proposal was that this supplementary registration tax would be based on the difference between a car's NOx emissions as measured in the real world and the limit value specified under Euro 6. The report proposed different options for setting this tax, but in each case the diesel cars with the largest discrepancy between real world and Euro 6 emissions would pay an additional registration tax of £3,500 at the minimum. The report also proposed changes to the various low emission zones (see below) and to the existing company car tax regime to penalise diesel cars emitting more than the specified Euro 6 limit value.[49] As discussed, the Government has now proposed an additional 'diesel tax' on new cars, although the details of this are still not clear at the time of writing.

6.4 Scrappage schemes

A report from Oxford University demonstrated that a NOx-based variable scrappage/purchase tax, ranging from £800 for small diesel cars to £2,500 for large diesels, could have significant benefits in terms of reduced NOx emissions. The report noted that while some, including the Mayor of London, have been calling for a national scrappage scheme for older diesel cars, such schemes are expensive, can be seen to be regressive and also potentially contradict the need to reduce CO_2 emissions, for which diesel cars are beneficial. As a result, the report concluded that further differentiation by fuel in the existing company car tax regime might be more appropriate.[50]

There has been much talk, even in government circles, of a national scrappage scheme to deal with the diesel car problem. However, considering the current diesel car fleet, it does not meet any of the criteria for an effective candidate for scrappage (see Box 6).

In particular:

- Almost all the diesel cars currently on the road could be classified as gross polluters where NOx is concerned: they are almost universally much worse than their petrol equivalents, and only a few of the newer models are as yet significantly better than the older ones. This amounts to around 40 per cent of all cars on the road or about 12 million vehicles
- Also they are newer on average than the petrol car fleet because diesel cars have only become popular in the last five to ten years. Combining this with their higher purchase prices and better residual values (at least until recently), and it can be seen that they would be very expensive to scrap – typically several £000s per car or even more.

In short this argues that a general diesel scrappage scheme would be prohibitively expensive and not cost-effective from the air quality perspective. Local schemes would of course be much cheaper but are unlikely to be effective for a range of reasons.

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Box 6: Scrappage schemes in theory

Scrappage incentives are sometimes advocated as a means of reducing emissions from the road transport sector, and the ongoing 'dieselgate' scandal is a case in point. It is generally necessary that a scrappage scheme, to maximise the environmental benefit, should target the oldest vehicles because these have the lowest residual values and can therefore maximise the price signal at the lowest possible cost per vehicle scrapped. This approach can be effective where there is a fairly small and identifiable class of gross polluters (or 'old bangers') that can be targeted.

There is however a high deadweight cost to scrappage incentives even at the best of times, as the people most likely to avail themselves of the incentives are those who use their cars least, have the very oldest cars, or were thinking of scrapping them anyway. Analysis shows that older vehicles are driven far less on average than newer ones – for example cars of more than ten years of age constitute about one third of all the cars on the road but account for less than 6 per cent of the total car mileage driven. Hence a very large number of old cars would need to be scrapped in order to have any measurable effect on fleet average emissions on the road, and are even less likely to improve urban air quality significantly.

Scrappage schemes in practice

In reality, scrappage schemes have rarely been used in Europe, and when they have, the primary motivation has generally been to provide a sales boost to the national car industry in difficult economic times. In essence motorists are offered a cash bonus if they scrap an old car at the same time as buying a brand new one. Incentives such as this can distort the market: common experience suggests that very few motorists normally decide to scrap an old banger and then immediately buy a brand new car, so secondary markets are needed in these cases.

In contrast, the environmental benefits of scrappage schemes (for example in cutting car CO_2 or tackling urban air quality) are generally far more limited and never conclusively demonstrated ex post. There are several good reasons for this, as outlined below.

However, there remain good arguments for a much more targeted and well-focussed scrappage scheme, most obviously to scrap the oldest diesel buses and taxis, and perhaps vans, and replace them with much cleaner modern alternatives including EVs and hybrids. Particularly for buses, the total number of vehicles involved (say, older than Euro IV) is relatively limited so a scheme should be manageable in terms of both practicality and cost, and would probably be very effective in terms of air quality.

6.4 Modal shift and national infrastructure spending

National transport policies and investment priorities also have an impact on the modes that are used, and therefore on modal shares, and hence on emissions of air pollutants. Campaign for Better Transport has recently claimed that more focused efforts to switch freight off road and onto rail and waterways could cut heavy goods vehicle traffic on the busiest roads by up to 21 per cent. This will not necessarily be relevant in many areas with poor air quality, but concerted efforts to encourage modal shift might deliver a useful reduction in HGV traffic on some non-compliant major roads. The parallel Tracks report on transport and carbon emissions made a number of recommendations

concerning measures that would reduce freight transport's carbon emissions, such as a national rail freight network and the development of Strategic Rail Freight Interchanges,[51] that would also potentially reduce air pollutant emissions, although much of the benefit from these policies would be felt outside of urban areas.

More generally, investing in road transport infrastructure that increases the capacity of the network to facilitate the movement of polluting diesel vehicles has the potential to adversely affect air quality. In practice, the scale of any impact will be determined by the location of the changes and the effect it has on exposure levels. If investment in road infrastructure increased air pollutant emissions, but moved these away from areas of human habitation or activity, the investment might be beneficial from a health perspective, if not from a wider environmental perspective. Alternatively, if road transport investment increases the flow of vehicles into an area of human habitation or activity, there is a risk of an increase in adverse health impacts as a result of increased emissions of air pollutants.

6.6 Discussion and recommendations

While both Euro standards and the EU's legislation in transport CO_2 emissions will have contributed, and will probably continue to contribute in spite of Brexit (see Box 2), to reducing the emission of air pollutants from road transport vehicles, these are long-term policy measures. As there is not likely to be a more stringent Euro emission standard within the next ten years, while EU legislation on transport CO_2 is likely to have a greater impact on the uptake of zero emission vehicles, including trucks and buses, in the medium-term, i.e. up to 2030. Even without further measures the vast majority of the country would be compliant with air quality standards by 2025. Consequently, other policy action needs to be taken in order to improve air quality in the short term, and thus avoid the subsequent unnecessary premature deaths and illness.

Apart from standards and financial support, the other potential area for policy intervention at the national level is in relation to taxation and incentives. Linking transport taxes to a vehicle's CO_2 emissions has proven to be beneficial in reducing the average CO_2 emissions from a fleet, although this has been a consistent policy over many years, e.g. with respect to VED and company car tax. The company car tax regime already differentiates between petrol and diesel cars – the rates to be applied for the purpose of taxation are 3 per cent higher for diesel cars than for petrol cars.

There are challenges with amending tax rates to penalise diesel cars. In particular, any tax change will take time before its impact is felt in terms of improving air quality. For example, if a new VED scheme was announced in the Autumn 2018 budget, it would be unlikely to come into force until the 2020 at the earliest. Hence, in 2020/21, the amended VED scheme would affect perhaps 1.2 million new diesel cars that are bought that year and a similar (or perhaps smaller) number in subsequent years.[52] By this time the real world emissions of most diesel cars will be a lot closer to their test cycle emissions, so such a reform is likely to have limited impact on air quality before most air quality zones will be in compliance with existing standards. For the company car taxation system, the relevant tax rates to be applied have already been set for the financial years up to and including 2020/21 in order to provide certainty for company car users. Any change to the approach to the taxation of diesel cars for years prior to this would face resistance, so any changes to the company car tax regime are only likely to have an impact from 2021/22.

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This is not to say that there is no case for taxing diesel cars differently to petrol cars. Indeed, as noted in Table 2, the current Euro 6 NOx limits for diesel cars are one third higher than those for petrol cars, which, as has been argued by Transport & Environment, encourages the development and sales of diesel cars in the European market, whereas in the US, which has the same standards for petrol and diesel, the latter has remained a niche.[53] On this basis, a differential tax treatment between petrol and diesel cars could be justified. However, the point is that it will take a few years for such changes to have an impact on the ground, and so they are not a solution to improving air quality in the short term. The problem is mainly with the diesel cars and vans already on the road, so a tax on new diesel cars would be largely a case of locking the door after the horse has bolted. In practice, local measures to discourage light duty diesel from polluted town centres are likely to be far more effective.

Increases in fuel duty and a general diesel scrappage scheme also risk being blunt instruments, with the latter being potentially expensive. Hence, perhaps the most promising approach to improve air quality in the short term at the national level is to support a targeted scrappage scheme for the oldest, most polluting diesel vehicles that are in frequent use in polluted towns and cities, such as buses and taxis. However, there are various local measures that might also be considered, as discussed in the next section.

7. What might local authorities do to tackle air pollution hotspots?

The draft guidance from Government appears to place great emphasis on the possibility of establishing differentiated charging zones to implement CAZs outside London. There is little doubt that this would be the most flexible and possibly the most effective approach – but not the simplest and is possibly way beyond the needs or resources of many local authorities. There are many other cheaper and simpler approaches that can be used to incentivise the cleanest vehicles or to exclude, discourage or divert the dirtiest; and the following sections offer some examples of these.

Potential local authority measures to improve transport emissions and air quality

National and EU-level policies and measures have been important in accelerating the improvements in tailpipe emissions and the entry of EVs into national vehicle markets, and will continue to be for some years to come.

In addition, however, in the air quality context it is now inevitable that local measures will be needed urgently to solve local air quality problems in the timescale required. These will be focussed on the removal of older vehicles that are non-compliant from a CAZ; encouraging the uptake of electric vehicles and other newer vehicles to substitute for non-compliant ones; and the encouragement of modal shift through improving conditions for cycling, walking and public transport.

Such measures have been usefully categorised and evaluated in three recent publications. The first of these is 'Local measures to encourage the uptake of low emission vehicles',[54] this is primarily a good practice guide aimed at UK local authorities, but contains many good practice examples from around Europe. The second is a recent International Council on Clean Transportation (ICCT) report which includes detailed and well-structured case studies from a range of countries. Closer to home, The National Institute for Health and Care Excellence (commonly known as NICE) has produced surprisingly detailed and practical guidance on using transport measures to improve air quality and health, and much of this is directed towards local authorities.[55]

Some specific good practice examples are included in the next section, but this brief summary categorises some of the key points from these studies:

- Through their role in city planning and infrastructure provision, local authorities can play a key part in facilitating and accelerating the installation of electric recharging infrastructure, reserved parking spaces, etc. for low emission vehicles. Designation of low emission zones or CAZs can also be an important indirect driver for the uptake of EVs and other clean vehicles
- Local authorities also typically operate large vehicle fleets, or procure services from private operators, for a wide variety of municipal functions, many of which are ideally suited to electric vehicle operation. In these areas, public procurement programmes can be an important driver of demand for EVs and other very low emission vehicles. Even where such fleets are contracted out (e.g. waste collection services) it should be possible to specify tighter emission standards in the tendering process
- Local authorities should also be in a position to give preferential access to road infrastructure for EVs and other compliant vehicles, or to restrict access for non-compliant vehicles. Powers to restrict access in the UK are arguably less comprehensive than under Germany's Electric Mobility Law of 2014, for example, but they do exist and some are already using them
- Similarly, local road charging schemes and toll points can offer free access or reduced rates as an incentive for the use of designated electric or other compliant vehicles. The London road charging scheme is a good example of a scheme that has effectively incentivised low emission vehicles for some years
- Interventions influencing dedicated urban fleets, such as distribution and maintenance vehicles and taxis, can also be particularly effective in improving air quality in central areas. This could include discouraging HGV deliveries and fostering a light electric vehicle distribution network for 'last mile' deliveries. In London, the Mayor proposes that from 2018 all new taxis and private hire vehicles must be capable of zero emissions operation for up to 30 miles
- Parking policy is an important area of local authority powers that can directly influence decisions on EV and compliant vehicle ownership in and around a CAZ. Measures available might include preferential parking rates or free parking in both residential and on street parking bays, reserved bays for EVs, etc. Dedicated parking bays for electric car sharing schemes are also an effective enabling measure. Charging building tenants for the number of private non-residential parking bays that they operate can also be an effective way of reducing off-street parking in city centres and hence cutting traffic
- Support for car sharing schemes is also becoming more widespread. Of these, the Paris Autolib' scheme is one of the most ambitious and best-known, but they are becoming more widespread in the UK as well. Not only do car schemes tend to use compliant vehicles (and increasingly electric ones), but evidence suggests that their members drive less and avoid traffic congestion, not least during rush hours
- More generally, measures to encourage walking, cycling and public transport are useful supporting measures for action on air quality. There are many good reasons to want to support sustainable transport but, in relation to air quality, it must be stressed that these measures are only relevant if they bring about a substantial modal shift away from cars. They are of course useful in 'sugaring the pill' by offering more sustainable alternatives to the car journey; but it is likely that 'sticks' (such as charging, parking restrictions, etc.) will be needed alongside these carrots in order to bring about significant modal shift.

Access restrictions: Low emission and clean air zones

There are various types of access restrictions, which can be used to improve air quality, even though they do not necessarily target air quality. At the basic level, pedestrianisation is an access restriction that could impact on local air quality; similarly any time-limited restrictions on vehicle access could have an impact on local air quality, as well as reducing transport's carbon emissions. Congestion charging zones, such as the ones in London, Stockholm, Milan and various cities in Norway, also have the potential to deliver improvements in air quality, even though that is not necessarily their main aim. However, some access restrictions, such as London's Low Emission Zone (LEZ), directly aim to improve air quality. London's LEZ is the largest zone to restrict access to certain types of vehicles in the UK and perhaps in Europe. In order to avoid being charged, lorries, buses and coaches have to meet at least Euro IV emission limit values, while other vehicles, including vans and minibuses, have to be at least Euro 3/III. A number

of other UK cities also have a LEZ in place, although these are much more limited than London's as they often focus on buses, e.g. in Brighton,[56] Norwich[57] and Oxford.[58]

While the LEZ delivered some improvements to London's air quality, these were not sufficient for the city to meet the EU's air quality standards. As a result, an Ultra Low Emission Zone (ULEZ) is now planned for 2019 to cover the centre of the city, which would also apply to cars and motorcycles. It has been estimated that the effect of ULEZ and its associated measures would reduce NOx emissions from vehicles in central London by around half and particulate emissions by around two thirds.[59] From October 2017, a T-charge has applied to older vehicles entering London's Congestion Charge depending on their Euro emissions standard.[60] The UCL report, which proposed the introduction of a 'supplementary NOx registration tax' for diesel cars, also proposed that Euro 6 diesel cars that exceeded the Euro 6 emission limit value for NOx by a specified value be charged for entering London's ULEZ. In the summer of 2017, the Mayor of London put out a draft transport strategy for consultation. This included plans to expand the ULEZ in terms of its geographical coverage in 2020/21, the introduction of Low Emission Bus Zones and the introduction of a zero emission zone in Central London from 2025.[61]

Elsewhere in Europe, national frameworks for local action to reduce air pollution from transport have been in place for many years. Germany put a national framework for Environmental Zones in place in 2007. All vehicles accessing such areas are required to have a sticker based on their respective Euro emissions level. Municipalities are allowed to choose to implement an Environmental Zone and to choose which vehicles to prohibit.[62] Additionally, some cities, including Munich, which is home of car maker BMW, are considering banning some diesels from entering the city.[63] Since 2006, Denmark has allowed its four largest cities – but no others unless PM limits are exceeded – to introduce LEZs. These apply to all trucks, buses and coaches and require that vehicles entering these zones must be at least Euro IV (but they could be retrofitted). The technical requirements are identical in all four zones.[64] Sweden's national provisions for environmental zones are based on rules set out 1998. As in Denmark, the rules apply only to trucks, buses and coaches. A time limit is set from the date of first registration (eight years) for the period in which vehicles can be driven in environmental zones, which effectively means that in 2016 all vehicles meeting Euro III standards or lower cannot be driven in environmental zones.[65] Netherlands' national framework requires that trucks, but not buses, must be at least Euro IV or not powered by a diesel engine to enter an environmental zone. Again, all zones must apply the same Euro standards. It is possible to have a LEZ that applies to cars and vans, but only two do this, i.e. those of Utrecht and Rotterdam.[66] France's CRIT'Air scheme is more recent, but operates on similar principles. Vehicles using specified major city centres must have a sticker, which can be used to either permanently exclude them from the city centre as a result of their age/emissions, or temporarily exclude them when pollution levels are high.[67]

Local parking measures

Another way of affecting access to an urban area is through parking controls. There are many elements to a city's parking policy, ranging from residential off-street parking, private car parks that can be used by the public for a fee to private car parks provided by employers for their staff. From the perspective of controlling access to a city, the focus is on non-residents, i.e. those visiting the city for the purpose of tourism or work. Visitors can be encouraged to park on the outskirts of towns, e.g. at park and ride locations from which they are transported into the city centre, or discouraged from parking in the city centre through parking charges. The latter could be based on a vehicle's emissions. Within towns and cities, the provision of real-time parking information can reduce the distances travelled, and so the resulting emissions, from searching for a parking space.

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to tackle air pollution hotspots?

Addressing the number of workplace parking spaces, and the way in which these are used, is potentially more challenging. The Transport Act 2000 introduced the possibility for local authorities to introduce a workplace parking levy, which would at least make employers think more about the number of spaces they offer their employees, and which could even lead to lower numbers of employee parking spaces in the medium to long term. The first, and so far only, local authority to introduce such a levy is that of Nottingham, although Oxford[68] and Cambridge[69] are both actively considering introducing a levy. Nottingham's scheme began operation in 2011 and charges nearly £400 per liable space. It raised over £25 million in its first three years of operation alone. The revenue is earmarked for improvements to transport, particularly for public transport. The levy has contributed to a decrease in CO_2 emissions and an increase in public transport use, while the increased investment in public transport has helped to support inward investment into the city.[70]

A local authority's control of residents parking only extends to locations where such parking is on the street. In such instances, charges for permits or on-road parking could be linked to a vehicle's emissions, with the more polluting vehicles charged higher rates. Low and zero emissions vehicles can also be incentivised through dedicated spaces (even if there is no charging point), by being given priority in the parking permit application process or by allocated parking spaces to car clubs, including those with only low emission vehicles.[71]

Action on freight, including freight consolidation centres and modal shift

A measure that has the potential to reduce the contribution of freight transport to air pollution is the introduction of a freight consolidation centre (FCC). The aim of a these centres is to replace multiple freights trips by different suppliers to city centre locations by consolidated shipments that have been delivered to the freight consolidation centre outside of the city. These are currently not that widespread, but have been implemented in a number of UK cities. One of the most successful to date is probably that which is operated in Bristol and Bath by DHL, which uses electric or low emission vehicles. It has been estimated that since it began, the Bristol-Bath Freight Consolidation Centre has reduced the number of HGVs entering the cities by 80 per cent, with an associated saving in NOx and CO_2 emissions.[72] A freight consolidation scheme is also operated in North London, including in the Boroughs of Camden and Islington, which has reduced the number of vehicle trips by half, with similar benefits for CO_2 and NOx.[73] Another FCC is operated for Southampton.[74]

In addition to the wider work that is being taken in London to improve the city's air quality, at the start of 2016 TfL launched its LoCITY programme. The programme aims to complement other relevant activities by providing a consistent framework for action to reduce freight's emissions. In this respect, the programme aims to help public and private fleets prepare for the introduction of the ULEZ by supporting them with the uptake of cleaner vehicles and alternative fuels.

The promotion of cycling is also a relevant option for reducing air pollutant emissions from freight. Research into the potential for cycle logistics, i.e. using cargo bicycles for moving freight around urban areas, has suggested that a cargo bicycle could replace 51 per cent of the freight trips in urban areas that are currently undertaken by motorised means.[75] The advent of electrically powered bicycles increases the potential for bicycles to be used to transport freight. Trials of cycle logistics have taken place in various cities, including Berlin, Budapest and Cambridge, and have proved largely successful in both meeting customers' needs and in reducing emissions.[76]

Land use planning

The link between land use planning, including a lack of planning, and transport has been well documented. Without good planning, cities will sprawl or develop in ways that are unsustainable in terms of transport demand and air quality. The subsequent reductions in density make cities less conducive to cycling and walking, less able and more costly to serve by public transport and therefore lead to a greater reliance on the car. As a result, demand for transport infrastructure, road use, traffic and congestion are likely to increase, as well as the emission of air pollutants.[77]

Consequently, land use planning is seen as an important element of transport strategies that aim to improve the environmental performance of transport, including reducing its air pollutant and carbon emissions. The integration of transport and land use planning in sustainable transport plans can help to reduce air pollution, as well as deliver other benefits including improved accessibility, less noise, fewer greenhouse gas emissions and a better quality of life.[78] Important elements of such an integrated approach include mobility management and the provision of infrastructure for public transport, cycling and walking (see below).

The UK planning system is largely reactive in nature, so does not easily allow for the type of strategic planning seen in the Netherlands, for example. However, some actions can be taken to ensure that future developments are consistent with long-term transport and sustainability goals. A recent court case has given legal backing to local authorities using the planning system to prevent the worsening of air quality.[79]

Mobility management

Mobility management focuses on how people use the transport system once the infrastructure is in place. It has a number of different elements, including those that aim to encourage people to use less polluting modes of transport, to use transport more efficiently or even not to travel at all. Many of these elements have been referred to under the banner of Smarter Choices, and include workplace and school travel plans; personalised travel planning; car clubs and teleworking.[80] Travel plans and personalised travel plans aim to engage directly with people in order to inform them of alternative, less polluting means of travel and to encourage them to use these.

Car clubs have been shown to reduce the number of cars on the road and reduce the distance travelled by car per person. Car club members contribute to reduced congestion, as they tend to use cars out of peak times and use public transport more. The cars that are driven by car club members also tend to have lower emissions, as they are newer, often make use of alternative technologies, such as electric vehicles, and their users tend to select the most appropriate car for the journey.[81]

Another element of mobility management is the management of traffic, including the interaction between different modes. This includes appropriate allocation of road space, signing and prioritisation at junctions for public transport and cyclists. The Dutch city of Nijmegen gives priority to public transport and bicycles within its ring road. On the ring road, it operates a 'green wave' where possible, in which traffic lights are set to enable traffic to move smoothly and continuously, thus helping to reduce emissions. Real time advice is also offered to drivers as they approach the city, including directing drivers to car parks that have spaces, thus reducing the need for unnecessary driving around the city.[82]

On major roads within an urban area, including on those managed by Highways England and equivalent agencies, consideration might also be given to reducing maximum speed limits. Vehicles tend to be more efficient at speeds lower than the maximum speed limits on major roads, e.g. between 45 and 50 miles per hour.[83] In the context of the potential introduction of speed limiters for various types of vehicles, work undertaken for the European Commission has concluded that limiting top speeds of trucks, coaches and vans could deliver reductions in NOx emissions, depending of course on the extent of the speed reduction that occurs.[84] Of course, potential issues with speed reduction might be a redirection of traffic onto local roads that are not suitable for heavy traffic, in particular. Consequently, any reduction in speed limits needs to be implemented in close cooperation with all of the relevant authorities.

While not really a mobility management measure, one small-scale option to be considered is to ban engine idling in stationary vehicles, particularly diesels. Likely targets should be taxis and buses on stands, touring coaches and parents dropping off and picking up their children on the school run. This is hardly likely to solve any community's air quality problems on its own, but it would help and it may at least generate more awareness and engagement with air quality issues.

Modal shift and the provision of infrastructure for public transport, cycling and walking

Many of the measures already mentioned, from access restrictions to land use planning, have the potential to stimulate modal shift to public transport, cycling and walking, as they make these modes relatively more attractive and car use less so. The provision of infrastructure for these modes is important to facilitate their use and to increase their relative benefits compared to car use. Given the limited amount of space available for new infrastructure in most UK cities, the provision of infrastructure for public transport, cycling and walking is often the result of the reallocation of road space from motorised transport, such as cars and vans. This is important, as it is not just about making other modes more attractive, but also about making car use less attractive. If road space is not reallocated to public transport, cycling and walking from other motorised modes, there is the risk that any modal shift will be temporary, as any space freed will soon be filled with new traffic. If this is allowed to happen there will be little or no air quality benefit from the changes made.

The provision of dedicated bus lanes, high quality bus stops, cycle lanes, safe and secure bicycle parking and safe pedestrian areas and routes will all make these modes relatively more attractive than car use. The integration of all modes, e.g. bicycle and bus facilities at major rail stations, bus and cycle facilities at car parks, particularly park and ride car parks, will also support the use of other modes. At the junctions where modes meet, priority should be given to facilitating the passage of cyclists and pedestrians, and to public transport. The more comprehensive and coherent the public transport and cycling networks are, the better they will be in encouraging people to use them.

The Danish capital Copenhagen is renowned for its positive approach to cycling. It has a number of elements to its cycling strategy, including the provision of missing links in the city's cycling network; the construction of dedicated cycling bridges; the development of bicycle superhighways; high quality maintenance of the existing cycling infrastructure; the provision of safe and secure cycle parking facilities, including at rail and metro stations; requirements that new buildings provide cycle parking; a bicycle sharing scheme; and bicycle priority at intersections.[85]

Local authorities also have a role in facilitating different types of mobility, including public bike sharing schemes and car clubs. Whether these are publicly or privately funded and operated, planning needs to enable such schemes, e.g. through allocating space for public bicycle racks and car parking spaces for car clubs. The latter could be used to encourage low emitting vehicles, as their provision could be dependent on the emissions category of the cars being offered.

Bus services: partnerships and franchising

The Bus Services Act 2017 has now introduced a range of new powers that local authorities can use to work with bus operators to improve local services. Enhanced partnership powers are available to all authorities, and these can be used to drive up emission standards on buses and also reduce emissions from other vehicles through bus lanes and other infrastructure. In addition, all the mayoral combined authorities now have the power to take on the franchising of local bus services, and other types of local transport authority can also request these powers from central government. Through both partnership and franchising, these local authorities now have the means to set environmental standards for the buses to be used and can use current powers to, for example, introduce bus priority measures to reduce idling and journey times, or to promote new park and ride schemes. These can promote modal shift to buses as well as reducing bus emissions directly.

Licensing and public procurement

Local authorities also have the potential to incorporate air quality considerations into their licensing of other transport operations, as well as their own procurement of transport vehicles and services. Local authorities are responsible for licensing taxis and other private hire vehicles.[86] Licensing fees charged to firms or individuals can be varied to take account of the emissions of the vehicle concerned, while licensing rules could require that vehicles meet specified emission standards. Grants and other incentives can also be offered to drivers who register low or zero emission vehicles. London will no longer license new diesel taxis from 2018 and will require all new taxis to be zero emissions capable, while all new public hire vehicles will have to meet Euro 6 standards (for diesel; Euro 4 for petrol); the 'zero emissions capable' requirements comes into force for these vehicles in 2023. TfL will provide an additional grant i.e. on top of the national plug-in grant, for the purchase of zero emissions capable taxis and will also offer a cash lump sum to owners of older vehicles who choose not to relicense their vehicles. Opportunities to convert the newest diesel taxis to cleaner fuels, such as liquid petroleum gas (LPG), will be explored, while zero emission taxi ranks and other incentives for low emission taxies will be explored.[87] As part of Manchester's air quality strategy, Transport for Greater Manchester (TfGM) will work with licensing authorities to first standardise and then make more stringent the minimum emissions standards for taxis and private hire vehicles operating in the city.[88]

Local authorities can also lead by example by ensuring that the transport vehicles that they procure, as well as the vehicles used in any services that they procure, are low emission vehicles. At the national level, there are Government Buying Standards (GBS) for a range of products, including for transport, which draw on standards that have been developed at the EU level. GBS are mandatory for central government departments, but their use is only encouraged for the rest of the public sector.[89] The current GBS for transport are from 2012 and make reference to the use of the Euro emissions standards of the vehicles and services covered, typically to Euro 5/V being used as a minimum requirement and to Euro VI being used as an award criterion for vehicles, and to a less stringent standard being used when purchasing services.[90] The European green public procurement (GPP) standards are currently under review and could include references to the real world RDE standards for Euro 6 cars.[91] Local authorities can either follow GBS or the revised European GPP standards or simply focus their procurement on cleaner vehicles.

Vehicles that belong to fleets, either owned by or working in service for, local authorities are a class of vehicles that is potentially quite important and is often overlooked. They are often used intensively within urban areas, and as local authorities have a much greater and more direct influence over the technologies chosen and used, they can make a useful difference. Furthermore, such vehicles are often depot based and travel relatively limited and well-understood distances each day. As such, they lend themselves to consideration of a range of alternative fuels that can dramatically reduce emissions, not least electrification. This can apply not only to directly owned vehicles, but also fleets and services under contract such as waste collection and home care. Local authorities do have some power to exert standards for the vehicles to be used in services under contract, and these can be a useful driver for emissions reduction in urban centres.

Other countries have similar GPP standards often based on the European GPP standards, although some go further and there are some alternative approaches. Sweden has a national definition of a 'green' and a 'super green' car, which are used for taxation and public procurement purposes. In Germany, a federal plan suggests to local authorities that they provide their employees with the possibility of using official bicycles or electric vehicles for short business trips. The German city of Hamburg underlines that car sharing, bicycle fleets and reduced rates on public transport can all be used to reduce the number of official cars. In Belgium, public bodies are required to buy vehicles with reference to an 'Ecoscore', which takes account of vehicles' air pollutant emissions, as well as their noise and CO_2 emissions.[92] In the Netherlands, an agreement between central government, regions and bus operators will ensure that from 2025 all new buses procured in the country will be zero emission vehicles. Furthermore, these vehicles will be powered by locally-produced sustainable energy sources, including wind and solar.[93]

Conclusions on local measures

Of the measures outlined in this section, access restrictions are potentially the most complex and are effectively what is being proposed in the draft CAZ framework. The fact that the proposed CAZ framework provides flexibility in allowing different categories of CAZ to be designated makes it similar to the approach that has been in place, in some cases for several years, in other EU Member States. However, CAZs, particularly if they are going to include charging, need additional infrastructure to be set up to properly enforce the schemes. If this could be developed as part of a longer-term strategy to manage traffic demand (and potentially raise revenue) in a city, e.g. as part of a wider congestion charging scheme, the required investment would be easier to justify. Otherwise, CAZs might be seen to be an expensive option, unless the local authority takes a longer-term perspective to air pollution and aims to improve air quality to levels beyond the required standards and/or to use such a charging framework to deliver other benefits for the urban environment.

Instead of city-wide approaches such as CAZs, there are other more targeted measures that might be applied. Targeted LEZs can be put in place that aim to address specific problem areas, e.g. by focusing on specific types of vehicle in specific locations, as has been done for buses in Brighton, Norwich and Oxford. Such measures will need to ensure that the competitiveness of buses as against car use is not disadvantaged, as any shift from bus to car use will be in danger of exacerbating the air quality problem. Targeting a small number of specific vehicles allows for direct engagement with the operators of those vehicles, which enables air pollution issues to be addressed through a partnership approach, which should limit the need for enforcement. The ability of local authorities to set up bus partnerships and to franchise local bus services, and to use environmental criteria when licensing taxis and private hire vehicles, also provides an opportunity to affect the environmental performance of the vehicles concerned. Public authorities can also set criteria relating to the emissions of vehicles that they procure directly, or which will be used by operators to provide services procured by public authorities.

Similar targeted approaches are potentially useful in addressing particular types of journey or types of driver. Actively working with freight companies to consolidate the delivery of freight within a city, and to ensure that freight is distributed in ways that pollute less, e.g. using electric vehicles or even cargo bikes, has the potential to remove smaller diesel delivery trucks from the road. Working directly with employers that provide parking spaces for their employees, and with other major transport generators, such as schools, colleges and hospitals, has also the potential to ease traffic, and reduce emissions. While the Transport Act 2000 allows local authorities to charge for the workplace parking that employers offer, alternative approaches, such as engaging organisations directly and developing travel plans for different locations, can also be beneficial if a mandatory approach is not preferred.

Local authorities can also use their powers over the local road network to manage it for the benefit of public transport, cycling and walking, and to encourage the use of cleaner, low emission vehicles. The provision of high quality infrastructure for public transport, cyclists and pedestrians, including dedicated infrastructure, a coherent network of routes and the prioritisation of these modes at intersections with private motorised transport, all help to provide incentives to use other modes instead of the car, which will contribute to improved air quality. Such measures are also likely to reduce the speeds of motorised transport using these areas, which will act as a further deterrent. Parking charges in local authority-owned car parks and residents' permits for on-street parking can be differentiated to reflect a vehicle's emissions, while the wider network can be managed to improve traffic flow.

Essentially, there is a range of targeted measures that local authorities can use to improve air quality by influencing the type of vehicles that are used, and the extent of their use. Ideally, modelling exercises should be performed to identify the potential impact of the measures, and so to identify which to implement to improve air quality in the city. In practice, it is likely that many local authorities will not have the resources for such exercises. However, many of the measures that would deliver improvements in air quality in a town or city will also contribute to other aims in line with the delivery of an integrated, sustainable transport system. In addition to contributing to reducing air pollution, towns and cities implementing many of the above measures would also help to reduce carbon dioxide and noise emissions from transport, improve safety in town and city centres, and improve the overall liveability and sustainability of the urban environment.

8. Summary and recommendations for national and local action

- Local authority measures need to target the sources of NOx emissions from transport, in order to consider how to remove the most polluting diesel vehicles from their roads
- A particular focus should be on older buses, taxis and delivery trucks, as these are generally much more polluting and are often used intensively in urban centres; the retirement of the oldest vehicles and retrofitting of other buses in particular is a potentially cost-effective way of reducing emissions
- As the cost of batteries continues to fall, and new electric buses are developed, electric or hybrid buses will increasingly be the preferred options in a few years' time
- Diesel cars and vans pose more of a challenge; older diesel cars might be replaced or removed; for vans the situation is a lot less clear-cut, although again electric alternatives will continue to emerge
- Existing policy mechanisms to ensure the development, purchase and use of vehicles that emit less CO_2 need to be continued, not least after Brexit, in order to ensure that the development of electric vehicles, and other low emission vehicles, continues
- National government has now made changes to the first year VED and company car tax to reflect the fact that the emission limit values for NOx for diesel cars are less stringent than those of petrol cars and that real-world emissions have been far higher. How far this will nudge consumer choices in a positive direction remains to be seen, however
- Central government should consider supporting targeted local scrappage schemes in order to remove the most polluting buses, taxis and delivery trucks from the roads
- Local authorities should consider the following measures:
  - For buses: Reaching agreement with bus operators to use less polluting buses on specific routes/at specific locations (via a LEZ or the powers under the Bus Services Act 2017 to enter into enhanced partnerships or to franchise local bus services). Ideally the aim should be to retire the oldest buses and retrofit or upgrade the newer ones, and avoid merely transferring air quality problems to other routes or areas. Where buses (or bus services) are procured ensure that the vehicles (or the vehicles to be used in the service) are low emission. Whichever course of action is agreed, care is required to ensure that the competitiveness of buses as against car travel is not damaged, as any shift from bus to car is likely to exacerbate the air quality problems. This will probably require a mix of public sector support for retrofit and bus priority measures
  - For taxis: Integrate emissions conditions in licensing arrangements and ban older, more polluting vehicles from being used as taxis

- For trucks and diesel vans: Consider promoting and enabling (i.e. through planning powers) freight consolidation centres that can use electric vehicles, or even cargo bicycles, for last mile delivery; for the services that it procures, such as waste collection, postal and courier services, etc., ensuring that the procurement procedure and conditions promote the use of less polluting vehicles
- For diesel cars: Reflect the higher emissions of these vehicles in parking charges and permits; engage with major employers and other organisations with existing extensive car parks to reduce the number of spaces and promote alternative modes of travel; consider developing park and ride locations to reduce the number of visitors driving into the centre
- Generally: Take measures to improve the infrastructure and the conditions for public transport, cycling and walking and ensure that the infrastructure for these modes is well integrated and provide coherent networks
- Promote and support the development of car clubs, and more generally promote alternatives to car use alongside the potential imposition of CAZs.

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Tracks

Tracks is a dynamic Thought Leadership programme that reacts to contemporary issues in the transport sector. The annual programme comprises four themes, linked to current and evolving challenges. 'Air pollution and transport: Time to clear the air?' is one theme within the 2017-18 programme.

Prepared by:

Consultants: Malcolm Fergusson and Ian Skinner

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Campaign for
Better Transport

16 Waterside
44-48 Wharf Road
London N1 7UX

Phone: 020 7566 6480
bettertransport.org.uk

@CBTransport

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