Demystifying Air Pollution in London

full report

LONDON COUNCILS

Demystifying Air Pollution in London

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Air pollution

Air pollution is the presence of materials or substances in the air, which have harmful effects on people's health. Air pollution also contributes to other environmental issues, such as global warming, acid rain, eutrophication and ozone depletion; and other environmental issues contribute to poor air quality. This is an important clarification as the term emissions is also used to refer to Carbon Dioxide (CO_2) which is more closely linked to climate change.

Important pollutants and their impacts

The pollutants most widely referred to in the literature are:

- Particulate matter (these are usually split into 2 sizes: $PM_{2.5}$ & PM_{10})
- Nitrogen dioxide (NO_2)
- Sulphur dioxide (SO_2)
- Ozone
- And occasionally, Carbon Monoxide (CO)

PM and NO_2 are commonly seen as the most dangerous forms of air pollution due to their high concentrations and the negative health impacts they create. The sections below look to provide more detail on PM and NO_2 but also some of the other air pollutants. Overall this report focuses on PM and NO_2.

Particulate Matter 2.5 & 10 (PM)

PM is made up of a wide range of materials and arises from a variety of sources. Concentrations of PM comprise primary particles emitted directly into the atmosphere from combustion sources and secondary particles formed by chemical reactions in the air. It consists of a complex mixture of solid and liquid particles of human-made (such as diesel soot) and natural substances suspended in the air (such as sea spray and Saharan dust). In the UK the biggest human-made sources are stationary fuel combustion (power generators) and transport.

NO_2

Nitrogen dioxide is human made, with the major sources of emissions of NO_2 being combustion processes (heating, power generation, and engines in vehicles and ships)[1]. Nitrogen is released during the combustion of fuel and then combines with oxygen atoms to create nitric oxide (NO). This further combines with oxygen to create nitrogen dioxide (NO_2). Nitric oxide is not considered to be hazardous to health at typical ambient concentrations, but nitrogen dioxide is. Nitrogen dioxide and nitric oxide are referred to together as oxides of nitrogen (NOx). NOx gases can also react to form smog and contribute to acid rain. NOx is also central to the formation of fine particles or particulate matter (PM) and ground level ozone (O_3), both of which are associated with adverse health effects.

Sulphur Dioxide

Sulphur dioxide (SO_2) is an invisible gas. It is created mainly from industrial processes, such as the generation of electricity from coal, oil or gas that contains sulphur. It reacts easily with

[1] Beevers, S. et al (2015) *Understanding the Health Impacts of air pollution in London*. King's College London, London.

other substances to form harmful compounds, such as sulfuric acid, sulphurous acid and sulphate particles. It is also present in vehicle emissions, as the result of fuel combustion, although this has reduced considerably in recent years.

Ozone (O_3)

Ground level ozone is created through chemical reactions between pollutants, such as NOx and CO in the presence of sunlight, hence of main concern during the summer months. Ground level ozone is affecting human health and can be transported great distances by weather systems and therefore also affect people in more rural locations where air pollution levels are otherwise low.

High level ozone in the stratosphere protects the life on earth from the sun's harmful ultraviolet (UV) rays and is in danger of being depleted due to human-made chemicals released into the atmosphere.

Carbon Monoxide

Carbon monoxide (CO) is a colourless, odourless gas. It is formed both naturally and by human activity when fuels containing carbon are burnt in low-oxygen conditions. The main source of carbon monoxide is from petrol vehicles which are not fitted with a catalytic convertor[2]. CO levels in urban areas closely reflect traffic density (in combination with weather conditions). Other man-made sources are power stations and waste incinerators. At a domestic level, faulty gas appliances and cigarette smoking are significant sources of carbon monoxide. Natural processes produce relatively small amounts.

Weather conditions affecting pollutants

In winter, when the ground is cold and there is little wind, emissions are trapped near to the ground. Winter episodes took place in 1991 in London and in 2001 in several locations (including Belfast, Glasgow and Manchester), with hourly average NO_2 concentrations reaching 700 µg/m-3 (EU hourly average limit is 200 µg/m3.

Summer episodes take place when the weather is hot and sunny and wind speeds are low. High concentrations of ozone can be created by chemical reactions in the atmosphere and in turn convert more NO into NO_2 in areas where high NO emissions are produced, for example, at roadsides[3].

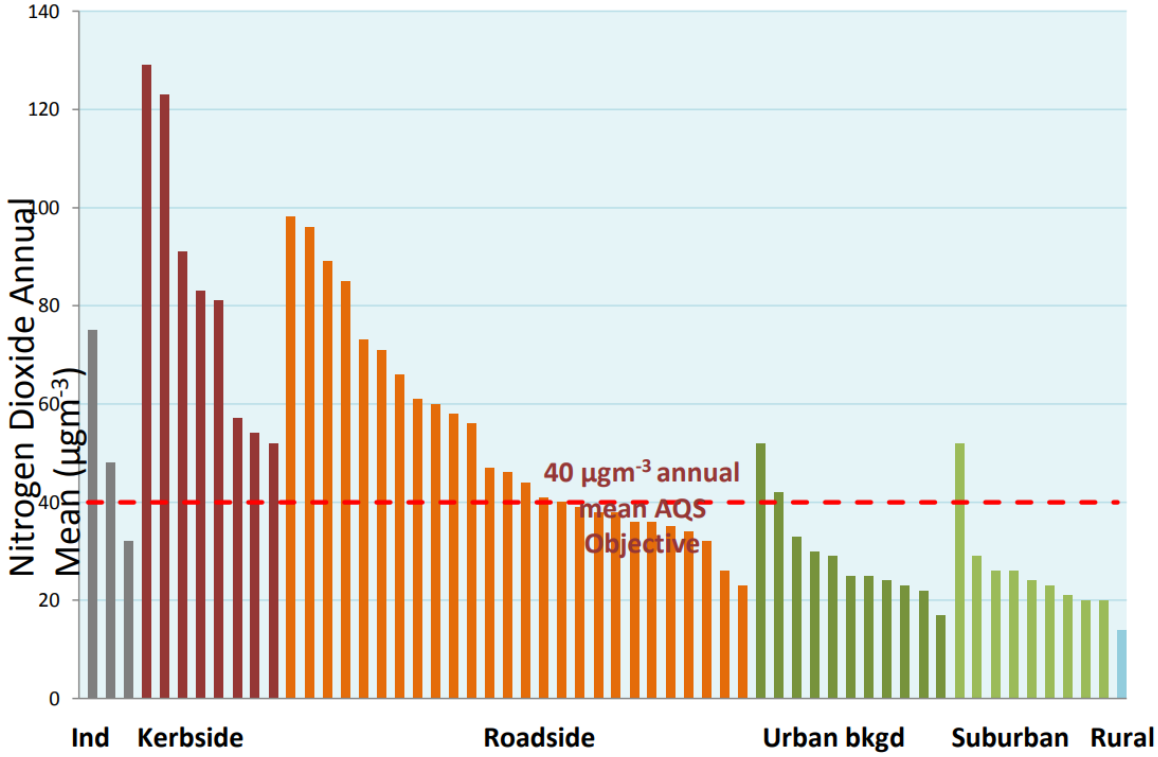
[2] http://naei.defra.gov.uk/overview/pollutants?pollutant_id=4

[3] https://uk-air.defra.gov.uk/assets/documents/reports/aqeg/nd-summary.pdf

2 Sources of Air Pollution

Air pollution does not respect administrative boundaries. Air pollution in London is a mixture of emissions created locally, and those from background concentrations. In particular, particles measuring between 0.1 µm and 1 µm in diameter can remain suspended for weeks and so can be transported long distances. It is difficult to breakdown air pollution to its main sources and locations, but a number of methods have been devised to do this. The below diagram shows how King's College London separate and identify different sources and locations of air pollution by layering the measurements taken from different types of area – such as roadside, urban background and rural, which can then be used to provide an overall picture of the makeup of air pollution within London.

Figure 1 - NO_2 levels in London



Research has shown that around 75 per cent of particulate matter pollution in Greater London is estimated to come from outside the city. While only 18 per cent of London's ambient NO_2 comes from outside the city[4]. Therefore it is crucial that local, national and international action is taken to ensure that dangerous levels of air pollution are tackled.

The following two graphs show the main sources of NOx and PM_{10} in London. Road transport is the main contributor for both pollutants and therefore depicted further with regards to types of vehicles. It is right therefore to have an emphasis on transport as a source of pollution in London; however the others should not be forgotten.

[4] Howard R (2015) *Up in the Air: How to Solve London's Air Quality Crisis: Part 1*, Policy Exchange. https://policyexchange.org.uk/publication/up-in-the-air-how-to-solve-londons-air-quality-crisis-part-1/

Figure 2 - NOx sources in Greater London in 2013 (LAEI 2013) – insert reference

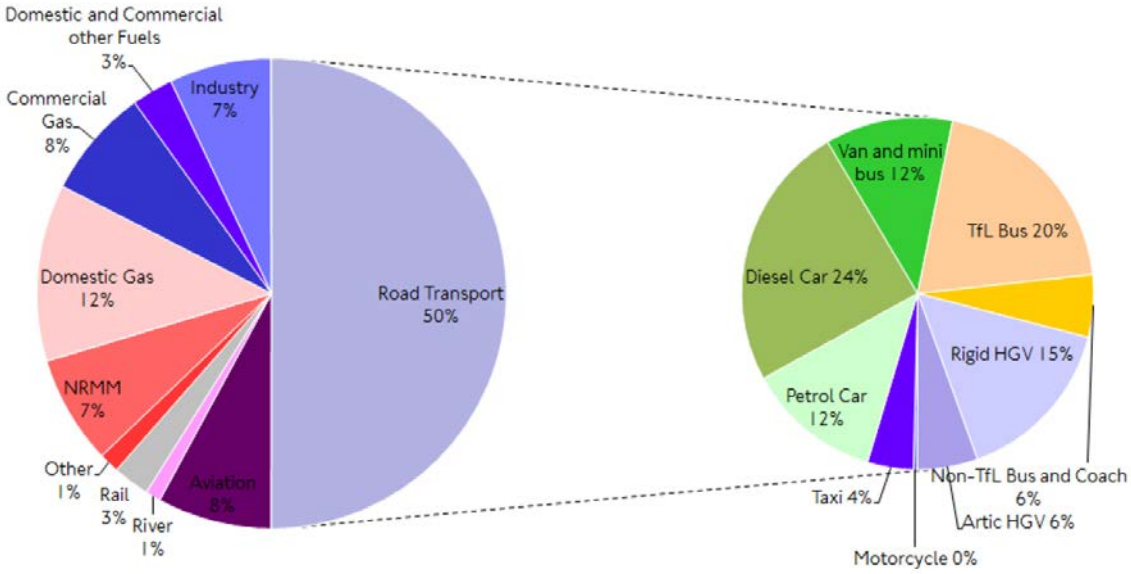
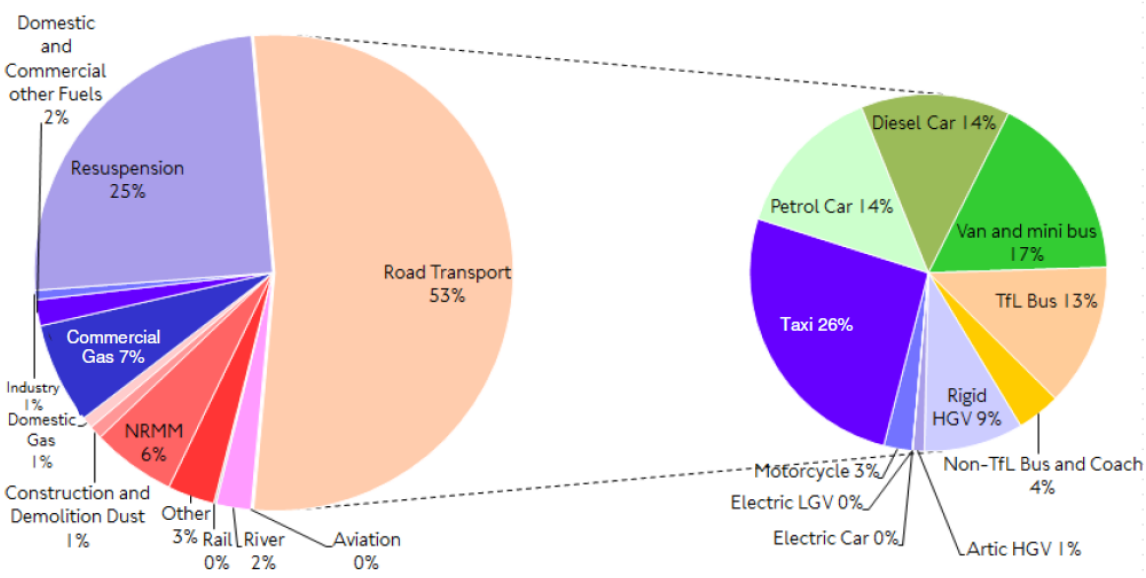


Figure 3 - PM_{10} sources in central London in 2013 (LAEI 2013)



3 Health Impacts

This section will provide an overview of the research on the health impacts of air pollution in London.

One of the key pieces of research often referred to is the King's College London report, '*Understanding the Health Impacts of Air Pollution in London'*. This is an important bit of research as it is one of the first to quantify the mortality burden of certain pollutants (namely Particulate Matter [$PM_{2.5}$] and Nitrogen Dioxide [NO_2]) specifically in London. The report shows that air quality is a major health challenge in London and the research estimates that 9,416 deaths in London are caused by long term exposure to NO_2 and, in this instance, $PM_{2.5}$.

The report shows that while $PM_{2.5}$ is dangerous (causing the equivalent of 3,537 deaths), it found that NO_2 was more lethal and responsible for more deaths (5,879).

There is growing evidence that air pollution does not only affect the respiratory system, but also impacts negatively on the cardiovascular system as well. This is because diesel and petrol fumes pollute the air with ultra-fine particles. These stop blood vessels relaxing and contracting, which increases the risk of clots and heart attacks[5].

There is also a growing amount of academic research indicating that ambient air pollution also negatively impacts on a person's cognitive performance (various)[6][7].

The health effects of the various pollutants

Particulate Matter

The most health-damaging particles are those with a diameter of 10 microns or less, (≤ PM_{10}) with PM_{10} & $PM_{2.5}$ being the most widely measured. These can penetrate and lodge deep inside the lungs. Chronic exposure to particles contributes to the risk of developing cardiovascular and respiratory diseases, as well as of lung cancer. The biggest impact of particulate air pollution on public health is understood to be from long-term exposure to $PM_{2.5}$, which increases the age-specific mortality risk, particularly from cardiovascular causes. Exposure to high concentrations of PM (e.g. during short-term pollution episodes) can also exacerbate lung and heart conditions, significantly affecting quality of life, and increase deaths and hospital admissions[8]. Children, the elderly and those with predisposed respiratory and cardiovascular disease, are known to be more susceptible to the health impacts from air pollution[9]. The King's College report, *Understanding the health impacts of air pollution in London*, states that in 2010 $PM_{2.5}$ and NO_2 were linked with approximately 1990 and 420 respiratory hospital admissions respectively with an additional 740 cardiovascular hospital admissions associated with $PM_{2.5}$.

Nitrogen Dioxide

NO_2 is an irritant gas, which, at high concentrations, causes inflammation of the airways. Studies have shown significant links between long term exposure to NO_2 in outdoor air with adverse effects on health, including:

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5 https://www.bhf.org.uk/research/where-we-fund-research/centres-of-research-excellence/university-of-edinburgh/exhaust-fumes-and-heart-attacks

6 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5017593/

7 http://bmjopen.bmj.com/content/6/6/e010004.full

8 http://www.rightcare.nhs.uk/index.php/atlas/respiratorydisease/

9 http://www.who.int/phe/air_quality_q&a.pdf

- decreased lung function;
- stunted lung growth in children;
- increased respiratory symptoms which can include coughing, difficulty breathing, and shallow breathing;
- increased asthma prevalence and incidence;
- increased cancer incidences;
- adverse birth outcomes;
- reduced life expectancy
- Increased mortality (US EPA, 2013; WHO, 2013)[10].

The impact on children is especially bad, with epidemiological studies showing that symptoms of bronchitis in asthmatic children increase in association with long-term exposure to NO_2, as well as stunting lung growth[11].

Sulphur dioxide

Sulphur dioxide (SO_2) affects human health when it is breathed in. It irritates the nose, throat, and airways to cause coughing, wheezing, shortness of breath, or a tight feeling around the chest.

Ozone

The health impacts of short term exposure to ozone (O_3) include coughing, throat irritation, chest tightness and reduced lung function. Long-term exposure is linked to aggravation of asthma and the development of a number of respiratory diseases, and stunted lung growth in children.

Carbon Monoxide

Inhalation of carbon monoxide (CO) at high concentrations can be fatal, because it prevents the transport of oxygen (in blood) around the body. Releases from poorly maintained appliances in poorly ventilated spaces could result in concentrations high enough to cause death. Long-term exposure to lower concentrations (such as through smoking) could harm unborn babies or cause neurological damage[12].

Air pollution levels in London

The UK legal limits for air pollutants have been set by the European Union (EU). But they differ from the safe levels set by the World Health Organisation (WHO). The EU set their limit value for $PM_{2.5}$ 250 per cent higher than the WHO guideline values and 100 per cent higher for PM_{10} to minimise the time and cost implications of potential legal proceedings from citizens against the relevant agencies or administrations for not meeting their targets[13].

Table 1- EU limit levels for pollutants

Pollutant	Concentration	Averaging period	Permitted exceedances each year
$PM_{2.5}$	25 µg/m3	1 year	n/a

[10] https://www.gov.uk/government/publications/nitrogen-dioxide-health-effects-of-exposure

[11] https://uk-air.defra.gov.uk/assets/documents/What_are_the_causes_of_Air_Pollution.pdf

[12] http://www.nhs.uk/conditions/Carbon-monoxide-poisoning/Pages/Introduction.aspx#symptoms

[13] http://www.europarl.europa.eu/RegData/etudes/STUD/2014/536285/IPOL_STU(2014)536285_EN.pdf

PM_{10}	50 µg/m3	24 hours	35
	40 µg/m3	1 year	n/a
Sulphur Dioxide (SO_2)	350 µg/m3	1 hour	24
	125 µg/m3	24 hours	3
Nitrogen dioxide (NO_2)	200 µg/m3	1 hour	18
	40 µg/m3	1 year	n/a
Carbon monoxide (CO)	10 mg/m3	Maximum daily 8 hour mean	n/a

Table 2- WHO limit levels for pollutants

Pollutant	Concentration	Averaging period
$PM_{2.5}$	25 µg/m3	24 hour
	10 µg/m3	1 year
PM_{10}	50 µg/m3	24 hour
	20 µg/m3	1 year
NO_2	200 µg/m3	1 hour
	40 µg/m3	1 year
Sulphur Dioxide (SO_2)	500 µg/m3	10 minute
	20 µg/m3	24 hour

The law states that hourly levels of NO_2 must not breach 200 micrograms per cubic metre (µg/m3) more than 18 times in a whole year. This limit is regularly broken in London within days. For example, in 2017 it was broken in 5 days into the year (5th January 2017) in one area (Brixton Road, Lambeth), with many more following before the end of January (Oxford Street, Putney High Street, the Strand, and Kings Road in Chelsea). In 2016 the annual mean limit for NO_2 pollution was broken at 59 of 97 air monitoring London sites.

The WHO has started in 2016 the revision process of the Air Quality Guidelines for outdoor air pollution, which will provide up-to-date recommendations on ambient pollutant concentrations in order to support policy makers and other decision-makers setting efficient standards and goals across the world for air quality management to protect public health[14].

A report by the Royal College of Physicians and the Lancet Countdown shows that most of London has dangerous limits of $PM_{2.5}$. The report shows that London has $PM_{2.5}$ level of 15 µg/m^3. This is within the EU limit values but exceeds the WHO limits which are safer, despite there being no agreed safe limit to $PM_{2.5}$[15].

Cost of air pollution

The estimated economic costs on the health system in London of air pollution have been calculated at between £1.4 billion - £3.7 billion per year – and this only reflects PM and NO_2[16]. Other less understood impacts of air pollution could also push this figure upwards.

A recent United Nations Economic Commission for Europe's report on air pollution found that air pollution control measures generally costs significantly less than the costs of damage to health and the environment[17].

[14] http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/policy/who-outdoor-air-quality-guidelines
[15] Braithwaite, I. Isherwood, J. Hillman, T. Goddard, A. Watts, N. Wheeler, N (2017) Lancet Countdown 2017 Report: Briefing for UK Policymakers. London, Lancet Countdown & Royal College of Physicians.
[16] Walton H, Dajnak D, Beevers S, Williams M, Watkiss P and Hunt A (2015) Understanding the Health Impacts of Air Pollution in London, King's College London. https://www.london.gov.uk/sites/default/files/hiainlondon_kingsreport_14072015_final.pdf
[17] Greenfelt, R. Towards Cleaner Air Scientific Assessment Report 2016. UNECE. 2016

4 Transport

Transport is the main contributor to the air pollution problem in London. This chapter explains the contribution of different technologies as well as a number of technological solutions to address this.

Difference between petrol, diesel, hybrid, EV & hydrogen

There are two key things that need to be kept in mind when comparing the environmental performance of different types of vehicles:

1) The air pollution performance, and;
2) The Carbon dioxide (CO_2) emissions performance.

In recent years, concern about exhaust emissions from motor vehicles has been increasing and there is a lack of clarity on benefits and draw-backs of the different types of vehicles. For example, in 2001 the UK Government and others actively encouraged motorists to swap their petrol cars for diesel cars as it was seen to be cleaner, due to the fact they emit less CO_2. However, diesel cars have very different emission characteristics, such as they actually tend to emit more NO_x and particulate matter, contributing to air pollution and therefore health effects (see chapter 2 in this report). Recently there has been much debate about which fuel, diesel or petrol, is the cleanest in terms of exhaust emissions. But there is a growing acceptance that it is more effective to look at the overall emissions of a vehicle encapsulating the production, energy generation and provision processes, as well as the emissions at 'tailpipe' (or the emissions the vehicle creates as a by-product of movement).

Lifecycle emissions are important to consider as a move towards electric vehicle (EV) will see greater demand on the national grid. But with the UK slowly moving towards increasing the proportion of its energy from renewable and low carbon sources, 24% at the time of writing, this will only improve electric vehicles' performance in this regard.

There are a number of reports looking into this, providing analysis of the different emissions from electric vehicles and petrol and diesel[18][19][20][21].

It is already known that EVs perform much better than any other vehicle type when it comes to air pollution. When it comes to tailpipe emissions, they produce no NOx and much less PM, with most of the PM coming from wear and tear of the tyres and resuspension[22]. EVs do not have the same issues with engine soot as petrol and diesel vehicles.

Regarding CO_2 emissions, this is dependent on the power generation mix. With the UK's broad mix of natural gas, coal, nuclear and renewables, this means that the carbon intensity of EVs will drop as renewable energy production rises, and should also make savings in the production process as an increase in the number of EVs produced should, in theory, provide greater efficiencies.

[18] http://shrinkthatfootprint.com/wp-content/uploads/2013/02/Shades-of-Green-Full-Report.pdf
[19] file://docserver/UsersFlderRedirect/OwainMortimer/Downloads/CONFERENCE+2013+Final+Report_Lifecycle+CO2+Assessment+of+Low+Carbon+Cars+2020-2030_PEJuly2013.pdf
*This report does not account for the emissions from bio-fuels
[20] https://d1v9sz08rbysvx.cloudfront.net/ricardo/media/media/news%20assets/lowcvp%20study%20demonstrates%20importance%20of%20whole%20life%20co2%20emissions.pdf
[21] https://www.theccc.org.uk/wp-content/uploads/2013/04/Ricardo-AEA-lifecycle-emissions-low-carbon-technologies-April-2013.pdf
[22] https://www.witpress.com/Secure/elibrary/papers/UT12/UT12008FU1.pdf

European Emission Standards

European emission standards define the acceptable limits for exhaust emissions of new vehicles sold in European Union and European Economic Area member states. Standards are set for different categories of vehicles. Over the past 20 years, regulators in Europe, the USA, and Japan have implemented increasingly more stringent emission standards for vehicle exhaust emissions. Many countries outside of Europe follow the European model for engine emission certification, including Brazil, China, India, Russia, South Korea and Thailand. Mexico has historically followed the U.S. model, but has recently changed to allow either the USA or European-certified engines. 'Developing countries' are expected to follow the same path to compliance with the Euro IV and Euro V standards/or equivalent as those seen in Europe.

The first European exhaust emissions standard for passenger cars was introduced in 1970. 22 years passed before the next big change when, in 1992 the 'Euro 1' standard heralded the fitting of catalytic converters to petrol cars to reduce carbon monoxide (CO) emissions, and since then all petrol cars built must have them included. The latest standard, 'Euro 6', applies to new type approvals from September 2014 and all new cars from September 2015 and reduces some pollutants (namely PM) by 96 per cent compared to the 1992 limits.

The standards apply to the following emission pollutants:

- Carbon Monoxide (CO)
- Nitrogen Oxides (NOx)
- Hydrocarbons
- Particulate Matter (PM).

The levels of carbon dioxide that vehicles are allowed to emit are set in a different EU regulation (EC 443/2009). The current regulation sets an average CO_2 emissions target for new passenger cars of 130 g/km, and was phased in between 2012 – 2015. A target of 95 g/km will apply from 2021.

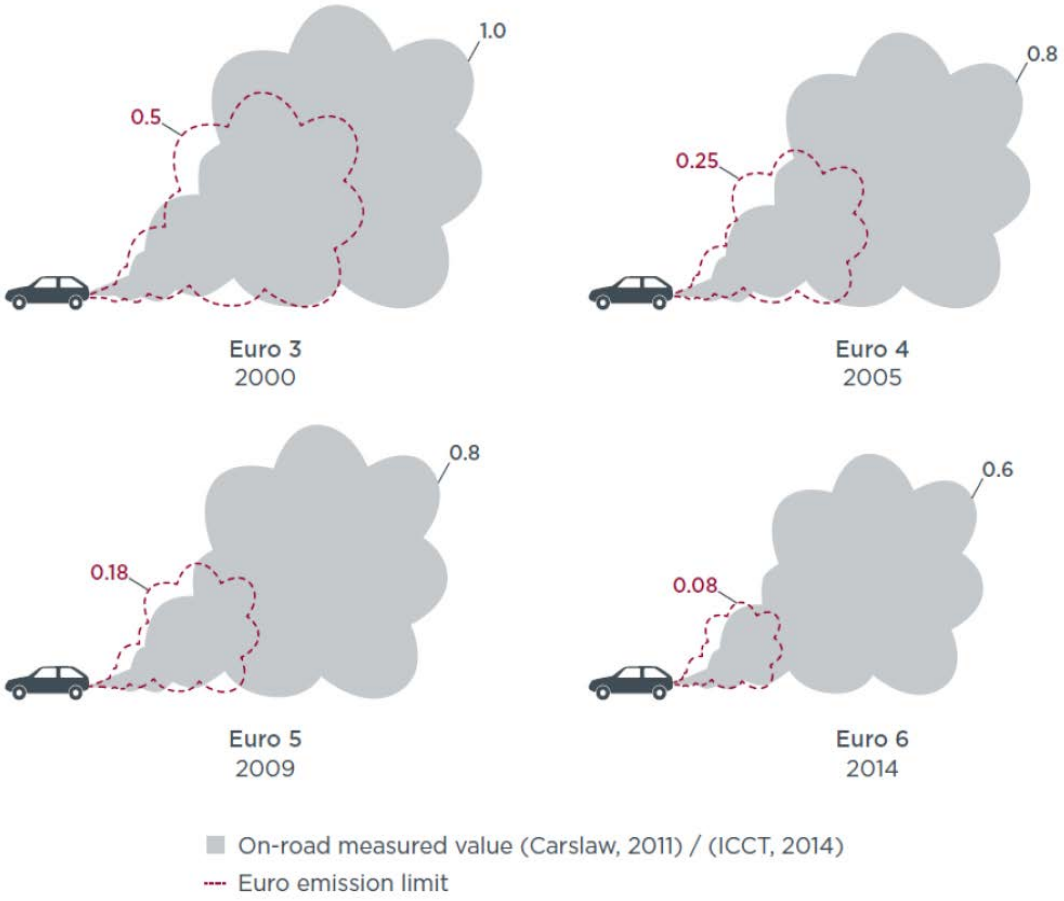
Emissions scandal

Something that has caused confusion regarding vehicle emissions is what has been dubbed the 'VW emissions scandal' or 'dieselgate'. This was the discovery in September 2015 by the US Environmental Protection Agency that for some of its vehicles, Volkswagen had developed methods of cheating the emissions testing regime to appear as if the cars emitted less NO_x than they actually did when driven in real world conditions. This raised awareness of the issue, and other countries began investigating whether their vehicles had also been subject to these testing cheats. The investigations have since shown that this practice was widespread amongst vehicle manufacturers across the globe.

The term 'real-world' in this context refers to the performance of the vehicles when being driven outdoors in normal situations, as opposed to in the testing labs, which involves testing the vehicles outputs on a treadmill-style machine. It was calculated that, on average, passenger cars emit seven times more NO_x than the Euro standard limit. To put that into context, if this figure was applied to an individual vehicle, this would correspond to a real-world level of approximately 560g/km of NO_x (compared to the regulatory limit under Euro 6 of 80 mg/km)[23]. A revised Euro standard, Euro 6c will be introduced in 2017, which essentially includes a more stringent testing regime, aimed to better reflect the performance of vehicles in the real-world.

[23] http://www.theicct.org/real-world-exhaust-emissions-modern-diesel-cars

Figure 4 –Diesel Euro 6 Performance



5 Key stakeholders and their roles

The United Nations

The United Nations (UN) introduced the United Nations Convention on Long-Range Transboundary Air Pollution in 1979. The UK is committed to reducing the emissions in accordance with the Convention (specifically, the Gothenburg protocol, agreed in November 1999) which set maximum national emission (emission ceilings) for various pollutants including NOx from 2010 onwards. The protocol was amended in 2012 to set more stringent ceilings that will apply from 2020; an amendment to the EU National Emissions Ceilings Directive to implement these and set ceilings for 2030 is expected to be agreed shortly.

World Health Organisation

The World Health Organization (WHO) is a specialized agency of the UN that is concerned with international public health. As part of their work the WHO conducts research into the health impacts of poor air quality and lobbies for improved international policy in this area and publishes numerous academic works on the subject of indoor and ambient air pollution. The WHO has set a number of limit values on different pollutants that they believe nations should meet, including for particulate matter (2.5 & 10) and NO2 (see Table 2 in the report).

The WHO published (September 2016) country estimates on air pollution exposure and health impact. The interactive maps highlight areas within countries that exceed air quality limits and confirms that 92 per cent of the world's population lives in places where this is the case.

EU

Action to manage and improve air quality is largely driven by European legislation. The 2008 ambient air quality directive[24] sets legally binding limits for concentrations in outdoor air of major air pollutants that impact public health such as particulate matter (PM_{10} and $PM_{2.5}$) and nitrogen dioxide (NO_2).

The 2008 directive replaced nearly all the previous European Union air quality legislation and was made law in England through the Air Quality Standards Regulations 2010. Equivalent regulations exist in Scotland, Wales and Northern Ireland.

In 2017 the EU passed stricter rules for the emissions of pollutants such as nitrogen oxide, sulphur dioxide, mercury and particulate matter from large combustion plants in Europe. This is an update to the Industrial Emissions Directive (which succeeded the Large Combustion Plant Directive in 2016). The stricter limits will apply to all 2,900 large combustion plants in the European Union – including coal-fired power stations and peat, oil and gas power plants – and will have to be met by 2021. This will continue to be the case for the UK until it formally completes the process of leaving the European Union, when its own legal positions will be adopted.

UK Government

In the UK, responsibility for meeting air quality limit values is devolved to the national administrations in Scotland, Wales and Northern Ireland. The Secretary of State for Environment, Food and Rural Affairs has responsibility for meeting the limit values in England

[24] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:EN:PDF

and the Department for Environment, Food and Rural Affairs (Defra) co-ordinates assessment and air quality plans for the UK as a whole.

The UK Government and the devolved administrations are required under the Environment Act 1995 to produce a national air quality strategy. This was last reviewed and published in 2007. The strategy sets out the UK's air quality objectives and recognises that action at national, regional and local level may be needed, depending on the scale and nature of the air quality problem.

The UK Government has been in breach of the limits set in the EU air quality directive since its implementation in 2010. The UK Government was ordered to revise its 'Air quality plan for nitrogen dioxide' in 2016 by the Supreme Court. The final draft was finally published in July 2017. Some of the key measures in the National Air Quality Plan include:

- Requiring local authorities to implement Clean Air Zones. These will include a package of interventions that should cut air pollution to legal levels in the "shortest possible time". The plan states that all measures should be investigated before implementing a charge on diesel and petrol vehicles.
- Introducing lorry emission roadside testing
- Funding to accelerate the transition of bus and taxi fleets to low emission.

The Government also committed to developing further measures and will set these out in:

a) the Clean Growth Plan which the Department for Business, Energy and Industrial Strategy will bring forward in the autumn.
b) a further strategy on the pathway to zero emission transport for all road vehicles to be published by March 2018.
c) a wider Clean Air Strategy in 2018 setting out how we will meet our international commitments to significantly reduce emissions of five damaging air pollutants by 2020, and 2030.
d) Commitment to exploring the appropriate tax treatment of diesel vehicles
e) Consider changes to the Heavy Goods Vehicles (HGV) Road User Levy.

The Office for Low Emissions Vehicles (OLEV) is part of the Department for Transport (DfT) and the Department for Business, Energy and Industrial Strategy (BEIS). OLEV funds a number of projects including plans to encourage the uptake of electric Light Goods Vehicles (LGV) through their Plug-In Van grant scheme. Alongside this are other pots of funding aimed at cleaning taxis, scooters & motorbikes and increasing charging infrastructure.

The government have announced plans to ban the sale of new diesel and petrol powered vehicles by 2040, although this only covers light vehicles and doesn't include hybrids.

The Environment Agency

The Environment Agency (EA) is a non-departmental public body with responsibility for the protection and enhancement of the environment in England. It is also the principle flood risk management operating authority in England. In relation to air quality the agency is a regulator for the release of pollutants into the atmosphere from large industrial plants, which it does through environmental permitting. Smaller industrial processes are regulated by local authorities. The Agency will also soon have power to regulate some agricultural processes, but many will remain unregulated.

The Committee on Medical Effects of Air Pollutants

The Committee on Medical Effects of Air Pollutants (COMEAP) is a committee of independent experts that provides advice to the Government on all matters relating to the impact of air pollution on public health.

The London Mayor

The London Mayor has powers to ensure London boroughs meet their statutory Local Air Quality Management requirements.

The Environment Act 1995 places a statutory responsibility for air quality on local authorities. Whilst this is still the case, it was agreed with Defra that the relevant local air quality management policy and technical guidance for London should be different from that in the rest of the country in recognition of the particular challenges London faces. Defra has agreed that this should be issued by the Mayor in the context of the new London Local Air Quality Management (LLAQM) system and in recognition of his London-wide supervisory role. As a result London boroughs need only refer to the guidance issued by the Mayor, rather than national statutory guidance.

London Local Authorities

London local authorities have a responsibility under the LLAQM legislation to monitor air quality. Where concentrations exceed national targets, boroughs have to designate an Air Quality Management Area (AQMA). They are then required to develop an Air Quality Action Plan (AQAP) with measures to reduce pollution. Currently all 32 London boroughs and the City of London have designated AQMA and the associated AQAP must have regard to the Mayor's London Environment Strategy. This strategy includes measures that build on initiatives being taken by boroughs through their AQAP. Following the Localism Act (2011) the Mayor is required to produce one, integrated Environment Strategy, which includes the provision for air quality.

6 Current Plans and Initiatives in London

There are a number of active plans to improve London's air quality currently underway at borough and Mayoral level. It can become difficult to keep track of the various initiatives and how they interact with each other. This section aims to layout the various schemes and initiatives currently underway in London, whilst detailing their main objectives and at what level they operate.

London Boroughs

Air Quality Monitoring

One of the borough's main statutory functions is to monitor air quality in various locations in their area. The data gained from this allows the boroughs to plan future policy interventions, and assess the effectiveness of their actions to reduce air pollution. As part of the London Local Air Quality Management (LLAQM) framework, boroughs produce Annual Status Reports (ASRs) that provide a detailed overview of air quality in their area, and the actions that have been undertaken to reduce air pollution during the last year. You can view the Greater London Authority (GLA) report on the ASRs for 2016/2017 here.

Reducing emissions from transport

As outlined earlier in the report, transport is one of the main contributors to poor air quality in London and boroughs are able to contribute to reducing this problem and some of the activities are outlined below. It is however important to note that local authorities' ability to control emissions from road transport is limited. Local authorities are unable to directly make changes to the Transport for London Road Network (TLRN), which consists of many of the busiest and more polluting roads in London. Local authorities are also not responsible or able to control the movement of black cab taxis or buses through the borough, which again falls under the remit of TfL.

Walking & cycling projects

Increasing modal shift from private vehicles to more sustainable and active travel options is an important aspect of reducing air pollution. There are a multitude of walking and cycling projects taking place across London. Boroughs are instrumental in implementing some of the schemes funded by the Mayor, such as Cycle Super Highways and Quietways. However, boroughs have long been committing their own funds to walking and cycling work, for instance in the form of engagement and promotion initiatives, such as active school and work travel projects, raising awareness of the many benefits of walking and cycling more, as well as providing cycle training, parking and local routes. Pedestrianisation and the re-designing of the urban realm to prioritise walking and cycling are other ways that the boroughs are currently actively trying to tackle air pollution. Examples of this include pedestrianisation and new Sustainable Drainage System (SuDS) on Australia Road in Hammersmith and Fulham, Van Gogh Walk in Lambeth, and the creation of a new small park at Alfred Place Camden as part of the Council's West End Project.

Parking initiatives

A number of London boroughs have implemented or are planning to implement emission based parking surcharges in a bid to discourage the most polluting vehicles. These range from Carbon Dioxide (CO_2) based charges, to charges based on engine type and size.

Idling

Engine idling policies have been introduced across a number of boroughs, which aim to reduce localised air pollution caused by motorists who leave their engines running when parked. “Idling Action” is a London-wide behaviour change programme focused on this issue, which sees volunteers ask cars to turn their engines off when stationary to reduce pollution.

Consolidation centres

An important aspect of reducing air pollution is to reduce the number of vehicles on the road. When it comes to freight, this is a hard thing to achieve, given that these journeys are necessary to the ‘growth’ of London, driving construction and economic activity and current expectations of consumers are such that on the spot delivery is expected in many circumstances. One option is for London to use freight consolidation centres, which reduce the number of journeys needed to deliver the same amount of goods, as seen in figure 5 & 6 below.

Figure 5 - Delivery model without an urban consolidation centre

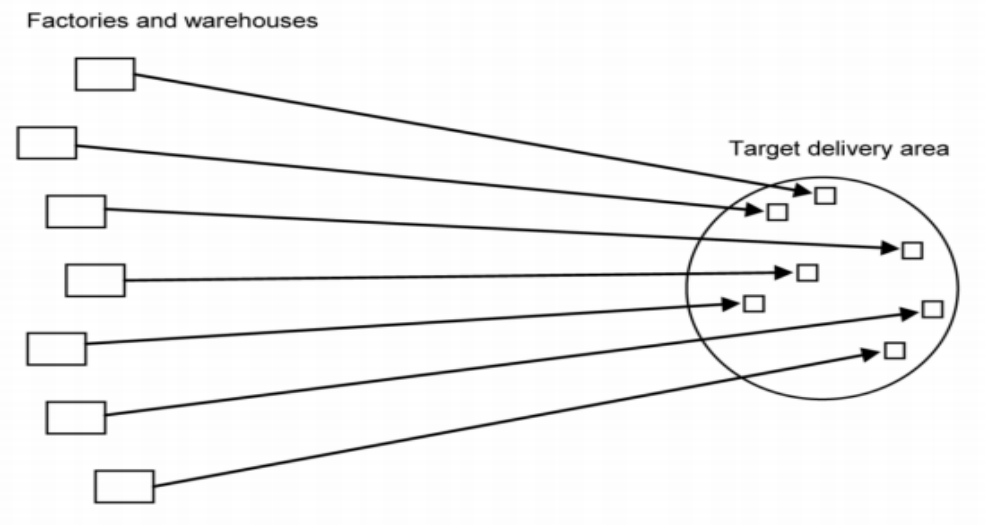
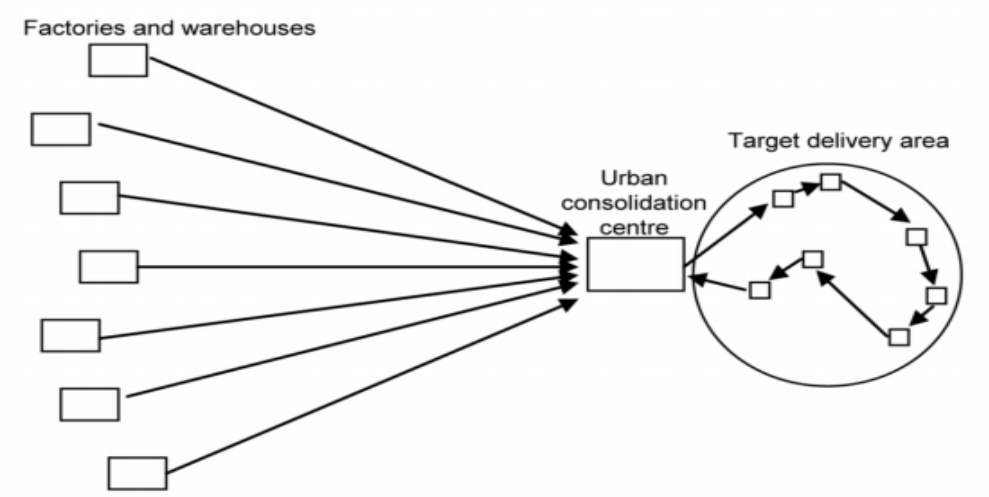


Figure 6 - Delivery model with an urban consolidation centre

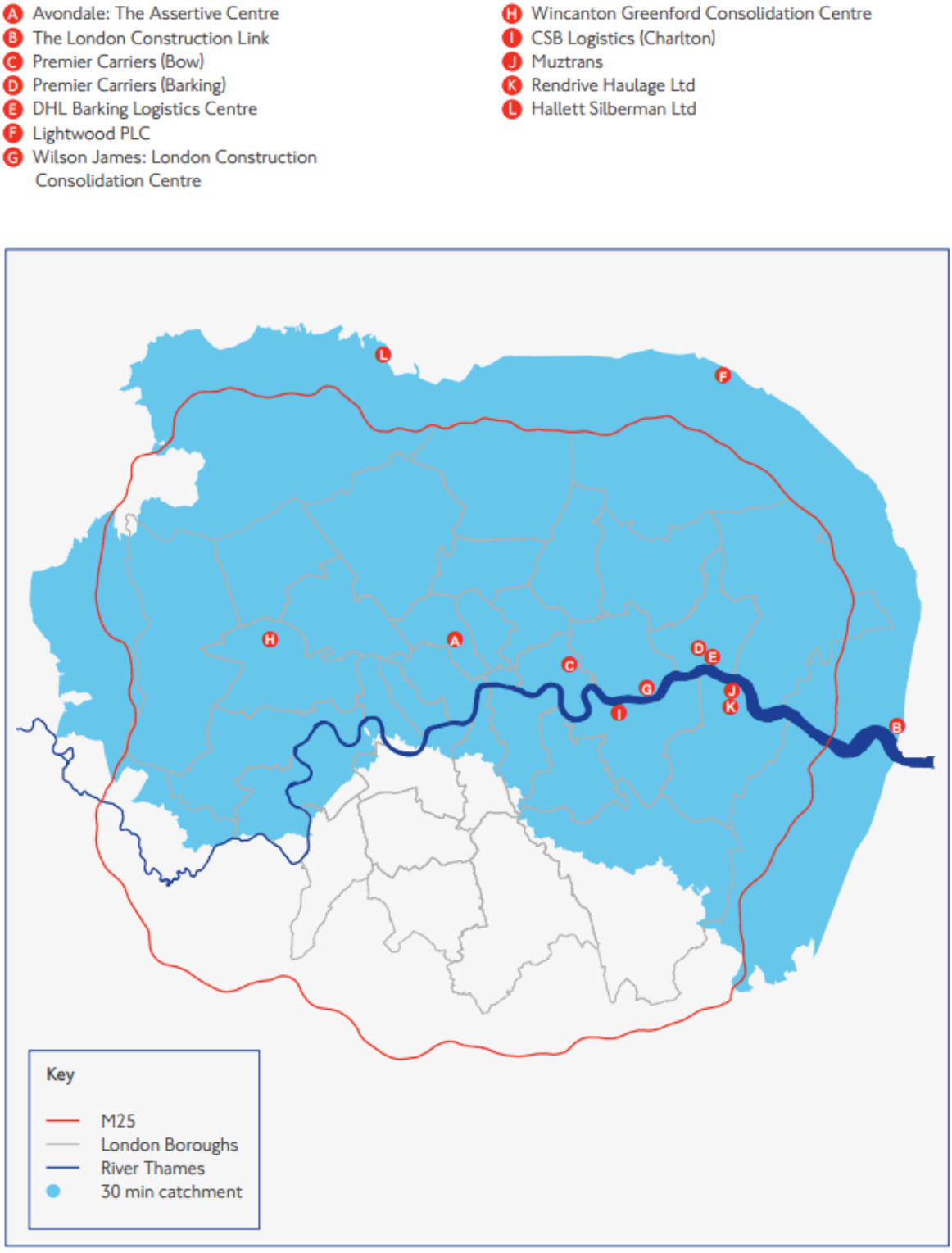


There are currently only two retail consolidation centres in London. The London Boroughs Consolidation Centre (used jointly by Waltham Forest, Camden, Islington and Enfield) and the Heathrow retail consolidation centre.

There are an additional twelve construction consolidation centres that currently serve London[25]. See figure 6 below for this.

[25] http://westminsterresearch.wmin.ac.uk/15247/1/SCFIJvol15-4-2014-Allen-etal.pdf

Figure 7 - Location of Construction consolidation centres across London[26]



London has seen an increase in the number of Heavy Goods Vehicles (HGVs) and Light Goods Vehicles (LGVs) due to, among other factors, the increase in construction work in London, and the increase in e-commerce, and the corresponding level of journeys by both HGVs and LGVs these two factors create. It is likely that, as London continues to grow, with

[26] http://content.tfl.gov.uk/directory-london-construction-consolidation-centres.pdf

its population expected to reach 10 million by 2029, the city will need to think even more carefully about freight and delivery planning. Consolidation centres will certainly be a part of this action.

Go Ultra Low City Scheme

London was awarded capital funding from the Office for Low Emission Vehicles (OLEV) to drive the uptake of ultra-low emission vehicles in the period 2015/16-2019/20.

There are four main streams of work that London is focusing on with the Go Ultra Low City Scheme (GULCS) funding and all three partners are working collaboratively to implement them;

a) **Residential**: Increase Ultra Low Emission Vehicle (ULEV) charging infrastructure in residential areas.

b) **Car Clubs**: Increase the provision of charging infrastructure in car club bays.

c) **Rapid charging**: Support the increase of rapid EV chargers across London.

d) **Neighbourhoods of the Future (NoF)**: Six local innovative schemes to prioritise and encourage the uptake of ULEVs.

Greening council fleets

London's local authorities have also been leading in terms of 'greening' their own council fleets, with the use of their procurement frameworks to begin replacing their older, dirtier vehicles with ultra low and zero emission vehicles.

Reducing emissions from Buildings and new developments

Energy efficiency and fuel poverty action

Domestic and commercial boilers account for a significant portion of London's Nitrogen Dioxide (NO_2) and particulate matter (PM). Local authorities have been addressing this issue through engagement with business and industry to raise awareness of energy efficiency practices and technologies, as well as providing home visits and energy efficiency measures to residents. London's boroughs also prioritise the improvement in performance of their own building stock through the installation of energy efficiency measures like insulation and modern, clean heating systems.

The Environmental Permitting (England and Wales) Regulations 2010 provides a mechanism to control emissions from plant above 20MW by the local authority and by the Environment Agency (EA) if over 50MW. But most generators installed in London are below this capacity. There has been a rapid growth in the use of low-cost, small scale, flexible power generators in the UK generally in the past few years. Whilst there is a legitimate role for some of these, they tend to be mainly diesel generators, which emit high levels of NO_x relative to other Medium Combustion Plants. This growth poses a concern for local air quality as well as for meeting future national emission reduction targets.

The EU has since developed the "Medium Combustion Plant Directive" (MCPD), to remove the loophole. The Directive introduces mandatory registration or permitting of Medium Combustion Plants between one and 50 Megawatt Thermal (MWt) and must be transposed

into UK law by 19 December 2017. The UK Government consulted on the proposed approach to implementation and looked at the possibility of local authorities being given the responsibility for permitting and monitoring. This consultation closed in February 2017, and there is no formal report published at the time of writing.

The Directive states that the controls will apply to new plants from December 2018. Existing plants must comply with requirements from 2024 or 2029, depending largely on size, with full implementation achieved in 2030. It is estimated that the MCPD will affect over 30,000 plants in England and Wales. However, it remains to be seen how generators will be dealt with under this regime as they only operate intermittently so may fall outside this legislation.

Boroughs are also responsible for the setting and enforcement of planning requirements for new developments, and this can ensure that construction sites take action to mitigate their air quality impacts, and ensure that the buildings themselves will not worsen air quality once built through best practice guidance and supplementary planning guidance. However, given cuts to local authority funding, it is becoming harder for boroughs to carry out effective enforcement of these policies.

Raising awareness

One of the key activities of London's local authorities is engaging with their residents and raising awareness of certain issues. Local authorities are best placed to do this in many examples, given their deep understanding of local issues and challenges. Air quality as an issue is one subject that many boroughs have long been campaigning locally on – for instance to raise awareness of the benefits of walking and cycling, supporting national clean air day and publishing travel planning strategies.

Working with businesses

Local authorities are also well placed to engage with businesses, and work with them to improve their impact on the local air quality, for instance, by setting up business air quality funds, and providing best practice guidance.

Green Infrastructure

Green infrastructure is the network of green spaces (as well as features such as street trees and green roofs) that is planned, designed and managed to deliver a range of benefits, including:

- healthy living;
- mitigating flooding;
- improving air and water quality;
- cooling the urban environment;
- encouraging walking and cycling; and
- enhancing biodiversity and ecological resilience.

It is increasingly being used at the city level, to break up the 'grey' infrastructure, and can bring a number of benefits.

Research shows that the installation of 'green infrastructure' can contribute to the reduction of air pollution in London[27]. The strategic and planned planting of certain types of trees and other plants could reduce air pollution at street level, as well as provide a number of other benefits,

[27] http://pubs.acs.org/doi/abs/10.1021/es300826w

such as protection against flooding, increased biodiversity not to mention the aesthetic benefits they can bring to urban areas.

Local Authorities in London have long been maintaining the city's green infrastructure, such as the management of parks, but also installing new green infrastructure, like green walls, green roofs, new pocket parks (or parklets) and planting new trees and plants.

Mayor of London (includes TfL & GLA)

Congestion Charge Zone

The Congestion Charge Zone (CCZ) was first introduced in 2003, by the first Mayor of London Ken Livingstone, as a way of reducing congestion in Central London. Although this policy's main focus was on reducing traffic in a certain area of London, it originally had a positive knock on effect on air pollution, with a number of sources stating that this has been the case[28]. London was able to do this due to powers devolved to it by the Greater London Authority Act 1999. But the benefits have slowly been eroded due to the increase in traffic in London since this time.

Low Emission Zone (LEZ)

The Low Emission Zone (LEZ) is an existing scheme that was introduced in 2008, which aims to reduce PM from large commercial vehicles. Its boundary covers most of Greater London and operates 24 hours a day, every day of the year including weekends and public and Bank holidays. Vehicles need to meet emissions standards or pay a daily charge between £100 - £200.

Table 4 – LEZ standards

Vehicle	Weight	Emissions standard	Charge	Implementation
Lorries, horseboxes, motor caravans and other specialist vehicles	>3.5T	Euro IV for PM	£200	February 2008 – Euro III for HGV > 12T July 2008 – Euro III for other vehicles January 212 – Euro IV
Buses and coaches with 9+ seats	>5T	Euro IV for PM	£200	July 2008 – Euro III January 2012 – Euro IV
Large vans, and other specialist vehicles	1.2 – 3.5T	Euro 3 for PM	£100	January 2012
Motor caravans and ambulances	2.5 – 3.5T	Euro 3 for PM	£100	January 2012
Minibuses with 9+ seats	<5T	Euro 3 for PM	£100	January 2012

Low Emission Neighbourhoods

A Low Emission Neighbourhood (LEN) is an area-based scheme that includes a package of measures focused on reducing emissions (and promoting sustainable living more generally). A LEN is delivered by a borough with support from TfL, the GLA and the local community. These schemes are funded through the Mayor's Air Quality Fund.

[28] http://www.c40.org/case_studies/londons-congestion-charge-cuts-co2-emissions-by-16

Air quality alerts

The current Mayor, Sadiq Khan, has introduced a system of air pollution alerts that are shown at a number of locations, including Tube stations, bus stops, river piers, on digital signs along major roads as well as the GLA and TfL websites. This information is gathered and shared by the London Air Quality Network managed by King's College London, which is made up of a number of air quality monitoring sites in and around London.

Emissions Surcharge (T-Charge)

From 23 October 2017, cars, vans, minibuses, buses, coaches and heavy goods vehicles (HGVs) in central London will need to meet minimum exhaust emission standards, or pay a daily £10 Emissions Surcharge. This will be in addition to the Congestion Charge. The minimum emissions standards are Euro 4/IV for both petrol and diesel vehicles and Euro 3 for motorised tricycles and quadricycles.

Ultra Low Emission Zone (ULEZ)

The T-Charge policy will be replaced by the introduction of the Ultra Low Emission Zone (ULEZ) which will be implemented in April 2019. From then onwards, all vehicles entering the Congestion Charge Zone will need to meet minimum exhaust emission standards or pay a daily charge. The vehicles include all cars (except taxis but including Private Hire Vehicles (PHV) as they are subject to environmental requirements through the taxi licensing system), motorcycles, vans, minibuses, buses, coaches and all HGVs. See the details below.

Table 5 – ULEZ standards

Vehicle type (includes hybrid vehicles)	ULEZ minimum emission standards	Date from which newly registered vehicles must meet the new emission standards	Daily charge if vehicle is not compliant with ULEZ standards
Motorcycle, moped etc – category L	Euro 3	From 1 July 2007	£12.50
Car and small van – categories M1 & N1(I)	Euro 4 (petrol) Euro 6 (diesel)	From 1 January 2006 From 1 September 2015	£12.50
Large van and minibus – categories N1 (II & III) and M2	Euro 4 (petrol) Euro 6 (diesel)	From 1 January 2007 From 1 September 2016	£12.50
HGV - categories N2 & N3	Euro VI	From 1 January 2014	£100
Bus/coach – category M3	Euro VI	From 1 January 2014	£100

Emission standards for taxis and private hire vehicles

The Mayor has announced a number of policies in order to 'clean up' the London taxi fleet. This will be done by:

- Not licensing any more new diesel taxis and only licensing new 'zero emission capable' taxis from 2018;
- Providing a £3,000 grant towards the first 9,000 Zero Emission Capable (ZEC) taxis, in addition to the Government's plug-in car grant;
- Delivering a rapid charging network from 2017;
- Introducing a scrappage scheme for the oldest taxis from 2017;
- Exploring options to convert to a cleaner fuel;

- Rewarding drivers who pioneer green technology, such as zero emission ranks.

There are also plans to clean private hire vehicles (PHVs). These include:

- From 2018 all PHVs presented for licensing for the first time must meet either:
  - Euro 6 (diesel/petrol) standards.
  - At least Euro 4 (petrol-hybrids) emissions standards.
- From 2020:
  - All newly manufactured PHVs (less than 18 months old) presented for licensing for the first time must be ZEC.
- From 2023:
  - All PHVs presented for licensing for the first time must be ZEC.

Emission standards for buses

New policies on London bus procurement introduced by the current Mayor means that no new pure diesel double-decker busses will be added to the capital's fleet from 2018 and that all new single-deckers for central London will be zero-emission. The Mayor has also committed to expanding the ULEZ retrofit programme to up to 3,000 buses outside the central zone.

12 Clean Bus Zones across the capital have been announced. Buses that run on these routes will be a combination of cleaner diesel buses that meet the new Euro VI standard, and also hybrid engines. This is expected to reduce NO_x on these routes by around 84 per cent according to the Mayor[29]. See the full list of the 12 Low Emission Bus Zones below:

List of clean bus zones

Putney High Street – from Putney Station to Putney Bridge Road

Brixton to Streatham – from Brixton Hill via Stockwell Road and Streatham High Road to Streatham Place

A12 Eastern Avenue – from Blake Hall Road via High Road Leyton and Homerton High Street to Marsh Hill

Lewisham to Catford – from Bromley Road via Rushey Green to Lewisham High Street

Stratford – from Abbey Lane via Mile End Road to Woodgrange Road

Haringey – from High Road to Green Lanes

Camberwell to New Cross – from Blackheath Road via Camberwell Green and Peckham High Street to Wood's Green

Wandsworth to St John's Hill – from Lavender Hill to Wandsworth Road

Edgware Road (Kilburn to Maida Vale) – from Cricklewood Broadway via Kilburn High Road to Shoot-Up Hill

Edmonton to Seven Sisters – from Amhurst Park via Green Lanes and Seven Sisters Road to The Broadway

[29] https://www.london.gov.uk/press-releases/mayoral/mayor-announces-10-new-low-emission-bus-zones

Uxbridge Road to Shepherds Bush – from Ealing Broadway via Hanger Lane to Uxbridge Road, The Broadway

Chiswick High Road to Kensington – via Hammersmith Broadway and Kensington High Street to Studland Street.

Construction

Construction is a source of air pollution in London. The GLA introduced Supplementary Planning Guidance (SPG) for the Control of Dust and Emissions during Construction and Demolition. The aim of this SPG is to reduce emissions of dust, PM_{10} and $PM_{2.5}$ from construction and demolition activities in London and it includes guidance on:

- preparing an Air Quality Statement for construction and demolition activities, including air quality (dust) risk assessments
- the stages of development the Air Quality Statement is to cover: demolition, earthwork, construction and 'trackout' (vehicles leaving the site)
- identifying the potential scale (large, medium, small) of dust emissions for each stage of work
- identifying the level of risk due to the scale of dust emissions on health, 'soiling' (dirt) and the natural environment
- best practice methods for controlling dust on-site and to prevent 'trackout'
- recommendations for monitoring
- early notification of new 2015 and 2020 standards for non-road mobile machinery

It also aims to control NO_x from these same activities by introducing a ULEZ for non-road mobile machinery (NRMM).

Domestic buildings

The Mayor of London also has programmes which look to reduce air pollution from domestic buildings through the RE:NEW programme. The main aim of the programme to tackle fuel poverty by improving the energy efficiency of London's homes, and one of the projects within this programme is the Better Boiler scheme which upgrades and/or replaces old inefficient boilers and reduces the NOx emitted from homes. This scheme is now closed.

Non-Domestic public buildings

RE:FIT is the programme that deals with emissions from non-domestic buildings. This also looks to improve the energy efficiency of buildings through a number of measures such as improved insulation, LED lighting and energy plans. This could also reduce NOx emissions from boilers slightly.

The Mayor's Air Quality Business Fund

The Mayor has also established the Mayor's air quality business fund, which will provide funding to businesses and business groups to install a number of measures that will improve air quality from their businesses, for example the development of new green areas for staff or low emission vehicle infrastructure.

Private Sector

Business Improvement Districts (BIDs)

A number of the BIDs in London have included a specific focus on tackling air pollution, recognising the negative impact this can have on the surrounding area and people. For example, in 2013 the Victoria BID launched the Victoria BID Air Quality Pledge Certificate and worked with theatres, hotels, developers, retailers, charities and professional bodies on ways to improve local air quality. Brixton BID is creating a public orchard on a patch of disused land to create new green space to combat air pollution. Others are trying to use opportunities, such as new development to make wider improvements to the area, including air quality benefits. An interactive map of the London BIDs is here.

International examples

Cities around the world are leading the way in tackling air pollution, given this tends to be an urban problem. Paris, Mexico City, Madrid and Athens recently pledged to ban diesel vehicles from their cities (or large parts of them) by 2025. There are many more examples, some of which have been detailed below.

Oxford

Oxford City Council has announced plans to introduce the 'world's first' zero emission zone in the city centre by 2020. The proposal would see diesel and petrol vehicles banned from Oxford city centre in phases, starting with some vehicle types and a small number of streets in 2020, and - as vehicle technology develops - moving to all vehicle types across the whole city centre in 2035.

Paris

Paris has implemented a number already of policies designed to improve air quality including:

- banning of cars in a number of historic central districts at weekends
- Banning odd-even (license plate number) vehicles
- Free public transport provision during major pollution events
- Encouraging car and bike-sharing programmes.

Paris has also reallocated space along the Right Banks of the Seine away from cars to create a pedestrianised area. Paris currently implements the Crit'Air system, which requires drivers to buy and display a sticker (or vignette) on their vehicles. The Vignettes come in six different categories and related colours, which represent the year of registration, the energy efficiency, and the vehicle's emission performance. Vehicles below a certain level are then banned from certain areas, and this is enforced by Traffic enforcement officers and cameras.

Paris has also announced plans to ban diesel vehicles from the city by 2024, and all petrol vehicles from the city by 2030.

Delhi

Following periods of extremely high air pollution, Delhi moved to ban all new large diesel cars and SUVs with engines of more than 2,000CC and to phase out tens of thousands of diesel taxis.

Freiburg

A suburb of Freiburg in Germany, Vauban, has introduced sky-high parking fees at €18,000 in order to force people to live without a car. In return, residents are offered cheaper housing, free public transport, and plentiful bicycle spaces to use the more than 500km of lanes on offer.

Copenhagen

Copenhagen prioritises bikes over cars and now has more cycles than people. Large parts of the Danish capital have been closed to vehicles for decades and the city plans to become carbon neutral by 2025.

Oslo

Norway is probably the world leader when it comes to electric vehicle market penetration. Oslo has pledged large car-free zones in the city centre through a number of proposals including:

- High congestion charges,
- A rush-hour fee for motorists
- The removal of many parking spaces
- The installation of 40 miles worth of new cycle lanes.

Helsinki

The Finnish capital plans to drastically reduce the number of cars on its streets by:

- Investing heavily in better public transport
- Imposing higher parking fees
- Encouraging bikes and walking
- Converting inner city ring roads into residential and walking areas.

The idea is to make the city's public transport so good that no one will want a car by 2050.

Zurich

The Swiss city of Zurich is seeking car reduction by directly controlling the number of cars that are allowed in the city at any one time only and also capping the number of parking spaces in the city. This is coupled with the building of more car-free areas, plazas, tram lines and pedestrianised streets.

Madrid

The Spanish capital plans to embark on a programme of urban redevelopment to redesign 24 of the busiest streets in the city in order to prioritise walkers and cyclists rather than drivers. The initiative is part of the city's "sustainable mobility plan".

Chengdu

The layout of a new residential area in the Chinese city, designed by Chicago-based architects Adrian Smith and Gordon Gill makes it easier to walk than drive, with streets designed so that people can walk anywhere in 15 minutes. Only half of the roads will allow cars.

7 Future Challenges

Population growth

Recent projections have predicted that London's population is expected to hit 10 million by 2030. This will cause increased pressure on borough services, but also on the transport network across the capital. London is already the UK's most congested city. Drivers spent more than 250 hours idling in traffic in 2013, which is double the UK average – and this is set to increase to 299 hours by 2030, equivalent to 40 working days a year. Although less than a third of Londoners commute to work by car, the cost of living and the value of time for the capital's 1.4 million car commuters is at such a premium that in 2030, traffic congestion has been calculated to cost London £9.3 billion, an increase of 71 per cent from today (approx. £4.4bn), costing each car commuting household more than £4,000 a year[30].

Funding pressures

Given the significant ongoing cuts to local government funding from central Government, it is becoming more difficult for local authorities to provide some of their services. Behaviour change programmes and communication activities will therefore suffer, as these are not statutory functions. Local authorities may also struggle to retain experienced and well qualified staff and may not be able to make some of the required procurement decisions, given that many of these will require an additional outlay of funding at the start with potentially long pay back periods. These are all challenges, local authorities will need to address in a very constraint funding envelope.

Working together

It is imperative for all levels of government to work together to tackle poor air quality. As has been mentioned before, air pollution does not respect administrative boundaries, and there are many things that local authorities do not have the power to control.

London Councils has previously called for a new Clean Air Act to improve on existing legislation, both EU and domestic, to ensure that the right to breathe clean air is enshrined in law. The act should also provide local authorities with more support and powers to address sources of air pollution that are currently outside of their control, for example appliances such as boilers, combined heat and power plant and generators, bonfires, wood burners, plus engine idling. A new Clean Air Act also presents an opportunity to re-evaluate the air pollution targets and the UK could consider strengthening this to World Health Organisation (WHO) limits, for example.

Brexit

Brexit will cause a great deal of confusion and uncertainty over air quality policy, as well as environmental policy as a whole. As has been highlighted, most of the air quality policies in the UK are derived from EU directives. It is crucial that this issue is not pushed to the back of the queue when it comes to delivering Brexit, and that a new Clean Air Act ensures UK residents' legal protections following the UK leaving the European Union.

[30] CEBR & INRIX (2014) The future economic and environmental costs of gridlock in 2030

Climate change

It is important to consider that a move towards increased electric and hydrogen vehicles will begin to have impacts on the national power grid. This is why strategies to tackle air pollution and climate change must be designed and delivered together. If there are more electric vehicles drawing down power from the grid, there is a need to ensure that the carbon intensity of the grid is lowered and that a zero carbon, renewable energy system is created. According to Bloomberg, by 2040, electric vehicles (EVs) will displace 8 million barrels of transport fuel per day, and add 5 per cent to global electricity consumption[31]. Overall, global power demand is expected to grow by 58 per cent between now and 2040, or 2 per cent per year, but of this, wind and solar will account for 48 per cent of installed capacity and 34 per cent of electricity generation world-wide by 2040. This shows that with further progress on renewable energy adoption, the impact of electric vehicles on the grid will become less intense moving forward[32].

There are big opportunities available to London from the increased use of solar power and energy storage and demand side response mechanisms. Again, different layers of government need to work together to achieve the best outcomes.

[31] https://about.bnef.com/electric-vehicle-outlook/

[32] https://data.bloomberglp.com/bnef/sites/14/2017/06/BNEF_NEO2017_ExecutiveSummary.pdf?elqTrackId=431b316cc3734996abdb55ddbbca0249&elq=76e0a3374b8841fab819cae181e38613&elqaid=7785&elqat=1&elqCampaignId=

8 Solutions

The numerous solutions to reducing air pollution and improving air quality have been alluded to throughout this report. This section sets out the most widely accepted solutions and their implications to Londoners.

1. **Reduce the number of all types of cars, LGVs & HGVs on roads**. Cars of all types emit a certain amount of PM. And even though this is lower for Batter Electric Vehicles due to their resistive braking and lack of engine soot, they still produce PM from tyre wear and also by re-suspending existing PM that sits on the roads. This means that the first priority should be to reduce people's dependency on private vehicles by providing excellent and efficient public transport, walking and cycling infrastructure – such as safe parking sites and work facilities like showers, and encouraging (electric) car sharing.

2. **Ensure that the cars that are driving on the roads are zero/ultra low emission (like electric, hydrogen and the best hybrids).** There is likely to be the need for some essential car trips for a while, so London needs to ensure that those cars that do remain on the roads are the cleanest available. A diesel scrappage scheme to help certain parts of society with the transition to cleaner and more sustainable transport modes could play a part in this. London also needs to install more infrastructure to support cleaner vehicles, such as electric vehicle charging points.

3. **Encourage more sustainable and active travel modes**. Modal shift is a big focus of the Mayor's recently published draft Transport Strategy. The benefits of people walking and cycling more are clear – reduced obesity and improved mental health are but two - therefore it is important that people feel able to do this across the city, where appropriate.

4. **Green Infrastructure**. Installing and maintaining green infrastructure is an important component for improving air quality but also has many other benefits, such as providing sustainable drainage systems, reducing the urban heat island effect, and improving biodiversity. It can also improve the look and feel of a place. A number of London boroughs have installed green screens near schools to lessen the impact of busy roads. One-third of London's schools are close to busy roads that suffer illegal levels of NO_2 pollution, according to Clean Air in London campaign[33] and given that children are particularly vulnerable to poor air quality, this needs to be addressed urgently.

5. **More efficient boilers and low carbon heating solutions**. Non transport sources of air pollution are significant and also need to be addressed. Improving the energy efficiency of homes and fuel poverty can play a part in tackling this source, as more efficient modern boilers emit less NO_2 and cost less to run. London needs to do more to install district heating networks, where appropriate, powered by renewable energy. There is a need to ensure that any solution to address carbon, does not negatively impact on air quality, as it is believed biomass does. This should be investigated before more biomass Combined Heat and Power units are installed.

6. **Influence planning requirements for new buildings to make them air quality neutral/positive**. Buildings have a big influence on air quality, right the way through from construction to their operation. Local authorities can use their planning powers to

[33] https://www.london.gov.uk/sites/default/files/analysing_air_pollution_exposure_in_london_-_technical_report_-_2013.pdf

ensure that new buildings will not contribute to worsening air quality, for example by including green infrastructure, and smart design aspects.

7. **Parking.** Local Authorities' control over local parking policy could be a significant mechanism for influencing the shift away from older, dirtier vehicles. A number of London boroughs have already introduced emissions based parking charges, which can include a surcharge on older, dirtier vehicles and/or discounts or exemptions for Zero Emission Vehicles (ZEVs).

8. **The use of car sharing.** Car sharing, particularly electric cars, is something else that local authorities can encourage to reduce emissions from road transport. The promotion of car clubs was identified in the Roads Task Force report in 2013 as one of a number of demand management measures, which could reduce overall car dependency by making access to cars more flexible, thereby reducing pressure on road space and encouraging sustainable transport. Car clubs were recognised as a key tool in providing for Londoners' urban mobility needs by offering a realistic and economical alternative to private car ownership. The 2013/14 Carplus Annual Survey calculated that for each round-trip car club vehicle in London, 5.8 cars were removed from the road as a result of car club members selling a car[34].

9. **Upgrade Council fleets.** Through the use of their own procurement practices, local authorities can help drive the use of EVs and other cleaner vehicles by replacing their own grey fleet with newer, cleaner vehicles.

10. **Traffic management.** Road layout improvements and the use of smart traffic management systems, such as Split Cycle Offset Optimisation Technique (SCOOT), which is a tool for managing and controlling traffic signals in urban areas), are key ways to improve traffic management, which in turn can help to reduce congestion and therefore improve air quality.

11. **Restricting access to polluting vehicles.** It is possible for local highways authorities, which all London boroughs are, to introduce areas with restricted access to non ULEVs on certain roads.

    Other cities are exploring banning diesel vehicles from their centre. London does not currently have the necessary powers to do this, however the Mayor of London through the GLA Act is able to charge certain vehicles, hence the introduction of the Ultra Low Emission Zone planned for 2019 or 2020.

    Prohibitions on traffic would need to be undertaken via Traffic Regulation Orders (TROs). Given that there is no London-wide traffic authority, for this to happen it would need:
    - all 34 Highways Authorities (TfL for the Transport for London Road Network [TLRN] and 32 boroughs and the City of London for their roads) would have to agree and make identical TROs to cover Greater London (or those individual boroughs where a smaller area is proposed);
    - Consent from DfT for any trunk roads covered.

    There are also a number of issues with this approach, including:
    - It is considered a weak mechanism due to the enforcement options:
      - criminal enforcement by Police;

[34] Carplus (2014), Annual Survey: London, p25. As only round-trip car clubs operated at the time of the survey, these findings apply to round-trip car clubs.

    - low Fixed Penalty Notice (£50);
    - or £1000 magistrates court fine if Fixed Penalty Notice (FPN) not accepted.
- There is no power to seize or impound vehicles that are in breach of the TRO.
- It has a potential impact on freedom of movement, trade and other EU laws.
- It presents a high legal risk given that it operates at the boundaries of what TROs are intended and designed to do.

Improving air quality will require a combination of different solutions. Tackling poor air quality needs to be part of a holistic, integrated approach to improving the wider environment for London's residents to ensure that the capital is a sustainable, healthy and enjoyable place to live.

Innovation and Technology

Innovation and technology have a role to play in addressing the existing air quality problem. There are a number of technological solutions to improving air quality, although these are mainly in the development phase at the moment and are expensive. See below for some of the more interesting ideas that could be available in the near future:

- Hong Kong is trialling air filtering bus stops[35]
- In a similar vein, the Dutch city of Rotterdam has opened the world's first air filtering tower[36]
- Another innovation is photocatalytic material. This can be seen with the development of concrete that essentially purifies air[37]
- An Indian company has invented a device that turns tailpipe emissions into ink[38]
- Vertical forests to increase green infrastructure[39]
- Retrofitting older vehicles[40]

[35] https://www.theguardian.com/environment/climate-consensus-97-per-cent/2015/aug/24/adapting-to-air-pollution-with-clean-air-stands-in-china
[36] https://www.theguardian.com/sustainable-business/2015/sep/19/worlds-first-smog-filtering-tower-on-tour-daan-roosegaarde-air-pollution
[37] http://edition.cnn.com/2010/TECH/innovation/08/06/concrete.pollution.solution/index.html
[38] http://fortune.com/2017/02/12/grviky-labs-india-car-exaust-ink/
[39] https://www.theguardian.com/cities/2017/feb/17/forest-cities-radical-plan-china-air-pollution-stefano-boeri
[40] https://www.healthyair.org.uk/documents/2013/10/black-carbon-retrofit-guidance.pdf

9 Conclusion

A collaborative approach to addressing air pollution is required. All levels of government need to play their part and make this a joint priority, given its serious, negative effects on public health.

With local government facing severe funding cuts, local authorities will continue to have to make efficiencies in their budgets, and only a holistic approach to air quality, linking together planning, environment, transport and health policies will be able to address the issue effectively. Businesses and third sector organisations need to play their part as well to produce the most sustainable solutions.

Policy makers need to base their decisions on thorough research and analysis to limit any unintentional, negative consequences. The move towards diesel was seen as a solution to carbon emissions, but little thought was given to the effects on air pollution at the time. This mistake should not be made again, which is another reason to address air pollution holistically and take into consideration the energy mix for producing electricity in the UK for example, as the uptake of electric vehicles is encouraged.

Reducing carbon and air pollution do not have to be mutually exclusive, and policies that can achieve both must be prioritised. As illustrated in this report, measures to address air pollution can have many positive effects on other serious challenges, such as flooding, creating pleasant public realm and cooling effects.

There is a need for joint efforts on both, mitigation (reduce existing air pollution) and adaptation (dealing with the causes of air pollution with a view to eliminate them) efforts, to spare Londoners the worst impacts of long-term exposure to dangerous levels of air pollution.

Glossary

Battery Electric Vehicle (BEV): This refers to a vehicle powered entirely from an electric battery.

Cardiovascular: Of or relating to the heart of blood vessels.

CO_2 (carbon dioxide): Principle greenhouse gas related to climate change.

Electricity generation: In the UK, our electricity is generated in a number of different ways. It is important to have different fuel sources and technologies to generate electricity so that we have a constant supply and are not overly reliant on one type of power generation. The different types include fossil fuels, nuclear, renewable sources and energy imports.

Energy Imports: The UK electricity network is connected to systems in France, the Netherlands and Ireland through cables called interconnectors. The UK uses these to import or export electricity when it is most economical. In 2015, the UK was a net importer from France and the Netherlands with net imports of 13.8 TWh and 8.0 TWh respectively which accounted for 5.8 per cent of electricity supplied in 2015. Total net exports to Ireland amounted to 0.9 TWh.

Euro standards: Standards set by the European Union for maximum emissions of air pollutants for new vehicles sold within EU member states. They range from Euro 1-6 for light vehicles and I-VI for heavy vehicles, with 6/VI being the most recent and stringent. The pollutants included are:

- **CO** = Carbon Monoxide
- **NOx** = Nitrogen Oxides
- **HC** = Hydrocarbons
- **PM** = Particulate Matter

Euro 6 emission limits (petrol)
CO – 1.0 g/km
HC – 0.10 g/km
NOx – 0.06 g/km
PM – 0.005 g/km (direct injection only)*
PM – 6.0x10 ^11/km (direct injection only)

Euro 6 emission limits (diesel)
CO – 0.50 g/km
HC – 0.17 g/km
NOx – 0.08 g/km
PM – 0.005 g/km
PM – 6.0x10 ^11/km

* Direct injection is when petrol is injected directly into the combustion chamber of an engine. While this is more efficient than non-direct injection in terms of fuel consumption, this process does create a slightly higher level of particulates.

Explanation & clarification of terms
Air pollution – NOx, CO_2, PM (2.5 & 10), CO, O_3 – and their significance (EU & WHO levels)

Fossil fuels: Most of the UK's electricity is produced by burning fossil fuels, mainly natural gas (3 per cent in 2015) and coal (22 per cent). A very small amount is produced from oil

(under 1 per cent). The volume of electricity generated by coal and gas-fired power stations changes each year, with some switching between the two depending on fuel prices.

Greenhouse gas: This term refers to a group of gases that absorb heat, contributing to climate change. This group includes CO_2.

Heavy Goods Vehicles (HGVs): Vehicles weighing 3.5 tonnes or more.

Hybrids: There are a number of types of hybrid vehicles on the market and their environmental performance is different in different contexts. They usually use a conventional petrol engine in conjunction with an electric motor and a battery. The extra power of the electric motor allows a smaller petrol engine to be used and for it to be loaded more efficiently. This can reduce CO_2 and local pollutant emissions such as NO_2. Some hybrids operate on their electric motor alone for short periods of time at low speeds. The following paragraphs explain the different types and their characteristics:

- **Series hybrid cars:** A series hybrid uses the electric motor to drive the wheels, and the petrol engine powers a generator that produces the electricity and charges the battery. The petrol engine never propels the car forward – it simply provides the energy for the electric motor. Series hybrids can use the two power sources together, or they can drive on just battery power for short distances. This is what makes them so efficient in stop-and-go city traffic. The petrol engine kicks in when the battery gets low or the car needs more power for a faster speed.
- **Parallel hybrids:** In a parallel hybrid, the petrol engine and electric motor are coupled so they work together to power the car. The petrol engine does most of the work, and the electric motor provides a boost. The main difference compared to series hybrids is that the petrol engine powers the car instead of generating electricity. This type is the cheapest to produce and buy but less fuel efficient than series hybrids.
- **Series-parallel hybrids:** These are a combination of the first two types. The car can be driven purely by petrol, purely by electricity or any combination of the two. The petrol engine also charges the battery like a series hybrid. In normal driving conditions, the petrol engine is the primary power source, with the electric motor helping to provide a boost, for example during overtaking. But in slow, city traffic the battery takes over. So series-parallel hybrids do run just on electric power, but only at low speeds.
- **Plug-in hybrid car:** A plug-in hybrid car, often called a PHEV (plug-in hybrid electric vehicle) is a modern configuration that is closer to an electric car. The battery can be charged by the petrol engine or it can be plugged into an external power source like a charging station. The batteries are generally much larger than in standard hybrids, meaning PHEVs can travel further purely on battery power.

Hydrogen (fuel cell): Hydrogen vehicles are often seen as a green alternative to petrol and diesel versions. This is mainly due to the fact their only exhaust emissions are heat and water. But producing it - most commonly by "cracking" hydrocarbons such as methane - uses a lot of energy and creates greenhouse gases as by-products. This is currently still the cheapest method of production and provides around 95 per cent of total production. One of the reasons for using hydrogen is to reduce the carbon footprint, so splitting methane leaves you with the problem of what to do with the CO_2 produced. If Carbon Capture and Storage (CCS) technologies are developed, this could make hydrogen an attractive and low carbon source of energy. But CCS is still in its infancy presently, and therefore this is not currently an option.

A more sustainable form of hydrogen production is through electrolysis - splitting water into its constituent hydrogen and oxygen molecules. This becomes even greener if the electricity

used has come from renewable sources, such as wind and solar. Another big advantage of electrolysis is that it allows hydrogen to be produced on site, cutting out distribution costs. However, this option is currently much more expensive than traditional methods of production.

LED: Light-emitting diodes.

Light Goods Vehicles (LGVs): This vehicle weighs no more than 3.5 tonnes.

Liquefied Petroleum Gas (LPG): LPG is produced both from oil and gas extraction and as a by-product of fossil fuel refining. LPG is a well-established, niche automotive fuel in a number of EU countries but is currently used in only a very small proportion of cars, vans and taxis in the UK. LPG is used in petrol engines so it is not well suited to use in heavy duty diesel vehicles such as buses and HGVs.

Megawatt Thermal (MWt): Megawatt thermal refers to the measure of energy that goes into heat engines, such as power plants. As these types of engines can't convert 100% of the energy to power, there is a separate measure for energy output, which is Megawatt Electric (MWe).

Micrograms per cubic meter: $\mu g/m^3$

NOx (nitrogen oxides): A generic term for nitrogen dioxide (NO_2) and nitrogen monoxide (NO), which can form NO_2 in the atmosphere.

NO_2 (nitrogen dioxide): A gas formed by combustion, identified as an air pollutant harmful to human health.

Nuclear: 21 per cent of the UK's electricity comes from nuclear reactors, in which uranium atoms are split to produce heat using a process known as fission. The UK's nuclear power stations will close gradually over the next decade or so, with all but one expected to stop running by 2025. Several companies have plans to build a new generation of reactors, the first of which could be running by 2018.

Parts per million: Concentration by volume of one part of a gas (or vapour), or by weight of a liquid or solid, per million parts of air or liquid. Regarding CO_2, there is consensus among the scientific community that a level of 450ppm is dangerously high. Today's atmospheric levels of CO_2 are around 400ppm, with pre-industrial levels at 280ppm.

Air quality measurements are typically reported in terms of **daily** or **annual mean** concentrations of particles per cubic meter of air volume (m^3). Routine air quality measurements typically describe such PM concentrations in terms of micrograms per cubic meter ($\mu g/m^3$).

Plug-in hybrid (PHEV): A vehicle which combines conventional internal combustion and electric propulsion with batteries charged from an electric power sources.

PM (particulate matter): A mixture of various solid and liquid particles of various chemical composition suspended in the air

PM_{10} (particulate matter < 10 microns in diameter): particulate matter that is harmful to human health and subject to EU limit values.

$PM_{2.5}$ (particulate matter < 2.5 microns in diameter): The smallest and most harmful form of particulate matter.

Pulmonary: Relating to the lungs, for example 'pulmonary blood flow'.

Renewable energy: Renewable technologies use natural energy to make electricity. Fuel sources include wind, wave, marine, hydro, biomass and solar. It made up 25 per cent of electricity generated in 2015 - this will rise as the UK aims to meet its EU target of generating 30 per cent of its electricity from renewable sources by 2020.

Respiratory: The system of organs and structures that allow us to breathe (via the exchange of oxygen and carbon dioxide – including the nasal passages, larynx, trachea, bronchial tubes and lungs).

Road User Levy: This refers to a financial levy on certain types of vehicles in order to contribute to the costs associated with maintenance of the road network. The UK Government has a road user levy for HGVs of 12 tonnes or more.

The Committee on the medical effects of air pollutants (COMEAP): is a body set up by Government to provide independent advice to government departments and agencies on how air pollution impacts on health. Its members come from a range of specialist fields such as air quality science, atmospheric chemistry, toxicology, physiology, epidemiology, statistics, paediatrics and cardiology. There is also a lay member, who helps ensure that the general public can access and understand the committee's work.

Ultra-Low Emission Vehicles (ULEVs): Cars with CO_2 emissions below 75 g/km at tailpipe.

Zero emission capable vehicle: A vehicle that is constructed to be capable of operating in zero emission mode for at least part of its operating cycle. The zero emission mode may be augmented by an internal combustion engine configured to extend the driving range of the vehicle, either by propelling the driven wheels or by powering an on-board generator.

Zero emission vehicle: This refers to any kind of vehicle that produces zero tailpipe emissions (e.g. electric and hydrogen).

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