EMISSION IMPOSSIBLE?

Air pollution, national governance and the transport sector

Ryan Shorthouse and William Nicolle

bright blue

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The polling included an online survey of 4,007 UK adults and was conducted between 28th February and 5th March 2018.

Executive summary

Since the first Clean Air Act 1956, the UK has enjoyed considerably cleaner air. Yet, parts of the UK still exceed legal levels of certain air pollutants set by the European Union (EU) and recommended by the World Health Organisation (WHO).

Stronger evidence has emerged in recent years about the detrimental impact of air pollution to human health, the economy and the environment. Consequently, there is growing public and political pressure for tougher action to reduce levels of air pollution in the UK. The UK's departure from the EU – triggered by the 2016 Referendum result – means that there is an opportunity to raise air pollution standards in the UK.

As Chapter One outlines, air pollution is the concentration of harmful gaseous and non-gaseous pollutants in the atmosphere. Four air pollutants dominated the total mass in the air in the UK in 2017: carbon monoxide (CO), nitrogen oxides (NO_x); ammonia (NH_3); and, non-methane volatile organic compounds (NMVOCs). Two further pollutants also formed sizeable minorities of the total mass in the air: particulate matter measuring less than 10 micrometres and less than 2.5 micrometres (PM); and, sulphur dioxide (SO_2). The emission of these leading air pollutants has decreased in the last few decades, except for NH_3, which has increased marginally.

Air pollution is also analysed by the concentration of air pollutants in the atmosphere. This is measured as the amount of a pollutant in one cubic meter of air by mass in micrograms ($\mu g/m^3$), using monitoring

stations at roadside, urban background, rural background and industrial sites. Doing so means we can gauge their presence at ground level, where people will be exposed to them.

Analyses of the concentration of air pollutants in the UK tend to focus on PM and NO_2, which is a form of NO_x, due to their known association with increased risks of cardiovascular and respiratory diseases. $PM_{2.5}$, PM_{10} and NO_x have all gradually declined in their annual mean concentrations across all types of monitoring stations over time. However, both $PM_{2.5}$ and PM_{10} have slowed in the rate of reduction in recent years.

The concentrations of PM and NO_2 vary greatly across the UK. Out of all the regions of the UK, Greater London has the highest annual running mean concentration across all types of monitoring stations for NO_2 and PM_{10}, and Yorkshire and Humberside the highest for $PM_{2.5}$. Scotland has the lowest running annual mean concentration across all types of monitoring stations for NO_2 and $PM_{2.5}$.

Importantly, the UK has legal 'targets', 'limits' and 'ceilings' for different pollutants. These derive from a mixture of international, EU and domestic legislation. This report refers to the permitted measure of the total emission of air pollutants as 'ceilings', and the permitted measure of the concentration of air pollutants as 'limits'. 'Targets' refer to a level of total emissions or concentrations of air pollutants fixed to be attained where possible over a given period.

The UK currently meets all its legal requirements on air pollutants, except for hourly and annual limits on NO_2. The UK is split into 43 zones for reporting purposes on legal limits of concentrations. In 2010, legal NO_2 limits were breached in 40 these reporting areas. Based on the most recent data, the UK still breaches its legal limits for NO_2 in 37 of these reporting areas.

The principal source of NO_2 concentrations in the UK is transport, which is why we focus on transport policy in this report.

Focus of this research and the methodology

This report focuses on the sources of, impacts of, and attitudes towards

air pollution across the whole of the United Kingdom. It then goes on to explore the role the national Government does and could play in reducing air pollution, particularly from NO_2.

This report seeks to answer the following five research questions:

1. What are the sources and consequences of air pollution in the UK?
2. What are the transport policies, both historically and currently, that the UK governments have adopted to reduce air pollution?
3. Is there a case for the UK Government taking further action on transport policy to reduce air pollution in the UK?
4. What is the level of understanding and concern about the impact of, and policies around, air pollution amongst the UK public?
5. Following Brexit, what new national-level transport legislation and policies are needed to further reduce air pollution?

In order to answer these questions, we employed three research methods, described in detail in Chapter Two. First, we conducted an extensive literature review of existing UK and international evidence. Second, we consulted with several leading academics, health professionals, politicians, opinion formers, campaigners and researchers, and industry professionals. Third, we commissioned nationally representative polling of 4,007 UK adults to explore public attitudes towards air pollution. The polling was conducted by Opinium. A full list of polling questions can be found in the Annex of this report.

These research methods enabled us to identify: the primary sources and consequences of, and public attitudes towards, air pollution in the UK (Chapter Three); and, different national transport policies and a range of technologies that can be used to reduce air pollution (Chapter Four).

Sources of air pollution in the UK

Air pollution has several different sources, both anthropogenic (man-

made) and natural. Anthropogenic and natural sources also interact to affect levels of air pollution.

The sources of air pollution vary from location to location. In dense urban areas, for instance, the emission of NO_x from transport will contribute a greater share of overall air pollution, whilst in the countryside, NH_3 and PM from animal agriculture and pesticides typically takes up a bigger proportion of air pollution.

A small number of sources dominated in terms of primary, secondary, and tertiary contributions of different air pollutants by total mass in 2017. 'Combustion' is the most significant source of different air pollutants, but, really, it is a process that occurs across economic sectors. We focus on a leading economic sector and source of air pollution, particularly NO_x: transport.

Transportation in the UK includes road transport, domestic shipping, aviation and rail emissions. For the air pollutants that the UK has legal ceilings for, transportation was responsible for the majority of total NO_x emissions in 2017, as well as a significant minority of total $PM_{2.5}$ and CO.

In 2016, 33.8% of the UK's total NO_x emissions came from road transport, with the other 66.2% attributable to other transport. More specifically, the contribution of the different types of road transport to the total emission of NO_x from transport in 2016 included cars (16.5%), buses and coaches (1.7%), heavy goods vehicles (4.5%), light goods vehicles (11%), and motorcycles and mopeds (0.1%). In contrast, the contributions of non-road transport to the emission of NO_x in 2016 were aviation (21.5%), railway (3.9%) and shipping (40.8%). Notably, shipping and aviation included international emissions.

On top of NO_x, transport is a significant source of PM, especially road transport. The abrasion of tyres, brakes and road surfaces produces micro-plastic particles.

Consequences of air pollution in the UK

Evidence shows there are three major consequences of air pollution: on human health, the economy, and the natural environment.

Health

Different air pollutants have different consequences for human health. NO_x and PM have been linked to respiratory and cardiovascular diseases, but also poor mental health and cognitive impairment. In addition, exposure to different pollutants affects individuals from different socio-economic groups differently, with more deprived groups more likely to develop the negative health outcomes

Ultimately, air pollution is associated with people living shorter, poorer quality lives. In July 2018, the death of a young child, triggered by repeated asthma attacks, was reported as the "first death directly attributed to illegal levels of air pollution in the UK". In 2016, the Royal College of Physicians and Royal College of Paediatrics and Child Health estimated that NO_x and PM contribute to 40,000 premature deaths in the UK per annum. More recently, the Committee on the Medical Effects of Air Pollutants (COMEAP) estimated that 28,000 to 36,000 deaths a year are linked to NO_2 concentrations, and previously estimated around 29,000 deaths a year can be linked to $PM_{2.5}$ concentrations.

Our polling revealed that a clear majority (71%) of UK adults reported that they were concerned about the impact of air pollution on the health of themselves and others The regions with the highest levels of concern about the health impact of air pollution were London (80%), Wales (74%), and the South West (73%).

The economy

Public Health England (PHE) has estimated that the economic cost of air pollution in the UK is roughly £20 billion per annum.

Our research highlighted that there are two elements to the economic costs of air pollution.

First, poor air quality harms businesses in several ways. It can impair worker performance and contribute to higher amounts of sick days taken. Higher levels of air pollution have been linked to increased rates of 'executive flight'.

Second, poor air quality has detrimental financial impacts on the

government. One study has estimated that the cost of air pollution generated by an individual car is £8,000 in London and £1,640 nationally. It has been estimated that between 2017 and 2025, the total cost to the NHS and social care will be £5.56 billion for diseases associated with $PM_{2.5}$ and NO_2.

Natural environment

When NO_x and SO_2 emissions go into the atmosphere, they can combine with water particles and eventually fall as acid rain. This can cause the eutrophication of watercourses, and the acidification of both watercourses and soils. According to the latest government figures, acid deposition exceeded critical levels in 42% of sensitive habitats in the UK in 2015.

Nitrogen deposition is caused in large part by road transport, especially diesel vehicles, in urban areas, as well as ammonia emissions from agriculture. Nitrogen deposition exceeded critical levels in 62% of sensitive habitats in 2015. There is also strong evidence that the deposition of nitrogen compounds has significantly reduced the number of plant species per unit area in a range of habitats of high conservation value in the UK.

PM is in fact a significant contributor to marine microplastic pollution. Specifically, PM generated from tyre abrasion coming off cars, vans and other modes of transport makes up to an estimated one-tenth of all ocean microplastic pollution, whilst plastic straws contribute just 0.03% of ocean plastic.

Public attitudes on air pollution

Our polling tested the attitudes of the UK public towards government action on air pollution.

- Nearly half (47%) of the UK general public think not enough is being done by the government to protect them and their family from air pollution, with only 11% disagreeing.

- At 56%, a majority of those aged 18-24 years old think that not enough is being done by the government to protect them and their family from air pollution, compared to just 39% of those aged 65 years old or over.
- A clear majority (69%) of adults agree that the Government should reduce air pollution below current levels. Generally, more young people strongly agreed that air pollution should be reduced below current levels.
- When asked whether the UK should have cleaner air then other EU countries, roughly half (49%) of adults thought the UK should have cleaner air, and only 9% thought the UK should not.
- A significant minority (40%) of the UK public agree that they would be more likely to vote for a political party which pledges to cut air pollution. A majority of under 40s reported that they agree that they are more likely to vote for a party which pledges to cut air pollution (52%).
- Fifty-seven percent of respondents believe that the UK Government should be most responsible for tackling air pollution, which polled nearly six times larger than the next most popular options of 'individuals' and 'heavy industry' (each 10%). Just 4% of UK adults believe that local authorities should be most responsible for tackling air pollution, despite the fact that a lot of responsibility for doing so is currently devolved to local authorities.

In this report, we examine the role of national government, which the public clearly believe has the primary role for tackling air pollution. We focused on the role of local authorities in managing air pollution in our last report, *Clearing the air: reducing air pollution in the West Midlands*.

National government policies on air pollution

There have been rules and regulations on air pollution in the UK for centuries. In the thirteenth century, the burning of coal was prohibited

in London on health grounds. Following the 'Great Smog' which afflicted London in 1952, killing an estimated 12,000 people, the Clean Air Act 1956, passed by a Conservative Government, was introduced. Further Clean Air Acts have been passed in 1956, 1968 and 1993.

The Environment Act 1995 is a significant piece of legislation on air quality in the UK. Part IV of the Environment Act 1995 and Part II of the Environment (Northern Ireland) Order 2002 requires local authorities to carry out reviews and assessments of air quality in their area. When a review identifies an exceedance of any given pollutant, the offending local authority must declare an 'Air Quality Management Area' (AQMA) and draw up an Action Plan to address the issue. Also, the local authority is required to provide Air Quality Annual Status Reports (AQASRs) which detail progress on addressing air pollution. But local authorities are not obliged to meet the objectives set out in their AQASRs. As of the beginning of 2019, 69% of local authorities have an AQMA, and 556 AQMAs have been declared since 2001 of which only 166 of these revoked.

Over the past decade, the UK Government has been repeatedly challenged by ClientEarth, an environmental law charity, in the courts on non-compliance with the EU-derived legal limits on NO_2. This legal pressure, coupled with growing public awareness and media campaigning, has prompted the UK Government to recently produce separate transport plans and policies for tackling air pollution.

The very latest transport policies and plans include, among others, ending the sale of all new conventional petrol and diesel cars and vans by 2040, establishing a number of funds, improving Electric Vehicle charging infrastructure, subsidising Electric Vehicle usage, and strengthening the powers and responsibilities of local authorities. All of these policies and plans are summarised in the *Clean Air Strategy 2019*.

Government recently published the Draft Environment (Principles and Governance) Bill, outlining plans to establish a new independent governance body, the Office for Environmental Protection (OEP). Informally, this body has been referred to as the "Green Watchdog". The policy areas that will be within the OEP's remit include air quality.

The Government has also indicated that it intends to introduce a new Environment Bill soon. The Government published a policy statement on the forthcoming Environment Bill, advocating: that the adoption of the WHO guideline limit for the concentration of $PM_{2.5}$ is technically feasible to meet; that the responsibility for air pollution should be shared "across local government and with relevant public bodies"; and, that powers should be introduced for the UK government to mandate recalls of vehicles and machinery that do not meet relevant legal emission standards.

Technological developments in the transport sector

The leading past, present and future technological developments that enable a reduction in air pollution from the transport sector are:

- **Catalytic converters.** Two-and three-way catalytic converters can be fitted to petrol and diesel cars to reduce toxic engine fumes, by passing them over a platinum group compound. It reduces the emission of NMVOCs, NO_x and CO. Buses and ships, too, can be fitted with Selective Catalytic Reduction (SCR) systems.
- **Particulate filters.** These can be fitted to both diesel cars as diesel particulate filters (DPFs) and petrol cars as gasoline particulate filters (GPFs) to reduce the emission of PM from exhaust fumes. The use of GPFs is mainly directed at vehicles with direct injection engines, rather than 'conventional' petrol cars.
- **Electrification.** Across different modes of transport, there is a general trend of electrifying, fully or in part, the propulsion systems of vehicles. The most rapid development has been seen in cars, thanks to lower upfront costs and larger battery ranges. Other types of EVs, such as plug-in hybrid electric vehicles (PHEVs), are also increasingly available. The train network is being increasingly electrified in the UK, with 36% of the network electrified as of 2018. Some ships are being fitted with batteries for hybrid engine systems, particularly in port areas. Challenges remain, though, in

developing light and high capacity batteries, as well as extensive and adequate EV charging infrastructure.

- **Idle-reduction technologies.** The most common technology fitted to reduce idling and therefore the emissions associated with this is the start-stop system. These automatically shut down and restart the engine based on when the vehicle is stationary.
- **Scrubbers.** Ships will often install scrubbers to meet EU and International Marine Organisation (IMO) SO_2 emission limits. They work by passing emissions over an alkaline material that neutralises acidic exhaust gases, and disposes of this through using wash water.
- **Compressed natural gas (CNG).** Some vehicles operate using compressed natural gas (CNG) as their fuel. CNG can be used in buses that are manufactured for it, or retrofitted to run solely on CNG or with an additional CNG system to increase vehicle range. CNG produces less CO, PM, NO_x, CO_2 and SO_x than petrol or diesel.
- **Liquified natural gas (LNG).** Liquefied natural gas (LNG) contains no sulphur and has comparatively lower PM emissions than other fuels like diesel. It is largely used in shipping, and has the potential to reduce greenhouse gas emissions from ships by 2 – 10%.
- **Hydrogen fuel.** Hydrogen fuelled vehicles do not produce any tailpipe exhaust fumes, but rather emit only water from their exhaust and, depending on the fuel cell, a small amount of NO_x. Hydrogen vehicles have longer ranges and shorter recharging times than EVs, but hydrogen is more expensive and emission intensive in its production. In the UK, hydrogen buses are growing in use and hydrogen trains are beginning to emerge. But hydrogen fuel cell cars and buses are outsold by a factor of one hundred by their electric equivalents.
- **Brake and tyre wear technology.** There are significant PM emissions from brake and tyre wear. However, coating brakes in more durable materials and regenerative braking, which uses

kinetic energy to recharge electric vehicle batteries, can reduce non-exhaust emissions.

- **Wind assist technologies.** The option of harnessing wind energy for propulsion in large, commercial trade and fishing shipping fleets is emerging with the development of new renewable technologies – such as a Flettner rotor, which is a large vertical sail, combined with a towing kite to drag a ship in the direction of the wind.

The relationship between public policy and technological development is critical. Policies can catalyse the creation and scaling up of technological developments. And technological developments can create new policies or enable policies to be effective.

New policies

In Chapter Five, we propose 12 new policies. Our policy recommendations are divided into two categories. First, policies aimed at reducing the amount of air pollution that derives from the transport sector. Second, policies that address the governance of air pollution at a national level

When formulating policies, we applied four key tests that had to be met. First, they had to be focused on national government powers and accountability. Second, policies should be fiscally responsible; they should not necessitate large amounts of additional central or local government spending. Third, policies should not be financially regressive; the poorest should not find new costs burdensome, and they should benefit the most from new subsidies. Fourth, policies should respect human freedom; generally, individuals themselves should decide whether they should carry out certain conduct, but policy makers can price into certain conduct the externalities of it.

The policy recommendations we propose are not exhaustive, but are original. Other organisations have proposed plausible policies which the government should consider adopting.

Policies to reduce air pollution from the transport sector

Recommendation one: Lift the freeze on the value of Fuel Duty and apply a surcharge on Fuel Duty for diesel fuel (a 'Diesel Duty')

Fuel duty is an excise tax that applies to the sale of fuel. The current Government committed to freezing the value of fuel duty yet again last year, meaning it has been frozen since 2010.

We recommend ending the freeze on the value of fuel duty from the next tax year. In addition, diesel fuel should attract a surcharge of fuel duty in its sale. This could be badged as a 'Diesel Duty'.

Recommendation two: Introduce an ongoing surcharge for Vehicle Excise Duty (VED) on new diesel cars in the UK ('Diesel Excise Duty' (DED)).

Vehicle Exercise Duty (VED) is currently paid on all vehicles registered, driven on or kept on a public road in the UK. The current system has different pricing features to it based on when you bought your car, and what type of car it is.

At present, there is a higher charge faced by drivers of diesel vehicles only on their first VED payment. After the first year of VED payment, petrol and diesel cars are subject to the same ongoing VED payments, and electric cars are fully exempt.

We recommend that a diesel surcharge on ongoing VED payments be introduced in the next tax year. Together with the tiered initial payment, this would create a separate 'Diesel Excise Duty (DED), for all new diesel vehicles registered.

Recommendation three: Exempt the purchase of ultra-low emission vehicles (ULEVs) from VAT

Ultra-low emission vehicles (ULEVs) are defined as vehicles that emit less than 75 grams of carbon dioxide (CO_2) per kilometre travelled (g/km).

Recently, it was forecast that EVs will only be 75% of new vehicle sales

by 2040 based on current incentives – falling short of the Government's target of phasing out fossil fuel car purchases by 2040. Indeed, recent growth in EVs has been slower in the UK when compared to other European countries.

We recommend that VAT should be scrapped on the purchase of all categories of ULEVs in the UK.

Recommendation four: Enable local and combined authorities to strive for 'reasonable profits' from their charging Clean Air Zones (CAZs) to fund further local air pollution abatement policies.

Local authorities cannot set charges in CAZs to raise revenue. Any additional revenue raised from CAZs must be reinvested to "facilitate the achievement of local transport policies".

We recommend the Government allows local and combined authorities to pursue 'reasonable profits' from their CAZs, as long as they are reinvested to pursue policies that will tackle roadside air pollution. We suggest the following criteria areas for these reasonable profits to be spent on:

a) Charging infrastructure for EVs;
b) Local scrappage schemes for diesel and petrol cars;
c) Local transport objectives, as currently defined

We propose that the reasonable profits raised need be first allocated to investment in EV infrastructure and local scrappage schemes for both diesel and petrol cars, prior to being used for the pursuit of local transport objectives

Recommendation five: Mandate introducing charging or banning Clean Air Zones (CAZs) for non-road mobile machinery (NRMM) alongside the establishment of all charging CAZs in England.

NRMMs are mobile machines, items of transportable industrial

equipment or vehicles which are: not intended for carrying passengers or goods on the road; and, installed with a combustion engine. Examples of NRMM include excavators, back-up generators, forklifts, and industry trucks.

London has a low-emission zone for NRMMs that sits alongside the city's ultra-low emission zone (ULEZ). The NRMM low-emission zone is distinct from the CAZ for vehicles, in terms of the standards it imposes and the parts of the city which it covers. It is not a 'charging' CAZ (whereby emitters of air pollution can pay for the pollution they create), but rather a 'banning' one which just sets minimum emissions standards and expects all parties to adhere to them.

There are CAZs for vehicles being introduced in different cities across the UK in the years ahead. Local authorities are expected to follow DEFRA's statutory guidance on establishing CAZs, which suggests they should, if appropriate, seek to implement minimum emissions standards for NRMM to be used within their Clean Air Zones. Nonetheless, there are no CAZs for NRMM in the UK at present, only London's LEZ for NRMMs.

We recommend, alongside future charging CAZs for vehicles, it should be mandatory for any new charging or banning CAZ to be established. As with the London LEZ, exemptions should apply to NRMM in a banning CAZ that is not otherwise available, or where comprehensive retrofitting is not feasible.

Recommendation six: Make it a requirement for local authorities with a charging CAZ to introduce a citizen-based reporting system to increase the enforceability of anti-idling measures.

Currently, local authority traffic officers have the power to issue fixed penalties to drivers if they fail to comply with exhaust emission reduction laws. This includes a 'stationary idling offence', which occurs when a vehicle's idling activity is deemed unnecessary and the driver fails to cease idling when instructed by a traffic officer. The UK Government

recently stated its intention to consider instant fines for drivers to deter stationary idling, rather than the current system of authorised traffic officers issuing a warning before being able to apply a fine

In the City of New York in the US, there is a system in place to allow citizens to report commercial trucks and buses that are idling for longer than the legal three minutes – or for longer than one minute if outside schools – through taking photographs and videos and filling out an online form run by the City of New York government. Citizens who report polluters get a 25% share of the income from the fine imposed. Emergency and passenger vehicles are exempt, and some exemptions apply based on the temperature outside. Crucially, tickets can be challenged. Overall, the number of enforcements for idling in New York City has increased since this scheme was introduced.

Alongside proposed new powers to enable local authority traffic officers to instantly apply fines for stationary idling, we recommend local authorities with a charging CAZ should be required to introduce such citizen-based reporting of stationary idling. The person reporting the offence should be able to provide evidence of the breach of anti-idling laws through a reporting system, and this evidence should consist of time and date stamped videos and images that clearly identify the vehicle and reflect an idling engine. If a fine is imposed, they could receive a portion of the fine, with the remainder going to the local authority to be spent on other local air pollution abatement policies. We further recommend the government consult on expanding this citizen-based reporting system from the City of New York to passenger vehicles.

Recommendation seven: Replace the current 30mph default speed limit on all 'restricted roads' in England and Wales with a 20mph default speed limit

In urban areas, speed limits are automatically set on 'restricted roads' at 30mph, unless specified as not. Local authorities do have the power to lower speed limits below the national speed limit.

Evidence shows that 20mph speed limits are beneficial in terms of

lowered amounts of pollutants being emitted by vehicles, particularly for NO_x and PM. Generally, arguments for the lowering of speed limits to 20mph are framed in terms of public safety, but there is now also a solid evidence base to be made for it lowering air pollution from vehicles.

We recommend that the default national speed limit on all 'restricted roads' in England and Wales be lowered from 30mph to 20mph.

Recommendation eight: Require the installation, checking and cleaning of particulate matter filters on all petrol cars through the annual Ministry of Transport (MOT) test.

Some petrol cars, specifically those that use direct injection engines, can emit more PM than conventional diesel cars. This is because modern diesel cars are normally fitted with diesel particulate filters (DPFs), meaning the PM they generate is filtered out of the exhaust fumes. Petrol cars, however, largely lack these filters.

Recent regulation means it is likely that most new petrol cars sold will have gasoline particulate filters (GPFs) fitted. But the existing stock of petrol cars in the UK continue to emit PM into the air unabated.

We recommend that, as part of the annual MOT tests, any petrol car without a GPF be required to have one installed. GPF filters are relatively cheap, on average costing £25. As part of the annual MOT test, the checking and, if appropriate, cleaning of the GPF should also be a requirement, as is currently required for Diesel Particulate Filters (DPFs).

Policies to improve national governance of air pollution

Recommendation nine: Adopt the World Health Organisation's (WHO) guideline limits for concentrations for all health-harming air pollutants as soon as possible after a feasibility study by the OEP or a new Committee for Clean Air.

The WHO have their own recommended limits for $PM_{2.5}$, PM_{10}, NO_2 and O_3. These are more demanding than the current EU-derived limits.

Recently, DEFRA stated they believed the WHO's recommended $PM_{2.5}$ limit was "technically feasible", but further analysis was needed as to its economic and practical feasibility. As of yet, the UK Government has only committed after Brexit to maintaining EU-derived air pollution limits.

We recommend the Government adopts all the WHO guideline limits for $PM_{2.5}$, PM_{10}, NO_2 and O_3 as soon as possible, but only after a feasibility study conducted by the Office for Environmental Protection (OEP) or a new Committee for Clean Air.

Recommendation ten: Provide the Office for Environmental Protection (OEP), or a new Committee for Clean Air, with the responsibility to recommend future legal limits for different air pollutants to parliament after conducting appropriate feasibility studies.

The OEP has been proposed as an "independent, statutory environmental body that will hold government and public bodies to account on environmental standards", including on air quality.

For the OEP to be able to properly uphold environmental standards, it should be given the power to recommend those standards to parliament.

We recommend that the OEP, or a new Committee for Clean Air, be given the power to recommend future legal limits for air pollutants to parliament following appropriate feasibility studies. This will be similar to the role of the Committee on Climate Change's (CCC) role in advising the UK Government on greenhouse gas emission targets, so that the setting of air pollutant targets will be properly evidenced and scrutinised.

Recommendation eleven: Provide the Office for Environmental Protection (OEP), or a new Committee for Clean Air, with the responsibility to recommend future

targets for different air pollutants, specifically focussed on additional targets relating to concentrations by population density and deprivation.

We recommend the OEP, or a new Committee for Clean Air, should be able to propose new future national targets that take into account two new considerations: first, population density; and, second, deprivation. These targets would be additional to the existing ones the UK has and, therefore, would not detract from any existing targets.

First, new targets based on the annual mean concentration of different air pollutants weighted by population density is important to track the average exposure of people to the concentration of different air pollutants.

Second, new targets based on the annual mean concentration of different air pollutants weighted by measures of deprivation is important to track progress on reducing air pollution is the most deprived areas.

Recommendation twelve: Legal duties should be placed on all local authorities to achieve compliance with relevant legal air pollution limits within their geographic area of responsibility. Relevant public bodies should have a legal duty to contribute to achieving compliance with legal air pollution limits within their geographic area of responsibility

Local authorities are obliged to monitor, review and if appropriate take action in relation to the air pollution within their boundaries. But local authorities do not have a clear legal responsibility to reduce air pollution below legal limits.

Equally, other public authorities that control some sources of air pollution do not face legal obligations to reduce air pollution levels to below legal limits in areas where they have authority.

We recommend that all local authorities have a legal requirement placed on them to achieve compliance with legal air pollutant limits in their geographic area of responsibility. We also recommend that relevant public bodies should have a new legal duty placed on them

to contribute to achieving compliance with legal air pollution limits within their geographic area of responsibility. The OEP should be tasked with identifying the relevant public bodies and putting these recommendations to parliament.

Conclusion

The evidence around the scale and impact of air pollution is growing and alarming. Although air quality has improved in recent decades, with significant declines in most of the main pollutants, the UK exceeds legal limits over one particular pollutant: NO_2. It is the transport sector that is the biggest contributor to this pollutant.

As the UK leaves the European Union, there is a need and an opportunity to improve legislation, policies and accountability around air quality. This report offers some policies for our national government around the UK's governance and for the transport sector. The policies do not provide the whole answer. But they will help to ensure the UK significantly improves its air quality, a laudable aim that is now widely supported by the press, politicians and the public.

Chapter 1: **Introduction**

The first Clean Air Act, which was passed by a Conservative Government in 1956, sought to improve air quality by abating air pollution and reducing exposure of individuals to it across the whole of the United Kingdom (UK).[1] Since then, the UK has enjoyed considerably cleaner air in terms of levels of pollutants in the atmosphere.[2] Yet, parts of the UK still exceed legal levels set by the European Union (EU) and recommended by the World Health Organisation (WHO). New sources of harmful air pollution have emerged in recent decades.[3] There is now growing public and political pressure for tougher action to reduce levels of air pollution in the UK.

What is air pollution?

Air pollution is the concentration of harmful gaseous and non-gaseous pollutants in the atmosphere.[4] In the UK, the Department for Environment, Food and Rural Affairs (DEFRA) has foremost

1. Clean Air Act 1956, *Ch*. 52. See: http://www.legislation.gov.uk/ukpga/1956/52/pdfs/ukpga_19560052_en.pdf
2. Department for Environment, Food and Rural Affairs, "Emissions of air pollutants in the UK, 1970 to 2017", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/778483/Emissions_of_air_pollutants_1990_2017.pdf (2019).
3. Ibid.
4. Eamonn Ives and Ryan Shorthouse, "Clearing the air: reducing air pollution in the West Midlands", http://brightblue.org.uk/wp-content/uploads/2018/10/BB42CTA-Clearing-the-air-WEB.pdf (2018).

responsibility for ensuring that air quality standards are met.[5] To assist in this, DEFRA maintains a 'Daily Air Quality Index' (DAQI) which monitors concentrations of five leading gaseous and non-gaseous pollutants in different areas of the country: nitrogen dioxide (NO_2); sulphur dioxide (SO_2); ozone (O_3); particulate matter measuring less than 2.5 micrometres ($PM_{2.5}$); and particulate matter measuring less than 10 micrometres (PM_{10}).[6] NO_2, SO_2 and O_3 are all gaseous pollutants, and PM_{10} and $PM_{2.5}$ are solid or liquid matter suspended within the air.[7]

The DAQI assigns scores to an area based on levels of air pollution, from one to ten (with a higher score indicating worse air quality), and provides forecasts in a similar sense as the pollen index.[8] Yet the DAQI does not capture all of the leading air pollutants in the UK. Legislation from the UK and EU cover other leading gaseous pollutants, such as nitrogen oxides (NO_x),[9] carbon monoxide (CO), benzene (C_6H_6), ammonia (NH_3), and non-methane volatile organic compounds (NMVOCs). Non-gaseous pollutants include mercury (Hg), polycyclic aromatic hydrocarbons (PAHs), and as well as lead (Pb) and other heavy metals such as arsenic (As), cadmium (Cd) and nickel (Ni).[10]

The total mass of pollutants in the air in a given year can be estimated using kilotonnes. Chart 1.1 below provides a graphical representation

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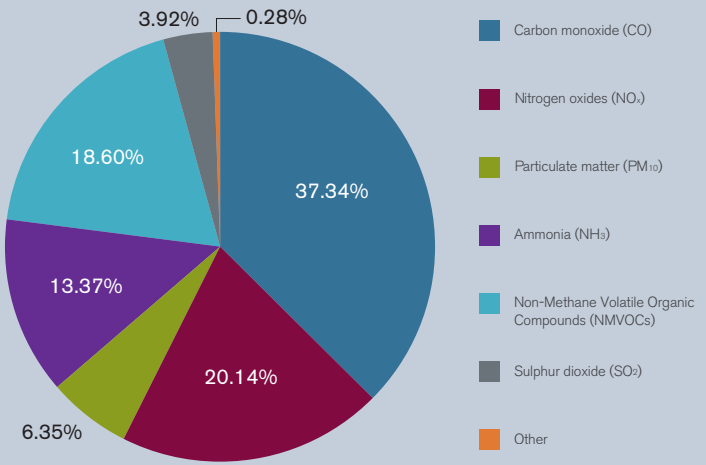
5. Department for Environment, Food and Rural Affairs, "UK and EU air quality policy context", https://uk-air.defra.gov.uk/air-pollution/uk-eu-policy-context (2018).
6. Department for Environment, Food and Rural Affairs, "What is the Daily Air Quality Index?", https://uk-air.defra.gov.uk/air-pollution/daqi?view=more-info (2019); Particulate matter is solid or liquid particles suspended in the air, and is measured in terms of diameter in microns, with the two most commonly cited gradations being $PM_{2.5}$ and PM_{10}. $PM_{2.5}$ is commonly referred to as 'fine' particulate matter, and PM_{10} as 'coarse' particulate matter.
7. There are other gradations of PM such as PM_1 and $PM_{0.1}$. However, these gradations are much less frequently used.
8. Ibid.
9. NO_2, mentioned above, is a component of NO_x, strictly, $NO_x = NO + NO_2$.
10. Air Quality Standards Regulations 2010. See: http://www.legislation.gov.uk/uksi/2010/1001/pdfs/uksi_20101001_en.pdf; European Parliament and Council, "Directive 2008/50/EC on ambient air quality and cleaner air for Europe", http://eur-3lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:EN:PDF (2008); European Parliament and Council, "Directive 2004/107/EC relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air", http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32004L0107&from=EN (2004).

of the contribution different pollutants made to overall air pollution emissions in the UK in 2017.

Chart 1.1. Total emissions of air pollutants in the UK, 2017 [11, 12]



Source: National Atmospheric Emissions Inventory, "Overview of air pollutants", http://naei.beis.gov.uk/overview/ap-overview (2019)[13]

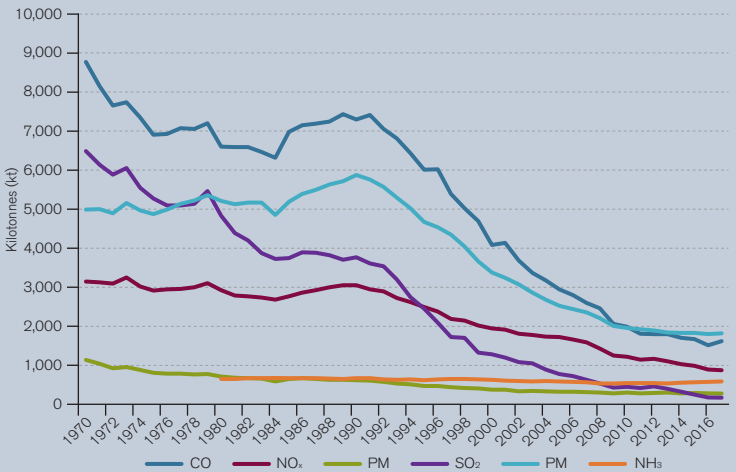
As can be seen in Chart 1.1, four pollutants dominated air pollution in the UK in 2017: CO (1512 kilotonnes, 37.34%); NO_x (873 kilotonnes, 20.14%); NH_3 (580 kilotonnes, 13.37%); and, NMVOCs (807 kilotonnes, 18.60%). Two other pollutants formed sizeable minorities, being PM_{10} (275 kilotonnes, 6.35%) and SO_2 (172 kilotonnes, 3.92%). At just over a combined 0.184 kilotonnes, the remaining six pollutants made up less than 0.28% of the total emission of air pollutants in the UK in 2017.

11. NO_x refers to a group of compounds called nitrogen oxides, and is used when referring to the emission of air pollutants. NO_2 refers more specifically to nitrogen dioxide, that is known to be bad for health, and for this reason is normally referred to when talking about the concentration of air pollutants resulting from the emission of NO_x.
12. PM_{10} includes all PM measuring less than 10 micrometres, and therefore includes $PM_{2.5}$ in the overall weight of air pollutants emitted.
13. Other comprises of C_6H_6, Pb, As, Ca, Hg, Ni, and PAHs; PAHs is expressed here as benzo[a] pyrene emissions, which is a commonly used indicator species for total PAH levels.

The scale of air pollution in the UK

The relative total masses of leading pollutants across the UK has already been illustrated in Chart 1.1. above. How the total mass of these leading air pollutants in the UK's atmosphere has changed overtime is demonstrated in Chart 1.2 below.

Chart 1.2. Trends in total emissions of leading UK air pollutants by weight (kilotonnes), 2017[14]



Source: National Atmospheric Emissions Inventory, "Overview of air pollutants", http://naei.beis.gov.uk/overview/ap-overview (2019)

As can be seen in Chart 1.2, the current leading types of air pollutant in the UK have fallen dramatically in recent decades. CO emissions declined hugely over the 1970s and into the mid-1980s. There was then a sizeable increase lasting until the early 1990s. After that, there was a rapid and steady reduction in CO emissions through the rest of the 1990s, 2000s and 2010s.

NMVOCs largely mirrored the trends in the emissions of CO, but noticeably exceeded the CO emissions by weight in 2006 for the first time, and this trend was maintained in 2017.

14. Data for NH_3 was not collected before 1980.

For NO_x, there was no real change in emissions between the 1970s and 1990s. After the early 1990s, however, progression in NO_x reduction has been better, falling steadily until today.

For NH_3, there was no noticeable reduction in emissions from 1970 until 2017. In fact, the emissions of NH_3 has increased since 1970, albeit by a very small amount.

For SO_2, there was a general trend of emissions reduction from the 1970s to 1980s. During the 1980s, emissions broadly plateaued. Since the start of the 1990s, however, SO_2 levels have fallen, first quite rapidly, but more slowly of late.

Finally, for PM, relative to the other pollutants, emissions reduction has been less dramatic – steadily falling at a gradual rate from 1970 until today.

It should be noted that Chart 1.2 might underplay the total amount of PM in the atmosphere since it can also be formed from the emission of other air pollutants, most notably NH_3, NMVOCs and O_3.[15]

On top of considering the total emissions of air pollutants, it is also important to consider the atmospheric concentration, or the ambient (outdoor) air quality. Air pollutant concentrations tend to be recorded with the unit $\mu g/m^3$. This states the amount of a pollutant in one cubic meter of air, by mass in micrograms (one millionth of a gram). Measuring the concentrations of air pollutants means we can gauge their presence at ground level, where people will be exposed to them. Concentrations vary highly with weather conditions and the activities that contribute to emissions, such as peak congestion times.[16] Concentrations of air pollutants are also transboundary in nature, because the activities of the UK's neighbours can contribute to short-term spikes.[17]

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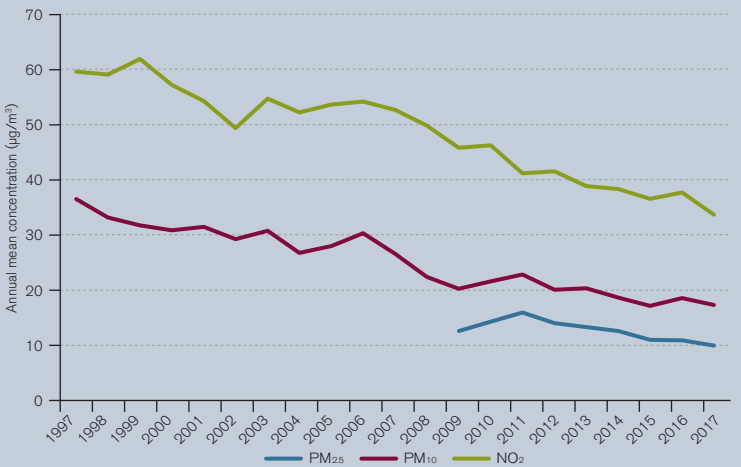
15. Department for Environment, Food and Rural Affairs, "Public health: Sources and effects of $PM_{2.5}$", https://laqm.defra.gov.uk/public-health/pm25.html (2017); Paul Monks et al, "Mitigation of United Kingdom $PM_{2.5}$ concentrations", http://eprints.whiterose.ac.uk/90507/1/1508060903_DEF-PB14161_Mitigation_of_UK_PM25.pdf (2015).
16. Department for Environment, Food and Rural Affairs, "Air Quality Statistics in the UK 1987 to 2017", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/702712/Air_Quality_National_Statistic_-_FINALv3.pdf (2019), 20; RJ Pope et al, "The impact of synoptic weather on UK surface ozone and implications for premature mortality", *Environ. Res. Lett*. (2016).
17. Ibid.

Analyses tend to focus on PM and NO_2[18] concentrations, two of the leading air pollutants in the UK, due to their known association with increased risks of cardiovascular and respiratory diseases.[19] DEFRA produces statistics on these concentrations nationally, based on a network of monitoring stations at roadside, urban background, rural background and industrial sites. The long-term trends of concentrations of PM and NO_2 are displayed in Chart 1.3 below.

Chart 1.3. Trends in the annual mean concentrations of NO_2, PM_{10} and $PM_{2.5}$[20] from all types of monitoring stations in the UK ($\mu g/m^3$)[21]



Source: Department for Environment, Food and Rural Affairs, "ENV02 – Air quality statistics", https://www.gov.uk/government/statistical-data-sets/env02-air-quality-statistics (2019)[22]

18. NO_2 is a form of NO_x.
19. Royal College of Physicians and the Royal College of Paediatrics and Child Health, "Every breath we take: the lifelong impact of air pollution", https://www.rcplondon.ac.uk/projects/outputs/every-breath-we-take-lifelong-impact-air-pollution (2016); Public Health England, "Review of interventions to improve outdoor air quality and public health", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/795185/Review_of_interventions_to_improve_air_quality.pdf (2019), 28; Committee on the Medical Effects of Air Pollutants, "COMEAP: reports and statements", https://www.gov.uk/government/collections/comeap-reports (2019).
20. Data for $PM_{2.5}$ only started being collected in 2009, and this is reflected in the broken line on the chart.
21. The four types of monitoring stations are: urban background, rural background, roadside and industrial.
22. 1997 has been chosen as the break year for this graph because PM_{10} was only recorded at both urban sites and at the road side from this date, making it more comparable with both NO_2 and $PM_{2.5}$ despite $PM_{2.5}$ only being recorded since 2009.

As Chart 1.3 illustrates, there has been a steady decline in PM_{10} concentrations measured at all types of monitoring stations since 1997. And whilst the $PM_{2.5}$ concentrations have only been monitored since 2009, they show a similar trend. Moreover, NO_2 concentrations from all types of monitoring stations have also seen long-term, gradual declines.[23] But in the last few years there has been seen a slowing in the rate of reduction of $PM_{2.5}$ and PM_{10} concentrations.

The annual mean concentrations of PM and NO_2 vary greatly across UK. DEFRA maintain the Automatic Urban and Rural Network (AURN), which is the UK's largest automatic air pollution monitoring network. It consists of two hundred and twenty six monitoring sites and contains data for the concentration of different air pollutants stretching back to 1973.[24] Data can be broken down by pollutant, region, and dates.

To give a sense of the variation across the UK, Table 1.1 below shows the regional running annual mean concentrations for PM_{10}, $PM_{2.5}$ and NO_2 for 2018 in all types of monitoring stations. The running annual mean is calculated from hourly measurements of the average concentrations of an air pollutant over a year.[25]

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23. Department for Environment, Food and Rural Affairs, "Air Quality Statistics in the UK 1987 to 2017", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/702712/Air_Quality_National_Statistic_-_FINALv3.pdf (2019).
24. Department for Environment, Food and Rural Affairs, "Automatic Urban and Rural Network (AURN)", https://uk-air.defra.gov.uk/networks/network-info?view=aurn (2019); Notably, of the 226 sites that make up AURN many monitoring stations are inactive. The actual number of inactive and active stations is specified on the website; Data availability varies for different air pollutants and therefore not all air pollutants or all sites have data going back to 1973.
25. The running annual mean is the mean of the hourly average concentration for that hour and the preceding 8759 hours (365 days), as defined by UK Air Information Resource. It is known as a 'moving average', as it is an calculation made to analyse data points through creating a series of averages of different subsets of the full data set.

Table 1.1. Averages of selected air pollutants for UK regions in all types of monitoring stations, 2018 (μg/m³)

	Regional running mean concentrations		
Region	$PM_{2.5}$	PM_{10}	NO_2
East Midlands	10.20	17.40	22.55
Eastern	11.25	18.00	22.20
Greater London	11.11	19.71	38.54
North East	9.00	14.75	19.89
North West and Merseyside	9.56	15.67	23.50
Northern Ireland	8.00	14.00	24.83
Scotland	6.13	11.00	23.70
South East	11.22	16.60	22.06
South West	10.00	17.20	19.58
Wales	9.57	17.00	21.64
West Midlands	10.43	16.50	23.29
Yorkshire and Humberside	11.57	17.29	24.25
National Average	9.84	16.26	23.83

Source: Department for Environment, Food and Rural Affairs, "Annual and exceedance statistics", https://uk-air.defra.gov.uk/data/exceedence? (2019); the running mean concentrations for each region were averaged based on the annual data for each monitoring station within each region

As Table 1.1 demonstrates, Greater London has the highest running annual mean concentration across all types of monitoring stations for PM_{10}, and Scotland has the lowest. Greater London, too, has the highest running annual mean concentration for NO_2. And this is by a notably large margin – with the second most polluted region in terms of running annual mean NO_2 concentrations being Northern Ireland. Greater London does not have the highest concentrations for all air pollutants, however. For $PM_{2.5}$ across all types of monitoring stations, Yorkshire and Humberside has the highest running annual mean concentration, whilst Scotland has the lowest.

Table 1.1 reflects the average annual mean concentrations from all types of monitoring stations. But this could underplay the annual mean concentration of particular air pollutants in certain areas. Roadside monitoring stations, for instance, typically record higher concentrations of air pollutants than the other types of stations.[26] So, in Table 1.2 below, we show the regional running annual mean concentrations for PM_{10}, $PM_{2.5}$ and NO_2 for 2018 at roadside monitoring stations.

Table 1.2. Averages of selected air pollutants for UK regions from roadside monitoring stations, 2018 (µg/m³)[27]

	Regional running mean concentrations (µg/m³)		
Region	$PM_{2.5}$	PM_{10}	NO_2
Eastern	10	19.5	31
Easy Midland	11.5	18.5	27.5
Greater London	11	21	43
North East	9	15	29
North West and Merseyside	N/A	19	25
Northern Ireland	9	12	25
Scotland	6	N/A	29.33
South East	12.5	24	30.50
South West	N/A	N/A	33.50
Wales	13	20	40.33
West Midlands	12	18.5	36.33
Yorkshire and Humberside	11	N/A	33
National roadside average	8.75	13.96	31.96

Source: Department for Environment, Food and Rural Affairs, "Annual and exceedance statistics", https://uk-air.defra.gov.uk/data/exceedence? (2019)

26. Mayor of London, "Guide for monitoring air quality in London", https://www.london.gov.uk/sites/default/files/air_quality_monitoring_guidance_january_2018.pdf (2018), 11.
27. Where results in the table are N/A, no roadside monitoring stations in the region recorded enough data to be representative.

The national average running mean concentration for NO_2 in 2018 from roadside monitoring stations (31.96 μg/m^3) was considerably higher than the national average running mean concentration across all types of monitoring stations in 2018 (23.83 μg/m^3). Greater London, again, has the highest roadside running mean concentration of NO_2 compared to all other UK regions. This highlights the significant contribution of the transport sector to the emission of NO_2.

Breaking limits

There are also other ways of measuring the scale of air pollution in the UK. Specifically, whether the country meets its legal 'targets', 'limits' and 'ceilings' for different pollutants. The 'targets', 'limits' and 'ceilings' that the UK currently has derive from a mixture of international, EU and domestic legislation, and apply to either the annual emissions by weight or ambient air concentrations of different air pollutants.

This report refers to the permitted measure of the total emission of air pollutants as 'ceilings', and the permitted measure of the concentration of air pollutants as 'limits' (thereby disregarding 'standards'). Under EU law, 'limits' refer to a level fixed to be attained within a given period and not to be exceeded once attained. This is in contrast to 'targets', which refer to a level of total emissions or concentrations of air pollutants fixed to be attained where possible over a given period.[28]

First, on international legislation: the UK is party to the 1979 United Nations Economic Commission for Europe (UNECE) Convention on Long-range Transboundary Air Pollution, which was extended in 1999 by the Gothenburg Protocol. This committed the UK to a series of 'national emission ceilings' (NECs), which refers to the obligation on parties to "reduce and maintain the reduction in its annual emissions in

28. European Parliament and Council, "Directive 2008/50/EC on ambient air quality and cleaner air for Europe", http://eur-3lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:EN:PDF (2008); European Parliament and Council, "Directive 2004/107/EC relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air", http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32004L0107&from=EN (2004).

accordance with that ceiling and the timescales specified".[29] The 1999 protocol set ceilings from 2010 up until 2020 for the air pollutants SO_2, NO_x, VOCs and NH_3.

Second, EU legislation, through a series of Directives, commits countries to reducing air pollution through limits and targets. There are two main pieces of legislation that set these limits and targets. First, the Ambient Air Quality Directive 2008/50/EC sets legally binding limits for ambient air pollutant concentrations, including all the main pollutants. Second, the NECD 2004/107/EC, more commonly known as the 'Fourth Daughter Directive', sets targets for levels in the concentration of ambient air of certain heavy metals and polycyclic aromatic hydrocarbons (PAHs).

Table 1.3 below illustrates the targets and legal hourly, daily, or annual limits for the main air pollutants set out by the Directives.[30]

Table 1.3. Selected air pollutant limit and target values set out in Directives 2008/50/EC and 2004/107/EC

Pollutant	Concentration (µg/m³, unless stated)	Averaging period	Permitted annual exceedances
	Limit values		
Fine particulate matter ($PM_{2.5}$)	25	Annually	N/A
Coarse particulate matter (PM_{10})	50	Daily	35
	40	Annually	N/A
Nitrogen dioxide (NO_2)	200	Hourly	18
	40	Annually	N/A
Sulphur dioxide (SO_2)	350	Hourly	24
	125	Daily	3

29. United Nations Economic Commission for Europe, "Protocol to the 1979 convention on long-range transboundary air pollution to abate acidification, eutrophication and ground-level ozone", https://www.unece.org/fileadmin/DAM/env/lrtap/full%20text/1999%20Multi.E.Amended.2005.pdf (1999), Article 3 Paragraph 1.
30. Ibid.

Carbon monoxide (CO)	10 mg/m³	Maximum daily eight hour mean	N/A
Lead (Pb)	0.5	Annually	N/A
Benzene (C_6H_6)	5	Annually	N/A
Ozone (O_3)	120	Maximum daily eight hour mean	25 days averaged over three years
Target values			
Arsenic (As)	6ng/m³	Annually	N/A
Cadmium (Cd)	5ng/m³	Annually	N/A
Nickle (Ni)	20ng/m³	Annually	N/A
Polycyclic aromatic hydrocarbons (PAHs)	1ng/m³ (expressed as concentration of Benzo(a)pyrene)	Annually	N/A

Source: European Parliament and Council, "Directive 2008/50/EC on ambient air quality and cleaner air for Europe", http://eur-3lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:EN:PDF (2008); European Parliament and Council, "Directive 2004/107/EC relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air", http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32004L0107&from=EN (2005)

These two EU Directives control the ambient concentration of air pollutants. Comparatively, the aforementioned Gothenburg Protocol focuses on the total annual emission of different air pollutants. The EU has most recently addressed the annual emission of air pollutants through the NECD 2016/2284/EU, that came into force at the end of 2016. This Directive effectively translated and extended the terms of the Gothenburg Protocol into EU law by establishing NERCs – outlined below in Table 1.4 – to be achieved by EU member states by 2020 and 2030.

The NECD 2016/2284/EU introduced National Emission Reduction Commitments (NERCs), which replaced the NECs of the original Gothenburg Protocol. These NERCs are targets to reduce the national total emissions of relevant air pollutants by weight based on a 2005 base line. They specify quantified reductions to be achieved by 2020. On top of the previous air pollutants covered under the original Gothenburg Protocol, an NERC was also set for $PM_{2.5}$. The core difference between the NECs and the NERCs is that the former set absolute emission ceilings for pollutants in kilotonnes, which applied up until 2019. The latter

obligate countries through targets to reduce their emissions of different air pollutants as a percentage of a 2005 baseline of emission levels.

The target percentage reductions required for different air pollutants under the NEC Directive that the UK is subject to for 2020 and 2030, and then beyond, are detailed in Table 1.4 below.

Table 1.4. The NERCs compared with a 2005 base year (% reduction on baseline value), as required by the National Emission Ceiling Directive 2016/2284/EU

Pollutant	Emission levels in 2005 (thousands of tonnes)	Target for 2020 – 2029 (Reduction from 2005 level (%) and equivalent emission reduction in thousands of tonnes)		Target for 2030 and beyond (Reduction from 2005 level (%) and equivalent reduction in thousands of tonnes)	
SO_2	706	59%	289	88%	85
NO_x	1580	55%	711	73%	427
NMVOCs	1088	32%	740	39%	664
NH_3	307	8%	282	16%	258
$PM_{2.5}$	81	30%	57	46%	44

Source: HM Gov, "The national emission ceilings regulations 2018", http://www.legislation.gov.uk/uksi/2018/129/schedule/3/made (2018), Schedule 3; Department for Environment, Food and Rural Affairs, "National Air Pollution Control Program consultation", https://consult.defra.gov.uk/environmental-quality/napcp-consultation/supporting_documents/napcpconsultprogdoc.pdf (2019:5)

Finally, this mixture of international and EU air pollution law has been translated into UK law through two main pieces of legislation. First, Air Quality Standards Regulations 2010 focuses on the concentration of different air pollutants. Second, the National Emission Ceilings Regulations 2018 pertain to the annual emissions of air pollutants. The first translates the EU limits on concentrations from 2004 and 2008 into UK law, whilst the latter translates the EU National Emission Ceilings Directive.

The responsibility for meeting these air pollution limits and targets is devolved to the national administrations of the United Kingdom. In England, the responsibility for meeting them sits with the Secretary of

State for Environment, Food and Rural Affairs. DEFRA coordinate air quality assessments and policies for the UK as a whole.[31]

The UK, in essence, has to comply with two types of air pollution legislation: one controlling the concentration of different air pollutants, and the other the emission of the most harmful air pollutants. In terms of the legal concentrations of leading air pollutants, the UK currently meets all its legal limits except for NO_2, which it is in breach of for both its hourly and annual limits.[32] Notably, many EU countries also fail to comply with their legal air pollution limits for NO_2.[33] As Chapter Three will explain, the principal source of NO_2 concentrations is transport – which is why we focus on transport policy later on in this report.

In terms of the total emissions of leading air pollutants, the UK has met its targets for the most damaging air pollutants between 2011 and 2019.[34]

The UK Government has been taken to Court over non-compliance on NO_2, as will be outlined in detail later in this report. The UK is split into 43 zones for reporting purposes on legal limits of concentrations. There are 28 'agglomeration zones' – specific, relatively urban areas, such as 'Greater London Urban Area' and 'West Midlands Urban Area' – and 15 'non-agglomeration zones', which are larger areas of the country such as 'South East' and 'Northern Ireland'.[35] In 2010, there was 40 of these zones in breach of legal NO_2 limits. Based on the most recent data, the UK still breaches its legal limits for NO_2 in 37 of these reporting areas.[36]

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31. Louise Smith, "Brexit and air quality", *House of Commons Library* (2018), 3.
32. Department for Environment, Food and Rural Affairs, "Air pollution in the uk 2017", https://uk-air.defra.gov.uk/assets/documents/annualreport/air_pollution_uk_2017_issue_1.pdf (2018), 15.
33. European Environment Agency (EEA), "Air Quality in Europe 2018", https://www.eea.europa.eu/publications/air-quality-in-europe-2017 (2018).
34. Department for Food and Rural Affairs, "Emissions of Air Pollutants in the UK, 1970 to 2017", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/778483/Emissions_of_air_pollutants_1990_2017.pdf (2019).
35. Department for Environment, Food and Rural Affairs, "Air pollution in the UK 2017", https://uk-air.defra.gov.uk/library/annualreport/viewonline?year=2017_issue_1#report_pdf (2018), 40.
36. Department for Environment, Food and Rural Affairs, "Air pollution in the uk 2017", https://uk-air.defra.gov.uk/assets/documents/annualreport/air_pollution_uk_2017_issue_1.pdf (2018), iii.

This report will demonstrate the sources and impact of the level of air pollution identified in this chapter, especially from NO_2, which the UK – along with other countries – is having the most difficulties with. Progress has certainly been made in reducing the total emissions and concentrations of different air pollutants. But much more needs to be done, particularly on NO_2.

Focus of this research

This report focuses on the sources of, impacts of, and attitudes towards air pollution across the whole of the United Kingdom. It then goes on to explore the role the national Government does and could play in reducing air pollution, specifically from the transport sector. In contrast, our recent report, *Clearing the air: reducing air pollution in the West Midlands*, explored the role which local and combined authorities do and could play in improving air quality.[37]

As this chapter has highlighted, for decades, air quality legislation in the UK has derived from European Union directives. Thus, the UK's leaving of the EU – triggered by the 2016 Referendum result – means that there is an opportunity to revise air pollution standards in the UK. Amidst the context of recent improvements in medical and scientific evidence on the impacts of air pollution, there is good reason to believe that such standards should be higher. Whilst the Government has shown it is committed to maintaining and raising these standards[38], more can be done than has been promised so far through the Environment Bill, which is expected to be introduced to Parliament soon.

37. Eamonn Ives and Ryan Shorthouse, "Clearing the air: reducing air pollution in the West Midlands", http://brightblue.org.uk/wp-content/uploads/2018/10/BB42CTA-Clearing-the-air-WEB.pdf (2018).
38. Department for Environment, Food and Rural Affairs et al., "Government launches world leading plan to tackle air pollution", https://www.gov.uk/government/news/government-launches-world-leading-plan-to-tackle-air-pollution (2019); Department for Food, Environment and Rural Affairs, "Clean Air Strategy 2019", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf (2019).

This report seeks to answer the following four research questions:

1. What are the sources and consequences of air pollution in the UK?
2. What are the transport policies, both historically and currently, that the UK governments have adopted to reduce air pollution?
3. Is there a case for the UK Government taking further action on transport policy to reduce air pollution in the UK?
4. What is the level of understanding and concern about the impact of, and policies around, air pollution amongst the UK public?
5. Following Brexit, what new national-level transport legislation and policies are needed to further reduce air pollution?

This report is structured as follows:

- **Chapter Two** describes the methodologies employed, including an extensive literature review, expert stakeholder consultation, and public polling;
- **Chapter Three** describes the primary sources and consequences of air pollution in the UK;
- **Chapter Four** outlines different national transport policies and a range of technologies that can be used to reduce air pollution;
- **Chapter Five** recommends new transport legislation and policies which could be adopted by the UK Government to further to reduce air pollution

Chapter 2: **Methodology**

This report examines the scale of, consequences of, and attitudes towards air pollution across the whole of the UK, before going on to appraise, and propose new transport policies and legislation for the UK government. This report is specifically focused on the historic, current, and future role of the national government. Local and combined authorities have an important role to play in reducing air pollution, but this has been examined in detail in our recent report, *Clearing the air: reducing air pollution in the West Midlands*.

This chapter explains in detail the methods employed to answer the research questions specified at the end of Chapter One.

Research techniques

We employed three research methods for this report.

- **Literature review.** An extensive literature review was conducted of existing UK and international evidence. This included:
  - Relevant academic work;
  - Think tank, civil society, and industry reports;
  - National government data, research and policy papers.
- **Expert stakeholder consultation.** Bright Blue consulted with a number of leading academics, health professionals, politicians, opinion formers, campaigners and researchers, and industry professionals when undertaking the research.

- **Public polling.** A nationally representative poll of UK adults was undertaken to explore public attitudes towards the air pollution (see the Annex for full list of air pollution questions). The polling was conducted by Opinium.

Polling

Polling was undertaken by Opinium through online interviews and conducted between 28th February and 5th March, 2018. It consisted of one large nationally representative sample of 4,007 UK adults. From this overall sample, we also produced two subsets, each individually weighted. The first was a sample of 1,422 British adults who were Conservative voters in the 2017 General Election. The second was a sample of 1,508 UK adults aged under 40. Each data set (the overall sample and the two subsets) was individually weighted in terms of age, gender, and region to reflect a nationally representative audience. This data enabled us to achieve two goals.

First, we were able to quantify levels of concern about air pollution, preferred solutions for tackling air pollution, and who respondents think should be most responsible for tackling air pollution. We were also able to identify views of Conservative voters at the 2017 General Election (whom we will refer to as 'Conservative voters') and of UK adults under 40, and identify discrepancies between these two groups and the general public at large. We chose to focus on Conservative voters, as the current Government, on whose votes it relies, is unlikely to enact policies to tackle air pollution which are unpopular with its supporters. We chose to focus on UK adults under 40 in particular, as the Conservative Party performed badly among this demographic at the last General Election and is interested in new policies that can increase its appeal with younger voters.[39]

Second, our polling allowed us to analyse the views of UK adults,

39. Chris Curtis, "How Britain voted at the 2017 general election", https://yougov.co.uk/news/2017/06/13/how-britain-voted-2017-general-election/ (2017).

Conservative voters, and under 40s according to other socio-demographic characteristics including gender, age, socio-economic grade, and EU Referendum vote (the full cross-breaks are listed in Box 2.1 below). This helped to reveal any further underlying diversity of opinion within the general public, Conservative voters, and those aged under 40.

Box 2.1. Complete polling cross-breaks

- Gender
- Age
- Region
- Socio-economic grade
- Area
- 2017 General Election Vote
- 2015 General Election Vote
- EU Referendum Vote

Chapter 3: Sources of, consequences of and public attitudes towards air pollution

Chapter One outlined what air pollution is, the scale of it across the United Kingdom, and how levels of air pollution have changed over time. It set out the United Kingdom's legal obligations on air pollution, showing that this country is currently not compliant with legal limits on a particular air pollutant, NO_2.

In this chapter, we outline the main sources of, consequences of and public attitudes towards air pollution in the UK, with a focus on the transport sector.

Sources of air pollution in the UK

Air pollution has a number of different sources, both anthropogenic (man-made) and natural. The main anthropogenic sources include transport, industrial processes, freight, agriculture, and heating, amongst others.[40] The main natural sources include vegetation (for instance, pollen), volcanic activity, sea spray, and desert dust,

40. Department for Environment, Food and Rural Affairs, "Clean Air Strategy 2019", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf (2019), 14; Mikhail Sofiev et al, "Cleaner fuels for ships provide public health benefits with climate tradeoffs", *Nature Communications* (2018), 1-12; Air Quality Expert Group, "Impacts of shipping on UK air quality", https://uk-air.defra.gov.uk/assets/documents/reports/cat11/1708081025_170807_Shipping_Report.pdf (2017), 1; Joanna Socorro et al., "The persistence of pesticides in atmospheric particulate phase: an emerging air quality issue", *Scientific Reports* (2016), 1-7.

amongst others.[41] Notably, there are many factors that affect the state of air quality at any given time, because different pollutants enter the atmosphere at different rates, at different times and in different places.

Thus, the sources of air pollution vary from location to location. In dense urban areas, for instance, the emission of NO_2 from transport – the focus of this report – will contribute a greater share of overall air pollution, whilst in the countryside, NH_3 and PM from animal agriculture and pesticides typically takes up a bigger proportion of air pollution.[42]

Anthropogenic and natural sources also interact to affect levels of air pollution. Levels of air pollution in an area are influenced by regional weather and climate patterns. It is often the case, for example, that air quality can deteriorate during colder months. This is primarily because more fossil fuels are being burnt for heating, but also because of meteorological phenomena which compounds air quality. Moreover, in colder months, there is little wind in the air to dissipate air pollutants.[43] Air pollutants in the air on hot, sunny days can react with each other to form O_3: as was the case in the hot summer of 2018.[44]

Furthermore, topography can influence the concentrations of air

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41. Marilena Kampa and Eliaas Castanas, "Human health effects of air pollution", *Environmental Pollution*, Vol. (2008), 362-367; Thomas Sandstrom and Bertil Forsberg, "Desert dust: an unrecognized source of dangerous air pollution?", *Epidemiology* (2008), 808-809; André Nel, "Air pollution-related illness: effects of particles", *Science* (2005), 804-806; Bernadette Longo et al., "Acute health effects associated with exposure to volcanic air pollution (vog) from increased activity at Kilauea volcano in 2008", *Journal of Toxicology and Environmental Health* (2010), 1370-1381; John H. Seinfeld and Spyros N. Pandis, *Atmospheric chemistry and physics: from air pollution to climate change* (Hoboken, New Jersey: John Wiley and Sons, Inc: 2006); Andreas Stohl, "Arctic smoke – record high air pollution levels in the European Arctic due to agricultural fires in Eastern Europe in spring 2006", *Atmospheric Chemistry and Physics* (2007), 511-534; Linsey J. DeBell et al., "A major regional air pollution event in the northeastern United States caused by extensive forest fires in Quebec, Canada", *Journal of Geophysical Research* (2004), 1.
42. Air Quality Expert Group, "Air pollution from agriculture", https://uk-air.defra.gov.uk/assets/documents/reports/aqeg/2800829_Agricultural_emissions_vfinal2.pdf (2018).
43. Toshikazu Abe et al., "The relationship of short-term air pollution and weather to ED visits for asthma in Japan", *The American Journal of Emergency Medicine*, Vol. 27, Iss. 2 (2009), 153-159; King's College, London, "London Air: How bad are winter smogs?", https://www.londonair.org.uk/LondonAir/guide/WinterSmog.aspx (2018); University of Birmingham, "Air pollution in Delhi is worse during winter, international research study shows", https://www.birmingham.ac.uk/news/latest/2014/12/air-pollution-delhi.aspx (2014).
44. Air Quality News, "Heatwave brings spike in Ozone air pollution", https://airqualitynews.com/2018/07/27/heatwave-brings-spike-in-ozone-air-pollution/ (2018).

pollution through the 'valley effect': where a cold layer of air below a warm layer inside a valley prevents the atmosphere mixing, trapping pollution near the valley floor. Narrower valleys, too, can reduce the rate at which air pollution is dissipated.[45]

Data from the Department for Business, Energy and Industrial Strategy (BEIS) is readily available for the leading anthropogenic sources of several different pollutants. The results of these can be seen in Table 3.1 below, which shows the total mass of each air pollutant in the UK that derives from each source in 2017.

Table 3.1. Leading anthropogenic sources of selected pollutants in the United Kingdom, 2017

Pollutant	Primary	Secondary	Tertiary
CO	Stationary combustion (442kt)	Combustion from residential (423kt)	Road transport (249kt)
NO_x	Transport (437kt)	Combustion in industry (294kt)	Public electricity and heat production (109kt)
NMVOCs	Solvent and other produce use (318kt)	Extraction and distribution of fossil fuels (138kt)	Production processes (123kt)
NH_3	Direct soil emissions (141kt)	Cattle, poultry and other livestock (104kt)	Waste (23kt)
PM_{10}	Combustion in industry/commercial/ residential (68kt)	Production processes (52kt)	Agriculture/waste (21kt)
SO_2	Combustion in energy and transformation industry (61kt)	Residential/ commercial/ institutional (45kt)	Combustion in manufacturing industry (39kt)
$PM_{2.5}$	Combustion in industry/commercial/ residential (66kt)	Production processes (13kt)	Road transport (13kt)

45. Julian Quimbayo-Duarte et al, "Impact of along-valley orographic variations on the dispersion of passive tracers in a stable atmosphere", *Atmosphere* (2019), 225; Air Quality, "Clean Air in the UK", http://www.air-quality.org.uk/06.php (2019).

Heavy metals covered by Directive 2004/107/EC[46]	Other stationary combustion (80,000kg)	Combustion in energy and transformation industry (11,170kg)	Transport (11,070kg)
PAHs	Residential/ commercial/ institutional (6,748kg)	Agricultural and waste (259kg)	Combustion in industry (216kg)

Source: National Atmospheric Emissions Inventory, "Overview of air pollutants", http://naei.beis.gov.uk/overview/ap-overview (2019)

As can be seen from Table 3.1 above, a small number of sources dominate in terms of primary, secondary, and tertiary contributions of different air pollutants by weight. 'Combustion' is the most significant source of different air pollutants by weight: from combustion in industrial processes for manufacturing goods or generating energy, to the combustion of fuels in road transport. Combustion, really, is a process that occurs across economic sectors.

We focus on a leading economic sector and source of air pollution: transport. As can be seen in Table 3.1, transport is a major contributor to CO, NO_x and PM. And, as Chapter One identified, the UK is non-compliant with legal limits on NO_2, a form of NO_x, which transport is by far the biggest source of.

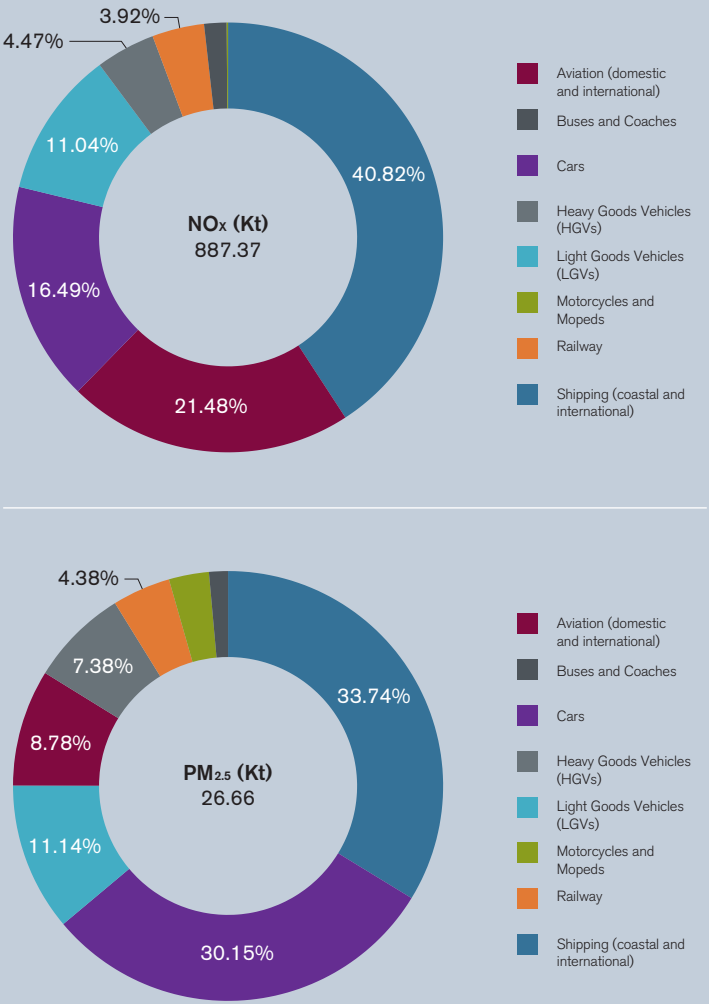
The contribution of transport to air pollution

Transportation in the UK includes road transport, domestic shipping, aviation and rail emissions. As shown in Table 3.1, for the air pollutants that the UK has legal ceilings for, transportation was responsible for the majority of total NO_x emissions, as well as a significant minority of total $PM_{2.5}$ and CO.

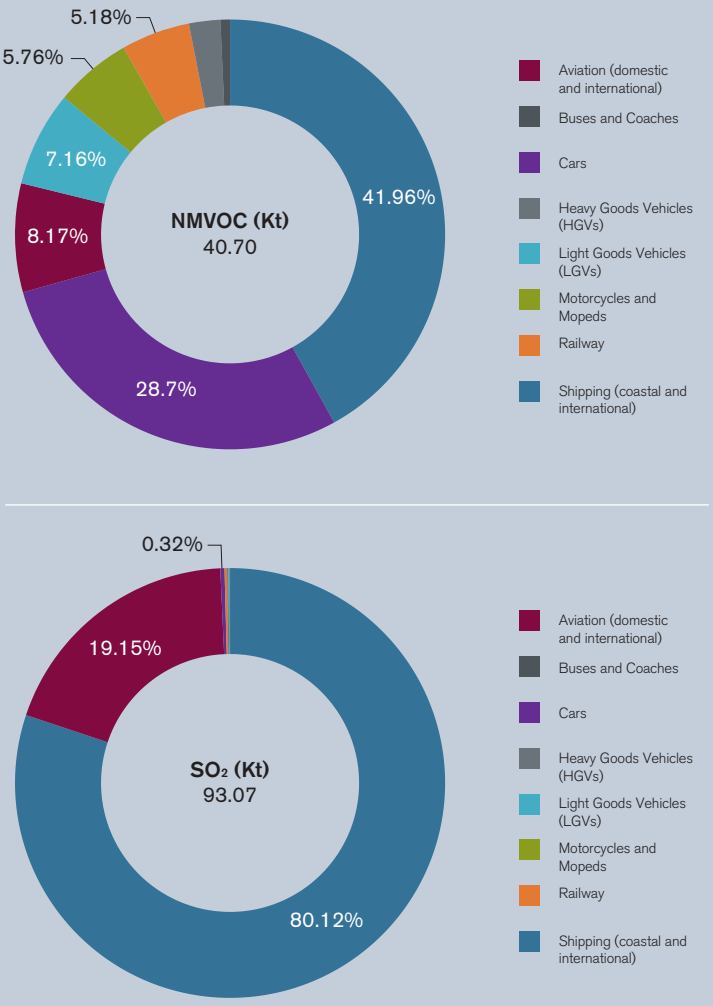
The proportion of different modes of transport's contribution to the total UK emissions of different air pollutants in 2016 is shown in Figure 3.1 below.[47]

46. As, Ni, Hg and Cd.
47. NH3 is not included in the box due to its emission from transport being negligible.

Figure 3.1. How different forms of transport contribute to total UK emissions of air pollution, 2016



Source: National Atmospheric Emissions Inventory (2019), "UK emissions data selector", http://naei.beis.gov.uk/data/data-selector?view=greenhouse-gases (2019)



Source: National Atmospheric Emissions Inventory (2019), "UK emissions data selector", http://naei.beis.gov.uk/data/data-selector?view=greenhouse-gases (2019)

As Figure 3.1 illustrates, NO_x is the most significant air pollutant to be emitted by transportation, and the UK is currently not compliant with legal limits on it. In 2016, 33.8% of the UK's NO_x emissions came from road transport, with the other 66.2% attributable to other transport. More specifically, the contribution of the different types of road transport to the total emission of NO_x from transport in 2016 includes cars (16.5%), buses and coaches (1.7%), heavy goods vehicles (4.5%), light goods vehicles (11%), and motorcycles and mopeds (0.1%). Comparatively, the contributions of non-road transport to the emission of NO_x in 2016 were aviation (21.5%), railway (3.9%) and shipping (40.8%).

The proportion of NO_x emissions attributable to the different modes of transport in Figure 3.1 actually includes international emissions. This refers to the emissions from different transport modes that are travelling between the UK and an overseas destination. This also applies to the other air pollutants detailed in Figure 3.1. Contrastingly, the government's *Clean Air Strategy 2019* excludes the contributions of NO_x and other pollutant emissions from the international elements of aviation and shipping. As a result of this, in the *Clean Air Strategy*, shipping and aviation are shown to contribute much less – in contrast to what is shown in Figure 3.1 – to overall UK NO_x emissions, whereas road transport is shown to contribute substantially more.[48]

NO_x can be formed in any high-temperature combustion engine, and results from the chemical combination of nitrogen and oxygen that exists in the air that is drawn into engines as they burn fuel.[49] For diesel engines, more NO_x is normally emitted than in petrol engines because

48. Department for Environment, Food and Rural Affairs, "Clean Air Strategy 2019", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf (2019), 18, 44.
49. European Environment Agency, "Transport emissions of air pollutants (CO, NH_3, NO_x, NMVOC, PM_{10}, SO_x) by mode", https://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-air-pollutants-6 (2006); Clean Carbon Energy, "NO_x emissions – formation, reduction and abatement", https://clean-carbonenergy.com/nox-emissions.html (2017).

of the higher temperature that these engines operate at.[50]

In 2016, shipping accounted for 40.8% of the UK's domestic NO_x emissions, 33.7% of $PM_{2.5}$, 42% of NMVOCs and 80.1% of SO_2.[51] However, the emissions accounting done by the National Atmospheric Emissions Inventory (NAEI), the source for most of the UK's air pollutant emission data, only considers domestic shipping (including overseas UK territories and UK company international cruises) and excludes international maritime traffic. A recent analysis estimated that in 2016 international shipping and shipping in transit (not stopped in ports) emitted three and six times more NO_x respectively than domestic shipping alone.[52]

The contribution of the aviation sector to NO_x was quite high (21.48%) in 2016. The biggest impacts occurring during take-off and landing.

Rail is generally considered a relatively clean form of transport, contributing only 3.92% of NO_x emissions.[53] Recently, there has been increasing focus from policymakers on the build-up of certain air pollutants within enclosed railway stations, and the Government is sponsoring independent studies into this to determine if there is a "widespread problem".[54]

On top of NO_x, transport is a significant source of PM, especially road transport. The abrasion of tyres, brakes and road surfaces produces

50. Diesel produces more energy for a given volume because it has a higher energy density than conventional petrol. Diesel engines are also more thermally efficient (the useful energy, on thermodynamic terms, put into a system divided by the total amount of energy put into that system); Rentar, "Why diesel engines are more fuel efficient than gasoline engines", https://rentar.com/diesel-engines-fuel-efficient-gasoline-engines/ (2018).
51. National Atmospheric Emissions Inventory, "UK emissions data selector", http://naei.beis.gov.uk/data/data-selector (2019).
52. Unpublished analysis carried out by Imperial College London, as mentioned in Department for Environment, Food and Rural Affairs, "Clean Air Strategy 2019", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf (2019), 47.
53. National Atmospheric Emissions Inventory, "UK emissions data selector", http://naei.beis.gov.uk/data/data-selector (2019).
54. Department for Environment, Food, and Rural Affairs, "Clean Air Strategy 2019", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf (2019), 51.

micro-plastic particles.[55]

The impact of these modes of transport on air pollution is often interrelated. For example, shipping generates increased road traffic from transporting goods to and from ports.

The consequences of air pollution in the UK

A growing body of evidence is demonstrating that both people and the planet are seriously and negatively affected by air pollution. In particular, evidence shows there are three major consequences of air pollution: on human health, the economy, and the natural environment.

Health

One of the foremost consequences of air pollution is the detrimental impact which it can have upon human health. Over recent years, a substantial evidence base has amounted which indicates associations between exposure to poor air quality and worse health outcomes.

Different air pollutants will have different consequences for human health. However, the majority have been linked to respiratory and cardiovascular diseases.[56] NO_2, for instance, is associated with decreased lung function,[57] increased susceptibility to lung infections,[58] as well as adverse birth outcomes, and cancer.[59] In 2010, UK hospital

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55. PJ Kole et al, "Wear and tear of Tyres: a stealthy source of microplastics in the environment", Int J Environ Res Public Health (2017), 1265; T. Grigoratos et al, "Experimental investigation of tread wear and particle emission from tyres with different treadwear marking", *Atmospheric Environment* (2018), 1.; M.L Kreider et al, "Physical and chemical characterization of tire-related particles: comparison of particles generated using different methodologies", *Sci. Total Environ* (2010), 652 – 659.
56. Committee on the Medical Effects of Air Pollutants, "Statement on the evidence for the effects of nitrogen dioxide on health", https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/411756/COMEAP_The_evidence_for_the_effects_of_nitrogen_dioxide.pdf (2015), 1; Byeong-Jae Lee, Bumseok Kim and Kyuhong Lee, "Air pollution exposure and cardiovascular disease", *Toxicology Research*, Vol. 30, No. 2 (2013), 71-75; Robert D. Brook et al., "Air pollution and cardiovascular disease", *Circulation*, Vol. 109, Iss. 21 (2004), 2655-2671; Robert, D. Brook et al., "Particulate matter air pollution and cardiovascular disease", *Circulation*, Vol. 121, Iss. 21 (2010), 2331-2378.
57. Ibid.
58. Australian Government Department of the Environment and Energy, "Nitrogen dioxide (NO_2)", http://www.environment.gov.au/protection/publications/factsheet-nitrogen-dioxide-no2 (2005).
59. Committee on the Medical Effects of Air Pollutants, "Statement on the evidence for the effects of nitrogen dioxide on health", https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/411756/COMEAP_The_evidence_for_the_effects_of_nitrogen_dioxide.pdf (2015), ibid.

admissions for cardiac and respiratory diseases associated with O_3 and $PM_{2.5}$ alone totalled over 20,000 incidences.[60] In Bradford, a 2018 study estimated that up to 38% of all annual childhood asthma cases may be attributable to NO_x.[61]

PM can be dangerous for human health both in and of itself, but also in the way that it can act as a carrier for toxic chemicals such as sulphates and nitrates which bond to PM whilst in the atmosphere, before being inhaled.[62] There is strong evidence linking PM to cardiovascular and respiratory diseases, as well as lung cancer and dementia.[63]

Exposure to certain air pollutants has been linked to poor mental health and cognitive impairment. A recent study found that greater exposure to NO_x and $PM_{2.5}$ when below the age of 18 means children are three to four times more likely to develop depression.[64] In another recent study, conducted in Barcelona involving 2,200 children from the ages of seven to ten years old, concluded that early life exposure to higher than average $PM_{2.5}$ levels was associated with reduced cognitive abilities.[65] Analysis across 75 general practices in Greater London showed a positive association between levels of air pollution and the likelihood of being diagnosed with dementia.[66] A further study found

60. Ibid., 84.
61. Hanenn Khreis et al., "Full-chain health impact assessment of traffic-related air pollution and childhood asthma", *Environment International* (2018), https://www.sciencedirect.com/science/article/pii/S0160412017320184
62. Committee on the Medical Effects of Air Pollution, "Statement on the evidence for differential health effects of particulate matter according to source or components", https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/411762/COMEAP_The_evidence_for_differential_health_effects_of_particulate_matter_according_to_source_or_components.pdf (2015), 6.
63. World Health Organization, "Health effects of particulate matter: policy implications for countries in eastern Europe, Caucasus and central Asia", http://www.euro.who.int/__data/assets/pdf_file/0006/189051/Health-effects-of-particulate-matter-final-Eng.pdf (2013), 6; Alzheimer's Society, "Dementia research news – spring 2017", https://www.alzheimers.org.uk/info/20056/our_care_and_cure_research_magazine/971/dementia_research_news_-_spring_2017 (2017); University of Oxford, "Toxic air pollution nanoparticles discovered in the human brain", http://www.ox.ac.uk/news/2016-09-07-toxic-air-pollution-nanoparticles-discovered-human-brain (2016).
64. Susanna Roberts et al, "Exploration of NO_2 and $PM_{2.5}$ air pollution and mental health problems using high-resolution data in London-based children from a UK longitudinal cohort study", https://www.sciencedirect.com/science/article/pii/S016517811830800X (2019).
65. Ioar Rivas et al, "Association between early life exposure to air pollution and working memory and attention", https://ehp.niehs.nih.gov/doi/pdf/10.1289/EHP3169 (2019).
66. Iain M Carey et al, "Are noise and air pollution related to the incidence of dementia? A cohort study in London, England", *BMJ Open* (2018) https://bmjopen.bmj.com/content/8/9/e022404.abstract

that exposure to air pollution during foetal life was related to alterations in the structure of the cerebral cortex.[67]

Ultimately, air pollution is associated with people living shorter, poorer quality lives. In July 2018, the death of a young child, triggered by repeated asthma attacks, was reported as the "first death directly attributed to illegal levels of air pollution in the UK".[68] In 2016, the Royal College of Physicians and Royal College of Paediatrics and Child Health jointly published a prominent report in which they estimated that NO_x and PM causes an estimated 40,000 premature deaths in the UK per annum.[69] More recently, the Committee on the Medical Effects of Air Pollutants (COMEAP) estimated that mortalities linked to the atmospheric concentration of just NO_2 in the UK is between 28,000 and 36,000 per annum.[70] Previously, COMEAP had also estimated that the number of deaths linked to just $PM_{2.5}$ concentrations is roughly 29,000 per year in the UK.[71]

An important factor that contributes to how our health is impacted by air pollution is how much and how long we are exposed to different pollutants. The evidence base for these complexities is still emerging.[72] Travelling in cars, for instance, is thought to be worse than cycling or walking due to the circulation of pollutants in a confined atmosphere.[73] In addition, exposure to different pollutants

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67. Mònica Guxens et al, "Air Pollution Exposure During Fetal Life, Brain Morphology, and Cognitive Function in School-Age Children", *Biological Psychiatry* (2018) https://www.sciencedirect.com/science/article/pii/S0006322318300647
68. Ben Webster, "Girl's death from asthma linked to car pollution", *The Times*, 4 July, 2018.
69. Royal College of Physicians and Royal College of Paediatrics and Child Health, "Every breath we take: the lifelong impact of air pollution", https://www.rcplondon.ac.uk/file/2916/download?token=5dnlDovZ (2016), 4.
70. COMEAP, "Associations of long-term average concentrations of nitrogen dioxide with mortality", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/734799/COMEAP_NO2_Report.pdf (2018).
71. COMEAP, "The mortality effects of long-term exposure to particulate air pollution in the UK", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/304641/COMEAP_mortality_effects_of_long_term_exposure.pdf (2009).
72. Kings College London, "Public Exposure", https://www.kcl.ac.uk/lsm/research/divisions/aes/research/erg/measurement/personal-exposure (2019).
73. Frank de Leeuw et al, "Assessment of personal exposure to particulate air pollution during commuting in European cities—Recommendations and policy implications", https://doi.org/10.1016/j.scitotenv.2014.05.036 (2014).

affects individuals from different socio-economic groups differently, with more deprived groups more likely to develop the negative health outcomes touched on above due to, for instance, living nearer major transport links.[74] A study of over 300,000 people aged 40-69 found that air pollution has twice the impact on lung function for members of lower income households.[75]

Box 3.1. The Daily Air Quality Index (DAQI)

To manage and communicate health impacts to the public, DEFRA calculate the Daily Air Quality Index (DAQI). As outlined in Chapter One, the DAQI is an area-based scoring system used by DEFRA to communicate the levels of air pollution in real time as well as recommended actions and health advice based on these levels. It assigns an area an indexed score of one to ten, and divides this into four bands with one being low and ten being high – as can be seen in Table 3.2 below. The score for a region or site is determined by the highest concentration of five air pollutants: NO_x, SO_2, O_3, $PM_{2.5}$ and PM_{10}.[76]

Table 3.2. Summary of the DAQI

Air pollution banding	Value	Accompanying health messages for at risk individuals[77]	Accompanying health messages for general population
Low	1-3	Enjoy your usual outdoor activities	Enjoy your usual outdoor activities

74. Defra and Department for Transport, "UK Plan for tackling roadside nitrogen dioxide concentrations: Technical Report", https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/632916/air-quality-plan-technical-report.pdf (2017), Annex D.
75. Thomas Barrett, "Air pollution has twice the impact on lung function for poorer households", *Air Quality News*, 9 July, 2019 https://airqualitynews.com/2019/07/09/air-pollution-has-twice-the-impact-on-lung-function-for-lower-income-households/
76. The five pollutants included are NO_x, SO_2, O_3, $PM_{2.5}$ and PM_{10}.
77. Taken to be adults and children with heart or lung problems.

Moderate	4-6	Adults and children with lung problems, and adults with heart problems, who experience symptoms, should consider reducing strenuous physical activity, particularly outdoors	Enjoy your usual outdoor activities
High	7-9	Adults and children with lung problems, and adults with heart problems, should reduce strenuous physical exertion, particularly outdoors, and particularly if they experience symptoms. People with asthma may find they need to use their reliever inhaler more often. Older people should also reduce physical exertion	Anyone experiencing discomfort such as sore eyes, cough or sore throat should consider reducing activity, particularly outdoors
Very high	10	Adults and children with lung problems, adults with heart problems, and older people, should avoid strenuous physical activity. People with asthma may find they need to use their reliever inhaler more often	Reduce physical exertion, particularly outdoors, especially if you experience symptoms such as cough or sore throat

Source: Department for Environment, Food and Rural Affairs, "Daily Air Quality Index", https://uk-air.defra.gov.uk/air-pollution/daqi (2019)

Data is readily available on DAQI scores in the UK, accessible for different geographic and urban agglomeration regions.[78] Between 1990 and 2019, the average DAQI score across the UK was three.[79] The DAQI scores for each day in 2018 across all UK regions is in Table 3.3 below.

78. UK Air Information Resources, "DAQI regional data", https://uk-air.defra.gov.uk/data/DAQI-regional-data (2019).
79. Based on data downloaded UK Air Information Resources, "DAQI regional data", https://uk-air.defra.gov.uk/data/DAQI-regional-data (2019); the geographic regions included are Greater London, Highlands, North East, North East Scotland, North Wales, North West and Merseyside, Northern Ireland, Scottish Borders, South East, South Wales, South West, West Midlands, Yorkshire & Humberside.

Table 3.3. DAQI score for every day in every region in the UK, 2018

	DAQI index brackets			
Geographic region	1 to 3	4 to 6	7 to 9	10
Central Scotland	343	22	0	0
East Midlands	318	45	2	0
Eastern	296	66	2	1
Greater London	302	62	1	0
Highland	324	41	0	0
North East	342	22	0	1
North Wales	362	3	0	0
North West & Merseyside	330	35	0	0
Northern Ireland	331	31	3	0
Scottish Borders	342	20	3	0
South East	349	16	0	0
South Wales	289	71	5	0
South West	298	67	0	0
West Midlands	264	99	2	0
Yorkshire & Humberside	319	45	1	0

Source: adapted from UK Air Information Resources, "DAQI regional data", https://uk-air.defra.gov.uk/data/DAQI-regional-data (2019)

The vast majority of days fall in the lowest brackets of one to three across all UK regions, which corresponds to a health message of "enjoy your normal activities." The West Midlands recorded the least days of all regions in the cleanest bracket of one to three, at two hundred and sixty-four days. Very few regions experienced a 'High' bracket index score range of seven to nine, and even fewer received the 'Very High' bracket index score of ten. There were only

two days in 2018 in the UK when the DAQI score was 'very high', and these days were in the Eastern and North Eastern regions.

Interestingly, the average DAQI score achieved by different geographic regions varies throughout the year. How the DAQI scores varied in 2018 is shown in Chart 3.1 below. This shows the total number of times a DAQI bracket was given to a geographic region each month as a cumulative count.

Chart 3.1. The total number of times each DAQI bracket was scored across geographic regions by month, 2018

Source: UK Air Information Resources, "DAQI regional data", https://uk-air.defra.gov.uk/data/DAQI-regional-data (2019)

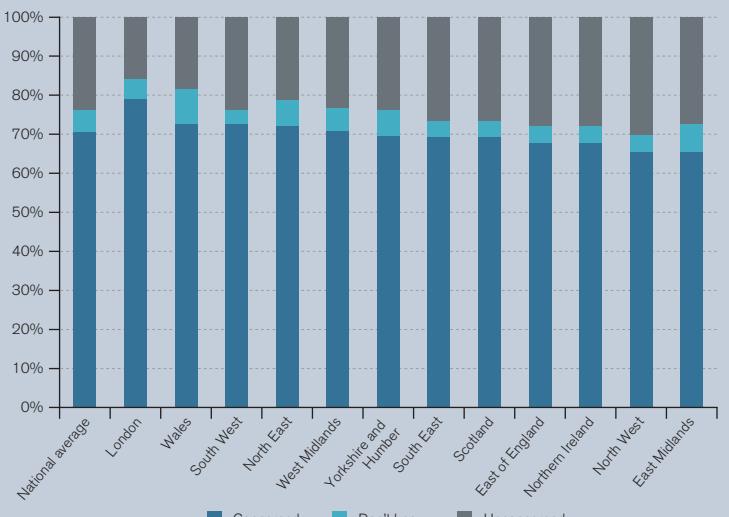
As Chart 3.1 demonstrates, early in the year, from January to March, and later from August to December, the lowest DAQI bracket of one to three dominates the scores achieved across the UK. However, in the spring and early summer, more of the higher brackets are common, especially bracket four to six. Whilst few in number, during this period, incidences of bracket seven to nine being awarded are

higher as well. The higher brackets around the summer time are most likely due to warmer weather causing gases in the air to react together to form O_3, as discussed earlier in Chapter One.

Our polling of the UK public found that large majorities of the public are concerned about the impact of air pollution on the health of themselves and others. A clear majority (71%) of UK adults reported that they were 'concerned', compared to just 24% who were 'unconcerned'. The term 'concerned' relates to the net responses of 'somewhat concerned' and 'very concerned'. We apply this approach to the reporting of polling data in all instances henceforth.

As Chart 3.2 below shows, there was a degree of regional variation in terms of which parts of the country are more or less concerned about the impact of air pollution on health.

Chart 3.2. Concern about the impact of air pollution on the health of a respondent and others, by region

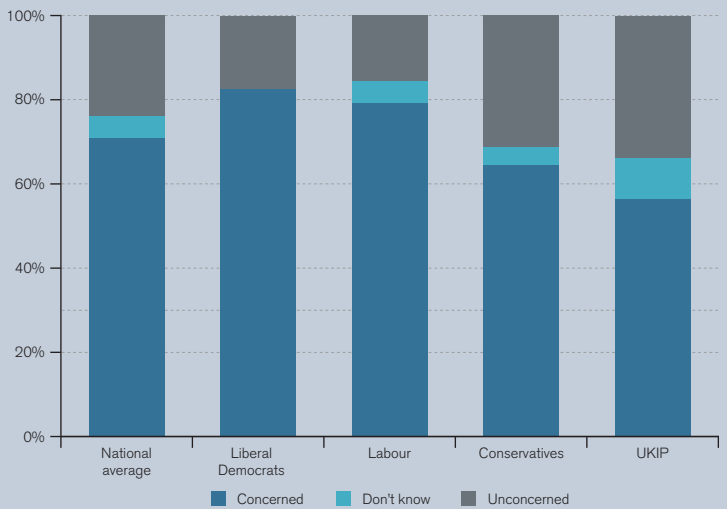


Base: 4,007 UK adults

Here, one can see that London leads the way in terms of concern (80%), followed by Wales (74%), and the South West (73%). The least concerned regions of the country are the East Midlands and North West (both 66%), and Northern Ireland and the East of England (both 68%). However, it is worth stressing that even in the areas where concern for the health impact is at its lowest, still a clear majority of respondents express concern.

Concern about the impact of air pollution on health also varies depending on the respondent's political affiliation, as defined by whichever party they voted for in the 2017 General Election. As Chart 3.3 below shows, Liberal Democrat voters are the most likely to express concern (83%). Sixty-five percent of Conservative voters say that they are concerned about the impact of air pollution on health. From these results, it is clear that there are majorities of concern amongst voters of all political parties for the health consequences of air pollution.

Chart 3.3. Concern about the impact of air pollution on the health of a respondent and others, by 2017 General Election vote



Base: 3,896 UK adults

Lastly, with respect for concern about the impact of air pollution on health, we found variances between those who voted for 'Remain' in the 2016 EU Referendum, and those who voted 'Leave'. Remain voters were more likely than the national average to express concern (80%), whilst Leave voters were slightly less (65%). Once again however, large majorities on each side of the debate expressed concern.

The economy

Evidence suggests that air pollution harms not just health but also the economy through placing financial costs on businesses and government. Altogether, the economic cost of air pollution in the UK stands at roughly £20 billion per annum, according to Public Health England (PHE).[80]

First, poor air quality harms businesses in several ways. It can impair worker performance and contribute to a higher number of sick days.[81] One study found that the extent of the impact of poor air quality within office buildings can be as high as 6-9% on productivity levels.[82] Another recent study also linked the opening of air pollutant emitting industrial plants with increased rates of 'executive flight', whereby well-paid executives leave firms which are geographically close to offending industrial plants in favour of ones in less polluted areas.[83]

Second, poor air quality has detrimental financial impacts on the government. One study quantified the cost of air pollution to the NHS generated per car, which conveys the cost each driver has on the health

80. Royal College of Physicians and Royal College of Paediatrics and Child Health, "Every breath we take: the lifelong impact of air pollution", Royal College of Physicians and Royal College of Paediatrics and Child Health, "Every breath we take: the lifelong impact of air pollution", https://www.rcplondon.ac.uk/file/2916/download?token=5dnlDovZ (2016), 6.
81. David Birchby et al., "Valuing the impacts of air quality on productivity", https://uk-air.defra.gov.uk/assets/documents/reports/cat19/1511251135_140610_Valuing_the_impacts_of_air_quality_on_productivity_Final_Report_3_0.pdf (2014).
82. David Wyon, "The effects of indoor air quality on performance and productivity", https://www.researchgate.net/publication/8381114_The_effects_of_indoor_air_quality_on_performance_and_productivity (2004).
83. Ross Levin, Chen Lin and Zigan Wang, "Toxic emissions and executive migration", http://www.nber.org/papers/w24389#fromrss (2018).

and social care system in England. Each individual car is estimated to cost the NHS around £8,000 in London, and nationally the average cost to the NHS of a car across an assumed 14-year life span was £1,640 – varying between the fuel type of car.[84]

PHE's valuation of the cost of air pollution to the NHS was £42.88 million in 2017. It has been estimated that between 2017 and 2025, the total cost to the NHS and social care will be £5.56 billion for diseases with which there is a strong association of incidence with the combined effects of $PM_{2.5}$ and NO_2.[85]

Earlier this year, DEFRA attempted to calculate the damages generated by different air pollutants. Their analysis focused on the financial impact of the emission of different air pollutants. It provided a national monetary damage estimate for each pollutant per tonne emitted, at 2017 prices. This can be seen in Table 3.4 below.

Table 3.4. Costs of different air pollutants from the different damages they cause, by £ per tonne in 2017 prices

	NO_x	SO_2	NH_3	VOC	$PM_{2.5}$
$PM_{2.5}$ Chronic mortality	593	2,305	2,528	–	40,238
PM_{10} Respiratory hospital admission	5	16	19	–	393
PM_{10} Cardiovascular hospital admission	3	10	12	–	240
SO_2 Deaths brought forward	–	14	–	–	–
SO_2 Respiratory hospital admission	–	26	–	–	–
O_3 Deaths brought forward	-9	–	–	4	–
O_3 Respiratory hospital admission	-47	–	–	18	–

84. Ibid.
85. Laura Pimpin et al, "Estimating the costs of air pollution to the National Health Service and social care: An assessment and forecast up to 2035", https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6039053/ (2018).

O_3 Cardiovascular hospital admission	-4	–	–	2	–
NO_2 Chronic mortality	2,223	–	–	–	–
$PM_{2.5}$ Productivity	52	201	221	–	3,515
O_3 Productivity	-56	–	–	22	–
O_3 Material damage	-18	–	–	5	–
PM_{10} Building soiling	–	–	–	–	881
SO_2 Material damage	–	237	–	–	–
SO_2 Ecosystems	–	-6	–	–	–
O_3 Ecosystems	-18	–	–	11	–
O_3 Ecosystems	-19	–	–	40	–
NO_2 Ecosystems	63	–	–	–	–
NH_3 Ecosystems	–	–	-539	–	–
$PM_{2.5}$ CHD	417	1,620	1,777	–	28,282
$PM_{2.5}$ Stroke	157	610	669	–	10,642
$PM_{2.5}$ Lung Cancer	10	39	43	–	687
$PM_{2.5}$ Asthma (Children)	309	1,201	1,317	–	20,959
NO_2 Asthma (Small Children)	1,958	–	–	–	–
NO_2 Asthma (Older Children)	580	–	–	–	–
Total cost of each pollutant per tonne emitted	6,199	6,273	6,046	102	105,836

Source: Department for Environment, Food and Rural Affairs, "Impact pathways approach: Guidance for air quality appraisal", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770649/impact-pathway-approach-guidance.pdf (2019), 21

The highest estimated damages per tonne of air pollutant emitted exist for $PM_{2.5}$, whilst the lowest estimated damages are generated by VOCs. Two notably high financial costs generated per tonne of $PM_{2.5}$ emitted is for health costs related to chronic mortality at £40,238 per

tonne and chronic heart disease (CHD) at £28,282 per tonne. Likewise, for NO_x, two major costs per tonne are chronic mortality at £2,223 per tonne and asthma in small children at £1,958 per tonne.

Essentially, Table 3.4 above includes the costs associated with different health, economic and environmental outcomes for different air pollutants. The next section focuses on the impacts of air pollution on the environment.

Natural environment

Air pollution can have both a profound and varied effect on the natural environment. When NO_x and SO_2 emissions, for instance, go into the atmosphere, they can combine with water particles and eventually fall as acid rain.[86] This causes the eutrophication of watercourses, and the acidification of both watercourses and soils.[87] Soil acidification can make it harder for plants to take root and develop healthily, thus inhibiting the growth of a useful ally in the fight against cleaner air.[88] According to the latest government figures, acid deposition exceeded critical levels in 42% of sensitive habitats in the UK in 2015.

Nitrogen deposition, meanwhile, exceeded critical levels in 62% of sensitive habitats in 2015. Indeed, the deposition of nitrogen compounds has significant impacts upon wildflowers in Britain.[89] The deposition of these compounds as NO_x is caused in large part by road transport (especially diesel vehicles) in urban areas, as well as more generally from ammonia emissions from agriculture. When the nitrogen in the air becomes affixed in soils, it makes them much more fertile. Yet wildflowers flourish in nitrogen poorer soils, because they do not face competition from other species such as stinging nettles

86. Air Pollution, "What is acid rain?", http://www.air-quality.org.uk/01.php (2017b).
87. Conserve Energy Future, "What is air pollution?", https://www.conserve-energy-future.com/causes-effects-solutions-of-air-pollution.php (2017).
88. Forest Service, United States Department of Agriculture, "Acidification impacts", https://webcam.srs.fs.fed.us/pollutants/acidification/index.shtml (2017).
89. Michael McCarthy, "Air pollution doesn't just harm humans – it is destroying nature too", *The Guardian*, 1 June, 2017.

and brambles which prefer nitrogen rich soils.[90] Indeed, over a third of flowering plants prefer low-nutrient conditions.[91] Fewer wildflowers (in terms of both quantity and diversity) has pernicious consequences for organisms which rely on them, such as pollinators, which are a crucial ecosystem actor.[92]

There remains strong evidence that the deposition of nitrogen compounds has significantly reduced the number of plant species per unit area – or 'species richness' – in a range of habitats of high conservation value in the UK.[93] One national study found a decline in mean plant species number when there was increased nitrogen compound deposition, across a range of different habitats.[94]

Moreover, whilst NO_x emissions have fallen in recent decades, changes in atmospheric chemistry have meant that the rate of deposition has not proportionally declined with these reductions. Between 1990 and 2010, there was a 62% reduction in the emissions of NO_x in the UK but only a 23% reduction in the deposition of oxidised nitrogen.[95]

Much attention of late has been paid to the effect of 'microplastics' in marine environments.[96] Whilst drinking straws, coffee cups and

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90. Plantlife, "We need to talk about nitrogen", https://www.plantlife.org.uk/uk/our-work/campaigning-change/nitrogen (2018).
91. Plant Life, "We need to talk about nitrogen: The impact of atmospheric deposition on the UK's wild flora and fungi", https://www.plantlife.org.uk/application/files/1614/9086/5868/We_need_to_talk_Nitrogen_webpdf2.pdf (2017).
92. Michael McCarthy, "Air pollution doesn't just harm humans – it is destroying nature too", *The Guardian*, 1 June, 2017; Öckinger E, et al, "The relationship between local extinctions of grassland butterflies and increased soil nitrogen levels", http://planet.uwc.ac.za/nisl/Gwen%27s%20Files/Conservation%20Biology/Chapters/Info%20to%20Use/Ockinger_local_extinctions_butterflies.pdf (2006); Ceulemans T, et al, "Nutrient enrichment is associated with altered nectar and pollen chemical composition in Succisa pratensis Moench and increased larval mortality of its pollinator Bombus terrestris L.", https://journals.plos.org/plosone/article?id=10.1371/ (2017).
93. RoTAP, "Review of Transboundary Air Pollution: Acidification, Eutrophication, Ground Level Ozone and Heavy Metals", https://www.sciencedirect.com/science/article/pii/S0269749115300609#bib64 (2012).
94. Lindsay Maskell et al, "Nitrogen deposition causes widespread loss of species richness in British habitats", https://onlinelibrary.wiley.com/doi/full/10.1111/j.1365-2486.2009.02022.x (2010).
95. Ibid, 9.
96. National Oceanic and Atmospheric Administration, "What are microplastics?", https://oceanservice.noaa.gov/facts/microplastics.html (2018); Damian Carrington, "Microplastic pollution in oceans is far worse than feared, say scientists", *The Guardian*, 12 March, 2018; Graham Readfearn, "WHO launches review after microplastics found in 90% of bottled water", *The Guardian*, 15 March, 2018.

microbeads have garnered much focus from decision makers and opinion formers, air pollution in the form of PM is in fact a significant contributor to marine microplastic pollution.[97] Specifically, PM generated from tyre abrasion coming off cars, vans and other modes of transport makes up to an estimated one-tenth of all ocean microplastic pollution.[98] This is in comparison to plastic straws, which contribute just 0.03% of ocean plastic waste.[99]

Just as air pollution harms human health, many wild animals – particularly birds and mammals – are no more or less immune to the impacts of pollutants in the atmosphere.[100] In 2014, over 90% of sensitive wildlife habitats in England, Wales and Northern Ireland had excessive nitrogen levels.

Public attitudes to air pollution

The growing evidence based about the scale, sources and impact of air pollution have not gone unnoticed. Prompted, no doubt, in part by media coverage and campaigning, the public have become increasingly aware and concerned about air pollution.

Our polling tested whether the general public in the UK think that the current Government is doing enough to protect them and their family from air pollution. The results, as can be seen in Chart 3.4, should make difficult reading for the Conservative Government.

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97. Hannah Ritchie and Max Roser, "Plastic pollution", https://ourworldindata.org/plastic-pollution (2018); Leslie Hook, "Banning straws not enough to solve plastic pollution, May warned", *The Financial Times*, 21 April, 2018; Sarah Gibbens, "A brief history of how plastic straws took over the world", https://www.nationalgeographic.com/environment/2018/07/news-plastic-drinking-straw-history-ban/ (2018); Roger Harrabin, "Ministers question 'latte levy' on cups", https://www.bbc.co.uk/news/science-environment-43337571 (2018); Department for Environment, Food and Rural Affairs, "World leading microbeads ban comes into force", https://www.gov.uk/government/news/world-leading-microbeads-ban-comes-into-force (2018); Department for Environment, Food and Rural Affairs, "Clean Air Strategy 2018", https://consult.defra.gov.uk/environmental-quality/clean-air-strategy-consultation/supporting_documents/Clean%20Air%20Strategy%202018%20Consultation.pdf (2018), 32.

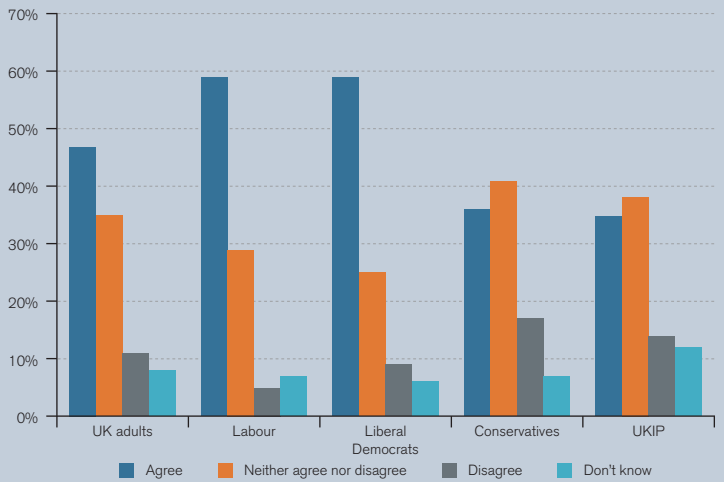
98. Pieter Jan Kole et al., "Wear and tear of tyres: a stealthy source of microplastics in the environment", *International Journal of Environmental Research and Public Health*, Vol. 14, No. 10 (2014), 1272.

99. Hannah Ritchie, "FAQs on plastics", https://ourworldindata.org/faq-on-plastics (2018).

100. James Newman, "Effects of industrial air pollution on wildlife", https://www.sciencedirect.com/science/article/pii/0006320779900399, *Biological Conservation*, Vol. 15, Iss. 3 (1979), 181-190.

Across the UK, slightly less than half (47%) of the general public think enough is not being done, with only 11% disagreeing – in effect believing that the current course of action being undertaken by the Government is sufficient.

Chart 3.4. Percentage of respondents who think the Government is not doing enough to protect them and their family from air pollution, by 2017 General Election vote

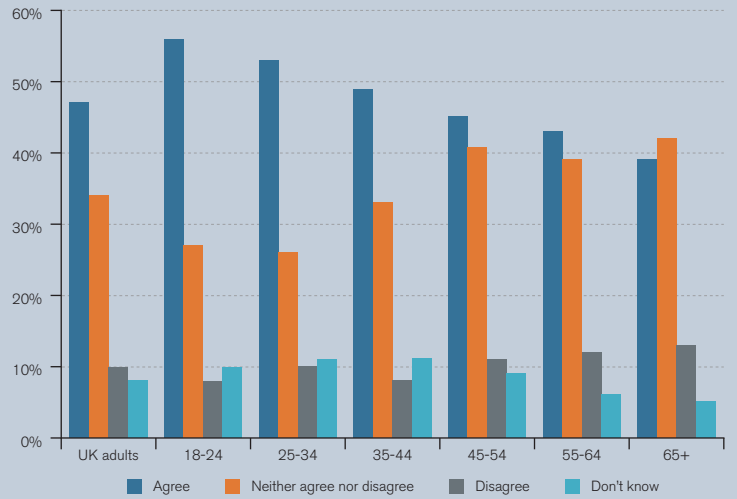


Base: 3,896 UK adults

As might be expected, those who voted for parties other than the Conservatives in the 2017 General Election are typically of the opinion that the Government is not doing enough, relative to the average member of the general public. Labour and Liberal Democrat voters lead the way, with 59% of each party thinking that not enough is being done. Yet, even amongst those who voted for the Conservatives, still 36% think that the Government is not doing enough to protect themselves and their family from air pollution.

It is also interesting to see these results broken down by age, as illustrated in Chart 3.5 below.

Chart 3.5. Percentage of respondents who think the Government is not doing enough to protect them and their family from air pollution, by age

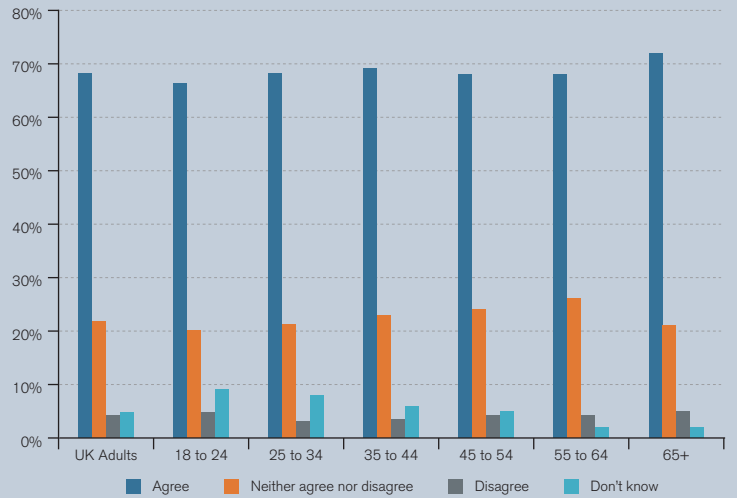


Base: 4,007 UK adults

From Chart 3.5, it can be seen that the younger a respondent is, the less likely they are to think that the Government is doing enough to protect themselves and their family from air pollution. At 56%, a majority of those aged 18-24 years old think that not enough is being done, compared to just 39% of those aged 65 years old or over.

Having established that nearly half of UK adults think the current Government are not doing enough to protect them and their family from air pollution, we tested whether the UK public wanted to reduce air pollution below current levels. They conclusively do, as Chart 3.6 below demonstrates.

Chart 3.6. Percentage of respondents who think the government should reduce air pollution below its current levels, by age



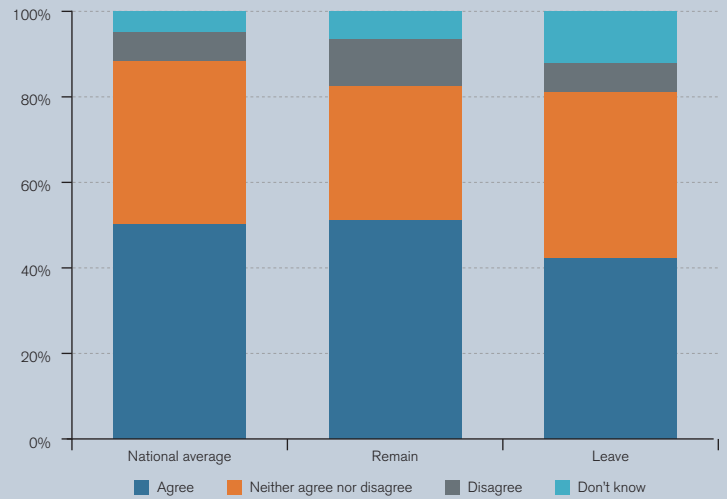
Base: 4,007 UK adults

Across the UK as a whole, a clear majority (69%) of adults agree that the Government should reduce air pollution below current levels. Only 4% disagreed. Generally, more young people strongly agreed that air pollution should be reduced below current levels, and the proportion of respondents providing this response decreased as age increased. This did not mean older people disagreed. Rather, as shown in Chart 3.6 above, older age brackets had a much higher proportion of somewhat agreeing with the statement posed. Clearly, then, the UK public think that the government should reduce air pollution below current levels – with younger voters agreeing with this principal more strongly than older votes.

Considering the UK's imminent departure from the EU, we also tested whether UK adults thought the UK should have cleaner air than other EU countries. As illustrated by Chart 3.7 below, roughly

half (49%) of UK adults believe the UK should have cleaner air, and only 9% thought the UK should not. Interestingly, Remain voters were slightly more likely to believe the UK should have cleaner air than other EU countries (56%), whereas Leave voters were less likely to agree (44%).

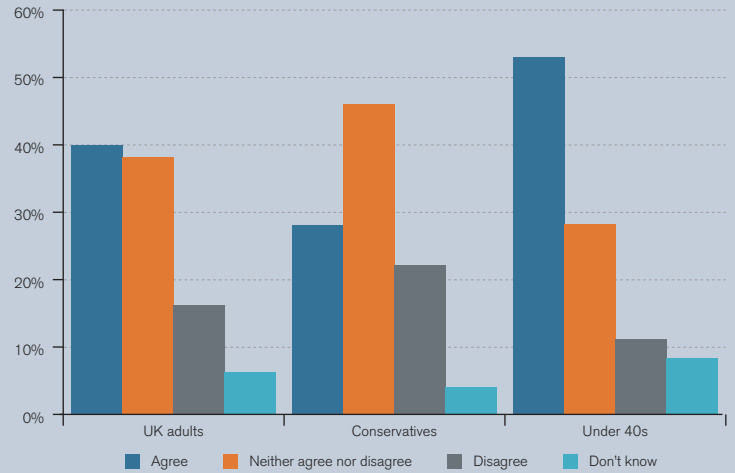
Chart 3.7. Percentage of respondents who think the UK should have cleaner air than other EU countries, by 2016 EU Referendum vote



Base: 4,007 UK adults

We were also interested to test the importance which voters attached to air pollution when casting their ballots. Chart 3.8 below shows whether respondents agree or disagree with the statement that they would be more likely to vote for a party which pledges to cut air pollution.

Chart 3.8. Percentage of respondents who would be more likely to vote for a party which pledges to cut air pollution, by age and 2017 General Election vote



Base: 4,007 UK adults

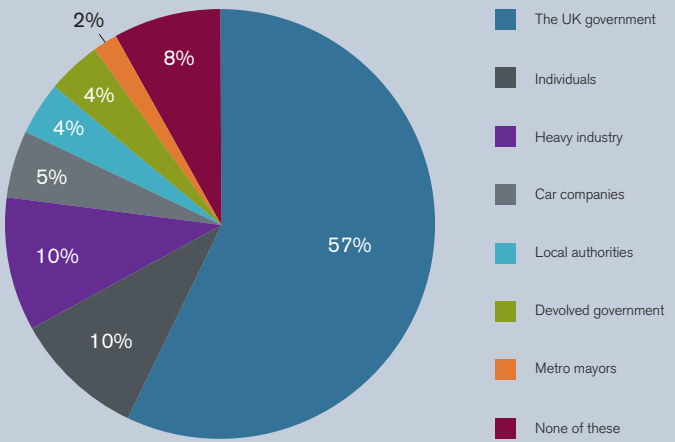
Amongst the general public, a significant minority (40%) agree that they would be more likely to vote for a political party which pledges to cut air pollution. With Conservative voters, less are likely to agree (28%), with more opting for either 'neither agree nor disagree' (46%) or disagreeing entirely (22%). Amongst those aged under 40, the opposite is true. Here, a majority of under 40s reported that they agree that they are more likely to vote for a party which pledges to cut air pollution (52%), and only 11% disagreed that they would be more likely to.

Reducing air pollution is clearly an important priority for the majority of voters, especially younger ones. But we also wanted to test who the public think has the most responsibility for reducing air pollution.

Truthfully, reducing air pollution will likely need to be addressed by several different actors – drawn from both public and private spheres.

We tested who respondents thought should be most responsible for tackling the UK's air pollution, as can be seen in Chart 3.9 below.

Chart 3.9. Who respondents think should be most responsible for tackling air pollution, UK adults



Base: 4,007 adults

A clear answer to this question was given. Fifty-seven percent of respondents believe that the UK Government should be most responsible for tackling air pollution, which polled nearly six times larger than the next most popular options of 'individuals' and 'heavy industry' (each 10%). However, as our polling only enquired about who respondents think should take primary responsibility for tackling air pollution, this is not to say that they do not believe other actors should be responsible, too.

Just 4% of UK adults believe that local authorities should be most responsible for tackling air pollution, despite the fact that a lot of responsibility on doing so is currently devolved to local authorities. We focused on the role of local authorities in managing air pollution in our

last report, *Clearing the air: reducing air pollution in the West Midlands*. In this paper, we examine the role of national government, which the public clearly believe has the primary role for tackling air pollution.

Conclusion

So far, the scale, sources and impacts of air pollution in the UK have been outlined in this report. As our polling shows, the public are very concerned about it. The majority of the UK public want the UK Government to do more to reduce current levels of air pollution. And it is the national UK Government that the public believe has the primary responsibility to reduce air pollution.

The next chapter examines the past and current legislation and policies on transport from national government to reduce air pollution. It also explores historical and future technological developments in transport that could reduce air pollution, especially from NO_2.

Chapter 4: Transport policies and technologies for reducing air pollution

Chapter Three outlined the sources and impacts of air pollution on a national scale in the UK. It also revealed the extent of concern about air pollution among the UK public.

In this chapter, we detail historical and current policies of national government on air pollution, especially in regards to transport. This chapter also looks at the past and current technological developments in transport to support cleaner air.

History of UK government action on air pollution

There have been rules and regulations on air pollution in the UK for centuries. In the thirteenth century, the burning of coal was prohibited in London on health grounds.[101] During the Industrial Revolution in the nineteenth century, the Town Improvement Clauses Act 1847 stipulated that any future furnace must "consume the smoke arising from the combustibles used in [it]".[102] Failure to comply was punishable with a fine of 40 shillings for each day the furnace was used illegally.[103]

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101. Parliamentary Office of Science and Technology, "Air quality in the UK", https://www.parliament.uk/documents/post/pn188.pdf (2002); Air Pollution, "History of air pollution in the UK", http://www.air-quality.org.uk/02.php (2018).
102. Town Improvement Clauses Act 1847, *c.* 34. See: http://www.legislation.gov.uk/ukpga/1847/34/pdfs/ukpga_18470034_en.pdf.
103. Ibid.

Following the 'Great Smog' which afflicted London in 1952, killing an estimated 12,000 people,[104] the Clean Air Act 1956,[105] passed by a Conservative Government, was introduced. This Act aimed to control domestic sources of air pollution through 'smoke control areas', in which only smokeless fuels could legally be burnt through chimneys.[106] Nowadays, smoke control areas cover many of the UK's major cities.[107] A follow-up Clean Air Act was passed in 1968 which regulated the minimum heights of chimneys, so that air pollution was released further from the ground.[108] Both Acts were then consolidated in the Clean Air Act 1993.[109]

The Clean Air Act 1993 sought to control levels and sources of air pollution. For example, it mandated local authorities to apply and supervise measures such as controlling dark smoke, approving new non-residential furnaces, and designating and monitoring smoke control areas.[110]

Two years after the Clean Air Act 1993 received its royal assent, the Environment Act 1995 was passed.[111] Part IV of the Environment Act 1995 and Part II of the Environment (Northern Ireland) Order

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104. Michelle L. Bell, Devra L. Davis and Tony Fletcher, "A retrospective assessment of mortality from the London smog episode of 1952: the role of influenza and pollution", *Environmental Health Perspectives*, Vol. 112, No. 1 (2004), 6-8.
105. Clean Air Act 1956, *Ch*. 52. See: http://www.legislation.gov.uk/ukpga/1956/52/pdfs/ukpga_19560052_en.pdf.
106. Air Pollution, "Changing air quality and Clean Air Acts", http://www.air-quality.org.uk/03.php (2018).
107. Mayor of London, "Guidance for wood burning stoves in London", https://www.london.gov.uk/what-we-do/environment/pollution-and-air-quality/guidance-wood-burning-stoves-london (2018); Manchester City Council, "Smokeless fuel (wood burning stove or oil fired cooker)", https://secure.manchester.gov.uk/info/100006/environmental_problems/2836/smoke_and_fire/6 (2018); Birmingham City Council, "What is Birmingham doing about air pollution", https://www.birmingham.gov.uk/info/20076/pollution/1280/what_is_birmingham_doing_about_air_pollution/5 (2018).
108. Clean Air Act 1968, *Ch*. 62. See: https://www.legislation.gov.uk/ukpga/1968/62/pdfs/ukpga_19680062_en.pdf.
109. Clean Air Act 1993, *Ch*. 11. See: http://www.legislation.gov.uk/ukpga/1993/11/pdfs/ukpga_19930011_en.pdf.
110. Department for Environment, Food and Rural Affairs, "Assessment of the effectiveness of measures under the Clean Air Act 1993", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/183198/20072012-AEA-Report-CAA.pdf (2012).
111. Environment Act 1995, *Ch*. 25. See: https://www.legislation.gov.uk/ukpga/1995/25/pdfs/ukpga_19950025_en.pdf.

2002 requires local authorities to carry out reviews and assessments of air quality in their area.[112] When a review identifies an exceedance of any given pollutant, the offending local authority must declare an 'Air Quality Management Area' (AQMA) and draw up an Action Plan to address the issue.[113] Also, the local authority is required to provide Air Quality Annual Status Reports (AQASRs) which detail progress on addressing air pollution. As of the beginning of 2019, 69% of local authorities have one or more AQMAs, the vast majority of which are for NO_2 concentrations.[114] However, local authorities are not obliged to meet the objectives which they set in Action Plans.[115] The start of 2019 saw a total of 556 AQMAs having been declared in England, but only 166 of these have been revoked since and some have been active since 2001.[116]

Current Government action on air pollution

As already outlined in Chapter One, the UK's current legal limits and targets on air pollution stem mainly from the EU. Achieving compliance with legislation on air pollution in England is the responsibility of DEFRA, which also has a coordinating role for the rest of the UK.[117] Annex XI of EU Directive 2008/50/EC set out dates by which the limits for different air pollutants, as detailed in Table 1.3 earlier, had to be met.[118] Provisions were made available in

112. Environment Act 1995, *Ch*. 25. See: https://www.legislation.gov.uk/ukpga/1995/25/pdfs/ukpga_19950025_en.pdf.
113. Department for Environment, Food and Rural Affairs, "Air pollution in the UK 2016", https://uk-air.defra.gov.uk/library/annualreport/viewonline?year=2016_issue_2 (2017), 14.
114. Department for Environment, Food and Rural Affairs, "Clean Air Strategy 2019", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf (2019), 76.
115. Environmental Protection UK, "Air Quality Strategy", http://www.environmental-protection.org.uk/policy-areas/air-quality/air-pollution-law-and-policy/air-quality-policy/ (2018).
116. Department for Environment, Food and Rural Affairs, "Clean Air Strategy 2019", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf (2019), 76.
117. Department for Environment, Food and Rural Affairs, "UK and EU air quality policy context", https://uk-air.defra.gov.uk/air-pollution/uk-eu-policy-context (2019).
118. Department for Environment, Food and Rural Affairs, "Air pollution in the UK 2017", https://uk-air.defra.gov.uk/library/annualreport/viewonline?year=2017_issue_1#report_pdf (2018), 40.

Directive 2008/50/EC to allow EU member states to apply for time extensions where they were not going to meet limit values, provided that credible and workable emission reduction plans were also drawn up.[119]

According to the government's latest *Air Quality in the UK* report, the UK is compliant with all legal limits, apart from for NO_2. Of the forty-three zones that the UK is divided into for reporting purposes, two zones exceeded the hourly mean limit values for NO_2 in 2017. However, for the annual mean limit for NO_2, 37 of 43 zones were non-compliant in 2017.

Box 4.1. Is the UK compliant with legal ceilings and targets on air pollution?

Although the UK is compliant with all legal limits on different air pollutants, apart from for NO_2, the story is different for targets and ceilings.

For instance, three zones exceeded the legal target for $C_{20}H_{12}$, whilst all zones were compliant for the target values for As, Cd and Ni.[120]

As elaborated in Chapter One, the UK has separate ceilings for the total emissions of – as opposed to the annual mean concentrations of – air pollutants. For these ceilings, the UK has been compliant for all air pollutants apart from NO_x, which it exceeded the legal 'ceiling' for in 2010 and 2012. Nevertheless, following an application to change how the UK's annual emission total was calculated, the total emissions for NO_x were brought into compliance for 2010.[121]

119. Louise Smith, "Brexit and air quality", https://researchbriefings.parliament.uk/ResearchBriefing/Summary/CBP-8195 (2018), 16.
120. Department for Environment, Food and Rural Affairs, "Air pollution in the UK 2017", https://uk-air.defra.gov.uk/assets/documents/annualreport/air_pollution_uk_2017_issue_1.pdf (2018), iii, iv.
121. Department for Environment, Food and Rural Affairs, "Emissions of air pollutants, 1970 to 2017" https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/778483/Emissions_of_air_pollutants_1990_2017.pdf (2019); The UK successfully updated it's emissions inventory for 2017 as allowed under the Gothenburg Protocol, which led to the updated annual emissions total for NO_x.

Over the past decade, the UK Government has been challenged by ClientEarth, an environmental law charity, in the courts on non-compliance with the legal limits on NO_2.

In 2010, 40 of the 43 reporting zones failed to meet legal limits for NO_2. As such, the UK Government needed to apply for time extensions by producing plans to show how it would meet legal limits in the shortest time possible and no later than 2015. However, for 16 of the non-compliant zones, the UK Government decided against applying for extensions on the grounds that it would be too difficult for these to comply even by 2015. According to DEFRA's projections, these zones would not come into compliance until at least 2020, and 2025 in the case of the Greater London urban area.

ClientEarth argued that this was not the correct interpretation of the 2008 Ambient Air Quality Directive and that the UK Government was obliged to produce plans that outlined the action it would take to meet legal limits on NO_2 in the shortest time possible. In light of this, in 2011, ClientEarth issued judicial review proceedings against the UK Government in the UK High Court. While the Court acknowledged that the Government was in breach of its duty to achieve the NO_2 limits, it declined to make any formal declaration or grant any remedy for that breach. The High Court did not see itself as having a role in enforcing the 2008 Ambient Air Quality Directive and that instead this was a matter for the European Commission and the Court of Justice of the European Union (the 'CJEU'). ClientEarth appealed to the UK Court of Appeal in May 2012, but again this Court declined to award any remedy.

So, ClientEarth decided to launch a further appeal to the UK Supreme Court in 2013. This Court made a formal declaration that the UK was in breach of its duty to achieve NO_2 limits. However, before deciding whether any further remedy was needed, the UK Supreme Court referred several questions to the CJEU concerning the correct interpretation of the 2008 Ambient Air Quality Directive

and the role of national courts.[122]

Following the referral from the UK Supreme Court, in 2014 the CJEU ruled that national courts were obliged to provide a remedy where air pollutant limits were breached. While national courts could determine exactly what kind of remedies to grant, including mandatory orders, they must at least ensure that the responsible authorities establish a plan that meets the requirements of the 2008 Ambient Air Quality Directive. It would also be up to national courts to scrutinise plans to ensure that they were adequate for this purpose.

As such, in April 2015, the case returned to the UK Supreme Court. A week before the 2015 General Election, the Supreme Court unanimously ruled in favour of ClientEarth and ordered the UK Government to prepare new air quality plans for the 16 zones originally named in the case by the end of 2015.

In December 2015, DEFRA published a new 'Air Quality Plan' (AQP) for the UK as a consequence of the Supreme Court ruling. This AQP was not just for the 16 original zones, but also for a further 22 zones that were still breaching limits despite DEFRA having previously produced different indicative plans to bring them into compliance by 2015. The key result of this 2015 AQP was that five English local authorities (Birmingham, Derby, Leeds, Nottingham and Southampton – now referred to as the 'first wave') were required to implement Clean Air Zones (CAZs)[123] by 2020, and additional action was also required in Greater London.

ClientEarth, however, deemed that the 2015 AQP was woefully inadequate and brought a fresh judicial review against the UK Government in the UK High Court. The key issues raised were that DEFRA had used overoptimistic emission factors for diesel vehicles to model the impact

122. Infocuria, "Reference for a preliminary ruling from Supreme Court of the United Kingdom (United Kingdom) made on 16 July 2013 – R on the application of ClientEarth v Secretary of State for the Environment, Food and Rural Affairs" http://curia.europa.eu/juris/document/document.jsf?docid=140698&mode=req&pageIndex=1&dir=&occ=first&part=1&text=&doclang=EN&cid=190454 (2013).
123. CAZs are areas where vehicles are restricted from entering if they do not meet minimum standards for emissions of air pollutants. Non-compliant vehicles can either be charged to enter the CAZ or banned from entering altogether.

of the 2015 AQP, an issue highlighted by the 'Dieselgate' scandal, where in 2015 the German automaker Volkswagen Group were found to have programmed certain diesel cars to detect and subvert laboratory emissions tests. ClientEarth argued that arbitrary dates were set for compliance by only modelling projections in 5-yearly intervals. The hearing also revealed how HM Treasury had sought to dilute the 2015 AQP.

In November 2016, the High Court held that the 2015 AQP was unlawful, and ordered the UK Government to publish a modified AQP by July 2017. In its judgment, the High Court clarified that AQPs must: aim to achieve compliance by the soonest date possible by a route which reduces exposure as quickly as possible, and ensures that meeting the value limits is not just possible, but likely.

The UK High Court also noted that the determining factor for selecting measures to include in AQPs had to be their efficacy. Factors such as cost and political considerations could only be secondary.

In response, the UK Government published a revised AQP in July 2017. This highlighted that 81 local authorities in the UK had been identified through its national air quality modelling as having road links that breached legal limits of NO_2.

However, it only required a further 23 English local authorities (referred to as the 'second wave'), in addition to the 'first wave', to produce final action plans by the end of 2018 for approval by the Secretary of State. Despite the UK Government's own evidence indicating that implementing CAZs is likely to be the quickest route to compliance, these local authorities were asked to first spend time considering whether there were other equally effective options that did not involve CAZs.

In ClientEarth's view, the 2017 AQP did not meet the legal tests as set out by the UK High Court in its 2016 ruling. So, in October 2017, ClientEarth launched a third judicial review.

The key concerns that ClientEarth had were that the 2017 AQP did not require formal action to be taken in 45 additional English local authorities that had been identified as breaching legal NO_2 limit values until as late as 2021. The Government's reasoning was that no further action was

needed as CAZs would take three years to implement, by which time these local authorities would have naturally complied. By doing this, the Government had failed to require these local authorities to consider how compliance might be brought forward by other means. In addition, the 2017 AQP also failed to set out in any detail how illegal levels of NO_2 in Wales would be addressed. Finally, whilst both the 2015 and 2017 AQPs stated that the 'first wave' of local authorities were expected to deliver CAZs by the end of 2019, the UK Government had not imposed any formal requirement for these cities to produce proposals.

In the run up to the 2017 High Court hearing, the Secretary of State for Environment, Food and Rural Affairs formally directed the five 'first wave' local authorities to produce final 'Full Business Cases' by 15 September 2018, setting out their preferred option for achieving compliance in the shortest possible time, thereby addressing ClientEarth's concerns.

In February 2018, the High Court again declared the 2017 AQP unlawful. The High Court granted a mandatory order requiring the production of a Supplement to the 2017 AQP by October 2018, setting out how NO_2 exceedances would be addressed in an additional 33 English local authorities projected to achieve compliance between 2019 and 2021 (referred to as the 'third wave').

Welsh Ministers of the UK Government also undertook to the UK High Court to produce a Welsh Supplementary Air Quality Plan by 31 July 2018.

After the 2018 High Court ruling, the Secretary of State for Environment, Food and Rural Affairs issued ministerial directions to the 'third wave' local authorities, which required each to identify options for achieving compliance in their area. The measures identified by these authorities informed the Supplemental Plan published by Government in October 2018. Notably, it identified eight English local authorities, including Bolsover, Broxbourne, Bradford, Leicester, Liverpool, Newcastle-under-Lyme, Portsmouth, and Stoke-on-Trent, where additional evidence revealed compliance with NO_2 limits would not be achieved until much later than originally indicated in the 2017 AQP. Further ministerial directions were issued to these eight local authorities to submit Final Plans by 31 October 2019.

Local authorities are under a statutory duty to comply with the terms of the ministerial directions issued to them by the Secretary of State for Environment, Food and Rural Affairs. If a local authority fails to meet its respective deadline, it will be in breach of this duty.

A number of local authorities have failed to meet the deadlines for submission of final proposals. For example, neither Derby nor Southampton City Councils met the 15 September 2018 deadline for submission of their Full Business Cases and have now been granted extensions. A large proportion of the 'second wave' local authorities directed to submit final plans by 31 December 2018 have also missed their deadline, including Bristol City Council and Bath and North East Somerset Council, with many now aiming to finalise their proposals months later than legally required.

New Government policies to reduce air pollution

The legal pressure just described, coupled with growing public awareness and media campaigning[124], has prompted the UK Government to recently produce separate plans and policies for tackling air pollution, especially for the pollutant NO_2. The latest plans are outlined in the *Clean Air Strategy 2019*, and the Government has indicated that it intends to introduce the Environment Bill soon.

Box 4.2. The impact of the Draft Environment (Principles and Governance) Bill on air pollution policy.

In December 2018, the Government published the Draft Environment (Principles and Governance) Bill, a precursor to the Environment Bill.[125] It establishes a new independent governance

124. The Times, "The Times air pollution campaign: Our manifesto for clean air", https://www.thetimes.co.uk/article/campaign-for-change-our-manifesto-to-tackle-air-pollution-2m82vsvs6 (2019)
125. Department for Environment, Food and Rural Affairs, "Draft Environment (Principles and Governance) Bill", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/766849/draft-environment-bill-governance-principles.pdf (2019), 3.

body, the Office for Environmental Protection (OEP), to make sure environmental standards are being met in the future by holding the Government and public bodies to account.[126] Informally, this body has been referred to as the "Green Watchdog".[127] Its creation is intended to replace the scrutiny and enforcement of environmental law that is currently performed by the European Commission, that can take national governments to the Court of Justice of the European Union (CJEU) if environmental regulations are breached.

The Draft Environment (Principles and Governance) Bill details what the OEP's remit will be.[128] It includes policy areas that will be within the OEP's remit: water resources and quality, marine, coastal and nature conservation; waste management; pollution; contaminated land; and, finally and most relevant, air quality.

Also incorporated in the Draft Environment (Principles and Governance) Bill are a set of environmental principles that will be enshrined in law and that policy makers will need to "have regard to" when making policy.[129] It also proposes establishing regular five-yearly reviews and reporting towards the progress

126. Department for Environment, Food and Rural Affairs, "Draft Environment (Principles and Governance) Bill", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/766849/draft-environment-bill-governance-principles.pdf (2019).
127. Damian Carrington, "Post-Brexit green watchdog could sue ministers, says Gove", https://www.theguardian.com/environment/2018/dec/19/post-brexit-green-watchdog-could-sue-ministers-says-gove (2018).
128. Department for Environment, Food and Rural Affairs, "Draft Environment (Principles and Governance) Bill", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/766849/draft-environment-bill-governance-principles.pdf (2019), Paragraph 211.
129. Department for Environment, Food and Rural Affairs, "Draft Environment (Principles and Governance) Bill", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/766849/draft-environment-bill-governance-principles.pdf (2019), 9. The nine environmental principles are: the precautionary principle; the prevention principle; the rectification at source principle; the polluter pays principle; the sustainable development principle; the integration principle; the public access to environmental information principle; the public participation in environmental decision-making principle; and, the access to justice principle.

of the goals set out in the government's 25-year Environment Plan statutory.[130]

On top of the Draft Environment (Principles and Governance) Bill outlined in Box 4.2 above, the former Prime Minister Theresa May confirmed in her evidence to the Liaison Committee in July 2018 that air quality would be part of the forthcoming Environment Bill. In addition, in a major speech on the environment in July 2019, the former Environment Secretary Michael Gove set out his vision for a legally-binding commitment to improving air quality. Later in July, the Government made a number of policy announcements on what the forthcoming Environment Bill would contain, including on air quality.

On top of the proposals in the Draft (Principles and Governance) Environment Bill, the Government published its *Clean Air Strategy* (CAS) earlier this year which sets out how national Government further plans to tackle air pollution.

The CAS outlines that the Government has committed to halving the number of people living in areas with an annual mean concentration of $PM_{2.5}$ of 10μg/m^3 by 2025 – as recommended by the World Health Organisation (WHO). Notably, the Government published evidence earlier in 2019 on what actions would be needed to fully meet the WHO limit for $PM_{2.5}$ – concluding it was "technically feasible" but required further analysis to gauge it's economic and practical feasibility.[131] The CAS also mentions the Government will in 2022 review whether adopting more challenging milestones towards WHO limits is will be feasible.[132]

The CAS details the intentions of the Government to incentivise

130. Ibid, 10.
131. Department for Environment, Food and Rural Affairs, "Environment Bill summer policy statement: July 2019", https://www.gov.uk/government/publications/draft-environment-principles-and-governance-bill-2018/environment-bill-summer-policy-statement-july-2019 (2019).
132. Department for Environment, Food and Rural Affairs, "Clean Air Strategy 2019", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf (2019), 31.

greater accountability at "the right tier of the local government structure" on air pollution. Policies proposed to encourage local leadership in this regard include:

- The creation of the 'lead authority' concept, where requirements will be placed on neighbouring local authorities and public bodies to work collectively to reduce the emission of air pollutants.
- Requiring local authorities to produce an action plan to reduce population exposure during an 'Air Pollution Episode', which is when air pollution is abnormally high for a period of time.
- Developing further guidance for local authorities on the interrelation of Smoke Control Areas, Air Quality Management Areas and Clean Air Zones. This will provide local authorities with a greater idea of how to use them to tackle local air pollution.
- Whilst no details are given, the CAS states existing local authority powers will be strengthened, and where appropriate new ones introduced, to aid in reducing local air pollution.
- The Local Area Quality Management (LAQM) system, as detailed earlier in this chapter, requires action to be taken once legal limits on air pollutants are exceeded. The Government states it will shift the focus to prevention of exceeding limits, rather than reacting once they are broken, although no specific details are included in the CAS as to this ambition.

The CAS states that the government will continue to support local authorities in their managing of air pollution. Currently, the Government provides support to local authorities to develop air quality plans through the *Clean Air Zone Framework*, that was developed in 2017 and provides non-statutory guidance in relation to implementing Clean Air Zones. It should be highlighted that there is also statutory guidance on how to manage Air Quality Management Areas (AQMAs)

and a National Air Quality Strategy, both of which local authorities must have regard to.[133]

The CAS also includes notable policies that will aid in the dissemination of information about air pollution between government departments, regulators and local authorities, and to the public. The key policies included in the CAS 2019 as to the communication of air pollution information are:

- The Government will invest £10 million into improving their modelling, data and analytical tools available to analyse air pollution data. This will aid in understanding current and future air quality, as well as testing the effectiveness of policies in generating reductions in the emission of air pollutants.
- The Government will develop a personalised air quality messaging system, particularly for those vulnerable to air pollution like the elderly and sufferers of respiratory conditions, about the air quality forecast and associated medical advice.
- To increase the transparency of the UK's data on air pollution, the Government will centralise local and national data in a single, accessible portal on air quality monitoring and modelling.

Transport policies from government

Table 4.1 outlines the most recent policies announced by the UK Government to reduce air pollution in the transport sector.

133. Department for Environment, Food and Rural Affairs, "National air quality objectives", https://uk-air.defra.gov.uk/assets/documents/National_air_quality_objectives.pdf (2019).

Table 4.1. Policies introduced by the current UK Government since 2017 to reduce air pollution in the transport sector

Name	Date	Policies
The UK Plan for tackling roadside nitrogen dioxide concentrations[134]	July 2017	• Ending the sale of all new conventional petrol and diesel cars and vans by 2040. • Creating the Implementation Fund of £255 million, to provide financial support to local authorities to prepare and deliver air quality plans to reduce local air quality issues. • Establishing a Clean Air Fund of £220 million to further aid local authorities in implementing air pollution abatement measures. • Committing £100 million for the retrofitting of existing buses and purchase of new low emission buses • Creating the Vehicle Market Surveillance Unit to increase checks carried out on emission standards of vehicles. This is due to the exposing of cheating software installed in some cars following the 2015 'Diesel-gate' scandal.
The Cycling and Walking Investment Strategy[135]	October 2017	• £50 million for the Bikeability scheme that provides children with training on cycling proficiency. • £101 million to deliver the pre-existing Cycle City Ambition scheme in full that provides funding to eight cities currently to invest in cycling infrastructure. • £85 million for Highways England to make improvements to 200 sections of the road network in England for cyclists. • £80 million through the Access Fund that funds cycling and walking schemes on a local authority scale.
The Clean growth strategy: Leading the way to a low carbon future[136]	October 2017	• Provided up to £20 million to support new clean technology early stage investment, including in the transport sector. • Investing £1 billion to support the take-up of ultra-low emission vehicles (ULEVs), primarily through grants to overcome the upfront costs for consumers. • Accelerating the uptake of low-emission taxis through £50 million for the Plug-in Taxi programme, giving drivers up to £7,500 off the purchase prices of new ULEV vehicles, as well as £100 million for a national programme of support for retrofitting buses and buying new low emission ones. • Investing £841 million of public funds in low carbon transport technology and fuels

134. Department for Environment, Food and Rural Affairs and Department for Transport, "UK Plan for tackling roadside nitrogen dioxide concentrations", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/633269/air-quality-plan-overview.pdf (2017).
135. Source: Department for Transport, "Cycling and walking investment strategy", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/603527/cycling-walking-investment-strategy.pdf (2017).
136. HM Gov, "The clean growth strategy: Leading the way to a low carbon future", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf (2017).

The Industrial Strategy: Building a Britain fit for the future[137]	November 2017	• £400 million for EV charging infrastructure investment • £100 million to extend the Plug-in car grant scheme beyond 2020. • A number of the Industrial Strategy Challenge Fund programmes, which are designed to provide money to projects that meet specified goals of the Industrial Strategy, have beneficial impacts for air quality. The CAS names the Transforming Food Production and the Transforming Construction fund as particularly impactful on air quality.
The Road to Zero: Next steps towards cleaner road transport and delivering our Industrial Strategy[138]	July 2018	• Extending the Clean Vehicle Retrofit Accreditation Scheme (CVRAS), a certification scheme for companies that retrofit vehicles to be compliant with CAZs, from buses, coaches and HGVs to include vans and black cabs. • Maintaining the ambition of current EU vehicle emissions regulations • Continuing to offer grants for plug-in cars, vans, taxis and motorcycles until at least 2020. Plug-in car and van rates were maintained until October 2020. • Ensuring 25% of the central Government car fleet is ultra-low emission by 2022, and that all new car purchases meet this criteria so that by 2030 100% of the central Government fleet is ultra-low emission by 2030. • Committed to launching a joint research project with Highways England to identify and assess zero emission technologies for HGVs. • Working with industry to develop ultra-low emission standards for trucks. • Providing £246 million for battery technology innovation through the Faraday Battery Challenge, a fund for projects that research new battery technologies or scale-up and advance the existing production, use and recycling of batteries. • Working with the Office of National Statistics to extend data collection to include jobs and exports attributable to both low and ultra-low emission vehicle technologies. • Launching a £400 million Charing Infrastructure Fund to accelerate EV charging infrastructure deployment • Continuing the Electric Vehicle Homecharge Scheme (EVHS), that provides £500 off of the purchase and installation costs of home charging EV infrastructure, until March 2019. • Increasing the grant level of the Workplace Charging Scheme, that provides subsidies for installing EV infrastructure in places of work, from £300 per socket to 75% of the purchase and installation costs of a chargepoint capped up to £500. • Making available at least £6 million to support local authorities in rolling out dedicated taxi charging EV infrastructure

137. HM Gov, "Industrial strategy: Building a Britain fit for the future", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/664563/industrial-strategy-white-paper-web-ready-version.pdf (2017).
138. HM Gov, "The road to zero: Next steps towards cleaner road transport and delivering our Industrial Strategy", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/739460/road-to-zero.pdf (2018).

The Automated and Electric Vehicles Act 2018[139]	July 2018	• Ensures motorway services will be upgraded with EV charging stations. • Provides Mayors with powers to request EV infrastructure be built in petrol stations. • Standardises pubic chargepoints to make sure they are compatible with all new electric vehicles. • Standardises how EV infrastructure is paid for. • Sets standards for the reliability of EV charging infrastructure.
Clean Air Strategy 2019[140]	January 2019	• Through the United Nations Economic Council (UNECE), the Government will continue to work internationally to develop new regulations to manage the emission of PM from tyre and brake wear. • DEFRA will publish a Call for Evidence to standardise environmental regulations for all shipping vessels operating domestically in the UK, as some vessels are not subject to existing regulations. • The Government will consult on extending to the Irish Sea the Emissions Control Areas (ECAs), that cover the North and Baltic seas and restrict the permitted emissions of NO_x and SO_x. This would mean that all UK territorial waters are covered by ECAs. • The Government will publish guidance for ports to develop Air Quality Strategies. Following the publication of this, ports within scope of the publication will be required to create Air Quality Strategies by the end of 2019. • The Government has asked the rail industry to create a taskforce to produce a roadmap on removing all diesel-only trains by 2040. • The Government is supporting alternative fuels that are cleaner than diesel or petrol – mainly hydrogen fuel cells – through various research projects. • The Government is sponsoring an independent assessment of air quality in enclosed railway stations, due to concerns these stations have higher levels of air pollution from lower ventilation. • DEFRA is currently implementing more stringent emissions standards that will be applied across new non-road mobile machinery (NRMM) engines from 2019 – effectively bringing down emissions within the existing NRMM fleet. • The Government will introduce legislation to enable the Secretary of State for Transport to compel manufacturers to recall NRMMs and vehicles that experience failures in their emissions control systems.

Most recently, the Government published a policy statement on the Environment Bill,[141] advocating:

139. Automated and Electric Vehicles Act 2018, https://services.parliament.uk/bills/2017-19/automatedandelectricvehicles.html (2018).
140. Department for Environment, Food and Rural Affairs, "Clean Air Strategy 2019", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/cleanair-strategy-2019.pdf (2019)
141. Department for Environment, Food and Rural Affairs, "Environment Bill summary policy update: July 2019", https://www.gov.uk/government/publications/draft-environment-principles-and-governance-bill-2018/environment-bill-summer-policy-statement-july-2019 (2019).

- That the adoption of the WHO guideline limit for the concentration of $PM_{2.5}$ is technically fesabile to meet.
- The responsibility for air pollution should be shared "across local government and with relevant public bodies"
- Powers should be introduced for the UK government to mandate recalls of vehicles and machinery that do not meet relevant legal emission standards.

Technological developments

It is not just public policy, but also technological developments, that will support the reduction in air pollution from transport. Indeed, technology has contributed to the reduction in the main air pollutants in the UK in recent decades, which was evidenced in Chart 1.2.

The leading past, present and future technological developments that are enabling a fall in air pollutants from the transport sector are: catalytic converters; particulate filters; electrification; idle-reduction technologies; scrubbers; compressed natural gas; liquefied natural gas; hydrogen fuel; brake and tyre wear technology; and, wind assistant technologies.

These technologies either apply across different transport modes, or to specific modes only. Some technologies are well-established, whereas others are nascent.

Catalytic converters

The two- and three-way catalytic converters were the first major innovation that reduced tail-pipe air pollution. They can be fitted to both petrol and diesel cars, and have little effect on fuel consumption or performance.

Catalytic converters reduce emissions through passing toxic engine fumes – including NMVOCs, NO_x and CO – over a platinum group compound with which they react, forming less harmful compounds such as nitrogen, carbon and water. The two-way catalytic converter is

normally fitted to diesel cars, to reduce hydrocarbon and CO emissions. However, the two-way was superseded by the three-way in the 1980s due to the latter's ability to control NO_x emissions. Policy helped drive the adoption of these, with a law setting strict emission limits in 1993 – from an EU Directive – effectively requiring all cars sold in the UK to have one fitted in order to be compliant.

Buses can also be fitted with different catalytic converters to reduce the emission of harmful air pollutants. Often, buses will be fitted with Selective Catalytic Reduction (SCR) emission control units that reduce NO_x emissions by 25 – 29%, through NO_x exhaust gases reacting with either urea or ammonia (the 'reductant') over a catalytic bed to produce N_2 and water.[142] Ships, too, often use SCR systems to reduce the emission of air pollutants.[143]

Particulate filters

Particulate filters compliment catalytic converters in reducing the amount of harmful tailpipe air pollutants. In diesel cars, diesel particulate filters (DPFs) are fitted so that the vehicles meet PM emission limits and are widely fitted on most modern diesel cars. Petrol cars can be fitted with gasoline particulate filters (GPFs), however many do not have these due to petrol cars generally emitting less PM than diesel cars.[144] Their use is directed chiefly at gasoline direct-injection vehicles rather than 'conventional' petrol cars.

142. Science Direct, "Selective catalytic reduction", https://www.sciencedirect.com/topics/engineering/selective-catalytic-reduction (2019).
143. Transport and Environment, "Air pollution from ships", https://www.transportenvironment.org/what-we-do/shipping/air-pollution-ships (2019); Paul Balcombe et al, "how to decarbonise international shipping: options for fuels, technologies and policies", *Energy Conversion and Management* (2019), 72 – 88.
144. Tiegang Fang and Libing Wang, "Particulate matter emissions from gasoline direct injection engines: research overview", *Automotive Safety and Energy* (2017), 226-238; The Truth about cars, "TUV Nord testing firm: Direct injected gasoline engines emit more particulates than diesels", https://www.thetruthaboutcars.com/2013/11/tuv-nord-testing-firm-direct-injected-gasoline-engines-emit-more-particulates-than-diesels/ (2013).

Electrification

Across different modes of transport, there is a general trend of electrifying, fully or in part, the propulsion systems of vehicles so that they emit less air pollutants related to the combustion of fossil fuels.

The most rapid transport mode to undergo electrification in recent decades is cars.[145] Actually, electric vehicles (EVs) first came into existence in the early twentieth century, but declined in popularity with the advent of the commercially and technologically viable internal combustion engine. As we have become more concerned about climate change, and, to a smaller extent, air pollution, EVs are becoming more popular. Recent research suggests the global EV market will grow from two million sales in 2018 to 2.8 million sales in 2019.[146] Some of the past concerns as about the viability of EVs are reducing, too. For example, technological developments with batteries, particularly Lithium-ion batteries, has led to greater driving ranges before EVs need recharging and reductions in size, weight and costs.

There are different types of EVs. The cleanest are battery electric vehicles (BEVs), that run purely on electricity supplied most commonly by Lithium-ion batteries and are predicted to be 68% of the global EV market in 2018.[147] Another major type is plug-in hybrid electric vehicles (PHEVs), that use a mixture of battery and conventional fossil fuel power. They are predicted to be the remaining 32% of EV sales in 2019.[148] Generally, the PHEVs can partly recharge their battery with an alternator when running on fossil fuels.[149] There are also conventional hybrid electric vehicles (CHEVs), that are similar to plug in PHEVs, but without a recharging capability of plugging into external EV infrastructure.

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145. Business, Energy, and Industrial Strategy Committee, "Electric vehicles: driving the transition", https://publications.parliament.uk/pa/cm201719/cmselect/cmbeis/383/383.pdf (2018), 6.
146. Research and Markets, "Global electric vehicle market outlook report 2019 – 2025", https://www.businesswire.com/news/home/20190409005921/en/Global-Electric-Vehicle-Market-Outlook-Report-2019-2025 (2019).
147. Ibid.
148. Ibid.
149. Toyota, "How do hybrid cars work?", https://www.toyota.co.uk/hybrid/how-hybrid-works (2019).

EVs do not emit air pollutants from their tailpipe. However, they do have impacts on air pollution: concerns have recently emerged over the impact of break and tyre wear on PM emissions[150], and the resuspension of particulates on the road surface through surface run-off[151]. Moreover, the impact of EVs on the emission of air pollutants indirectly depends on how the electricity they run on is generated.

Buses, too, are experiencing significant electrification. The most common type of electric bus is the battery electric bus (BEB). Whilst there is no database for the number of such buses, there is widespread adoption of them by local and municipal authorities.[152]

Trains in the UK are being electrified to reduce the emission of air pollutants. In 2017-18, around 36% of the UK rail network was electrified, an increase of 2% on 2016-17.[153] Electrification of the rail network takes more diesel trains out of action that produce high amounts of NO_x and PM, but, it has come under scrutiny as an expensive and slow way to reduce emissions. This culminated in DfT scrapping many electrification schemes in 2017, relying on other technologies as a faster way to reduce emissions.[154]

Battery power trains operate using rechargeable batteries to drive its traction motors. Whilst having zero direct emissions, these trains often have low ranges of roughly 300 – 600 km, and currently have higher upfront purchase and running costs than diesel trains.[155] The UK trialled its first modern battery powered passenger trains in 2015.[156]

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150. Julie Panko et al, "Evaluation of tire wear contribution to $PM_{2.5}$ in urban environments", *Atmosphere* (2019), 1 – 14; Department for Environment, Food and Rural Affairs, "Clean Air Strategy 2019", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf (2019), 46.
151. Magdalena Penkala et al, "Particulate matter from the road surface abrasion as a problem of non-exhaust emission control", https://www.mdpi.com/2076-3298/5/1/9/pdf (2018).
152. Business, Energy and Industrial Strategy Committee, "Electric vehicles: driving the transition", https://publications.parliament.uk/pa/cm201719/cmselect/cmbeis/383/383.pdf (2018).
153. Office of Rail and Road, "Rail statistics compendium, Great Britain, 2017-18 annual", https://orr.gov.uk/__data/assets/pdf_file/0010/39871/rail-statistics-compendium-2017-18.pdf (2018).
154. Railnews, "DfT scraps electrification schemes".
155. Railway technology, "Powering the trains of tomorrow", https://www.railway-technology.com/features/featurepowering-the-trains-of-tomorrow-5723499/ (2017).
156. Andy Bounds, "Hybrid battery trains set to shorten commuter journey times", https://www.ft.com/content/4f7d9fd8-ba98-11e8-8274-55b72926558f (2018).

Moreover, newer trains coming are often much more efficient than older models, such as the new Bi-Mode Class 800 Intercity Express trains that are replacing Class 43 trains, the latter of which is a classification for high-speed diesel trains that can travel up to 148 mph.[157] The bi-mode trains produce less air pollution because, like hybrid cars, they can operate on electric power when on sections of the track that are electrified, or using a diesel engine.

Some companies have been beginning to retrofit existing ships with electric battery systems as well as fitting new build smaller ships with just electric batteries, bringing emissions reductions.[158] Notably, retrofits are focused on smaller ships at the moment that are designed for short journeys rather than deep sea voyages due to the energy requirements of the latter. Around 15% of EU vessels are of this small type to be fully electrified.[159] With larger ships, larger battery systems are emerging that allow these ships – such as heavy cargo and high capacity cruise vessels – to run on electricity in ports when the amount of energy needed to travel is lower.[160]

To a lesser extent when compared to other modes of transport, aircraft are being developed that are either fully electric or that use hybrid systems are under development to reduce emissions. But this is an emerging sector.[161]

A note of caution, however. A significant technological barrier to the

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157. Department for Environment, Food and Rural Affairs, "Clean Air Strategy 2019", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf (2019), 50.
158. DNV, "Battery and hybrid ships", https://www.dnvgl.com/maritime/advisory/battery-hybrid-ship-service.html (2019); The Royal Institution of Naval Architects, "Power and propulsion alternatives for ships", https://www.rina.org.uk/Power_Propulsion_Alternatives.html (2019); Paivi Aakko-Saksa and Kati Lehtoranta, "Ship emissions in the future – review", https://cris.vtt.fi/en/publications/ship-emissions-in-the-future-review (2019).
159. Jacques Moss, "Electrification could wipe out 15% of the EU's shipping emissions", https://knect365.com/energy/article/df461d19-80b7-401e-8cb7-ee4850476886/electrification-could-wipe-out-15-of-the-eus-shipping-emissions (2018); Catatay Iris and Jasmine Siu Lee Lam, "A review of energy efficiency in ports: Operational strategies, technologies and energy management systems", *Renewable and Sustainable Energy Reviews* (2019), 170 – 182.
160. Elly Yates-Roberts, "Are battery-powered cruise ships a viable option?", https://www.cruiseandferry.net/articles/are-battery-powered-cruise-ships-a-viable-option (2018).
161. HM Gov, Aviation 2050: The Future of UK aviation", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/769695/aviation-2050-web.pdf (2018), 169.

further electrification of transport is the development of light and high capacity batteries.

Lithium-ion batteries in road EVs make up a significant percentage of the upfront purchase costs of the vehicle. These costs are expected to fall continuously until 2030.[162] Moreover, technological developments are expected to increase the energy density of lithium-ion batteries through the use of new materials, improved pack design and optimised cooling – increasing the range of EVs and, in turn, reducing range anxiety, that is the biggest concern of consumers in the UK when purchasing EVs.[163]

Aside from battery technologies, there are challenges to developing national scale charging infrastructure to support the future uptake of EVs. There are three major concerns as to developing EV charging infrastructure.[164] First, whether local electricity network capacity will be able to support the increased demand created by greater EV ownership. Second, the degree to which a lack of EV charging points will limit the uptake of EVs through concerns over not being able to charge EVs. Third, whether the right kind of charging infrastructure will be installed, such as 'rapid chargers' that generally can charge EVs in about thirty minutes[165] or 'smart' charger that can optimise when it charges based on energy prices and supply.[166]

Idle-reduction technologies

In cars, the most common technology fitted to reduce idling and

162. Deloitte, "New markets. New entrants. New challenges. Battery electric vehicles", https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/manufacturing/deloitte-uk-battery-electric-vehicles.pdf (2018), 8.
163. Ibid, 6-7; Eamonn Ives, "Public polling analysis of attitudes towards the impact of and policies on air pollution", https://brightblue.org.uk/eamonn-ives-public-polling-analysis-of-attitudes-towards-the-impact-of-and-policies-on-air-pollution/ (2018).
164. Catapult energy systems, "Preparing the UK electricity networks for electric vehicles: report", https://es.catapult.org.uk/wp-content/uploads/2018/10/Preparing-UK-Electricity-Networks-for-Electric-Vehicles-FINAL.pdf (2018).
165. UK electric vehicle supply equipment association, "Charge points", http://ukevse.org.uk/charge-points-chargers/ (2019).
166. Ovo energy, "Introducing ovo smart charger", https://www.ovoenergy.com/ev-everywhere/smart-charger (2019).

therefore the emissions associated with this is the start-stop system. These automatically shut down and restart the engine based on when the vehicle is stationary.[167]

Idle-reduction technologies are present in buses but are more piecemeal. For example, earlier this year FirstGroup stated that "where possible" all new bus models will include technology to cut out the engine if stationary for a set period of time.[168]

Scrubbers

In order for many ships to meet EU and International Marine Organisation (IMO) SO_2 emission limits, aside from using low-sulphur content fuel, they install scrubbers that can remove 99% of SO_2 and significantly reduce the emission of other air pollutants.[169] They generally work by passing exhaust fumes through a 'scrubber' that contains an alkaline material to neutralise the acidic nature of exhaust gases such as SO_2, but also PM. Wash water is then used to collect the waste material, and the cleaner fumes are released into the atmosphere. [170]

Compressed natural gas (CNG)

Some vehicles operate using compressed natural gas (CNG) as their fuel. CNG is made by compressing natural gas to that it occupies less than 1% of the volume it occupies under regular atmospheric pressures.

CNG can be used in buses that are manufactured for it, or retrofitted to run solely on CNG or with an additional CNG system to increase vehicle range. CNG produces less air pollution than petrol or diesel in

167. Reality Check Team, "Air pollution: How damaging are idling cars and buses?", https://www.bbc.co.uk/news/science-environment-47525885 (2019).
168. BBC News, "Air pollution: How damaging are idling cars and buses?", https://www.bbc.co.uk/news/science-environment-47525885 (2019).
169. Transport and Environment, "Air pollution from ships", https://www.transportenvironment.org/what-we-do/shipping/air-pollution-ships (2019).
170. Sargun Sethi, "A guide to scrubber system on ship", https://www.marineinsight.com/tech/scrubber-system-on-ship/ (2019); Yara marine, "Sox cleaning technology", https://yaramarine.com/sox-cleaning-technology/ (2019).

terms of CO, PM, NO_x, CO_2, SO_x.

Ricardo Energy and Environment estimate that, for a 5% natural gas vehicle share of the bus fleet in Europe, NO_x emissions would not be changed, but PM emissions would be reduced by 5.4% a year.[171] Notably, the broader air pollution impacts can depend on the amount of natural gas leakage as well.[172]

Liquefied natural gas (LNG)

Liquefied natural gas (LNG) contains no sulphur and has comparatively lower PM emissions than other fuels like diesel.

LNG is used in shipping. Indeed, a recent research paper suggested LNG as fuel is now viable for all vessel types due to the development of large, low-speed gas engines. The actual reductions in different pollutants varies by ship size and engine type, but LNG has the potential to reduce greenhouse gas emissions between 2 – 10% from individual ships.[173]

Hydrogen fuel

Hydrogen fuelled vehicles do not produce any tailpipe exhaust fumes, but rather emit only water from their exhaust. Depending on the fuel cell, a small amount of NO_2 can be emitted as well.[174] This makes them much cleaner relative to conventional vehicles with internal combustion engines.

Hydrogen vehicles, compared to electric ones, also have longer

171. Transport and Environment, "Natural gas in vehicles – on the road to nowhere", https://www.transportenvironment.org/sites/te/files/publications/2015_02_TE_briefing_natural_gas_road_transport_FINAL.pdf (2016), 2.
172. Ibid.
173. Amir Sharafian et al, "Natural gas as a ship fuel: Assessment of Greenhouse gas and air pollutant reduction potential", https://www.sustainablegasinstitute.org/wp-content/uploads/2019/01/Technical-report-2-Natural-Gas-as-a-Ship-Fuel-Assessment-of-Greenhouse-Gas-and-Air.pdf (2019).
174. Richard Muller, "A pollution-free hydrogen economy? Not so soon", https://www.technologyreview.com/s/401988/a-pollution-free-hydrogen-economy-not-so-soon/ (2003).

ranges and more rapid refuelling times.[175] Hydrogen vehicles remain in the minority, however, due to the difficulty with producing hydrogen cheaply and keeping emissions down in the production process: but costs are expected to fall as European procurement of hydrogen fuel cells develops.[176]

Hydrogen fuel cell cars and buses are outsold by a factor of one hundred by their electric equivalents in the UK.[177] The use of them in cars is minimal when compared to larger vehicles. In the CCC's recent report, their most conservative estimations of the role of hydrogen in transitioning to net-zero by 2050 involve the UK using 53 TWh of hydrogen annually, with 2 TWh of this being used in buses.[178]

In 2018, London had ten hydrogen buses operating out of 9,396 buses, all of which are single decker.[179] However, in May 2019, Transport for London procured its first double decker hydrogen fuel-cell bus, with a further twenty ordered, although they still remain just a fraction of the overall bus fleet in London.

Hydrogen fuelled trains could be operating on UK railways by 2022, due to the technology arriving that can retrofit hydrogen fuel cells onto the existing stock of trains. The Government have adopted the goal of decarbonising the existing stock of trains by 2040, and where electrification of routes is not possible or costly, hydrogen trains are likely to be needed to meet this target.[180]

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175. Tim Wyatt, "World's first hydrogen double-decker buses coming to London to fight air pollution", https://www.independent.co.uk/news/uk/home-news/hydrogen-bus-doubledecker-london-tfl-sadiq-khan-air-pollution-a8909326.html (2019).
176. Committee on Climate Change, "Net zero technical report", https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-Technical-report-CCC.pdf (2019), 59, 60.
177. Motoring World, "More torque for hydrogen-powered vehicles research report", http://motoringworldng.com/torque-hydrogen-powered-vehicles/ (2018).
178. Committee on Climate Change, "Net zero technical report", https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-Technical-report-CCC.pdf (2019), 61.
179. Transport for London, "Bus fleet audit", http://content.tfl.gov.uk/bus-fleet-audit-31-march-2018.pdf (2018), 1.
180. Ed Wiseman, "Hydrogen fuel cell trains to run on British railways from 2022", https://www.telegraph.co.uk/cars/news/hydrogen-fuel-cell-trains-run-british-railways-2022/ (2019); Alstom, "Alstom hydrogen train Coradia iLint first successful run at 80km/h", https://www.alstom.com/press-releases-news/2017/3/alstoms-hydrogen-train-coradia-ilint-first-successful-run-at-80-kmh (2017).

Brake and tyre wear technology

Whilst this is still an emerging area of research[181], there are a number of products emerging to reduce PM emissions from brakes and tyres. For instance, Bosch recently released an 'iDisc' brake. Due to its tungsten-carbide coating, it emits up to 90% less PM than conventional cast iron brake discs.[182]

Regenerative braking in EVs, in which kinetic energy is extracted from parts of the brake, stored and then used to recharge the batteries of the car, reduces non-exhaust emissions.[183] Due to city driving being heavily stop-start, EVs in urban areas are especially well-placed to utilise this regenerative breaking.[184] It drastically reduces the amount of PM generated through brake and tyre wear.

Wind assist technologies

The option of harnessing wind energy for propulsion in large, commercial trade and fishing shipping fleets is emerging with the development of new renewable technologies.[185] Different technologies exist to achieve this. For example, modelling on two technologies – a Flettner rotor that is a large vertical sail, often which is combined with multiple towers, and a towing kite that is deployed to drag the ship in the direction of the wind – suggest that they can provide a significant proportion of power needed for travel dependent on wind conditions and ship type.[186]

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181. Theodoros Grigoratos and Giorgio Martini, "Non-exhuast traffic related emissions. Brake and tyre wear PM", http://publications.jrc.ec.europa.eu/repository/bitstream/JRC89231/jrc89231-online%20final%20version%202.pdf (2014).
182. Bosch, "Less brake dust: iDisc helps alleviate particulate-emission problem in cities", https://www.bosch-mobility-solutions.com/en/highlights/automated-mobility/idisc/ (2019).
183. Air Quality Expert Group, "Non-exhaust emissions from road traffic", https://uk-air.defra.gov.uk/assets/documents/reports/cat09/1907101151_20190709_Non_Exhaust_Emissions_typeset_Final.pdf (2019), 9, 16, 17, 24, 69 – 76.
184. Christopher Lampton, "How regenerative breaking works", https://auto.howstuffworks.com/auto-parts/brakes/brake-types/regenerative-braking.htm (2019).
185. Paul Gilbert, "Five ways the shipping industry can reduce its carbon emissions", https://theconversation.com/five-ways-the-shipping-industry-can-reduce-its-carbon-emissions-94883 (2018).
186. Michael Traut et al, "Propulsive power contribution of a kite and a Flettner rotor on selected shipping routes", *Applied Energy* (2014), 362 – 372.

In addition to the technological developments of existing modes of transport outlined in Box 4.2 above, there are a number of other forms of transport that are emerging that will encourage greater 'modal shift' away from more polluting forms of transport. This includes the use of dockless bike schemes, e-bikes and electric scooters.

Conclusion

This chapter has outlined the historical and present transport policies of national government used to reduce air pollution. It has mapped out technological developments in transport that offer pathways to reducing air pollution.

The relationship between public policy and technological development is critical. Policies can catalyse the creation of and scaling up of technological developments. And technological developments can create new policies or enable policies to be effective.

In Chapter Five, we propose new transport policies for the UK national government to implement to decrease levels of air pollution, especially for NO_2, even further. In doing this, we will be mindful of how current and new technologies can help.

Chapter 5: **New policies**

Chapter Four outlined past, present and future transport policies and technologies for reducing air pollution in the UK. In this chapter, we propose new transport policies for the UK national government to adopt to reduce air pollution levels. Policies to enhance government accountability over air pollution limits and targets are also suggested, to capitalise on the opportunities from leaving the European Union.

Policy approach

When formatting policies, we applied four particular key tests that had to be met:

1. **Focussed on national government powers and accountability.** The policies we propose to tackle air pollution should be focused on the powers and accountability of national government. Responsibility for air pollution is heavily devolved, but previous Bright Blue research has focused on the role that local and combined authorities could play in reducing air pollution.[187] Leaving the EU offers the opportunity to appraise the legislation and role of national government in regards to air pollution.
2. **Fiscal responsibility.** Policies to tackle air pollution should be fiscally

187. Eamonn Ives and Ryan Shorthouse, "Clearing the air: reducing air pollution in the West Midlands", http://brightblue.org.uk/wp-content/uploads/2018/10/BB42CTA-Clearing-the-air-WEB.pdf (2018).

prudent in that they do not necessitate excessively large amounts of government spending. That being said, central government should approach the challenge of poor air quality holistically, and recognise the potential savings which stand to be made in terms of lower health costs, and the potential benefits which stand to be realised in terms of higher productivity, for example.

3. **Progressivity.** Policies to tackle air pollution should be financially progressive. This is true for both costs and subsidies. Where additional charges are being levied on particular transport modes, they should not be burdensome for the least well-off. Where public subsidy is being made available for cleaner transport modes, that help should be prioritised towards the least well-off. It should also be kept in mind that the very poorest in society already suffer the most from air pollution.[188]
4. **Respecting human freedom.** Policies to tackle air pollution should not excessively curb human freedom. Sometimes, it is right to ban or seek to curtail certain conduct because of the harm caused to others. But, generally, individuals themselves should decide whether they should carry out certain conduct. Having said that, policymakers can price into certain conduct the externalities of it.

Our policy recommendations are divided into two categories. First, policies aimed at reducing the amount of air pollution that derives from the transport sector. Second, policies that address the governance of air pollution at a national level. Leaving the EU creates a gap around legislation and accountability on air pollution. The policies we offer around the governance of air pollution will not just affect the transport sector, but all economic sectors.

The policy recommendations we propose are not exhaustive, but are original. Other organisations have proposed plausible policies which

188. Daniela Fecht et al., "Associations between air pollution and socioeconomic characteristics, ethnicity and age profile of neighbourhoods in England and the Netherlands", Environmental Pollution, Vol. 198 (2015), 201-210.

the government should consider adopting. However, we do not repeat these policies here. Ultimately, we hope that this report is one of many helpful contributions for tackling air pollution.

Policies to reduce air pollution from the transport sector

Recommendation one: Lift the freeze on the value of Fuel Duty and apply a surcharge on Fuel Duty for diesel fuel (a 'Diesel Duty')

Fuel duty is an excise tax that applies to the sale of fuel. It is levied per unit of fuel purchased, and varies based on the type of fuel. Currently, ultra-low sulphur petrol and diesel is taxed at 57.95p per litre. The current Government committed to freezing the value of fuel duty yet again last year, meaning it has been frozen for the ninth year in a row as the current freeze was initiated in 2010.

Fiscally this has led to a reduction in potential revenues. The Institute of Fiscal Studies (IFS) estimates that freezes in fuel duty have amounted to £6 billion in total for the period 2011 to 2017, compared to if fuel duty rose 1p above inflation as proposed by the then Chancellor Alistair Darling.[189] A recent report estimated that the increase in traffic attributable to nine consecutive years of a freeze on fuel duty is 4%, worsening both congestion and therefore roadside air pollution.[190]

We recommend ending the freeze on the value of fuel duty from the next tax year. In addition, diesel fuel should attract a surcharge of fuel duty in its sale. This could be badged as a 'Diesel Duty'. It is logical that taxation in this country applies more to activities that cause the most harm to others.

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189. Institute of Fiscal Studies, "Tax and benefit measures", https://www.ifs.org.uk/tools_and_resources/budget/520 (2017); Antony Seely, "Taxation of road fuels", http://researchbriefings.files.parliament.uk/documents/SN00824/SN00824.pdf (2019), 4.
190. David Begg and Claire Haigh, "The unintended consequences of freezing fuel duty", https://greenerjourneys.com/wp-content/uploads/2018/06/THE-UNINTENDED-CONSEQUENCES-OF-FREEZING-FUEL-DUTY-JUNE-2018.pdf (2018), 2.

Recommendation two: Introduce an ongoing surcharge for Vehicle Excise Duty (VED) on new diesel cars in the UK ('Diesel Excise Duty' (DED)).

Vehicle Exercise Duty (VED) is currently paid on all vehicles registered, driven on or kept on a public road in the UK. The current system has different pricing features to it based on when you bought your car, and what type of car it is. There are three different VED systems: one on cars and light goods vehicles that were registered before March 2001, one on cars registered between March 2001 and March 2017, and one on cars and some motorhomes registered on or after April 2017.

Changes to how VED operates were further announced in the 2017 Autumn Budget, which moved diesel vehicles which did not meet certain emission standards up a bracket in their initial payment.[191]

Under the latest system, that applies to cars or motorhomes registered on or after April 1st 2017, the first payment you make when you register a vehicle places your car in one of thirteen bands based on its CO_2 emissions, from 0 to over 255 CO_2 g/km. The tax you pay yearly is based on this, as outlined in Table 5.1 below.

Table 5.1. First payment of VED on vehicles registered on or after April 1st 2017[192]

CO_2 emissions (g/km)	Diesel cars (TC49) that meet the RDE2 standard and petrol cars (TC48)	All other diesel cars (TC49)	Alternative fuel cars (TC59)
0	£0	£0	£0

191. HM Treasury, "Autumn Budget 2017 (archived)", https://www.gov.uk/government/topical-events/autumn-budget-2017 (2017).
192. The Government categorises vehicles into three different bands when paying VED after the first year: petrol and diesel cars are classed as 'TC48' and 'TC49' respectively, whereas 'alternative fuel cars' – that includes hybrids and biofuel vehicles – are classed as 'TC59'. 'RDE2' refers to the Real Driving Emissions standards, which must be met by all new cars sold in the European Union. The current standard is that, under standard laboratory testing, a new diesel or petrol car must emit no more than 0.080g/KM of NO_x, and a car is allowed to emit up to one and a half times this limit during laboratory testing.

1 – 50	£10	£25	£0
51 – 75	£25	£110	£15
76 – 90	£110	£130	£100
91 – 100	£130	£150	£120
101 – 110	£150	£170	£140
111 – 130	£170	£210	£160
131 – 150	£210	£530	£200
151 – 170	£530	£855	£520
171 – 190	£855	£1,280	£845
191 – 225	£1,280	£1,815	£1,270
226 – 255	£1,815	£2,135	£1,805
Over 255	£2,135	£2,135	£2,125

Source: HM Gov, "Vehicle tax rates", https://www.gov.uk/vehicle-tax-rate-tables (2019)

As Table 5.2 illustrates, there is already a higher charge faced by drivers of diesel vehicles for their first VED payment. After paying VED for the first year, drivers face different rates of VED, as outlined in Table 5.2 below.

Table 5.2. VED that applies after the first year, for vehicles registered on or after April 1st 2017

Fuel type	Single 12 month payment	Single 12 month payment by Direct Debit	Total of 12 monthly payments by Direct Debit	Single 6 month payment	Single 6 month payment by Direct Debit
Petrol or diesel	£145	£145	£152.25	£79.75	£76.13
Electric	£0	N/A	N/A	£0	N/A
Alternative	£135	£135	£141.75	£74.25	£70.88

Source: HM Gov, "Vehicle tax rates", https://www.gov.uk/vehicle-tax-rate-tables (2019)

As Table 5.2 demonstrates, petrol and diesel cars are subject to the same ongoing VED payments, and electric cars are fully exempt. 'Alternative' refers to vehicles with lower air pollutant emissions than petrol and diesel cars, and include hybrids, bioethanol and liquid petroleum gas vehicles. If you have a vehicle worth over £40,000, you also pay a higher rate of VED.

In the 2019 Budget, it was confirmed that in the future cars, vans and motorcycles will be subject to VED rates that increase in line with the Retail Price Index.[193]

However, the ongoing VED rates that apply to cars registered on or after April 1st 2017 do not tax diesel vehicles in a way that reflects their contribution to air pollution. Although the actual payment is tiered, petrol and diesel cars pay the same rate of ongoing VED.

We recommend that a diesel surcharge on ongoing VED payments be introduced in the next tax year. Together with the tiered initial payment, this would create a separate 'Diesel Excise Duty (DED); for all new diesel vehicles registered.

The overall DED should be lower for less polluting diesel vehicles that meet the Real Driving Emissions 2 (RDE2) standard, as is the case on the first VED payment, outlined in Table 5.1 above. To prevent those on lower incomes from being penalised, who may have invested in diesel vehicles following government advice, the surcharge would apply only to newly registered diesels. As such, the surcharge would avoid being socially regressive.[194]

Recommendation three: Exempt the purchase of ultra-low emission vehicles (ULEVs) from VAT

Ultra-low emission vehicles (ULEVs) are defined as vehicles that emit

193. Luke Smith, "Car tax will rise for millions of drivers in 2019 – heres how much more it'll cost you", https://www.express.co.uk/life-style/cars/1039889/car-tax-DVLA-UK-increase-2019-how-much (2018).
194. Heather Stewart, "Sadiq Khan: government must pay drivers £3,500 to scrap diesel cars", https://www.theguardian.com/uk-news/2017/feb/12/london-mayor-plans-to-scrap-diesels (2017).

less than 75 grams of carbon dioxide (CO_2) per kilometre travelled (g/km).[195] Notably, ULEVs as a category also includes electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs), described in Chapter Four, as these vehicles typically emit less than 75 g/km of CO_2.[196] ULEVs in the UK are important to encourage the take up of due to their lower emissions of air pollutants on the roads.

The UK Government currently has three main fiscal policies in place to encourage greater take up of ULEVs. First, as outlined earlier, ULEVs have favourable Vehicle Excise Duty (VED) rates. EVs are exempt from paying any VED, whilst PHEVs if first registered after 2017 are subject to VED rates based on their CO_2 (g/km). Second, Value Added Tax (VAT), which is a tax applied to all good and services sold in the UK, is charged at a lower rate of 5% for the electricity used to charge these vehicles. However, ULEVs are still charged at the standard rate of VAT which stands at 20%.[197] Third, 'plug-in grants' are available for the upfront purchasing of the cleanest ULEVs, currently at a rate of £3,500, albeit reduced from £4,500. Before October 2018, a greater proportion of ULEVs were eligible for these plug-in grants.

Recently, though, it was forecasted that EVs will only be 75% of new vehicle sales by 2040 based on current incentives – falling short of the Government's target of phasing out fossil fuel car purchases by 2040.[198] Indeed, recent growth in EVs has been slower in the UK when compared to other European countries. New EV registrations in the UK increased by 2.9% in the first quarter of 2019 compared to the first quarter of 2018, which is comparatively lower when compared to an

195. Office of Low Emission Vehicles, "Tax benefits for low emission vehicles", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/709655/ultra-low-emission-vehicles-tax-benefits.pdf (2018), 1.
196. Department for Transport, "A guide to ultra low emission vehicles for fleet managers", (2018), 3.
197. Office of Low Emission Vehicles, "Tax benefits for low emission vehicles", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/709655/ultra-low-emission-vehicles-tax-benefits.pdf (2018), 1 – 6.
198. Peter Campbell, "UK to miss electric car sales target, Auto Trader warns", https://www.ft.com/content/760c487a-3a86-11e9-b72b-2c7f526ca5d0 (2019).

EU average of an equivalent 40% increase.[199]

In particular, Norway is an international leader in terms of encouraging EV uptake, with half of all new cars sold in the country in 2018 being EVs. This was a markedly large increase from 2011 when only 1.6% of new car sales were EVs.[200] Further, 30% of the new car market in Norway in 2018 was battery electric vehicles, that run purely on electricity, with a further 19% being plug-in hybrids, and the remaining 51% being conventional diesel or petrol cars.[201]

This rapid uptake of EVs has been incentivised by the Norwegian Government since the 1990s through different fiscal incentives, such as EVs being made exempt from a 'vehicle registration tax' 1990 and from VAT in 2001. This latter policy was extended in 2015 until 2020.[202] Partly as a consequence of such policies, NO_2 emissions in Norway from road transport fell 93% between 1990 and 2017.[203]

We recommend that VAT should be scrapped on the purchase of all categories of ULEVs[204] in the UK.

Recommendation four: Enable local and combined authorities to strive for 'reasonable profits' from their charging Clean Air Zones (CAZs) to fund further local air pollution abatement policies.

Under the Transport Act 2000, and the amendments made under

199. Will Beddingfield, "Why the UK's lagging behind in the booming electric car revolution", https://www.wired.co.uk/article/uk-electric-car-sales-2019 (2019); European Automobile Manufacturers Association, "New passenger car registrations by fuel type in the European Union: Quarter 1 2019", https://www.acea.be/uploads/press_releases_files/20190508_PRPC_fuel_Q1_2019_FINAL.pdf (2019), 3 – 6.
200. Norsk elbilforening, "Norweigian EV market", https://elbil.no/english/norwegian-ev-market/ (2019).
201. Ibid.
202. Erik Lorentzen et al, "Charging infrastructure experiences in Norway – the worlds most advanced EV market", https://wpstatic.idium.no/elbil.no/2016/08/EVS30-Charging-infrastrucure-experiences-in-Norway-paper.pdf (2017), 3.
203. Statistics Norway, "Emissions to air", https://www.ssb.no/en/natur-og-miljo/statistikker/klimagassn/aar-endelige (2019), tables 3 and 4.
204. The Department for Transport has three categories for ULEVS: first, Category 1 ULEZs (CO_2 emissions of less than 50g/km and zero emission range (ZER) of at least 70 miles); second, Category 2 ULEVs (emittance of less than 50g/km CO_2 and a ZER of between 10 and 69 miles); and, third, Category 3 ULEVs (emittance of 50-75g/km and ZER of at least 20 miles).

Part VI of the Local Transport Act 2008[205], local authorities cannot set charges in CAZs to raise revenue. Any additional revenue raised from CAZs must be reinvested to "facilitate the achievement of local transport policies".[206]

We recommend the Government amends the Transport Act 2000 to allow local and combined authorities to pursue 'reasonable profits' from their CAZs, as long as they are reinvested to pursue policies that will tackle roadside air pollution. We suggest two policy focus areas for these reasonable profits to be spent on:

a) Charging infrastructure for EVs;
b) Local scrappage schemes for diesel and petrol cars;
c) Local transport objectives, as currently defined

We propose that the reasonable profits raised need be first allocated to investment in EV infrastructure and local scrappage schemes for both diesel and petrol cars, prior to being used for the pursuit of local transport objectives.

Recommendation five: Mandate introducing banning or charging Clean Air Zones (CAZs) for non-road mobile machinery (NRMM) alongside the establishment of all charging CAZs for vehicles in England.

NRMMs are mobile machines, items of transportable industrial equipment or vehicles which are: not intended for carrying passengers or goods on the road; and, installed with a combustion engine.[207]

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205. Local Transport Act 2008, *Ch*. 26. See: https://www.legislation.gov.uk/ukpga/2008/26/pdfs/ukpga_20080026_en.pdf
206. Transport Act 2000, *Ch*. 38. See: http://www.legislation.gov.uk/ukpga/2000/38/pdfs/ukpga_20000038_en.pdf; Department for Environment, Food and Rural Affairs and the Department for Transport, "Clean air zone framework: principles for setting up clean air zones in England", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/612592/clean-air-zone-framework.pdf (2017), 27.
207. Vehicle Certification Agency, "Outline of Non-road mobile machinery (NRMM) emissions regulations", http://www.dft.gov.uk/vca/other/non-road-mobile-mach.asp (2018).

Examples of NRMM include excavators, back-up generators, forklifts, and industry trucks. They are responsible for the emission of NO_x, PM, SO_2 and VOCs. NRMM are responsible for an estimated 7% of NO_x emissions, 14% of $PM_{2.5}$ and 8% of PM_{10} in London alone.[208]

London has a low-emission zone (LEZ). For NRMMs that sits alongside the city's ultra-low emission zone (ULEZ). The NRMM low-emission zone is distinct from the CAZ for vehicles, in terms of the standards it imposes and the parts of the city which it covers. Importantly, it is not a 'charging' CAZ (whereby emitters of air pollution can pay for the pollution they create), but rather a 'banning' one, which just sets minimum emissions standards and bans vehicles or equipment that do not meet them. From 1st September 2020, all NRMMs that are used within Greater London will be expected to meet the EU-derived emissions standard Stage IIIB as set in EU directive 97/68/EC, and any NRMM used in the Central Activity Zone or Canary Wharf will need to meet the Stage IV emission limits.[209] All NRMMs have to meet these standards unless it can be shown that the machinery is not otherwise available, or that a comprehensive retrofit to meet emission standards is not feasible.[210]

Above and beyond London, CAZs will soon be introduced in Leeds, Birmingham, Bath, Coventry, Greater Manchester, and Sheffield.[211] A 'Low Emission Zone' in Glasgow is being introduced to ban, as opposed

208. Ibid.
209. Centre for Low Emission Construction, "London's 'low emission zone' for non-0road mobile machinery", http://www.clec.uk/advice/londons-low-emission-zone-non-road-mobile-machinery (2019); for details of EU Directive 97/68/EC, see: https://ec.europa.eu/growth/sectors/ automotive/environment-protection/non-road-mobile-machinery_en.
210. NRMM London, "Retrofit technology", https://nrmm.london/content/retrofit-technology (2017).
211. BBC News, "Leeds clean air zone: £6m camera system being installed", https://www.bbc.co.uk/news/uk-england-leeds-48773460 (2019); BBC News, "Leeds and Birmingham clean air zones 'delayed by government'", https://www.bbc.co.uk/news/uk-england-48679008 (2019); Clean Air Greater Manchester, "Greater Manchester clean air plan proposals", https://cleanairgm.com/clean-air-plan (2019); Clean Air Sheffield, "Our plans", https://www.sheffield.gov.uk/cleanair (2019); Bath and North East Somerset Council, "Breathe: Tackling air pollution in Bath and north east Somerset", https://www.bathnes.gov.uk/bath-breathes-2021-overview (2019); Coventry City Council, "Air Quality", https://www.google.com/search?q=coventry+clean+air+zone&oq=coventry+clean+air+zone&aqs=chrome..69i57j69i60j0l4.2473j0j4&sourceid=chrome&ie=UTF-8 (2019).

to charge, non-compliant vehicles that enter the zone.[212] Last year, the Government also ordered 33 local authorities to carry out feasibility studies over whether charging CAZs are needed to tackle illegal levels of air pollution.[213]

Local authorities are expected to follow DEFRA's non-statutory guidance on establishing CAZs.[214] The guidance suggests that local authorities should "assess the contribution of emissions" from NRMMs, and if appropriate, seek to implement "minimum emissions standards for NRMM to be used within their Clean Air Zone".[215] Nonetheless, there are no CAZs for NRMM in the UK at present, only London's LEZ for NRMMs as outlined above that is a banning CAZ.

We recommend going further and mandating that, alongside future charging CAZs for vehicles, it should be mandatory for a new banning or charging CAZ to be established for NRMM, akin to the one in London. These standards could be the same as the Stage IIIB emission standards as set in EU directive 97/68/EC, that will come into effect in the Greater London 'low emission zone' for NRMMs from September 2020. However, as with the London LEZ, exemptions should apply to NRMM in a banning CAZ that is not otherwise available, or where comprehensive retrofitting is not feasible.

Recommendation six: Make it a requirement for local authorities with a charging CAZ to introduce a citizen-based reporting system to increase the enforceability of anti-idling measures.

Currently, under the Road and Traffic (Vehicle Emissions) (Fixed

212. Glasgow City Council, "Low Emission Zone (LEZ)", https://www.google.com/search?q=coventry+clean+air+zone&oq=coventry+clean+air+zone&aqs=chrome..69i57j69i60j0l4.2473j0j4&sourceid=chrome&ie=UTF-8 (2019).
213. Air Quality News, "Ministers issue direction for next steps in NO_2 plan", https://airqualitynews.com/2018/10/05/ministers-issue-direction-for-next-steps-in-no2-plan/ (2018).
214. Department for Environment, Food and Rural Affairs and Department for Transport, "Clean air zone framework: Principles for setting up Clean Air Zones in England", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/612592/clean-air-zone-framework.pdf (2017).
215. Ibid, 16.

Penalty) (England) Regulations 2002, local authority traffic officers have the power to issue fixed penalties to drivers if they fail to comply with exhaust emission reduction laws.

There are two types of offences currently in law. First, an 'emissions offence', which refers to the exceeding of allowed emission limits from a vehicle, which carries a fine of £60. Second, and most relevant here, a 'stationary idling offence' occurs when a vehicle's idling activity is deemed unnecessary and the driver fails to cease idling when instructed by a traffic officer, unless queuing at a traffic light, having the engine checked or running auxiliary machines. This carries a fine of £20, rising to £40 if not paid within 28 days.[216] Further, Rule 123 of The Highway Code states that drivers must not leave the engine running on a vehicle "unnecessarily" while parked on a public road. [217]

The UK Government recently stated its intention to consider instant fines for drivers to deter stationary idling, rather than the current system of authorised traffic officers issuing a warning before being able to apply a fine.[218]

However, there is a major limitation with this current and proposed future legislation on stationary idling. Namely, it is only enforceable through a local authority traffic officers who must be present at the time of the idling offence.[219]

In the City of New York in the US, to assist in the enforcement of idling laws, there is a system in place to allow citizens to report commercial trucks and buses that are idling for longer than the legal three minutes – or for longer than one minute if outside schools – through taking photographs and videos and filling out an online form

216. HM Gov, "The Road Traffic (Vehicle Emissions) (Fixed Penalty) (England) Regulations 2002", http://www.legislation.gov.uk/uksi/2002/1808/pdfs/uksi_20021808_en.pdf (2002), 5.
217. Drivinged, "The Highway Code", http://www.highwaycodeuk.co.uk/uploads/3/2/9/2/3292309/the-official-highway-code-with-annexes-uk-en-12-04.pdf (2019), 53.
218. Ben Webster, "Instant fines for idling drivers 'would send message about air pollution'", https://www.thetimes.co.uk/article/instant-fines-for-idling-drivers-would-send-message-about-pollution-g575tlf2x (2019).
219. Ibid, Part 3 Clause 6.

run by the City of New York government.[220] Citizens are required to submit date and time stamped videos of the offence in which an idling engine can clearly be heard, as well as date and time stamped images of the vehicle licence plate and logo.[221] Citizens who report polluters get a 25% share of the income from the fine imposed. Emergency and passenger vehicles are exempt, and some exemptions apply based on the temperature outside. Crucially, tickets can be challenged. Overall, the number of enforcements for idling in New York City has increased since this scheme was introduced.[222]

Alongside proposed new powers to enable local authority traffic officers to instantly apply fines for stationary idling, we recommend local authorities with a charging CAZ should be required to introduce such citizen-based reporting of stationary idling. The person reporting the offence should be able to provide evidence of the breach of anti-idling laws through a reporting system, and this evidence should consist of time and date stamped videos and images that clearly identify the vehicle and reflect an idling engine. If a fine is imposed, they could receive a portion of the fine, with the remainder going to the local authority to be spent on other local air pollution abatement policies. We further recommend the government consult on expanding this citizen-based reporting system from the City of New York to passenger vehicles.

Recommendation seven: Replace the current 30mph default speed limit on all 'restricted roads' in England and Wales with a 20mph default speed limit

In urban areas, speed limits are generally set at 30mph as set by the Road

220. City of New York, "Vehicle Idling Complaint", https://www1.nyc.gov/nyc-resources/service/2684/vehicle-idling-complaint (2019); City of New York, "Citizen's Air Complaint Guidelines", http://www.nyc.gov/html/dep/pdf/air/citizens-air-complaint-form.pdf (2019).
221. NYC Environmental Protection, "Citizens Air Complaint Program", https://www1.nyc.gov/site/dep/environment/idling-citizens-air-complaint-program.page (2019).
222. New York Post, "NYC will pay you big bucks for ratting out idling trucks, buses", https://nypost.com/2018/07/06/nyc-will-pay-you-big-bucks-for-ratting-out-idling-trucks-buses/, (2018).

Traffic Regulation Act 1984 section 81(1).[223] Current speed limits are automatically set at 30 mph on 'restricted roads' in England and Wales, unless specified as not. 'Restricted roads' are defined as any road with a "system of street lighting furnished by means of lamps placed not more than 200 yards apart", therefore covering most roads in urban areas.[224]

Nevertheless, local authorities do have the powers to lower speed limits below the national speed limit through Traffic Regulation Orders (TROs).[225] In fact, many local and combined authorities have moved to implement a 20mph speed limit on the vast majority of restricted roads, such as the West Midlands Combined Authority, the City of Edinburgh, and South Tyneside.[226]

Evidence shows that 20mph speed limits are beneficial in terms of lowered amounts of pollutants being emitted by vehicles, particularly for NO_x and PM. According to one study, a 20mph speed limit can generate a 25-32% reduction in NO_x emissions.[227] But a 20 mph speed limit is only effective at reducing air pollution if driving patterns remain 'smooth'; that is, they are not characterised by increased breaking and acceleration. Speed bumps, for instance, can generate greater air pollution from vehicles due to increased rates of breaking and acceleration.[228]

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223. HM Gov, "Road Traffic Regulations Act 1984", https://www.legislation.gov.uk/ukpga/1984/27/contents (1984).
224. Department for Transport, "DfT circular 01/2006: Setting local speed limits", https://en.wikipedia.org/wiki/Built-up_area_(Highway_Code)#cite_note-1 (2007).
225. HM Gov, "Roads: Traffic Regulation Orders (TROs)", https://researchbriefings.parliament.uk/ResearchBriefing/Summary/SN06013 (2014); TROs are a legal means for local transport authorities to place temporary or permanent restrictions on traffic, including control parking regimes and the types of vehicles allowed on the portions of road in question; Department for Transport, "Setting local speed limits", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/63975/circular-01-2013.pdf (2013).
226. Dominic Tobin, "20 mph speed limits spread across Britain", https://www.driving.co.uk/news/20mph-speed-limits-spread-across-britain/ (2015); BBC News, "City of Edinburgh council plans widespread 20 mph zones", https://www.bbc.co.uk/news/uk-scotland-edinburgh-east-fife-28970224 (2014); South Tyneside Council, "Traffic management", https://www.southtyneside.gov.uk/article/57730/Traffic-management (2019).
227. Public Health Wales, "Background Paper – Public Health Wales believes that lowering the default speed limit to 20mph in Wales could have substantial public health benefits", http://www.wales.nhs.uk/sitesplus/documents/888/Position%20Statement%20Background%20Paper%20-%2020mph%200b.pdf (2018), 5; Archer, J. et al, "The impact of lowered speed limits in urban and metropolitan areas", https://www.monash.edu/muarc/our-publications/muarc276 (2008).
228. Fiamma Peres-Prada et al, "Managing traffic flows for cleaner cities: The role of green navigation systems", Energies (2017), 1 – 18.

Generally, arguments for the lowering of speed limits to 20mph are framed in terms of public safety – through reducing the number of road accidents, where there is robust evidence[229] – but there is now also a solid evidence base to be made for it lowering air pollution from vehicles.[230]

We recommend that the default national speed limit on all 'restricted roads' in England and Wales be lowered from 30mph to 20mph. This would require a change in the Road Traffic Regulation Act 1984, to lower the default speed limit on all of these roads. Local authorities would still have the power to set lower speed limits for specific roads based on local circumstance.

Recommendation eight: Require the installation, checking and cleaning of particulate matter filters on all petrol cars through the annual Ministry of Transport (MOT) test.

Petrol cars are favoured over diesel for their lower NO_x outputs.[231] However, petrol cars are not so simply better than diesel in terms of their contribution to air pollution. Some petrol cars, specifically those that use direct injection engines, can emit more PM than conventional diesel cars. This is because modern diesel cars are normally fitted with diesel particulate filters (DPFs), meaning the PM they generate is filtered out of the exhaust fumes. Petrol cars, however, largely lack these filters. Direct injection engines, which an estimated 40% of petrol cars have, provide fuel-efficiency benefits but produce much more PM than other engine types – creating a situation where a large minority of petrol cars are producing a large

229. Sarah Brightwell, "Hull reaps safety rewards from slowing the city's traffic", *Local Transport Today* (2003), 10-11.
230. Sarah Jones and Huw Brunt, "Twenty miles per hour speed limits: a sustainable solution to public health problems in Wales", *Epidimol Community Health* (2017), 1-8.
231. Paul Nieuwenhuis, "Fact check: are diesel cars really more polluting than petrol cars?", https://theconversation.com/fact-check-are-diesel-cars-really-more-polluting-than-petrol-cars-76241 (2017).

amount of PM unabated.[232]

Recent regulation that subjects all new cars sold to strict PM tests, equivalent to Euro 6 standards for PM emissions[233], means it is likely that most new petrol cars sold will have gasoline particulate filters (GPFs) fitted.[234] Some manufacturers, such as Volkswagen, have begun equipping new petrol car models with GPFs as standard.[235]

But the existing stock of petrol cars in the UK continue to emit PM into the air unabated. Indeed, London's recently established Ultra Low Emission Zone (ULEZ) subjects diesel cars to Euro 6 standards but allows petrol vehicles to only be charged if below Euro 4 standards – thereby allowing petrol cars to emit higher amounts of PM than diesel cars with DPFs fitted.[236]

Considering our knowledge of the damages of PM for health, as outlined earlier in Chapter Three, and the Government's announcement of a target to reduce the number of people living in areas above the WHO's annual mean guideline limit for $PM_{2.5}$ of 10μg/m^3 by half by 2025, policies to limit PM emissions at source are needed.[237] Legislating to install GPFs on the existing stock of UK petrol cars, to complement new PM tests for new cars, presents an opportunity to reduce roadside PM emissions.

We recommend that, as part of the annual MOT tests, any petrol car without a GPF be required to have one installed. Notably, GPF filters

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232. Tiegang Fang and Libing Wang, "Particulate matter emissions from gasoline direct injection engines: research overview", *Automotive Safety and Energy* (2017), 226-238; The Truth about cars, "TUV Nord testing firm: Direct injected gasoline engines emit more particulates than diesels", https://www.thetruthaboutcars.com/2013/11/tuv-nord-testing-firm-direct-injected-gasoline-engines-emit-more-particulates-than-diesels/ (2013).
233. Euro 6 PM emission limits for new direct injection petrol cars are 6.0x1011 particles per km.
234. Andrew Leadbetter, "Gasoline Particulate Filter (GPF)", https://www.greencarguide.co.uk/features/gasoline-particulate-filter-gpf/ (2019).
235. Jesse Crosse, "Volkswagen equips petrol cars with particulate filter technology", https://www.autocar.co.uk/car-news/industry/volkswagen-equips-petrol-cars-particulate-filter-technology (2018).
236. Felix Leach, "Pollution problem is just being pushed around", https://www.theguardian.com/environment/2017/nov/09/pollution-problem-is-just-being-pushed-around (2017).
237. Department for Environment, Food and Rural Affairs, "Clean Air Strategy 2019", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf (2019), 30.

are relatively cheap, on average costing £25[238] – although the exact cost will vary by specific petrol engine type and labour costs.[239] As part of the annual MOT test, the checking and, if appropriate, cleaning of the GPF should also be a requirement, as is currently required for Diesel Particulate Filters (DPFs). If installation or cleaning costs are particularly expensive, and an individual has extenuating financial circumstances, they should be able to apply to the government's Clean Air Fund for assistance in the cost to install a GPF.

Policies to improve national governance of air pollution

Recommendation nine: Adopt the World Health Organisation's (WHO) guideline limits for concentrations for all health-harming air pollutants as soon as possible after a feasibility study is conducted by the new Office for Environmental Protection (OEP) or a new Committee on Air Quality.

As detailed in Box 1.1 earlier in the report, the current legal limits for the emission of different air pollutants in the UK is derived from EU law, enacted in the UK through secondary legislation.

The WHO, however, have their own recommended limits for $PM_{2.5}$, PM_{10}, NO_2 and O_3. These are more demanding than the current EU-derived limits, and these were most recently updated last year in the face of a growth in the body of evidence of the negative health effects of air pollution since the WHO's last update of their guideline limits in 2006.[240] These are summarised in Table 5.3 below, and compared against the UK's existing EU-derived legal limits.

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238. Andrew Leadbetter, "Gasoline Particulate Filter (GPF)", https://www.greencarguide.co.uk/features/gasoline-particulate-filter-gpf/ (2019).
239. Ray Minjares and Francisco Posada Sanchez, "Estimated cost of gasoline particulate filters", https://www.theicct.org/sites/default/files/publications/GFPworkingpaper2011.pdf (2011).
240. WHO, "Update of WHO Global Air Quality Directive Guidelines", http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/activities/update-of-who-global-air-quality-guidelines (2016).

Table 5.3. Selected air pollutant limit values for the UK and the WHO's corresponding Air Quality Guideline value

Pollutants	Averaging Period	EU-derived limits	Equivalent WHO Air Quality Guideline value	
		Concentration limit (μg/m³, unless stated)	Concentration limit (μg/m³, unless stated)	Difference of EU and WHO concentration limits (μg/m³)
$PM_{2.5}$	Annually	25	10	-15
	Daily	N/A	25	N/A
PM_{10}	Daily	50	50	0
	Annually	40	20	-20
NO_2	Hourly	200	200	0
	Yearly	40	40	0
O_3	8 hours	120	100	-20

Source: European Parliament and Council, "Directive 2008/50/EC on ambient air quality and cleaner air for Europe", http://eur-3lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:EN:PDF (2008); World Health Organisation, "Ambient (outdoor) air quality and health", https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health (2018)

As discussed in Chapter Four, the UK Government has committed in its *Clean Air Strategy 2019* to a new, long-term $PM_{2.5}$ exposure target, as recommended by the WHO, of reducing the number of people living in areas of $PM_{2.5}$ concentrations above WHO guidelines in half by 2025.[241] The WHO's guidelines specify a maximum average annual concentration of 10 μg/m³ for $PM_{2.5}$, and the Government has stated it will publish evidence in 2019 to examine what needs to be done to fully achieve this.[242] It has further stated in the *Clean Air Strategy 2019* that in 2022 it will consult if further air pollution targets could be set

241. Department for Environment, Food and Rural Affairs, "Clean Air Strategy 2019", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf (2019), 7.
242. Ibid, 30.

in line with WHO standards.[243] And more recently, DEFRA announced in a policy statement update on the Environment Bill that they believe it would be technically feasible to meet the WHO guideline level for the annual mean concentration of $PM_{2.5}$, albeit based on their own scientific modelling that "has not considered the full economic viability and practical deliverability" of the target.[244] But, as of yet, Government has only committed after Brexit to maintaining EU-derived air pollution limits, stopping short of improving them by legally committing to more stringent air pollution limits.

We recommend that the Government adopts all the WHO guideline limits for $PM_{2.5}$, PM_{10}, NO_2 and O_3, as stated above in Table 5.4, as soon as possible, after a feasibility study is conducted by the new Office for Environmental Protection (OEP) or a new Committee for Air Quality.

Recommendation ten: Provide the Office for Environmental Protection (OEP), or a new Committee for Air Quality, with the responsibility to recommend future legal limits for different air pollutants to parliament after conducting appropriate feasibility studies.

The OEP has been proposed as an "independent, statutory environmental body that will hold government and public bodies to account on environmental standards", including on air quality, as outlined in Chapter Four.[245]

However, due to how the OEP has been proposed in the Draft Environment (Principles and Governance) Bill, there remain questions over the independence of the body as well as what powers it will have to uphold environmental law. These questions will be answered once the Environment Bill that will contain the final provisions for the OEP

243. Ibid, 31.
244. Department for Environment, Food and Rural Affairs, "Environment Bill summer policy statement: July 2019", https://www.gov.uk/government/publications/draft-environment-principles-and-governance-bill-2018/environment-bill-summer-policy-statement-july-2019 (2019).
245. HM Gov, "New environment protections set out in flagship bill", https://www.gov.uk/government/news/new-environment-protections-set-out-in-flagship-bill--2 (2018).

has been published.

For the OEP to be able to properly uphold environmental standards, it should be given the power to recommend those standards. Such standards on air quality should, as has already been stated, be in line with those set by the WHO. But once the WHO limits have been introduced, in the future, any review to the UK's legal limits should be recommended by the new OEP. Or, alternatively, a new Committee for Air Quality could be established, mirroring the current Committee on Climate Change.

We recommend that the OEP, or a new Committee for Air Quality, be given the power to recommend future legal limits for air pollutants to parliament, following appropriate feasibility studies. It should be able to recommend the setting of the future limits for the four air pollutants detailed in Table 5.3 above, as well other air pollutants not covered by the WHO's guideline limits. This will be similar to the role of the Committee on Climate Change's (CCC) role in advising the UK Government on greenhouse gas emission targets.[246] In this way, prior to any air pollutant limits being put to parliament to become legal, the setting of such targets will be properly evidenced and scrutinised by an independent, authoritative body. It is also important that targets are set following public consultation and stakeholder engagement.

Recommendation eleven: Provide the Office for Environmental Protection (OEP), or the new Committee for Air Quality, with the responsibility to recommend future new targets for different air pollutants, specifically focussed concentrations by population density and deprivation.

The UK's targets on air pollution relate to progress towards meeting the limits on concentration, and ceilings on total emission, by different air pollutants. These targets have to be achieved by a certain date, as

246. Committee on Climate Change, "About the Committee on Climate Change", https://www.theccc.org.uk/about/ (2019).

outlined earlier in Chapter One.

Due to developments in the evidence base on the effects of air pollution, the OEP or new Committee for Air Quality should be able to propose new future national targets that take into account two new considerations: first, population density; and, second, deprivation. These targets would be additional to the existing targets the UK has.

First, new targets based on the annual mean concentration of different air pollutants weighted by population density is important to track the average exposure of people to the concentration of different air pollutants. A target based on reducing the concentration of an air pollutant, but weighted by population density, provides a metric to track progress in reducing the average concentration of an air pollutant per person in an area.

Second, new targets based on the annual mean concentration of different air pollutants weighted by measures of deprivation is important to track progress on reducing air pollution is the most deprived areas. The trend of the poorest generally being subject to higher air pollution levels has increasingly come to the fore.[247, 248, 249] The annual average concentration of different air pollutants could be compared with the Index of Multiple Deprivation (IMD), a relative measure of deprivation in England that ranks small areas in terms of their deprivation.

We recommend that the OEP or the new Committee for Air Quality

247. Arthur neslen, "Europe's most deprived areas 'hit hardest by air pollution'", https://www.theguardian.com/environment/2019/feb/04/europes-most-deprived-areas-hit-hardest-by-air-pollution (2019); Sarmad Jawad and Ashley Kirk, "Mapped: where is air pollution killing the most people?", https://www.telegraph.co.uk/news/earth/environment/11991350/Mapped-Where-is-air-pollution-killing-the-most-people.html (2018); Matthew Taylor, "Poorest London children face health risks from toxic air, poverty and obesity", https://www.theguardian.com/environment/2017/sep/19/poorest-london-children-face-health-risks-toxic-air-poverty-obesity (2017).
248. Daniela Fecht et al, "Associations between air pollution and socioeconiomc characteristics, ethnicity, and age profile of neighbourhoods in England and the Netherlands", Environmental Pollution (2014), 201-210; for a recent analysis relevant to the UK see Department for Environment, Food and Rural Affairs and Department for Transport, "UK Plan for tackling roadside nitrogen dioxide concentrations: Technical report", https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/632916/air-quality-plan-technical-report.pdf (2017), Annex D.
249. Department for Environment, Food and Rural Affairs, "Clean Air Strategy 2019", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf (2019), 24.

be given the power to recommend new, additional future targets for different air pollutants, including targets weighted by population density and deprivation.[250]

Recommendation twelve: Legal duties should be placed on all local authorities to achieve compliance with relevant legal air pollution limits within their geographic area of responsibility. Relevant public bodies should have a legal duty to contribute to achieving compliance with legal air pollution limits within their geographic area of responsibility

Air pollution is 'polycentric', meaning it requires policy focusing on multiple actors as it is produced by multiple sources. Central Government is required to achieve legal air pollution compliance. Local authorities, meanwhile, are obliged to monitor, review and if appropriate take action in relation to the air pollution within their boundaries. But local authorities do not have a clear legal responsibility to reduce air pollution below legal limits. Equally, other public authorities that control some sources of air pollution do not face legal obligations to reduce air pollution levels to below legal limits in areas where they have authority.[251] For example, Highways England, the public body that operates and maintains England's motorways and major A-roads, has been shown to have illegal levels of NO_2 on a third of the roads it has authority over.[252] Yet, no legal obligations have been placed on the body to actually achieve compliance with legal air

250. Department for Communities and Local Government, "The English Indices of Deprivation 2015 – frequently asked questions", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/579151/English_Indices_of_Deprivation_2015_-_Frequently_Asked_Questions_Dec_2016.pdf (2016).
251. Eloise Scotford, "Investigating compliance with air quality standards: Administering "diffuse implementation" (forthcoming); UK100, "Our clean air asks", https://www.uk100.org/our-clean-air-asks/ (2019); Department for Environment, Food and Rural Affairs, Public Health England and Local Government Association, "Air quality: A briefing for directors of public health", https://www.local.gov.uk/sites/default/files/documents/6.3091_DEFRA_AirQualityGuide_9web_0.pdf (2017).
252. Thomas Barret, "Exclusive: Highways England 'sitting on money' as just £7m of £75m toxic air fund spent", https://airqualitynews.com/2019/05/29/exclusive-highways-england-sitting-on-money-as-just-7m-of-75m-toxic-air-fund-spent/ (2019).

pollution limits.

We recommend that all local authorities have a legal requirement placed on them to achieve compliance with legal air pollutant limits in their geographic area of responsibility. We also recommend that relevant public bodies should have a new legal duty placed on them to contribute to achieving compliance with legal air pollution limits within their geographic area of responsibility. The OEP or new Committee for Air Quality should be tasked with identifying the relevant public bodies and putting these recommendations to parliament.

Conclusion

The evidence around the scale and impact of air pollution is growing and alarming. Although air quality has improved in recent decades, with significant declines in most of the main pollutants, the UK exceeds legal limits over one particular pollutant: NO_2. It is the transport sector that is the biggest contributor to this pollutant.

As the UK leaves the European Union, there is a need and an opportunity to improve legislation, policies and accountability around air quality. This report offers some policies for our national government around the UK's governance and for the transport sector. The policies do not provide the whole answer. But they will help to ensure the UK significantly improves its air quality, a laudable aim that is now widely supported by the press, politicians and the public.

Annex:
Polling questions

1) **In a normal week, which of the following modes of transport do you use? Pick as many as apply.**
   - Walking
   - Petrol vehicle
   - Bus
   - Diesel vehicle
   - Overground train
   - Bicycle
   - Underground/Metro
   - Taxi
   - Tram
   - Hybrid or electric vehicle
   - Coach
   - Other
   - None of these

2) **You mentioned you do not use a hybrid or electric vehicle. Which of the following factors, if any, are preventing you from buying an electric or hybrid vehicle? Choose all that apply to you.**
   - High upfront cost
   - Lack of charging points on the road network
   - Concern about short battery life
   - Lack of funds to buy any car
   - Lack of suitable charging space at home
   - I cannot drive
   - No need or wish to buy any car
   - Concern about poor performance
   - Not available second-hand
   - Never considered it
   - Preference for familiar brands or models
   - Unattractive designs of electric vehicles
   - Don't really understand what they are
   - Another factor

3) **To what extent are you concerned about the impact of air pollution on your and other people's health?**
   - Very concerned
   - Somewhat concerned
   - Not very concerned
   - Not at all concerned
   - Don't know

4) **Which of the following sources of air pollution are you most concerned about? Pick up to three.**
   - Heavy industry
   - Diesel vehicles
   - Coal-fired power stations
   - Pesticides
   - Petrol vehicles
   - Diesel generators
   - Construction sites
   - Animal waste
   - Wood-burning stoves
   - Ships
   - Open wood fires in people's homes
   - Outdoor wood fires
   - None of these

5) **To what extent do you agree or disagree with the following statements about pollution? [Strongly agree, Somewhat agree, Neither agree nor disagree, Somewhat disagree, Strongly disagree, Don't know]**
   - Air pollution is a significant health risk to me and my family
   - The government is not doing enough to protect me and my family from air pollution
   - The UK should have cleaner air than other European countries
   - The government should reduce air pollution below its current levels
   - Stronger air pollution laws are an economic opportunity for the UK to develop cleaner industries
   - I would be more likely to vote for a political party that would cut air pollution
   - I'm not really worried about levels of air pollution

6) **Which, if any, of the following measures would you support to tackle air pollution?**

- Creating more green spaces and planting more trees in urban areas
- Investing in public transport to encourage more people to use it
- Encouraging farmers to use fewer pesticides
- Offering diesel vehicle owners money off a new electric vehicle
- Banning the use of polluting vehicles in city centres
- Ending tax breaks for diesel used in generators and machinery
- Banning the burning of polluting solid fuels, such as coal or wet wood, in urban homes
- Higher road and fuel taxes for polluting vehicles
- New charges for polluting vehicles driving in city centres
- Building more bike lanes in areas where there is high pollution
- Banning the sale of new petrol and diesel cars in the next ten years (those who already own a petrol car could continue to use it)
- Subsidising public transport for owners of polluting vehicles
- Higher parking fees for polluting vehicles
- Reducing the number of parking spaces in areas with high levels of pollution
- None of the above

7) **Which of the following potential effects of air pollution do you think are the most important for politicians to take into account when discussing action to curb air pollution? Pick up to three.**

- The harm of pollution to people's health
- The strain on the NHS from lung and heart conditions caused by pollution
- The economic benefit of developing cleaner industries and technologies
- The unfairness of air pollution disproportionately affecting children and the poorest
- The contribution of vehicles emissions to climate change
- Reduced traffic jams on roads from anti-pollution measures
- The cost of anti-pollution measures on businesses and individuals
- The potential loss of business from town centres that have anti-pollution measures
- The international prestige of leading on clean air
- None of the above

8) **Who do you think should be most responsible for tackling air pollution?**

- The UK government
- Individuals
- Heavy industry
- Car companies
- Local authorities
- Devolved government
- Metro mayors (e.g. Mayor of London, Mayor of Greater Manchester)
- None of the above

Stronger evidence has emerged in recent years about the detrimental impact of air pollution to human health, the economy and the environment. Consequently, there is growing public and political pressure for tougher action to reduce levels of air pollution in the UK. The report focuses on the sources of, impacts of, and attitudes towards air pollution across the whole of the UK.

The UK's departure from the EU means that there is an opportunity to raise air pollution standards in the UK. The report proposes new, ambitious legal limits, legal responsibilities and policies on air pollution.

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