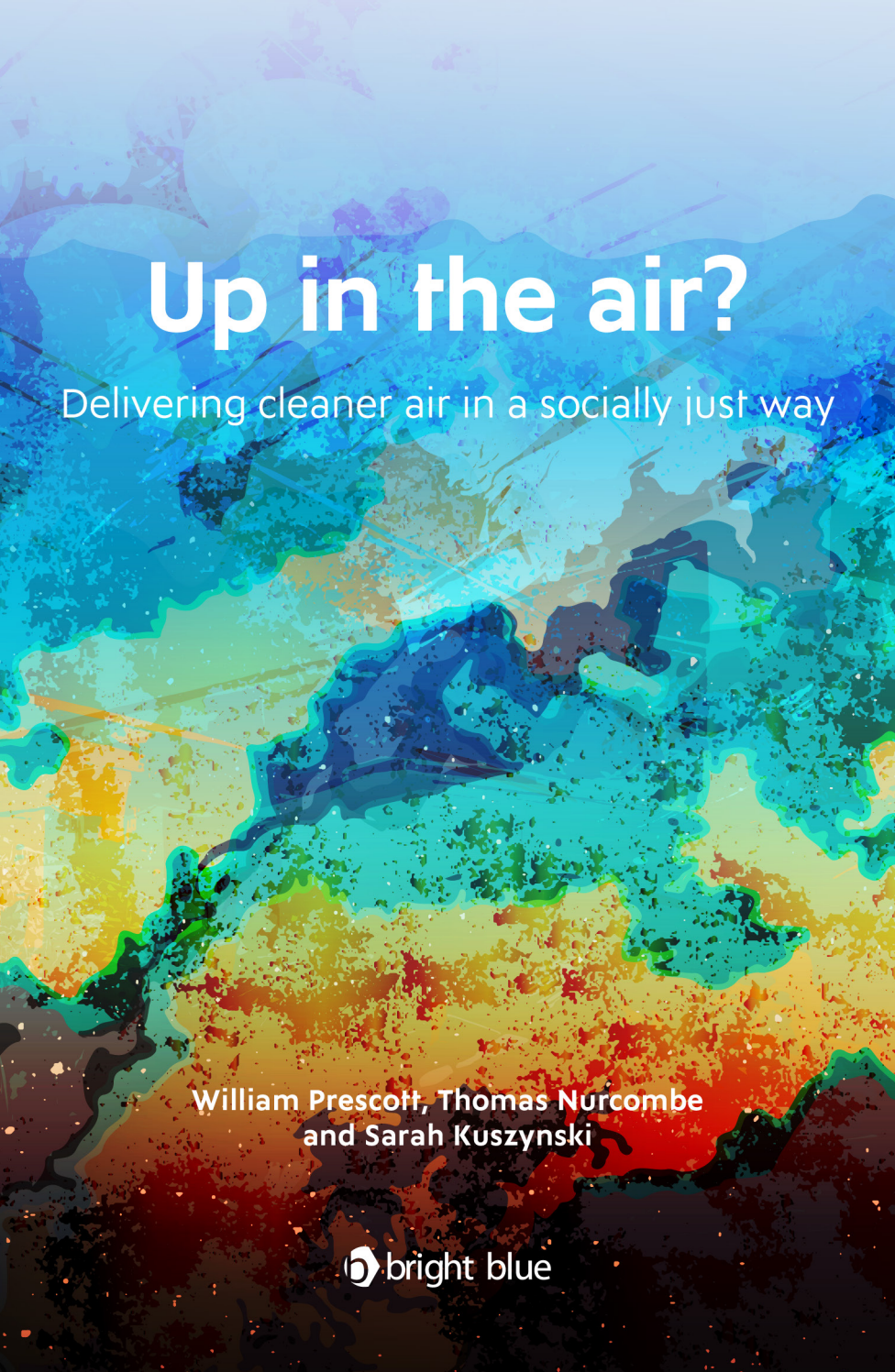
Up in the air?

Delivering cleaner air in a socially just way



William Prescott, Thomas Nurcombe
and Sarah Kuszynski

bright blue

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About the authors

William Prescott

Will Prescott is a Researcher at Bright Blue. He previously worked, among other roles, as a Senior Associate at Nurole and as a civil servant in the South Australian Education Department. He has been published in The Conversation, CapX, City AM and ConservativeHome. In 2020 Will finished a DPhil (PhD) in history at the University of Oxford on the British Conservative Party and the role of the state between 1929 and 1940. Before this, he completed his undergraduate and master's degrees at the University of Adelaide, Australia.

Thomas Nurcombe

Thomas is a Researcher at Bright Blue. He graduated with first-class honours in Ancient History and History from the University of Nottingham in 2021. Subsequently, he graduated from King's College London with distinction in MA International Political Economy. Thomas is also a member of Chatham House's flagship youth programme, Common Futures Conversations, researching issues such as climate adaptation, conflict and security and democratisation. He has been featured in and commented for several media outlets, such as City AM, the I Paper, CapX and The Guardian. Thomas co-authored a polling report on alternative policies for the UK's asylum system.

Sarah Kuszynski

Sarah is a Research Assistant at Bright Blue. She previously worked for the Pinsker Centre where she focused on Middle Eastern geopolitics and the promotion of free speech on university campuses. She has various domestic and foreign policy interests, such as environmental, technology and national security policy. In 2019 Sarah graduated from Durham University with first-class honours in Geography and Economics (BA) and in 2020 she graduated with distinction in Geographical Research (MA). From 2022 to 2023 Sarah studied for a Masters in Data Science (MDS) also at Durham University. Her MDS thesis applied machine learning and natural language processing to assess the use of moral rhetoric in UK parliamentary speeches.

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Executive summary

Long-term exposure to man-made air pollution in the UK contributes to an estimated 29,000 to 43,000 deaths per year. There is increasing evidence that the harmful effects of air pollution can be felt across people's lifetimes: exposure to polluted air negatively affects foetal development, lung growth, cognitive abilities and increases the risk of dementia and many types of cancer.

Air pollution refers to the contamination of the air by gaseous and non-gaseous substances which are harmful to human health and the environment. The main air pollutants are: fine particulate matter ($PM_{2.5}$), PM_{10}, nitrogen oxide (NO_x), non-methane volatile organic compounds (NMVOCs), sulphur dioxide (SO_2) and ammonia (NH_3).

Between 1970 and 2021, there was a substantial drop in the UK's total annual emissions of NO_x (down 77%), NMVOCs (down 68%), PM_{10} (down 79%), $PM_{2.5}$ (down 85%), and SO_2 (down 98%), although total annual NH_3 emissions have remained largely flat (down just 14%). Unfortunately, progress to reduce air pollution has slowed in the past decade.

Air pollution concentrations in the UK are regulated by a series of legal limits and targets. Limits are "legally binding and must not be exceeded". By contrast, targets to reduce concentrations of certain pollutants "are to be attained where possible by taking all necessary measures not entailing disproportionate costs." The UK's targets and limits are expressed as averages over a given time period, typically

measured by the number of micrograms per cubic metre ($\mu g/m^3$) of each pollutant that can be detected. In addition to the UK's legal obligations, the World Health Organization (WHO) has produced non-binding recommended limits, officially known as the WHO Air Quality Guidelines.

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

Compliance with WHO limits for NO_2 is far worse, however, with only 46% of neighbourhoods in England and Wales falling within or below the recommended average annual limit. The situation is even worse for $PM_{2.5}$ concentrations, where only 4.6% of neighbourhoods fall within the WHO's recommended annual limit.

In addition to legal limits and targets, there are legal ceilings, which set caps on how much NO_x, $PM_{2.5}$, NH_3, SO_2 and NMVOCs in total can be released each year. Unlike limits or targets, ceilings cap how much of a specified pollutant can be emitted in total into the atmosphere per year as opposed to the concentration of that pollutant. The UK is compliant with emissions ceilings for all pollutants except $PM_{2.5}$.

For decades, data has shown that air pollution concentrations are higher in deprived areas of the UK compared to wealthier areas, as defined by the Index of Multiple Deprivation (IMD). For example, one 2015 study estimated that 85% of the people in the UK living in areas exceeding legal NO_2 limits come from the poorest 20% of the country's population.

Unfortunately, however, action on air pollution has become increasingly politicised in recent years, which risks stalling necessary progress on reducing air pollution. We do need bold policies to reduce air pollution, but ones that support rather than penalise those living in deprived areas and ones that command public support.

Focus of this research and the methodology

This report will be unique in public policy literature by applying a special lens on the scale of, effects of and solutions for air pollution for people living in England's deprived areas. A lot of existing evidence and policies tend to focus on air pollution generally, rather than particularly focusing on the relationship between air pollution and deprivation. By contrast, this report has a particular focus on people living in deprived areas of England.

Because $PM_{2.5}$ and NO_x are disproportionately responsible for the harmful air pollution affecting people from deprived areas, and are the focus of much existing air pollution literature, this report's recommendations will focus on efforts to reduce emissions from these two pollutants.

This report seeks to answer the following six research questions:

- What does the latest evidence tell us about the health, economic and environmental effects of air pollution in England, especially in England's deprived areas?
- What are the key sources and sectors that contribute to air pollution, especially in England's deprived areas?
- How effective have existing measures been at curbing air pollution across different economic sectors in England?
- What do those people in England's deprived areas think about the scale of, effects of and solutions for air pollution?
- What further measures across different government departments are needed to curb air pollution whilst not penalising the poorest in society?
- How could future road pricing be implemented to tackle air pollution in an efficient and equitable way?

We employed three main research techniques for this report. First, we conducted an extensive literature review examining relevant UK and international evidence. Second, we consulted with a number of

academic experts, representatives from charities, as well as officials and advisers from national and local governments. Third, we developed and organised three deliberative focus groups of people from deprived areas in England in partnership with BMG Research conducted between 28 and 29 June 2023. The full focus group discussion guide can be found in Annex A of this report.

Sources of air pollution

According to the most recent figures (from 2021), the leading sources (as sectors) of total primary air pollution emissions are industrial processes (27%), agriculture (19%), road transport (11%), manufacturing industries and construction (11%), energy (8%) and domestic combustion (7%).

In terms of specific pollutants, road transport was the most common (27%) source of total NO_x emissions in 2021. This was followed by manufacturing and construction (20%), energy industries (19%) and other forms of transport, which include aviation, rail and shipping (14%).

In part due to the overlap between deprivation and exposure to traffic pollution, there is evidence suggesting a link between NO_x concentrations and deprivation.

Domestic combustion (or heating) was the largest single contributor of $PM_{2.5}$ emissions in 2021 responsible for just over a quarter of the total. This largely comes from the burning of wood in closed stoves and open fires. This is followed by emissions from manufacturing industries and construction (26%), industrial processes (14%) and road transport (13%).

Although there is some regional variation, the UK evidence points to $PM_{2.5}$ being worse in deprived urban areas than in less deprived urban areas.

As the evidence on NO_x and $PM_{2.5}$ shows, two sectors that are especially responsible for air pollution in deprived areas are transport and domestic burning. So these two sectors are the main focus of this

report, both in terms of analysing existing policies but also formulating new ones.

Transport – cars in particular, but also planes, trains and ships – was the source most commonly associated with air pollution in all of the focus groups we conducted for this report. Participants across all the focus groups bemoaned "dirty" fumes and the negative health effects they associated with them, although they also highlighted the necessity of using these modes of transport in daily life, especially where clean alternatives such as public transport are not readily available or affordable.

Pollution from transportation is especially important for this report, given that people living in deprived areas are more likely to live in inner-city areas located near major transport corridors where NO_2 concentrations are particularly high.

The participants of all three of our focus groups generally saw domestic burning as significantly less relevant to air pollution than other sectors such as transport and industry.

Despite this view among our focus group participants, domestic burning, mostly of wood, is now the largest source of UK annual $PM_{2.5}$ emissions. Moreover, the problem of wood-burning induced $PM_{2.5}$ emissions is a growing one – the National Atmospheric Emissions Inventory estimated that $PM_{2.5}$ emissions from domestic wood burning increased by 35% between 2010 and 2020.

Effects of air pollution

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

There are two main types of health effects: physical health and mental health. Across all three focus groups, the effects on physical health were one of the first things participants mentioned when they were asked to write down what came to mind when they when they thought about air pollution.

Air pollution has long been known to have adverse health effects – to date, there are roughly 60,000 studies available on the effects of air pollution on health. Effects include both short-term (which includes "worsening of symptoms, hospitalisations, deaths") and long-term impacts (which includes "disease development, attributable premature deaths and years of lost healthy life"). Evidence shows that air pollution is causally linked to respiratory diseases, such as asthma and chronic obstructive pulmonary disease (COPD), and increased risk of heart disease, stroke and cancers, especially lung cancer. Emerging evidence also shows that air pollution is associated with worse cognitive and mental health for both children and adults.

People from deprived areas typically have less access to jobs, healthy food, quality housing and green spaces, which all contribute to poorer health. This means that people in deprived areas "are more likely to suffer greater harm as a consequence of their exposure [to air pollution] since they are more vulnerable to its effects".

People living in deprived areas tend to live in areas with higher air pollution, which may in large part be due to the link between lower house prices and proximity to busy main roads that have greater exposure to NO_2 and PM emissions.

Air pollution negatively affects the economy by increasing the burden on the NHS, reducing workforce participation, increasing the number of workdays lost to illness and, by impairing cognitive performance, reducing productivity among those still able to work.

Unsurprisingly, air pollution can negatively affect natural habitats and ecosystems. Serious environmental impacts of air pollution occur due to nitrogen deposition, acid deposition and the direct effects of toxic air pollutants being in the air.

Recent UK local and national policies on air pollution

While central government is responsible for legislating clean air targets, limits and ceilings, it has delegated substantial responsibility for the design and implementation of policies to reduce air pollution

from transport and domestic burning to local and combined authorities.

Under the UK's Transport Act 2000 and the Greater London Authority Act 1999, local authorities and the Mayor of London have the power to introduce Clean Air Zones (CAZs). The Traffic Management Act 2004 gives local authorities the power to introduce Low Traffic Neighbourhoods (LTNs).

The three main types of policy interventions to reduce air pollution from the transport sector and domestic burning in the UK over the past decade have included bans, regulations and subsidies.

Bans

The main examples of bans to reduce air pollution relate to domestic burning. Local authorities are empowered to regulate domestic burning by the Clean Air Act 1993.

The UK Government recently banned the sale of house coal and wet wood to reduce pollution from domestic household burning in England. Small volumes of house coal and wet wood – under $2m^3$ – can no longer be sold and sales of wet wood in large volumes must be sold with advice on how to dry it before burning. Additionally, Government regulations require that all new wood-burning stoves and fireplaces meet guidelines known as Ecodesign, which permit stoves to emit a maximum 375g of $PM_{2.5}$ for every gigajoule of energy they produce. The UK Government has also increased penalties for non-compliance and reduced emission limits on individual household stoves.

Unfortunately, proving that stoves have exceeded emissions limits is expensive and practically difficult. Moreover, local authorities, who are responsible for enforcement, have limited resources to go after offenders.

Regulations

The main examples of regulations to reduce air pollution relate to

the transport sector. Specifically, road pricing schemes, which includes CAZs, toll roads, bridge and tunnel charges, and zonal charging schemes and LTNs.

Road pricing refers to charges that are directly imposed on drivers for using public roads. Such charges can serve two primary functions: to reduce the harms caused by driving such as air pollution and congestion; and/or to raise money.

Clean Air Zones (CAZs)

A CAZ is officially defined as "an area where a local authority applies charges using powers under the Transport Act [2000] to deliver NO_2 reductions".

There are four types of CAZ: classes A, B, C and D. Each of these classes charges non-compliant vehicles to enter the CAZ, but each class encompasses different types of vehicles. In addition to London's ULEZ, seven cities in England currently have CAZs. These are: Bath, Birmingham, Bradford, Bristol, Portsmouth, Sheffield and Tyneside.

Where they have been implemented, CAZs have shown some success in reducing NO_2 concentrations, although there is less evidence for their success in reducing concentrations of $PM_{2.5}$.

Despite their apparent success at reducing NO_2 concentrations, there have been concerns that CAZs disproportionately affect those living in deprived areas.

Participants in our own Birmingham focus group, where a CAZ currently exists, had a strong negative reaction to the idea of CAZs. Almost all of the participants in that group believed that it was wrong to charge people with older cars to drive in the city centre, largely due to the perception that those with older cars that did not meet emissions standards were poorer and could not afford to upgrade cars.

In Liverpool, by contrast, where there is no CAZ and no plans to implement one, the positive views outweighed the negative ones by some margin.

Ultra Low Emission Zone (ULEZ)

Only one city in the UK has a large, city-wide CAZ – the London ULEZ. First proposed by then Mayor Boris Johnson in 2015 and introduced in Central London in 2019, it now extends to almost the entire Greater London area, and regulates petrol and diesel cars, motorcycles, minibuses up to five tonnes, and vans and specialist vehicles up to 3.5 tonnes.

Evidence suggests the ULEZ has improved air quality in Central London – one report found that, by 2022, NO_x emissions were 26% lower within the ULEZ's boundaries than would have been the case if the ULEZ had not been implemented, while $PM_{2.5}$ emissions were 19% lower.

Despite this, ULEZ has proven hugely controversial. Its recent expansion to include almost all of outer London has been criticised for disproportionately affecting lower-income households during a cost-of-living crisis. Public opposition to the impending expansion of ULEZ – instigated by a Labor Mayor of London – was blamed by some for the Labour Party's unexpected defeat at the Uxbridge and South Ruislip by-election in July 2023

The scheme, and particularly its then-impending expansion to outer London boroughs, generated a strong negative response from participants in the Barking and Dagenham focus group. The group participants' primary concern was the impact it might have on deprived areas.

Other road pricing schemes

While there can be an overlap between congestion charge schemes and CAZs and congestion charge schemes, the key difference is that congestion charges are levied based on road usage rather than the type of vehicle driven. By contrast, CAZs are specifically intended to reduce concentrations of NO_2 by driving only the most polluting vehicles off the roads, which can be achieved without reducing the overall number of vehicles on the road.

The most relevant types of road pricing schemes are zonal, meaning charges are imposed to enter a designated area. There are two instances of these in England: Durham and the Congestion Charge Zone (CCZ) in London.

The London CCZ requires the payment of a £15 daily charge for driving within a specified zone in Central London between 7:00am and 6:00pm, Monday to Friday, and between 12:00pm and 6:00 pm on weekends and bank holidays.

Evidence suggests the London CCZ has had some positive impact on reducing air pollution. Once study found that, between 2019 and 2021, while air pollution fell throughout London, average annual concentrations of $PM_{2.5}$ fell by 4.6 percentage points more inside the London CCZ compared to sites within 3km of it, and 7.1 percentage points more inside the London CCZ compared to sites within 10km of it.

Several members of our Barking and Dagenham focus group, which lies outside the London CCZ, viewed it negatively, criticising the apparent overlap with the ULEZ.

Low Traffic Neighbourhoods (LTNs)

Finally, and different to road pricing, the other major regulation that seems to reduce air pollution from transport is LTNs. While there is no official definition, LTNs involve the placement of bollards, planters and plate-recognition cameras to get rid of 'through' traffic on residential streets. By lowering the number of vehicles on roads and reducing traffic, they increase the number of people walking or cycling.

LTN-like traffic barriers have existed since the 1960s, with one study estimating that over 25,000 had been installed by 2021. More recently, in spring 2020, the Government announced a £250 million emergency active travel fund, which supported the rollout of LTNs; especially in London, but also in Oxford, Manchester, Birmingham and Sheffield, with an estimated 200 being installed across the UK in total.

Although some evidence suggests that LTNs have helped to reduce air pollution where they have been implemented, a perception exists –

despite evidence to the contrary – that they merely divert traffic rather than reduce it.

There was no clear consensus reached, either across or within our focus groups on attitudes towards LTNs. While some participants agreed they reduce air pollution and improve the amenity of particular areas, others thought that they merely diverted pollution elsewhere.

Subsidies

The main examples of regulations to reduce air pollution relate to the transport sector. Specifically, CAZ exemptions and scrappage schemes.

CAZ exemptions

While local authorities cannot charge certain types of vehicles, such as fully electric or hydrogen-powered vehicles, for entering a CAZ, most other exemptions are at the discretion of local authorities. Because of this, the extent and duration of these exemptions vary considerably across different CAZs.

There has been significant criticism at the lack of exemptions offered by local authorities in CAZs across England. The London ULEZ offers more extensive exemptions than other CAZs, including temporary exemptions ('grace periods') for drivers of vehicles registered under the disabled tax class, wheelchair-accessible vehicles, and those in receipt of certain disability benefits. This is alongside the £160million scrappage scheme. The ULEZ is also refundable for some NHS patients attending hospital appointments. However, even the ULEZ has attracted criticism because of its failure to exempt all Blue Badge holders from the charge.

Were asked if there should be any further exemptions to CAZ charges, participants in our focus groups specifically mentioned poorer and disabled residents.

Scrappage schemes

Scrappage schemes are financial incentives, typically in the form of

cash or vouchers, offered to vehicle owners either to retrofit (that is, upgrade) or replace more polluting vehicles with more environmentally friendly ones, or simply to scrap older, more polluting vehicles. They typically sit alongside the implementation of CAZs, to enable drivers to switch to compliant vehicles.

Because responsibility for scrappage schemes lies with local authorities or the Mayor of London, the level of support offered to upgrade or scrap non-compliant vehicles varies considerably across England.

There is some evidence that scrappage schemes help to reduce air pollution. One recent report from Transport for London (TfL) estimated that the scrappage schemes for the 2021 expansion of the ULEZ to inner London supported the removal of 140 tonnes of NO_x emissions and 0.5 tonnes of $PM_{2.5}$ emissions in Greater London.

Unlike the ULEZ, all those living within the London congestion zone are eligible for a 90% discount on the CCZ charge. All Blue Badge holders are eligible for a 100% exemption. Additionally, NHS and emergency services vehicles, drivers of two-wheeled motorbikes and mopeds, taxis, as well as certain vehicles operated by London boroughs and the armed forces are also exempt.

Finally, those with fully electric vehicles are exempt, but, unlike with the ULEZ, this exemption is set to be removed by 2025.

Unfortunately, there have been major concerns about the adequacy of even the relatively generous London ULEZ existing scrappage schemes. For example, the £2,000 available to scrap a non-compliant car is insufficient to cover the cost of a replacement, ULEZ-compliant, one. According to August 2023 data from AutoTrader, the cost of a compliant second-hand car has increased to just over £18,000, with only around 5,000 of the 43,359 ULEZ-compliant cars listed for sale priced at under £5,000.

International policies on air pollution

Other countries around the world offer unique and additional policies that have been used to reduce total air pollution emissions from

transport and domestic burning. When examining international examples, the report's focus was on examples of bans, regulations and subsidies.

Bans

In Stuttgart, wood-burning fireplaces and stoves in private households were the second largest source of PM after road traffic. The policy effectively helped to reduce the number of days when concentrations of PM_{10} exceeded the EU legal limit of 50μg/m³, which declined from 58 days in 2016, to 25 days in 2019 and then to just 20 days in 2020. Consequently, the Baden-Württemberg State Government scrapped the ban on domestic burning in Stuttgart in April 2022.

Bans can also be features of Low Emission Zones, which is the term commonly used in continental Europe to describe CAZs. For example, the city of Paris, France outright bans all pre-2006 diesel cars, as well as all pre-1997 vehicles, from driving within its LEZ.

Regulations

Road pricing schemes

Singapore has introduced the world's most sophisticated road pricing scheme. Unlike the London CCZ, the Singaporean Electronic Road Pricing (ERP) system requires all Singapore-registered vehicles to acquire an in-vehicle unit (IU) that tracks each vehicle's movement. This feature makes it easier to regularly alter the ERP's rates and hours of operation than it is for the London CCZ. Likely because the ERP was targeted at reducing congestion rather than the types of air pollution discussed in this report, there do not appear to be any studies that consider its impact on emissions of NO_2, $PM_{2.5}$ or PM_{10}. However, by reducing traffic volumes, it has likely reduced traffic-related emissions of NO_2, $PM_{2.5}$ and PM_{10}.

Stockholm's congestion zone also offers a more variable pricing system than the London CCZ. The zone is charge-free between 6.00pm and

6.29am, and from 6.30am charges 10 Krona for entry (approximately) £0.95. The charge peaks at 20 Krona between 7.30am and 8.29am and also between 4.00pm to 5.29pm. In contrast, the CCZ charges the same £15 daily rate throughout all of its hours of operation. It was estimated that the congestion charge reduced PM_{10} and NO_2 by 10-15% and 15-20% respectively between 2004 and 2010.

Subsidies

Stove scrappage schemes

International governments have offered financial support for households to upgrade or replace their existing stoves to reduce air pollution, chiefly PM emissions.

In the former mining town of Libby in Montana, USA, domestic burning was responsible for 82% of the town's particle pollution. To tackle this, in 2005, low-income residents of the town were offered less polluting wood burners with free installation that met US emissions limits. Secondly, between 2006 and 2008, homeowners were offered vouchers to upgrade their stores to ensure compliance. The upgrades led to noticeable reductions in pollutant emissions, with $PM_{2.5}$ emissions falling by 30% between the winters of 2005 and 2009 and ceasing to exceed US legal limits.

Similarly, confronted by some of the worst air pollution of any Australian city, Launceston in Tasmania combined a scrappage scheme with an education programme to reduce the wood burning that lay at the heart of its pollution problem. Between 2001 and 2007, winter PM_{10} fell by nearly 40%, respiratory deaths by 28% and heart issue-related deaths fell by 20%.

New policies

It is clear from the evidence that the UK needs to consider additional policies to reduce air pollution in deprived areas. Here, we put forward policy recommendations to reduce total emissions from

transport and domestic burning, with a particular focus on those living in deprived areas.

When formulating policies, we applied six tests that had to be met:

1. **Focussed on central government powers and accountability.** The policies we propose to tackle air pollution are focused on the powers and accountability of central government. Although responsibility for air pollution is heavily devolved, central government is still responsible for determining the legal framework for the policies that local authorities may pursue to reduce air pollution. Since local authorities shape the specific design of their air pollution policies, we think it is right to provide recommendations only to central government on what the framework should be.
2. **Focussed on reducing air pollution from transport and domestic burning.** As argued in Chapter Three, these are especially consequential deprived areas, specifically in terms of total annual emissions of NO_x and $PM_{2.5}$.
3. **Focus on private rather than public transport.** While there also need to be policies to encourage the uptake of public transport, these are beyond the scope of this report.
4. **Fiscal responsibility.** Policies to tackle air pollution should be fiscally prudent in that they do not necessitate excessively large amounts of central government spending. This 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.
5. **Progressivity.** Policies to tackle air pollution should be progressive. Where additional charges are being levied on particular transport modes or on domestic burning, they should not be burdensome for the least well-off. Where public subsidies

are being made available, that help should be prioritised towards the least well-off. The importance of progressivity was stressed across all our focus groups.

6. **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 externality costs of it.

Recommendation one: Require CAZs to differentiate charges for driving in inner cities and outer urban areas.

Local authorities and the Mayor of London have discretion as to how much vehicles are charged for entering a CAZ/ULEZ.

To date, London ULEZ is the only CAZ that covers almost an entire urban area. When the ULEZ expanded on 31 August 2023 to include the entire territory under the jurisdiction of the Greater London Authority, all non-compliant vehicles became liable to pay a £12.50 daily charge to drive within the zone. This is notwithstanding that the quality of public transport is significantly worse in outer London than it is in inner London and outer London residents are more car-dependent as a result.

We recommend that central government require that local authorities and the Mayor of London introduce differentiated charging regimes between their inner city and outer urban areas for any city-wide CAZ, to reflect the varying availability of public transport.

Recommendation two: Clean Air Zones should provide exemptions for all Blue Badge holders.

Local authorities and the Mayor of London have discretion as to whether they wish to apply any exemptions for any road charging schemes, such as CAZs. Local authorities may grant discounts or exemptions for Blue Badge holders "should analysis of local

circumstances warrant such an approach".

Reflecting this, the cities with Class D CAZs, that is those CAZs that charge non-compliant private cars to enter, have provided different exemptions for disabled residents. For example, Bristol's CAZ introduced temporary exemptions for Blue Badge holders, while Birmingham's CAZ did not provide any exemptions for Blue Badge holders.

We recommend that central government require local authorities and the Mayor of London to grant exemptions to all Blue Badge holders in Class D CAZs. As the clearest legal indicator of disability, Blue Badge holder status would be the fairest way to protect disabled people from the adverse consequences of charging CAZs.

Recommendation three: Enable local authorities to strive for 'reasonable profits' from their charging Clean Air Zones (CAZs) to fund targeted, generous scrappage schemes in the short term.

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

To provide support to those needing to upgrade non-compliant vehicles, the UK Government provided funding for two of the cities with Class D CAZs (Birmingham and Bristol), but did not provide any support for London's ULEZ scrappage scheme, which was entirely funded by the GLA itself. Unfortunately, the support available to vehicle owners has not proved enough to cover the cost of purchasing compliant vehicles.

We recommend the UK central government allow local and combined authorities to pursue 'reasonable profits' from their CAZs, so long as those profits are only used to provide more generous scrappage schemes that are specifically targeted at those from deprived areas.

Recommendation four: The Government should immediately pilot a voluntary road pricing scheme for all road users ahead

of a national rollout, that includes a discount for those on low incomes.

Unless it finds an alternative source of income to offset the decline of Fuel and Vehicle Excise Duties, the UK Treasury faces a £30 billion budget shortfall between 2020-21 and 2050-51 as a result of the phase out of internal combustion engine vehicles. Moreover, if action is not taken soon to address this shortfall, drivers of electric vehicles may become used to not paying any taxes, making it politically far more difficult to introduce any motoring taxes in the future. This is especially the case with the UK set to phase out all sales of combustion engine vehicles by 2035.

In terms of air pollution, a growth in the number of car journeys is a problem because electric vehicles still produce harmful $PM_{2.5}$ emissions, specifically from tyres and road wear.

The most viable and most equitable replacement for Fuel and Excise Duties, is a road pricing scheme that applies to all vehicles, charging road users on a per-mile basis.

However, introducing such a scheme will be politically difficult. In particular, as our focus groups suggested, it is likely to be viewed cynically as a revenue-raising measure and there are likely to be privacy concerns owing to the need to electronically track the distance each vehicle travels. This is especially the case with the UK set to phase out all sales of combustion engine vehicles by 2035.

We recommend that, to gradually detoxify per-mile road pricing, central government immediately trial a road pricing scheme for all road users. It would be an 'opt in' scheme, with those volunteering to participate being exempt from Fuel Duty. An immediate set of pilots would lay the groundwork for a national rollout of road pricing schemes from around 2035. To incentivise participation in the trial, the government might consider what sorts of monetary incentives would be appropriate.

Because of the risk that the introduction of a road pricing scheme slows the adoption of electric vehicles, government could also introduce

a temporary 'green miles' scheme that offers a certain proportion of discounted or free miles to those electric vehicles. This would be phased out over time.

We further recommend that such a scheme provide a 'free mileage' which means allowing motorists to drive a set number of miles before they would have to start paying. This would be targeted, with those from deprived areas, those living in areas with inadequate access to public transport, as well as disabled people, receiving higher free mileage allowances than the general population.

Recommendation five: Amend the Clean Air Act 1993 to permit local authorities to ban completely domestic burning in smoke control areas on days when the DAQI score is forecast to be at a level harmful to human health.

Local authorities may currently designate certain areas to be smoke control areas. In those areas, domestic burning is prohibited unless is done using an 'exempt appliance', that is a Defra-approved stove, or, if the stove is not an exempt appliance, the burning is carried out with a Defra-approved fuel. While Defra-approved stoves and fuels produce less $PM_{2.5}$ emissions than non-approved stoves or fuels, they still produce substantial emissions that local authorities cannot stop. This is especially significant given that domestic burning is now the largest single source of $PM_{2.5}$ emissions in the UK.

To help address this problem, we recommend that local authorities be given the power to ban domestic burning completely on days when air pollution is forecast to be harmful to human health. Exemptions would be available for the very small number of households with no alternative source of heating.

There are several ways to communicate these temporary bans to the public. Australia provides several examples of these. Australia communicates regional fire bans through a combination of announcements on radio, television and internet weather forecasts, social media updates, and government agency websites. Although in a

different context – to stop outdoor burning to prevent the outbreak of bushfires rather than to stop domestic burning to reduce concentrations of air pollution – these approaches could be used to communicate when the bans are in effect.

Recommendation six: Warning labels to be added to all new and refurbished stoves.

The UK recently banned the installation of new stoves that failed to meet the new Ecodesign standards, meaning stoves that emit up to 375g of $PM_{2.5}$ for every gigajoule of energy produced.

However, Ecodesign stoves still produce $PM_{2.5}$ emissions 750 times greater per hour than an HGV vehicle, and more than 450 times more $PM_{2.5}$ emissions per hour than a gas boiler. As such, even the new standards still permit far higher than acceptable emissions of $PM_{2.5}$.

While we do not support an outright ban on the installation of new stoves, we recommend that Defra further tighten emissions standards to ensure that no new stoves emit more than 150g of $PM_{2.5}$ for every gigajoule of energy produced, which is the official standard in the Nordic countries.

Recommendation seven: Warning labels to be added to all new and refurbished stoves.

There is little public awareness of the harmful medical effects that domestic burning causes not only to people who burn domestically themselves, but, to their neighbours. This is reflected in the recent increase in sales of stoves in recent years. It is also reflected in the mistaken belief among many people, especially among more affluent households, that domestic burning is a safer, more environmentally friendly way of heating one's home than gas boilers.

New stoves are required to have an energy rating label attached, but not a health warning. The UK's statutory guidance for combustion appliances, which includes stoves, requires them "to incorporate an appropriate means of warning of a release of carbon monoxide".

However, the guidance contains no requirement for new stoves to contain labels warning about the negative health consequences of the outdoor pollution that stoves emit, particularly emissions of $PM_{2.5}$.

We recommend that Defra require that all new stoves have mandatory warning labels attached that specifically highlight the negative medical consequences of the outdoor air pollution that even Defra-approved stoves still produce.

Conclusion

Air pollution is both linked to growing numbers of serious health problems, but also disproportionately affects those from deprived areas. Despite reductions in the total emissions of the main air pollutants in the UK over recent decades, exposure to dangerous concentrations of those pollutants, especially $PM_{2.5}$ and NO_x, still causes an estimated 29,000 to 43,000 premature deaths per year. As highlighted in this report, transport and domestic burning are two sources of air pollution that are especially important for reducing air pollution in deprived areas of England.

This report offers some policies for central government to both reduce air pollution and to mitigate the negative effects that measures to reduce air pollution will have on those in deprived areas in England. These policies will not singlehandedly resolve the problems of air pollution from transport and domestic burning. However, they will help to ensure that England reduces its air pollution to some extent in ways that directly benefit, rather than penalise, people living in deprived areas.

Chapter 1:
Introduction

Despite decades of improvements to air quality, long-term exposure to man-made air pollution in the UK still contributes to an estimated 29,000 to 43,000 deaths per year.[1] There is increasing evidence that the harmful effects of air pollution can be felt across people's lifetimes: exposure to polluted air negatively affects foetal development, lung growth, cognitive abilities and increases the risk of dementia and many types of cancer.[2]

Worse still, the negative consequences of air pollution fall most heavily on England's deprived areas, which disproportionately experience the worst air quality.[3] Air pollution also disproportionately affects people from ethnic minority backgrounds and disabled people.[4] Both of these groups are also more likely to live in deprived areas.[5] Thus, by focusing

1. UK Health Security Agency, "Chemical Hazards and Poisons Report Issue 28 – June 2022", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1083447/CHaPR_AQ_Special_Edition_2206116.pdf (2023), 15.
2. Gary Fuller, Stav Friedman and Ian Mudway, "Impacts of air pollution across the life course – evidence highlight note", Environmental Research Group, Imperial College London, https://www.london.gov.uk/sites/default/files/2023-04/Imperial%20College%20London%20Projects%20-%20impacts%20of%20air%20pollution%20across%20the%20life%20course%20%E2%80%93%20evidence%20highlight%20note.pdf, (2023); Chit Ming Wong et al., "Cancer Mortality Risks from Long-term Exposure to Ambient Fine Particle", *Cancer Epidemiology, Biomarkers & Prevention* (2016), 839–845.
3. Asthma UK and British Lung Federation, "Clear the air. Improving air quality to protect future generations and level up our communities", https://web.archive.org/web/20220218153905/https://www.blf.org.uk/sites/default/files/Clear_the_air_report_v2.pdf (2021), 15
4. Damien Gayle, "People of colour far likelier to live in England's very high air pollution areas", *The Guardian*, 4 October 2022, https://www.theguardian.com/environment/2022/oct/04/people-of-colour-likelier-live-england-very-high-air-pollution-areas.
5. HM Government, "People living in deprived neighbourhoods", https://www.ethnicity-facts-figures.service.gov.uk/uk-population-by-ethnicity/demographics/people-living-in-deprived-neighbourhoods/latest (2020); Office for National Statistics, "Disability by age, sex and deprivation, England and Wales: Census 2021", https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/disability/articles/disabilitybyagesexanddeprivationenglandandwales/census2021 (2023).

on deprived areas, this report's findings and recommendations will be particularly relevant to people from ethnic minority backgrounds and disabled people.

This report's unique contribution is to analyse the scale of, impact of and solutions for poor air quality in England's deprived areas. In doing so, this report expands on Bright Blue's previous work on air pollution, specifically on the West Midlands Combined Authority[6] and also on reducing air pollutants for transport generally.[7] Since air pollution strategy is a devolved matter, this report primarily focuses on England.

What is air pollution?

Air pollution refers to the contamination of the air by gaseous and non-gaseous substances which are harmful to human health and the environment. The main air pollutants are listed below.

- **Fine particulate matter ($PM_{2.5}$).** Particles smaller than or equal to 2.5 µm (micrometres). The particles can either result from human activity (such as combustion) or have a natural origin (such as from soil or pollen).[8]
- **PM_{10}.** As above, but with particles smaller than or equal to 10 µm.
- **Nitrogen oxide (NO_x).** Groups of gases formed during the combustion of fossil fuels. Most nitrogen oxides come in the form of nitric oxide which can react with other gases in the air to form nitrogen dioxide (NO_2).[9]
- **Sulphur dioxide (SO_2).** An acidic gas primarily generated through the burning of coal or crude oil. It contributed heavily to the infamous 1952 London smog and, when mixed with water

6. Eamonn Ives and Ryan Shorthouse, "Clearing the air: reducing air pollution in the West Midlands", https://brightblue.org.uk/wp-content/uploads/2019/08/Emission_Impossible_Final.pdf (2018).
7. Ryan Shorthouse and William Nicolle, "Emission impossible? Air pollution, national governance and the transport sector", http://brightblue.org.uk/wp- content/uploads/2019/08/Emission_Impossible_Final.pdf (2019).
8. Department for the Environment and Rural Affairs ("Defra"), "Air quality PM2.5 targets: detailed evidence report", https://consult.defra.gov.uk/natural-environment-policy/consultation-on-environmental-targets/supporting_documents/Air%20quality%20targets%20%20Detailed%20Evidence%20report.pdf (2022), 11.
9. House of Commons Library, "Expansion of the Ultra Low Emission Zone", https://researchbriefings.files.parliament.uk/documents/CDP-2022-0240/CDP-2022-0240.pdf (2022), 9.

vapour in the atmosphere, can react to form acid rain.[10]

- **Non-methane volatile organic compounds (NMVOCs).** A large group of organic compounds that are emitted into the air as combustion products, mainly as vapour arising from petrol and solvents. They can react with other air pollutants outdoors to produce ground-level ozone, which increases the risk of asthma and damage to crops.[11]
- **Ammonia (NH_3).** A lighter-than-air gas mainly released into the atmosphere from agricultural activity. It can form $PM_{2.5}$ and PM_{10} when it mixes with NO_x and SO_2 in the atmosphere.[12]

In addition to the main pollutants listed above there are other air pollutants.

This report will discuss each of the main pollutants listed above, but not consider in detail ozone (O_3), ultrafine particles (UFPs), or carbon monoxide (CO), benzene (C_6H_6), benzo[a]pyrene, 1,3-butadiene, lead (Pb), arsenic (AS), cadmium (Cd) and nickel (Ni).[13] Although damaging to human health, O_3 is not directly emitted into the atmosphere.[14] As such, it is more logical to examine the sources of O_3, such as NMVOCs and NO_x. Further, while a growing body of research suggests various short- and long-term harms caused by UFPs, there is not yet enough evidence for the World Health Organization (WHO) to formulate clear

10. Defra, "National statistics Emissions of air pollutants in the UK – Sulphur dioxide (SO2)", https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-sulphur-dioxide-so2#:~:text=Sulphur%20dioxide%20(SO2)%20is%20a,and%20constriction%20of%20the%20airways (2023)
11. Defra, "Emissions of air pollutants in the UK – Non-methane volatile organic compounds (NMVOCs)", https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-non-methane-volatile-organic-compounds-nmvocs (2023). For a more detailed background of NMVOCs in the UK, see Air Quality Expert Group, "Non-methane Volatile Organic Compounds in the UK", https://uk-air.defra.gov.uk/assets/documents/reports/cat09/2006240803_Non_Methane_Volatile_Organic_Compounds_in_the_UK.pdf (2020).
12. Defra, "Emissions of air pollutants in the UK – Ammonia (NH3) ", https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-ammonia-nh3#:~:text=Ammonia%20(NH3)%20is%20a%20gas,and%20be%20transported%20large%20distances, (2023).
13. Defra, "Air Pollution in the UK 2021" (2021), https://uk-air.defra.gov.uk/library/annualreport/viewonline?year=2021_issue_1#report_pdf (2022), 7, 112-14.
14. Defra, "National Statistics Ozone (O3)", https://www.gov.uk/government/statistics/air-quality-statistics/concentrations-of-ozone (2023).

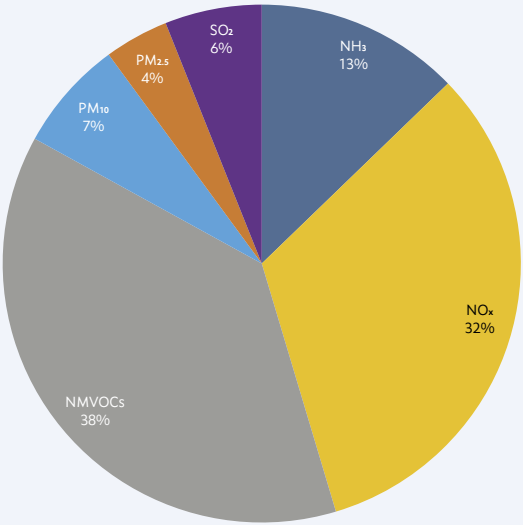
analysis and policies for that pollutant.[15] Additionally, while CO is toxic, people are more commonly exposed to it indoors, whereas outdoor air pollution is the focus of this report.[16] Finally, C_6H_6, benzo[a]pyrene, 1,3-butadiene, Pb, AS, Cd and Ni feature much less frequently in the air pollution literature and contemporary policy debates than the main pollutants and as such are largely beyond the scope of this report.

Chart 1.1 below shows the percentage contribution of each main pollutant to overall air pollution emissions in the UK in 2021, which is the year for which the latest figures are available.[17]

Although the 2021 figures include a period during which COVID-19 restrictions were in place, which massively impacted human activity and mobility, the relative contribution of each pollutant was little changed from the 2019 figures, the last full year before the pandemic.[18]

15. Lidia Morawska et al., "Ambient ultrafine particles: evidence for policy makers. A report prepared by the 'Thinking outside the box'", team https://efca.net/files/WHITE%20PAPER-UFP%20evidence%20for%20policy%20makers%20(25%20OCT).pdf (2019), 16.
16. COMEAP, "Review of the UK Air Quality Index", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/304633/COMEAP_review_of_the_uk_air_quality_index.pdf (2011), 11.
17. Defra, "ENV01 – Emissions of air pollutants", https://www.gov.uk/government/statistical-data-sets/env01-emissions-of-air-pollutants (2023).
18. Ibid.

Chart 1.1. Percentage contribution of each main pollutant to total UK annual air pollution emissions, 2021



Source: Defra, "ENV01 – Emissions of air pollutants", https://www.gov.uk/government/statistical-data-sets/env01-emissions-of-air-pollutants (2021).

As will become clearer later this report, however, these percentages in Chart 1.1 do not necessarily correspond to the degree of harm each main pollutant causes. For example, although $PM_{2.5}$ only made up 4% of total air pollution emissions in 2021, it arguably causes the most harm of any individual air pollutant. This is due to the ability of such small particles to reach into the lungs and the bloodstream.[19]

It should also be stressed that, while the report will discuss the sources of, and harms caused by, the main air pollutants, its policy recommendations will focus on efforts to reduce $PM_{2.5}$ and NO_x emissions. This is because, as Chapters Three and Four explain, these

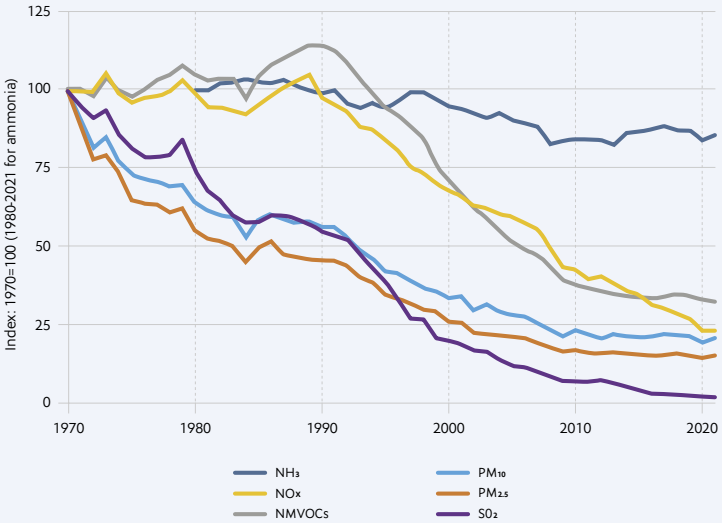
19. Clean Air Fund, "The Pathway to Healthy Air in the UK" https://s40026.pcdn.co/wp-content/uploads/The-Pathway-to-Healthy-Air-in-the-UK.pdf (2022), 5.

two air pollutants are disproportionately responsible for the harmful air pollution affecting people from deprived areas.[20]

Trends in the emissions of the main air pollutants

As we can see from Chart 1.2 below, since 1970 there has been a substantial drop in total annual emissions of NO_x, NMVOCs, PM_{10}, $PM_{2.5}$, and SO_2.

Chart 1.2. Trends in annual emissions of main air pollutants, 1970-2021



Source: Defra, "National statistics Emissions of air pollutants in the UK – summary", https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-summary (2023).

The steepest fall in annual total emissions for any pollutant is SO_2, with emissions down by 98% since 1970, from 6.53 million tonnes to 125,600 tonnes. Annual total emissions of $PM_{2.5}$ saw the second

20. See Chapter Three.

steepest decline, having fallen by 85% between 1970 and 2021, from 545,800 tonnes to 83,200 tonnes. Following this, total emissions of PM_{10} in 2021 were 79% lower than they had been in 1970, falling from 689,400 tonnes to 144,000 tonnes.

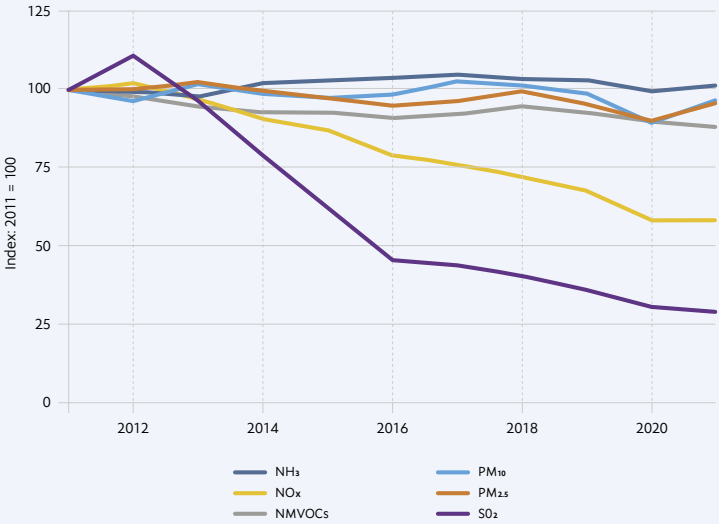
Despite remaining largely flat between 1970 and 1990, total annual emissions of NO_x were 77% lower in 2021 than they had been in 1970, falling from 2.92 million tonnes to 677,100 tonnes. Similarly, despite rising during the late 1980s and only peaking in 1989, total emissions of NMVOCs were 68% lower in 2021 than they had been in 1970, falling from 2.41 million tonnes to 781,000 tonnes.

The notable exception to this trend is total annual NH_3 emissions, which have remained largely flat, falling just 14% between 1980 (the earliest date for which data is available) and 2021, from 309,800 tonnes to 265,000 tonnes.[21]

Unfortunately, progress to reduce air pollution has slowed in the past decade, as shown in Chart 1.3 below.

21. Defra, "Statistical data set ENV01 – Emissions of air pollutants".

Chart 1.3. Recent trends in emissions of main air pollutants, 2011-2021



Source: Defra, "National statistics Emissions of air pollutants in the UK – summary", https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-summary (2023).

While SO_2 and, to a lesser extent, NO_x emissions have continued to fall, progress on reducing $PM_{2.5}$, PM_{10} and NMVOC emissions has stagnated, while NH_3 emissions were slightly higher in 2021 than they were in 2011. To regain momentum in the fight for cleaner air, further action is needed.

Geographical distribution of the main air pollutants

Air pollution is unevenly distributed across the UK. We can illustrate this through evidence from the Daily Air Quality Index (DAQI). Table 1.1 much further below shows the breakdown of the number of days in 2022 that each UK region recorded of each Daily Air Quality Index (DAQI) banding. 2022 is the year with the latest available data for DAQI scores, which contrasts with 2021 for total emissions.

Calculated on a scale of one to ten, with one indicating the lowest level of air pollution and ten indicating the highest, DAQI is calculated daily based on the maximum concentrations of NO_2, SO_2, O_3, $PM_{2.5}$ and PM_{10} in a particular area.[22] That is, DAQI is determined by the amount of each pollutant in the air on a given day rather than the total emissions, or how much of each pollutant is released into the atmosphere, on a given day. The pollutants included in DAQI were those recommended by the UK Committee on the Medical Effects of Air Pollutants (COMEAP),[23] an expert group that advises the UK government on "all matters concerning the health effects of air pollutants".[24]

It should be emphasised that while O_3 is not a core focus of this study, it can still cause health problems including "inflammation of the respiratory tract, eyes, nose and throat as well as asthma attacks".[25]

While NMVOCs are not directly included in DAQI, O_3 and NO_x, which are included, are produced from the photochemical reactions between NMVOCs and other pollutants.[26] Similarly, while NH_3 is not directly included in DAQI, the PM that it can form when reacting to other gasses in the atmosphere is.[27]

Produced by Defra, DAQI's purpose is to provide "recommended actions and health advice".[28] A score of four or higher indicates pollution severe enough to impact those with pre-existing health conditions.[29]

DAQI is divided into four bands. A score of between one and three is considered 'low', between four and six is considered 'moderate', between seven and nine is considered 'high' and ten is considered 'very high'.

As Table 1.1 below shows, most days across all UK regions fall within the 'low' 1-3 band, which according to Defra advice, means that everyone,

22. Defra, "What is the Daily Air Quality Index?", https://uk-air.defra.gov.uk/air-pollution/daqi?view=more-info (2023).
23. COMEAP, "Review of the UK Air Quality Index", 14, 44.
24. HM Government, "Committee on the Medical Effects of Air Pollutants", https://www.gov.uk/government/groups/committee-on-the-medical-effects-of-air-pollutants-comeap (2023).
25. Defra, "National Statistics: Ozone (O3)", https://www.gov.uk/government/statistics/air-quality-statistics/concentrations-of-ozone (2023).
26. Ibid.
27. Defra, "National statistics: Ammonia (NH3)".
28. Defra, "Daily Air Quality Index", https://uk-air.defra.gov.uk/air-pollution/daqi (undated).
29. Met Office, "Air Pollution", https://www.metoffice.gov.uk/weather/guides/air-quality (2023).

including those with underlying health conditions, is advised to "enjoy your usual outdoor activities".

However, there are notable regional variations as to the number of days where a DAQI score of between four and six is recorded, at which point Defra advises that "[a]dults and children with lung problems, and adults with heart problems, who experience symptoms, should consider reducing strenuous physical activity, particularly outdoors". As Table 1.1 above shows, heavily urbanised and densely-populated areas such as Greater London recorded a higher number of days where air pollution exceeded a DAQI score of between four and six (53) than in less densely populated areas such as Yorkshire & Humberside (34), or the North East (14). The higher pollutant concentrations in those regions there reflect not just greater population density but greater exposure to air currents from continental Europe than other parts of the UK.[30]

By contrast, no region recorded more than seven days where the DAQI score fell within the 'high' seven to nine range, the level at which Defra advises that "[a]dults and children with lung problems, and adults with heart problems, should reduce strenuous physical exertion, particularly outdoors". Every English region, however, recorded at least one day within this range.

No region recorded more than one day where the DAQI score reached ten, the level at which Defra advises that "[a]dults and children with lung problems, adults with heart problems, and older people, should avoid strenuous physical activity".

30. Defra, "Environmental targets consultation summary of responses and government response", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1125278/Environmental_targets_consultation_summary_of_responses_and_government_response.pdf (2022), 28.

Table 1.1. DAQI score for every day in every region in the UK, 2022

	DAQI value banding			
Region	**1 to 3**	**4 to 6**	**7 to 9**	**10**
Greater London	307	53	4	1
South East	305	53	6	1
South West	312	49	3	1
East Midlands	314	45	6	0
Eastern	314	45	6	0
South Wales	317	43	4	1
West Midlands	325	39	1	0
Yorkshire & Humberside	323	34	7	1
North West & Merseyside	338	25	2	0
North Wales	342	21	2	0
Northern Ireland	348	17	0	0
Central Scotland	351	14	0	0
North East	349	14	2	0
Highland	354	11	0	0
North East Scotland	360	5	0	0
Scottish Borders	361	4	0	0

Source: Figures taken from Defra, "Daily Air quality pollution Index data search", https://uk-air.defra.gov.uk/data/DAQI-regional-data (2023).

Main air pollutant limits and targets in the UK

Despite the reductions in air pollution over many decades, concentrations of air pollutants in parts of the UK remain well above the limits recommended by the World Health Organization (WHO) and, in the case of NO_x, above the UK government's own legal limits. This is especially the case in urban areas.[31]

Air pollution concentrations in the UK are regulated by a series of limits and targets. This is in contrast to total emissions, which are regulated by ceilings, as defined later in the chapter. Limits are "legally binding and must not be exceeded".[32] By contrast, targets to reduce concentrations of certain pollutants "are to be attained where possible by taking all necessary measures not entailing disproportionate costs".[33] The UK's targets and limits are expressed as averages over a given time period. The most common limits are annual, meaning the highest permissible average concentration of that pollutant throughout a given year, or daily, meaning the highest permissible concentration of a given pollutant during a 24-hour period. Both limit and target concentrations are typically measured by the number of micrograms per cubic metre ($\mu g/m^3$) of each pollutant that can be detected. Table 1.2 below provides a breakdown of the UK's limits and targets for the main air pollutants.

31. ClientEarth, "New data shows 75% of UK 'zones' illegally polluted – don't pause action now, say lawyers", https://www.clientearth.org/latest/press-office/press/new-data-shows-75-of-uk-zones-illegally-polluted-don-t-pause-action-now-say-lawyers/ (2020).
32. Defra, "Air Pollution in the UK 2020 – Compliance Assessment Summary", https://uk-air.defra.gov.uk/library/annualreport/assets/documents/annualreport/air_pollution_uk_2020_Compliance_Assessment_Summary_Issue1.pdf (2021), 6.
33. Defra, "UK Air Quality Limits" https://uk-air.defra.gov.uk/air-pollution/uk-eu-limits (2023).

Table 1.2. Pollutant limits and targets

Pollutant	Limit time period	2021 WHO recommended limits (µg/m³)[34]	UK limits (µg/m³)[35]	UK 2040 targets (µg/m³)[36]
$PM_{2.5}$, µm³	Annual	5	20	10 + Population exposure to $PM_{2.5}$ is at least 35% less than in 2018
	24-hour	15	N/A	Population exposure to $PM_{2.5}$ is at least 35% less than in 2018
PM_{10}, µm³	Annual	15	40	N/A
	24-hour	45	50 no more than 35 times each year	N/A
NO_2, µm³	Annual	10	40	N/A
	24-hour	25	N/A	N/A
	1-hour	N/A	200 not to be exceeded more than 18 times per year	N/A
SO_2, µm³	24-hour	40	125 not to be exceeded more than three times a year	N/A
	1-hour	N/A	350 not to be exceeded more than 24 times a year	N/A
	15-minute	N/A	125 µg/m³ not to be exceeded more than three times a year	N/A

Source: Detailed in footnotes 34-36 inclusive.

34. WHO, "What are the WHO Air Quality Guidelines?", https://www.who.int/news-room/feature-stories/detail/what-are-the-who-air-quality-guidelines (2021).
35. Defra, "National air quality objectives and European Directive limit and target values for the protection of human health", https://uk-air.defra.gov.uk/assets/documents/Air_Quality_Objectives_Update.pdf (undated).
36. Defra, "National statistics: Particulate matter (PM10/PM2.5)".

In the UK, the average annual air concentrations of NO_2, $PM_{2.5}$, PM_{10} and SO_2 are legally capped under the Air Quality Standards Regulations 2010, which were enacted to comply with the EU Ambient Air Quality Directive.[37] Under the limits, NO_2 and PM_{10} should not exceed an annual average concentration of 40 μm^3, $PM_{2.5}$ should not exceed an average annual concentration of 20 μm^3, and NO_x should not exceed an annual average concentration of 40 μm^3. For SO_2, the limit of 125$\mu g/m^3$ over a 24-hour period should not be exceeded more than three times per year.[38]

There are no legal concentration limits for NMVOCs or NH_3, however.[39] As with the DAQI, while concentrations of NMVOCs are not directly recorded, O_3 and NO_x, which are included, are produced from the photochemical reactions between NMVOCs and other pollutants.[40] Also as with DAQI, while concentrations of NH_3 are not recorded, the PM that it can form when reacting to other gasses in the atmosphere is.[41]

As can be found in Table 1.2 above, in addition to the UK's legal obligations, the WHO has produced non-binding recommended limits, officially known as the WHO Air Quality Guidelines, which are intended to "serve as a global target for national, regional and city governments to work towards improving their citizen's health by reducing air pollution".[42]

Having considered new evidence, in 2021, the WHO published revised recommended limits for acceptable concentrations for some of the main air pollutants. The 2021 limits significantly lowered the recommended average annual concentrations for $PM_{2.5}$ and PM_{10} from 10 $\mu g/m^3$ to

37. Defra, "Air Pollution in the UK 2020", https://uk-air.defra.gov.uk/assets/documents/annualreport/air_pollution_uk_2020_issue_1.pdf (2021), 13-14.
38. Defra, "National air quality objectives and European Directive limit and target values for the protection of human health", https://uk-air.defra.gov.uk/assets/documents/Air_Quality_Objectives_Update.pdf (undated).
39. Defra, "UK Air Quality Policy Context", https://uk-air.defra.gov.uk/air-pollution/uk-eu-policy-context (undated).
40. Defra, "National Statistics: Ozone (O3)".
41. Defra, "National statistics: Ammonia (NH3)".
42. WHO, "What are the WHO air quality guidelines", https://www.who.int/news-room/feature-stories/detail/what-are-the-who-air-quality-guidelines (2021).

5 µg/m³ and 20 µg/m³ to 15 µg/m³ respectively compared to the previous 2005 limits. Unlike the other pollutants, the recommended limit for the average annual concentration of SO_2 actually increased from 20 µg/m³ in 2005 to 40 µg/m³ in 2021.[43]

Following the 2021 Environment Act, the UK Government set a target to reduce the annual limit of $PM_{2.5}$, described by the then Secretary of State for Environment, Food and Rural Affairs, George Eustice MP, as "most damaging pollutant",[44] to 10 µg/m³ by 2040.[45] The 2021 Environment Act set a further target that population exposure to $PM_{2.5}$ by 2040 should be reduced by 35% from the concentration recorded in 2018. Population exposure is "calculated by summing average exposure over large population groups".[46] However, the 10 µg/m³ target is double the WHO limit and, for reasons not entirely clear, $PM_{2.5}$ was the only air pollutant where a target was set in legislation.

Part of the stated reason for not following the WHO target was that an estimated "6 – 8 µg per m³ of the 2018 [$PM_{2.5}$] levels people experienced in parts of southeast England came not from man-made UK sources but from a combination of natural sources, emissions from other countries (such as air blown across the English Channel from Europe) and from shipping". As such, meeting the WHO limit would be impossible, "even if we removed all people from England".[47]

To ensure compliance with its legal limits for concentrations of the main pollutants, the UK government established the Automatic Urban and Rural Network (AURN). Comprising 174 monitoring sites across the country, the AURN provides hourly data on average concentrations of $PM_{2.5}$, PM_{10}, NO_x, and SO_2.[48] Reflecting their exclusion from Air

43. World Health Organization, "WHO global air quality guidelines. Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide", https://www.who.int/publications/i/item/9789240034228 (2021).
44. House of Common Debates, vol. 672, col. 345, 26 February 2020 (George Eustice).
45. Defra, "Environmental targets consultation summary of responses", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1125278/Environmental_targets_consultation_summary_of_responses_and_government_response.pdf (2022), 27.
46. Ibid., 29.
47. Ibid., 28.
48. Defra, "Automatic Urban and Rural Network (AURN)", https://uk-air.defra.gov.uk/networks/network-info?view=aurn (2023).

Quality Standards Regulations 2010, the AURN does not, however, provide data for concentrations of NMVOCs or NH_3.

The Met Office also combines data from the AURN with its own weather forecast and climate prediction model to improve the accuracy of DAQI forecasts,[49] as described earlier.

To assess compliance with the UK's air pollutant concentration limits and because not all parts of the UK are monitored, data from the AURN is combined with modelled estimates to produce an "a national assessment of air quality against the [UK's legal] limit and target values".[50] As mandated by the Air Quality Standards Regulations 2010, this assessment is published in the annual *Air pollution in the UK report*.[51]

Within the *Air pollution in the UK report*, Defra records compliance by dividing the UK into 43 zones, 28 of which are large urban areas.[52] For each zone, average concentrations of $PM_{2.5}$, PM_{10}, NO_2 and SO_2 over specified time periods are measured against the limits outlined in Table 1.2. Table 1.3 below outlines the UK's performance against its legal limits for the main pollutants in 2021, the latest year for which figures are available.

49. Defra, "How are the forecasts produced?", https://uk-air.defra.gov.uk/forecasting/how-forecasts-are-produced (2023).
50. Defra, "Air quality and emissions statistics", https://www.gov.uk/government/collections/air-quality-and-emissions-statistics#:~:text=In%20September%20each%20year%2C%20measurements,pollutants%20set%20internationally%20and%20domestically (2020); Defra, "Air Pollution in the UK 2021" (2021), https://uk-air.defra.gov.uk/library/annualreport/viewonline?year=2021_issue_1#report_pdf (2022), 5, 49.
51. Ibid.
52. Ibid., 52-3.

Table 1.3. Compliance with UK air pollutant concentration limits, 2021

Pollutant	Limit time period	UK limits (μg/m³)[53]	No. zones compliant
$PM_{2.5}$, μm³	Annual	20	All zones compliant
	24-hour	N/A	All zones compliant
PM_{10}, μm³	Annual	40	All zones compliant
	24-hour	50 no more than 35 times each year	All zones compliant
NO_2, μm³	Annual	40	Ten zones non-compliant: • Greater London Urban Area • West Midlands Urban Area • Greater Manchester Urban Area • West Yorkshire Urban Area • Liverpool Urban Area • Sheffield Urban Area • Nottingham Urban Area • Bristol Urban Area • Glasgow Urban Area • South Wales
	1-hour	200 not to be exceeded more than 18 times per year	All zones compliant
SO_2, μm³	24-hour	125 not to be exceeded more than three times a year	All zones compliant
	1-hour	350 not to be exceeded more than 24 times a year	N/A
	15-minute	125 μg/m³ not to be exceeded more than three times a year	All zones compliant

Source: Defra, "Air Pollution in the UK 2021" (2021), https://uk-air.defra.gov.uk/library/annualreport/viewonline?year=2021_issue_1#report_pdf (2022), 55-61.

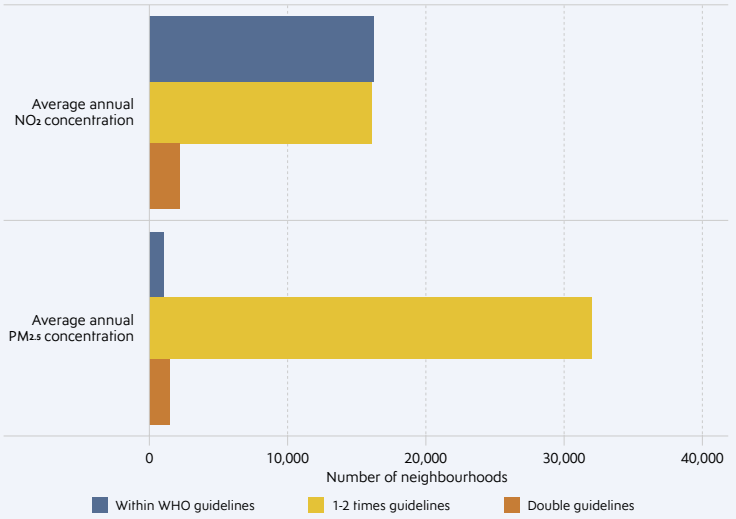
As Table 1.3 shows, the UK is compliant with all its average pollutant concentration limits across all time intervals across all 43 zones. The only exception is annual average concentrations of NO_2 across the ten zones that comprise the UK's major urban areas.

Evidence suggests, however, that the UK is less compliant with the WHO limits than it is with its own legal limits. Using data from a

53. Defra, "National air quality objectives and European Directive limit and target values for the protection of human health", https://uk-air.defra.gov.uk/assets/documents/Air_Quality_Objectives_Update.pdf (undated).

2022 Friends of the Earth study that compared NO_2 and $PM_{2.5}$ concentrations,[54] Chart 1.4 below reveals that a very considerable proportion of English and Welsh neighbourhoods remain well above WHO limits for average annual concentrations of those two pollutants. By neighbourhoods, it meant Lower-layer Super Output Areas (LSOAs), which are small areas used for Census purposes and which typically include between 1,000 and 3,000 residents.[55]

Chart 1.4. Air pollution in England and Wales, compared to WHO limits, 2020



Source: Damien Gayle, "People of colour far likelier to live in England's very high air pollution areas", The Guardian, 4 October 2022, https://www.theguardian.com/environment/2022/oct/04/people-of-colour-likelier-live-england-very-high-air-pollution-areas.

54. Friends of the Earth, "Which neighbourhoods have the worst air pollution?", https://policy.friendsoftheearth.uk/insight/which-neighbourhoods-have-worst-air-pollution?_ga=2.16894201.1781982685.1690898571-331936538.1690898568 (2022).
55. Office for National Statistics, "Census 2021 geographies", https://www.ons.gov.uk/methodology/geography/ukgeographies/censusgeographies/census2021geographies (2021).

As Chart 1.4 above illustrates, only 46% of neighbourhoods in England and Wales fell within or below the recommended average annual limit for NO_2. The situation is even worse for $PM_{2.5}$ concentrations, where only 4.6% of neighbourhoods in England and Wales fall within the recommended annual limit. This shows that, even though the UK complies with its own legal limits on $PM_{2.5}$ and NO_2 concentrations, barring ten zones out of 43, large parts of the country are still exposed to unsafe concentrations of these two major air pollutants.

Main air pollutant ceilings in the UK

In addition to limits and targets, there are ceilings, which set caps on how much NO_x, $PM_{2.5}$, NH_3, SO_2 and NMVOCs in total can be released each year.[56] Unlike limits or targets, ceilings cap how much of a specified pollutant can be emitted in total into the atmosphere per year as opposed to the concentration of that pollutant.

As illustrated in Table 1.4 below, there are two overlapping sources of air pollution ceilings in the UK: the 2018 National Emission Ceilings Regulations (NECR), which were enacted to comply with the EU National Emission Ceilings Directive (2001/81/EC), and the Gothenburg Protocol to the Convention on Long Range Transboundary Air Pollution (CLRTAP).[57] The Gothenburg Protocol represents the most recent extension to the CLRTAP, which was originally signed in 1979 to tackle acid rain in Europe, North America and the former Soviet Union.[58] Both the Gothenburg Protocol and the NECR are legally binding.[59]

56. Defra, "National statistics emissions of air pollutants in the UK – Background", https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-background (2023).
57. Defra, "National statistics emissions of air pollutants in the UK – Background"; The National Emission Ceilings Regulations 2018 (UK). See: https://www.legislation.gov.uk/uksi/2018/129/contents/made.
58. Gary Fuller, *The invisible killer: The rising global threat of air pollution – and how we can fight back* (London: Melville House, 2018), 82, 113; US Department of State, "Convention on Long-Range Transboundary Air Pollution", https://www.state.gov/key-topics-office-of-environmental-quality-and-transboundary-issues/convention-on-long-range-transboundary-air-pollution/#:~:text=The%201979%20Convention%20on%20Long,pollution%20and%20better%20understanding%20air (undated).
59. HM Government, "Air Quality Common Framework: Provisional Framework Outline Agreement and Concordat", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1052059/air-quality-provisional-common-framework.pdf (2022), 7; Defra, "Policy paper: Air quality strategy: framework for local authority delivery", https://www.gov.uk/government/publications/the-air-quality-strategy-for-england/air-quality-strategy-framework-for-local-authority-delivery (2023).

The specific emissions ceilings for the main pollutants are set out in Table 1.4. As Table 1.4 shows, the emissions ceilings are identical for NH_3, SO_2 and $PM_{2.5}$, although the NECR imposes tighter standards for NO_x than the CLRTAP. Also, unlike the CLRTAP and for reasons not entirely clear, the NECR does not count emissions from the agricultural sector in its ceiling of NMVOC emissions.

Table 1.4. UK annual pollutant emission ceilings

	Annual pollutant emission ceilings (1,000 tonnes)				
Source of limit	NO_x	NH_3	NMVOCs	SO_2	$PM_{2.5}$
CLRTAP	782.9	257.4	841.9 (includes emissions from agriculture)	321.9	80.8
NECR	769.4	257.4	763.3 (excludes emissions from agriculture)	321.9	80.8

Source: Defra, "National statistics Emissions of air pollutants in the UK – Background", https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-background (2023).

Because it is impractical to measure all sources of emissions directly, Defra uses detailed models to make an informed estimate of the annual total emissions of the main pollutants.[60] These calculations include emissions from "industry, transport, agriculture, waste and domestic sources".[61]

To assess the UK's compliance against the CLRTAP and NECR, these estimates are then compiled into a database of air pollutant emissions, known as the National Atmospheric Emissions Inventory (NAEI).[62] Updated annually, the NAEI provides "a consistent time series of anthropogenic [man-made] UK emissions of air pollutants from 1970 onwards (from 1980 for emissions of ammonia)".[63]

To report on the UK's compliance, NAEI data is used to produce an

60. Defra, "National statistics: Emissions of air pollutants in the UK – background", https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-background (2023).
61. Defra, "Air quality and emissions statistics".
62. National Atmospheric Emissions Inventory, "National Emissions Ceilings Regulations (NECR)" https://naei.beis.gov.uk/about/why-we-estimate?view=necr (2023).
63. Defra, "Air quality and emissions statistics".

annual Informative Inventory Report. This report, which provides detailed estimates of the total annual emissions of the main pollutants, including the sources of those pollutants.[64]

Table 1.5 below shows total emissions of the main pollutants in 2021, the latest year for which figures are available.

Table 1.5. UK pollutant total emissions, 2021

	Pollutant total emissions, 2021				
Pollutant	**NO_x**	**NH_3**	**NMVOCs**	**SO_2**	**$PM_{2.5}$**
Total emissions (1,000 tonnes)	677.1	265.0 (without adjustment) 251.8 (with adjustment)[65]	781.2 (including emissions from agriculture) 648.3 (excluding emissions from agriculture)	125.6	83.2

Source: Defra, "National statistics Emissions of air pollutants in the UK – summary", https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-summary (2023).

As Table 1.5 shows, the UK is compliant with its NO_x, SO_2 and NMVOC emission ceilings as set out in Table 1.4.

At 265,000 tonnes, total NH_3 emissions appear to exceed the permitted 257,4000 tonne ceiling under both the CLRTAP and NECR. However, the UK was permitted to adjust its total of NH_3 emissions by removing non-manure digestate, which is "a nutrient-rich substance produced by anaerobic digestion that can be used as a fertiliser",[66] from its official emissions inventory. The consequent 13,200 tonne reduction in total NH_3 emissions brought the UK total down below the cap permitted under the CLRTAP and NECR. The UK was entitled to do this because non-manure digestate were "not included in the [NH_3 total emissions] inventory when these commitments were set".[67]

64. Ricardo Energy and Environment for Defra, "UK Informative Inventory Report (1990 to 2021), https://uk-air.defra.gov.uk/assets/documents/reports/cat09/2303151609_UK_IIR_2023_Submission.pdf (2023).
65. Defra, "Emissions of air pollutants in the UK – Ammonia" (NH3).
66. Pippa Neill, "'Astonishing': DEFRA 'off the hook' on air quality targets after data adjustment", https://www.endsreport.com/article/1813109/astonishing-defra-off-hook-air-quality-targets-data-adjustment (2023).
67. Defra, "Emissions of air pollutants in the UK – Ammonia" (NH3).

$PM_{2.5}$, of which the UK emitted 83.2 tonnes in 2021, is the only pollutant for which the UK is clearly not meeting its obligations.[68]

That the UK has largely complied with its emissions ceilings has not been enough to protect large parts of the UK population from exposure to dangerous concentrations of air pollution.

The relationship between deprived areas and air pollution

For decades, data has shown that air pollution concentrations are higher in the more deprived areas of the UK compared to wealthier areas, as defined by the Index of Multiple Deprivation (IMD), described in Box 1.1 below.

A 2015 study showed that annual concentrations of PM_{10} were on average 1.5 µg/m³ higher in the most deprived 20% of English LSOAs compared to the least deprived 20% of English LSOAs. It also showed that annual concentrations of NO_2 were 4.4 µg/m³ higher on average in the most deprived 20% of English LSOAs compared to the least deprived 20% of English LSOAs.[69] Another 2015 study estimated that 85% of the people in the UK living in areas exceeding legal NO_2 limits come from the poorest 20% of the country's population.[70] This is especially the case in cities such as London, Birmingham, Leeds and Liverpool.[71]

68. Defra, "National statistics Emissions of air pollutants in the UK – Background".
69. Daniela Fecht et al., "Associations between air pollution and socioeconomic characteristics, ethnicity and age profile of neighbourhoods in England and the Netherlands", https://www.sciencedirect.com/science/article/abs/pii/S0269749114005144 (2015).
70. Gordon Mitchell, Paul Norman and Karen Mullin, "Who benefits from environmental policy? An environmental justice analysis of air quality change in Britain, 2001–2011", Environmental Research Letters, 11.
71. Clean Cities, "Win-Win: 5 fast and fair solutions for cleaning up urban transport", https://cleancitiescampaign.org/wp-content/uploads/2023/02/Win-win_5-fast-and-fair-solutions-for-cleaning-up-urban-transport.pdf (2023), 6.

Box 1.1. The UK Index of Multiple Deprivation (IMD)

To measure deprivation, the official and most common method in the UK is the Index of Multiple Deprivation (IMD), which measures the relative deprivation of small areas known as Lower layer Super Output Areas (LSOAs). There are 32,844 LSOAs in England, the most deprived of which is ranked first, and the least deprived of which is ranked 32,844th. To calculate each area's score, it assesses data across the following seven domains: income deprivation; employment deprivation; education, skills and training deprivation; health deprivation and disability; crime; barriers to housing and services; and living environment.

It should be emphasised that "there is no definitive threshold above which an area is described as 'deprived'". Rather, the IMD is a relative measure, which compares deprivation rates against different parts of the country.[72]

It should be stressed that the extent of the correlation between air pollution and deprived areas varies across countries. Studies into it do not always show consistent results. For example, European studies diverge as to the link between deprived areas and exposure to air pollution. One Europe-wide study, for instance, found that while more deprived areas were more likely to endure higher concentrations of O_3 and PM, wealthier areas tended to experience higher concentrations of NO_2.[73]

However, the correlation between air pollution and deprived areas appears stronger within the UK than it does in Europe. A 2015 study comparing the concentrations of PM_{10} and NO_2 across six English cities found that there was a statistically significant relationship between

72. Ministry of Housing, Communities & Local Government, "The English Indices of Deprivation 2019 (IoD2019)", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/835115/IoD2019_Statistical_Release.pdf (2019), 2.
73. European Environment Agency (EEA), "Unequal exposure and unequal impacts: social vulnerability to air pollution, noise and extreme temperatures in Europe", EEA Report No 22/2018 (2018), 40; Sir Chris Whitty, "Chief Medical Officer's Annual Report 2022: Air pollution", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1124738/chief-medical-officers-annual-report-air-pollution-dec-2022.pdf (2022), 29.

deprived areas and pollutant concentrations in Birmingham, Leeds, Liverpool, London and Sheffield.[74] The only exception to this, the study found, was in Bristol, where concentrations of both pollutants were only slightly lower in the least deprived quintile of the population than in the most deprived quintile of the population. These differences could be due to the gentrification of more polluted inner-city areas in some cities across Europe, which has seen some wealthier residents drawn to more polluted inner-city areas.[75]

Finally, existing studies looking at the correlation between deprived areas and air pollution tend to concentrate on NO_x, O_3, $PM_{2.5}$ and PM_{10}. Because of this, it is more difficult to link concentrations for the other pollutants considered in this report – NH_3, NMVOCs and SO_2 – to deprived areas.

A 2019 study for the Greater London Authority (GLA) of $PM_{2.5}$ and NO_2 average annual concentrations in the Greater London area provides evidence for the overlap between deprived areas and exposure to air pollution.[76] The study specifically examined $PM_{2.5}$ and NO_2 because these pollutants have been the focus of efforts to reduce air pollution in Greater London.[77] Using data from that study, Table 1.6 below plots annual average $PM_{2.5}$ and NO_2 concentrations against deprived areas, as measured by the IMD.[78] Decile one includes the most deprived LSOAs in Greater London, whilst decile ten includes the least deprived LSOAs in Greater London.

74. Daniela Fecht et al., "Associations between air pollution and socioeconomic characteristics, ethnicity and age profile of neighbourhoods in England and the Netherlands", *Environmental Pollution* (2015), 201-210, 204-205.
75. European Environment Agency, "Unequal exposure and unequal impacts"; Daniela Fecht et al., "Ethnicity and age profile of neighbourhoods in England and the Netherlands", 201-210.
76. Tim Williamson, Joshua Nunn and Helen Pearce, "Air pollution and inequalities in London: 2019 update", Logika Air Quality Consultants Ltd for the Greater London Authority, https://www.london.gov.uk/sites/default/files/air_pollution_and_inequalities_in_london_2019_update_0.pdf (2021).
77. Ibid., 4.
78. Ibid., 16-17.

Table 1.6. Mean concentration values and ranges for NO_2 and $PM_{2.5}$, by IMD decile in Greater London

Pollutant	IMD decile									
	1	2	3	4	5	6	7	8	9	10
NO_2 (µg/m³)	30.3	30.1	29.9	30.1	29.6	29.2	29.0	28.4	28.0	26.5
$PM_{2.5}$ (µg/m³)	12.1	12.0	12.0	12.0	11.9	11.8	11.8	11.7	11.6	11.4

Source: Tim Williamson, Joshua Nunn and Helen Pearce, "Air pollution and inequalities in London: 2019 update", Logika Air Quality Consultants Ltd for the Greater London Authority, https://www.london.gov.uk/sites/default/files/air_pollution_and_inequalities_in_london_2019_update_0.pdf, 16.

Annual $PM_{2.5}$ emissions average 12.1 µm³ in the lowest London decile, but 11.4 µm³ in the highest London decile.[79] Exposure to NO_2 also correlates with how deprived an area is, in fact more strongly than for $PM_{2.5}$. NO_2 emissions average 30.3 µm³ in London decile one, emissions in London decile ten average only 26.5 µm³ in 2019.[80]

The focus of this research

There has been growing contention in recent years about how to tackle air pollution. On the one hand, there has been increased pressure on the UK Government by the civil society to take further action.[81] The charity ClientEarth successfully sued the UK Government three times over its failure to reduce NO_2 emissions to UK legal limits.[82] Most notably, in 2020, air pollution was legally recognised as making "a material contribution" to the death of nine-year-old Ella Adoo-Kissi-Debrah who lived near the South Circular Road in London, Lewisham. This was the first time that air pollution had been officially recognised as a cause of death.[83] The Ella Roberta Foundation, established by Ella Adoo-Kissi-Debrah's mother Rosamund, campaigns for UK air pollution legal limits to be brought into

79. Ibid., 17.
80. Ibid., 16-17.
81. For a list of organisations campaigning for cleaner air in the UK, see the partners of the Healthy Air Coalition, at "Healthy Air Coalition", https://www.healthyair.org.uk/ (2023).
82. ClientEarth, "What do ClientEarth's legal cases mean for local authority plans to deliver nitrogen dioxide compliance in England and Wales?" https://www.clientearth.org/media/m1borg0p/what-do-clientearths-legal-cases-mean-for-local-authority-plans-to-deliver-nitrogen-dioxide-compliance-in-england-and-wales-ce-en.pdf (2019).
83. Claire Marshall, "Air pollution death ruling: what comes next?", BBC, https://www.bbc.co.uk/news/science-environment-55352247 (2020).

line with WHO limits, as described in Table 1.2 earlier.

On the other hand, the main strategies employed to deliver clean air have come under fire for their disproportionate impact on those with lower incomes.[84] In particular, the charging Clean Air Zones (CAZs) introduced in Birmingham, Bristol and London,[85] which charge private cars to enter, are causing increasingly high-profile public opposition. A proposed charging CAZ in Manchester, which would have charged buses, coaches, taxis, private hire vehicles, heavy goods vehicles, vans and minibuses, though not private cars,[86] was abandoned due in part to concerns about the financial impact it would have on low-income residents.[87] The Mayor of London's expansion of the city's CAZ, the Ultra Low Emission Zone (ULEZ), to all of Greater London, has also become controversial.[88] Five local authorities (Bexley, Bromley, Harrow, Hillingdon and Surrey) unsuccessfully challenged the expansion of ULEZ in the courts.[89] Public opposition to the impending expansion of ULEZ was widely blamed for the Labour Party's unexpected defeat at the Uxbridge and South Ruislip by-election in July 2023.

Similarly, Low Traffic Neighbourhoods (LTNs), which involve the placement of bollards, planters and cameras to get rid of 'through' traffic on residential streets and that have proliferated since the COVID-19 pandemic to reduce air pollution, have attracted much controversy.[90] Angry residents have vandalised bollards and, despite evidence to the contrary, opponents have condemned the schemes for merely diverting

84. Disability Rights UK, "Low-traffic schemes overlook Disabled people's needs", https://www.disabilityrightsuk.org/news/2021/april/low-traffic-schemes-overlook-disabled-people%E2%80%99s-needs (2021); Adam Postans, "Fears Bristol Clean Air Zone will 'trap' disabled people at home", Bristol Post, 21 October, 2022, https://www.bristolpost.co.uk/news/bristol-news/fears-bristol-clean-air-zone-7727520.
85. Defra, "Guidance: clean air zones", https://www.gov.uk/guidance/driving-in-a-clean-air-zone#cities-with-clean-air-zones (2023).
86. Clean Air Greater Manchester, "Clean Air Plan FAQs", https://cleanairgm.com/faqs/ (2023).
87. House of Commons Library, "Clean Air Zones, Low Emission Zones and the London ULEZ", https://researchbriefings.files.parliament.uk/documents/CBP-9816/CBP-9816.pdf (2023), 20.
88. Tom Edwards, "ULEZ: Ultra Low Emission Zone expansion and the price of pollution", BBC, https://www.bbc.co.uk/news/uk-england-london-64733216 (2023); John Pring, "Disabled campaigners welcome mayor's 'significant improvements' to clean air scheme", Disability News Service, https://www.disabilitynewsservice.com/disabled-campaigners-welcome-mayors-significant-improvements-to-clean-air-scheme/ (2022).
89. Gwyn Topham, "London Ulez: court dismisses challenge by five councils over expansion", *The Guardian*, 28 July 2023, https://www.theguardian.com/uk-news/2023/jul/28/london-ulez-court-dismisses-challenge-by-five-councils-over-expansion.
90. Simon Evans, "How opponents of LTNs are adopting the climate-sceptic playbook" *The Guardian*, 19 May, 2023, https://www.theguardian.com/uk-news/2023/may/18/how-opponents-of-ltn-are-adopting-the-climate-sceptic-playbook.

traffic away from side streets to main roads. The Government recently ordered a review into what it termed "anti-motorist" policies that fail to consider how "families live their lives", including LTNs.[91] This followed an earlier UK Government decision to ban local authorities from using central government funds to install any further LTNs.[92]

It is clear therefore that attitudes towards action on air pollution are becoming increasingly politicised and contentious. The disagreements are in danger of stalling necessary progress on reducing air pollution which, as Chapter Four will demonstrate, still leads to serious environmental, health and economic health impacts, especially for deprived areas. We therefore need bolder policies to reduce air pollution, but ones that support rather than penalise those living in deprived areas and ones that command public support at a time when charging CAZs in particular have become increasingly contentious. This report will outline policy solutions that aim to do just that.

This report has a particular focus on people living in deprived areas, by which we mean those in the bottom deciles of the IMD. A lot of evidence and policies tend to focus on air pollution generally, rather than particularly focusing on the relationship between air pollution and deprived areas. This report will be unique in public policy literature by applying a special lens on the scale of, effects of and solutions for air pollution for people living in deprived areas.

This report seeks to answer the following six research questions:

- What does the latest evidence tell us about the health, economic and environmental effects of air pollution in England, especially in England's deprived areas?

91. Edward Malnick, "I am on motorists' side, says Sunak as he orders review of anti-car schemes", *The Telegraph*, 29 July 2023, https://www.telegraph.co.uk/politics/2023/07/29/rishi-sunak-on-motorists-side-review-anti-car-policies/.
92. Nick Gutteridge, "Low traffic neighbourhoods stripped of government funding in boost for drivers", *The Telegraph*, 19 May 2023, https://www.telegraph.co.uk/politics/2023/05/19/low-traffic-neighbourhoods-no-government-money/.

- What are the key sources and sectors that contribute to air pollution, especially in England's deprived areas?
- How effective have existing measures been at curbing air pollution across different economic sectors in England?
- What do those people in England's deprived areas think about the scale of, effects of and solutions for air pollution?
- What further measures across different government departments are needed to curb air pollution whilst not penalising the poorest in society?
- How could future road pricing be implemented to tackle air pollution in an efficient and equitable way?

This report is structured as follows:

- **Chapter Two** describes the methodologies employed, including an extensive literature review, expert stakeholder consultation and focus groups with residents in different deprived areas.
- **Chapter Three** describes the primary sources of air pollution in the UK, with a particular focus on deprived areas.
- **Chapter Four** describes the primary consequences of air pollution in the UK, with a particular focus on deprived areas.
- **Chapter Five** outlines and evaluates the different local and national policies that have been introduced to reduce air pollution in the UK, with a particular focus on how they have impacted deprived areas.
- **Chapter Six** outlines and evaluates examples of how foreign countries have enacted policies that seek to reduce air pollution.
- **Chapter Seven** recommends new policies which could be adopted by the UK Government to further reduce air pollution in deprived areas and to improve air pollution more generally without harming those from deprived areas.

Chapter 2:
Methodology

The aim of this report is to outline the scale of, sources of, impacts of and solutions to air pollution, with a particular focus on those from England's deprived areas.

As explained in Chapter One, this report defines air pollution as the contamination of the air by gaseous and non-gaseous substances which are harmful to human health and the environment. Although the report will discuss the sources of, and harms caused by, the main air pollutants $PM_{2.5}$, PM_{10}, NO_x, NMVOCs, SO_2 and NH_3, its policy recommendations will focus on efforts to reduce $PM_{2.5}$ and NO_x emissions. This is because, as Chapters Three and Four explain, these two air pollutants are disproportionately responsible for the harmful air pollution affecting people from deprived areas.[93] Finally, many existing public policies, such as charging Clean Air Zones (CAZs), Low Traffic Neighbourhoods (LTNs), or smoke control areas, focus on NO_x or $PM_{2.5}$.

The focus of the report is in deprived areas. To identify a deprived area in England, most studies cited in this report have used the Index of Multiple Deprivation (IMD), which was described in the previous chapter in Box 1.1. Where a different measure is used, this is specified.

It should also be stressed that, as mentioned in Chapter One, because they are more likely to live in deprived areas,[94] this report's findings will

93. See Chapter Three.
94. HM Government, "People living in deprived neighbourhoods; Office for National Statistics, "Disability by age, sex and deprivation".

be particularly relevant to people from ethnic minority backgrounds and disabled people.

Conducting focus groups was an important way of ensuring that our analysis was rooted in the lived experience of people from deprived areas. For the focus groups, however, rather than use the IMD, we selected participants from households earning 20% less than the UK median household income, which is £35,000 as of 2023.[95] In other words, we focused on people from deprived households, not just those living in deprived areas, although they are closely correlated. Doing this enables us to get detailed insights from the people we are most interested in understanding and supporting. Because incomes in London are on average higher than those in the rest of the country, we used a higher figure of £35,000 per annum for the London group, as outlined in Box 2.1 below.

This chapter provides a detailed overview of the methods used to answer the research questions outlined in Chapter One.

Research techniques

We employed three main research techniques for this report.

- **Literature review.** An extensive literature review was conducted examining relevant UK and international evidence. This included academic work, think tank, civil society and industry reports, as well as national government data, research and policy papers.
- **Expert stakeholder consultation.** Bright Blue consulted with a number of academic experts, representatives from charities, as well as officials and advisers from national and local governments.
- **Focus groups.** We developed and organised three deliberative focus groups of people from deprived areas in partnership with BMG Research conducted between 28 and 29 June 2023.

95. Office for National Statistics, "Effects of taxes and benefits on UK household income: financial year ending 2022", https://www.ons.gov.uk/peoplepopulationandcommunity/personalandhouseholdfinances/incomeandwealth/bulletins/theeffectsoftaxesandbenefitsonhouseholdincome/financialyearending2022 (2023).

Focus groups

Each focus group invited and included between five and seven participants and had a particular geographical composition:

- Those who live within an existing charging Clean Air Zone (CAZ) (group one)
- Those who lived in an area that was not at the time included within, but were shortly to be included within, a charging CAZ (group two); and
- Those who live in an area that does not fall in a charging CAZ and where there are no plans to introduce one (group three).

The groups were structured around whether they had a charging CAZ because of how topical and controversial charging CAZs have become, as well as the fact that they are currently one of the main public policies used to reduce air pollution.

To ensure a more geographically representative spread of responses across England, group one took place in the Midlands (Birmingham), group two took place in London (in the boroughs of Enfield and Barking and Dagenham), while group three took place in the north (Liverpool).

The participants were recruited through a panel and given a monetary incentive to participate.

The sociodemographic attributes used to select focus group participants are set out in Box 2.1 below. To ensure that we only captured those on lower incomes, only those earning less than the median household income (£28,000 per annum outside London and £35,000 per annum in London) were selected. Additionally, at least two participants in each group were in receipt of Universal Credit (UC).

To ensure a diversity of lived experience, we sought a gender balance, a varied age range and, where possible, to have several participants in each group come from the sectors most heavily affected by CAZs: transport, health and education. Because of the overlap between ethnicity and the likelihood of exposure to air pollution, each group included at least

one person from an ethnic minority background. Finally, because of the impact that both air pollution and the measures to tackle it have on those with disabilities, each group included at least one disabled person or the carer of someone with a disability.

Box 2.1. Sociodemographic composition of each focus group

- **Household income.** All living in households with income less than £28,000 per annum (outside London) and £35,000 per annum (in London).
- **Age.** One participant from each of the following age bands: 16 to 24, 25 to 34, 35 to 44, 45 to 54, 55 to 64, and 65+.
- **Gender.** At least three men and three women per group.
- **Ethnicity.** At least one to two participants from ethnic minority groups per group.
- **Disability.** At least one participant with a disability/long-term health condition, or a carer for someone with a disability/long-term health condition per group.
- **Parental status.** At least three participants should be parents to children under 18.
- **Job.** At least one participant should have a transport-related career, one participant should have a health career and one participant should have an education career.
- **Universal Credit.** At least two participants should currently be receiving Universal Credit.

While the deliberative focus groups revealed both common and divergent views on air pollution and different policies to address it, it is crucial to not extrapolate this evidence as representative of the views of people from certain communities and sociodemographic backgrounds. Rather, the evidence that emerges from the focus groups provides clarification or colour to existing evidence. The reason why each deliberative focus group cannot be deemed representative is that each focus group is too small to capture the potential range of opinions

within each demographic.

Bright Blue and BMG Research jointly co-authored the deliberative focus group guide, which is included in the Annex. Each deliberative focus group ran for 90 minutes and was both recorded and transcribed for accurate reporting purposes. Questions to participants centred on three main themes: their understanding of the effects of air pollution, their understanding of the key sources of air pollution, and their attitudes towards various policies aimed at reducing air pollution.

Chapter 3:
Sources of air pollution

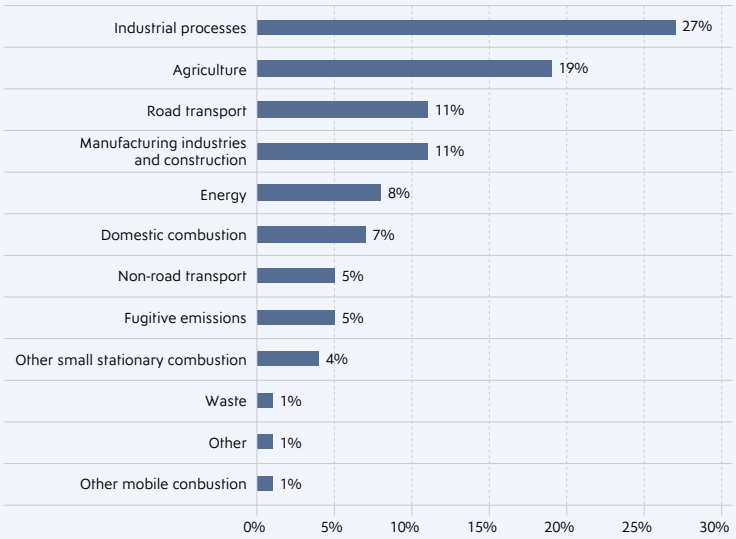
This chapter examines the different sources of air pollution, in particular in deprived areas.

The key sources

Chart 3.1 below shows that the key sources (as sectors) contributing to total primary emissions[96] of the main air pollutants in 2021, the latest year for which figures are available, are industrial processes (27%), agriculture (19%), road transport (11%), manufacturing industries and construction (11%), energy (8%) and domestic combustion (7%).[97]

96. In addition to primary emissions, which are emitted directly into the atmosphere, pollutants can also be generated by secondary processes. Secondary processes are chemical reactions in the atmosphere that form new air pollutants. See United States Government, "National Library of Medicine: Sources of air pollutants", https://www.ncbi.nlm.nih.gov/books/NBK368029/ (2016).
97. Defra, "Emissions of air pollutants in the UK – Summary", https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-summary (2022).

Chart 3.1. Sources of total emissions of air pollution, 2021



Source: Defra, "ENV01 – Emissions of air pollutants", https://www.gov.uk/government/statistical-data-sets/env01-emissions-of-air-pollutants (2023).

Industrial processes, which include generating energy as well as the production of food and goods,[98] were the largest contributor to total air pollution in 2021, emitting 571,700 tonnes of air pollution, or 27% of the UK total, mainly in the form of NMVOCs.

This was followed by agriculture, which emitted 409,600 tonnes of air pollution in 2021, or 19% of total emissions, mostly in the form of NH_3.

Third, road transport emitted 240,600 tonnes of air pollution, mostly NO_x. Road transport made up 11% of total air pollution emissions in the UK in 2021.

This was roughly the same contribution to total UK emissions as

98. Defra, "Clean Air Strategy 2019", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf (2019), 11.

manufacturing industries and construction, emitting 234,400 tonnes of air pollution in 2021, or 11% of total emissions, with most of its emissions being NO_x.

Following that, the energy sector released 167,200 tonnes of air pollution in 2021, or 8% of the total, of which NO_x was the chief pollutant.

Domestic combustion, which is the burning of solid fuels such as wood and coal, was responsible for 142,500 tonnes of total air pollution emissions, or 7% of the total, in 2021. This was split between NO_x, SO_2, NMVOCs tonnes, PM_{10}, $PM_{2.5}$ and NH_3. Domestic combustion has been rising steadily over the past decades.[99] Fugitive emissions, which are irregular releases of gases from pressurised containment, contributed 5% of total air pollution in 2021, emitting 115,100 tonnes of air pollution, of which 101,900 are NMVOCs.

Non-road transport, which includes aviation, the railways and shipping, contributed a further 5% of total air pollution in 2021, releasing 114,400 tonnes of pollutants, including 93,500 tonnes of NO_x.

Other small stationary combustion released 78,300 tonnes of air pollution in 2021, mainly NO_x, contributing 4% of air pollution in the UK, in 2021.

Finally, waste produced 31,000 tonnes of air pollution, or 1% of the total, while the remaining 19,200 tonnes, or just below 1% of total emissions in 2021, came from other sources.[100]

Having established the sources of air pollution generally, we can now ascertain the sources of each of the main pollutants, again as of 2021, the year for which the last data is available. It begins by considering NO_x and $PM_{2.5}$, the two air pollutants of most relevance to this report and the two which received the most academic and policy attention in recent years. It then considers PM_{10}, NMVOCs and NH_3, with these pollutants also discussed in order of their importance to this report.

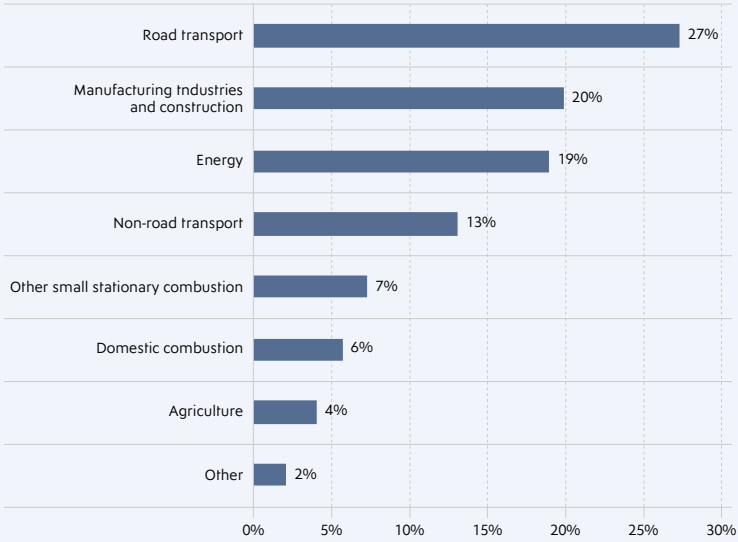
99. Alastair Lewis, Deborah Jenkins and Christopher Whitty, "Indoor air pollution: five ways to fight hidden harms", *Nature*, (2023), 220-3.
100. Defra, "Emissions of air pollutants in the UK – Summary".

The key sources, by air pollutant

NO_x

Starting with NO_x, we can see from Chart 3.2 below the main sources of total emissions of this pollutant, as of 2021.

Chart 3.2. NO_x emissions by source, 2021



Source: Defra, "ENV01 – Emissions of air pollutants", https://www.gov.uk/government/statistical-data-sets/env01-emissions-of-air-pollutants (2023).

Until the 1990s, total emissions of NO_x primarily came from road transport. However, with the introduction of catalytic converters and emissions regulations, the percentage of NO_x total emissions caused by road transport declined. Nonetheless, as Chart 3.2 shows, road transport still contributed 184,900 tonnes of NO_x total emissions in 2021, or 27%, of the total, making it the most common source.

Manufacturing and construction is the second largest contributor, emitting 134,600 tonnes, or 20% of the total in 2021. Due to the trend away from coal and oil in favour of gas and renewables in recent decades, annual NO_x emissions from energy industries fell by 74% between 2005 and 2021 but the sector still accounts for 128,300 tonnes of NO_x pollution, or 19% of the total, making it the third most common source.

Meanwhile, other forms of transport including aviation, rail and shipping accounted for 14% of total NO_x in 2021.[101]

In part due to the overlap between deprived areas and exposure to traffic pollution, there is evidence suggesting a link between NO_x concentrations and deprived areas.[102]

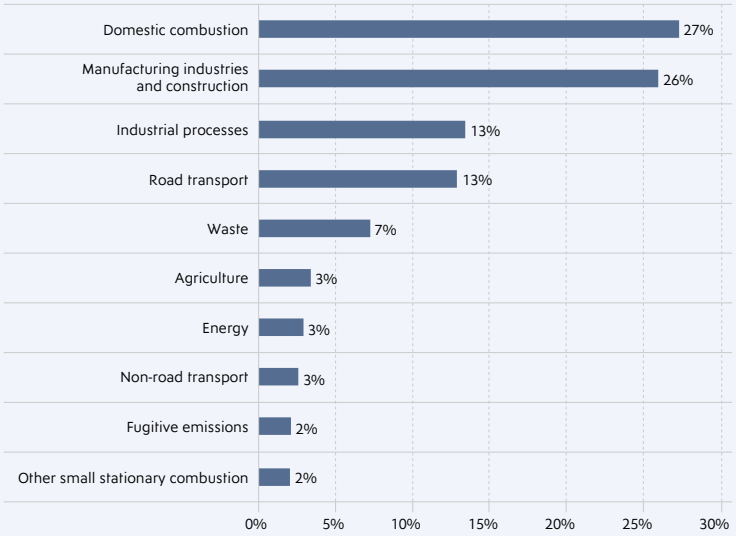
Comparing 2011 Defra NO_2 concentration data and 2011 census data, a 2019 study measured average NO_2 concentrations in England and Wales at the LSOA level against the percentage of households in poverty levels according to the Breadline Britain Index (BBI). It found that LSOAs with the highest poverty levels recorded NO_2 concentrations over 50% higher than those with the lowest poverty levels.[103]

101. Defra, "Emissions of air pollutants in the UK – Nitrogen oxides (NOx)", https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-nitrogen-oxides-nox (2023).
102. Joanna H. Barnes et al., "Emissions vs exposure: Increasing injustice from road traffic related air pollution in the United Kingdom", *Transportation Research* (2019), 56-66.
103. Ibid., 56-66, 58-9, 61.

$PM_{2.5}$

We can see from Chart 3.3 below the main sources of total emissions of $PM_{2.5}$, as of 2021.

Chart 3.3. $PM_{2.5}$ emissions by source, 2021



Source: Defra, "ENV01 – Emissions of air pollutants", https://www.gov.uk/government/statistical-data-sets/env01-emissions-of-air-pollutants (2023).

Chart 3.3 above shows that domestic combustion is the largest single contributor of total $PM_{2.5}$ emissions in 2021, responsible for 22,700 tonnes, or over a quarter of the total. This largely comes from the burning of wood in closed stoves and open fires.

Emissions from manufacturing industries and construction make up a further 26%. Then, industrial processes contribute 11,200 tonnes (14%), although these have fallen in recent decades owing to the decline of the steel and chemical industries. Road

transport also remains a major source of total $PM_{2.5}$ emissions, contributing 13% of total $PM_{2.5}$ in 2021. Non-exhaust emissions, particularly brake, tyre and road wear, make up a sizable proportion of this.[104]

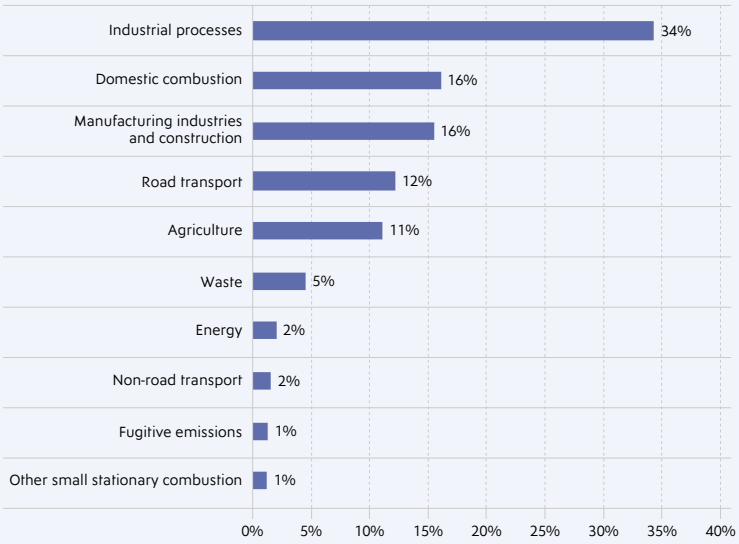
Although there is some regional variation, the UK evidence points to $PM_{2.5}$ being worse in deprived urban areas than in less deprived urban areas. A 2019 study for the Mayor of London found that average annual concentrations of $PM_{2.5}$ were 6% higher in the most deprived London areas than they were in the least deprived London areas, as referenced in Chapter One.[105]

104. Ibid.
105. Tim Williamson, Joshua Nunn and Helen Pearce, "Air pollution and inequalities in London: 2019 update", Logika Air Quality Consultants Ltd for the Greater London Authority, 4.

PM_{10}

We can see from Chart 3.4 below the main sources of total emissions of PM_{10}, as of 2021.

Chart 3.4. PM_{10} emissions by source, 2021



Source: Defra, "ENV01 – Emissions of air pollutants", https://www.gov.uk/government/statistical-data-sets/env01-emissions-of-air-pollutants (2023).

Chart 3.4 above shows the main contributors to total emissions of PM_{10} in 2021. Annual total emissions of PM_{10} have fallen by 79% since 1970, amounting to 146,000 tonnes in 2021.[106]

Industrial processes produce 49,300 tonnes of PM_{10} emissions, or about a third of the total. Domestic combustion follows with 23,200 tonnes, or 16% of total PM_{10} emissions, followed in turn by

106. Ibid.

manufacturing industries and construction with 22,400 tonnes (16%). Road transport and agriculture are the next largest contributors with 17,500 tonnes (12%) and 16,000 tonnes (11%) respectively.

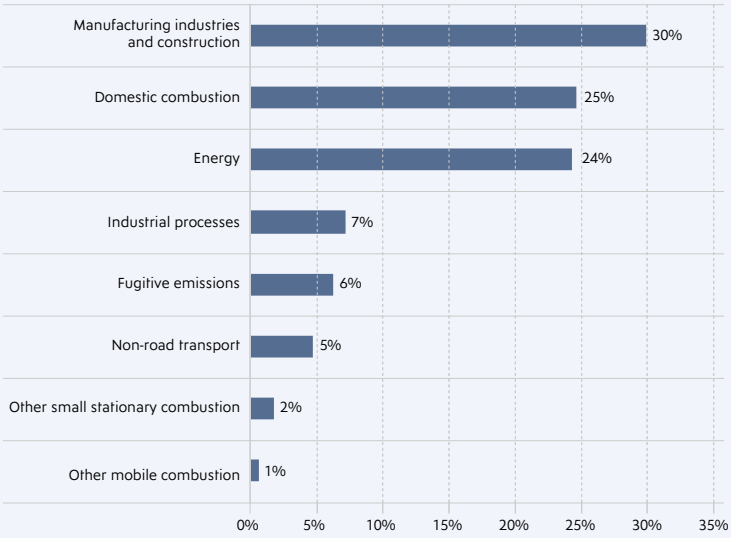
Like NO_x, there is evidence suggesting a link between mean concentrations of PM_{10} and deprived areas. The 2019 Dorling et al. study mentioned earlier, for example, found that the higher the proportion of households in poverty in an LSOA, the greater their exposure to PM_{10} emissions. It found that LSOAs with over 70% of households living in poverty endure an average of nearly 3μg/m³ higher concentrations of PM_{10} than LSOAs with fewer than 20% of households living in poverty in 2011.[107]

107. Joanna H. Barnes et al. "Emissions vs exposure", 56-66, 58-9.

SO_2

We can see from Chart 3.5 below the main sources of total emissions of SO_2, as of 2021.

Chart 3.5. PM_{10} emissions by source, 2021



Source: Defra, "ENV01 – Emissions of air pollutants", https://www.gov.uk/government/statistical-data-sets/env01-emissions-of-air-pollutants (2023).

SO_2 is a corrosive, acidic gas which is produced mainly from the combustion of coal or crude oil. This gas leads not only to public problems such as asthma and bronchitis, but also has several environmental issues, such as when it combines with water vapour to produce acid rain.

As Chart 3.5 above shows, the main source of SO_2 is combustion in manufacturing and construction industries, emitting 37,000 tonnes of SO_2, accounting for 30% of the total of SO_2 emissions in 2021. Long-

term reductions in SO_2 emissions, as documented in Chart 1.2 earlier, have been driven by a shift away from coal, a high-sulphur fuel, to gas and biomass fuels. This has resulted in a decrease in SO_2 emissions of 74% between 2012 and 2021.

Domestic combustion accounted for a quarter of SO_2 emissions in 2021 and combustion in energy production and transformation 24%.[108]

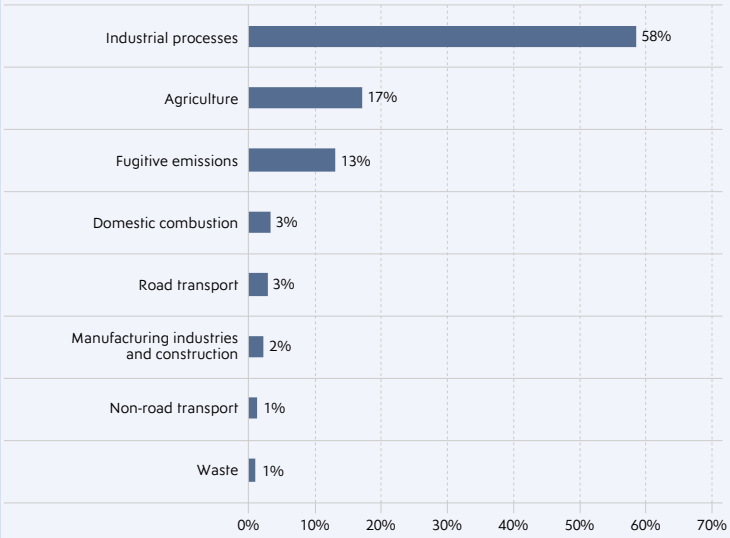
While a 2006 report produced for Defra suggested found there was a link between more deprived areas and exposure to higher concentrations of SO_2 in England and Northern Ireland (though not in Scotland and Wales),[109] there do not appear to be any more recent studies confirming this.

108. Defra, "National Statistics: Sulphur dioxide (SO2)", https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-sulphur-dioxide-so2 (2023).
109. AEA Technology, "Air Quality and Social Deprivation in the UK: an environmental inequalities analysis", https://uk-air.defra.gov.uk/assets/documents/reports/cat09/0701110944_AQinequalitiesFNL_AEAT_0506.pdf (2006), iv.

NMVOCs

We can see from Chart 3.6 below the main sources of total emissions of NMVOCs, as of 2021.

Chart 3.6. NMVOC emissions by source, 2021



Source: Defra, "ENV01 – Emissions of air pollutants", https://www.gov.uk/government/statistical-data-sets/env01-emissions-of-air-pollutants (2023).

Industrial processes, as Chart 3.6 above shows, comprise the majority of NMVOC emissions, contributing 451,700 tonnes, or 58% of total emissions in 2021. Included within the figures from industrial processes,[110] emissions from the food and beverage industry contribute 15% of total NMVOC emissions. The largest source of

110. Defra, "Methods and quality processes for UK air pollutant emissions statistics", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1136022/Methods_quality_processes_UK_air_pollutant_emissions_statistics.pdf (2023), 48.

emissions from the food and drink industry comes from the making of Scotch Whisky, contributing 63% of total NMVOC emissions in the food and drink sector in 2021.[111]

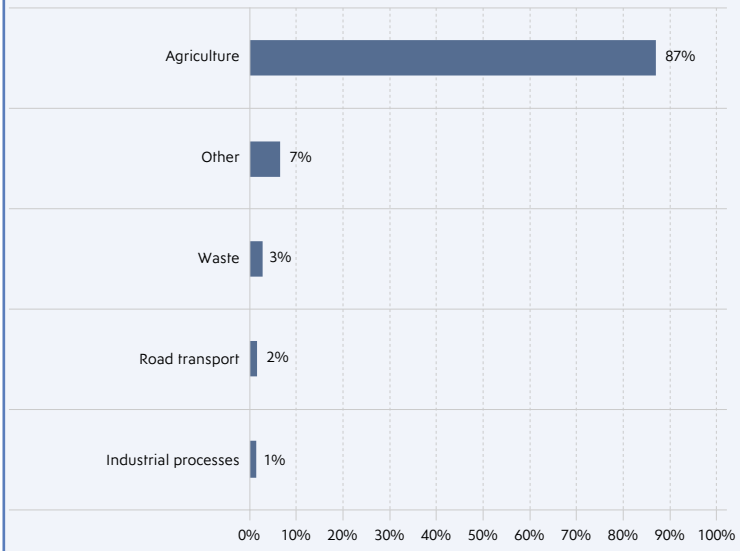
Next, agriculture is the second most common source of NMVOC total emissions at 17%, which equates to 132,900 tonnes. Fugitive emissions, which are irregular leaks of gases from pressurised containment in industry, such as storage tanks and pipelines, account for 13% of NMVOC emissions or 101,900 tonnes in 2021. Road transport, whilst contributing to 33% of NMVOC emissions in 1990, now contributes just 3% due to stricter emissions standards,[112] notably the introduction of the Euro emissions standards for new vehicles.

111. Defra, "Emissions of air pollutants in the UK – Non-methane volatile organic compounds (NMVOCs)", https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-non-methane-volatile-organic-compounds-nmvocs (2023).
112. Ibid.

NH_3

We can see from Chart 3.7 below the main sources of total emissions of NH_3, as of 2021.

Chart 3.7. NH_3 emissions by source, 2021



Source: Defra, "ENV01 – Emissions of air pollutants", https://www.gov.uk/government/statistical-data-sets/env01-emissions-of-air-pollutants (2023).

Agriculture, as Chart 3.7 shows, is by far the largest single contributor, responsible for 87% of total ammonia emissions in 2021, equalling 230,500 tonnes.[113] Other sources of ammonia emissions include waste, which contributes 3% of ammonia emissions or 7,400 tonnes in 2021. Road transport's contribution to ammonia emissions has fallen, however, from 4% in 2011 to 2% in 2021.[114] There is little evidence,

113. Defra, "National Statistics: Sulphur dioxide (SO2)".
114. Ibid.

however, for a link between NH_3 concentrations and deprived areas.

Having established the main sources of the main air pollutants, we now examine in detail the major sources that are especially responsible for air pollution in deprived areas.[115] These are transport and domestic combustion.

The key sources for deprived areas

Transport

Transport – cars in particular, but also planes, trains and ships – was the source most commonly associated with air pollution in all of the focus groups we conducted for this report. Participants across all the focus groups bemoaned 'dirty' fumes and the negative health effects they associated with them, although they also highlighted the necessity of using these modes of transport in daily life, especially where clean alternatives such as public transport are not readily available or affordable.

> "We have got a lot of busy roads and there's lots of cars going past at all times of the day … That doesn't help the area."
>
> **Participant D, Liverpool group**

> "When you live in main city areas, the traffic is ridiculous … More and more people are using cars and walking less. It is very polluted."
>
> **Participant C, Birmingham group**

> "I worry for future generations [because of] the busy roads."
>
> **Participant C, Barking and Dagenham group**

115. Jouni Paavola "Health impacts of climate change and health and social inequalities in the UK", *Environmental Health* (2017), 61-8, 63.

Pollution from transportation is especially important for this report given that people living in deprived areas are more likely to live in inner-city areas[116] located near major transport corridors where NO_2 concentrations are particularly high.[117] For instance, London especially endures road transport-induced air pollution. Transport for London (TfL) has observed that "[poor] air quality is impacting the health of Londoners, and it's mainly caused by polluting vehicles." Indeed, transport accounts for around half of London's NO_x emissions.[118]

But, outside London, road transport is also a problem for those living in deprived areas. As previously mentioned, it has been found that 85% of people living in areas with NO_2 concentrations above UK legal limits make up the poorest 20% of the UK population. Birmingham, Liverpool and Manchester have some of the highest proportions of deprived neighbourhoods in England and these cities all have main roads that breach legal NO_2 limits.[119]

The disproportionate impact of air pollution from road transport on those living in deprived areas is even more striking considering the lower car ownership rates among those groups. In 2019, just over half of those on the lowest incomes had access to a motor vehicle in their household. Conversely, almost 90% of those on the highest incomes had access to a motor vehicle.[120] This demonstrates that lower-income families, as Asthma UK and the British Lung Foundation suggested, contribute the least but are harmed the most.[121]

Road transport is also a large contributor to PM, as illustrated earlier in this chapter. A sizable proportion of road transport emissions in London now come from non-exhaust emissions such as tyre, brake and road wear.[122] The concern is that, even if NO_2 concentrations reduce as

116. Office for National Statistics, "Does exposure to air pollution increase the risk of dying from the coronavirus (COVID-19)?", https://www.ons.gov.uk/economy/environmentalaccounts/articles/doesexposuretoairpollutionincreasetheriskofdyingfromthecoronaviruscovid19/2020-08-13 (2020).
117. Paavola "Health and social inequalities in the UK", *Environmental Health* (2017), 61-8, 63.
118. House of Commons Library, "Expansion of the Ultra Low Emission Zone", 4-9.
119. Asthma UK and British Lung Foundation, "Clear the air", 15.
120. Ibid.
121. Ibid.
122. House of Commons Library, "Expansion of the Ultra Low Emission Zone", 14.

more people buy electric or hybrid cars, PM concentrations will remain high as people continue to drive and produce tyre, brake and road wear.

The reduction in NO_2 and PM concentrations when road transport levels decline is evidenced by the COVID-19 pandemic. During the Spring 2020 lockdown, there was a 69% reduction in traffic overall, which translated to a mean reduction in NO_2 across the UK of 39% and a $PM_{2.5}$ reduction of 17% compared to 2017-19. These improvements in NO_2 and $PM_{2.5}$ concentrations were greatest in urban areas.[123] In suburban areas, such as Horley in Surrey and Sharston in Greater Manchester, there was also a reduction in NO_2 concentrations.[124]

Internationally, the outcomes were similar. NO_2 concentrations fell by 50% in Barcelona and 62% in Madrid as a result of the sizeable reduction in road traffic levels in each city during the 2020 COVID-19 lockdowns. In Rio De Janeiro in Brazil, there was a 24% reduction in PM_{10} concentrations and a 43% drop in NO_2 concentrations during the first week of that city's 2020 COVID-19 lockdown. Moreover, studies from across Europe showed that NO_2 emissions in France, Spain and Italy dropped by 20-30% due to a massive reduction in road travel in March 2020 compared to March 2019.[125]

Domestic combustion

The participants of all three of our focus groups generally saw domestic combustion (or burning) as a thing of the past and significantly less relevant to air pollution than other sources such as transport.

Interestingly, one participant in the Liverpool group identified house fires as the main danger from domestic burning rather than air pollution. A participant in the Barking and Dagenham focus group saw the threat of smoke inhalation as a significant threat to life. And in Birmingham, one participant mentioned the toxicity of domestic burning.

123. Calvin Jephcote et al., "Changes in air quality during Covid-19 'lockdown' in the United Kingdom", *Environmental Pollution* (2021), 1.
124. Ibid., 8.
125. Ibid., 9.

> "Personally, it doesn't seem as much of a problem."
>
> **Participant D, Liverpool group**

> "How many people currently have those sorts of systems in their homes? Most people nowadays have a gas burner or gas heating or even electric hearing. [Domestic burning] is the type of stuff you'd expect in areas where you can't get gas supply or mains."
>
> **Participant E, Birmingham group**

However, across all three focus groups, domestic burning was largely seen not as an urban phenomenon, but as a source of heating in rural areas.

> "I don't think it's a large percentage of people that have got a wood burner. I think it's only a small percentage, maybe in rural areas. But in the city, most people have got radiators."
>
> **Participant C, Birmingham group**

Indeed, some participants in both the Liverpool and Birmingham groups saw slight positives of domestic burning in terms of cost efficiency for low-income households.

> "Especially in the winter, it makes a difference … some people can't have central heating … it's cheaper to run on wood … rather than pay for gas all the time."
>
> **Participant D, Liverpool group**

> "I've noticed a trend of people wanting to have fireplaces because of the cost of gas and electricity."
>
> **Participant B, Birmingham group**

Due to the belief that domestic burning was not a major cause of pollution, participants in all the focus groups were reluctant to advocate for banning domestic burning.

> "I don't know about banning them."
>
> **Participant B, Barking and Dagenham group**

> "From an air pollution perspective, I think that the level that household fires contribute to air pollution is nowhere near that of industry. So, if they were to ban household fires, they'd have to start restricting pollution caused by businesses because it's nowhere near that sort of level."
>
> **Participant A, Liverpool group**

> "No, I think that's too excessive."
>
> **Participant C, Birmingham group**

One participant in the Liverpool group, however, did advocate for banning domestic burning, but not for air pollution reasons, but for personal safety reasons.

> "I think it should be banned totally because of the amount of accidents that have happened … These accidents do happen because of wood burners in the home. They should be left outside or banned totally."
>
> **Participant C, Liverpool group**

Overall, domestic burning did not feature as a primary concern for focus group participants, unlike transportation. Whilst there was an acknowledgement of the health impacts of domestic burning, there was no decisive belief in concrete action to tackle domestic burning across the focus groups.

Despite this view among focus group participants, domestic burning, mostly of wood, is now in fact the largest source of UK annual average $PM_{2.5}$ emissions, as shown in Chart 3.3 earlier.[126]

Interestingly, between 2010 and 2020, the National Atmospheric Emissions Inventory, the official database tracking emissions of air pollutants in the UK, first introduced in Chapter One, estimated that $PM_{2.5}$ emissions from domestic wood burning increased by 35%.[127] The domestic burning problem seems to be a growing one.

Studies conducted for Defra found that 19% of the UK public had burned solid fuels in their homes in the year 2019-2020.[128] In the UK, 500,000 households had stoves for domestic burning in 2003. By 2016, however, this figure had increased to 1.7 million. Research from 2017 also suggests that up to 200,000 stoves are sold each year.

A study by Kantar shows the most common reasons for installing domestic burning appliances, a term which includes include stoves, open fires, range cookers and biomass boilers.[129] Fifty percent of people stated that one of the reasons they chose to purchase one was due to the heat they give off. Thirty-seven percent liked the aesthetic and design of stoves. Meanwhile, 6% stated that they chose one due to its impact on air quality outside.[130] Many wrongly see wood burning as environmentally friendly and harmless to health.[131]

Moreover, a key reason for people burning solid fuel at home was to create a homely feel, with 46% saying this was a reason.[132] Others viewed solid fuel burning as environmentally friendly and carbon neutral, with

126. Defra, "National Statistics: Emissions of air pollutants in the UK – Particulate matter (PM10 and PM2.5)", https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-particulate-matter-pm10-and-pm25 (2023).
127. Anna Font et al., "Long term trends in particulate matter from wood burning in the United Kingdom: dependence on weather and social factors", *Environmental Pollution* (2022), 2.
128. Kantar, "Burning in UK homes and gardens", https://randd.defra.gov.uk/ProjectDetails? ProjectID=20159&FromSearch=Y&Publisher=1&SearchText=AQ1017&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description (2020), 30.
129. Ibid., 6.
130. Ibid., 53.
131. Ibid., 45, 90.
132. Ibid., 86.

burning wood seen as part of a "natural cycle of absorption".[133]

Almost half of those who burn at home (47%) do so to save money or to supplement their main source of heating to reduce their energy costs.[134] This was evidenced during the 2022-2023 cost-of-living crisis.[135] In October 2022, demand for stoves soared due to rising energy bills.[136]

Only one in ten households who burn solid fuel domestically has an income below £20,000 per year.[137] Domestic heating is weighted heavily towards more affluent groups. Of those with a domestic stove, 48% are from the highest two social grades, that is, classifications of groups of people "mainly based on their social and financial situation",[138] and 42% owned their own home.[139]

Nevertheless, those with domestic burners from deprived areas are more likely to suffer from PM derived from domestic combustion. Those from deprived areas are less likely to be able to afford repairs to inefficient or broken domestic heating systems. Moreover, since many from deprived areas rent from private or social landlords — less than one-fifth of the lowest household income quintile own their own homes[140] — they are reliant on landlords to organise repairs to domestic burners.[141] Because many of those who burn at home tend to be better off, it should be possible to reduce this source of pollution without harming those in a more precarious financial situation.

133. Ibid., 90.
134. Ibid., 14.
135. Ioana Diac, "Government support is needed to avoid a huge increase in indoor burning this winter", CapX, https://capx.co/government-support-needed-to-avoid-a-huge-increase-in-indoor-burning-this-winter/ (2022).
136. Osob Elmi and Sacha Bigwood, "Sales of wood burners rise as people battle increased energy bills", BBC https://www.bbc.co.uk/news/uk-england-bristol-63241940 (2022).
137. Kantar, "Burning in UK homes and gardens", 92.
138. Office for National Statistics, "Approximated Social Grade data", https://www.ons.gov.uk/census/aboutcensus/censusproducts/approximatedsocialgradedata (2023).
139. James Heydon, "Between ordinary harm and deviance: evaluating the UK's regulatory regime for controlling air pollution from wood burning stoves", *The British Journal of Criminology* (2023), 3.
140. Lauren Ferguson et al., "Systemic inequalities in indoor air pollution exposure in London, UK", *Build Cities*, (2021), 28.
141. Ibid., 7, 28.

Conclusion

As this chapter has outlined, while there are multiple sources of air pollution, transport and domestic burning are particularly important to air pollution in deprived areas.

The next chapter will discuss the health, economic and social consequences of air pollution, especially in deprived areas.

Chapter 4:
Effects of air pollution

Having established the main sources of air pollution in the UK in Chapter Three, this chapter sets out the health, economic and environmental consequences of air pollution, especially for those from deprived areas.

Health effects

There are two main types of health effects: physical health and mental health. Air pollution has long been known to have adverse health effects – to date, there are roughly 60,000 studies available on the effects of air pollution on health.[142] This includes both short-term effects (which includes "worsening of symptoms, hospitalisations, deaths") and long-term effects (which includes "disease development, attributable premature deaths and years of lost healthy life", as well as cancers).[143] Emerging evidence shows that air pollution is also associated with worse cognitive and mental health for both children and adults.[144]

Physical health

Across all three focus groups, ill-health was one of the first things participants mentioned when they were asked to write down what came to mind when they thought about air pollution.

142. Fuller, Friedman and Mudway, "Impacts of air pollution across the life course", 2.
143. Ibid, 2, 4.
144. Ibid, 2.

> "I popped down detrimental to our health caused by emissions, dirty."
>
> **Participant B, Barking and Dagenham group**

> "The words that I had were toxic, unhealthy cause, greenhouse gases and smoking fumes, and that hard to breathe."
>
> **Participant A, Birmingham group**

When discussing the impacts of air pollution, several participants in the focus groups personally felt the effects of air pollution in their everyday lives.

> "Yeah, like I hate it when I walk past a car that I've got a long walk behind it and the few like, it's just one of my pet hates and like, you can't breathe while you there. And I just really don't like it."
>
> **Participant D, Birmingham group**

One participant in the Birmingham group felt that, because of exposure to air pollution, people in urban areas were less healthy than those in rural areas.

> "People in the city are more sick I see, like more in hospitals, but when they're outside in the countryside they're like, they look like fresh and everything."
>
> **Participant A, Birmingham group**

Among those who raised concerns about the impact of air pollution on physical health, there was particular concern about the impact that air pollution could have on those with pre-existing conditions such as asthma, chronic obstructive pulmonary disease (COPD) or long COVID.

> "It hasn't been having health impacts on me, but.... I can see I can see like why it could do to others like to other people that are like asthmatic or and have like health conditions that affect their lungs."
>
> **Participant D, Liverpool group**

> "And sometimes it's more susceptible to maybe asthma or COPD rather than people who don't work on ships or highly sort of polluted areas."
>
> **Participant E, Liverpool group**

> "The smells and the fumes, right from cars and traffic is sometimes unbearable for people who have like... Any asthma problems or people that suffer with long COVID symptoms, which just in general will make it really difficult for them to breathe."
>
> **Participant E, Birmingham group**

Not everyone, however, felt that air pollution was still a major problem. One Liverpool participant felt that health issues caused by air pollution had fallen considerably due to improvements in air quality over their lifetime.

> "You know, that's not as much nowadays as it was like years ago, you know. So we are getting like, you know, it sounds silly, but, you know, less people are catching things like, well, not catching like the likes of asthma, which air pollution can cause. And like, you know, but I just think the airs [sic] starting to now actually start getting a lot cleaner."
>
> **Participant C, Liverpool group**

Turning to secondary evidence, an independent analysis by Imperial College London, published earlier in 2023, gives an overview of existing findings on the impact of air pollution on physical health. Among adults, air pollution is linked to respiratory diseases such as asthma and COPD, and increased risk of heart disease, strokes and cancer, especially lung cancer.[145]

A 2016 study by the Royal College of Physicians found that exposure to air pollution was linked to an increased likelihood of having cardiovascular disease. However, there was no conclusive evidence on the association between exposure to air pollution in childhood and subsequently developing cardiovascular disease in adulthood.[146]

In 2022, the US Health Effects Institute conducted a systematic review of 355 studies, carried out over the previous 40 years, that examined the health impacts of long-term exposure to traffic-related air pollution.[147] The review attached "an overall high or moderate-to-high level of confidence" to the association between exposure to traffic-related air pollution and "adverse health outcomes" such as ischemic heart disease and death from lung cancer.[148]

Air pollution exacerbates the symptoms of those with pre-existing health conditions, particularly cardiovascular and/or respiratory conditions.[149] A 2022 study by Asthma + Lung UK found that air pollution "triggers or worsens symptoms" for the up to 3.4 million estimated to suffer from COPD in the UK. In a 2022 survey, almost 60% of respondents with a lung condition said that air pollution makes them feel breathless, 51% reported that it makes them feel wheezy and 43% said that it made their symptoms flare up. Almost 8% said that they have been hospitalised due to high air pollution.[150]

145. Ibid.
146. Royal College of Physicians, "Every breath we take".
147. Fuller, Friedman and Mudway, "Impacts of air pollution across the life course", 11.
148. H. Boogaard et al., "Long-term exposure to traffic-related air pollution and selected health outcomes: A systematic review and meta-analysis", *Environment International* (2022), 4.
149. Royal College of Physicians, "Every breath we take".
150. Asthma + Lung UK. "Alerting the nation. Improving the way information is used to protect the most vulnerable from air pollution", https://www.blf.org.uk/sites/default/files/Alerting%20the%20Nation%20Report_v4.pdf (2022).

Now focusing on individual pollutants, since the 1993 Harvard 'Six Cities' study, we have known that higher concentrations of $PM_{2.5}$ contribute to reduced life expectancy.[151] In 2014, the European Study of Cohorts for Air Pollution Effects (ESCAPE) Project, which tracked over 100,000 participants across five European countries between 1997 and 2007, found that acute coronary events were linked to air pollution exposure, with effects detectable at $PM_{2.5}$ concentrations below even the legal pollution limits at the time.[152]

The Committee on the Medical Effects of Air Pollutants (COMEAP) estimated in 2018 that the mortality burden of long-term exposure to any level of air pollution in the UK was equivalent to 28,000 to 36,000 deaths per year. When the mortality burden is calculated for exposure to an annual concentration of NO_2 from 5 $\mu g/m^3$ upwards, COMEAP estimated that it caused the equivalent of 16,000 to 19,000 deaths per year.[153]

Taking together the effects for children and adults, UK Health Forum and Imperial College London estimated in 2018 that there "could be around 2.5 million new cases of coronary heart disease, stroke, lung cancer, childhood asthma, COPD, diabetes, low birth weight and dementia in England by 2035" in total, if 2018 NO_2 and $PM_{2.5}$ concentrations persist. Modelling estimates in the same study suggest that, for people aged over 18 years, reducing $PM_{2.5}$ concentration by one $\mu g/m^3$ in England could prevent 50,900 cases of coronary heart disease, 16,500 strokes, 4,200 lung cancers and 9,300 cases of asthma by 2035.[154]

A report prepared for Defra by Ricardo Energy & Environment in

151. Dockery et al., "An association between air pollution and mortality in six U.S. cities", *The New England Journal of Medicine* (1993), 1753-9. For the impact of the study, see Fuller, *Invisible Killer*, 85-94.
152. Giulia Cesaroni et al., "Long term exposure to ambient air pollution and incidence of acute coronary events: prospective cohort study and meta-analysis in 11 European cohorts from the ESCAPE Project", *British Medical Journal* (2014); Fuller, Friedman and Mudway, "Impacts of air pollution across the life course", 10.
153. 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, 74.
154. Ryan O'Hare, "Air pollution in England could cost as much as £5.3 billion by 2035", https://www.imperial.ac.uk/news/186406/air-pollution-england-could-cost-much/, Imperial College London (2018); Public Health England, "Estimation of costs to the NHS and social care due to the health impacts of air pollution", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/836720/Estimation_of_costs_to_the_NHS_and_social_care_due_to_the_health_impacts_of_air_pollution.pdf (2018).

2023 calculated that for every µg/m³ rise in $PM_{2.5}$ concentrations (24-hour average), the number of respiratory hospital admissions increases by 0.96% and cardiovascular hospital admissions by 0.90%; for NO_2, admission numbers would increase by 0.57% and 0.66%, respectively. A one µg/m³ rise in $PM_{2.5}$ concentrations (24-hour average) increases the incidence of ischemic heart disease by 7% and that of a stroke by 10%.[155]

Mental health

Only one of our focus group participants felt that air pollution affected their mental health, with no one else seeming to be aware of the link between air pollution and poorer mental health.

> "You definitely notice the difference and I feel like if even walking through like to the train station every day, things like that, walking through the air, I'm sure it has an effect on like my skin and my mood as well. I agree with that. I thought I really affects different parts of you."
>
> **Participant A, Barking and Dagenham group**

Air pollution has been shown to harm mental health. This sub-section will in turn discuss the evidence around the overall effects air pollution has on mental health and then specifically the evidence around the effects that PM has on mental health.

In terms of the overall effects, a 2021 study of 1,698 adults living in Lambeth and Southwark in London between 2008 and 2013 found urban air pollution "to have a significant impact on poor mental health, which could not be explained by other indices of urbanicity or socioeconomic deprivation".[156] Comparing those in the least and greatest concentrations of $PM_{2.5}$, PM_{10}, NO_x, NO_2 and O_3, there were robust associations with "18–39% increased odds of common mental

155. Ricardo Energy & Environment, "Air quality damage cost update 2023 – Final report", https://uk-air.defra.gov.uk/assets/documents/reports/cat09/2301090900_Damage_cost_update_2023_Final.pdf (2023), 22.
156. Fuller, Friedman and Mudway, "Impacts of air pollution across the life course", 11.

disorders, 19–30% increased odds of poor physical symptoms and 33% of psychotic experiences", the last of which was only found with PM_{10} exposures.[157] Another study in 2021 found that exposure to air pollution leads to increased mental health service use among people recently diagnosed with psychotic and mood disorders.[158]

PM especially has been shown to cause harm to mental health. A 2019 meta-analysis, pooling studies published between 1974 and 2017 to examine the effects of $PM_{2.5}$ and PM_{10} exposure, supported the idea of links between long-term $PM_{2.5}$ exposure and depression, between long-term $PM_{2.5}$ exposure and anxiety, and between short-term PM_{10} exposure and suicide rates. Human and animal studies also provide solid evidence that exposure to PM "induces oxidative stress and neuroinflammation",[159] as well as "being directly neurotoxic and associated with structural brain changes",[160] and affecting the production of stress hormones.[161] These are the most probable biological mechanisms underpinning a presumed association between mental health and exposure to PM.[162]

In terms of why these mental health problems are correlated with higher exposure to air pollution, scientists have hypothesised that PM may enter the brain via several channels: the lungs, the bloodstream and the nasal pathway. The PM entering through these could cause damage to: the respiratory tract, the immune system as well as to genetic material. The PM which enters the brain via the nasal pathway

157. Ioannis Bakolis et al., "Mental health consequences of urban air pollution: Prospective population-based longitudinal survey", *Social Psychiatry and Psychiatric Epidemiology* (2021), 1587-1599, 1587.
158. Joanne Newbury et al., "Association between air pollution exposure and mental health service use among individuals with first presentations of psychotic and mood disorders: Retrospective cohort study", *The British Journal of Psychiatry* (2021), 678-685.
159. Michelle L Block and Lilian Calderón-Garcidueñas. "Air pollution: Mechanisms of neuroinflammation and CNS disease", *Trends in Neurosciences* (2009): 506-51; Shannon Levesque et al., "Air pollution & the brain: Subchronic diesel exhaust exposure causes neuroinflammation and elevates early markers of neurodegenerative disease", *Journal of Neuroinflammation* (2011), 1-10, 2; Isobel Braithwaite et al., "Air pollution (particulate matter) exposure and associations with depression, anxiety, bipolar, psychosis and suicide risk: A systematic review and meta-analysis", *Environmental Health Perspectives* (2019), 20
160. Braithwaite et al., "Air pollution (particulate matter) exposure and associations", 20.
161. Huichu Li et al., "Particulate matter exposure and stress hormone levels: A randomized, double-blind, crossover trial of air purification", *Circulation* (2017), 618-627; Braithwaite et al., "Air pollution (particulate matter) exposure and associations", 20.
162. Braithwaite et al., "Air pollution (particulate matter) exposure and associations", 20.

may induce oxidative stress, resulting in brain degeneration and limbic damage.[163]

Children's health

Several participants in the Birmingham and Liverpool focus groups were concerned about the potential health threat that air pollution posed to their children. They were specifically concerned that their children could develop asthma, and one participant even worried about taking his child to busy areas.

> "Definitely it does like if I'm in areas with lots of diesel exhaust, I'll notice that like my nostrils. Like if I blow my nose, it's like black afterwards, you know? So, you know, some of that is getting into your lungs. And I worry like taking my son to really crowded places."
>
> **Participant C, Birmingham group**

> "Can't say [I am worried about air pollution] personally, the only thing I worry about is what happens to the kids when they're older… And whereas if they develop asthma or anything like that due to it."
>
> **Participant D, Liverpool group**

In one case, the participant's children had asthma, which they believed air pollution may have caused.

> "So my children suffer with it [asthma], so that's what. It's been put down to kind of thing."
>
> **Participant D, Birmingham group**

163. Ioannis Bakolis et al., "Mental health consequences of urban air pollution: Prospective population-based longitudinal survey", *Social Psychiatry and Psychiatric Epidemiology* (2021), 1596.

During pregnancy, exposure to air pollution is associated with impaired foetal development, lower birth weight and pre-term births. This can happen indirectly through the mother's exposure to pollution or directly through air pollutants crossing the placental barrier, which is the protective barrier separating the maternal and foetal circulatory systems. A recent study showed that in 2010, 5-10% of total preterm births in the UK were linked with $PM_{2.5}$ concentrations greater than 4.3 $\mu g/m^3$.[164] According to Ghosh et al., the average reduction in gestational age attributable to $PM_{2.5}$ was approximately three to five days in 2019.[165]

Exposure to dangerous concentrations of outdoor air pollutants, specifically NO_2, $PM_{2.5}$, also disproportionately affects pregnant black women. Partly as a result, their risk of dying during childbirth is quadruple that of pregnant white women.[166]

For children in particular, air pollution is associated with reduced lung volume, increased risk of asthma and, as recent evidence indicates, potential detrimental effects on the cardiovascular system, such as atherosclerosis or changes in blood pressure.[167] The effects of NO_2 exposure on lung development are especially clear.

Most significantly, infants have a higher metabolic rate, which means they breathe a greater volume of air per minute than an adult relative to their size. This is doubly problematic: their exposure to doses of toxic pollutants is higher and they are more vulnerable to their harmful effects.[168]

Reductions in air pollution have been found to have positive effects on the development of children's lung function. For example, in a 2015 study in California, long-term reductions in $PM_{2.5}$, PM_{10}, and NO_2 were

164. Christopher S Malley et al., "Preterm birth associated with maternal fine particulate matter exposure: A global, regional and national assessment", *Environment International* (2017), 173-182, 177.
165. Rakesh Ghosh et al., "Ambient and household PM2.5 pollution and adverse perinatal outcomes: A meta-regression and analysis of attributable global burden for 204 countries and territories", *PLoS Medicine* (2021), 1-22.
166. "Black Child Clean Air Report", https://www.blackchildcleanair.com/ (2023); Black Child Clean Air, "Black child clean air report: Air pollution in pregnancy: Exploring the views and experiences of Black mothers and Black pregnant women living in London", https://www.blackchildcleanair.com/_files/ugd/6e0914_196127e14c154fac978b66d391f7f9ac.pdf (2023).
167. Fuller, Friedman and Mudway, "Impacts of air pollution across the life course", 2.
168. Li-Zi Lin et al., "Ambient air pollution and infant health: a narrative review", *EBioMedicine* (2023), 1-2.

associated with measurable improvements in the development in the lung function of children with and without asthma between the ages of 11 and 15, compared with those growing up earlier when concentrations of those pollutants were higher. While small changes in lung function might not seem significant on an individual level, on a population level a small change in average lung function means more people fall below the disease threshold.[169]

The elderly

When asked about the effects of air pollution on themselves and their communities, only one focus group member specifically mentioned the disproportionate impact that air pollution has on older citizens.

> "I think [air pollution has an impact on] the vulnerable people as well... Like um, uh, 60 to 70 year olds with or with asthma lung problems?"
>
> **Participant A, Birmingham group**

Imperial College London point out in a 2023 report that the elderly, defined as those older than 65 in most studies, are particularly vulnerable to air pollution.[170] Imperial College London described the link between exposure to air pollution and instances of respiratory diseases among the elderly as "well-documented". The same report also highlighted an earlier review from 2015 which found that, among the elderly, prolonged exposure to air pollution correlated with having reduced lung function, COPD and asthma.[171]

The Royal College of Physicians noted that exposure to air pollution may heighten the risk of dementia.[172] In 2022, a Committee on the

169. James W Gauderman et al., "Association of improved air quality with lung development in children", *The New England Journal of Medicine* (2015), 905-913.
170. Fuller, Friedman and Mudway, "Impacts of air pollution across the life course", 2.
171. Ibid.
172. 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/projects/outputs/every-breath-we-take-lifelong-impact-air-pollution (2016).

Medical Effects of Air Pollutants (COMEAP) review of 69 studies also concluded that there is likely an association between air pollution exposure and an increased risk of cognitive decline and dementia – most probably from exposure to PM.[173]

Deprived areas

Several participants in the Barking and Dagenham focus group noticed that air pollution was worse where they lived than elsewhere in the UK.

> "We're more inclined to have different diseases in comparison to other people. So I mean, obviously, air pollution is bad all around the country, but I know I can feel it's bad here. Yeah."
>
> **Participant B, Barking and Dagenham group**

> "The grime that's on me. The grease that's on me and I agree. And what the lady was saying before. Couple weeks ago, I went to a cabin on the lakes and I was like, why was up here so different? It's. Ohh yeah. You don't feel that heavy... Heaviness that you feel when you're in London, and you are actually breathing differently with your lungs? It feels different."
>
> **Participant F, Barking and Dagenham group**

One participant expressed frustration at the unequal standards of air quality and the consequences this had for the health of their community.

173. COMEAP, "Cognitive decline, dementia and air pollution", https://www.gov.uk/government/publications/air-pollution-cognitive-decline-and-dementia (2022); Fuller, Friedman and Mudway, "Impacts of air pollution across the life course", 11.

> "It's quite unfair. I don't know. I feel like, why should our standard of air be any different to anybody else's? Enough said. Like I said, it's detrimental to our health."
>
> **Participant B, Barking and Dagenham group**

People from deprived areas typically have less access to jobs, healthy food, quality housing and green spaces, which all contribute to poorer health. As successive Chief Medical Officers for England have noted, those living in deprived areas are more likely to suffer from existing medical conditions, which may render them more vulnerable to the negative effects of air pollution.[174] Similarly, while, as mentioned in Box 4.1, European studies have not always consistently found a link between deprived areas and exposure to air pollution, they have found that those in deprived areas "are more likely to suffer greater harm as a consequence of their exposure since they are more vulnerable to its effects".[175]

Within the UK, for example, the British Lung Foundation (BLF) found that someone from the most deprived areas is two-and-a-half times more likely to have COPD and nearly twice as likely to develop lung cancer as someone from the least deprived sector of society. They argue that this can largely be explained by greater exposure to air pollution, workplace dust and chemicals, as well as higher rates of smoking.[176] Similarly, the BLF also found that residents of the more deprived London boroughs of Tower Hamlets, Newham and Barking and Dagenham were up to twice as likely to die from lung diseases than those in wealthier areas such as

174. Dame Sally C Davies, "Annual Report of the Chief Medical Officer 2017: Health Impacts of All Pollution – what do we know?", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/690846/CMO_Annual_Report_2017_Health_Impacts_of_All_Pollution_what_do_we_know.pdf (2017), 4; Whitty, "Chief Medical Officer's Annual Report 2022: Air pollution", 26.
175. Brunt et al., "Air pollution, deprivation and health: understanding relationships to add value to local air quality management policy and practice in Wales, UK", *Journal of Public Health* (2016), 485–497, 491.
176. British Lung Foundation, "The battle for breath – the impact of lung disease in the UK", https://web.archive.org/web/20210709080617/https://cdn.shopify.com/s/files/1/0221/4446/files/The_Battle_for_Breath_report_48b7e0ee-dc5b-43a0-a25c-2593bf9516f4.pdf?7045701451358472254 (2016), 5.

Kensington and Chelsea, Westminster and Barnet.[177]

People living in deprived areas tend to live in areas with higher air pollution, which may in large part be due to the link between lower house prices and proximity to busy main roads that have greater exposure to NO_2 and PM emissions.[178] This link between exposure to air pollution and deprived areas has been shown to worsen health outcomes. A study looking at the effects of traffic-related PM_{10} emissions in Leicester, for example, indicated that "significant global relationships… exist between children's hospitalisation rates and social-economic-status, ethnic minorities, and PM_{10} road-transport emissions".[179]

Economic effects

Air pollution negatively affects the economy by increasing the burden on the NHS, reducing workforce participation, increasing the number of workdays lost to illness, and reducing productivity among those still able to work.

The cost to the NHS is considerable. A 2018 study estimated that diseases associated with $PM_{2.5}$ and NO_2, such as cardiovascular disease, respiratory disease and lung cancer will cost the NHS £5.56 billion between 2017 and 2025.[180] A 2018 report by Public Health England warned these costs could reach £18.6 billion by 2035 unless action is taken to reduce air pollution from current concentrations. This figure only factors in costs related to GP visits, medical prescriptions, hospital treatment and social care due to long-term health conditions and does not account for the economic costs of lost productivity.[181]

177. Fiona Harvey, "London: fatal lung conditions 'more likely' in deprived boroughs", *The Guardian*, 6 June 2016 https://www.theguardian.com/environment/2016/jun/06/london-fatal-lung-conditions-more-likely-in-deprived-boroughs.
178. Royal College of Physicians, "Every breath we take".
179. Calvin Jephcote and Haibo Chen, "Environmental injustices of children's exposure to air pollution from road-transport within the model British multicultural city of Leicester: 2000-09", *Science of the Total Environment*. (2012), 140-151, 140.
180. 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", *Plos Medicine* (2018), 2-3.
181. Public Health England, "Estimation of costs to the NHS and social care due to the health impacts of air pollution", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/836720/Estimation_of_costs_to_the_NHS_and_social_care_due_to_the_health_impacts_of_air_pollution.pdf (2018).

Unsurprisingly, the burden of sickness from air pollution negatively affects the wider economy. A 2014 report by Defra developed a method to quantify the economic effects due to productivity loss via five pathways. Productivity loss is measured as the length of potentially productive time that a person is unable to work multiplied by a value of marginal productivity revealed in the market. Focusing on the direct impacts of air pollution via inhalation, ways air pollution reduces economic output include: mortality (due to chronic and acute exposure) in the workforce; morbidity in the workforce (absenteeism); morbidity in the workforce (presenteeism); absence in the workforce due to morbidity in dependents; and health impacts (mortality and morbidity) in non-market productive activities (such as volunteering and non-paid caring). Defra then estimated that at 2012 pollution levels, the loss in productivity cost a total of £2.7 billion, "equivalent to a reduction in GDP of 0.11%".[182]

In September 2020, CBI Economics found that three million working days could be gained by reducing absences from work and absences from sick children caused by high air pollution. It quantified the economic benefits of cleaner air and found that meeting WHO air pollution guidelines would bring a £1.6 billion annual economic benefit to the UK.[183]

Air pollution also reduces productivity among those still able to work. A 2023 analysis found that there was clear evidence that air pollution reduced productivity both in indoor and outdoor settings at different skill levels.[184] Similarly, a 2016 study on workers at a pear-packing factory in the US observed that increases in $PM_{2.5}$ significantly reduce the number of boxes that the workers pack. $PM_{2.5}$ also had effects on productivity at concentrations below US air quality limits, with effects

182. Defra, "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).
183. Confederation of British Industry, "What is the economic potential released by achieving clean air in the UK?", https://www.cbi.org.uk/articles/what-is-the-economic-potential-released-by-achieving-clean-air-in-the-uk-1/ (2020).
184. Matthew Neidell and Nico Pestel, "Air pollution and worker productivity", IZA World of Labor (2023), 9.

arising at 20–25 μg/m³.It estimated that the productivity of indoor workers fell by 6% for every 10μm³ increase in $PM_{2.5}$ concentration.[185]

There is even evidence linking higher concentrations of $PM_{2.5}$, O_3, NO_2 and CO to stock market performance. One 2021 study found that "stock market anomalies are stronger following high rather than low pollution periods [of air pollution]". This link is likely explained by the detrimental effects that air pollution has on cognitive performance, and the resulting deteriorating quality of investor decision making.[186]

Similarly, evidence also suggests that poorer air quality increases the crime rate, at least for less serious offences such as pickpocketing. Based on daily data from 2004-2005, a 2018 LSE study found that crime in London increased by 0.9% when the Air Quality Index (the US equivalent of the DAQI, which the researchers used for the paper and which is expressed as a score between one and 1,000) increased by 10 points. This is link is believed to be partly due to the increased stress levels that air pollution causes.[187]

International evidence also demonstrates the harm to growth caused by air pollution. A 2020 study examined the economy-wide harms of air pollution, specifically the harms caused by $PM_{2.5}$ in OECD countries between 2000 and 2015. The study estimated that "a 1 μg/m³ increase in $PM_{2.5}$ concentration causes a 0.8% reduction in real GDP that same year" It also found that ninety-five percent of the reduction in GDP could be put down to reduced output per worker from greater absenteeism and reduced productivity among those still physically present.[188]

185. T Chang et al., "Particulate pollution and the productivity of pear packers", *American Economic Journal: Economic Policy* (2016), 141–169, 163-4.
186. Hung T. Nguyen and Mia Hang Pham, "Air pollution and behavioral biases: Evidence from stock market anomalies", *Journal of Behavioral and Experimental Finance*, 2021).
187. Malvina Bondy, Sefi Roth and Lutz Sager "Crime is in the air: the contemporaneous relationship between air pollution and crime", London School of Economics working paper, https://www.lse.ac.uk/GranthamInstitute/publication/crime-is-in-the-air-the-contemporaneous-relationship-between-air-pollution-and-crime/ (2018); Gary Haq, "Air pollution increases crime in cities – here's how", *The Conversation*, https://theconversation.com/air-pollution-increases-crime-in-cities-heres-how-95975 (2018).
188. Antoine Dechezleprêtre, Nicholas Rivers and Balazs Stadler, "The Economic Cost of Air Pollution: Evidence from Europe", OECD Economics Department Working Papers (2020).

Environmental effects

Unsurprisingly, air pollution can negatively affect natural habitats and ecosystems. Serious environmental impacts of air pollution occur due to nitrogen deposition, acid deposition and the direct effects of toxic air pollutants being in the air.[189]

Air pollution contributes to acidification and eutrophication, which is the increased levels of nutrients in watercourses of waterways, such as through acid rain. This can lead to an imbalance in the variety of fish species and result in fish deaths.[190] According to a 2017 study, there is evidence that toxic air pollutants can lower the reproductive capacity of animals.[191] NO_x and SO_2 compounds can also react with water in the air or soil to have an acidifying effect on the soil.[192] Acidification of soils alters nutrient cycles and damages plant growth.[193]

Eutrophication encourages excessive plant growth, leading to algal blooms which reduce light and oxygen levels. This process affects ecosystems, killing fish and altering plant communities. Increased nitrogen deposition to land can change the composition and diversity of plant communities, for instance by benefitting certain plants which then outcompete nitrogen-sensitive species.[194] This has been reported to significantly reduce the number of plant species per unit area in a range of habitats of high conservation value in the UK.[195] High concentrations of NO_2 have been observed to reduce crop yield and plant growth efficiency.[196]

189. Environment Agency, "The state of the environment", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/729820/State_of_the_environment_air_quality_report.pdf (2018).
190. Ioannis Manisalidis et al., "Environmental and Health Impacts of Air Pollution: A Review", *Front Public Health* (2020).
191. Julie Carré, "Does air pollution play a role in infertility?: A systematic review", *Environmental Health* (2017), 1.
192. Air Pollution, "What is acid rain?", http://www.air-quality.org.uk/01.php (2017).
193. Environment Agency, "The state of the environment", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/729820/State_of_the_environment_air_quality_report.pdf (2018).
194. Ibid.
195. Defra, "Review of Transboundary Air Pollution: Acidification, Eutrophication, Ground Level Ozone and Heavy Metals", https://uk-air.defra.gov.uk/library/reports?report_id=701, (2012).
196. Ioannis Manisalidis et al., "Environmental and Health Impacts of Air Pollution: A Review", *Front Public Health* (2020).

In 2019, 73% of the 23,000km² of the terrestrial habitat areas in England sensitive to acidification, meaning those land areas containing species vulnerable to the effects of acidification, exceeded the critical load for acidification.[197] That same year, 97% of the 26,000km2 of terrestrial habitat areas sensitive to eutrophication, meaning those land areas containing species vulnerable to the effects of eutrophication, recorded nutrient nitrogen deposition that exceeded the critical load for eutrophication.[198]

Moreover, air pollution increases the level of ocean microplastics as a result of PM caused by vehicle tyre abrasion. The PM generated from tyre abrasion coming off cars, vans and other modes of transport makes up an estimated one-tenth of all ocean microplastic pollution.[199]

PM pollution produced by all types of burning reduces the amount of sunlight that reaches the Earth's surface. This makes less sunlight available for plants' photosynthesis which makes forests grow at a slower rate and reduces the productivity of crops.[200]

Conclusion

Action is particularly important given the effects that air pollution has on physical and mental health, especially in children, the elderly, those with pre-existing conditions and, most relevant to this report, those living in deprived areas. Having outlined the sources and effects of air pollution, this report now turns to how central and local governments have tried to reduce air pollution, especially in deprived areas, recently in the UK.

197. Environmental Indicators, Statistics and Reporting team, DEFRA, "Indicator 19: Trends in pressures on biodiversity: pollution", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1123307/19_Pollution_air_and_marine_2022_finalv2.pdf (2022), 1-2.
198. Ibid.
199. 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* (2014), 1272.
200. University Corporation for Atmospheric Research, "Effects of Air Pollution", https://scied.ucar.edu/learning-zone/air-quality/effects-air-pollution (2022).

Chapter 5:
Key UK national and local air pollution policies

Introduction

Having outlined, in the last chapter, the effects of air pollution, especially in deprived areas of the UK, this chapter explores some key and recent UK policies that both UK national and local governments have taken to reduce air pollution. Specifically, it focuses on policies to reduce total emissions from transport and domestic burning, because, as argued in Chapter Three, are especially consequential on deprived areas. This chapter examines both universal and targeted key policies to reduce air pollution in more deprived areas. It focuses on the key types of policy interventions – namely, bans, regulations and subsidies – and gives leading examples of these types of government policy interventions over the past decade.

Key legislation and powers for central and local government

As Chapter One explained, central government is responsible for legislating clean air targets, limits and ceilings. However, it has delegated substantial responsibility for the design and implementation of policies on transport and domestic burning to reduce air pollution to local and combined authorities.

Before describing key and relevant bans, regulations and subsidies for reducing air pollution from transport and domestic burning, we first

describe the key legislation and powers of central and local governments which underpin these policies.

The legal basis for introducing charging CAZs and other road pricing schemes is Part III of the UK's Transport Act 2000. This "empowers local authorities (as 'charging authorities') to make a local charging scheme in respect of the use or keeping of motor vehicles on roads".[201]

Section 193 of the Transport Act 2000 permits central government to issue guidance around local authority charging schemes,[202] which it has done via the Clean Air Zone Framework, first introduced by the May Government in 2017.[203] However, as will be discussed in this chapter, while the Clean Air Zone Framework sets out the different classes of CAZ and which vehicles may be included within each class, most details around the design of individual CAZs are left for local authorities to determine. These include whether or not to introduce a CAZ at all, how much non-complying vehicles should be charged to enter a CAZ and whether to grant exemptions to specific groups.[204]

Because the Greater London Authority (GLA) is a devolved authority, separate legislative provisions, namely section 295 and Schedule 23 of the Greater London Authority Act 1999, underpin the Mayor of London's Ultra Low Emission Zone (ULEZ), Low Emission Zone (LEZ) and Congestion Charge Zone (CCZ). However, section 295 and Schedule 23 of the Greater London Authority Act are in practice similar to Part III of the Transport Act 2000, although they are not subject to central government guidance. It should be stressed that, under the Greater London Authority Act 1999, the Mayor of London, not the London Assembly, is responsible for transport policy.[205]

Local governments are also permitted to introduce LTNs, which, as

201. Transport Act 2000, Pt. III. See: https://www.legislation.gov.uk/ukpga/2000/38/contents.
202. Transport Act 2000, Ch. 193. See: https://www.legislation.gov.uk/ukpga/2000/38/contents.
203. Defra and Department for Transport, "Air quality: clean air zone framework for England", https://www.gov.uk/government/publications/air-quality-clean-air-zone-framework-for-england (2022).
204. Defra, "Clean air zone framework", https://www.gov.uk/government/publications/air-quality-clean-air-zone-framework-for-england/clean-air-zone-framework (2022).
205. House of Commons Library, "The Greater London Authority", https://researchbriefings.files.parliament.uk/documents/SN05817/SN05817.pdf (2022), 10-11.

Chapter One described, involve the placement of bollards, planters and cameras to get rid of 'through' traffic on residential streets under section 16 of the Traffic Management Act 2004.[206] As it has with CAZs, Defra also issued guidance under section 18 of the Traffic Management Act 2004 regarding the design of LTNs. This guidance made clear that, while LTNs should be "accessible to everyone from 8 to 80 and beyond", the design details were a matter for individual local authorities.[207] However, the existing guidance was scrapped in October 2023 and had not yet been replaced at the time of writing.[208] Unlike the ULEZ, responsibility for LTNs within London lies mainly with borough councils and not the Mayor of London.[209]

Next, in regards to domestic burning, early Clean Air Acts represented the first UK central government attempts to control air pollution, specifically the Clean Air Act 1956 and 1968. The Clean Air Act 1956 was introduced in response to the 1952 Great Smog. The result of the widespread domestic burning of poor-quality coal, it likely caused the deaths of 12,000 people.[210]

To prevent any repeat of the 1952 Great Smog, the Clean Air Act 1956 gave local authorities the power to introduce 'smoke control areas', in which households could only burn certain types of fuel, such as 'smokeless' coal.[211]

Between 1956 and 1967, smoke concentrations in England declined by 40%. The large cities saw the greatest reductions in smoke concentrations. London saw the biggest decline in smoke concentrations, which fell 80% in seven London sites between 1956 and 1967.[212] It is

206. Traffic Management Act 2004, s. 26., https://www.legislation.gov.uk/ukpga/2004/18/part/2.
207. Defra, "Statutory guidance: Traffic Management Act 2004: network management to support active travel" https://www.gov.uk/government/publications/reallocating-road-space-in-response-to-covid-19-statutory-guidance-for-local-authorities/traffic-management-act-2004-network-management-in-response-to-covid-19 (2020), 6, 9.
208. Department for Transport, "The plan for drivers", https://assets.publishing.service.gov.uk/media/651fe3022548ca000dddee82/the-plan-for-drivers.pdf (2023).
209. London Assembly, "Low Traffic Neighbourhoods and Streetspace Legal Implications", https://www.london.gov.uk/who-we-are/what-london-assembly-does/questions-mayor/find-an-answer/low-traffic-neighbourhoods-and-streetspace-legal-implications (2021).
210. Fuller, *Invisible Killer*, 44, 48.
211. Clean Air Act 195. See https://www.legislation.gov.uk/ukpga/Eliz2/4-5/52/enacted.
212. Ibid., 272, 279.

worth noting, however, that the reduction in smoke pollution during the subsequent decade was arguably was much the result of new and cleaner heating technologies, such as natural gas, becoming available, as it was due to the 1956 Clean Air Act.[213]

Moreover, deprived areas were less likely to benefit than more prosperous ones. Under the Clean Air Act 1956, considerable financial support was offered to compensate households to upgrade their stoves.[214] However, because 30% of the cost of upgrades came from local authorities with varying financial resources (with 40% coming from the central government and the remaining 30% from households themselves), households in more deprived areas were less likely to upgrade than those in wealthier ones.[215]

To further reduce air pollution, the 1968 Clean Air Act made it an offence to emit dark smoke from chimneys. This helped to induce a large-scale shift in industry away from using coal towards using oil, gas and electricity.[216] Consequently, the 1968 Clean Air Act decreased pollution (specifically concentrations of SO_2) from coal burning almost immediately and caused a more noticeable decrease in coal usage than the 1956 Clean Air Act had done.[217]

However, while the 1956 and 1968 Clean Air Acts together helped to reduce air pollution in the form of smoke, they did not stop UK SO_2 emissions from industrial coal and oil from blowing as far as Scandinavia, where they caused acid rain.[218] The acid rain in turn resulted in forest diebacks and substantial damage to local ecosystems.[219] As mentioned in Chapter One, this problem would be addressed until the 1979 Convention on Long Range Transboundary Air Pollution (CLRTP),

213. Fuller, *Invisible Killer*, 48-9.
214. Howard A. Scarrow, The Impact of British Domestic Air Pollution Legislation, *British Journal of Political Science* (1972), 261-282, 261; Fuller, *Invisible Killer*, 48.
215. Scarrow, "Air Pollution Legislation", 267.
216. Stephan Heblich, Alex Trew and Yanos Zylberberg, "East-side story: historical pollution and persistent neighborhood sorting", *Journal of Political Economy* (2021), 1510-1513.
217. Ibid.
218. Fuller, *Invisible Killer*, 51-2; Gary Fuller, "Pollutionwatch: lessons to learn from UK's 1956 Clean Air Act", *The Guardian*, 16 July 2021, https://www.theguardian.com/environment/2021/jul/16/pollutionwatch-lessons-to-learn-from-uks-1956-clean-air-act.
219. Fuller, *Invisible Killer*, 73-77.

which the UK ratified in 1982,[220] and which required signatories to reduce their SO_2 emissions. A combination of stricter limits on SO_2 emissions and the closure of coal-fired power stations, however, have resulted in UK SO_2 emissions falling by 98% between 1970 and 2021.[221]

Twenty-five years after the 1968 legislation, the Clean Air Act of 1993 consolidated, that is, drew together, both the 1956 and 1968 Clean Air Acts.[222] Further, it allowed local authorities to ban the domestic burning of fuels unless their SO_2 content was lower than 2%.[223]

Bans

The main examples of bans to reduce air pollution relate to domestic burning. As detailed in previous chapters, the growing popularity of domestic burning contributes disproportionately to air pollution in the UK and is disproportionately a middle-class activity carried out for aesthetic reasons,[224] but its reduction would benefit those from more deprived areas.

In May 2021, the UK Government banned the sale of house coal and wet wood to reduce pollution from domestic burning in England.[225] Small volumes of house coal and wet wood – under $2m^3$ – can no longer be sold and sales of wet wood in large volumes must be sold with advice on how to dry it before burning. Instead, people burning domestically are now encouraged to use less polluting alternatives, such as dry wood and manufactured solid fuels.[226]

Additionally, in 2022, the UK Government introduced regulations to ensure that all new wood-burning stoves and fireplaces meet guidelines

220. United Nations Treaty Collection, "1. Convention on long-range transboundary air pollution", https://treaties.un.org/Pages/ViewDetails.aspx?src=IND&mtdsg_no=XXVII-1&chapter=27&clang=_en#:~:text=The%20Convention%20was%20adopted%20on,United%20Nations%20Office%20in%20Geneva.&text=ratification%2C%20acceptance%2C%20approval%2C%20accession%20or%20succession (2023).
221. Defra, "National Statistics: Sulphur dioxide (SO2)".
222. Clean Air Act 1993, Ch.11. See: https://www.legislation.gov.uk/ukpga/1993/11/contents.
223. Peter Brimblecombe, "The Clean Air Act after 50 years", *Weather* (2006), 311-314, 313.
224. Kantar, "Burning in UK homes and gardens", 53.
225. Defra, "Restrictions on sale of coal and wet wood for home burning begin", https://www.gov.uk/government/news/restrictions-on-sale-of-coal-and-wet-wood-for-home-burning-begin#:~:text=Sales%20of%20bagged%20traditional%20house,a%20small%20amount%20of%20smoke (2021).
226. Defra, "Government takes action to cut pollution from household burning", https://www.gov.uk/government/news/government-takes-action-to-cut-pollution-from-household-burning (2020).

known as Ecodesign, which permit stoves to emit a maximum 375g of $PM_{2.5}$ for every gigajoule of energy they produce.[227] Ecodesign banned non-compliant stoves from being sold from 2022 onwards.[228] However, existing wood-burning stoves could still be used even if they do not meet new standards. And as wood burners and fireplaces have a long lifespan, it could take decades for all wood burners and fireplaces to meet Ecodesign standards. Worse still, research by the European Environmental Bureau found that even Ecodesign wood stoves emit still 750 times more $PM_{2.5}$ than a modern HGV truck.[229]

Central government has also increased penalties for non-compliance and reduced emission limits on individual household stoves. A legacy of the 1956 Clean Air Act, most of Britain's major cities are now in smoke control areas, in which individuals in households face now civil penalties of up to £300 if the local authority decides that one's chimney releases more than 3g of smoke per hour. Before 2023, households were permitted to emit 5g per hour.[230] A higher fine of £1,000 can be administered if one burns unauthorised fuel.[231] Repeat offenders risk larger fines of up to £5,000 and a criminal record.[232]

Unfortunately, proving that stoves have exceeded emissions limits is expensive and practically difficult.[233] Moreover, local authorities, who are responsible for enforcement, have limited resources to go after offenders. As Professor Frank Kelly of Imperial College London explained: "If you report that you've walked past a property and you can

227. Damian Carrington, "'Eco' wood stoves emit 750 times more pollution than an HGV, study shows", *The Guardian*, 9 October 2021, https://www.theguardian.com/environment/2021/oct/09/eco-wood-stoves-emit-pollution-hgv-ecodesign.
228. Home Owners Alliance, "Wood burning stoves regulations: what do the new rules mean for your fireplace", https://hoa.org.uk/2021/11/wood-burning-stove/ (2023).
229. European Environmental Bureau, "Where there's fire, there's smoke. Emissions from domestic heating with wood", https://eeb.org/wp-content/uploads/2021/09/Where-theres-fire-theres-smoke_domestic-heating-study_2021.pdf (2021).
230. Alex Binley, "Log burner rule change in England could land users with £300 fine", BBC https://www.bbc.co.uk/news/uk-64261624 (2023).
231. Home Owners Alliance, "Wood burning stoves regulations".
232. Adam Vaughan, "Your wood-burning stove could land you with a £300 fine and a criminal record", *The Times*, 1 February 2023, https://www.thetimes.co.uk/article/wood-burning-stoves-homeowners-criminal-record-pollution-environment-plan-2x9df0tr0.
233. Helena Horton and Fiona Harvey, "'A serious threat': Calls grow for urgent review of England's wood-burning stoves", *The Guardian*, 2 February 2023, https://www.theguardian.com/environment/2023/feb/02/calls-grow-for-urgent-review-of-damage-done-by-wood-burning-stoves.

see smoke coming out of a chimney when there shouldn't be, it's very, very unlikely that an enforcement officer is going to turn up at that door and do anything. It's down to the local council to enforce them and they haven't got the manpower to do it."[234]

Consequently, despite receiving over 18,000 complaints about illegal domestic burning over the six years prior to 2021,[235] English local authorities only issued 19 fines in the six years up to 2021.[236]

The only transport-related ban in the UK is the phasing concerns the phasing out of combustion engine vehicles, with sales of new combustion vehicles set to be banned by 2035.[237]

Regulations

The main policy examples of regulations relate to transport: specifically road pricing schemes such as charging CAZs.

Road pricing refers to charges that are directly imposed on drivers for using public roads. Such charges can serve two primary functions: to reduce the harms caused by driving such as air pollution and congestion; and/or to raise money.[238]

There are several different road pricing schemes. These are: Clean Air Zones, toll roads, bridge and tunnel charges and zonal charging schemes.

The other main regulatory policy is Low Traffic Neighbourhoods. We examine both in detail below.

Clean Air Zones

The Department for Environment, Food and Rural Affairs (Defra)

234. Adam Vaughan, "Your wood-burning stove could land you with a £300 fine and a criminal record", *The Times*, 1 February 2023, https://www.thetimes.co.uk/article/wood-burning-stoves-homeowners-criminal-record-pollution-environment-plan-2x9df0tr0.
235. Robyn Vinter, "English councils issue only 19 fines for wood smoke despite 18,000 complaints", *The Guardian*, 14 October 2021, https://www.theguardian.com/environment/2021/oct/14/english-councils-issue-only-19-fines-for-wood-smoke-despite-18000-complaints.
236. Damian Carrington, "Wood burners in effect banned in new and refurbished homes in London", *The Guardian*, 8 February 2023, https://www.theguardian.com/environment/2023/feb/08/wood-burners-in-effect-banned-new-refurbished-homes-london.
237. George Parker, Lucy Fisher and Jim Pickard, "Rishi Sunak announces series of U-turns on net zero pledges", *Financial Times*, 20 September 2023, https://www.ft.com/content/02ecb92e-1e67-4db1-ad73-6c0e76bdc6ca.
238. House of Commons Transport Committee, "Road Pricing", https://committees.parliament.uk/publications/8754/documents/88692/default/ (2022), 4.

defines a CAZ as "an area where a local authority applies charges using powers under the Transport Act [2000] to deliver NO_2 reductions".[239] While focused on tackling NO_2 concentrations, it is intended that these charging CAZs will also "help to reduce public exposure to pollutants such as particulate matter".[240]

Previous versions of the government's Clean Air Zone Framework also referred to 'non-charging' CAZs. Non-charging CAZs were areas where local authorities introduced measures other than charging vehicles to reduce air pollution, such as improving traffic flow and ensuring that local authority vehicle fleets satisfied the CAZ's emissions standard.[241] However, "for the avoidance of confusion", the term CAZ is now exclusively reserved for charging schemes.[242]

Defra outlines that there are four types of CAZ: classes A, B, C and D. Each of these classes charges non-compliant vehicles to enter the CAZ, but each class encompasses different types of vehicles, as shown in Table 5.1 below.

Table 5.1. Types of vehicles charged in each CAZ class

CAZ class	Types of vehicles charged
Class A	Non-compliant buses, coaches, taxis and private hire vehicles
Class B	Non-compliant buses, coaches, taxis, private hire vehicles and heavy goods vehicles
Class C	Non-compliant buses, coaches, taxis, private hire vehicles, heavy goods vehicles, vans and minibuses
Class D	Non-compliant buses, coaches, taxis, private hire vehicles, heavy goods vehicles, vans, minibuses, cars and, if the local authority chooses, motorcycles

Source: Defra, "Guidance: clean air zones", https://www.gov.uk/guidance/driving-in-a-clean-air-zone (2023).

In addition to London's ULEZ, seven cities in England currently have CAZs, as set out in Table 5.2 below.

239. Defra, "Clean Air Zone framework".
240. Ibid.
241. Defra, "Annex B: general approach to clean air zones", https://www.gov.uk/government/publications/air-quality-clean-air-zone-framework-for-england/annex-b-general-approach-to-clean-air-zones (2022).
242. Defra, "Clean Air Zone Framework".

Table 5.2. Existing CAZs in England

City	CAZ class	Date introduced
Bath	Class C	March 2021[243]
Birmingham	Class D	June 2021[244]
Bradford	Class C	September 2022[245]
Bristol	Class D	November 2022[246]
Portsmouth	Class B	November 2021[247]
Sheffield	Class C	February 2023[248]
Tyneside	Class C	July 2023[249]

Source: Detailed in footnotes 243-249 inclusive.

In addition to the above, Greater Manchester's proposed Class C CAZ, which was meant to have been launched in May 2022,[250] remains under review at the time of writing.[251] As can be seen from Table 5.2, Bristol and Birmingham are the only cities outside London that have introduced schemes charging private vehicles to enter. All schemes operate 24 hours a day, 365 days a year.

Moreover, unlike the London ULEZ, none of the UK's seven CAZs encompasses an entire urban area, instead covering only small inner-city areas. At time of writing, there were no plans to introduce further city-wide CAZs.

When a vehicle enters the CAZ, it may be charged based on the type of vehicle it is and what its Euro standard is. Euro standards define

243. Paul Barltrop, "Bath air quality improves since introduction of clean air zone", BBC, https://www.bbc.co.uk/news/uk-england-somerset-66608299 (2023).
244. Birmingham City University, "Clean Air Zone", https://www.bcu.ac.uk/about-us/corporate-information/environment-sustainability/sustainable-travel-plan/clean-air-zone (2023).
245. BBC News, "Bradford Clean Air Zone generates almost £2m", BBC, https://www.bbc.co.uk/news/uk-england-leeds-64107296 (2022).
246. Bristol City Council, "Bristol's Clean Air Zone charges and vehicle checker", https://www.bristol.gov.uk/residents/streets-travel/bristols-caz/charges-and-vehicle-checker#:~:text=Bristol's%20Clean%20Air%20Zone%20started,in%20Bristol's%20Clean%20Air%20Zone (2023).
247. Portsmouth City Council, "Clean Air Zone – penalty charge notices", https://www.portsmouth.gov.uk/services/parking-roads-and-travel/clean-air-zone-penalty-charge-notices/ (2023).
248. Gwyn Topham and Safi Bugel, "Sheffield becomes latest city to implement clean air zone", *The Guardian*, 26 February 2023, https://www.theguardian.com/uk-news/2023/feb/27/sheffield-becomes-latest-city-to-implement-clean-air-zone.
249. Newcastle City Council, "Clean Air Zone charging date for vans confirmed", https://www.newcastle.gov.uk/citylife-news/transport/clean-air-zone-charging-date-vans-confirmed (2023).
250. Helen Pidd, "Vindication or cowardice? Andy Burnham's clean air gamble in Manchester", *The Guardian*, 1 August, 2023, https://www.theguardian.com/politics/2023/aug/01/andy-burnham-clean-air-manchester-ulez-caz.
251. Defra, "Clean Air Zones", https://www.gov.uk/guidance/driving-in-a-clean-air-zone (2023).

the limits for exhaust emissions of vehicles sold in the EU and the European Economic Area (EEA).[252] The UK, as a former member of the EU, retains these regulations. To enter the CAZ and not be charged, the vehicle must achieve the minimum Euro standard for that vehicle type. These minimum standards, which are consistent across all CAZs, are shown in Table 5.3 below.

Table 5.3. CAZ Minimum emission standards

Vehicle type	CAZ minimum standard	Minimum age of compliant vehicles
Diesel vans, minibuses, taxis, private hire vehicles, cars	Euro 6	New vehicles registered from September 2015
Petrol vans, minibuses, taxis, private hire vehicles, cars	Euro 4	New vehicles registered from January 2006
Buses, coaches, heavy goods vehicles	Euro 6	New vehicles registered from January 2006

Source: Table from Department for Environment, Food & Rural Affairs, "Clean Air Zones", https://www.gov.uk/guidance/driving-in-a-clean-air-zone (2023) and TfL, "Ways to meet the standard", https://tfl.gov.uk/modes/driving/ultra-low-emission-zone/ways-to-meet-the-standard (2023).

Each CAZ charges non-compliant vehicles a daily fee to enter, but the amount charged is at the discretion of local authorities.[253] Birmingham, for example, charges non-compliant cars, vans and taxis £8 per day and non-compliant heavy goods vehicles (HGVs) £50 per day.[254] The Bristol CAZ charges non-compliant private cars £9 per day and non-compliant HGVs £100.[255] By contrast, the Newcastle CAZ charges non-compliant vans and light goods vehicles £12.50 per day and non-compliant buses, coaches and HGVs £50.00 per day.[256]

Where they have been implemented, CAZs have shown some success in

252. RAC, "Euro 1 to Euro 6 guide – find out your vehicle's emissions standard", https://www.rac.co.uk/drive/advice/emissions/euro-emissions-standards/ (2023).
253. Defra, "Policy paper: Clean air zone framework".
254. Birmingham City Council, "Payments for the Clean Air Zone go live", https://www.birmingham.gov.uk/news/article/888/payments_for_the_clean_air_zone_go_live (2021).
255. Bristol City Council, "Bristol's Clean Air Zone charges and vehicle checker", https://www.bristol.gov.uk/residents/streets-travel/bristols-caz/charges-and-vehicle-checker (2023).
256. RAC, "Newcastle and Gateshead Clean Air Zone: what you need to know", https://www.rac.co.uk/drive/advice/emissions/newcastle-and-gateshead-clean-air-zone-what-you-need-to-know/#:~:text=The%20level%20of%20the%20charge,charged%20%C2%A312.50%20per%20day (2023).

reducing NO_2 concentrations. For example, in Bath, there were previously severe problems with NO_2 emissions. Under the Air Quality Standards Regulations 2010, the annual mean concentrations of NO_2 must not exceed 40µg/m³. However, in parts of Bath, concentrations exceeded 60µg/m³ in 2019.[257] Consequently, in March 2021, a Class C CAZ was launched.[258]

After the Bath CAZ's introduction, NO_2 concentrations appeared to have reduced considerably. In comparison to 2019, there was a 21% reduction in annual mean NO_2 concentrations within the zone by 2021 and a 22% reduction in annual mean NO_2 concentrations in the urban area outside the zone. In addition, only three air pollution monitoring sites exceeded the UK legal average annual NO_2 concentration limit of 40 µg/m³, down from 11 in 2019.[259] The CAZ also resulted in 50% fewer polluting vehicles entering the zone than before its introduction. Given the COVID-19 restrictions that reduced transport activity during parts of 2021, however, "the impact of the zone alone on air quality remains inconclusive until further data is collected".[260]

Similarly, one study found that Birmingham's CAZ, which was introduced in June 2021, reduced NO_2 concentrations by 20% in September 2021 compared to September 2019 and September 2020.[261] Unfortunately, data was not provided on the effects the CAZ had on other air pollutants. A 2023 study, however, which measured the impact of the CAZ over its first year, found that it resulted in a "significant but modest" 5.4% reduction in concentrations of NO_x. Moreover, the CAZ had "no detectable effects on $PM_{2.5}$ [concentrations]" over the same period.[262]

257. Bath and North East Somerset Council, "2019 Air Quality Annual Status Report", https://www.bathnes.gov.uk/sites/default/files/sitedocuments/Environment/Pollution/bnes_asr_2019.pdf, 71-80.
258. Bath & North East Somerset Council, "Bath's Clean Air Zone: annual report summary 2021", https://beta.bathnes.gov.uk/sites/default/files/1803.CAZ%20Annual%20Summary_v14.pdf (2021), 3.
259. Ibid., 4.
260. Ibid., 4.
261. Guilherme Rodrigues, "Is Birmingham's Clean Air Zone hurting its city centre?, https://www.centreforcities.org/blog/is-birminghams-clean-air-zone-hurting-its-city-centre/#:~:text=The%20zone%20appears%20to%20have%20had%20a%20positive,cause%20900%20early%20deaths%20per%20year%20in%20Birmingham (2022).
262. Bowen Liu et al., "Assessing the Impacts of Birmingham's Clean Air Zone on Air Quality: Estimates from a Machine Learning and Synthetic Control Approach", *Environmental and Resource Economics* (2023), 203–231, 201, 219.

Despite this evidence, CAZs have faced criticisms. Before it was launched, there was fear that the Birmingham CAZ would hurt local businesses. After it was launched, however, there was only a momentary drop in footfall before spending activity quickly recovered.[263] The lack of automated data and the consequent difficulty in tracking multiple vehicles simultaneously creates significant problems for operators of large vehicle delivery services fleets. It also means that individual drivers sometimes unknowingly enter CAZs and incur charges that they did not expect.[264]

More pressingly, there is evidence that CAZs can adversely affect those on low incomes living in or near the zone. In Bradford, for example, 40% of the population ranks in the most deprived quintile in the country, according to the IMD.[265] The city's Class C CAZ means that non-compliant taxis and private hire vehicles are charged £7 per day to enter.[266] With 5,000 registered taxi drivers in the city, the inclusion of taxis in the CAZ caused anxiety, especially as many taxi drivers are not able to purchase electric or ultra-low emission vehicles. These concerns were reflected in the results of ten focus groups made up of those from deprived and highly polluted areas of Bradford. The study, undertaken before the CAZ's introduction, found that all 87 participants were worried about the financial impact that the CAZ would have, especially on deprived areas.[267]

Likewise, in Birmingham, a Distributional Impact Appraisal commissioned by Birmingham City Council found that households on the lowest income would "bear a disproportionate amount of the increased vehicle costs for personal journeys". This is because those living

263. Rodrigues, "Is Birmingham's Clean Air Zone hurting its city centre?".
264. Commercial Fleet, "Lack of data on clean air zones a problem for fleets", https://www.commercialfleet.org/news/latest-news/2022/04/11/lack-of-data-on-clean-air-zones-a-problem-for-fleets#:~:text=Councils%20are%20being%20criticised%20for%20a%20lack%20of,can%20become%20a%20cost%20burden%20for%20a%20business (2022).
265. Rukhsana Rashid et al., "Taking a deep breath: a qualitative study exploring acceptability and perceived unintended consequences of charging clean air zones and air quality improvement initiatives amongst low-income, multi-ethnic communities in Bradford, UK", *BMC Public Health* (2021), 3.
266. Bradford City Council, "Check if you need to pay", https://www.bradford.gov.uk/breathe-better-bradford/check-if-you-need-to-pay/check-if-you-need-to-pay/ (2023).
267. Ibid., 1, 3, 9-13.

near the city's Class D CAZ tended to be poorer than the city average.[268]

Participants in our own focus group in Birmingham had a strong negative reaction to the idea of CAZs. Indeed, almost all of the participants in that group believed that it was wrong to charge people with older cars to drive in the city centre, largely due to the perception that those with older cars that did not meet emissions standards were poorer and could not afford to upgrade cars.

> "I think it's bad that they're charging people with old cars to travel in those zones, because some people can't afford better cars."
>
> **Participant D, Birmingham group**

Building on this perceived link between deprived areas and those who drove older vehicles, one participant felt that the charging drivers of non-compliant vehicles was unfair because "some people just can't afford to pay those sorts of fees". This was especially unfair, another Birmingham participant felt, given the poor state of the city's public transport system.

> "The public transport [links are] just unreliable and a mess. It is a shame that they charge the sort of people who have these older cars … it unfairly punishes poor people."
>
> **Participant B, Birmingham group**

Another participant in our Birmingham focus group, however, felt that the CAZ could work, but only if the city's public transport system was reliable enough and cycling lanes safe enough to provide viable alternatives to car transport.

268. Jonathan Walker, "City council admitted poorest suffer most from Clean Air Zone but scrapped plans to help them", *Birmingham Mail*, 29 May 2021, https://www.birminghammail.co.uk/news/midlands-news/city-council-admitted-poorest-suffer-20690176.

> "It would be fine if our city's public transport system was up to a good standard. But it's not. The trains are always delayed … You have the public buses which are a mess and the prices just keep going up … For all the cycling lanes, they're always taken over by cars."
>
> **Participant E, Birmingham group**

One participant mentioned that, because their son drives a non-compliant vehicle, the introduction of the CAZ had meant that he could no longer travel into the city centre to perform charity work.

> "Like I said, like Participant D said, poor people can't go into the to the city centre. We used to do like every week. We used to do it, go feed the homeless and I can't do actually do that because my son's car is a diesel, so I can't really go to the city centre and pay charges, and go feed the homeless. So that's a bad thing."
>
> **Participant A, Birmingham group**

Despite overriding feelings focusing on the negatives of CAZ, one participant in the Birmingham acknowledged that CAZs had noticeably improved the city's air quality.

> "I noticed a big difference in traffic, especially if you go near where Bullring is in Birmingham. I noticed a huge difference in how busy it was as soon as the Clean Air Zone was implemented and I found it much more pedestrian friendly."
>
> **Participant B, Birmingham group**

The negative perceptions from the Birmingham focus group are most likely determined by the city having a CAZ. In Liverpool, by contrast, where there is no CAZ and no plans to implement one, the positive

views outweighed the negative ones by some margin. Participants thought introducing a CAZ would be great for the environment.

> "I think just for the environment, it is a fantastic idea … it's a positive incentive really."
>
> **Participant C, Liverpool group**

One Liverpool participant thought that the introduction of a CAZ would help to encourage the city's residents to take more environmentally-friendly forms of transport.

> "I think it's quite a positive incentive and something that definitely needs to be rolled out in most cities … I'm sure it'll be cheaper to get a bus or maybe an electric scooter, or maybe even walk [than drive]. So, I think it would help people to think about the choices they are making."
>
> **Participant E, Liverpool group**

However, like in Birmingham, questions were raised about how the charge would impact working people and people in deprived areas, who may not be able to afford a compliant vehicle.

> "People might not be in a position to drive a more environmentally sustainable vehicle, even if they want to, and they might not have the choice to make that change."
>
> **Participant B, Liverpool group**

While acknowledging concerns about the impact that introducing a CAZ would have on those who were financially struggling, participants in the Liverpool group still felt that on balance the positives of doing so outweighed the negatives.

> "It's a great idea [introducing a CAZ] and it should be rolled out pretty much everywhere, but it could have a negative impact on some of the families that are just getting by … It's mostly a positive idea though."
>
> **Participant D, Liverpool group**

One participant in the Liverpool group was especially concerned about the impact a CAZ would have on younger residents, but still thought introducing one was "a great idea".

> "It's normally people on the breadline who have got older vehicles … A lot of them are finding it hard to feed themselves already and throwing an extra £12.50 at them is a bit harsh … But overall, I think it's a great idea. I'm all for clean air zones … But I just feel about young people who are living on the breadline cause [they will] get charged."
>
> **Participant C, Liverpool group**

Unlike in the Birmingham group, concerns about the adequacy of local public transport did not arise in the Liverpool group. While participants in both focus groups expressed concern over the impact on poorer families, the hostility towards CAZ was far more prominent from the Birmingham group than the Liverpool group.

London's Ultra Low Emission Zone (ULEZ)

One city in the UK has a large, city-wide CAZ. First introduced to cover Central London in 2019,[269] in 2021 the ULEZ expanded to include the areas up to North and South circular roads.[270] In August 2023,

269. Tom Edwards, "ULEZ: The politics of London's air pollution", BBC, https://www.bbc.co.uk/news/uk-england-london-47814416 (2019).
270. House of Commons Library, "Research briefing: clean air zones, low emission zones and the London ULEZ", https://commonslibrary.parliament.uk/research-briefings/cbp-9816/#:~:text=In%20October%202021%20the%20ULEZ,to%20cover%20all%20London%20boroughs (2023).

the Mayor further expanded the ULEZ to include almost all Greater London. Transport for London (TfL) states that the "aim of ULEZ is to improve air quality by reducing the number of vehicles in London that don't meet emissions standards".[271]

Like the other CAZs across England, the ULEZ operates 24 hours a day. Unlike the other CAZs, however, the ULEZ does not operate on Christmas Day. If a vehicle fails to meet the ULEZ emission standards and is not exempt, the owner pays a £12.50 daily charge to drive within the zone.

The charge applies to petrol and diesel cars, motorcycles, minibuses up to five tonnes and vans and specialist vehicles up to 3.5 tonnes which fail to meet emission standards. The ULEZ compliance standards are the same as they are for other CAZs, as set out in Table 5.3. The only difference is that, unlike the other CAZs, London has also introduced a minimum standard for motorcycles: Euro 3, that is motorbikes registered from 1 January 2007. Also unlike the other CAZs, emissions standards for vehicles over 3.5 tonnes are regulated by the city's separate Low Emission Zone (LEZ).

So far, the ULEZ has been successful in improving air quality in Central and Inner London. A peer-reviewed report examining the impact of ULEZ estimated that, by 2022, average annual concentrations of NO_2 were 21% lower in Inner London and 46% lower in Central London than they would have been had the ULEZ not been introduced.[272] More recently, a University of Bath study found that the introduction of the ULEZ reduced annual average concentrations of NO_2 across Greater London by 18.4% between 2016 and 2019.[273] In addition, as of September 2023, 95% of vehicles driving seen driving in London meet

271. TfL, "Why do we have a ULEZ", https://tfl.gov.uk/modes/driving/ultra-low-emission-zone/ulez-expansion (2023).
272. Mayor of London, "Inner London Ultra Low Emission Zone — one year report", https://www.london.gov.uk/sites/default/files/2023-02/Inner%20London%20ULEZ%20One%20Year%20Report%20-%20final.pdf (2023), 7.
273. Eleonora Fichera, Habtamu Beshir, Andrea Serna Castaño, "Low Emission Zones improve air quality, physical health and mental well-being: Evaluating the impact of the Low Emission Zone (LEZ) and Ultra-Low Emission Zone (ULEZ) schemes in England", IPR Policy Brief, https://www.bath.ac.uk/publications/low-emission-zones-improve-air-quality-physical-health-and-mental-well-being/attachments/Low_Emission_Zones_improve_air_quality__physical_health_and_mental_well-being.pdf (2023), 5.

the strict emissions standards, up from 39% in 2017.[274]

Moreover, it is also expected that $PM_{2.5}$ emissions will drop by 1.5% in 2023 due to the expansion of ULEZ to the outer boroughs compared to what would have been the case had the expansion not gone ahead. For PM_{10}, a 0.9% reduction is expected.[275]

The ULEZ has proven hugely controversial, however. Its recent expansion to include almost all of outer London has been criticised for disproportionately affecting lower-income households during a cost-of-living crisis.[276] Additionally, some owners of diesel vehicles were particularly unhappy since vehicles less than ten years old became liable for the ULEZ charge.[277] Because, owing to poorer public transport links, outer London is much more car-dependent than inner London,[278] the expansion was attacked for unjustly imposing a "one-size-fits-all approach".[279] For instance, according to 2023 data, only 19% of all journeys (including those made by walking or cycling) made in inner London were made using a car. However, in more car-dependent outer London, 38% of trips were made using one. Moreover, while 69% of outer London households own or have access to a car, only 42% of inner London households do.[280]

As mentioned in Chapter One, public opposition to the impending expansion of ULEZ – instigated by a Labor Mayor of London – was blamed by some for the Labour Party's unexpected defeat at the Uxbridge and South Ruislip by-election in July 2023.[281]

274. TfL, "Why do we have a ULEZ".
275. Yasmin Rufo, "ULEZ expansion: contested claims examined", BBC, https://www.bbc.co.uk/news/uk-england-london-64798395 (2023).
276. Ross Lydall, "Ulez expansion forces choice between heating and eating or getting around, Mayor warned", 7 February 2023, *Evening Standard*, https://www.standard.co.uk/news/transport/ulez-expansion-hits-low-income-cost-of-living-sadiq-khan-b1058431.html
277. Gwyn Topham, "Ulez: what is it, how much does it cost and why is it so controversial?", *The Guardian*, 23 July 2023, https://www.theguardian.com/environment/2023/jul/23/ulez-london-what-is-it-how-much-does-it-cost-and-why-is-it-so-controversial.
278. Zarin Mahmud, Josh Cottell, Claire Harding, "Moving with the Times: Supporting sustainable travel in outer London", https://centreforlondon.org/reader/sustainable-travel-outer-london/travel-today/#the-factors-influencing-people8217s-travel-choices (2023).
279. "ULEZ: Four councils oppose London-wide scheme", https://www.bbc.co.uk/news/uk-england-london-63833268 (2022).
280. Centre for London, "Moving with the times", https://centreforlondon.org/wp-content/uploads/2023/06/Centre-for-London-Supporting-Sustainable-Travel-in-Outer-London-6-June.pdf (2023), 8, 27-8.
281. George Wright & Chas Geiger, "Uxbridge by-election: Khan defends Ulez after Starmer blames it for poll setback", BBC, https://www.bbc.co.uk/news/uk-politics-66264893 (2023).

Participants in our Barking and Dagenham focus group were asked their opinions on ULEZ. When the Barking and Dagenham focus group was conducted, the area was about to be included within the expanded ULEZ.

The scheme and particularly its then-impending expansion to all London boroughs generated a strong negative response from participants in the focus group. Much like scepticism of CAZs in Liverpool and Birmingham groups, the primary concern about ULEZ from the Barking and Dagenham Group was that it would harm those in deprived areas.

> "It just penalises people that may not be able to afford a newer car or to update it. I don't think it is going to be inclusive."
>
> **Participant A, Barking and Dagenham group**

Several participants also highlighted the perceived unfairness of imposing an additional cost on households in the middle of a nationwide cost-of-living crisis.

> "You just add an additional cost on to an already difficult cost of living crisis. You're adding additional money per day for people to get to work. I think a better idea would be more emphasis on promoting other forms of transport."
>
> **Participant G, Barking and Dagenham group**

> "When gas, electricity and water bills have gone up, I don't think it's fair at all."
>
> **Participant F, Barking and Dagenham group**

Other participants dismissed the ULEZ as a mere revenue-raising exercise rather than a genuine measure to help the environment.

> "They're money making."
>
> **Participant E, Barking and Dagenham group**

One participant viewed the ULEZ as sinister, going so far as to label it an "evil" because of what they saw as the malicious use of environmental concerns to extract money from ordinary Londoners.

> "I just feel like it's quite malicious ... [it] takes more money from Londoners under the guise of helping the environment... and I thought there's something evil about that."
>
> **Participant B, Barking and Dagenham group**

This view is despite the fact that, by law, any road user charging scheme in London must be implemented for policy objectives. Any net revenue from the ULEZ must be reinvested back into public transport, walking and cycling.[282]

London Low Emission Zone (LEZ)

In addition to the ULEZ, London has also introduced the London Low Emission Zone (LEZ), a type of CAZ which regulates the entry of lorries, vans, coaches and specialist heavy vehicles weighing over 3.5 tonnes.[283] First launched in 2008, the LEZ, like the ULEZ covers almost the entire Greater London Area.[284] Also like the ULEZ, the LEZ sets minimum standards for emissions and charges vehicles that do not meet these standards.

Unlike ULEZ, which regulates the emissions of private cars, the LEZ regulates heavy vehicles that exceed 3.5 tonnes.[285] Vans or specialist diesel vehicles weighing up to 3.5 tonnes and minibuses weighing up to five tonnes not meeting Euro 3 standards are charged £100 per day to drive within the LEZ. Similarly, HGVs, lorries, vans and specialist heavy vehicles weighing up 3.5 tonnes, as well as buses/minibuses and coaches weighing over five tonnes which meet Euro 6 standards but do meet

282. Greater London Authority Act 1999, Sch. 23. See: https://www.legislation.gov.uk/ukpga/1999/29/schedule/23.
283. TfL, "LEZ: Where and when", https://tfl.gov.uk/modes/driving/low-emission-zone/about-the-lez (undated).
284. Mayor of London, "London Low Emission Zone – six month report", https://www.london.gov.uk/sites/default/files/lez_six_month_on_report-final.pdf (2021), 4.
285. Tamara Davison, "What is the difference between London's ULEZ and LEZ?", *Evening Standard*, 16 August 2023, https://www.standard.co.uk/news/ulez-london-lez-difference-emission-zone-b1101031.html.

Euro 4 standards, are also charged £100 per day to drive within the LEZ. Finally, HGVs, lorries, vans, and specialist heavy vehicles over 3.5 tonnes, as well as buses/minibuses and coaches over five tonnes which do not meet Euro 4 standards are charged £300 per day to drive within the LEZ.[286] Like the ULEZ, it operates 24 hours a day but, unlike the ULEZ, it also operates on Christmas Day.[287]

There is, however, some overlap with the ULEZ in that vans weighing between 1.2 tonnes and 3.5 tonnes, as well as minibuses under five tonnes are regulated by both the ULEZ and the LEZ. Those vehicles covered by both the ULEZ and the LEZ "need to comply with both schemes if they drive within the ULEZ area or pay both sets of charges".[288] However, they only need to pay the LEZ if they do not meet the Euro 3 standard.

While studies looking into the direct impact of the LEZ are few, the most recent data from the Greater London Authority reported that the proportion of large and heavy vehicles compliant with the Euro 6 standards increased from 48% in February 2017 to 97.3% in September 2023, a 49.3 percentage point increase.[289] Although assessing the LEZ's impact separately from the ULEZ is difficult and there is little data on it, the Mayor of London has noted that upgrading the TFL bus fleet to meet the Euro 6 standards reduced NO_x emissions from TFL busses by 90% between 2016 and 2020.[290] More recently, a 2023 study found that the introduction of the LEZ reduced average annual concentrations of PM_{10} in Greater London by 13% between 2007 and 2013.[291] There is also evidence that, because heavy duty vehicles driven in London, regularly travel outside the capital, the introduction of less polluting vehicle fleets to comply with LEZ standards will also benefit residents of major cities

286. TfL, "How to pay a LEZ charge", https://tfl.gov.uk/modes/driving/low-emission-zone/make-a-payment#on-this-page-2 (2023).
287. Davison, "What is the difference between London's ULEZ and LEZ?".
288. Ibid., 9
289. Mayor of London, "London-wide Ultra Low Emission Zone first month report", https://www.london.gov.uk/programmes-strategies/environment-and-climate-change/environment-and-climate-change-publications/london-wide-ultra-low-emission-zone-first-month-report (2023), 54-55.
290. Ibid., 3.
291. Fichera, Beshir and Serna Castaño, "Low Emission Zones improve air quality", 5.

and towns throughout England.[292]

Other road pricing schemes

On top of CAZs, as mentioned earlier, there are three different types of road pricing: toll roads, bridge and tunnel charges, and zonal charging schemes. Toll roads, bridge and tunnel charges refer to levies imposed on drivers for using a particular road, tunnel, bridge or canal. By contrast, zonal charges are levies imposed to enter a designated area. Congestion Charge Zones, such as the London Congestion Charge Zone (CCZ) is an example of the latter.

Rather than reduce congestion or the air pollution associated with it, toll roads, bridge and tunnel charges are typically used to finance the construction and maintenance of road, bridge, tunnel and canal infrastructure, respectively. As such, they are of less relevance to this report than congestion charges are. The report therefore focuses on zonal charging schemes.

While there can be an overlap between CAZs and congestion charge schemes, the key difference is that congestion charges are levied based on road usage rather than the type of vehicle driven. By contrast, CAZs are specifically intended to reduce concentrations of NO_2 by driving only the most polluting vehicles off the roads, which can be achieved without reducing the overall number of vehicles on the road. The government's Clean Air Zone Framework, for instance, explicitly states that electric vehicles "will not be charged for entering or moving through a clean air zone".[293]

At the time of writing, there were only two congestion charge zones in England. In 2002, the City of Durham implemented a £2 daily congestion charge which spans from the Cathedral to the Market Place.[294] The next year, the London congestion charge was implemented which, as of 2023, requires the payment of a £15 daily charge if you drive within the specified zone in Central London – from the City of London in the east

292. Environmental Defense Fund, Examining the 'reach' of Greater London's Clean Air Zone, https://globalcleanair.org/wp-content/blogs.dir/95/files/2021/07/EDF-Europe-Examining-the-reach-of-Greater-Londons-Clean-Air-Zone.pdf (2021).
293. Defra, "Clean Air Zone Framework".
294. Ibid., 7.

to Marylebone in the west and from Lambeth in the south to Finsbury in the north.[295] All vehicle types are liable to pay the charge, although registered taxis are exempt. Private hire vehicles, examples of which include minicabs and Ubers, were exempt until June 2020.[296]

In contrast to the ULEZ, which operates 24/7, the Central London Congestion Charge applies between 7:00am and 6:00pm between Monday and Friday and 12:00pm-6:00 pm on weekends and bank holidays.[297]

With far more studies examining the impact of the ULEZ on air pollution than the London CCZ, it is more difficult to assess the latter's impact. The studies that do exist have given "mixed" results as to the CCZ's effectiveness.[298] One early study looking at the health effects of the CCZ's introduction, for example, found that it only had a "modest" impact on NO_2 and PM_{10} concentrations.[299]

A recent study assessing the impact of air pollution on school attendance used data from 2012-2019 and found that the London CCZ has contributed to reductions in air pollution.[300] Hence, while air pollution fell throughout London, it found that average annual concentrations of $PM_{2.5}$ fell by 4.6 percentage points more inside the CCZ compared to sites within 3km of it, and 7.1 percentage points more inside the CCZ compared to sites within 10km of it.[301]

However, there have been criticisms of the London CCZ. Chiefly, while the scheme reduced the number of private cars entering the London CCZ by 39% between 2002 and 2014, because taxis and private hire vehicles were both exempt, the number of those vehicles entering the London CCZ increased by 29.2% between 2000 and 2016. The number of minicab registrations also increased from 49,854 in 2013 to 87,409

295. Claire Evans, "London Congestion Charge: everything you need to know", https://www.whatcar.com/advice/owning/london-congestion-charge-everything-you-need-to-know/n23042 (2021).
296. Transport for London, "PHVs and the Congestion Charge", https://tfl.gov.uk/info-for/taxis-and-private-hire/phvs-and-the-congestion-charge#on-this-page-3 (2023).
297. TfL, "Congestion Charge", https://tfl.gov.uk/modes/driving/congestion-charge (undated).
298. Risto Conte Keivabu and Tobias Rüttenauer, "London congestion charge: the impact on air pollution and school attendance by socioeconomic status", *Population and Environment* (2022), 576–596, 580.
299. C Tonne et al., "Air pollution and mortality benefits of the London Congestion Charge: spatial and socioeconomic inequalities", *Occupational and Environmental Medicine* (2007), 620–627, 626.
300. Ibid., 580.
301. Ibid., 586.

in 2017. This increase in the number of private hire vehicles in turn slowed down traffic within the London CCZ. This also led to a fall in bus passenger numbers, with members of the public put off by increased travel times.[302] For example, the number of bus journeys in London fell by 6% between 2014-15 and 2016-17.[303]

Notably, several members of our Barking and Dagenham focus group, which lies outside the London CCZ, viewed it negatively, with one participant describing the £15 charge as "ridiculous".

The same participant further complained that the funds apparently being raised through what they saw as overlapping policies (the London CCZ and ULEZ) were not being reinvested into city's roads. This lack of investment, in their view, was in turn worsening air pollution.

> "It's [the revenue from the CCZ is] certainly not [spent on] the roads where I am. The potholes are absolutely ridiculous and then they fix them and they're broken again or they fix them and...it's not done properly that then causing more traffic, more pollution. You know, you've got all that, as I say, you've got ULEZ and then you've got the congestion [charge] as well."
>
> **Participant E, Barking and Dagenham group**

Another participant also complained about the high cost of having to pay both the London CCZ and the ULEZ for the same vehicle on the same trip.

> "Yeah, that really before you, if you're paying two charges, you're paying nearly 30 pounds before you've even blown your nose."
>
> **Participant C Barking and Dagenham group**

302. Nicole Badstuber, "London congestion charge: what worked, what didn't, what next", *The Conversation* https://theconversation.com/london-congestion-charge-what-worked-what-didnt-what-next-92478 (2018).
303. London Assembly Transport Committee, "London's bus network", https://www.london.gov.uk/sites/default/files/bus_network_report_final.pdf (2017).

Box 5.1. Per-mile road pricing schemes

Another potential type of road pricing scheme is one that would be charged on a per-mile basis. It should be emphasised that, as of 2023, there are no per-mile road pricing schemes in existence.

A per-mile road pricing scheme has often been recommended to fill the fiscal black hole resulting from drivers switching to electric vehicles and consequently no longer paying Fuel and Vehicle Excise Duty.[304] The displacement of existing petrol and diesel vehicles by electric vehicles (EVs) is expected to result in revenues from those taxes falling by more than £30 billion between 2020-21 and 2050-51.[305]

A recent report by the Social Market Foundation (SMF) found that replacing existing taxes with a road pricing system is likely to be fairer than existing Fuel Duty taxation.[306] First, the existing Fuel Duty regime already falls disproportionately on those with lower incomes. This is because, even though they tend to drive fewer miles than higher-income households, lower-income households spend a higher proportion of their income on Fuel Duty.[307] Second, as lower-income households are less likely to drive electric vehicles, the remaining Fuel Duty will increasingly fall on lower-income households. The SMF also suggested that giving drivers a free mileage allowance, which means allowing motorists to drive a set number of miles before they would have to start paying, would aid support for per-mile road pricing.[308]

Unfortunately, there was little support for per-mile road pricing schemes among any of our focus groups.

One participant in the Barking and Dagenham focus group said that the idea was "horrible" and "just ****** me off".

Further concerns about adding to the cost of living also weighed on members of the Liverpool focus groups.

304. Scott Corfe, "Miles ahead: road pricing as a fairer form of motoring taxation", Social Market Foundation, https://www.smf.co.uk/wp-content/uploads/2022/05/Miles-Ahead-May-2022.pdf (2022), 15.
305. Ibid, 12-13.
306. Ibid.
307. Ibid., 14-15.
308. Ibid., 8.

> "It's still just an extra cost, isn't it? It's just, yeah, another sale to add on to you your month."
>
> **Participant D, Liverpool group**

The most positive reaction to the idea of introducing a per-mile road pricing scheme came from a Birmingham participant, who still thought it would divide public opinion.

> "You know, people will see it as a money grabbing scheme or the people would see as a much better alternative to what they currently have."
>
> **Participant E, Birmingham group**

Another participant from the Birmingham focus group raised doubts about whether the funds generated from a proposed per-mile scheme would be reinvested in the areas with the worst pollution.

> "I mean, just the idea of like it I don't see any anything in this making sure that like the areas where people are driving the most is where that money is going to be spent to tackle the pollution and the emission."
>
> **Participant B, Birmingham group**

A participant in the Liverpool group also expressed concerns about the practicalities of administering such a scheme, and whether it could be done so equitably.

> "I think it would be a kind of tricky scheme to introduce perhaps... Just all the, um, kind of bureaucratic side of it and coming to being able to actually work out a fair way in which it could be implemented if you know what I mean."
>
> **Participant B, Liverpool group**

Lastly, the notion of a free mileage allowance was viewed by Participant E in the Liverpool group and Participant A in Barking and Dagenham group as being "controlling", especially for those from on lower incomes.

Low Traffic Neighbourhoods (LTNs)

The other main policy for transport and air pollution is Low Traffic Neighbourhoods (LTNs). While there is no official definition, LTNs involve the placement of bollards, planters and plate-recognition cameras to get rid of 'through' traffic on residential streets.[309] By lowering the number of vehicles on roads and reducing traffic, they increase the number of people walking or cycling. According to TfL, LTNs stop motor vehicles from "using quiet roads as shortcuts". They are seen as fundamental in delivering plans – especially in London – to make the majority of trips by active or sustainable means.[310] It should be stressed, however, that, in Greater London, LTNs are the responsibility of borough councils rather than the Mayor.

LTN-like traffic barriers have existed since the 1960s, with one study estimating that over 25,000 had been installed by 2021.[311] More recently, in spring 2020, the Government announced a £250 million emergency active travel fund, which supported the rollout of LTNs,[312] especially in London. Since then, they have expanded into other cities such as Bristol and Oxford. Cities such as Manchester, Birmingham and Sheffield have all applied for funding from the Department for Transport to introduce their own LTNs.[313] An estimated 200 LTNs were installed across the UK between 2020 and 2022.[314] The size of LTNs varies across the UK

309. Peter Walker, "Sunak review raises question: what exactly is a low-traffic neighbourhood?", *The Guardian*, 30 July, 2023, https://www.theguardian.com/uk-news/2023/jul/30/low-traffic-neighbourhood-ltn-traffic-planning.
310. TfL, "Low Traffic Neighbourhoods: what, why and where?", https://madeby.tfl.gov.uk/2020/12/15/low-traffic-neighbourhoods/ (2020).
311. Peter Walker, "Critics of UK low-traffic schemes told that 25,000 filters already existed", *The Guardian*, 16 May 2021, https://www.theguardian.com/environment/2021/may/16/critics-of-uk-low-traffic-schemes-told-that-25000-filters-already-existed.
312. HM Government, "£2 billion package to create new era for cycling and walking", https://www.gov.uk/government/news/2-billion-package-to-create-new-era-for-cycling-and-walking (2020).
313. RAC, "Low Traffic Neighbourhoods – what are they? And will they appear nationwide?", https://www.rac.co.uk/drive/advice/driving-advice/low-traffic-neighbourhoods-what-are-they-and-will-they-appear-nationwide/ (2022).
314. Peter Walker, "Sunak review raises question: what exactly is a low-traffic neighbourhood?"

depending on local conditions.[315]

Some evidence suggests that LTNs have helped to reduce air pollution. A 2022 Imperial College study into the effects of LTNs on concentrations of NO_2, for example, found that they were 5.7% lower within the LTNs and almost 9% lower on the boundaries of the LTN compared to control sites. While the study did not measure the effects the LTNs had on $PM_{2.5}$, because traffic fell by more than 50% within the LTNs,[316] it would likely also have reduced concentrations of that air pollutant.

LTNs are not without their criticisms, however. Although they reduce air pollution where they are situated, some argue that they merely divert traffic and the resulting air pollution with it. For instance, many drivers who previously would have driven through the LTN are having to spend more time in traffic to get around the LTN.[317] The Leader of Wandsworth Council in 2020 argued that LTNs caused "gridlocks on our roads which increased carbon emissions; emergency vehicles were getting blocked in, and the daily lives of many residents were being disrupted".[318] In response to this political backlash, central government, as mentioned in Chapter One, withdrew financial support for any further LTNs in 2023.

However, there is no categorical evidence that LTNs merely divert car traffic onto roads peripheral to the LTN. A study of ten selected London LTNs found that, while there was an increase in traffic on peripheral roads for five LTNs, ranging from 2% to 19%, there were decreases ranging from 3% to 21% in the other five LTNs.[319] The same study also found no evidence that LTNs increased emergency vehicle response times.[320]

315. Sustrans, "3. Low traffic neighbourhood definition", https://www.sustrans.org.uk/for-professionals/infrastructure/an-introductory-guide-to-low-traffic-neighbourhood-design/an-introductory-guide-to-low-traffic-neighbourhood-design-contents/design-guide/all/3-low-traffic-neighbourhood-definition (2023).
316. Hayley Dunning, "Low-traffic neighbourhoods reduce pollution in surrounding streets", Imperial College London, https://www.imperial.ac.uk/news/241731/low-traffic-neighbourhoods-reduce-pollution-surrounding-streets/ (2022).
317. RAC, "Low Traffic Neighbourhoods – what are they? And will they appear nationwide?".
318. Tom Edwards, "Low Traffic Neighbourhoods: anger, hate and the politics of the planter", https://www.bbc.co.uk/news/uk-england-london-54180647 (2020).
319. Centre for London, "Street shift: the future of low-traffic neighbourhoods", 21, 42.
320. Peter Walker, "Low-traffic neighbourhoods make roads safer but need a rebrand – report", *The Guardian*, 9 June 2022, https://www.theguardian.com/world/2022/jun/09/low-traffic-neighbourhoods-report-london-ltn-schemes.

The rollout of LTNs has also faced criticism from disability groups. Despite Defra guidance specifically requiring that "cycle infrastructure should be designed for significant numbers of cyclists, and for non-standard cycles",[321] bollards have not always been spaced widely enough apart to fit in the non-standard cycles that some disabled people use.[322]

There was no clear consensus reached, either across or within our focus groups on attitudes towards LTNs. In Liverpool, some participants viewed LTNs positively as a means of tackling air pollution in specific areas.

> "They are making steps [installing LTNs] and that's going to encourage people to cycle more and use electric scooters … it's definitely really important."
>
> **Participant E, Liverpool group**

However, several other participants thought that LTNs would just push air pollution elsewhere by causing congestion elsewhere.

> "I struggle to see how it would be effective and wouldn't just create traffic congestion in surrounding areas. I can't imagine it would be practical."
>
> **Participant B, Liverpool group**

There were equally mixed reviews of LTNs in the Birmingham group. Some responses were positive as it was understood that LTNs may make an area more welcoming and less noisy.

> "I think it is a good idea. It's less noise, less [pollution] in the air is good as well."
>
> **Participant A, Birmingham group**

321. Ibid., 10.
322. Wheels for Wellbeing, "LTNs Part 1 – The Good, the Bad, and the Ugly", https://wheelsforwellbeing.org.uk/ltns-part-1-the-good-the-bad-and-the-ugly/ (undated).

Another participant specifically mentioned that getting rid of cars could create a more sociable environment.

> "I like the idea because you get cafes that put out tables and chairs and it stops cars from gathering or parking nearby... People can join together and have a social gathering."
>
> **Participant D, Birmingham group**

However, like in the Liverpool group, several participants in the Birmingham group believed that introducing LTNs would merely shift air pollution elsewhere.

> "For me it's 50/50. It's a good idea in terms of reducing traffic in residential areas ... but at the same time, if you have barriers in place, the main roads are going to be congested really badly."
>
> **Participant E, Birmingham group**

Likewise, in the Barking and Dagenham focus group, there were mixed reviews on LTNs. There was a belief that they would contribute to cleaner air, with one participant saying "I think that would help with air pollution".

Another participant was more interested in how LTNs could reduce noise pollution near their home than how they could reduce air pollution.

> "[LTN's sound] Great, because I live next to a main road and hear everything. I'd love to live in one of them [LTNs]."
>
> **Participant B, Barking and Dagenham group**

However, personal experience factored into some negative views. Frustration over being charged for driving through an LTN irritated

several participants.

> "We went through [the LTN] and it was too late. We realised we got a ticket … I'm not a fan."
>
> **Participant C, Barking and Dagenham group**

One participant complained about being fined £60 for driving through an LTN despite not knowing what it was.

> "Blooming, flower pot things. If you go through it, that I didn't know, I got a £60 ticket. I've got screwed by that."
>
> **Participant E, Barking and Dagenham group**

Subsidies

The main policy examples of regulations relate to transport: specifically exemptions and scrappage schemes from road pricing schemes.

Road pricing exemptions

As mentioned earlier, most exemptions from road pricing charges are a matter for local authorities and, in the case of ULEZ, the Mayor of London. The government's Clean Air Zone Framework mandates exemptions of CAZs for historic vehicles (defined as those over 40 years old), military vehicles, and "certain types of non-road going vehicles which are allowed to drive on the highway such as agricultural machines; digging machines; and mobile cranes". In addition, local authorities cannot charge fully electric or hydrogen fuel cell vehicles for entering a CAZ. All other exemptions, however, are at the discretions of local authorities.[323]

Because of this, the extent and duration of these exemptions varies considerably across the different CAZs. For example, exemptions from Birmingham's CAZ charges, implemented in 2020, were available for

323. Defra, "Clean air zone framework".

low-income workers (those earning less than £30,000 per annum) and businesses based in the CAZ for up to two years. There were no exemptions for Blue Badge holders.[324] By contrast, Bristol's CAZ did not grant exemptions for low-income households or local businesses but did for Blue Badge holders. However, these were only available between November 2022 and March 2023.[325]

The London ULEZ offers more extensive exemptions than other CAZs. Until October 2027, exemptions ('grace periods) are available for disabled people who are registered with the Driver and Vehicle Licensing Agency (DVLA) with a 'disabled' or 'disabled passenger vehicle' tax class, wheelchair-accessible vehicles and disabled people receiving certain disability benefits, such as the Personal Independence Payment (PIP). In addition, not-for-profit organisations operating minibuses for community transport may apply for an exemption until October 2025. Registered London taxis are exempt and there is a grace period for small businesses who have ordered a new ULEZ-compliant light van or minibus, or arranged for their existing non-compliant light van or minibus to be upgraded to meet ULEZ emissions standards. The ULEZ is also refundable for some NHS patients attending hospital appointments.[326]

There are also exemptions available for zonal charging: specifically under London's CCZ scheme, which are in fact more comprehensive than those available under the ULEZ.[327]

Unlike the ULEZ, all those living within the congestion zone are eligible for a 90% discount on the charge. Regarding disabled people, all Blue Badge holders are eligible for a 100% exemption.[328] Additionally, NHS and emergency services vehicles, drivers of two-wheeled motorbikes and

324. Birmingham City Council, "Applications Open for Clean Air Zone Exemption Permits." https://www.birmingham.gov.uk/news/article/548/applications_open_for_clean_air_zone_exemption_permits (2022).
325. Bristol City Council, "Clean Air Zone and Blue Badge Holders." https://www.bristol.gov.uk/residents/streets-travel/bristols-caz/exemptions/clean-air-zone-and-blue-badge-holders (undated).
326. TfL "Discounts and exemptions", https://tfl.gov.uk/modes/driving/ultra-low-emission-zone/discounts-and-exemptions (2023).
327. TfL, "Discounts and Exemptions."
328. TfL, "Residents' Discount", https://tfl.gov.uk/modes/driving/cc-provisional-resident-before-you-begin-33357 (2023).

mopeds, taxis, as well as certain vehicles operated by London boroughs and the armed forces are also exempt.[329]

Finally, those with fully electric vehicles are exempt, but, unlike the ULEZ this exemption is set to be removed by 2025.[330]

There has been significant criticism at the lack of exemptions offered by local authorities in CAZs across England. Smaller not-for-profit businesses have expressed concern at their not being exempt from CAZ charges. For example, in Newcastle's CAZ one food bank accrued charges of £400 and had to rely on others to bring food to the bank.[331] Disabled people have also pleaded for more generous exemptions. For example, the expiry of Bristol's Blue Badge exemptions, prompted fears that many disabled residents would become "trapped in their homes".[332]

Despite offering the most generous exemptions, the London ULEZ has also attracted criticism because of its failure to exempt all Blue Badge holders from the charge.[333] The Mayor of London himself acknowledged that a "short-to-medium term moderate differential negative impact on health" could be expected for disabled people due to stress and anxiety caused by the ULEZ expansion to outer London.[334] These findings do not, however, take into account the further mitigations subsequently brought in by the Mayor.

Participants across the three focus groups were asked if there should be any exemptions to CAZ charges. Participants from both the Birmingham and Liverpool groups specifically mentioned poorer and disabled residents.

329. Ibid.
330. Claire Evans, "London Congestion Charge: everything you need to know".
331. BBC News, "Newcastle Food Bank Pleads for Caz Exemption after 32 Fines." https://www.bbc.com/news/ukengland-tyne-67027711 (2023).
332. Adam Postans, "Fears Bristol Clean Air Zone will 'trap' disabled people at home", *Bristol Post*, 21 October 2022, https://www.bristolpost.co.uk/news/bristol-news/fears-bristol-clean-air-zone-7727520.
333. Disability Rights UK, "ULEZ changes for Disabled drivers announced", https://www.disabilityrightsuk.org/news/ulez-changes-disabled-drivers-announced (2023).
334. London Assembly, "Negative health benefits of ULEZ expansion for disabled Londoners", https://www.london.gov.uk/who-we-are/what-london-assembly-does/questions-mayor/find-an-answer/negative-health-benefits-ulez-expansion-disabled-londoners (2022).

> "People that are off low-income households, right? They should have, you know, the exception as well. Anybody would like a blue badge. Something as well giving them an exemption."
>
> **Participant E, Birmingham group**

Unlike the participants in Birmingham group, however, several Liverpool focus group members mentioned the need for exemptions for local businesses and traders.

> "So workers, there's a lot of tradespeople that need to work within the city and a lot of them often have, like vans, say, so they're amid particularly high levels of, you know, toxic stuff. And it's already, you know, that's going to take away from their business and also cost them a lot more. And it also cuts off the supply chain for a lot of local businesses. Like I say, if you go to Bold St early in the morning, there's [sic] hundreds of vans, isn't there? There're [sic] loads all delivering into the businesses out there."
>
> **Participant A, Liverpool group**

One participant also suggested an exemption for those who accidentally enter a CAZ.

> "For people who accidentally enter the zone, there's no flexibility … it's so easy to accidentally go into the zone and there's no way to turn out once you go in … [It] seems unfair."
>
> **Participant B, Birmingham group**

Yet, in the Liverpool group, the focus of exemptions was on businesses and tradespeople as there was a belief that their trade would lose profitability with the implementation of a CAZ.

> "If there were incentives for workers, hopefully you wouldn't see too much of a disruption to business and general livelihood."
>
> **Participant A, Liverpool group**

By contrast, no members of the Barking and Dagenham focus group suggested introducing any further exemptions to the ULEZ. One participant, however, when asked about exemptions, said they were more interested in what was being done with the funds raised through ULEZ than in granting more exemptions.

> "For me personally, it's more about what they're actually doing with the money. If I can't see what you're doing with the money to actually justify, or I need to see clearly that this thing is actually working, has pollution actually gone down because you've still got your industrial estates, you still got your smokers, you still got big trucks, you still got people building stuff, all of that still going on, so."
>
> **Participant F, Barking and Dagenham group**

Scrappage schemes

Scrappage schemes are financial incentives, typically in the form of cash or vouchers, offered to vehicle owners either to retrofit (that is, upgrade) or replace more polluting vehicles with more environmentally friendly ones,[335] or simply to scrap older, more polluting vehicles.[336] Where they have been implemented, they typically sit alongside the implementation of a CAZ.

While central government has the discretion to support local scrappage schemes financially, it has no obligation to do so. Thus, it has

335. RAC, "Scrappage schemes – a simple guide", https://www.rac.co.uk/drive/advice/emissions/scrappage-schemes/ (2020)
336. Birmingham, "Applications to the Clean Air Zone Vehicle Scrappage and Travel Credit Scheme are now open", https://www.birmingham.gov.uk/news/article/871/applications_to_the_clean_air_zone_vehicle_scrappage_and_travel_credit_scheme_are_now_open (2021).

financially contributed to scrappage schemes connected to CAZs in Bath, Birmingham, Bradford, Portsmouth and Sheffield, but has declined to provide any support for scrappage schemes in Tyneside or London.[337]

Because, as mentioned much earlier in this chapter, responsibility for scrappage schemes lies with local authorities or the Mayor of London, the level of support offered varies considerably across England. For example, Birmingham's scrappage scheme offered £2,000 grants to those earning less than £30,000 who work in the CAZ.[338] By contrast, Bristol's scrappage scheme only entitles residents to a £1,500 grant plus a £500 loan.[339] Like the Birmingham scheme, however, the Bristol scrappage scheme is targeted at those living within the CAZ earning less than £30,000 per annum.[340]

The Mayor of London's £160 million scrappage scheme is the most generous. Unlike the Birmingham and Bristol scrappage schemes, every Londoner regardless of income is eligible for a grant of up to £2,000 to scrap a non-compliant car or motorcycle. Larger grants of £10,000 are available to scrap, or £6,000 to retrofit, wheelchair-accessible vehicles.[341] In addition, the Mayor of London offers "eligible sole traders, micro businesses, small businesses and charities" grants of up to £11,500, to "to scrap or retrofit a light van or minibus or to put towards the cost of a cleaner vehicle".[342]

There is some evidence that scrappage schemes help to reduce air pollution. One recent report for TfL estimated that scrappage schemes associated with ULEZ since 2021 have reduced total annual emissions

337. House of Commons Library, "Clean Air Zones, Low Emission Zones and the London ULEZ", https://researchbriefings.files.parliament.uk/documents/CBP-9816/CBP-9816.pdf (2023), 17-18, 29-30.
338. Birmingham City Council, "Applications to the Clean Air Zone Vehicle Scrappage and Travel Credit Scheme are now open", https://www.birmingham.gov.uk/news/article/871/applications_to_the_clean_air_zone_vehicle_scrappage_and_travel_credit_scheme_are_now_open (2021).
339. Birmingham City University, "Clean Air Zone", https://www.bcu.ac.uk/about-us/corporate-information/environment-sustainability/sustainable-travel-plan/clean-air-zone; Asthma and Lung UK, "Putting the brakes on toxic air: our transport plan for a cleaner, fairer future", https://www.asthmaandlung.org.uk/aluk-putting-brakes-toxic-air-report-full-report (2023), 51.
340. Bristol City Council, "Clean Air Zone financial support", https://www.bristol.gov.uk/residents/streets-travel/bristols-caz/financial-support (2023).
341. TfL, "Scrappage scheme", https://tfl.gov.uk/modes/driving/ultra-low-emission-zone/scrappage-schemes (2023).
342. Mayor of London and TfL, "ULEZ van and minibus scrappage scheme", https://tfl.gov.uk/modes/driving/ultra-low-emission-zone/scrappage-schemes/van-minibus (2023).

of NO_x by 140 tonnes and $PM_{2.5}$ by 0.5 tonnes in Greater London.[343]

Unfortunately, there have been major concerns about the adequacy of even the relatively generous London ULEZ existing scrappage schemes. The £2,000 support available is insufficient to cover the cost of a ULEZ-compliant replacement vehicle. According to August 2023 data from AutoTrader, the cost of a compliant second-hand car has increased to just over £18,000, with only around 5,000 of the 43,359 ULEZ-compliant cars listed for sale priced at under £5,000.[344] Moreover, the average cost of a ULEZ-compliant wheelchair-accessible vehicle is around £30,000, which is significantly above the £6,000 on offer to retrofit, or £10,000 to scrap, a non-compliant wheelchair-accessible vehicle.[345]

The Mayor of London has also criticised central government's refusal to contribute any support to the city's scrappage scheme and warned that this has in turn limited his capacity to offer more generous support.[346]

Conclusion

This chapter has described the details and evidence of key policies by both national and local governments to reduce air pollution caused by transport and domestic burning. The policies outlined are not meant to be exhaustive; instead they are a spotlight on the leading policies implemented in recent times.

There are two main conclusions that emerge from this. First, policy interventions have not always been ambitious enough. Second, there has often been inadequate support to help those in deprived areas adapt to new clean air policies.

Having discussed central and local government policies in England,

343. Mayor of London and TfL, "ULEZ scrappage schemes evaluation report", https://tfl.gov.uk/corporate/publications-and-reports/ultra-low-emission-zone?cid=scrappage-report#on-this-page-3 (2022), 24.
344. Yasmin Rufo, "Ulez expansion: Contested claims examined", *BBC*, https://www.bbc.co.uk/news/uk-england-london-64798395 (2023).
345. Mayor of London, "Biggest ever vehicle scrappage scheme launched by Mayor to help businesses, charities, low-income and disabled Londoners", https://www.london.gov.uk/biggest-ever-vehicle-scrappage-scheme-launched-mayor-help-businesses-charities-low-income-and (2023).
346. Jim Pickard, George Parker and Philip Georgiadis, "Sadiq Khan calls on UK government for extra Ulez funding", *Financial Times*, 26 July 2023, https://www.ft.com/content/d138e675-4c47-42f7-b621-24f163fe5d52.

the next chapter discusses unique and additional policies in other countries that have been used to reduce total emissions from transport and domestic burning.

Chapter 6:
Effective international policies on air pollution

Introduction

The previous chapter looked at some key recent UK national and local government policies to reduce total air pollution from transport and domestic burning. This chapter unearths and explains some unique and additional policies in other countries that have successfully been used to reduce air pollution from transport and domestic burning but have not been adopted in the UK. It meant to be an exhaustive list of the different policies adopted internationally to reduce these two sources of air pollution. Like the previous chapter, it respectively discusses three main types of policies: bans, regulations and subsidies.

Bans

We discuss three examples of unique bans in different countries – one for reducing domestic burning and two for transport emissions.

In Stuttgart, Germany, wood-burning fireplaces and stoves in private households were the second largest source of PM after road traffic.[347] As a result, in 2017, the Baden-Württemberg State Government issued an ordinance banning Stuttgart residents from using their wood-burning stoves on days between October and April when the German Weather

347. Baden-Wurttemberg, "Comfort fireplaces will be banned in the future with fine dust alarm in Stuttgart", https://www.baden-wuerttemberg.de/de/service/presse/pressemitteilung/pid/komfortkamine-kuenftig-bei-feinstaubalarm-in-stuttgart-verboten/ (2017).

Service forecast the city's PM_{10} concentration to exceed EU's PM_{10} daily concentration limit of 50µg/m³.[348]

The bans were communicated by emails sent directly to households and notices on the Stuttgart city council's website.[349] They applied to households who were already equipped with central heating and who used their wood-burning stoves as an additional source of heating. The rule was enforced by Stuttgart's chimney sweeps who updated a central database and neighbours who were encouraged to report signs of illicit combustion.[350] Exemptions to the ban were available for comfort fireplaces that had been retrofitted with a downstream dust reduction device, as well as for solid fuel which met the requirements of the Baden-Württemberg Renewable Heat Act.[351]

Although, as discussed in Chapter Five, the UK's designated smoke control areas limit the types of fuel that can be burned in stoves and the amount of smoke that the stoves can emit, there is no UK legislation allowing local authorities to restrict burning during the colder months.

The policy effectively helped to reduce the number of days when concentrations of PM_{10} exceeded the legal limit declining from 58 in 2016, to 25 in 2019 and just 20 in 2020.[352] Consequently, the Baden-Württemberg State Government scrapped the ban on domestic burning in Stuttgart in April 2022.[353]

Low Emission Zones (LEZs)

In regards to transport, bans can also be features of 'Low Emission

348. Government of Baden-Württemberg "Verordnung der Landesregierung über Betriebsbeschränkungen für kleine Feuerungsanlagen (Luftqualitätsverordnung-Kleinfeuerungsanlagen)", https://vm.baden-wuerttemberg.de/fileadmin/redaktion/m-mvi/intern/Dateien/PDF/PM_Anhang/Luftqualitaetsverordnung_Kleinfeuerungsanlagen_Verordnung.pdf (2017). Prathap Nair, "Stuttgart residents sue mayor for 'bodily harm' caused by air pollution", *The Guardian*, 2 March 2017, https://www.theguardian.com/cities/2017/mar/02/stuttgart-residents-sue-mayor-bodily-harm-air-pollution; "How other countries are reducing air pollution", *The Times*, 10 May 2019, https://www.thetimes.co.uk/article/how-other-countries-are-tackling-air-pollution-0nk2mkh97.
349. Konstantin Schwarz, "Ban on the use of comfort fireplaces ends soon", https://www.stuttgarter-zeitung.de/inhalt.stuttgarter-verbot-endet-im-april-bald-feuer-frei-fuer-komfortkamine.9bccbfbc-f5ee-48ad-b05d-ae1d14c7e3d6.html (2021).
350. "How other countries are reducing air pollution".
351. Ibid.
352. Schwarz, "Ban on the use of comfort fireplaces ends soon".
353. Ibid.

Zones', which is the term commonly used in continental Europe to describe Clean Air Zones (CAZs). As of 2022, there were 320 LEZs across the continent. That number is expected to increase to 507 by 2025.[354]

In France, eleven major French cities, beginning with Paris in 2015, but now including Lyon, Marseilles and Strasbourg, have introduced what are termed Zones à Faibles Émissions (ZFE-ms). Unlike England, where decisions to introduce CAZs are taken at a local level, all French cities with populations exceeding 150,000 will be expected to implement ZFE-ms by 2025.[355]

Also unlike CAZs in England, all vehicles entering the zones, regardless of whether or not they are registered in France, must apply a colour-coded Crit'Air sticker indicating their Euro emission standard classification. Cars registered before January 1997 cannot be given any sticker and thus cannot be driven where and when the ZFE-m rules apply.[356] Failure to display the stickers can result in a €68 fine.[357]

For example, in addition to all pre-1997 vehicles, the city of Paris, France outright bans vehicles required to display the Crit'Air 4 and 5 stickers (meaning all pre-2006 diesel cars) from driving within its LEZ. This was to have been extended to include vehicles required to display the Crit'Air 3 sticker (meaning all pre-2011 diesel and pre-2006 petrol cars) in July 2023, but this has twice been postponed, with the French Government citing "year on year" improvements air quality.[358] The outright banning of certain vehicles is in contrast to the UK CAZs,

354. Clean Cities, "The development trends of low and zero-emission zones in Europe", https://cleancitiescampaign.org/wp-content/uploads/2022/07/The-development-trends-of-low-emission-and-zero-emission-zones-in-Europe-1.pdf (2022). Gary Fuller, "The evidence is clear: low-emission zones like London's Ulez work", *The Guardian* 5 May 2023 https://www.theguardian.com/environment/2023/may/05/pollutionwatch-debunking-myths-low-emission-zones-health-air-pollution.
355. "The Crit'Air anti-pollution vehicle sticker", https://www.france.fr/en/holiday-prep/crit-air-anti-pollution-vehicle-sticker (2023).
356. RAC, "Crit'Air clean air stickers – your guide for driving in France", https://www.rac.co.uk/drive/news/motoring-news/law-change-for-uk-drivers-in-french-cities/ (2023).
357. Miles Brignall, "Britons driving to France warned over clean air fines", *The Guardian*, 8 July 2023, https://www.theguardian.com/money/2023/jul/08/britons-driving-to-france-warned-over-clean-air-fines.
358. French Directorate for Legal and Administrative Information, "Which vehicles can drive in Paris and the Greater Paris metropolis?" (2022), https://www.service-public.fr/particuliers/actualites/A14948?lang=en; Hannah Thompson, "Where in France are low-emission zone restrictions being eased?", *The Connexion*, 19 July, 2023, https://www.connexionfrance.com/article/French-news/Where-in-France-are-low-emission-zone-restrictions-being-eased.

which only seek to deter more polluting vehicles by means of charging them to enter.

Regulations

We next discuss two examples of unique regulations in different countries – both for reducing transport emissions.

Road pricing schemes

Singapore introduced the world's first urban traffic congestion scheme in 1975. The scheme was mainly introduced to reduce traffic levels rather than air pollution, but as the most sophisticated of its kind in the world,[359] is important to discuss.[360] Further, Singapore's use of Electronic Road Pricing (ERP) in concert with an in-vehicle unit (IU) marks it out as unique from London's CCZ.

Originally, the Singapore Area Licensing Scheme (ALS) charged drivers who entered a 7.25km2 area in the Central Business District called the 'Restricted Zone.' However, in 1998, the ALS was replaced by the ERP system. The ERP system employs gantries that used sensors and licence plate recognition cameras.[361] To use the ERP-priced roads, Singapore-registered vehicles have to acquire an in-vehicle unit (IU) device which costs S$155.80, which is approximately £90. Foreign vehicles can install IUs or pay a flat rate of S$5 per day, which is approximately £3, to gain unlimited access to all ERP-priced roads. By contrast, the London CCZ relies solely upon automatic numberplate technology to track vehicles driving in and out of it.[362]

Given the digital nature of the ERP system, it is easier to regularly

359. House of Commons Transport Committee, "Road Pricing: Fourth Report of Session 2021–22", https://committees.parliament.uk/publications/8754/documents/88692/default/ (2022), 4.
360. Sreyus Palliyani et al., "Sustainable transport policy — An evaluation of Singapore's past, present and future", Journal of Infrastructure, Policy and Development, https://systems.enpress-publisher.com/index.php/jipd/article/viewFile/23/341 (2017), 113.
361. Lee Nian Tjoe, "Fewer than 1 in 4 ERP gantries in use today, even as rates at some locations go up", *The Straits Times*, 13 February 2023, https://www.straitstimes.com/singapore/transport/just-under-one-in-four-erp-gantries-in-operation-today.
362. TfL, "FOI request detail: Congestion charge PCNs", https://tfl.gov.uk/corporate/transparency/freedom-of-information/foi-request-detail?referenceId=FOI-2394-2122#:~:text=The%20Congestion%20Charging%20scheme%20uses,Automatic%20Number%20plate%20Recognition%20cameras (2022).

alter the rates and hours of operation than it is for the London CCZ. Charges vary depending on vehicle type, time of entry and location. The rates are set based on the traffic conditions at the time and are regularly adjusted to keep traffic moving at an optimal speed of between 20 and 30km/h on arterial roads and 45 to 65km/h on expressways.[363] This is in contrast to the London CCZ, which charges a flat £15 daily fee to enter regardless of which part of the zone is entered.

In the initial months after the ERP's introduction in Singapore, the central business district saw a traffic reduction between 10% to 15% during ERP operational hours compared to traffic under the ALS.[364] Likely because the ERP was targeted at reducing congestion rather than the types of air pollution discussed in this report, there do not appear to be any studies that consider its impact on emissions of NO_2, $PM_{2.5}$ or PM_{10}. However, by reducing traffic volumes, it has likely reduced traffic-related emissions of NO_2, $PM_{2.5}$ and PM_{10}. This system has also proved very effective at raising revenue, contributing $150 million per year, or 10% of the Land Transport Authority's revenue.[365]

However, introducing a Singapore-style approach with an IU device in England would likely be politically fraught owing to privacy concerns, specifically around fears that the government would be able to track drivers' movements. For example, polling of UK adults by the Social Market Foundation found that only 23% of respondents supported the idea of having a device installed in their cars to track the number of miles travelled. By contrast, 48% opposed the idea.[366]

Another example of a unique road pricing scheme is in Europe. Since 2007, Sweden's capital city, Stockholm, has also operated a congestion pricing system in its city centre. Unlike the Singaporean ERP system,

363. Singapore Land Transport Authority, "Electronic road pricing (ERP)", https://onemotoring.lta.gov.sg/content/onemotoring/home/driving/ERP/ERP.html (2023).
364. Kian-Keong Chin, "Road Pricing – Singapore's 30 years of experience", https://www.ifo.de/DocDL/dicereport305-forum3.pdf, CESifo DICE Report, (2005), 15.
365. Guilherme Rodrigues and John Gibson, "Raising cash from car-restricting policies: What can London learn from Singapore?", https://www.centreforcities.org/blog/what-can-london-learn-from-singapore-transport/ (2022).
366. Corfe, "Miles ahead", 7.

vehicles entering the Stokholm congestion zone are identified using automatic numberplate recognition at unmanned electronic control points stationed at entrances to the city centre area. The congestion tax is applied on both entry and exit of the affected area.

Crucially, however, Stockholm's congestion zone offers a more variable pricing system compared to the London CCZ. The zone is free between 6pm and 6.29am, and from 6:30am it costs 10 Krona, which is approximately £0.95, to enter. The charge peaks at 20 Krona between 7.30 to 8.29am and 4 to 5.29pm.[367] In contrast, the CCZ charges the same £15 daily rate throughout its hours of operation. The variability in charging is due to the aim of the congestion charge being to "more evenly distribute the flow of traffic entering its city centre" rather than simply reduce traffic.[368]

It was estimated that the congestion charge reduced PM_{10} and NO_2 by 10-15% and 15-20% respectively between 2004 and 2010. An absence of reliable data meant that effects on $PM_{2.5}$ concentrations could not be measured, but they were also thought likely to have fallen. This had the knock-on effect of reducing the rate of acute asthma attacks among young children by nearly 50%.[369]

Subsidies

Finally, we discuss three examples of unique subsidies in different countries – both for reducing domestic burning emissions.

Stove scrappage schemes

Governments across the world have also offered financial support for households to upgrade or replace their existing stoves to reduce air

367. Swedish Transport Agency, "Hours and amounts in Stockholm", https://www.transportstyrelsen.se/en/road/road-tolls/congestion-taxes-in-stockholm-and-goteborg/congestion-tax-in-stockholm/hours-and-amounts-in-stockholm/ (2022).
368. Joe Peach, "The Success of Stockholm's Congestion Pricing Solution", *This Big City*, https://thisbigcity.net/the-success-of-stockholms-congestion-pricing-solution/ (2019).
369. Emilia Simeonova et al., "Congestion pricing, air pollution and children's health", https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3143315, National Bureau Of Economic Research (2018), 3.

pollution, chiefly PM emissions.[370]

A particularly well-documented upgrade scheme occurred in the former mining town of Libby in Montana, USA.[371] With a population of 2,600 at the turn of the century,[372] domestic burning was responsible for 82% of the town's PM pollution. Thirty-two percent of the town's population used wood as a primary heating source.[373] Libby's geography compounded the effects of its dependence on burning – because it is situated in a valley, the resulting air pollution failed to disperse rapidly and lingered in the town.[374]

To tackle this, in 2005, low-income residents of the town, as determined either by a non-profit agency or their enrolment in the US Low Income Energy Assistance Program, were offered less polluting wood burners that met US emissions limits. Free installation was included in the package and 260 stoves were replaced at a cost of US$2,900, which is approximately £2,260, per installation. In the scheme's second phase, from 2006 to 2008, homeowners with non-US Environmental Protection Agency certified wood stoves were offered vouchers of up to US$1,050, which is approximately £820, and homeowners with uncertified wood furnaces up to US$1,750, which is approximately £1,360, to either switch to compliant stoves or bring their existing stoves into compliance. A further 1,147 stoves or furnaces were upgraded or replaced this way.[375] The programme was the result of a combined effort by federal, state and local authorities, as well as private enterprises.[376]

The upgrades led to noticeable reductions in pollutant emissions, with $PM_{2.5}$ emissions falling by 30% between the winters of 2005

370. Fuller, *Invisible Killer*, 164.
371. Ibid.
372. Noonan et al., "Assessing the impact of a wood stove replacement program on air quality and children's health", 5.
373. Font et al., "Long-term trends in particulate matter from wood burning in the United Kingdom: Dependence on weather and social factors", 10.
374. Fuller, *Invisible Killer*, 164.
375. Noonan et al., "Assessing the impact of a wood stove replacement program on air quality and children's health", 12.
376. Ibid, 4.

and 2009 and ceasing to exceed US legal limits.[377] This translated into better health outcomes for residents, with lower rates of childhood wheezing, other respiratory illnesses and school absences among older children.[378] However, because the scheme merely upgraded wood burners rather than replacing them with a different heating source, smoke from burning did not completely disappear.[379] Unfortunately, given that Libby was not connected to any natural gas line,[380] this was more difficult to achieve.

Scrappage schemes have also been combined with educational programmes to tackle air pollution from domestic burning. Confronted by some of the worst air pollution of any Australian city, Launceston in Tasmania combined a scrappage scheme with an education programme to reduce the woodburning that lay at the heart of its air pollution problem.[381] As in the UK, wooden stoves became more common during the 1980s and 1990s, to the point where 66% of the city's households used wood burning as the primary means to warm their homes. In winter, approximately 85% of the city's PM came from wooden stoves.[382] As with Libby, Montana in the US, the city's location in a valley made pollutant concentrations to build up, exacerbating the problem.[383]

In response to this, in the 1990s leaflets were circulated to raise awareness of the issue among the public. The Australia Bureau of Meteorology began to issue air quality forecasts during winter and the city's electricity provider launched a campaign to promote electricity as a greener alternative to heating.[384] While this made some difference,

377. Ibid., 42.
378. Curtis W. Noonan et al., "Assessing the impact of a wood stove replacement program on air quality and children's health", Health Effects Institute (2011), https://www.healtheffects.org/system/files/Noonan162.pdf, 3, 23-4.
379. Fuller, *Invisible Killer*, 164.
380. Noonan et al., "Impact of a wood stove replacement program", 12.
381. Fay Johnston, "Everyone loves a wood-burning heater but is the harm worth it?", *The Conversation* https://theconversation.com/everyone-loves-a-wood-burning-heater-but-is-the-harm-worth-it-13536 (2013).
382. Fay H Johnston et al., "Evaluation of interventions to reduce air pollution from biomass smoke on mortality in Launceston, Australia: retrospective analysis of daily mortality, 1994-2007", *British Medical Journal*, https://www.bmj.com/content/bmj/346/bmj.e8446.full.pdf (2013), 2.
383. Fuller, *Invisible Killer*, 168.
384. Fay H Johnston et al., "Evaluation of interventions to reduce air pollution", 2.

more substantial reductions to air pollution took place after 2001, when the £1.34 million federally-funded Launceston Wood Heater Replacement Program was introduced to help households switch from wood burners to electric heating. This was combined, however, with the local authorities running awareness campaigns and hiring Environment Officers to oversee air pollution limits by monitoring chimneys and issuing infringement notices to homes whose chimneys continued to emit excessive amounts of smoke after the initial educational programme. In addition, schools made efforts to highlight the issue to local students.[385] No equivalent education campaign has been attempted in the UK.

The results were impressive. By 2004, when the scheme ended, the proportion of households with wood burners fell from 66% to just 30%.[386] Additionally, winter PM_{10} emissions fell by nearly 40%, respiratory deaths by 28% and heart issue-related deaths fell by 20% between 2001 and 2007.[387] Overall, it is estimated that this prevented around 30 deaths per year among the small city's 70,000 inhabitants.[388]

385. Ibid.
386. Ibid.
387. Font et al., "Long term trends in particulate matter from wood burning in the United Kingdom: dependence on weather and social factors", 2; Fay H Johnston et al., "Evaluation of interventions to reduce air pollution".
388. Fay H Johnston, "Everyone loves a wood-burning heater but is the harm worth it?", *The Conversation*, https://theconversation.com/everyone-loves-a-wood-burning-heater-but-is-the-harm-worth-it-13536 (2023).

Box 6.1. Discounted public transport

Subsidies have also been used to reduce air pollution by reducing or eliminating ticket prices for public transport. Although our policy recommendations focus on private transport use, it is worth highlighting a notable successful example of increasing public transport use to reduce air pollution.

From June to the end of August 2022, as part of a wider package of measures to address cost-of-living issues and encourage the use of sustainable transport, the German Federal Government offered passengers unlimited regional travel on its network of trains, buses and trams for €9 per month.[389] With nearly 60 million tickets sold by the beginning of August, 31% of adults said they frequently used the ticket on routes they would otherwise have taken by car and a further 18% said they had replaced their vehicle with local public transport.[390]

According to one study, which determined its results using an air quality index looking at concentrations of NO_2, $PM_{2.5}$ and PM_{10}, the policy improved air quality in Germany by more than 6%.[391] The effect was most evident in areas with a strong public transport network.[392]

Conclusion

This chapter has demonstrated that internationally, there are some successful examples of bans, regulations and subsidies where central and local authorities have gone beyond what the UK has done either at a central or local authority level to reduce total emissions of air pollution from transport and domestic burning. While not all these policy ideas might be feasible in the UK context, some could be adapted

389. Niklas Gohl, "Ticket to paradise? The effect of a public transport subsidy on air quality", https://publishup.uni-potsdam.de/opus4-ubp/frontdoor/deliver/index/docId/55846/file/cepa50.pdf (2022), 3.
390. DPA Economy, "Germany's €9 ticket resulted in cars being left at home, survey says", https://www.anews.com.tr/economy/2022/08/27/survey-germanys-9-ticket-resulted-in-cars-being-left-at-home (2022).
391. Gohl, "Ticket to paradise?", 3, 5.
392. Ibid., 14.

to reduce air pollution, especially in deprived areas of the UK.

Evidently, to reduce air pollution, the UK needs to consider additional policies. The next chapter will put forward policy recommendations – in part based on the success of such policies in other countries – to reduce total emissions from transport and domestic burning, with a particular focus on helping deprived areas.

Chapter 7:
New policies

Chapter Five and Six outlined policies in the UK and internationally, both by central and local governments, to reduce air pollution from transport and domestic burning, two leading sources of air pollution in deprived areas. In this chapter, we propose new policies for the UK central government to adopt to reduce air pollution, in England, with a particular focus on those living in deprived areas.

Policy Approach

When formulating policies, we applied six tests that had to be met:

- **Focussed on central government powers and accountability.** The policies we propose to tackle air pollution are focused on the powers and accountability of central government. Although responsibility for air pollution is heavily devolved, central government is still responsible for determining the legal framework for the policies that local authorities may pursue to reduce air pollution. Since local authorities shape the specific design of their air pollution policies, we think it is right to provide recommendations only to central government on what the framework should be.
- **Focussed on reducing air pollution from transport and domestic burning.** As argued in Chapter Three, these are especially consequential deprived areas, specifically in terms of

total annual emissions of NO_x and $PM_{2.5}$.

- **Focus on private rather than public transport.** While there also need to be policies to encourage the uptake of public transport, these are beyond the scope of this report.
- **Fiscal responsibility.** Policies to tackle air pollution should be fiscally prudent in that they do not necessitate excessively large amounts of central government spending. This 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.
- **Progressivity.** Policies to tackle air pollution should be progressive. Where additional charges are being levied on particular transport modes or on domestic burning, they should not be burdensome for the least well-off. Where public subsidies are being made available, that help should be prioritised towards the least well-off. The importance of progressivity was stressed across all our focus groups.
- **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 externality costs of it.

Our policy recommendations are divided into two categories. First, policies aimed at reducing air pollution that derives from private transport. Second, policies aimed at reducing air pollution that derives from domestic burning.

Policies to reduce air pollution from the transport sector

Recommendation one: Require CAZs in all English cities to differentiate charges for driving in inner cities and outer urban areas

According to Part III of the Transport Act 2000, the Clean Air Zone Framework, and section 295 of the Greater London Authority Act 1999, local authorities and the Mayor of London have discretion as to how much vehicles are charged for entering a CAZ.[393]

To date, London ULEZ is the only CAZ that covers almost an entire urban area. As Chapter Five discussed, the other seven CAZs (Bath, Birmingham, Bradford, Bristol, Tyneside, Portsmouth and Sheffield) only encompass smaller inner-city areas.

When the ULEZ expanded on 31 August 2023 to include the entire territory under the jurisdiction of the Greater London Authority, all non-compliant vehicles became liable to pay a £12.50 daily charge to drive within the zone. This is notwithstanding that the quality of public transport is significantly worse in outer London than it is in inner London and outer London residents are more car-dependent as a result.[394] While the Mayor of London has tried to address this by introducing a new 'Superloop' bus service in outer London boroughs,[395] it seems it will not be enough to bring outer London public transport services into line with those of inner city areas.

We recommend that, to reflect the different circumstances of inner and outer London, the central government amend section 295 of the Greater London Authority Act 1999 to require the Mayor of London to differentiate the charges levied on non-compliant vehicles in inner and outer London.

393. Defra, "Clean air zone framework".
394. Zarin Mahmud, Josh Cottell, Claire Harding, "Moving with the times: Supporting sustainable travel in outer London", https://centreforlondon.org/reader/sustainable-travel-outer-london/travel-today/#the-factors-influencing-people8217s-travel-choices (2023).
395. TfL, "Mayor unveils plans for the Superloop: over four million kilometres of express bus services circling outer London", https://tfl.gov.uk/info-for/media/press-releases/2023/march/mayor-unveils-plans-for-the-superloop-over-four-million-kilometres-of-express-bus-services-circling-outer-london (2023).

We further recommend that the Clean Air Zone Framework be amended to require that all English local authorities introducing city-wide CAZs introduce differentiated charging regimes between their inner city and outer areas, to reflect the varying availability of public transport.

Recommendation two: CAZs should provide exemptions for all Blue Badge holders

According to Part III of the Transport Act 2000, the Clean Air Zone Framework, and section 295 of the Greater London Authority Act 1999, local authorities and the Mayor of London have discretion as to whether they wish to apply any exemptions for any road charging schemes.[396] The Clean Air Zone Framework further states that local authorities may grant discounts or exemptions for Blue Badge holders "should analysis of local circumstances warrant such an approach".[397]

Reflecting this, the cities with Class D CAZs, that is those CAZs that charge non-compliant private cars to enter, have provided different exemptions for disabled residents. The London ULEZ scheme provides exemptions for people who are registered with the Driver and Vehicle Licensing Agency (DVLA) with a 'disabled' or 'disabled passenger vehicle' tax class, wheelchair-accessible vehicles and disabled people receiving some disability benefits, such as the Personal Independence Payment (PIP).[398] While welcome, these exemptions, however, still do not provide exemptions for all Blue Badge holders[399] and will expire on 24 October 2027.[400]

Not all schemes are as generous as the ULEZ. Bristol, for example, introduced temporary exemptions for Blue Badge holders, but these

396. Defra, "Clean air zone framework".
397. Ibid.
398. TfL, "Discounts and exemptions".
399. Disability Rights UK, "ULEZ changes for Disabled drivers announced", https://www.disabilityrightsuk.org/news/ulez-changes-disabled-drivers-announced (2023).
400. TfL "Discounts and exemptions".

ended on 31 March 2023.[401] Bath's Blue Badge exemptions similarly ended in March 2023.[402] Birmingham, meanwhile, did not offer any exemptions for Blue Badge holders.[403]

We recommend that central government amend the Clean Air Zone Framework and section 295 of the Greater London Authority Act 1999 to require local authorities and the Mayor of London to grant exemptions to all Blue Badge holders in Class D CAZs. There is some divergence as to who is eligible for a Blue Badge between local authorities, who are responsible for issuing them.[404] However, as the clearest legal indicator of disability, Blue Badge holder status would be the fairest way to protect disabled people from the adverse consequences of charging CAZs. Blue Badge status is widely used for determining exemptions from many other transport-related charges, such as the London Congestion Charge Zone,[405] and various toll road charges across the UK.[406]

Recommendation three: Enable local and combined authorities to strive for 'reasonable profits' from their CAZs to fund targeted, generous scrappage schemes in the short term.

As discussed in Chapter Five, one of the most significant concerns about CAZs is their effect on poorer people who cannot afford to upgrade their non-compliant vehicles.

As mentioned in Chapter Five, scrappage schemes are financial incentives offered to vehicle owners either to upgrade and replace more polluting vehicle with more environmentally friendly ones,[407] or

401. Bristol City Council, "Clean Air Zone and Blue Badge holders", https://www.bristol.gov.uk/residents/streets-travel/bristols-caz/exemptions/clean-air-zone-and-blue-badge-holders (2023).
402. Bath and Northeast Somerset Council, "Get an exemption or discount in Bath's Clean Air Zone", https://beta.bathnes.gov.uk/get-exemption-or-discount-baths-clean-air-zone (2023).
403. Birmingham City Council, "Applications open for Clean Air Zone exemption permits", https://www.birmingham.gov.uk/news/article/548/applications_open_for_clean_air_zone_exemption_permits (2020).
404. Alex Homer & Ollie Sirrell, "Blue badge permit 'shocking disparity' revealed", BBC, https://www.bbc.co.uk/news/uk-55221474 (2021).
405. Transport for London, "Blue Badge discount", https://tfl.gov.uk/modes/driving/cc-blue-badge-before-you-begin-29758 (2023).
406. Motability, "Toll road and congestion scheme charges across the UK", https://news.motability.co.uk/everyday-tips/toll-road-and-congestion-scheme-charges-across-the-uk/ (2021).
407. RAC, "Scrappage schemes – a simple guide", https://www.rac.co.uk/drive/advice/emissions/scrappage-schemes/ (2020)

simply to scrap older, more polluting vehicles.[408] They can also be used to subsidise the cost of retrofitting older vehicles, or upgrading them to satisfy current emissions standards.

To provide support to those needing to upgrade non-compliant vehicles, central government provided funding for two of the cities with Class D CAZs (Birmingham and Bristol),[409] but did not provide any support for London's ULEZ scrappage scheme, which was entirely funded by the GLA itself. Unfortunately, the support available has not proved enough to cover the cost of purchasing compliant vehicles. The £2,000 grants offered by the Birmingham City Council[410] and the Mayor of London,[411] for example, are still far below the current £5,000 average cost of a second-hand ULEZ/CAZ-compliant car.[412]

At present, local authorities cannot use funds raised from CAZs to fund more generous scrappage schemes. Under the Transport Act 2000, and the amendments made under Part VI of the Local Transport Act 2008,[413] local authorities cannot set charges in CAZs to raise additional revenue above and beyond what is necessary to maintain the administration of the CAZ. Any additional revenue raised from CAZs must be reinvested to "facilitate the achievement of local transport policies". Similarly, Schedule 23 of the Greater London Authority Act 1999 requires that any proceeds from the ULEZ "be available only for application for relevant transport purposes".[414]

We recommend the UK Government amend the Transport Act 2000 and the Greater London Authority Act 1999 to allow local and combined

408. Birmingham, "Applications to the Clean Air Zone Vehicle Scrappage and Travel Credit Scheme are now open", https://www.birmingham.gov.uk/news/article/871/applications_to_the_clean_air_zone_vehicle_scrappage_and_travel_credit_scheme_are_now_open (2021).
409. House of Commons Library, "Clean Air Zones, Low Emission Zones and the London ULEZ", https://researchbriefings.files.parliament.uk/documents/CBP-9816/CBP-9816.pdf (2023), 17.
410. Birmingham City Council, "Applications to the Clean Air Zone Vehicle Scrappage and Travel Credit Scheme are now open", https://www.birmingham.gov.uk/news/article/871/applications_to_the_clean_air_zone_vehicle_scrappage_and_travel_credit_scheme_are_now_open (2021).
411. Mayor of London, https://www.london.gov.uk/media-centre/mayors-press-release/MAYOR-ANNOUNCES-SCRAPPAGE-EXPANSION (2023).
412. Rufo, "ULEZ expansion: contested claims examined".
413. Local Transport Act 2008, Pt. 6. See: https://www.legislation.gov.uk/ukpga/2008/26/part/6.
414. Greater London Authority Act 1999, Sch. 23. See: https://www.legislation.gov.uk/ukpga/1999/29/schedule/23.

authorities to pursue 'reasonable profits' from their CAZs, so long as these profits are used to provide more generous scrappage schemes that are specifically targeted at those from deprived areas.

Recommendation four: The Government should immediately pilot a voluntary road pricing scheme for all road users ahead of a national rollout, that includes a free mileage allowance for those on low incomes

As highlighted in Chapter Five, unless HM Treasury finds an alternative source of income to offset the decline of Fuel and Vehicle Excise Duties, the UK Treasury faces a £30 billion budget shortfall between 2020-21 and 2050-51 as a result of the phase out of internal combustion engine vehicles.[415] Moreover, if action is not taken soon to address this shortfall, drivers of electric vehicles may become used to not paying any taxes, making it politically far more difficult to introduce any motoring taxes in the future.[416] This is especially the case with the UK set to phase out all sales of combustion engine vehicles by 2035.[417]

Additionally, because charging electric vehicles is significantly cheaper than refuelling petrol and diesel vehicles, driving is likely to become cheaper than it is now after most car owners switch to electric cars. This in turn is predicted to increase the overall number of car journeys, with the Department for Transport estimating "a shift to electric vehicles would increase national traffic levels by 51% between 2015 and 2050". Although this figure assumes that "all car and LGVs sold are zero emission by 2040 and 97% of car and LGV mileage powered by zero emission technologies by 2050",[418] it still highlights what could happen if no steps are taken to offset the disappearance of Fuel and Excise Duty.

In terms of air pollution, a growth in the number of car journeys

415. Corfe, "Miles ahead", 12-13.
416. House of Commons Transport Committee, "Road Pricing", 6.
417. George Parker, Lucy Fisher and Jim Pickard, "Rishi Sunak announces series of U-turns on net zero pledges", *Financial Times*, 20 September 2023, https://www.ft.com/content/02ecb92e-1e67-4db1-ad73-6c0e76bdc6ca.
418. House of Commons Transport Committee, "Road Pricing", 7.

is a problem because electric vehicles still produce harmful $PM_{2.5}$ emissions, specifically from tyres and road wear.[419] Other existing clean air measures, specifically CAZs, also fail to address the problem of $PM_{2.5}$ emissions from electric vehicles. As Chapters Five and Six showed, by deterring older petrol and diesel cars from driving, CAZs play a key role in reducing transport-related emissions of NO_x, but, because they impose no cost on electric vehicles, are less effective at reducing transport-related $PM_{2.5}$ emissions.[420]

The most viable and most equitable replacement for Fuel and Excise Duties, while also ensuring a reduction in traffic and the consequent $PM_{2.5}$ emissions, is a road pricing scheme that applies to all vehicles, charging road users on a per-mile basis.

However, introducing such a scheme will be politically difficult. Although Social Market Foundation polling found that voters may be open to per-mile road pricing schemes,[421] the recent experience with the ULEZ expansion and the universally negative reaction from our focus groups to the idea suggests that introducing such a scheme will be politically fraught. In particular, as our focus groups suggested, it is likely to be viewed cynically as a revenue-raising measure and there are likely to be privacy concerns owing to the need to electronically track the distance each vehicle travels.[422] These challenges will, however, have to be overcome soon given the 2035 phase out date for petrol and diesel vehicles.

We recommend that, to gradually detoxify per-mile road pricing, central government immediately trial a road pricing scheme for all road users. It would be an 'opt in' scheme, with those volunteering to participate being exempt from Fuel Duty. An immediate set of pilots would lay the groundwork for a national rollout of road pricing schemes

419. Whitty, "Chief Medical Officer's Annual Report 2022: Air pollution", xviii.
420. University of Birmingham, "Clean Air Zone reduces air pollution levels in Birmingham – study", https://www.birmingham.ac.uk/news/2023/clean-air-zone-reduces-air-pollution-levels-in-birmingham-study#:~:text=As%20predicted%2C%20Birmingham's%20CAZ%20reduced,pollutant%20with%20greatest%20health%20effects (2023).
421. Corfe, "Miles Ahead", 7.
422. House of Commons Transport Committee, "Road Pricing", 11.

from around 2035. To incentivise participation in the trial, government might consider what sorts of monetary incentives would be appropriate.

Government could also introduce a temporary 'green miles' scheme that offers a certain proportion of discounted or free miles to those using electric vehicles. This would be phased out over time.

We further recommend that such a scheme provide a 'free mileage' which means allowing motorists to drive a set number of miles before they would have to start paying. This would be targeted, with those from deprived areas, those living in areas with inadequate access to public transport, as well as disabled people, receiving higher free mileage allowances than the general population.

Policies to reduce air pollution from domestic burning

Recommendation five: Amend the Clean Air Act 1993 to permit local authorities to completely ban domestic burning in smoke control areas on days when the DAQI score is forecast to be at a level harmful to human health

Under section 18 of the Clean Air Act 1993, local authorities may designate certain areas to be smoke control areas.[423] In those areas, domestic burning is prohibited unless is done using an 'exempt appliance', that is a Defra-approved stove,[424] or, if the stove is not an exempt appliance, the burning is carried out with a Defra-approved fuel.[425] While Defra-approved stoves and fuels produce less $PM_{2.5}$ emissions than non-approved stoves or fuels, they still produce substantial emissions that local authorities cannot stop. This is especially significant given that domestic burning is now the largest single source of $PM_{2.5}$ emissions in the UK.[426]

423. Clean Air Act 1993. See: https://www.legislation.gov.uk/ukpga/1993/11/part/III.
424. Defra, "Smoke Control Areas: Do you know the rules?, https://uk-air.defra.gov.uk/assets/documents/reports/cat07/1901291328_Smoke_Control_Web.pdf (2022); Defra, "Exempt appliances England", https://smokecontrol.defra.gov.uk/appliances.php?country=england (2023).
425. Defra, "Authorised/Certified Fuels for England", https://smokecontrol.defra.gov.uk/fuels.php?country=england (2023).
426. Defra, "National Statistics: Particulate matter (PM10 and PM2.5)".

To help address this problem, we recommend that section 18 of the Clean Air Act 1993 be amended to give local authorities the power to ban domestic burning completely on days when DAQI is forecast to produce a score of four or higher – the level at which air pollution becomes harmful to human health. Exemptions would be available for the very small number of households with no alternative source of heating.[427] Because this policy would target any smoke emissions, as opposed to smoke emissions below a certain threshold, this would likely be easier for local authorities to enforce than the existing some control regime.

There are several ways to communicate these temporary bans to the public. Australia provides several examples of these. Australia communicates regional fire bans through a combination of announcements on radio, television and internet weather forecasts, social media updates, and government agency websites.[428] Although in a different context – to stop outdoor burning to prevent the outbreak of bushfires rather than to stop indoor domestic to reduce concentrations of air pollution – these approaches could be used to communicate when the bans are in effect.

Recommendation six: Ban the sale of new stoves that emit more than 150g of $PM_{2.5}$ for every gigajoule of energy produced

From 1 January 2022, fulfilling commitments made while it was still a member of the EU,[429] the UK banned the installation of new stoves that failed to meet the new Ecodesign standards, meaning stoves that emit up to 375g of $PM_{2.5}$ for every gigajoule of energy produced.

However, as mentioned in Chapter Five, while Ecodesign stoves are 90% less polluting than non-Ecodesign stoves, they still produce $PM_{2.5}$ emissions 750 times greater per hour than an HGV vehicle, and more than 450 times more $PM_{2.5}$ emissions per hour than a gas boiler.[430] As

427. Defra, "Daily Air Quality Index", https://uk-air.defra.gov.uk/air-pollution/daqi (2023).
428. Government of Western Australia, "Emergency WA", https://www.emergency.wa.gov.au/ (2023).
429. Defra, "Clean Air Strategy 2019", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf, 59.
430. Whitty, "Chief Medical Officer's Annual Report 2022: Air pollution", xiv.

such, even the new standards still permit far higher than acceptable emissions of $PM_{2.5}$.

While we do not support an outright ban on the installation of new stoves, we recommend that Defra further tighten emissions standards to ensure that no new stoves emit more than 150g of $PM_{2.5}$ for every gigajoule of energy produced, which is official standard in the Nordic countries.[431]

Recommendation seven: Warning labels to be added to all new and refurbished stoves

As outlined in Chapter Three, there is little public awareness of the harmful medical effects that domestic burning causes not only to people who burn domestically themselves, but, to their neighbours. This is reflected in the recent increase in sales of stoves in recent years.[432] It is also reflected in the mistaken belief among many people, especially among more affluent households, that domestic burning is a safer, more environmentally friendly way of heating one's home than gas boilers.

Under EU Regulation 2015/1186, which remains incorporated into UK domestic law, new stoves are required to have an energy rating label attached, but not a health warning.[433] The UK's statutory guidance for combustion appliances, which includes stoves, requires them "to incorporate an appropriate means of warning of a release of carbon monoxide". However, the guidance contains no requirement for new stoves to contain labels warning about the negative health consequences of the outdoor pollution that stoves emit, particularly emissions of $PM_{2.5}$.[434]

431. European Environmental Bureau and Green Transition Denmark, "Where there's fire, there's smoke: Emissions from domestic heating with wood", https://eeb.org/wp-content/uploads/2021/09/Where-theres-fire-theres-smoke_domestic-heating-study_2021.pdf (2021), 7.
432. Damian Carrington, "Wood burning at home now biggest cause of UK particle pollution", *The Guardian*, 16 February 2021, https://www.theguardian.com/environment/2021/feb/16/home-wood-burning-biggest-cause-particle-pollution-fires.
433. Commission Delegated Regulation (EU) 2015/1186, https://www.legislation.gov.uk/eur/2015/1186.
434. HM Government, "Statutory guidance: Combustion appliances and fuel storage systems: Approved Document J", https://www.gov.uk/government/publications/combustion-appliances-and-fuel-storage-systems-approved-document-j (2022), 17.

We recommend that Defra require that all new stoves have mandatory warning labels attached that specifically highlight the negative medical consequences of the outdoor air pollution that even Defra-approved stoves still produce.

Conclusion

Air pollution is linked to growing numbers of serious health problems, but also disproportionately affects people from deprived areas. Despite reductions in the total emissions of the main air pollutants, exposure to dangerous concentrations of those pollutants, especially $PM_{2.5}$ and NO_x, still causes an estimated 29,000 to 43,000 deaths per year.[435] As highlighted in this report, transport and domestic burning are two sources of air pollution that are especially consequential in deprived areas.

This report offers some policies for central government to both reduce air pollution and to mitigate the negative effects that measures to reduce air pollution will have on those in deprived areas. These policies will not singlehandedly resolve the problems of air pollution from transport and domestic burning. However, they will help to ensure that the UK reduces its air pollution to some extent in ways that directly benefit, rather than penalise, people living in England's deprived areas.

435. UK Health Security Agency, "Chemical Hazards and Poisons Report", 15.

Annex:
Focus group discussion guide

Welcome and thank you to you all for volunteering to take part in this focus group today, I appreciate your time. My name is X and I work at an independent research agency called BMG Research. I will be guiding and moderating today's discussion.

This discussion is designed to help inform a report by a think tank called Bright Blue on how to deliver clean air in a socially just way. The report is sponsored by Impact on Urban Health, a non-profit organisation, whose mission is to improve the health and well-being of urban communities by removing the obstacles to good health.

Confidentiality: All information you provide will be treated confidentially. We will not identify any individuals or share the personal details of those who took part. I am independent. Your responses are strictly confidential which is required by the Market Research Society.

- Views stated are not linked to individuals and the more open and honest you can be the better.
- We may use some of the things you say in our reports, but we won't reveal who said them. This is in line with the Market Research Society Code of Conduct.
- You do not have to take part in this research. Participation is voluntary and you can withdraw your consent to take part at any time.

Ground rules: Before we get to the discussion, I wanted to take the opportunity to lay out some ground rules, some of which we've already touched on:

1. There are no right or wrong answers to any of the questions today, so please bear that in mind and respect the opinions of others even if you do not agree.
2. We want to have a good discussion so please try not to interrupt others and allow one person to speak at a time.
3. Again, we want the discussion to flow naturally, but I might sometimes step in to make sure we keep on track.
4. Let's remember to respect everyone's confidentiality and privacy after the focus group is over by not discussing what was said with others.

Recording: We would like to audio-record the discussion for the purposes of accurately capturing all the information you share with us. The audio will be used for analysis purposes only and will not be shared with anyone outside of BMG research.

Introduction:

Ice breaker and introductions (Moderator to go around the group and get name and what people like to do in free time)

Part 1: Effects of air pollution:

1. When you think of air pollution, what comes to mind?
2. How do you think air pollution affects the area you live in?
3. How do you think air pollution might affect you?
   Prompt: how do you think it might affect your health or your children's?

Part 2: Key sources of air pollution in their area

1. How bad do you think air pollution in your area is?
   Prompt: Why do you think that is?
2. What do you think contributes to air pollution in your area?
   Prompts: what kind of activities/jobs/sectors do you think contribute the most e.g., car exhaust, construction activity, indoor wood/coal burning?

Part 3: Current policies

1. How important do you think it is for the UK national Government to try and tackle air pollution in your area?
2. Are you aware of any of the things the UK national Government has done, or is doing, to reduce air pollution?
   Prompt: How do you feel about these policies? (Good/bad, working/not working)
   Why?
3. How important do you think it is for your local government to try and tackle air pollution in your area?
4. Are you aware of any thing the local government is trying to do to fix air pollution in your area? How do you think these policies are working? (Very well/fairly well/not well)
   Prompt: Why?
5. How do you think the policies from either national or local governments affect/will affect you?
   Prompt: and what about the people of your area?

Part 4: CAZs

BIRMINGHAM GROUP

Questions for groups living where a CAZ is in place:

1. Who here has heard of 'Clean Air Zones (CAZ)'? IF YES: Can you tell me how it works in practice?

Brief description of CAZs: specific locations where targeted action is taken to improve air quality, particular by discouraging the most polluting vehicles from entering the zone. In charging zones, drivers must pay a fee to enter the area if their vehicle fails to meet the required environmental standards for that zone.

The vehicles affected are typically petrol cars from before 2006 and diesel cars from before 2015. Daily charges for private cars vary by city. In Birmingham, for example, it costs £8 per day to drive a polluting vehicle, but in London it costs £12.50.

2. How do you feel about Clean Air Zones generally and the Clean Air Zone in your area?
   Prompt: How important do you think they are for reducing air pollution?
3. Based on what you saw/heard, how do you feel the introduction of the CAZ was communicated?
4. What impact do you think the CAZ has on your area?
5. How do you think the CAZ affects your daily life?
   Prompt: positively/negatively/not at all?
6. How do you feel the CAZ has changed your behaviour? If so, how?
7. How do you feel the CAZ has affected the wider community? If so, how?
8. Has the CAZ been fair?
9. Do you think there should be more exemptions for charging in CAZs?
10. Do you think the CAZ is working?
11. If you were to make any changes to the CAZ, what would they be?

LONDON GROUP

Questions for groups who live in areas to be included within the expanded ULEZ:

1. Who here has heard of the ULEZ? IF YES: Can you tell me how it works in practice?

   Brief description of the ULEZ: a designated area, currently limited to central London, but soon to include all Greater London, that charges drivers £12.50 per day to enter if their vehicle does not meet the required environmental standards. The purpose of the ULEZ is to improve air quality, particular by discouraging the most polluting vehicles from entering the zone.
2. How do you feel about the ULEZ?
3. How do you feel the about the ULEZ being introduced in your area?
4. How do you feel the ULEZ expansion has been communicated to you?
   Prompt: How do you think the ULEZ will affect your daily life? Do you think they are for reducing air pollution?
5. What impact do you think the ULEZ will have on your area?
   Prompt: positively/negatively/not at all?
6. How do you feel the ULEZ will change your behaviour?
7. How do you feel a ULEZ will affect the wider community?
8. Is introduction of the ULEZ fair?
9. Should there be any exemptions from ULEZ charges?
10. Should there be any changes to the ULEZ?

LIVERPOOL GROUP:

Questions for areas with no CAZ and no plans for one:

7. Who here has heard of 'Clean Air Zones (CAZ)'? IF YES: Can you tell me how it works in practice?

Brief description of CAZs: specific locations where targeted action is taken to improve air quality, particular by discouraging the most polluting vehicles from entering the zone. In charging zones, drivers must pay a fee to enter the area if their vehicle fails to meet the required environmental standards for that zone.

The vehicles affected are typically petrol cars from before 2006 and diesel cars from before 2015. Daily charges for private cars vary by city. In Birmingham, for example, it costs £8 per day to drive a polluting vehicle, but in London it costs £12.50.

8. How do you feel about Clean Air Zones?

9. How do you feel about the idea of introducing a Clean Air Zone in your area?

Prompt: How do you think a CAZ would affect your daily life? Do you think they are for reducing air pollution?

10. What impact do you think a clean air zone would have on your area?

Prompt: positively/negatively/not at all?

11. How do you feel the introduction of a CAZ has would change your behaviour?

12. How do you feel a CAZ would affect the wider community?

13. Should there be any exemptions from CAZ charges?

14. Would the introduction of a CAZ be fair?

ALL GROUPS

Part 5: Alternative transport-based policies

Road Pricing Schemes

Description of road pricing schemes: As the UK transitions away from petrol and diesel towards electric vehicles, the government will face a budget shortfall due to the disappearance of vehicle excise duty and fuel duty.

In those circumstances, road pricing schemes could be introduced to offset lost revenue. Road pricing schemes are when drivers have to pay on a per-mile basis. They have two purposes: first, to generate revenue; and, secondly, to manage the costs of motoring such as pollution, emissions and congestion.

The schemes could include, for example, giving everyone a free mileage allowance, giving a smaller allowance to those living near good public transport would receive, or giving a larger allowance to those with disabilities

a. How would you feel about introducing a pricing system to offset the lost revenue?
b. How would a road pricing scheme affect your behaviour?
c. Should there be exemptions in any road pricing schemes?
d. What changes would you make to any road pricing scheme?

Low Traffic Neighbourhoods

Brief description of Low Traffic Neighbourhoods: Schemes introduced by the local authorities to reduce traffic in residential areas and so reduce air and noise pollution.

This is achieved through a series of measures including the installation of barriers such as bollards, boom barriers, and planters.

Private vehicles would still have easy access to all homes and businesses, they just won't drive directly through the LTN.

1. How do you feel about Low Traffic Neighbourhoods (called Places for People in Birmingham)
2. If living near a Low Traffic Neighbourhood?
   a. How has the LTN affected your behaviour?
   b. Do you think the introduction of the LTN has been fair?
   c. Do you think the LTN has been effective?
   d. What changes would you make to the LTN?

ALL GROUPS

Part 6: Alternative policies

1. How do you feel about the impact of indoor burning on air pollution (such as through burning wood in indoor stoves or open fires)?
2. How do you feel about restricting or banning indoor wood burning to reduce air pollution?
3. Who here has heard of heat pumps? IF YES: Can you tell me how they work in practice?

   Brief description of heat pumps: devices that use a small amount of energy to move heat from one location to another. During winter, heat pumps move warm air from outside into the house. Because they are powered by electricity, heat pumps can be powered by renewable energy, which means they are more environmentally friendly than gas boilers, which rely on burning fossil fuels.

   a. How do you feel about replacing gas boilers from homes with more environmentally-friendly heat pumps?
   b. What level of support would you need to consider installing a heat pump?
   c. If the government provided enough financial support to cover the full cost, would you instal a heat pump?
   d. If not, why?

4. Is there anything else you would like to see done to reduce air pollution in your area? If so, what kind of things?
   Prompt: e.g. restricting domestic wood burning, phasing out gas boilers from homes, phasing out diesel cars, tighter regulation of the construction industry (such as stricter controls over the emission of dust particles coming from construction sites).

Wrap up:

1. Invite any final comments
2. Thank and close

Man-made air pollution contributes to an estimated 29,000 to 43,000 deaths in the UK each year. Moreover, there is increasing evidence that the harmful effects of air pollution can be felt across people's lifetimes, from infancy to old age.

Worse still, the negative consequences of air pollution fall most heavily on England's deprived communities, who disproportionately live in areas with the worst air quality. This report's unique contribution is to analyse the scale of, impact of and original solutions for the poor air quality in England's deprived areas.

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Bright Blue Campaign
brightblue.org.uk

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