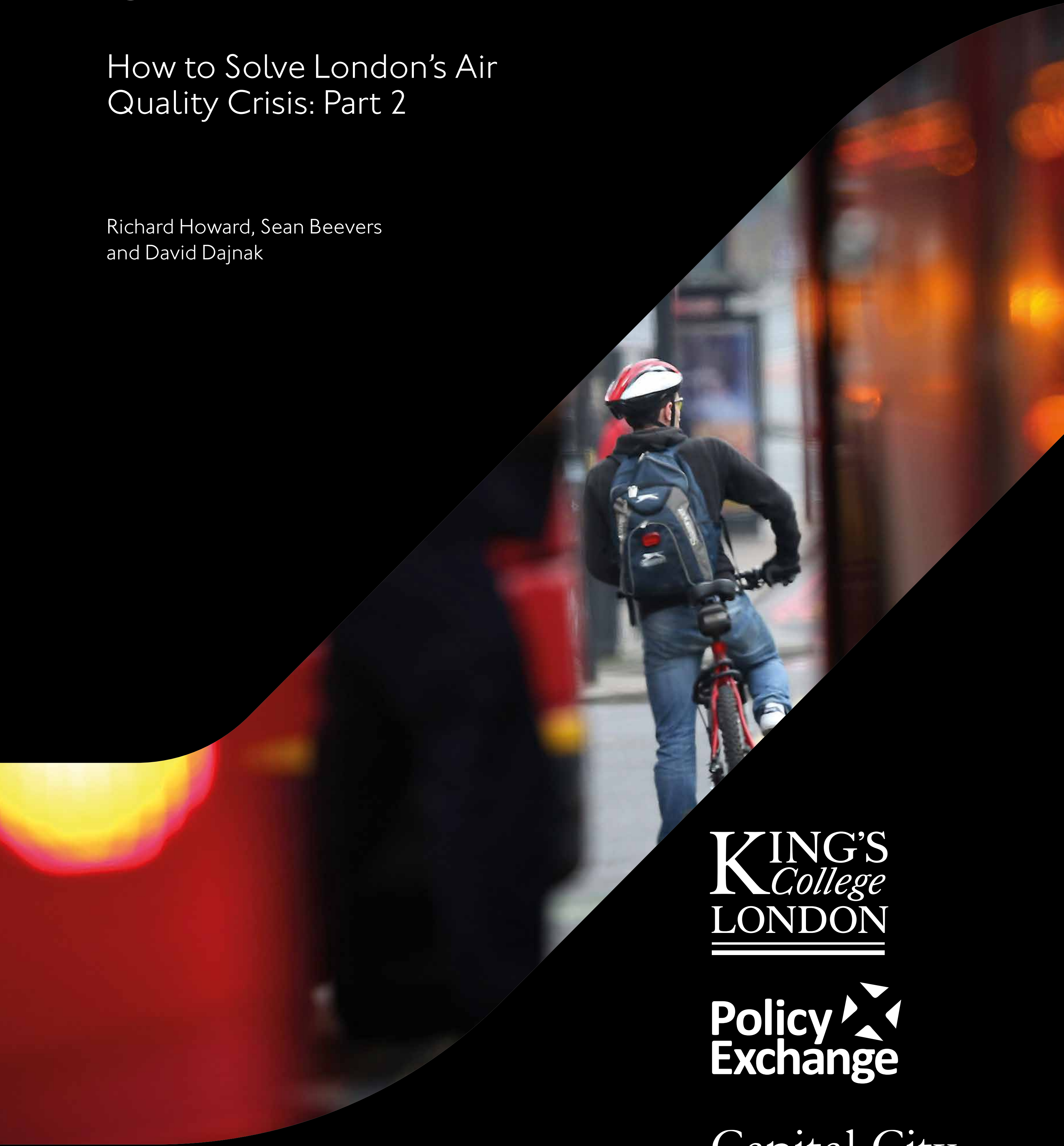
UP IN THE AIR

How to Solve London's Air Quality Crisis: Part 2

Richard Howard, Sean Beevers
and David Dajnak



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Executive summary

London is facing an air pollution crisis. Our previous report *Up in the Air: Part 1* documented the fact that 12.5% of London's total area exceeded legal and healthy limits for nitrogen dioxide (NO_2) in 2010. This area contained a workplace population of 3.8 million people, as well as 979 schools attended by a quarter of London's school population. Poorer parts of London are disproportionately affected by air pollution. The European Court of Justice has ruled that the UK must put in place a plan to achieve air quality limits in the "shortest time possible". If air pollution stayed at current levels it would reduce the average life expectancy across all Londoners born in 2010 by up to 2 years. Short term exposure to air pollution is responsible for nearly 3,500 hospital admissions per year in London. **In short, there is a legal and moral imperative to improve London's air quality, and more needs to be done about it.**

The next Mayor of London needs to create and deliver an ambitious plan to clean up London's air. Exactly sixty years on from the Clean Air Act in 1956, London still faces a significant air pollution challenge and requires an equally robust response. Current and planned policies will not deliver a sufficient improvement in air quality: as it stands air quality limits are unlikely to be achieved in London until at least 2030. This report proposes a package of measures to achieve a step change in emissions and air quality. We focus on two main sectors – road transport and gas combustion – which together are responsible for more than 85% of Nitrogen Oxide (NO_x) and Particulate Matter (PM) emissions in Central London, where pollution levels are highest.

Care needs to be taken to avoid unduly penalising local residents and businesses. Recent polls show that air quality is the most pressing environmental concern identified by Londoners.[1] At the same time, the experience from the implementation of other air quality measures such as the Ultra Low Emission Zone has shown that businesses and residents need time to accommodate change, and will resist change if it involves significant cost, disruption or retrospective policy changes. London needs an air quality strategy which is more ambitious, but also incorporates views from residents and businesses on what is realistic and in what timescale. Our policy recommendations seek to strike an appropriate balance between the need to improve air quality as soon as possible, and the cost and acceptability of making further interventions.

London cannot act alone in addressing air pollution. This report proposes a mix of policies at London, UK and European level, many of which fall outside the Mayor's direct control. The next Mayor of London will need to provide strong leadership on this issue in order to bring about change. Central Government departments such as HM Treasury, Defra, DECC, and DfT must also look at how national policies can be used to deliver improvements in air quality.

Road transport

Road transport is the most significant source of NO_x emissions and is overwhelmingly a diesel problem. The UK has undergone a massive shift towards diesel vehicles over the last 15 years, supported by European legislation and UK financial incentives geared towards lower CO_2 vehicles. Whilst diesel cars had a CO_2 advantage in the past, this has now been eroded. However, diesels have much higher emissions of local pollutants (NO_x and PM) than petrol or alternatively fuelled vehicles. For example, Euro 5 diesel cars sold in the period 2009–2014 emit on average 20 times more NO_x per kilometre than petrol cars sold during the same period. The growth in diesel emissions has meant that NO_2 concentrations around Inner London roads have shown little if any improvement since the early 2000s. **In hindsight, the shift from petrol to diesel vehicles over the last 15 years has been disastrous in terms of its impact on air quality and health.** There needs to be recognition at European, UK and London level that diesel has been the primary cause of the current air pollution crisis, and that only by moving away from diesel can the situation be improved.

Vehicle manufacturers have failed to deliver a sufficient improvement in NO_x emissions from diesels. Research shows that Euro 5 diesel cars and vans are no better than the Euro 1 diesels sold in the early 1990s in terms of NO_x emissions on the road. The latest Euro 6 diesel cars show some improvement but still have on-road emissions some 2.5 to 7 times higher than the Euro 6 standard. On this basis, a key priority must be to tighten and enforce European diesel emissions standards. The introduction of a "Real Driving Emissions" test which better reflects real world emissions performance is a welcome step forward. But the European Commission has undermined the effectiveness of the test by incorporating a huge margin of error into the way that it will be implemented, in the form of so-called "conformity factors". **We recommend that the European Commission makes further changes to deliver the original Euro 6 diesel car standards in full by 2021, removing unnecessary margin of error**. Failure to do so will significantly undermine efforts to clean up road transport.

The failure of the emission standards regime has been compounded by the significant shift towards diesels over the last 15 years. **Shifting away from diesels to a mix of petrol, hybrid, electric and LPG vehicles can significantly reduce local pollutants whilst having no adverse impact on CO_2 emissions.** In order to achieve this, the financial incentives that promoted the uptake of diesels in the first place need to be removed and reversed. Changes to Vehicle Excise Duty, Company Car Tax and Capital Allowances are required to reflect the higher NO_x emissions associated with diesels.

Government should also create a diesel scrappage scheme, providing grants to motorists to take diesel cars and vans off the road and replace them with lower emission alternatives such as petrol or electric. There is also a potential role for vehicles powered by Liquefied Petroleum Gas (LPG) which have substantially lower emissions than diesel vehicles, and are widespread across Europe. **Government needs to provide greater certainty about LPG fuel duty in order to drive its adoption.**

At London level, we propose a number of targeted policies to restrict the most polluting vehicles and promote low emission alternatives, as follows:

- **Low Emission Zones:** There is already a Low Emission Zone (LEZ) in place across Greater London, but emissions limits are too weak for it to have a significant impact on NO_x emissions. Emissions standards for buses, coaches and HGVs in the Low Emission Zone should be tightened by no later than 2023 (and potentially earlier). There are also plans for an Ultra Low Emission Zone (ULEZ) in Central London from 2020. We propose that the ULEZ emissions standards are tightened further for diesel cars by 2025.

- **Buses:** Transport for London should upgrade all buses to a minimum of the Euro VI standard in Central London by 2020 and across the whole of London by 2023 at the latest.
- **Taxis:** Policies already require that newly registered taxis must be 'Zero Emission Capable' from 2018 onwards, but this still leaves a large fleet of existing highly-polluting diesel taxis. We recommend reducing the age limit for taxis from 15 years to 10 years by 2025, upgrading all taxis to a minimum of Euro 6. TfL should support the financing of taxi retrofit solutions (for example LPG conversion) provided that these can be shown to meet the equivalent of the Euro 6 standard.
- **Electric Vehicles and Car Clubs:** the widespread adoption of electric vehicles will lead to a significant reduction in local emissions. Electric vehicle car sharing clubs offer the potential to transform car usage patterns, reducing the amount that people drive, as well as overall car ownership. Transport for London needs to work with the London Boroughs to drive the rollout of a competitive pan-London network of charging points and car clubs.

Overall, the combination of existing policies and our proposals is predicted to result in a 75% reduction in NO_x emissions from road transport across Greater London by 2025, and an 82% reduction in Central London. The changes to Low Emissions Zones, buses and taxis are predicted to result in significant savings in Central London; whilst the changes to emissions standards and fiscal policies are more significant across London as a whole. The proposed changes to emission standards and fiscal policies would also result in a significant reduction in NO_x emissions across the UK as a whole, benefitting other cities which face air pollution issues. The policies also result in a small reduction in CO_2 and PM emissions across London.

Gas combustion and decentralised energy

Gas combustion in buildings (e.g. boilers and cookers) is a major source of local pollution, producing 21% of total NO_x emissions across Greater London, and 38% in Central London. Modelling shows that gas combustion is likely to overtake road transport as the single biggest source of NO_x emissions in Central London by 2020, although road transport will remain the most significant when it comes to its contribution to pollution hotspots (since gas combustion emissions are more dispersed than emissions from road transport).

Despite its significance, gas combustion has been largely overlooked in air quality terms. Regulations concerning building standards and boilers tend to focus on efficiency and CO_2 emissions, and have only recently begun to consider emissions of local pollutants. **It is imperative that policymakers also address emissions from gas combustion if air quality limits are to be reached.**

The next Mayor of London needs to set out an ambitious plan to clean up London's stock of boilers in order to improve air quality. National policies such as the Energy Company Obligation will deliver some boiler improvements in London, but further policies are likely to be required in London. We advocate the creation of a **boiler scrappage scheme**, providing grants to households and businesses in London to upgrade their heating systems. This has been shown to be a cost effective and impactful way to reduce NO_x emissions. London has recently created a boiler cashback scheme, but the ambition of the scheme needs to be substantially increased, and it needs to be targeted more towards air quality improvement in Inner London.

We have also identified a risk associated with the growth of "decentralised energy" in London. Decentralised energy is being promoted by the GLA and DECC as a means to reduce carbon emissions and ensure security of supply. However, certain forms of decentralised energy produce significant NO_x emissions, for example small scale gas and diesel engines, biomass boilers and CHP (Combined Heat and Power) installations. **We recommend that the next Mayor of London reconsiders London's Climate Change and Energy Strategy to reconcile the potential conflict between decentralised energy and air pollution. We also recommend changes to national energy policies led by DECC in order to resolve potential conflicts with local air pollution.**

Air quality and health

Our modelling suggests that these policies (together with current and committed policies) will deliver compliance with NO_2 limits across 99.9% of London's area by 2025, representing a massive improvement over and above the status quo.

However, despite this improvement in air quality, our analysis still shows an area of 2 sq km (or 0.1% of Greater London) which would not meet NO_2 limits despite the proposed policies. Although this is a relatively small area, it represents a total of around 220 individual roads (315km road length), mainly within Central London as well as some of the main arterial routes into Central London. **In order to achieve full compliance with air quality limits across London, further targeted actions will be required to tackle air pollution in areas where it would otherwise remain stubbornly high.**

We have identified three roads – Oxford Street, Brixton Road and Knightsbridge – which would still exceed NO_2 limits by a significant margin despite the policies we propose. Our analysis shows that buses and coaches make up 70% of the residual emissions on these roads. **This suggests that localised action to clean up the bus fleet on the most polluted roads is likely to be required, creating "clean bus corridors" where only ultra low emission buses are used (e.g. hybrid, electric, hydrogen), and rerouting some services.**

In addition we have identified a larger number of roads which are only slightly above the NO_2 limit after taking into account our proposed policies. Pollution on these roads relates to a wide range of vehicle types, although the bulk of emissions relates to vans and lorries (nearly 40%). **On this basis we suggest that the most polluted parts of London should adopt "smarter freight" approaches, such as using freight consolidation centres to reduce the number of vehicle movements.**

The improvements in air quality as a result of the proposed policies will deliver a significant improvement in health outcomes across London, increasing the average life expectancy of Londoners born in 2025 by over 1 month. The economic value associated with the improvement in life expectancy is estimated at £600 million per annum. Some of the policies will also lead to air quality and health benefits outside London, for example the proposed changes to fiscal incentives apply across the UK, and emissions standards across Europe. These benefits have not been quantified here but are likely to be very significant.

01 Tackling diesel emissions

Background

This Chapter of the report considers a range of policies to significantly reduce emissions from road transport – the primary source of NO_x and PM emissions in London (see the Part 1 report, Table 1.1 for a definition of key pollutants). Road transport was responsible for 45% of NO_x emissions and 70% of PM_{10} emissions in Greater London in 2010, and 48% of NO_x emissions and 77% of PM_{10} emissions in Central London (the area defined by the Congestion Charge Zone). Road transport tends to make a disproportionate contribution to pollution hotspots as emissions are highly concentrated in specific areas such as busy roads and junctions, whilst other sources of emissions such as gas combustion are much more dispersed. **Tackling road emissions is therefore essential if air quality limits are to be met.**

Trend data shows that NO_2 concentrations at roadside locations in Inner London Boroughs[2] have barely improved since the early 2000s (see Part 1 report, Figure 2.2). This is due to the "dieselisation" of the vehicle fleet which has taken place over the last 15 years, combined with the systematic failure of emissions standards to limit NO_x emissions from diesels, both of which are explored further below.

There are a range of existing and planned policies to address NO_x emissions from road transport, including European emissions standards ("Euro standards"), the existing Low Emission Zone across London, the planned Ultra Low Emission Zone to be introduced in Central London from 2020, upgrades to TfL buses, and rules requiring newly licensed taxis to be "Zero Emission Capable" from 2018 onwards. These policies form a "Base Case" for the purposes of our analysis. Modelling shows that these policies, combined with natural turnover of the vehicle fleet, are expected to yield a significant reduction in NO_x emissions from road transport – a 47% reduction by 2020, and a 61% reduction by 2025 in the Greater London area (Figure 1.1).[3] Within this it is expected that there will be a very sharp reduction in emissions from buses, coaches, HGVs and petrol cars.

Figure 1.1: Forecast NO_x emissions from road transport (Base Case)[4]

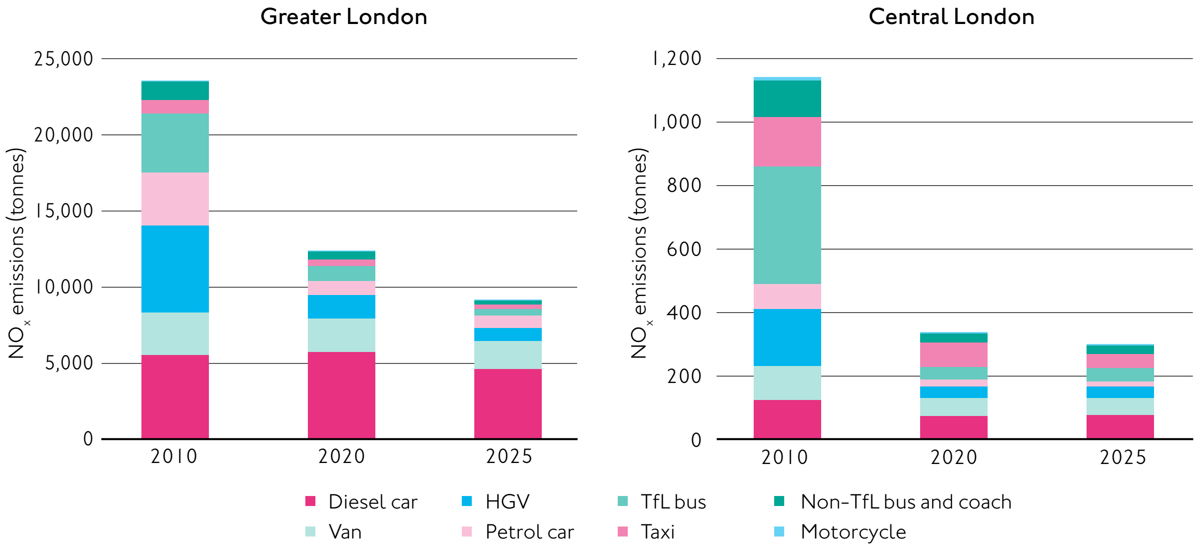
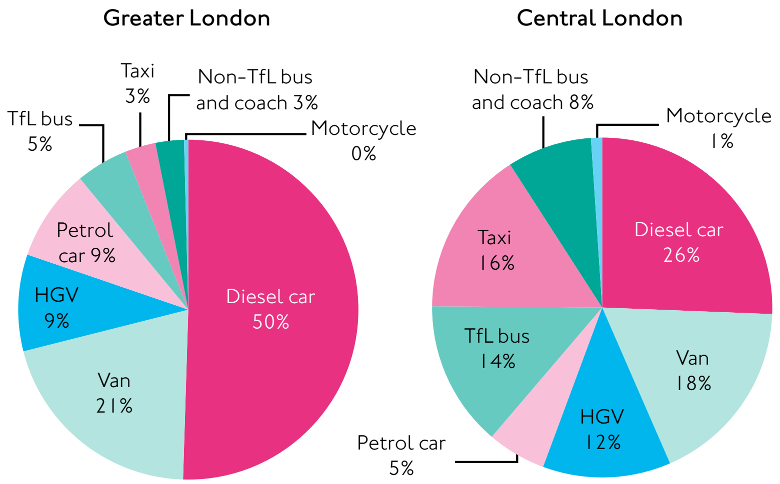


Figure 1.2: NO_x emissions from road transport, 2025[5]



However by contrast, it is expected that even with the current suite of policies, NO_x emissions from diesel cars will remain stubbornly high across Greater London (Figure 1.2)**.** By 2025, based on current and committed policies, it is predicted that diesel cars will account for around half of all NO_x emissions from road transport in Greater London. NO_x emissions in Central London are more skewed towards taxis, buses and coaches, which together are expected to make up 38% of road transport emissions in 2025, although emissions from diesel cars are still very significant (26%). **For these reasons, we have focused our policy analysis and recommendations on measures to reduce emissions from diesel cars, whilst also including opportunities for further improvements in other vehicle types such as vans, taxis, buses, coaches and HGVs.**

Although London faces the highest levels of NO_2 pollution within the UK, it is not purely a London-specific problem. Equally, London cannot solve its air pollution problem entirely on its own. The Mayor of London has a legal responsibility to develop and implement an Air Quality Strategy to achieve air quality limits, and together with London Boroughs has control over many policy levers to address air pollution (e.g. Low Emission Zones, parking charges, planning policies, taxi licencing, and some public transport). But there are many policy levers which are outside the Mayor's direct control, such as vehicle emissions standards and fiscal policies. **Our view is that tackling air pollution will require a combination of policy interventions at European, National and London level.**

In this chapter we describe three sets of policies aimed at reducing emissions from diesel vehicles:

1. **Tighten emissions standards for diesel cars** (European level)
2. **Use fiscal incentives to encourage a shift away from diesel** (UK policy)
3. **Targeted measures to restrict the most polluting vehicles from London and promote alternatives** (London level)

These policies are described in turn and the impact of all policies is presented at the end of this Chapter. The air quality and health impact of all policies is described in Chapter 3. It should be noted that all of these policies are additional to the policies already in place or previously committed (which for modelling purposes are included in the Base Case).

Policy 1: Tighten emissions standards for diesel cars

The primary causes of the air pollution crisis we now face are that emissions standards have failed to control emissions from diesel vehicles, and our use of diesel vehicles has increased over time. The Part 1 report documented the fact that diesel vehicles, especially cars and vans, have failed to perform in line with Euro emissions standards in practice. As part of a growing evidence base, researchers at King's College London undertook testing of over 80,000 vehicles at roadside locations in 2011, finding that there had been little or no improvement in terms of NO_x emissions from diesel cars, vans, HGVs or buses over the preceding 20 years.[6] In contrast, the same study also showed that there had been a significant improvement in the NO_x emissions performance of petrol cars (see Part 1 report, Figure 2.5). A range of other studies have come to similar findings, for example a study by the European Joint Research Centre concluded that petrol cars largely performed within Euro emissions limits, whilst diesel cars had emissions 4 to 7 times higher than the limits, and showed little improvement between Euro 3 and Euro 5.[7] Vehicle manufacturers have employed a range of increasingly sophisticated strategies simply to pass the emissions test, leading to an increasing gap between test figures and real world performance.

Diesel cars continue to emit far more NO_x than petrol cars. For example, Euro 5 diesel cars emit nearly 20 times as much NO_x per km as Euro 5 petrol cars, whilst Euro 6 diesel cars emit more than five times as much NO_x as Euro 6 petrol cars (Table 1.1).[8] The comparative performance of diesel cars is even worse when it comes to emissions of "primary NO_2" – the component of NO_x which is emitted directly from the exhaust as NO_2 and is both the greatest health concern and of greatest importance in meeting NO_2 limits close to roads. Euro 5 diesel cars have primary NO_2 emissions some 310 times higher than Euro 5 petrol cars.[9]

Table 1.1: Summary of emissions data for diesel and petrol cars

Vehicle type	NO_x (g/km)	
	Real world performance	**Euro Standard**
Euro 1 diesel car (1992–1996)	0.98#	0.97
Euro 5 diesel car (2009–2014)	1.12#	0.50
Euro 6 diesel car (2014 onwards)	0.27*	0.08
Euro 1 petrol car (1992–1996)	1.15#	0.97
Euro 5 petrol car (2009–2014)	0.06#	0.06
Euro 6 petrol car (2014 onwards)	0.05*	0.06

Sources:
based on Remote Sensing Data from Carslaw, D. et al (2011) *Trends in NO_x and NO_2 emissions and ambient measurements in the UK*. Defra.
* based on emissions factors from COPERT version 10.

In recognition of this problem, the European Commission is now proposing the introduction of a new on-road "Real Driving Emissions" (RDE) test which new vehicles will have to pass in addition to laboratory tests (this standard is referred to as "Euro 6c").[10] It has been proposed that the RDE test will be introduced for new models in Europe from the 1st September 2017, and for all new vehicles sold from September 2019. In theory the introduction of the RDE test will reduce or remove the discrepancy between real-world performance and test results, and bring about a significant reduction in emissions.

However, the European Commission has agreed to introduce the RDE test in stages, reflecting the fact that it will take time for car manufacturers to develop and implement new emission reduction technologies and comply with the standard. The EC has proposed a set of "conformity factors" which require manufacturers to reduce the discrepancy between real world emissions and the Euro 6 diesel car standard over time. The current discrepancy of real world diesel car emissions compared with the Euro 6 emissions standard is estimated to be approximately 340%, or a conformity factor of 3.4 (e.g. real world NO_x emissions of 0.27 g/km, compared to the Euro 6 standard of 0.08g/km). The EC has proposed that this discrepancy should be reduced as follows:

- **Euro 6c Stage 1**: To have a maximum conformity factor of 2.1 for new models sold from September 2017 and for all new vehicles sold from September 2019 (e.g. NO_x emissions of 0.168g/km or below); and
- **Euro 6c Stage 2**: To have a maximum conformity factor of 1.5 for new models sold from January 2020 and for all new vehicles from January 2021 (e.g. NO_x emissions of 0.12g/km or below).

We believe that the European Commission's proposals do not go far enough. Under current proposals, in 2021 and thereafter, seven years after the introduction of Euro 6, new diesel cars may still be sold legally emitting 50% more NO_x than the Euro 6 standard. Diesel cars sold in the period up to 2021 will legally be allowed to emit 110% more NO_x than the Euro 6 standard. Although the current proposals achieve some improvement versus the status quo, the improvement is too small and too late.

Part of the justification for the conformity factor of 1.5 in 2021 is to accommodate a 50% margin of error in the testing method. On-road performance will be tested using a Portable Emissions Measurement System (PEMS), which like any measurement technique has an associated level of uncertainty. However, the EC's own analysis shows that PEMS systems have a typical margin of error of 30%,[11] implying that the conformity factor for any single vehicle should be 1.3, not 1.5.

Moreover the EC could think more cleverly about how it applies this margin of error, creating requirements at manufacturer level in addition to requirements for individual vehicles. Whilst it is right to allow a margin of error for any individual vehicle, this should average out across the fleet of cars sold by each manufacturer, with a range of values above and below the Euro 6 standard. **Therefore we propose that in addition to the requirement for each individual vehicle not to exceed a conformity factor of 1.3, each manufacturer should also be required to meet a conformity factor of 1.0 across their fleet of diesel cars from 2021 onwards (on a sales weighted basis).** As an interim step we propose a fleet-wide conformity factor of 1.5 plus a 30% margin of error for individual models, to be applied to new models from September 2017 and all cars sold from September 2019.

Emissions impact of Policy 1

To test the emissions impact of Policy 1, we have made the following assumptions:

- All Euro 6 diesel cars sold until 2018 are assumed to have a NO_x emissions rate reflecting their current on-road performance – e.g. 0.27g/km NO_x or a conformity factor of 3.4.
- New diesel cars sold between 2018 and 2020 are assumed to achieve a conformity factor of 1.5 (e.g. 0.12 g/km NO_x) at average London road speeds.
- New diesel cars sold from 2020 onwards are assumed to achieve a conformity factor of 1.0 (e.g. 0.08 g/km NO_x) at average road speeds, meeting the original Euro 6 diesel standard.
- The modelling methods employed build in a relationship between vehicle speed and emissions. In congested parts of the city, where vehicle speeds are lower, the NO_x emissions from these vehicles will be higher than at the average London road speed.

The emissions impact of all policies is presented in Table 1.3 towards the end of this Chapter. This sets out road transport emissions in the Base Case (i.e. assuming all current and committed policies) as well as the additional emission reductions associated with the policies proposed in this report. As shown, the proposed changes to emissions standards in Policy 1 would have a significant impact, reducing road transport NO_x emissions in the Greater London Area by 11% in 2025 (over and above the emissions reduction in the Base Case). The impact is far more limited in 2020, at a 2.5% reduction in NO_x emissions, which is to be expected given that the proposed policy would not be delivered in full until 2021 onwards.

Policy 2: Use fiscal incentives to encourage a shift away from diesel

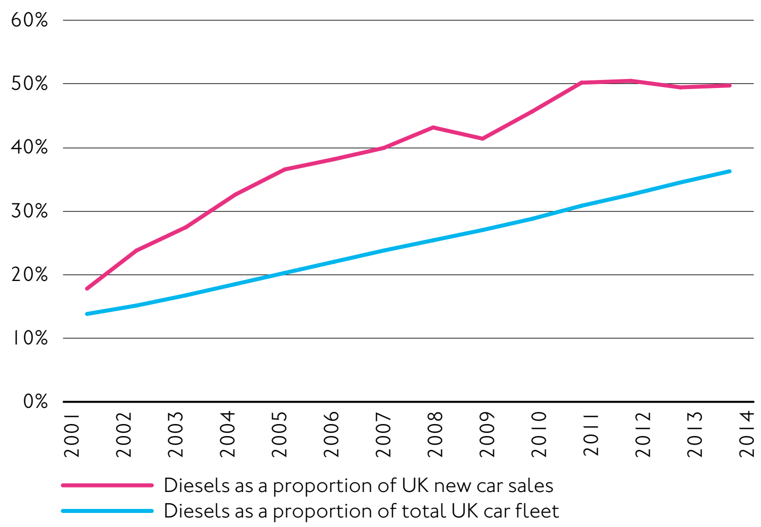
In addition to failing emissions standards, the other principal cause of the air pollution crisis we now face is the "dieselisation" of the vehicle fleet which has taken place over the last 15 years. Diesels have been promoted by Europe and by the UK Government since the late 1990s on the grounds that they produce lower CO_2 emissions than petrol vehicles. In 2000, CO_2 emissions from diesel cars were around 8% lower than petrol cars (on a sales weighted basis), and this differential increased to 15% by 2007.[12] As noted in a report by the RAC Foundation, *"the automobile industry's response to the European average new car CO_2 emissions targets… has been to make more diesel cars, as these are more fuel-efficient than their petrol counterparts… and greater fuel efficiency equals lower CO_2 emissions."* [13]

A number of fiscal incentives at UK level also created a clear economic advantage for diesel vehicles compared to petrol based on their lower CO_2 emissions:

- The system of Vehicle Excise Duty (VED) was reformed by the Labour Government in 2001 to link it to CO_2 emissions.[14]
- A "first year" VED rate was introduced from 2010, and this too was linked to CO_2 emissions.
- Company Car Tax was reformed in 2002 and linked to CO_2 emissions (with a modest 3% surcharge for diesels).[15]
- Businesses can also take advantage of Capital Allowances when purchasing a low CO_2 vehicle.[16]

The combination of these policies resulted in a dramatic shift towards diesels, which increased from 18% of new car sales across the UK in 2001, to 50%+ from 2011 onwards (Figure 1.3). Diesels now make up 36% of the total car fleet across the UK.[17] Since diesel cars are generally driven more miles than petrol cars, they now make up just under half (49%) of total car mileage in London.[18]

Figure 1.3: Diesel cars as a proportion of UK new car sales and total car fleet[19]



In hindsight, the shift from petrol to diesel over the last 15 years has been disastrous in terms of its impact on air quality and health. As documented in the previous section, diesel cars emit far more NO_x than petrol cars, and emissions standards are still failing to deliver a sufficient improvement. Moreover, **there is evidence that the CO_2 advantage of diesel cars has now been eroded.** In 2013, CO_2 emissions from new petrol cars were marginally *lower* than for new diesel cars for the first time (at 128.8g CO_2 per km for petrol and 129.2g/km for diesel, on a sales-weighted basis).[20]

It is clear that the UK needs to revisit its position on diesel to reflect the greater damage it causes in terms of air pollution, and to rebalance objectives concerning CO_2 reduction and improving air quality. At high level, this requires Government to recognise that the promotion of diesels through fiscal incentives has had and continues to have a detrimental effect on air quality, and that the trend towards diesels needs to be reversed if air quality objectives are to be achieved. This will require two main types of policy interventions: firstly to influence new purchasing behaviour to promote alternatives to diesel vehicles, and secondly to accelerate the replacement of the existing stock of diesel vehicles. However, it is important that the shift away from diesel does not unduly penalise existing diesel owners who bought their vehicles in good faith based on their lower CO_2 emissions.

Improving air quality needs to be balanced against the need to also meet legally binding CO_2 targets under the Climate Change Act. On that basis, this ought not to be a shift purely from diesels back to petrol vehicles, but also to alternatively fuelled vehicles which have both low NO_x and low CO_2 emissions, such as Liquefied Petroleum Gas (LPG) and "Ultra Low Emission Vehicles" including Electric Vehicles. These options are explored below.

Influencing new purchasing behaviour

There is a strong argument for rebalancing tax incentives to recognise the greater air pollution associated with diesels, and encourage car buyers to shift to alternatives. Even with the reforms we propose to emissions standards above, Euro 6 diesel cars will continue to have higher NO_x emissions than petrol cars sold today. There are several ways to change tax incentives to influence new purchasing behaviour without penalising existing diesel owners, as follows:

- **Amending the Vehicle Excise Duty (VED) "first year" rate for new diesel cars.** VED is levied on all cars with a rate payable per annum plus an additional first year rate. This is currently linked to the car's CO_2 emissions as described above. A diesel surcharge could be introduced for all new diesel cars purchased, to reflect the higher levels of local pollution they cause relative to petrol cars over their lifetime. Our proposal is for the diesel surcharge only to apply to new diesel cars, not to existing diesel cars. Given that there are currently few alternatives to diesel for vans, we propose that the diesel surcharge should not apply to vans at this stage.

  The surcharge could be linked to the health and environmental impact caused by the vehicle – sometimes referred to as a "damage cost". Using Defra guidelines, we have calculated that the damage cost of an average Euro 6 diesel car is around £800 higher than an average Euro 6 petrol car over its lifetime based on real-world NO_x emissions (not to mention other pollutants such as PM).[21] However, it would be preferable to base the increase in VED on the real world performance of individual vehicles, rather than an industry average figure. This requires improved data on real world emissions (see Box 2). Further research would be required to understand the behavioural response to an increase in VED for diesels.

- **Increasing and extending the 3% diesel surcharge under the Company Car Tax regime.** Diesel vehicles are liable for a higher rate of taxation under the Company Car Tax regime. However the current diesel surcharge of 3% is insufficient to significantly influence purchasing behaviour. It could be increased in order to better reflect the additional damage associated with diesels in terms of local air pollution. The Government's current position is that the diesel surcharge will be removed from 2021.[22] However given that diesels are likely to continue to have higher NO_x emissions than petrol cars, there is a rationale to maintain the surcharge even beyond this date.
- **Removing or reducing the tax breaks available for diesel vehicles under the Capital Allowances scheme.** Capital Allowances are currently available for companies that purchase any vehicle with low CO_2 emissions. However the scheme does not currently reflect other emissions such as NO_x and PM, and does not distinguish between diesel, petrol or alternatively fuelled vehicles. The scheme could be amended to either remove or reduce the tax breaks available for diesel vehicles purchased by companies, in order to reflect their relatively high NO_x and PM emissions.

Replacement of existing diesels

Our suggested reforms to fiscal incentives will discourage the purchase of new diesels, but this still leaves a residual issue concerning the 10.7 million diesel cars already on the road across Britain. The relative emissions of diesel and petrol cars has changed over time, however **our analysis suggests that the average diesel car within the London fleet emits more than 5 times as much NO_x and 80 times more direct NO_2 than the average petrol car within the London fleet.** These diesel cars will take a very long time to be replaced as a result of natural churn in the vehicle stock, particularly since diesel vehicles tend to last longer and be replaced less frequently than petrol vehicles. Using DfT vehicle statistics we estimate an average replacement rate since 2001 of 5% per year for diesel cars, compared to 8% per year for petrol cars.

Therefore we suggest that additional policy intervention is required to accelerate the replacement of existing diesels. This can be achieved, whilst avoiding penalising existing diesel owners, by offering a **scrappage grant to those who choose to replace an older diesel vehicle early.** The UK Government previously ran a vehicle scrappage scheme in 2009–10 to encourage the replacement of older vehicles and to act as an economic stimulus. This provided a grant of £1,000 towards the purchase of a new vehicle when a car or van was scrapped (the scrapped vehicle had to be over 10 years old, in working condition, and owned by the current owner for at least 12 months). Manufacturers matched the £1,000, giving a total of £2,000 off the list price of a new vehicle.

The scheme was criticised at the time on the basis that as a fiscal stimulus it benefitted only one industry in which there are significant imports, and that in the main it would result in bringing forward purchases of cars, rather than additional purchases.[23] It was also criticised on environmental grounds since new purchases were not limited to more environmentally friendly cars.[24]

However despite this there is merit in revisiting the vehicle scrappage concept as a means to accelerate the replacement of polluting vehicles and improve air quality, provided it is designed correctly. Indeed, there is broad support for introducing a vehicle scrappage scheme to address air pollution including from the Environmental Audit Committee,[25] the Mayor of London[26] and the London Assembly.[27] A scrappage scheme would have a financial cost attached to it, but could be paid for out of the increase VED charged on diesels. In order to maximise the benefit in air quality terms, the scrappage scheme should target the replacement of diesel vehicles, but not petrol vehicles. The scheme need not be restricted to vehicles over 10 years old, since the evidence suggests that even relatively new diesel cars emit high levels of NO_x. The scheme should be targeted towards the purchase of vehicles with lower NO_x and PM emissions such as petrol, petrol hybrid, electric or LPG vehicles, but not new diesels. Consideration would be needed in terms of how the scrappage grants would interact with the existing grants available for electric vehicles (described below). Combined with the proposed increase in the first year VED rate for a new diesel car this would create a significant set of incentives to replace older diesels with new lower emission vehicles.

Liquefied Petroleum Gas (LPG) vehicles

There is an opportunity for LPG vehicles to play a role in improving air quality in London and elsewhere in the UK. LPG vehicles have much lower emissions than comparable diesel or petrol vehicles, for example a study found that LPG cars have NO_x emissions some 96% lower than diesel cars and 68% lower than petrol cars; and CO_2 emissions 12% lower than petrol cars.[28] The use of LPG has been recognised by Defra in its latest plan to meet NO_2 limits.[29]

LPG vehicles are relatively cheap to run, partly due to their high fuel efficiency and partly due to the low tax levied on LPG fuel in the UK. Duty on LPG is 31.6 pence per litre, compared to 57.95 pence per litre for petrol/diesel. There is already a significant LPG infrastructure of over 1,400 filling stations in the UK[30] and 37,500 across Europe.[31] However, despite the economic and environmental benefits of LPG, it remains a niche transport fuel in the UK, with only around 43,000 LPG cars on the road in Great Britain (0.1% of the total fleet) and 10,000 LPG vans (0.3% of the fleet).[32] This is in contrast to the rest of Europe where LPG is far more common: there are 10 million LPG vehicles across Europe as a whole, representing 4% of the car fleet.[33]

The main reason for the low uptake of LPG in the UK is simply the lack of LPG production vehicles available to the UK market, despite widespread availability elsewhere. For example Opel offers LPG-powered versions of all of its models in continental Europe, but its UK brand Vauxhall does not currently offer any LPG models. Most of the existing LPG vehicles in the UK are petrol vehicles that have been retrofitted to run on LPG. Despite the apparent savings available from converting to LPG, uptake has been limited by the up-front cost of conversion, at around £1,200 for an average car.[34]

It is also thought that uncertainty concerning the future direction of LPG fuel duty could act as a significant barrier to uptake of LPG (both for new LPG vehicles and conversions). Over the period 2001 to 2011, the duty on LPG increased more than threefold, compared to only a 26% increase for petrol and diesel duty.[35] This may have caused motorists to be wary about converting to LPG on the basis that the cost advantage may be removed in the future. Indeed, a report for the RAC Foundation (2014) suggests that the differential in LPG prices needs to be guaranteed for at least ten years in order for road hauliers to consider conversion to LPG.[36]

Despite these concerns, a switch towards the use of LPG in place of diesel and petrol could make a material contribution to improving air quality as well as reducing CO_2 emissions. **We therefore recommend that Government provides a signal to motorists that the fuel duty differential between LPG and other fuels will be maintained (e.g. for a ten year period).** This would be expected to result in an increase in the number of existing vehicles converted to LPG, as well as encouraging manufacturers to bring new LPG vehicles to the UK market.

Ultra Low Emission Vehicles and car clubs

Another way to achieve a step change in road transport emissions in the future is the widespread adoption of "Ultra Low Emission Vehicles" or ULEVs – an umbrella term for a range of technologies including battery electric vehicles, plug in hybrid electric vehicles, range extended electric vehicles and hydrogen fuel cell vehicles. These vehicles have low or zero tailpipe emissions of greenhouse gases such as CO_2 and local air pollutants such as NO_x and PM.

The adoption of ULEVs is being promoted by Government both at a national level, through the Office for Low Emission Vehicles, and in individual cities such as London. The Mayor of London developed an Electric Vehicle Delivery Plan in 2009 with an ambitious aim to have 100,000 electric vehicles (EVs) in operation in London "as soon as possible", together with a network of 25,000 charging points by 2015.[37] However, progress has been slower than expected, with only 3,600 electric cars on the road in London in 2015.[38] Despite this, the UK remains the third largest market for EVs in Europe in terms of new car registrations, after the Netherlands and Norway.[39]

EVs can be extremely cheap to run, with fuel costs of around one sixth of a petrol or diesel car.[40] They also benefit from exemptions from Vehicle Excise Duty, the Congestion Charge, and the proposed Ultra Low Emission Zone charge, as well as subsidised parking in some London Boroughs. However, one of the main barriers to the uptake of electric vehicles is the upfront cost, with electric vehicles typically costing £8,000 more than a standard petrol or diesel car.[41] The Government provides grants of up to £4,500 for the purchase of a plug in electric vehicle, plus a grant of £500 per household for the installation of a charging point. These subsidies need only to be temporary: forecasts show that EVs will be as cheap as conventional vehicles by 2022 (on an unsubsidised basis).[42]

Another factor which has inhibited the uptake of EVs in London has been the rollout of public charging infrastructure, which has experienced delays and reliability issues. Evidence shows that the availability and proximity of charging points is extremely important to EV users.[43] London currently has 13 different charging networks with around 2,000 individual vehicle charging points[44] – a significant network, but still well short of the Mayor's aspiration for 25,000 charging points by 2015. The main charging network in London is Source London, which was set up by TfL in 2009, and now has 850 charging points. The scheme initially experienced significant issues including financial difficulties and a dispute over who was responsible for maintenance, which resulted in poor reliability and charging points being out of service. [45, 46] In 2014, Source London was transferred to the private sector and is now run by Bluepoint London, a subsidiary of the Bolloré group. The Bolloré Group also runs the Autolib' scheme in Paris, which provides both electric vehicle charging points and an electric vehicle car club (see Box 1).

Box 1: Autolib' electric car scheme in Paris

Autolib' is an electric car scheme that was launched in Paris in December 2011. It comprises a fleet of almost 4,000 electric cars and 6,000 charging points across the Paris region. The vehicles are available for short term rental to members of the scheme, similar to Boris bikes in London (in fact a similar bike sharing scheme called Vélib' has been operating in Paris since 2007).[47]

The Autolib' network is proving to be a success, with around 100,000 active members driving over 1 million kilometres per week. One of the scheme's main selling points is free and accessible parking for the users. The scheme has led to a change in behaviour amongst its members with many choosing to no longer own a car. It is estimated the scheme has taken around 30,000 cars off the road.

There is evidence that having access to a car club (whether a conventional or electric vehicle) can lead to members either selling their car altogether, or deferring the purchase of a new vehicle,[48] and also to people reducing the amount they drive.[49] Electric vehicle car clubs have the combined benefits of reducing vehicle mileage and zero tailpipe emissions. Bluepoint London has plans to launch an electric car club scheme in London comprising 3,000 cars, as well as increasing the number of charging points to 6,000 by 2018.[50] A competing network, Chargemaster, is also planning to install 1,000 charging points, whilst car club operators such as ZipCar are looking to add electric vehicles to their existing fleets.

There is potential for electric vehicles and car clubs to have a transformative impact on the way people move around London, significantly improving air pollution and congestion. **The next Mayor of London must embrace these opportunities and deliver the recently produced Ultra Low Vehicle Delivery Plan and separate Car Club Strategy for London.**

However there are a few significant issues which need to be addressed in order to realise these ambitions. Although the charging network is growing, it remains patchy in parts of the city. This is due to the fragmented ownership of charging networks, the fact that network operators must negotiate arrangements with each London Borough individually and also due to legacy issues associated with repairing existing charging points.[51] **TfL needs to work with London Boroughs and charging network providers to create a robust pan-London electric vehicle charging network.**

It is in the best interest of consumers to create a *competitive* market for car clubs and electric vehicle charging points. Vehicle charging networks have many similar characteristics to other regulated networks such as energy and rail, but at present are largely unregulated. For example, in the energy and rail sectors there must be separation of ownership between network assets and other activities, but this is currently not the case with electric vehicle charging networks. The creation of a dominant network which provides both charging infrastructure and its own car sharing service carries risks. Bluepoint London has said that it will introduce fees from 2016, but as yet has not provided details to users (including other car club operators). It remains unclear how other car clubs will be able to utilise the charging infrastructure. In recognition of this, TfL is now looking to create additional charging networks, using funds from the Office of Low Emission Vehicles. **TfL and OLEV need to consider further how to create a competitive marketplace for charging infrastructure and car clubs. This may require electric vehicle charging networks to be regulated in the future, in particular in the way they set charges and make arrangements for third party access.** Car clubs must be granted access to the charging networks on a fair and equal basis in order to create a competitive marketplace.

In order for EV car clubs to become a mainstream activity they also needs to be incorporated into the ways that people navigate the city. For example, Citymapper is a leading application which provides an integrated set of information on public transport, walking, cycling, and even Uber private hire vehicles in London, but it does not currently provide information on car club locations. Possible reasons behind this are the fragmented ownership of car clubs, and the fact that car clubs are not included in the Transport for London open data feed. **We recommend that TfL works with car clubs to produce a consolidated feed of data on car sharing locations and availability to integrate into navigation applications.**

Emissions impact of Policy 2

In order to model the impact of Policy 2 we first examined the trend *towards* diesels which occurred between 2005 and 2015, in which diesel cars increased as a share of total car mileage by 2.9% per annum in London. We assume that the combined effect of the policies set out above would be to reverse this trend, starting from 2017 onwards. The overall impact of this would be for diesel cars to fall to 25–28% of total car mileage by 2025, rather than increasing to 54% (as in the Base Case). This assumption is justified on the basis that fiscal incentives created a push towards diesels in the past, and a reversal of these incentives could create a similar shift in the opposite direction going forward.

Table 1.2 Assumptions on composition of the London car fleet, proportion of miles driven (%)

Year	Scenario	Zone	Petrol car	Diesel car	Petrol hybrid	Diesel hybrid	Electric	LPG
2020	Base Case	GLA and ULEZ	45	55	0	0	0	0
2025			46	54	0	0	0	0
2020	Policy 2	ULEZ	58	34	7	0.4	0.6	0.5
2025			60	25	11	0.3	3	1
2020		Rest of London	50–53	39–42	6	0.6–0.7	0.6	0.5
2025			57–58	27–28	11	0.4–0.5	3	1

To offset the reduction in diesel vehicles in Policy 2, we have assumed that there would be an increase in the use of electric, LPG, petrol and petrol hybrid vehicles, as follows:

- **Electric vehicles:** Current emissions models assume a low uptake of electric vehicles, for example the London Atmospheric Emissions Inventory 2010 (which forms the Base Case) assumes zero electric cars even in 2025. In modelling Policy 2 we have assumed figures that are in line with the "high deployment" scenario in the Mayor's Ultra Low Emission Vehicle Delivery Plan for London, e.g. 50,000 electric cars and 9,000 electric vans in London by 2020 (220,000 and 40,000 respectively in 2025).[52]
- **LPG vehicles:** we assume the policies would lead to an increase in LPG cars in London from around 12,000 today to around 40,000 in 2020, and 100,000 in 2025. This assumes annual sales of 40,000 LPG cars per annum nationally from 2018 onwards.[53]
- **Petrol and Petrol Hybrid:** it has been assumed that the remainder of the shift away from diesel vehicles is taken up by an increase in petrol vehicles, and that 10% of petrol cars are hybrids in 2020, increasing to 15% in 2025.

The emissions impact of Policy 2 is presented in Table 1.3 towards the end of this Chapter. The fiscal incentives proposed in Policy 2 have a very significant impact, reducing road transport NO_x emissions in the Greater London Area by 20% in 2025 (over and above the emissions reduction in the Base Case plus Policy 1). The impact on NO_2 emissions is even greater, delivering a 25% reduction in emissions across the Greater London area in 2025. Of the policies modelled, Policy 2 has by far the biggest impact in 2020, reducing NO_x emissions across Greater London by 8%.

Policy 3: Restricting the most polluting vehicles from London and promoting alternatives

Policy 3 combines a number of related policies at London level, including Low Emission Zones and improvements to the bus and taxi fleet.

Low Emission Zones

One of the key air pollution policies in London is the Low Emission Zone (LEZ), which restricts the most polluting vehicles from operating within the Greater London area. The LEZ was introduced in 2008 to tackle Particulate Matter emissions and requires that vans, HGVs, buses and coaches meet PM emissions standards (equivalent to Euro III for vans and Euro IV for the other vehicle types). Vehicles which do not comply with the standards must either be upgraded, or pay a daily charge of £100–200 to enter the zone. In addition to the LEZ, there are also plans to create an Ultra Low Emission Zone (ULEZ) in Central London from 2020, covering the same area as the Congestion Charge Zone. This will set much tougher vehicle standards: Euro 6/VI for diesel cars, vans, HGVs, buses and coaches, and Euro 4 for petrol cars. Again, vehicles will have to pay to enter the zone, with a daily charge of £12.50 for smaller vehicles and £100 for HGVs.

In principle the LEZ and ULEZ represent an incredibly powerful set of tools to limit road transport emissions. However recent research[54] has shown that the predicted air quality improvements from the LEZ have not materialised due to a combination of factors including: the delay in implementing later phases of the LEZ policy, the increasing proportion of diesels in the vehicle fleet, and the fact that the Euro 3–5 standards have largely failed to control NO_x emissions from diesel cars and vans. The LEZ was introduced to control PM emissions, and the current LEZ standards are essentially too weak to have a significant impact on NO_x emissions.

It is thought that the ULEZ policy will have a much more significant impact on emissions in Central London. Modelling suggests that the policy could deliver a 51% reduction in NO_x emissions, a 64% reduction in PM emissions, and a 15% reduction in CO_2 emissions within the ULEZ area in 2020.[55] The ULEZ will be undermined to an extent by the failure of Euro 6 diesel cars to meet the Euro 6 standard on the road. Our proposed reforms to vehicle emissions standards (Policy 1) is aimed at correcting this, although there will still be a large number of Euro 6 diesel cars sold in the intervening period with relatively high NO_x emissions.

Despite the LEZ and ULEZ policies, it is expected that NO_2 limits will still be breached close to major roads in London in 2025 (as documented in the Part 1 report, Figure 2.11a). Overall, this suggests the need to strengthen the LEZ and ULEZ policies, either by tightening standards or revising the geographic coverage of the zones. London Councils and TfL have been considering the future of the LEZ and ULEZ, and recently released a scoping document that outlines a long-list of 15 potential options for further consideration.[56] These options include a strengthened London-wide LEZ, a strengthened ULEZ in Central London, or alternatively an expanded ULEZ defined by the North-South circular boundary. There have also been calls to extend the ULEZ either to all of Inner London, or to any boroughs that wish to have a ULEZ. In our view it could potentially be problematic to introduce an additional Low Emission Zone or expanded ULEZ covering the North-South circular, since this could potentially create confusion amongst motorists and would also involve investment in an additional set of enforcement cameras to cover the new boundary. The proposal to define the ULEZ by borough boundaries is problematic since boroughs boundaries are generally not known to motorists and do not conform well to the road layout.

We have therefore focused our analysis on potential reforms to the existing LEZ and ULEZ as follows:

- **Low Emission Zone (LEZ):** The principle way to strengthen the LEZ is to tighten the emissions standards to Euro VI (since Euro V shows little or no benefit compared to the existing LEZ standards). To provide sufficient notice of this change and avoid an excessive financial burden associated with upgrading vehicles, we suggest that the standards should be increased in 2021 or 2023, giving 8–10 years notice since the introduction of Euro VI in 2013 to comply with the standard. This is reasonable since it compares to an *average* vehicle age since registration of 7.5 years for HGVs, and 9.9 years for buses and coaches.[57] We have proposed that LEZ standards should be tightened for buses, coaches and HGVs, but not vans at this stage given the number of vehicles that would need to be replaced or upgraded. If the Mayor of London wished to pursue a more ambitious LEZ policy then the standards could be tightened earlier, or tightened for other vehicle types such as vans; however the financial impact of this would need to be considered further.
- **Ultra Low Emission Zone (ULEZ):** the ULEZ will to an extent be undermined by Euro 6 diesel cars, which under the current policy will be exempt from charges yet still emit relatively high levels of NO_x. Tighter standards will be introduced over the period to 2021 with the introduction of RDE tests (see Policy 1 above), but there will still be a number of Euro 6 vehicles sold in the meantime. In order to mitigate this, the ULEZ standards could be

tightened in the future such that only diesel cars which actually meet the Euro 6 standard on the road are exempt (i.e. those with a conformity factor of 1 or less). This change could be introduced by 2025, but signalled well in advance of implementation in order to discourage Londoners from purchasing Euro 6 diesel cars in the meantime. Implementing this would require the introduction of vehicle emission labelling based on real-world emissions (see Box 2). In modelling this proposal, we have assumed that the rate of compliance with the Euro 6 standard increases from 94.2% to 97% in 2025, removing a small number of pre Euro 6 vehicles. We have also assumed that all Euro 6 diesel cars driving in the ULEZ area from 2025 will comply with the Euro 6c standard proposed in Policy 1 (e.g. 0.08 g/km NO_x).

BOX 2: VEHICLE LABELLING

At present car manufacturers are required to provide official information on fuel efficiency and CO_2 emissions at the point of purchase and in all marketing material. On this basis, diesel vehicles are currently promoted as a more "environmentally friendly" option. However, there is no information available to consumers on actual emissions of NO_x or PM for individual vehicles. Whilst manufacturers are required to pass relevant emissions standards, it is clear that many vehicles do not in fact conform to the standards (see Part 1 report, Chapter 2).

We recommend that Government works with the motoring industry to provide robust data on real world emissions (of NO_x and PM) to consumers. Emissions Analytics, a specialist company which undertakes vehicle emissions analysis, is already developing a voluntary NO_x accreditation scheme in which they would undertake independent testing of real world emissions and make this data available publically.[58] Alongside this, manufacturers will be required to publish the results of RDE for new models from 2016 onwards (although not at the point of sale). Either way, manufacturers should be obliged to provide real world NO_x emissions data for new and existing models (with data on new vehicles available at the point of sale).

Once this information is in place it would allow consumers to make a more informed choice about the vehicle they are purchasing. It would also allow more sophisticated policies to be developed, such as Low Emission Zones based on real-world emissions, which would encourage manufacturers to improve performance ahead of the Euro standard requirements.

Buses and taxis

Buses and taxis are a significant source of NO_x emissions, particularly in Central London where together they make up 30% of total road transport emissions (see Figure 1.1). Note that this figure includes taxis (or "black cabs") but excludes Private Hire Vehicles, which are discussed separately in Box 3 below. Policies to clean up the bus and taxi fleets have been developed alongside the LEZ and ULEZ policies through TfL's procurement of bus services and taxi licensing policies.

TfL is already making a significant investment into low emission buses. As it stands, there are 1,500 low emission hybrid buses already in service (20% of the total fleet) and TfL plans to increase this to 1,700 by the end of 2016.[59] There are also a small number of electric single decker buses and hydrogen buses in operation in Central London. As part of the ULEZ policy, TfL has committed that by 2020 all single decker buses operating in Central London will be zero emission, and the majority of double decker buses in the ULEZ area will be Euro VI hybrids.[60] However, TfL has created a special exemption for 300 New Routemasters which are Euro V hybrids and will not be required to meet the Euro VI standard in the ULEZ area, despite the fact that they have NO_x emissions more than three times that of a Euro VI bus (2 g/km compared to 0.6 g/km).[61] **We propose that all buses operating in the ULEZ area should meet a minimum of the Euro VI standard by 2020.** Within this, the Euro V Hybrid New Routemasters should be upgraded to a minimum of Euro VI, which can be achieved for a reported cost of £15 million.[62]

Whilst significant improvements are planned for Central London, there is a risk that the bus fleet in the rest of London could be left behind. Under current policies, it is assumed that 33% of buses operating outside the ULEZ area will not meet the Euro VI standard in 2020, and 10% in 2025. The Euro VI standard has achieved a step change in emissions from buses, with a 98% in emissions compared to Euro V buses in real-world tests (see Part 1 report, Figure 2.6), and is therefore the minimum standard that TfL should aim for across its fleet. In line with our proposals for other vehicle types, **we propose that all buses operating across the LEZ area should meet a minimum of the Euro VI standard by 2023 at the latest.** This can largely be achieved through replacement of buses at the end of their operational lifetime (typically 10–14 years). In modelling this policy, we have assumed that the bus fleet outside the ULEZ area will be comprised as follows in 2025: 37.1% Euro VI hybrid double decker, 28.9% Euro VI single decker, 23.9% Euro VI double decker, 7.0% Euro VI Routemaster, 3.1% hydrogen/Electric single decker and 0.04% Euro VI hybrid single decker.

There has also been significant policy development in respect of taxis in recent years. Taxis are exempt from the Euro 6 emission standard under the ULEZ as it was thought that it would be too onerous for the taxi trade to accommodate this change within a relatively short space of time. However, as part of the ULEZ policy, TfL proposed that from 2018 all newly registered taxis should be "Zero Emission Capable" (ZEC) electric or hybrid vehicles, with new taxi models coming to the market that meet this requirement. The Mayor's Air Quality Strategy (2012) also brought in a 15 year age limit for taxis, which means that over time the oldest taxis are retired from the fleet.

However, the combination of these policies means that operators are permitted to use existing Euro 3 taxis until 2020, Euro 4 taxis until 2025, and Euro 5 taxis until 2029 (i.e. since they were sold until 2005, 2010 and 2014 respectively). These vehicles are highly polluting, emitting significantly more NO_x than private cars, and showing limited improvement in NO_x emissions between Euro 3 and Euro 5.[63] As part of the ULEZ policy development, TfL considered reducing the taxi age limit from 15 years to 10 years from 2020 to accelerate the replacement of the taxi fleet, but this was opposed by taxi operators on grounds of the cost of compliance (although it was supported by many other stakeholders).

Alongside the long-term move to ZEC taxis, there is a complementary short to medium-term option to retrofit existing taxis. For example, taxis can be retrofitted to run on LPG, which significantly reduces their emissions compared to diesel taxis, as well as reducing their running costs. Test results for a Euro 4 London taxi converted to run on LPG show an 80% reduction in NO_x emissions, 99% reduction in PM emissions, and 7% reduction in CO_2 emissions compared to a diesel equivalent.[64] LPG conversion was raised as an option during the ULEZ consultation but has not progressed further in London. However, there are trials ongoing in other parts of the country, for example the Department for Transport provided a grant to convert 80 black cabs to LPG in Birmingham at a cost of £500,000. In theory, this is a cost effective solution, with an LPG conversion costing around £8,000 per taxi and paying for itself within around 70,000 miles through lower running costs (or 2–3 years at an average of 30,000 miles per year). However, financing this sort of retrofit is likely to be a challenge for taxi operators, many of whom are small businesses or individuals. Banks may be able to provide loans to taxi operators in order to finance retrofits, although discussions conducted as part of this research revealed that this is potentially too niche and small an opportunity to generate significant interest from mainstream banks. **Therefore, there may be a role for Transport for London or London Boroughs to coordinate or channel financing to retrofit taxis in London.** For example, Transport for London could provide loans to individual taxi operators to retrofit their vehicles, with financing coming either from a commercial bank or the Public Works Loan Board. Unlike a conventional unsecured loan, TfL could use the taxi license itself as a form of security in order to reduce their risk exposure.

Overall, we propose that TfL should reconsider its position with regards both to the 15 year age limit and its position on retrofit options such as LPG conversion. The long term aim should remain to move towards zero emission taxis, but in the meantime the retrofit of existing taxis appears to be a cost effective and deliverable solution. **We propose that TfL should reduce the age limit from 15 years to 10 years by 2025 (or sooner), with an exemption for retrofitted taxis which meet the Euro 6 standard.** This would have the practical effect of removing all pre-Euro 6 taxis from the fleet across London by 2025, although retrofits can take place in advance of this. In modelling this policy we have assumed that in 2025, within the LEZ area, the taxi fleet is comprised of 75% zero emission capable taxis, 15% LPG conversions, and 10% Euro 6 taxis.

BOX 3: PRIVATE HIRE VEHICLES

There are a growing number of Private Hire Vehicles (PHVs) on London's roads – including minicabs, Uber cars and chauffeur driven vehicles. Statistics show that there were 62,800 PHVs registered in London in March 2015, nearly three times the number of black cabs (22,500).[65] Around 14,000 PHVs are registered each year in London, [66] although unofficial estimates suggest the number of PHVs has grown to over 100,000 in London. For the purposes of air pollution modelling, PHVs are treated as private cars rather than taxis hence the figures in this report for emissions from taxis include black cabs only.

Alongside the air quality policies for taxis outlined above, TfL has also introduced similar policies for PHVs. Unlike taxis, PHVs will be required to meet the emissions standards in the ULEZ or else pay the daily charge. There is also a 10 year age limit for PHVs (i.e. more stringent than the 15 year age limit for taxis). TfL also recently brought in a number of additional policies for PHVs as follows:

- In 2018 and 2019, all vehicles licensed as a PHV for the first time must feature a minimum of a Euro 6 petrol or diesel engine, or a Euro 4 petrol hybrid engine.
- From 2020 all new vehicles licensed for the first time as a PHV must be "Zero Emission Capable".

Overall, the policies relating to PHVs are stronger than for taxis in some areas, and weaker in other areas. Given that there are many more vehicle options available to PHV operators, there is an opportunity for the PHV fleet to be cleaned up more quickly. Under current proposals it is still possible to register a pre-Euro 6 diesel car as a PHV until January 2018. Given the evidence showing the excessive emissions from these vehicles (see Table 1.1), **we recommend that TfL takes action to prevent pre-Euro 6 diesels from entering the PHV market with immediate effect** (rather than waiting until 2018). Furthermore, PHVs would be subject to the proposed changes to the ULEZ outlined above, namely that from 2025 only Euro 6c diesel cars would be exempt from the daily charge, but not standard Euro 6 diesels.

Emissions impact of Policy 3

The proposed changes to the LEZ, ULEZ, buses and taxis have been modelled together as a combined package of measures (referred to as "Policy 3"). As shown in Table 1.3 below, these policies deliver a 4% reduction in NO_x emissions across the Greater London area in 2025, over and above the Base Case and Policies 1 and 2. This is a relatively small impact compared to Policies 1 and 2. However, Policy 3 delivers a significant reduction in emissions in the ULEZ area (16% reduction in NO_x emissions and 24% reduction in NO_2 emissions in 2025) where it overshadows Policies 1 and 2.

Overall impact on road transport emissions

The emissions impact has been calculated for all of the proposed policies set out above. The starting point for the analysis is a "Base Case" taken from the Interim Update to the London Atmospheric Emissions Inventory (2010), which includes all current and committed policies including the ULEZ. We have then calculated the additional change in emissions as a result of the proposed policies in the three groups discussed above:

- **Policy 1** – Tightening emissions standards
- **Policy 2** – Using fiscal policies to encourage a shift away from diesel (including changes to Vehicle Excise Duty, Company Car Tax, Capital Allowances, introduction of a diesel scrappage scheme, clarity around LPG Fuel Duty, and measures to promote electric vehicles)
- **Policy 3** – Restricting the most polluting vehicles from London and promoting alternatives (including changes to the Low Emission Zone, Ultra Low Emission Zone, and improvements in the bus and taxi fleet)

The impact on NO_x, NO_2, $PM_{2.5}$, PM_{10} and CO_2 emissions has been calculated for the Greater London area, as well as Central London (the area included in the ULEZ). A description of the modelling approach can be found in Appendix 1 of the Part 1 report.

Overall, it is predicted that the Base Case will deliver a reduction in road transport related NO_x emissions from 23,600 tonnes in 2010, to 12,400 tonnes in 2020 and 9,100 tonnes in 2025 (Figure 1.3). This represents a reduction of 47% in 2020 and 61% in 2025. The reduction in the ULEZ area is even greater at 71% by 2020 and 74% by 2025.

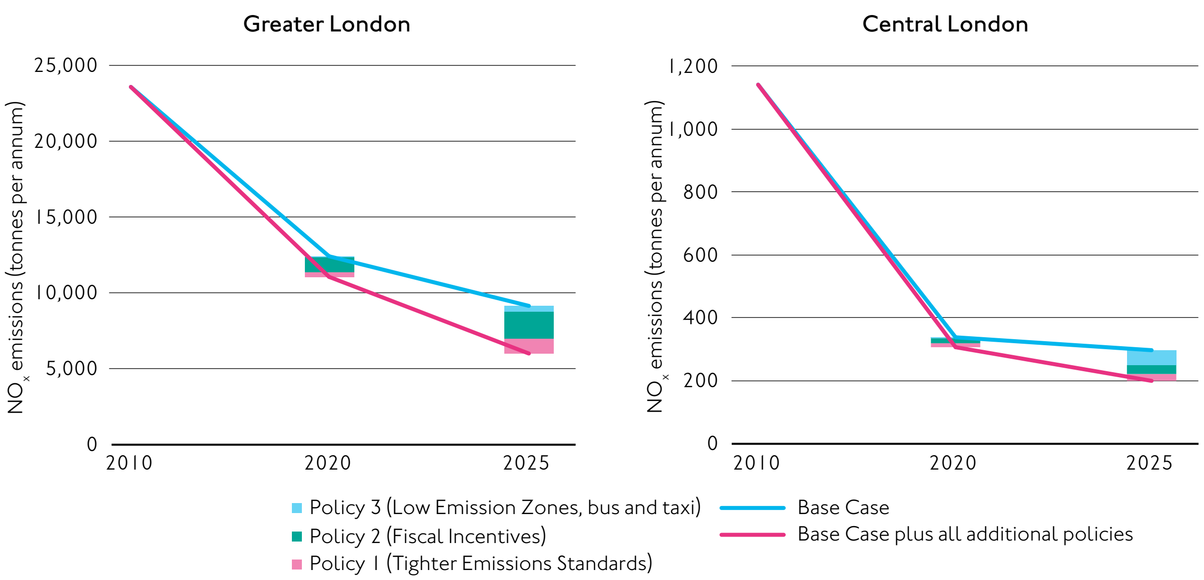
Table 1.3: Summary of road transport emissions in the Base Case and reductions associated with Policies 1, 2 and 3

			NO_x			NO_2		
Scenario	**Zone**	**Year**	**Total emissions (tonnes)**	**Policy reductions (tonnes)**	**Policy reductions (%)**	**Total emissions (tonnes)**	**Policy reductions (tonnes)**	**Policy reductions (%)**
Base Case	ULEZ	2010	1,140			222		
Base Case	ULEZ	2020	338			96		
Policy 1				12	3.6		3	3.1
Policy 2				14	4.1		4	4.2
Policy 3				4	1.2		0	0
Base Case + Policy 1, 2 & 3			**308**	**30**	**8.9**	**89**	**7**	**7.3**
Base Case	ULEZ	2025	297			79		
Policy 1				21	7.1		6	7.6
Policy 2				28	9.4		9	11.4
Policy 3				47	15.8		19	24.1
Base Case + Policy 1, 2 & 3			**200**	**97**	**32.7**	**46**	**33**	**41.8**
Base Case	GLA	2010	23,592			5,068		
Base Case	GLA	2020	12,389			3,657		
Policy 1				310	2.5		894	2.4
Policy 2				988	8.0		327	8.9
Policy 3				4	< 1		0	0
Base Case + Policy 1, 2 & 3			**11,087**	**1,302**	**10.5**	**3,241**	**416**	**11.4**
Base Case	GLA	2025	9,124			2,533		
Policy 1				1,001	11.0		289	11.4
Policy 2				1,785	19.6		624	24.6
Policy 3				329	3.6		110	4.3
Base Case + Policy 1, 2 & 3			**6,010**	**3,115**	**34.1**	**1,510**	**1,023**	**40.4**

The three proposed policies lead to a further reduction in NO_x emissions of 1,300 tonnes in 2020 – a 10% reduction compared to the Base Case. The modest scale of this reduction is to be expected given that we are already relatively close to 2020, and it will take time for new policies to take effect. However, by 2025, the impact of the policies is much greater, reducing NO_x emissions by 34% compared to the Base Case in the GLA area, and by 33% in the ULEZ area. The reduction in direct NO_2 emissions is even greater at 42% in the GLA area and 40% in the ULEZ area respectively.

The most impactful policies in the GLA area are the switch away from diesel (Policy 2) and tighter emissions standards (Policy 1), with the London specific measures in Policy 3 having a much less significant effect. The vast majority of this additional reduction stems from reductions in emissions from diesel cars (87%), with the remainder from taxis (7%), diesel vans (6%) and buses (4%). By contrast, in the ULEZ area, the London-specific measures to tighten the ULEZ and improve the bus and taxi fleet are the most effective (Policy 3). In this case the additional reductions across all three policy scenarios mainly relate to diesel cars (57%) and taxis (37%).

Figure 1.4: Forecast for road transport emissions in the Base Case and with Policies 1, 2 and 3



This analysis underlines the conclusion that London cannot act alone in tackling air pollution. **It is only through a combination of policy changes at London, National and European level that significant reductions in NO_x emissions can be achieved across London.**

Whilst our analysis focuses on policies to reduce NO_x and NO_2 emissions, we have also been mindful of the impact of the policies on important pollutants such as $PM_{2.5}$, PM_{10} and CO_2. Table 1.4 provides a comparison between emissions in 2020 and 2025 for the proposed policies, compared to the "Base Case", for the ULEZ area and the GLA area. **Overall, the policies result in a small reduction in emissions of $PM_{2.5}$, PM_{10}, and CO_2 emissions.** The shift to diesel cars over the last 15 years has been driven by a desire to reduce CO_2 emissions, and in promoting a shift away from diesel we had some concern that this may lead to an increase in CO_2 emissions. However, our proposed policies manage to avoid any increase in CO_2 emissions by switching from diesel vehicles to a combination of petrol, hybrid and electric vehicles (e.g. Policy 2) and in doing so lead to a 2% reduction in CO_2 emissions in 2025.

Table 1.4: Impact of the proposed Policies on CO_2 and PM emissions (tonnes/year)

Year	Zone	Pollutant	Base Case emissions (tonnes/year)	Base Case + Policies 1, 2, 3 emissions (tonnes/year)	Percentage change (%)
2020	GLA	CO_2	6,291,204	6,227,772	–1.0
		PM_{10}	3,019	3,014	–0.2
		$PM_{2.5}$	1,002	997	–0.5
	ULEZ	CO_2	215,270	213,856	–0.7
		PM_{10}	94	94	–0.2
		$PM_{2.5}$	30	30	–0.4
2025	GLA	CO_2	6,227,303	6,084,722	–2.3
		PM_{10}	3,033	3,031	–0.1
		$PM_{2.5}$	970	968	–0.3
	ULEZ	CO_2	214,799	210,503	–2.0
		PM_{10}	93	92	–0.9
		$PM_{2.5}$	28	27	–2.6

02 Gas combustion and decentralised energy

Gas combustion

Aside from road transport, the other major source of NO_x emissions in London is gas combustion in buildings, for example from gas boilers and cookers in homes, businesses and public buildings. In 2010, gas combustion accounted for 21% of total NO_x emissions in Greater London. Due to the concentration of buildings in Central London, gas combustion makes a more significant contribution here at 38% of total NO_x emissions, and this is very heavily skewed towards non-domestic buildings (see Part 1 report, Figures 2.7 and 2.8).

Despite its significant contribution to emissions, there has been relatively little attention paid to gas combustion from a local air pollution perspective, with the focus to date being primarily on reducing emissions from road transport. As a result of this discrepancy, gas combustion could *increase* as a proportion of future NO_x emissions as improvements are made more quickly in other areas such as road transport. Modelling shows that gas combustion is set to overtake road transport as the largest source of NO_x emissions in Central London between now and 2020, and increase to 48% of total NO_x emissions in Central London by 2025. That said, emissions from gas combustion tend to be more dispersed than those from road transport, making less of a contribution than road transport to pollution hotspots. **Overall, it is important that air quality policies do not overlook gas combustion and seek to reduce emissions both from gas combustion and road transport.**

Equally, regulations and policies related to gas boilers have generally focused on improving efficiency and reducing greenhouse gas emissions, and have only relatively recently begun to consider the air quality impacts of gas boilers. For example, current Building Regulations require all boilers fitted to conform to a minimum energy efficiency standard, but do not include any standards concerning NO_x emissions.[67] The European Eco-design Directive requires all energy related products (including boilers) to be labelled according to their energy performance from 2015. A requirement for all boilers to emit a maximum of 56mg/kWh of NO_x is being introduced, but not until 2018.[68] The energy efficiency and NO_x performance of boilers was considered under the Code for Sustainable Homes – a rating system for the sustainability of new homes – however this system has recently been scrapped.[69]

Since 2005, it has been a requirement under Building Regulations that any newly installed boiler must be a high efficiency condensing boiler. The latest boilers achieve efficiencies of around 90%, compared to efficiencies of 70% or lower for some non-condensing boilers. They also perform significantly better in terms of emissions of greenhouse gases such as CO_2 and local air pollutants such as NO_x. Analysis by AMEC (2015) shows that most of the condensing boilers currently on the market emit less than 40 mg NO_x per kWh whilst emissions from older non-condensing boilers are many times higher at between 150–260 mg NO_x per kWh.[70] However, the problem with boilers, as with road vehicles, is that there is a significant stock of older units which perform very badly compared to the latest available technologies. According to DECC, there were still 12.6 million non-condensing boilers in the UK in 2012 (i.e. 45% of all boilers in the UK).[71] Assuming that the rate of boiler replacements has continued in line with recent trends, we estimate that this figure has reduced to around 7–8 million non-condensing boilers in the UK in 2015, including around 1 million in London.

Replacing a boiler can be a cost effective investment for some households. Analysis by the Energy Savings Trust suggests that a household living in a semi-detached property could save £340 per annum by replacing a G-rated boiler with an A-rated boiler and heating controls.[72] At a typical cost of £1,200 to £3,000[73] to purchase and install a new boiler, this equates to a payback period of 4–9 years. However despite the apparent savings, many people are put off replacing a boiler or investing in energy efficiency either by the up front costs of doing so, or other non-financial and behavioural factors, as discussed in our recent report *Efficient Energy Policy.*[74]

There have been a few national policies which have encouraged the replacement of boilers, namely:

- The **Energy Company Obligation** (ECO) is a regulation which requires energy suppliers to provide energy efficiency measures mainly to fuel poor and vulnerable households. Boiler replacement is one of a number of eligible measures, and to date the scheme has resulted in 330,000 boilers being replaced across Britain since it was introduced in 2012.[75]
- The now defunct **Green Deal** mechanism was set up to provide grants and loans to households to invest in energy efficiency. Again, boiler replacements were eligible alongside a number of other efficiency measures; although the scheme only supported around 23,000 households to install a new boiler (combining those supported through the Green Deal finance and cashback schemes).[76] However the Green Deal has now been closed to new applications as a result of Government withdrawing funding for the scheme.
- DECC previously ran a **Boiler Replacement Programme** during 2010. This offered a £400 voucher for anyone replacing a G-rated boiler with a new boiler. Many energy suppliers and boiler manufacturers matched the payments, knocking a total of £800 off the installation price.[77] The scheme was hugely popular with the entire £50 million budget allocated within less than three months, to 134,000 households across England.

These policies have generally pursued boiler replacement for reasons of CO_2 reduction and fuel poverty alleviation, usually alongside other energy efficiency measures. However, analysis by Aether/Amec shows that from a NO_x emissions point of view, boiler scrappage is far more impactful and cost effective than more general energy efficiency programmes.[78]

Policy proposals to reduce emissions from gas combustion (Policy 4)

It is clear from the above analysis that there is significant potential to reduce NO_x emissions associated with gas boilers in London, making a significant contribution to the achievement of air quality limits. The analysis also suggests that whilst current policies such as ECO are beneficial, there is potential to accelerate the replacement of boilers in London (and the UK more generally) through additional policy interventions.

We recommend that the Mayor of London sets an ambition to improve air quality by targeting a substantial improvement in London's boilers. For example, a target could be set to replace 500,000 boilers by 2020 in London, and for all boilers to meet the "ultra low NO_x" standard of less than 40mg/kWh of NO_x by 2025. This could be justified on the basis of improving air quality alone, but will have additional benefits in terms of CO_2 reduction and fuel poverty alleviation, hence should be integrated with these other policy areas.

This ambition could be delivered in part through additional policies at national level. In our recent report *Efficient Energy Policy* we advocated a number of policies to encourage energy efficiency improvements by "able to pay" households, such as **linking the Stamp Duty system to the energy performance of a home and improving mortgage affordability tests to reflect energy performance**. These policies could spur investment in energy efficiency, including boiler replacement.

However, given the extent of the air pollution crisis in London, additional interventions are likely to be required at a local level. As discussed above, providing grants for the replacement of older boilers can be a cost-effective and impactful way to deliver a significant reduction in NO_x emissions. The Mayor of London recently launched a boiler cashback scheme which will provide grants of £400 per household towards the replacement of a G-rated boiler. **We welcome the creation of the boiler cashback scheme, but it needs to be expanded and refocused in order to maximise the benefits in terms of air quality.** As it stands, the £2.6m of funding being made available will secure 6,500 boiler replacements across London, which represents less than 1% of the stock of older non-condensing boilers across London. In our view the scheme needs to be expanded significantly in order to achieve the required step-change in boiler-related emissions. For the purposes of our modelling we have assumed a much larger scheme targeting the replacement of 250,000 boilers between now and 2020, at a total cost of £100 million. From an air quality perspective it would also be beneficial to target the scheme towards Inner London boroughs, where NO_2 concentrations are highest, rather than a London-wide scheme as currently presented. There may be opportunities to target air pollution and fuel poverty simultaneously by focusing the scheme on Boroughs which contain pollution and deprivation hotspots such as Tower Hamlets, Southwark, Hackney, and Lewisham.

In addition to this, additional intervention may be required in order to improve boilers in the private rented sector. We estimate that there are around 250,000 non-condensing boilers in private rented dwellings in London. The private rented sector is often the most challenging part of the housing market in which to promote energy efficiency. This is due to the split incentives between landlords who would pay for energy efficiency measures, and tenants who stand to benefit from reductions in energy costs. Because of this the Government has generally targeted energy efficiency in the rented sector through regulations rather than incentives. The new Private Rented Sector Energy Efficiency regulations require all private rented properties to achieve a minimum energy performance rating by

2018. This regulation relates to energy efficiency performance generally, rather than boiler efficiency specifically, although upgrading a boiler could be one of the measures implemented to reach the standard. **We recommend that the Private Rented Sector Energy Efficiency regulations are expanded to require private landlords to meet minimum standards for boiler efficiency (e.g. by 2018 or 2020) in addition to the existing regulations concerning energy efficiency.** Government will need to ensure that there are appropriate mechanisms in place to finance these upgrades, in place of the Green Deal.

There are also further steps that London could take in requiring the lowest NO_x boilers to be installed in new developments. The GLA recently developed an "Air Quality Neutral" policy which requires all major developments (e.g. 10 dwellings or more) to be assessed against emissions benchmarks, and all newly fitted boilers to emit less than 40mg/kWh of NO_x.[79] However, some of the boilers currently available on the market achieve even lower emissions, with many in the range 13–30mg/kWh NO_x. **We therefore recommend that the GLA revisits its Air Quality Neutral policy and revises down boiler emission limits in order to require the lowest NO_x boilers available in new properties.**

Emissions impact of Policy 4

The emission saving from the above policies has been calculated based on the following assumptions:

- We have assumed a boiler scrappage scheme providing grants to replace 250,000 boilers between now and 2020. In addition we have assumed that non-condensing boilers in all Private Rented Sector homes are replaced by 2020. There are a total of 951,000 Private Rented dwellings in Greater London,[80] and we estimate that around 26% of these dwellings currently have a non-condensing boiler (based on an extrapolation of recent trends in boiler replacement). [81] Combining these two policies we assume a total of around 500,000 non-condensing boilers are replaced by 2020.
- We have applied an "additionality" factor of 61%, based on experience from the previous national boiler scrappage scheme.[82] In other words we assume that 61% of these boiler replacements occur as a result of the proposed policies and the other 39% would have occurred anyway (and are therefore assumed to be reflected in the Base Case).
- We have calculated that the switch from a non-condensing boiler to a condensing boiler delivers a reduction in NO_x emissions of 3.2 kg per year. This is based on an assumed 25% reduction in gas use, combined with a reduction in emissions factor from 200mg/kWh NO_x for a non-condensing boiler to 26mg/kWh NO_x for a condensing boiler.[83]
- We have also calculated the impact of lowering the emission standard for boilers in new developments from the current standard of 40mg/kWh NO_x to an ultra low NO_x standard of 30mg/kWh. Based on the current rate of housing completions this would yield a further saving of 60 tonnes NO_x by 2025 across London.

As shown in Table 1.1, the "Base Case" assumes that NO_x emissions from gas combustion will decrease from 11,100 tonnes in 2010, to 7,700 tonnes, in 2020 and 7,100 tonnes in 2025, as a result of policies already in place plus natural churn in the stock of boilers over time. The proposed policies would deliver a further reduction of just over 1,000 tonnes NO_x in 2020, representing an additional 13% reduction. The majority of this saving accrues to Inner London, in line with our proposal to focus the boiler scrappage scheme on Inner London Boroughs.

Table 2.1: Emissions impact of Policies to reduce emissions from gas combustion (tonnes NO_x per year)

Scenario	Year	Domestic	Non-domestic	Total
Base Case	2010	6,686	4,419	11,104
Base Case	2020	4,582	3,094	7,677
Base Case + Policy 4		3,823	2,850	6,673
Emissions reduction (Policy 4)		**-759**	**-245**	**-1,004**
Base Case	2025	4,013	3,094	7,107
Base Case + Policy 4		3,224	2,850	6,074
Emissions reduction (Policy 4)		**-789**	**-245**	**-1,034**

Decentralised energy including CHP (Combined Heat and Power)

The UK power system is undergoing a significant transformation from a small number of large centralised power stations (e.g. coal, gas and nuclear) to a system with far more decentralised power generation, including renewables and smaller-scale fossil fuel generators. In the Part 1 report we identified a risk to air quality in London associated with the growth of decentralised power generation in the city. Some decentralised energy technologies are benign in air quality terms (e.g. solar photovoltaics) but others technologies such as gas and diesel engines, biomass boilers, and CHP boilers (which use gas or biomass to produce heat as well as power) can produce significant local emissions.

Decentralised power generation is being encouraged both by the GLA at local level and by DECC at national level because it can be a more efficient way of delivering energy to end users than large centralised power stations, and is therefore beneficial in meeting carbon reduction targets. The GLA has set targets to reduce carbon emissions by 60% by 2025 (compared to 1990 levels) and for 25% of power consumed in London to come from decentralised generation by 2025. A particular area of focus in London is CHP, with 195MWe of capacity already installed. The use of CHP can be beneficial in terms of reducing overall greenhouse gas emissions, but increases local emissions of NO_x and other pollutants compared to other forms of heat (such as a low NO_x condensing gas boiler).

Decentralised energy is also being promoted by DECC on the basis that it contributes to the security of supply of electricity. The UK is currently experiencing very low power capacity margins. Consequently DECC has created the Capacity

Market and a number of other mechanisms to providing payments to new and existing generators to ensure security of supply. Whilst this intervention is required from a security of supply point of view, there is a risk that it could lead to the deployment of polluting forms of generation, since the Capacity Market does not distinguish power plants according to their location, fuel type, or emissions. The latest Capacity Market auction in December 2015 awarded contracts to over 1GW of "peaking plant" – small scale diesel or gas generators.[84] Peaking plant are highly polluting both in terms of greenhouse gas emissions and local pollutants such as NO_x and PM. Unfortunately it is not possible to establish the exact location of these projects since neither Government nor National Grid (which operates the Capacity Market auction) provides access to this information. As part of this research we contacted several of the main developers of peaking plant, but most were unwilling to provide details of their project locations. **It is possible that national level policies to ensure security of supply are contributing to air quality issues in cities such as London.**

In the future, peaking plant and other medium scale power stations will be regulated under the European Medium Combustion Plant Directive, which sets emission limits for new and existing power plants with a capacity of 1–50MW. However, there are some significant issues with the Directive which in practice limit its ability to control emissions. Firstly, the emission limits will be phased in over time, applying to new installations from 2018, but not to all existing installations until 2029. Secondly, the emissions limits have been set reasonably high, for example the limit for a gas turbines (150 mg/Nm^3 NO_x, or 0.3g NO_x per kWh) is more than seven times that of a new domestic heat only gas boiler (less than 0.04g NO_x per kWh). Thirdly, there are some significant exemptions to the Directive, for example it will not apply to peaking plant operating for fewer than 500 hours per year, or to CHP plant connected to a district heat network (of which there are numerous examples in London).

In 2013, the GLA developed its own emissions standards for gas, diesel, biomass and CHP installations which are enforced through the planning system. However, again the policy still allows significant emissions from gas turbines (0.3g NO_x per kWh) and diesel engines (1.1g NO_x per kWh).[85]

Policy proposals to mitigate air quality impacts of decentralised energy

There are a number of possible options to manage the risks associated with emissions from decentralised generation, both at London and National level:

Firstly, the Mayor of London should revisit the Climate Change Mitigation and Energy Strategy (2011)[86] to reconcile the potential inconsistency between the promotion of decentralised energy in London and improving air quality. The GLA should carry out further research to quantify the potential air quality impacts of delivering significant quantities of (fossil fuel based) decentralised energy, and if necessary revise the target to deliver 25% decentralised energy by 2025.

Secondly, the GLA and London Boroughs need to ensure that there are adequate safeguards to prevent the deployment of more polluting forms of generation in London. This is best achieved through planning policy at local level, rather than changes at national level. As noted above, the GLA has already put in place a set of emissions standards, which apply tighter restrictions than in other parts of the UK. That said, it is clear that these standards could still allow forms of generation to be deployed which could have a detrimental effect on London's air quality. **We therefore recommend that the GLA's emissions standards should be reviewed and tightened in light of the current air pollution crisis in London.**

Thirdly, there needs to be much greater regard to the air quality impacts associated with policy decisions taken within DECC. With the creation of DECC in 2008, energy and climate change policy was separated in departmental terms from air quality policy, which is led by Defra. DECC routinely considers air quality impacts as part of its Impact Assessment process for new policies, but inevitably there are significant trade-offs.

By way of example, we have reviewed the Impact Assessment for the Renewable Heat Incentive (RHI), which provides subsidies for the deployment of biomass and CHP. This estimates that the RHI scheme will yield carbon reductions valued at £10 billion, but at the same time results in "very significant" air quality impacts valued at £1.8 billion over the lifetime of the policy. In other words, in proceeding with this policy, DECC has traded off carbon benefits with local air pollution impacts. Since DECC has no control over where deployment takes place under the scheme, it is entirely possible that it is taking place within areas such as London which already experience high levels of air pollution. **Going forward, DECC and Defra need to work more closely to avoid policies which are likely to exacerbate pollution in areas already in excess of air quality limits.**

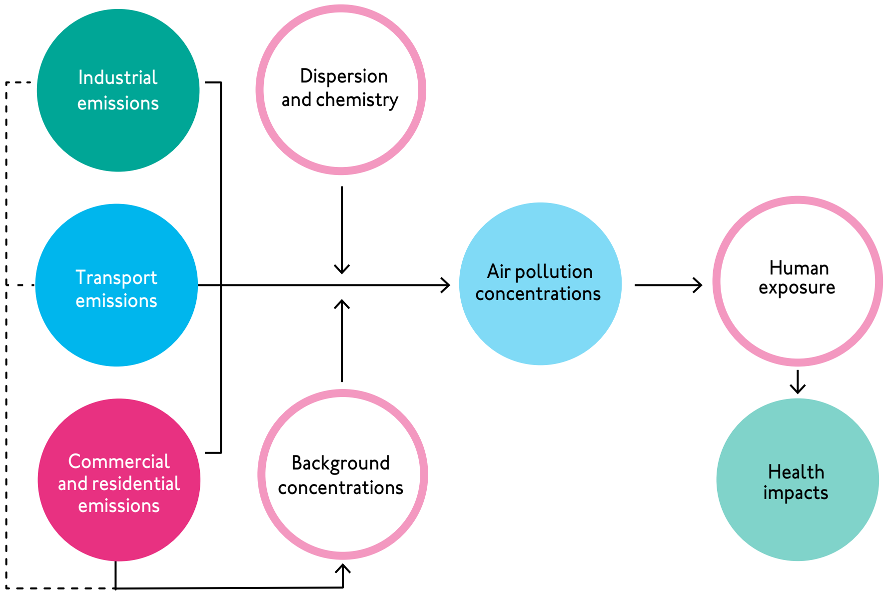
Finally, DECC also needs to take specific action to ensure that the air quality impact of CHP is minimised. At present CHP receives many benefits including financial incentives under the Renewables Obligation and Renewable Heat Incentive; tax breaks under the Carbon Price Floor, Climate Change Levy and Enhanced Capital Allowances; and preferential Business Rates. Access to these benefits is limited to schemes meeting DECC's definition of "Good Quality CHP", but this is defined only in terms of efficiency of the CHP unit with no reference to its impact in terms of local pollutants. **We recommend that DECC amends its definition of "Good Quality CHP", setting minimum standards for local pollutants (NO_x and PM) which CHP installations must achieve in order to receive tax breaks or other financial benefits.**

03 Air quality and health impacts

In Chapter 1 and 2 we presented projections for emissions of key pollutants in 2020 and 2025, in both a "Base Case" and with the proposed policies in place. This Chapter of the report uses these emission projections as a basis to assess the impact of all of the proposed policies in terms of air quality and health. A description of the methodology can be found in the Part 1 report (Chapter 3 and Appendices 1 and 2).

As described in the Part 1 report, health impacts arise from human exposure to high concentrations of pollutants. Local concentrations of pollution are influenced both by emissions in the immediate vicinity, as well as emissions transported from elsewhere, and the level of human exposure depends on the extent to which high pollution areas coincide with areas where people live, work, or travel (Figure 3.1).

Figure 3.1: The relationship between emissions, concentrations and health impacts[87]



Air quality

Our analysis considers both the overall improvement in air quality, as well as the extent to which compliance with air quality limits has been reached. We have used the following three key metrics to summarise the findings:

- Firstly, the overall air quality improvement can be expressed by looking at the area of London which exceeds the EU limit value for NO_2 and how pollution levels vary across the city, measured by area (see Table 3.1).

- Secondly, since the NO_2 problem is associated with locations close to roads, and that in area terms these zones are small, another metric which can be used is the length of road exceeding the EU limit value. This metric is also used by Defra to summarise their results nationally. This focus on roadside concentrations also recognises that whilst roads can be small in area, people are often exposed to air pollution close to roads, either by living close to them or whilst walking and cycling on roads or travelling in vehicles.
- Finally, whilst the length of road exceeding the EU limit value is an important summary statistic for London, it is also important to understand how air pollution levels vary geographically. For this we have produced maps showing annual mean NO_2 concentrations, (see Figures 3.2 and 3.3).

Importantly, the EU Air Quality Framework Directive only requires compliance with limit values in areas to which the public has access. In order to mirror this in our analysis, we have masked out areas such as roadways, junctions, railway lines, and other non-public areas such as the airport site at Heathrow, where air quality limit values do not apply. As a consequence, the highest concentrations reported are those within a few metres of the kerb, but not on actual roadways.

Table 3.1 shows the air pollution results in terms of the area of London experiencing a range of NO_2 concentration levels. This shows that in the Base Case in 2010, the total area exceeding the EU limit value for NO_2 is estimated at 186 sq km (or 12.7% of the Greater London Authority area). This is predicted to reduce to 22 sq km in 2020 (1.5%), and 9 sq km in 2025 (0.6%) based on the current and committed policies included in the Base Case.

The addition of the policies proposed in this report is predicted to reduce the area of exceedance in 2025 significantly to just 2 sq km, or 0.1% of the area of London in 2025. To put this another way, the proposed policies would result in compliance with the EU limit value for NO_2 across 99.9% of London's area by 2025. The impact of the policies is also significant in 2020, reducing the area of non-compliance from 22 sq km to 15 sq km.

Table 3.1: Average annual NO_2 concentration, by area in sq km (and as proportion of Greater London area)

Scenario	<20 µg/m³	20–40 µg/m³	40–60 µg/m³	60–80 µg/m³	80+ µg/m³	Total 40+ µg/m³
2010 Base Case	0 *(0.0%)*	1,285 *(87.3%)*	175 *(11.9%)*	9 *(0.6%)*	2 *(0.1%)*	186 *(12.7%)*
2020 Base Case	84 *(5.7%)*	1,364 *(92.7%)*	21 *(1.4%)*	1 *(0.1%)*	0 *(0.0%)*	22 *(1.5%)*
2020 Base Case + Policies 1, 2, 3 & 4	**140** (9.5%)	**1,316** (89.5%)	**14** (1.0%)	**1** (0.1%)	**0** (0.0%)	**15** (1.0%)
2025 Base Case	229 *(15.6%)*	1,233 *(83.8%)*	8 *(0.6%)*	0 *(0.0%)*	0 *(0.0%)*	9 *(0.6%)*
2025 Base Case + Policies 1, 2, 3 & 4	**467** (31.7%)	**1,003** (68.1%)	**2** (0.1%)	**0** (0.0%)	**0** (0.0%)	**2** (0.1%)

The analysis also shows that the policies would result in a significant improvement in the most polluted parts of the city, with the proportion of London at NO_2 concentrations over 60 μg/m^3 predicted to reduce from 0.8% of London in 2010 (11 sq km), to almost zero in 2025 with the proposed policies in place (0.03 sq km). The policies also deliver an air quality improvement for areas which are already below the limit value for NO_2. For example the proportion of the city at or below 20 μg/m^3 NO_2 is predicted to increase from zero in 2010 to 15.6% in the Base Case in 2025, and to nearly 32% with the proposed policies in place. This is also significant, since the health impact of NO_2 does not disappear entirely at 40 μg/m^3 and further reductions in NO_2 concentrations below the limit value are also beneficial in terms of health (this is explored further below).

Whilst the above results show an encouraging improvement, it is clear that compliance will not be reached in 2020 or 2025 even with the proposed policies in place. Figures 3.2 and 3.3 show the geographical distribution of annual average concentrations of NO_2 in 2020 and 2025, with points exceeding the NO_2 limit of 40 μg/m^3 shown in black. Although the area of non-compliance in 2020 is relatively small at 15 sq km, this area represents the majority of roads in Inner London. This is important since people live close to these roads and they are the main routes by which people travel as part of their daily lives. By 2025, the situation is much improved, with a much smaller area predicted to still have NO_2 concentrations in excess of legal limits (Figure 3.3). The areas still exceeding the NO_2 limit are now limited to roads within the ULEZ area, plus west into Kensington, as well as some of the main arterial routes in the city (including the North Circular, A102 Blackwall, A11, A13 and A4) and a small area around Heathrow airport. This represents a significant improvement compared to the Base Case in 2025 (see Figure 2.11a in the Part 1 report for a corresponding map for the Base Case in 2025).

Figure 3.2: Annual average NO_2 concentrations in 2020 (Base Case + Policies 1, 2, 3 & 4)

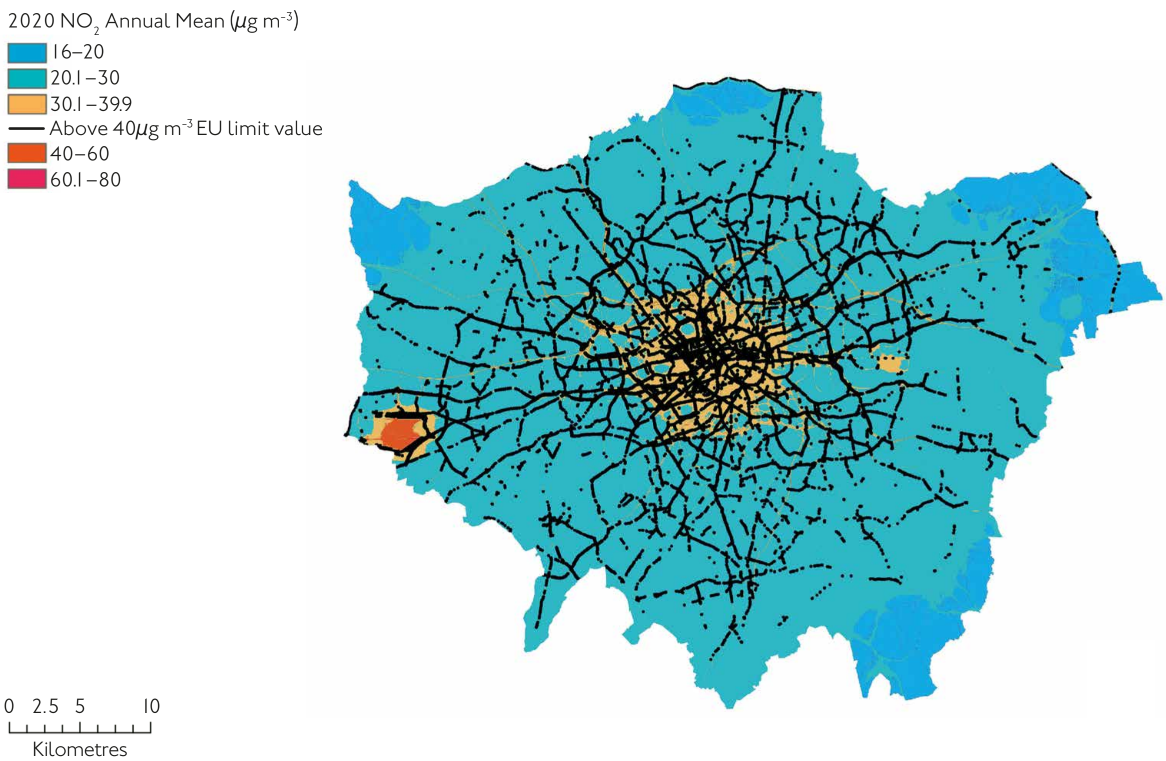
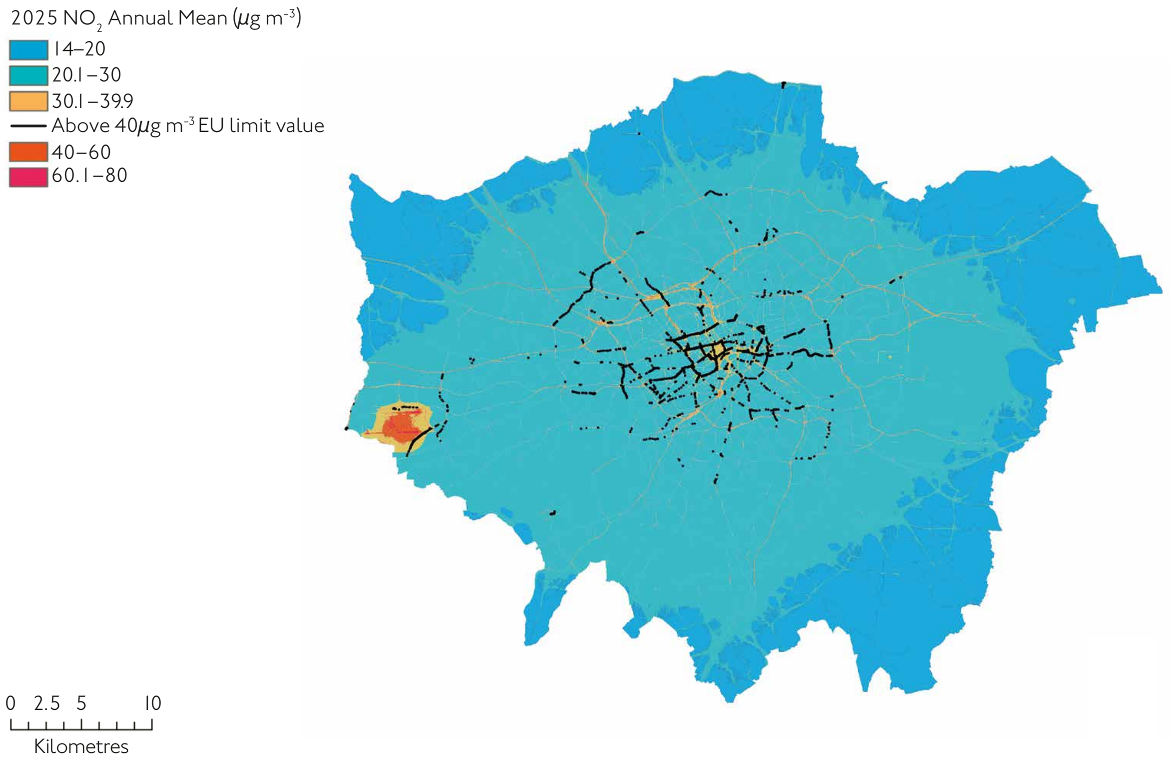


Figure 3.3: Annual average NO_2 concentrations in 2025 (Base Case + Policies 1, 2, 3 & 4)



Overall this analysis shows that although the proposed policies make significant progress towards the achievement of air quality limits, they may not deliver full compliance across London. **Further targeted measures will be required at a local level in order to address air quality issues in the remaining 0.1% of London where pollution levels would otherwise remain stubbornly high.**

To that end, we have conducted further analysis of the areas that are predicted to exceed the NO_2 limit in 2025, despite the proposed policies. **We have identified a total of 221 individual roads where the NO_2 concentration exceeds the limit of 40µg/m³** (having first excluded all points that occur within the roadway itself which are not subject to the NO_2 limit). This corresponds to 315km of total road length where the limit value is exceeded (11.2% of total major road length in London). We have then classified these roads into three groups according to the maximum NO_2 concentration level, and analysed them further in terms of the contribution of different vehicle types to pollution levels on each group of roads (Table 3.2).

Table 3.2: Contribution to NO_2 pollution on the most polluted roads

Road groupings by maximum NO_2 concentration	Number of roads	Contribution to road NO_x emissions by vehicle type					
		Petrol car	Diesel car	TfL bus	Coach	Diesel van	HGV
Group 1 (40–55 $\mu g/m^3$)	196	9%	19%	16%	11%	24%	15%
Group 2 (55–65 $\mu g/m^3$)	22	8%	16%	20%	13%	22%	15%
Group 3 (>65 $\mu g/m^3$)	3	3%	7%	43%	27%	11%	6%

At the extreme, we have identified three roads which still experience NO_2 concentrations of over 65 $\mu g/m^3$ despite the proposed policies – Oxford Street, Brixton Road and Knightsbridge. Our analysis suggests that TfL buses and coaches make up around 70% of the NO_x emissions on these roads. **This suggests that localised action to clean up the bus fleet on the most polluted roads is likely to be required, creating "clean bus corridors".** On the most polluted roads, TfL could selectively reroute some bus services, deploy the cleanest buses available (e.g. Euro VI hybrid, electric or hydrogen), and operate hybrid buses in zero emission mode (a technique known as "geofencing").

In addition, we have identified a larger number of roads (n=196) which exceed the NO_2 limit by a smaller margin at between 40 to 55 $\mu g/m^3$ and a second group (n=22) in the range 55–65 $\mu g/m^3$. Freight vehicles (diesel vans and HGVs) are the largest source of NO_x emissions on these roads, although diesel cars and buses are also significant emitters. **This suggests that further action to clean up freight in specific areas may be beneficial, for example through freight consolidation schemes (see Box 4 below).**

BOX 4: SMARTER FREIGHT AND FREIGHT CONSOLIDATION

Freight is essential to how cities and economies function. In London, 85% of goods are transported by road.[88] On a typical weekday, across London, goods vehicles make an average of 281,000 journeys, equivalent to over 8 million miles,[89] contributing to 17% of the total traffic[90] and 36% of NO_x emissions in London.[91]

There are several ways to make freight more efficient in order to reduce these impacts. During the 2012 Olympic Games, TfL adopted an approach to minimising the impact of freight on businesses operating in London, based on '4Rs': reduce, re-time, re-route and re-mode.[92] The logistics behind the Games proved to be a success from which a number of lessons can be learnt.

The first 'R' for reduce aims at lowering the number of good vehicles on the road as well as limiting the distance they travel, thus reducing congestion and improving air quality. One approach to this is known as "freight consolidation", in which freight shipments from multiple suppliers are consolidated at a single location from which they can be distributed locally, often by zero or low emission vehicles. The role of freight consolidation has been recognised widely, for example in the London Freight Plan (2007),[93] by the Mayor of London (2013)[94] as well as in the City of London Air Quality Strategy (2015).[95] Since then there has been some uptake of freight consolidation, as shown by the following examples, although it is yet to go beyond a niche level:

- The London Boroughs Consolidation Centre was initiated by Camden council, in partnership with Enfield, Waltham Forest and Islington councils. These councils now use a single consolidation centre for all council deliveries.[96] The project has led to a 46% reduction in the number of vehicles delivering to council sites and a 45% reduction in the total distance travelled by these vehicles. As a result, the project achieved a 41% reduction in CO_2 emissions, a 51% reduction in NO_x emissions and 61% reduction in PM compared with the previous delivery systems.[97]
- In 2009, The Crown Estate introduced a voluntary consolidated delivery scheme in London's West End to cut deliveries to retailers, reduce carbon emissions, improve air quality and limit congestion. With supporting funding from The Crown Estate, Clipper Logistics Ltd launched a consolidation centre in Enfield where goods from all suppliers are brought. Electric lorries then bring the stock to 40 retailers, who have joined the scheme on a voluntary basis. This has streamlined a previously complex system of individual deliveries resulting in a reduction in the number of deliveries to retailers by as much as 85% and freight mileage by about 30%.

We recommend that all London Boroughs establish consolidation schemes for their own operations, as well as working with businesses and major landowners in their area to develop additional freight consolidation schemes. The GLA should provide seed-corn funding through the Mayor's Air Quality Fund to establish new consolidation centres.

Our analysis has not described the impacts of the proposed policies on PM_{10} and $PM_{2.5}$ concentrations, since the impact of the proposed policies on direct PM emissions is small (see Table 1.4). However, it is worth noting that NO_x and NO_2 are precursors to the formation of nitrates, a component of PM, hence the reduction in NO_x and NO_2 emissions would also result in a reduction in PM concentrations. This has the potential to have important PM related health benefits but has not been quantified here.

Uncertainty in the emissions and air quality predictions

Although air quality models are an important tool for the development of air quality policy, they are subject to a degree of uncertainty as with any modelling approach. The model used in the analysis above performs well against observations in the base year (2010) and as a consequence any uncertainties in future predictions are driven primarily by the changes in the emissions used in the model runs. There is however a need both to monitor progress against predicted improvements in air quality, as well as conducting research to improve the robustness of air quality models.

An important component of the Mayor's approach to improving air quality will therefore be to monitor how air pollution concentrations are changing over time and to evaluate the impact of air quality proposals. In Box 2 (above) we proposed the introduction of a vehicle labelling scheme to provide improved data on real world emissions from vehicles. This will be an important source of information to increase the robustness of emissions predictions and the analysis of air quality trends. In addition to this, there is a need for a regular review of progress to ensure that London remains on track to achieve air quality limits. **We recommend that the Mayor of London commits to an independent annual audit of the Air Quality Strategy in London to review and track progress towards the achievement of air quality limits.**

Health impact

A 2010 study by the Committee on the Medical Effects of Air Pollutants (COMEAP) estimated that $PM_{2.5}$ pollution had an effect on mortality of 340,000 life years lost, equivalent to nearly 29,000 deaths across the UK in 2008.[98] In reality air pollution is likely to contribute a small amount to the deaths of a larger number of exposed individuals, rather than being solely responsible for the number of attributable deaths, but "equivalent deaths" is the accepted measure. Another way of expressing the impact is that it leads to a loss of life expectancy from birth of approximately 6 months across the entire population.

In the Part 1 report we presented estimates from a previous report by King's College London on the health impacts of air pollution in London in 2010.[99] This report estimated that $PM_{2.5}$ pollution has a mortality burden of 53,000 life-years lost, equivalent to 3,500 deaths in 2010 (Table 3.4). The study also, for the first time, estimated the health impact associated with NO_2 pollution in London, concluding that it has a mortality burden of up to 88,000 life-years lost, equivalent to 5,900 deaths in 2010. These figures can be added together to give an upper limit, after accounting for some overlap between NO_2 and $PM_{2.5}$, and acknowledging that some of the effect may be due to other traffic pollutants. On this basis, the total mortality impact of $PM_{2.5}$ and NO_2 pollution has been estimated as up to 141,000 life years lost, equivalent to up to 9,400 deaths in London in 2010. Put another way, it has been calculated that $PM_{2.5}$ exposure reduces female average life expectancy by 9 months on average across the population of London (9.5 months for males), and NO_2 pollution reduces life expectancy by up to 15.5 months (17 months for males). The same study also calculated that the mortality burden associated with poor air quality is valued at up to £3.7 billion (based on 2010 data).

The evidence on the health effects of NO_2 has strengthened substantially in recent years, and COMEAP is currently considering how this should best be quantified.[100] As this work is still ongoing and the recommendations have not been finalised, the previous methods have been used here. The previous methods emphasise that there are a range of possible answers up to an upper limit and so recommendations leading to lower figures in future are compatible with that range.

Table 3.4: Summary of health effects of air pollution in London in 2010

Indicator	$PM_{2.5}$	NO_2	Total
Equivalent deaths at typical ages	3,500	Up to 5,900	Up to 9,400
Life years lost as a result of equivalent deaths	53,000	Up to 88,000	Up to 141,000
Average loss of life expectancy	9.5 months (male) 9 months (female)	Up to 17 months (male) Up to 15.5 months (female)	n/a
Number of deaths brought forward as a result of short term exposure	787	461	1,248
Hospital admissions as a result of short term exposure	2,732	419	3,151
Monetary value of mortality burden (2014 prices)	£1.4 billion	Up to £2.3 billion	Up to £3.7 billion

To calculate the health benefits of the policies proposed in this report, we linked the air quality projections shown in Figures 3.2 and 3.3 to London's population. We then quantified the health benefits of projected improvements in $PM_{2.5}$ and NO_2 in London, comparing the impact of being exposed to 2010 pollution levels for a lifetime, against being exposed to 2025 pollution levels in the Base Case for a lifetime, and finally against being exposed to 2025 pollution levels in the Base Case including Policies 1 to 4 for a lifetime (see Table 3.5). The following metrics were then calculated for each year and policy combination:

- The change in average life-expectancy for those born in 2025;
- The total number of life years saved for the whole London population over time; and
- The change in economic costs associated with air pollution, annualised over time.

Our analysis shows that if NO_2 concentrations reduce as predicted to 2025 in the Base Case, then this would result in a gain in life expectancy of 5 months for males and 4.5 months for females, across the whole population of Greater London. The policies proposed in this report are predicted to result in an additional gain in life expectancy of 1.3 months for males and 1.2 months for females. Given that the impact of the proposed policies on PM emissions is very small (see Chapter 1), they do not bring about any significant health benefit.

Our analysis also shows that if NO_2 concentrations reduce as predicted to 2025 in the Base Case, then this would result in a gain of 4.5 million life years across the Greater London population (Table 3.6). The annualised monetary benefit of this improvement is £2.5 billion. The additional policies proposed in this report would result in a further gain of 1.1 million life years, adding an annualised monetary benefit of £0.6 billion to this total.

Table 3.5: Average loss of life-expectancy for people born in 2025, exposed to 2010 and 2025 NO_2 concentrations for a lifetime

Scenario	Impact on life expectancy for those born in 2025	
	Males	**Females**
If NO_2 concentrations stay at 2010 levels	-17.5 months*	-16.0 months*
If NO_2 concentrations stay as in 2025 Base Case	-12.5 months*	-11.5 months*
If NO_2 concentrations stay as in 2025 Base Case + Policies 1, 2, 3 & 4	-11.25 months*	-10.25 months*
Gain in life expectancy due to improved NO_2 between 2010 and 2025 in Base Case	+5 months*	+4.5 months*
Additional gain in life expectancy due to proposed Policies (1, 2, 3 & 4 combined)	+1.3 months*	+1.2 months*

*Figures shown as up to a maximum value assuming NO_2 (rather than other traffic pollutants) is responsible for all the effect. A 30% overlap with $PM_{2.5}$ is already taken into account.

Table 3.6: Impact of the improvement in NO_2 concentrations from 2010 to 2025, total life years saved for the whole population and annualised economic impact

Scenarios	Life years lost	Annualised economic impact (2010 prices)
If NO_2 concentrations stay at 2010 levels	Up to 16.8 million*	Up to £9.5 billion*
If NO_2 concentrations stay as in 2025 Base Case	Up to 12.2 million*	Up to £7.1 billion*
If NO_2 concentrations stay as in 2025 Base Case + Policies 1, 2, 3 & 4	Up to 11.1 million*	Up to £6.5 billion*
Life years gained due to improved NO_2 between 2010 and 2025 in Base Case	**Gain of up to 4.5 million life years***	**Gain of up to £2.5 billion***
Additional life years gained due to proposed Policies (1, 2, 3 & 4 combined)	**Gain of up to 1.1 million life years***	**Gain of up to £0.6 billion***

* Figures shown as up to a maximum value assuming NO_2 (rather than other traffic pollutants) is responsible for all the effect. A 30% overlap with $PM_{2.5}$ is already taken into account.

04 Summary of recommendations

The following table provides a summary of all of the recommendations made in this report, together with an indication of the required timescales and responsibility for action:

Table 4.1: Summary of policy recommendations

Policy recommendation	Responsibility	Timescale	
		Reach agreement	Implementation by/effective from
Create and deliver an ambitious plan to clean up London's air	Mayor of London, Defra	2016	2016 onwards
Test the impact of air quality policies to ensure that costs to local residents and businesses are minimised	HM Treasury, DECC, Defra, DfT, Mayor of London, GLA, TfL, London Boroughs	Ongoing	Ongoing
Commit to an independent annual audit of London's air quality plan to review and track progress	Mayor of London	2016	2016–2020
Tighten emission standards for new diesel cars	European Commission, Defra	2016	2017–2021
Increase first year VED rates for diesel cars	HM Treasury	2016	2017
Increase and extend diesel surcharge under the Company Car Tax regime	HM Treasury	2016	2017
Remove or reduce tax breaks for diesels under the Capital Allowances scheme	HM Treasury	2016	2017
Introduce vehicle labelling showing real-world emissions of NO_x and PM	European Commission, DfT, private sector	2016	2017 onwards
Introduce diesel scrappage scheme	HM Treasury, DfT	2016	2016/17
Provide greater certainty over LPG fuel duty	HM Treasury	2016	2017
Create a competitive pan London vehicle charging network	Mayor of London, TfL, London Boroughs	Ongoing	Ongoing
Consider how vehicle charging networks should be regulated.	TfL, DfT, BIS	2017	2017

Policy recommendation	Responsibility	Timescale	
		Reach agreement	**Implementation by/effective from**
Tighten emission standards for buses, coaches and HGVs to Euro VI in the Low Emission Zone	TfL	2017	2021/2023
Tighten emission standards for diesel cars in the Ultra Low Emission Zone to Euro 6c	TfL	2017	2025
Upgrade bus fleet in Central London to a minimum of Euro VI	TfL	2016	2020
Upgrade bus fleet in the rest of London to a minimum of Euro VI	TfL	2017	2023
Create clean bus corridors on the most polluted roads, using only ultra low emission buses	TfL	2017	2020–25
Reduce the age limit for taxis from 15 years to 10 years (with an exemption for retrofitted vehicles which meet the Euro VI standard)	TfL	2017	2025
Put in place financing solution for LPG/retrofit of taxis	TfL, London Boroughs	2016	2017
Amend Private Hire Vehicle licensing regulations to prevent pre-Euro 6 diesels from registering as PHVs	TfL	2016	2016
Create additional freight consolidation centres targeting the most polluted parts of London	Mayor of London, TfL, London Boroughs	2016	2020
Set an ambition to substantially improve London's boiler stock	Mayor of London, GLA	2016	2016
Introduce national measures to promote energy efficiency and boiler replacement amongst able to pay households	HM Treasury, DECC	2016	2017/2018
Expand London boiler cashback scheme, refocusing on air quality improvement	Mayor of London, GLA	2016	2017–2020
Tighten Private Rented Sector Energy Efficiency regulations to set minimum boiler standards	DECC, DCLG	2016	2018/2020
Revise boiler standards and Air Quality Neutral policy	GLA	2016	2017
Reconsider the London Climate Change Mitigation and Energy Strategy to test air pollution impact of decentralised energy	GLA	2017	2017
Mitigate air pollution impacts from national energy policies	DECC, Defra	2017	2017
Revise the definition of Good Quality CHP to include a NO_x emission standard	DECC	2016	2017

Endnotes

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