Next steps for reducing emissions from road transport

January 2022

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Executive Summary

The challenge

The Mayor of London's world-leading programme to tackle poor air quality has delivered significant reductions in nitrogen dioxide (NO_2) emissions from road transport in London over the last five years. This has already had a significant impact in reducing the negative effects of air pollution on Londoners' health and the inequalities it causes.

However, there is still a long way to go to achieve the air quality, environmental and health outcomes to ensure that London is a world-class, attractive, healthy city, in which to live and work, as well as to visit. NO_2 levels remain above legal limits, and there is work required to reduce particulate matter. The climate emergency has also brought into sharp focus the need to urgently reduce carbon dioxide (CO_2) emissions and the Mayor has set an ambitious target for London to be a net zero carbon city by 2030.

Reducing emissions from road transport has a direct impact on human health and creates a more pleasant environment with cleaner air to breathe. This acts as a conduit to increased walking and cycling which in turn brings further health benefits from increased physical activity.

In September 2021, the World Health Organisation (WHO) updated its recommended guidelines for air pollutants and, following the passage of the Environment Act 2021, the UK government is currently preparing secondary legislation in light of these new guidelines. The Mayor has already made the case for these to be aligned with the new WHO interim targets.

The latest estimates from the London Atmospheric Emissions Inventory (LAEI) tells us that 16 per cent of major roads in London still exceed the UK legal limits for NO_2 and of 2,258 state primary and secondary schools, 88 per cent are in areas exceeding the 2021 WHO $PM_{2.5}$ interim target of 10µgm-3, with all exceeding the 2021 WHO $PM_{2.5}$ guideline of 5µgm-3.[1]

For carbon, as the contribution of other sectors has fallen, transport is responsible for an increasing proportion of total emissions: 25 per cent[2] of London's CO_2 emissions now come from road transport. The aim for London to be net zero by 2030 will require further significant transport-based interventions.

We know that taking the right action can deliver significant benefits for London. The action already committed by the Mayor will reduce the number of air quality-related hospital admissions by one million by 2050, helping save the NHS and social care system £5 billion. However, despite these significant improvements, if no additional action is taken to reduce air pollution beyond the existing policies committed to by the Mayor, around 550,000 Londoners would develop diseases attributable to air pollution over the next 30

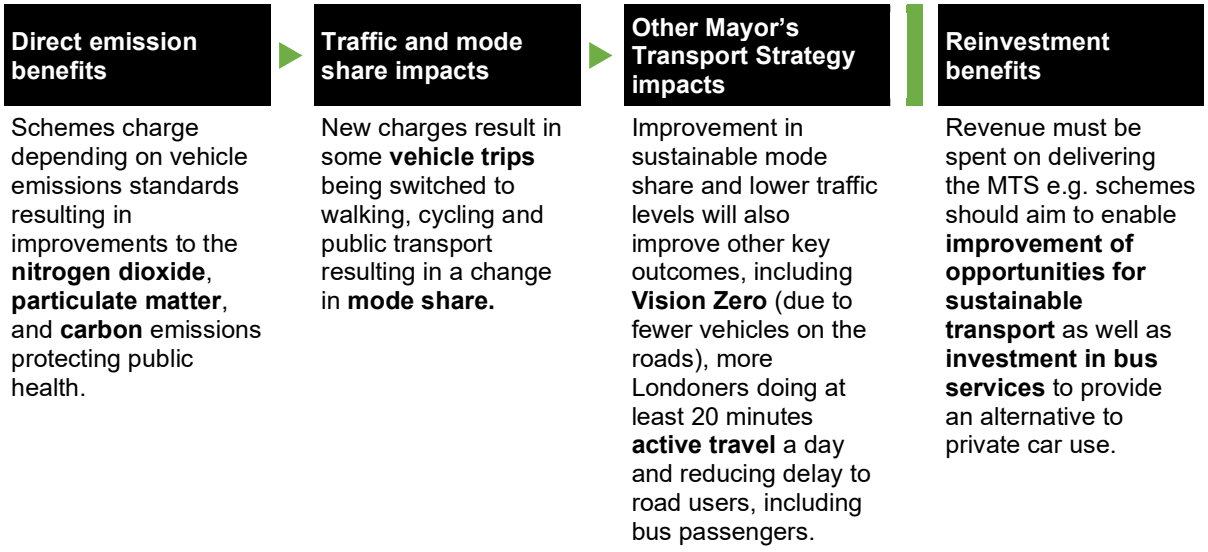
[1] LAEI 2019 Summary Note

[2] The LAEI has been used as it is the latest available estimate with data for 2019. The London Energy and Greenhouse Gas Inventory (LEGGI) gives the most definitive view on greenhouse gas emissions in London and is being updated with data for 2019 and expected to be available later this year.

years and the cumulative cost to the NHS and social care system is estimated to be £10.4 billion. The benefit of improving air quality to the UK and local economies has been analysed by CBI Economics who found the UK economy could benefit to the tune of £1.6 billion each year if it were to achieve the guidelines set by the WHO for air quality.[3]

Using road user charging to improve emissions and other outcomes

Traffic reduction is not only an objective in itself in the Mayor's Transport Strategy (MTS) but is the key to achieving a range of MTS objectives including reduced emissions. The MTS evidence base and further optioneering work (considering a wide range of traffic reduction measures, not limited to road user charging schemes) has shown that road user charging (RUC) policies have the greatest potential to deliver the required level of traffic reduction and associated benefits as quickly as possible. This paper sets out four potential approaches to reducing emissions from road based transport to address wider transport emission challenges. It summarises the approaches and sets out the key issues to consider for each, including the potential impacts on traffic levels and on the three key emissions of nitrogen dioxide, particulate matter and CO_2. While the focus of this paper is on strengthening London's approach to emissions, other benefits are also considered– as outlined below. Further analysis of the impacts and benefits would be needed before any of the approaches discussed could be progressed further.



[3] https://www.cbi.org.uk/media/5539/2020-09-cbi-economics-caf-report.pdf

Potential approaches to adapting emissions based charging

In this paper we have considered four approaches to emissions based charging; expanding current schemes, modifying current schemes, introducing a new type of scheme or making more fundamental changes to the way we pay for road use.

An example of each approach is outlined below to show the potential benefits and impacts of each type of intervention. This early work could form the basis of future scheme development, and approaches could be adapted or refined. Any new scheme would have to be effective, simple for customers to use and fair and proportionate to its aim. The four potential approaches considered include:

1. **Extending the Ultra Low Emission Zone (ULEZ) to tackle more of the dirtiest vehicles**: extending the current zone beyond the north and south circular roads to cover the whole of Greater London, using the current charge level and emissions standards.

2. **Modifying the ULEZ to make it even more impactful in reducing emissions**: extending the current zone beyond the north and south circular roads to cover the whole of Greater London, and introducing a new, tighter emissions standard, charged at a low level to further reduce emissions from road based transport and accelerate the shift to electric vehicles (EVs).

3. **A low-level emissions charge**: a low-level daily charge across all of Greater London for all but the cleanest vehicles e.g. zero emission capable or zero emission vehicles. This could work as a 'nudge' to behaviour change in a similar way to the 10p charge for plastic bags.

4. **Next-generation charging**: an integrated scheme which incorporates existing schemes and charges a single charge per mile (distance-based charging). This could not be delivered until later than other approaches, but any approaches taken forward in 2023 could potentially transition to such a scheme in later years.

The potential impacts[4] of the four types of intervention are summarised in the table below. The table also includes an overview of the impacts of a potential Greater London Boundary Charge (GLBC), which would be focussed on cross boundary driving and is also effective in reducing traffic and emissions. The GLBC has been subject to its own feasibility study[5] but is included here to allow for easy comparison of all potential approaches.

[4] Note figures are early indicative findings
[5] Greater London Boundary Charge: Feasibility Study, TfL (January 2022)

	1. ULEZ expansion to outer London	2. ULEZ expansion with a tighter standard	3. Low-level emissions charge	4. Next generation charging (London-wide)	Greater London Boundary Charge
Policy impacts					
MTS Objective: reaching compliance with UK and EU legal limits as soon as possible					
NO_x emissions*	▼ 285 to 330 tonnes NO_x	▼ 330 to 390 tonnes NO_x	▼ 28 to 35 tonnes NO_x	▼ 139 to 162 tonnes NO_x	▼ 50 tonnes NO_x
MTS Objective: net zero carbon					
CO_2 emissions	▼ 135,000 to 150,000 tonnes CO_2	▼ 173,000 to 193,000 tonnes CO_2	▼ 21,000 to 24,000 tonnes CO_2	▼ 110,000 to 111,000 tonnes CO_2	▼ 27,000 tonnes CO_2
*For NO_x and CO_2 emissions figures given above, the higher figure excludes a phase-out of ICE vehicles by 2030 and the lower figure includes this.					
MTS Objective: at least 3m fewer daily car trips and 250,000 fewer cars owned in London by 2041					
Traffic reduction	▼ <1% car trips ▼ 0.5 to 1% veh kms ▼ This equates to 20,000 to 40,000 fewer cars on London's roads every day	▼ 3% car trips ▼ 1.5% veh kms ▼ This equates to 100,000 fewer cars on London's roads every day	▼ 2.5% car trips ▼ 0.8% veh kms ▼ This equates to 60,000 to 80,000 fewer cars on London's roads every day	▼ 6% car trips ▼ 5.5% veh kms ▼ This equates to 400,000 to 500,000 fewer cars on London's roads every day	▼ 3% car trips ▼ 1% veh kms ▼ This equates to 60,000 to 70,000 fewer cars on London's roads every day
MTS Objective: 80 per cent sustainable mode share by 2041					
Mode shift	Marginal as 60,000 to 70,000 of the most polluting cars from London's roads are replaced with ULEZ compliant cars	▲ 0.5% With a strong shift to walk trips	▲ 0.5% With a strong shift to bus and walk trips	▲ 1.5%	▲ 0.5%
Implementation cost and date					

	1. ULEZ expansion to outer London	2. ULEZ expansion with a tighter standard	3. Low-level emissions charge	4. Next generation charging (London-wide)	Greater London Boundary Charge
Implementation cost	£225-275m (+ c. £100m tbc scrappage fund)	£375m (+ c. £100m tbc scrappage fund)	£325m	£270m (based on central / inner London cost – London wide would depend on what else is in place in 2025/6)	£220m
Earliest date	Late 2023	Late 2023	Late 2023	2025/2026	Late 2023

The approaches outlined above have the potential to raise a net operating surplus which would need to be used in achieving the aims of the MTS. Further detailed work is required on future levels of compliance with emissions standards as this will significantly impact revenues generated.

Moving forward

If the potential approaches within this paper were to be developed into new scheme proposals, they are likely to require revision of the MTS as well as public and stakeholder consultation, an integrated impact assessment and compliance with other statutory procedures. Consideration would need to be given to mitigations and complementary measures, including to address impacts on people sharing protected characteristics and from low income households. The recent expansion of the ULEZ has highlighted how such households are often the most adversely affected by poor air quality but also may need help to shift to cleaner vehicles.

A scheme based on daily charges i.e. the first three of the approaches considered within this report (and the GLBC) could, subject to proper processes (further analysis, the outcome of public and stakeholder consultation, MTS revision, integrated impact assessment and Mayoral approval) be implemented by the end of 2023. The announcement of any scheme could start to bring benefits in terms of behaviour change, as has been seen with the ULEZ, well in advance of this.

1.Introduction

Since 2016 we have made significant progress in reducing toxic emissions from road transport across London. In March 2021 we tightened the standards for the London-wide Low Emission Zone (LEZ) for heavy vehicles and in October 2021 we expanded ULEZ from central to inner London. Both schemes have been effective in increasing the percentage of vehicles that are compliant with the higher vehicle standards, with a compliance rate of over 90 per cent for both schemes.

And while these schemes focus on NO_2 emissions (owing to the need to comply with legal limits to protect public health), in principle a scheme can have as its objectives other aims which are set out in the MTS, such as the reduction of CO_2 and particulate matter to further protect public health (e.g. by meeting WHO recommended guidelines), or to reduce vehicle kilometres overall. Schemes which reduce motorised traffic, properly implemented, can potentially bring many benefits in line with the objectives set out in the MTS.

This paper sets out potential approaches that could be taken to modify RUC schemes in London and which could be focused on reducing emissions from road transport. As it is only preliminary work based on indicative approaches, detailed quantification of impacts has not been provided, but information on traffic impacts demonstrates the potential of these approaches to achieve MTS objectives including emissions reductions. If any scheme proposals were to be developed and progressed as a result of this work, they would be subject to further detailed development, scheme design and assessment including other environmental impacts, economic impacts, health and social impacts including an Equality Impact Assessment (EqIA) and data protection and privacy impacts.

In Greater London, a RUC scheme may only be made if it appears desirable or expedient for the purpose of directly or indirectly facilitating the achievement of any policy or proposal set out in the MTS. The MTS sets out that the current RUC schemes will be kept under review, and changes made if they are needed (Proposal 20); and that the next generation of RUC schemes – such as distance-based charging – will be investigated (Proposal 21). A scheme must also be in conformity with the MTS with schemes usually referred to and described in the MTS.

We have also developed a set of sustainable road use objectives for future schemes in London:

- To **reduce motor vehicle traffic**, particularly private car trips, and increase sustainable mode share in London, in line with the MTS target of 10-15 per cent traffic reduction across London (including at least three million fewer daily car trips) and 80 per cent sustainable mode share by 2041.
- By reducing motor vehicle traffic, support the **achievement of mode share, road danger reduction and environmental objectives**; and help to reduce congestion and support the efficient movement of traffic.
- To **reduce CO_2 emissions** from motor vehicles contributing to the Mayor's ambition for London to be carbon-neutral by 2030.

- To **reduce air quality emissions** (including non-exhaust emissions) from transport, working towards legal limits for NO_2 and the WHO health-based limits for particulate matter ($PM_{2.5}$).
- To enable the **optimum use of streetspace** for active travel, bus and essential trips such as freight and servicing movements (including emergency services). More effective use of our finite road and kerb space is key to enabling more walking and cycling in our city, improving journey time for essential trips, and appropriate access for goods and servicing vehicles.
- To have a **net positive impact on London's economy and businesses**, contributing to green recovery objectives and Good Growth in the longer term.
- To support other objectives including Vision Zero and the aspiration for a healthy and inclusive city set out in the **London Recovery Programme**, and for all Londoners to be supported to achieve the 20 minutes of active travel that is recommended for good health and wellbeing.

Current RUC schemes in London are enforced via automatic number plate recognition (ANPR) camera captures. A more technological approach, such as one based on GPS, would require additional development time, but could integrate existing schemes, simplify the customer experience and incorporate future distance based charging, which could be a fairer way to charge for road use. Approaches 1-3 in this paper assume that existing technology is used, but there is scope for the introduction of other approaches over time just as there is scope to tighten emissions standards (as was the case for the LEZ in March 2021) or vary the charging hours and charge level (as has recently been the case for the Congestion Charging scheme). Flexibility in the way in which policy objectives can be achieved – subject to statutory requirements including the need to undertake impact assessments and carry out public consultation – is a key strength of RUC powers.

Another important feature of RUC schemes in London has been the inclusion of mitigations such as discounts (for Blue Badge holders in the Congestion Charging scheme, for example) and support schemes such as the scrappage scheme for low income and disabled Londoners which preceded the recent ULEZ expansion. In developing any new scheme, it is assumed that similar measures would be considered and included as appropriate.

A new scheme would be likely to require a revision of the MTS to ensure that the Strategy provides a sufficient policy basis for the scheme and encompasses all of the purposes for which the net proceeds of the scheme are proposed to be used. The main features of a scheme (such as the proposed charging area) are also usually described in the MTS as part of the requirement for a scheme to be in conformity with the MTS. An MTS revision would require public and stakeholder consultation and an integrated impact assessment (encompassing as a minimum the required strategic environmental and equality impact assessments), and involve the statutory revision procedures, including the pre-publication draft being laid before the Assembly. Most of the approaches set out in this paper could, subject to following this procedure and Mayoral approval, be implemented by the end of 2023, including a reasonable pre-compliance period after confirmation. As we have seen with ULEZ, a scheme could start to bring benefits in terms of behaviour change – as people change how they travel or switch to a cleaner vehicle – well in advance of the operational start date.

Revenue from RUC schemes must be spent on delivering the MTS: for example, schemes which improve opportunities for the use of sustainable transport in London including initiatives to encourage walking and cycling as well as investment in bus services to maintain and enhance their attractiveness as an alternative to private car use.

2. Transport emissions

Why do we need to do more to reduce road transport emissions?

There are a number of key interactions between transport and health, which if acted upon, could lead to health and wellbeing improvements for Londoners. Reducing emissions from road transport has a direct impact on human health and creates a more pleasant environment with cleaner air to breathe. This acts as a conduit to increased walking and cycling which in turn brings further health benefits from increased physical activity.

The twin challenges of tackling air pollution and climate change therefore mean we need to urgently reduce emissions in London. Environmental hazards increase the risk of cancer, heart disease, asthma, and many other illnesses, and CO_2 emissions are contributing to climate change and the catastrophic impacts this is already having on people, businesses and infrastructure. Road transport accounts for the following emissions in London:

- 44 per cent of NO_x emissions;
- 33 per cent of $PM_{2.5}$ emissions; and
- 29 per cent of London's CO_2 emissions.[6]

Whilst zero emission capable (ZEC) vehicles have reduced adverse impacts in terms of tailpipe emissions compared to internal combustion engine (ICE) vehicles[7], they still produce non-exhaust particulate emissions (e.g. from tyre and brake wear).

There are two main air pollutants of concern in London, based on their impact on human health: NO_2[8] and fine particulate matter ($PM_{2.5}$). There is a compelling body of evidence that highlights that poor air quality has immediate impacts on health. Poor air quality stunts the growth of children's lungs and worsens chronic illnesses, such as asthma, lung and heart disease. There is also growing evidence linking exposure to air pollution with the worst effects of Covid-19. A report from Imperial College London confirms that exposure to air pollution before the pandemic increases the risk of hospital admissions from Covid-19, as well as other lung infections such as pneumonia and bronchitis.[9]

Not only does London have high levels of emissions, being a dense, urban area, it also has high numbers of people exposed to air pollutants. A recent report found that if no wider action is taken to reduce air pollution, around 550,000 Londoners will develop diseases attributable to air pollution over the next 30 years.[10] Further to this, data shows that communities which have higher levels of deprivation or a higher proportion of people

[6] The LAEI has been used as it is the latest available estimate with data for 2019. The LEGGI gives the most definitive view on greenhouse gas emissions in London and is being updated with data for 2019 and expected to be available later this year.

[7] Internal Combustion Engine, i.e. petrol or diesel-fuelled

[8] NO_2 concentrations in the atmosphere derive from NO_x (nitrogen oxides) emitted from vehicles.

[9] https://www.london.gov.uk/WHAT-WE-DO/environment/environment-publications/investigating-links-between-air-pollution-and-covid-19

[10] https://www.london.gov.uk/press-releases/mayoral/ulez-to-save-billions-for-nhs

from a non-white ethnic background are more likely to be exposed to higher levels of air pollution.[11]

Delayed efforts to reduce CO_2 emissions will have negative and potentially irreversible consequences for global warming, resulting in rising sea levels and extreme weather conditions (already being experienced in London), which in turn have potentially disastrous consequences for human and environmental wellbeing.

In 2018 when the Mayor published his Transport Strategy and the London Environment Strategy (LES), he committed to support London in reaching compliance with legal limits for air pollutants and to a 2050 Net Zero Carbon target, as well as introducing London level carbon budgets, which decrease over time. The 2017 UK Air Quality Plan for Roadside NO_2 states that London will be in compliance with NO_2 limit values by or before 2025 if all measures in the plan are implemented and effective. Since then, both the local and national ambition has increased. For air quality, the WHO guidelines were tightened in September 2021 so that there are lower thresholds for safe levels of pollutants. This highlights that, although we have come a long way, there is a lot more still to do to ensure that ambitions can be achieved.

Tackling CO_2 emissions is a further consideration. The Mayor committed in 2020 to set a target for London to be net zero by 2030. At the national level, the Climate Change Act 2008 requires the UK to achieve net zero (a 100 per cent reduction in greenhouse gas (GHG) levels below 1990 level) by 2050. In December 2020, the UK committed in its Nationally Determined Contribution to the United Nations Framework Convention on Climate Change to reduce economy-wide GHG emissions by at least 68 per cent by 2030 compared to 1990 levels. The Climate Change Act 2008 also provides for carbon budgets which set limits on the net UK carbon account. The UK has committed within the Sixth Carbon Budget to a 78 per cent reduction in GHG by 2035.[12]

Air quality has improved but still has a long way to go

In recent years, London has had considerable success in tackling air pollution with strong policies including the Congestion Charging scheme, the ULEZ in central London, the LEZ London-wide, and the recent ULEZ expansion to inner London in October 2021. A notable feature of these schemes is that they have been modified over time so that they continue to deliver benefits and reflect changes to technology and the vehicle fleet, with tighter emissions standards and, in the case of ULEZ, geographical expansion. To support the introduction and expansion of ULEZ, the Mayor committed over £61 million towards disposing of over 14,000 dirty vehicles with vehicle scrappage schemes, limiting the impacts on low-income and disabled Londoners, charities and small businesses.

London has taken significant steps to meeting UK legal limits for NO_x and the Mayor has made a commitment to achieve the 2005 WHO air quality guideline of 10µgm-3 for $PM_{2.5}$.[13]

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[11] https://www.london.gov.uk/press-releases/mayoral/bame-and-poorer-londoners-face-air-quality-risk
[12] Sixth Carbon Budget (2020) https://www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-The-UKs-path-to-Net-Zero.pdf
Government press release detailing new legal targets https://www.gov.uk/government/news/uk-enshrines-new-target-in-law-to-slash-emissions-by-78-by-2035
[13] Policy 7 MTS

The Air Quality in London Report[14], published in October 2020, looking at the period 2016 to 2020 reports that since February 2017 there has been a 44 per cent reduction in roadside NO_2 in the central London ULEZ, with 44,100 fewer polluting cars being driven in the zone daily. Similarly, the updated LAEI 2019[15], published by the Greater London Authority (GLA) in December 2021, shows that the impact of air pollution is reducing widely across London, with the number of state primary and secondary schools in areas exceeding legal limits for NO_2 falling from 455 in 2016 to 20 in 2019, a reduction of 96 per cent.

However, the LAEI 2019 also tells us that 16 per cent of major roads in London still exceed the UK legal limits for NO_2 and of 2,258 state primary and secondary schools, 88 per cent are in areas exceeding the 2021 WHO $PM_{2.5}$ interim target of 10µgm-3 (along with 86 per cent of care homes), with all exceeding the 2021 WHO $PM_{2.5}$ guideline of 5µgm-3.[16] Significant improvements in reducing the number of people living in areas of high pollution has been made, reducing from two million in 2016 to around 170,000 in 2019. However, we estimate 2.8 million Londoners are still living in areas that exceed the new WHO interim targets for NO_2 (30µg/m^3). Despite significant improvements in London's air quality between 2016 to 2019, research by Imperial College London found that in 2019 toxic air contributed to the premature deaths of more than 4,000 Londoners.[17] The greatest number of deaths attributable to air pollution were in outer London boroughs, mainly due to the higher proportion of elderly people in these areas, who are more vulnerable to the impacts of air pollution.[18] This – combined with the evidence supporting the changes made to the WHO air quality guidelines – underscores that, despite the significant progress made in London, accelerated additional action is needed to meet the 2021 WHO interim targets (as a minimum), and bring about compliance and lower exposure as quickly and effectively as possible to protect human health.

The 2019 LAEI modelled concentration maps for NO_2, $PM_{2.5}$ and PM_{10} are given in Appendix A, alongside previous LAEI maps from 2013 and 2016.

There are now new World Health Organisation (WHO) guidelines

In September 2021 the WHO updated its recommended guidelines for air pollutants[19], based on the best available health evidence. The WHO also published a set of interim targets which authorities can use to develop pollution reduction policies that are achievable within realistic time frames. These reflect the overwhelming weight of evidence about the devastating health impacts of air pollution, even at low levels. Table 1 summarises the updated air quality guidelines and interim targets alongside the UK's current legally binding air quality limits set by the EU (which require compliance as soon as

[14] Air quality in London 2016 – 2020 https://www.london.gov.uk/what-we-do/environment/pollution-and-air-quality/air-quality-london-2016-2020
[15] LAEI press release: https://www.london.gov.uk/press-releases/mayoral/huge-progress-made-in-improving-londons-aq and LAEI 2019 summary note
[16] LAEI 2019 Summary Note
[17] Health burden of air pollution in London – study by Imperial College, published January 2021 https://www.london.gov.uk/WHAT-WE-DO/environment/environment-publications/health-burden-air-pollution-london
[18] https://www.london.gov.uk/WHAT-WE-DO/environment/environment-publications/health-burden-air-pollution-london
[19] WHO global air quality guidelines 2021 9789240034228-eng.pdf (who.int)

possible but by or before 2025). The UK government is currently in the process of preparing secondary legislation following the passage of the Environment Act in 2021 to amend the UK's existing air quality limits. The Mayor has made the case for these to be aligned with the new WHO interim targets.

Table 1: Recommended WHO 2021 air quality guideline levels compared to interim targets and UK limits

Pollutant	2010 Air Quality Limits	WHO Interim target*				2021 WHO Air Quality Guideline
		1	2	3	4	
$PM_{2.5}$µgm-3	25	35	25	15	10	5
PM_{10}µgm-3	40	70	50	30	20	15
NO_2µgm-3	40	40	30	20	-	10

***WHO interim targets are proposed as incremental steps in a progressive reduction of air pollution and intended for use in areas where pollution is high**

We need to accelerate the shift to zero emission vehicles

Whilst the focus of the emission zones in London has been to shift away from older dirtier vehicles, we have also been encouraging a shift to the new generation of cleaner zero emission vehicles.

We have some of the strongest emissions-based licensing policies for taxis and private hire vehicles (PHVs) in Europe, where since January 2018 all newly licensed taxis have been required to be ZEC. As of 11 January 2022, a total of 5,149 ZEC taxis have to date been licensed in London. 4,781 of these are actively operating; over a third of the current total operating fleet. To ensure that emission reductions from taxis are achieved at the pace needed to meet our air quality targets, we have also introduced a mandate for maximum applicable taxi operating age limits. Currently, the maximum age limit for Euro 3, 4 and 5 diesel taxis is 13 years and this will reduce to 12 years (and remain at 12 years) from 1 November 2022. The maximum age limit for Euro 6 diesel taxis and ZEC taxis remains at 15 years, which is also the age limit for taxis that are newly converted to Liquid Petroleum Gas (LPG). The industry has been supported to transition to newer, greener vehicles with a delicensing scheme for older taxis, ZEC taxi grants and a network of rapid chargers, some of which are taxi-dedicated.

Current emission standards for PHVs require that vehicles under 18 months old must be ZEC and meet the Euro 6 emissions standard when licensed for the first time, and those over 18 months old must have a Euro 6 (petrol or diesel) engine. These standards will be tightened in January 2023, at which point all PHVs licensed for the first time will have to be ZEC and meet the Euro 6 emissions standard.

We have also brought forward the timeframe for having a zero emission bus fleet from 2037 to 2034 following an announcement by the Mayor that all new London buses will be zero emission. Furthermore, it would be possible to have a 2030 zero emission bus fleet with appropriate support from Government. London has western Europe's largest zero emission bus fleet and there are currently 566 zero emission vehicles, which will increase to around 800 by the end of March 2022.[20] The faster transition time will enable London to have a total of 10 per cent of its fleet zero emission by the end of 2022. We are also continuing to support the piloting of complementary technologies such as hydrogen, and now have 20 double-deck hydrogen buses in operation.

Many businesses in the freight and servicing sector are committing to shifting to zero emission vehicles. To support this transition the public sector has supported the installation of around 45 per cent of the 8,600+ public EV charging points across London, which is an 85 per cent increase on the total in London since 2019. London currently has around 32 per cent of the UK's total number of charge points.[21] The Mayor has exceeded his target for delivering 300 rapid charge points by the end of 2020 and is now actively looking at using GLA Group land to roll out further rapid charge points.

Reducing carbon dioxide emissions is vital to tackling climate change

Global warming is going to exceed 2˚C during this century unless there are deep and rapid reductions in CO_2 and other greenhouse gas emissions.[22] The impacts (including flooding and heatwaves) will be severe. As CO_2 emissions are cumulative, each additional tonne of CO_2 emitted contributes to global warming. Emitting less greenhouse gases in total will lead to lower levels of warming and climate change.

We are already experiencing the impacts of high temperatures and flooding on our network:

- several London Underground points systems regularly fail under high temperatures, causing train diversions and delays
- Hammersmith Bridge was closed due to microfractures widening as a result of high temperatures in 2020
- flooding incidents closed London Underground stations 38 times Jan-Aug 2021.

In October 2021, the Government published a national net zero strategy setting out how it plans to meet the UK's legally binding emissions targets out to 2050. The strategy includes a range of policy measures alongside funding to support the UK's transition to net zero. This strategy is supported by government's transport decarbonisation plan, published in July 2021, which sets out a number of policy measures to decarbonise transport across the UK. Within the decarbonisation plan, London is upheld as a leader in encouraging modal shift and improving air quality and has a key role to play in encouraging the rest of the UK to take action as it has with Clean Air Zones. As the UK's largest city, London must also play its part to reduce its emissions to contribute to national targets.

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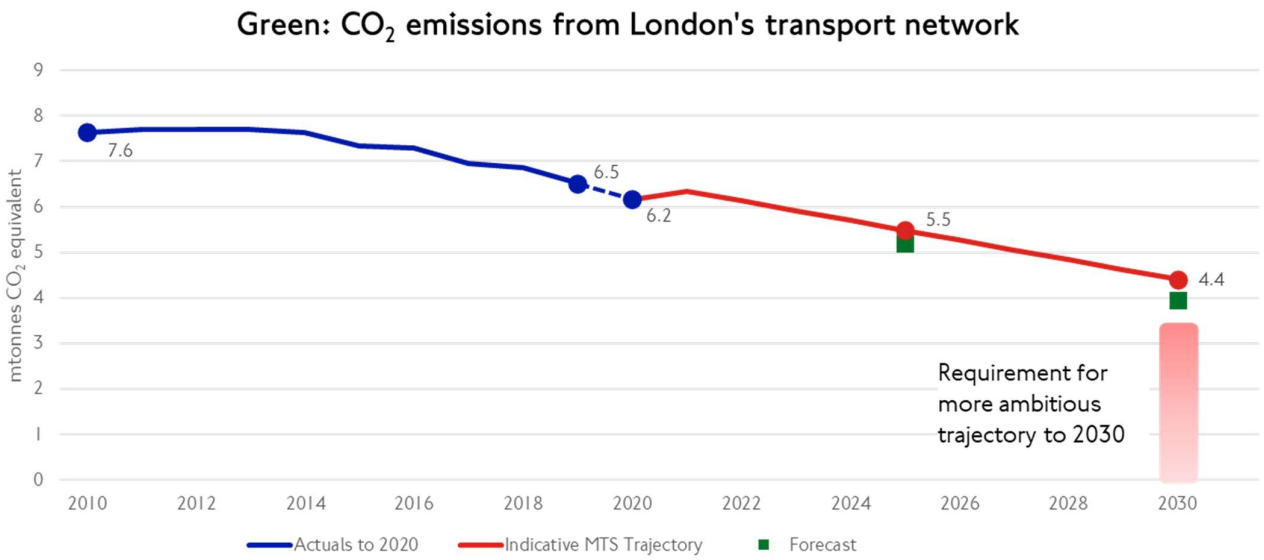
[20] This is subject to the ability of the bus manufacturing industry to build and supply, and the necessary grid and garage infrastructure being put in place
[21] Zap-Map data, updated 13 January 2022 (www.zap-map.com/statistics/)
[22] IPCC (2021) Sixth Assessment Report (ipcc.ch)

London's overall CO_2 emissions have been falling over the last 20 years. As transport is a major contributor to overall CO_2 emissions, this is thanks in part to policies that encourage people to switch to sustainable modes of travel and more recently interventions such as the central ULEZ (although the scheme is primarily aimed at reducing air quality pollutants, it also has CO_2 reduction benefits). Since 2017 CO_2 emissions in the central zone are estimated to have reduced by 12,300 tonnes, a reduction of six per cent because of the ULEZ.[23] However it is important to note that CO_2 emissions from transport have not been decreasing as fast as those in other sectors[24]; further action is required.

Modelling suggests we are on course to achieve the zero carbon 2050 target set out in the MTS (red line in Figure 1 below), which was itself an ambitious target. This has been driven primarily by a shift to EVs in London, influenced by both London policies and the government commitment to phase out internal combustion engine vehicles. However, it is now clear that we need to move faster. The contribution of other sectors has fallen as the national grid has begun to decarbonise and industry has relocated out of London. Transport is, therefore, responsible for an increasing proportion of total emissions (29 per cent25). The aim for London is to be net zero by 2030 and emerging findings suggest, under the preferred accelerated decarbonisation pathway, a 27 per reduction in car vehicle kilometres compared to 2018 will be required to meet this target.26 This will therefore require further significant transport-based interventions.

[23] Air quality in London 2016 – 2020 https://www.london.gov.uk/what-we-do/environment/pollution-and-air-quality/air-quality-london-2016-2020
[24] London Energy and Greenhouse Gas Inventory (LEGGI), interim 2018 figures https://data.london.gov.uk/dataset/leggi
[25] The LAEI has been used as it is the latest available estimate with data for 2019. The LEGGI gives the most definitive view on greenhouse gas emissions in London and is being updated with data for 2019 and expected to be available later this year.
[26] Analysis of a Net Zero 2030 Target for Greater London (2022) https://www.london.gov.uk/sites/default/files/nz2030_element_energy.pdf

Figure 1: Carbon dioxide emissions from London's transport network[27]



[27] TfL, City Planning

3. Public health

Transport has a vital role to play in improving health outcomes for Londoners

Health and wellbeing improvements have an intrinsic value as well as bringing economic benefits. London needs a healthy workforce free from physical and mental ill health to remain open for business and to reduce the financial burden on health and social care services. In London, premature deaths attributed to poor air quality cost between £1.4 and £3.7 billion a year to the health service and the wider economy[28]; the costs of physical inactivity are estimated to amount to between 1.5 and three per cent of total direct healthcare costs in developed countries.[29] These stark figures represent real human impacts. Perhaps the most powerful example of this is the death of Ella Adoo-Kissi-Debrah in 2013, where in December 2020 the coroner made an unprecedented ruling that air pollution contributed to her death.

The MTS recognises the vital role of health and wellbeing in improving the lives of Londoners and aims for all Londoners to do at least 20 minutes of active travel every day by 2041. It also highlights that during an average journey by car less than one minute is spent being physically active compared to eight to 15 minutes for public transport, 17 minutes for walking and 22 minutes for cycling. A mode shift to walking and cycling also brings further health benefits in addition to those gained from increased physical activity including saving money in treatment costs for the NHS[30], people taking fewer sick days[31] and feeling more productive at work.[32]

Interactions between transport and health play out across the city and they feature within the Mayor's strategies for London, including the Transport Strategy. These interactions reflect the negative impact that congestion can have on air quality, climate change, physical activity, road danger, noise and severance. The MTS commits to a Healthy Streets Approach designed to put human health and experience at the heart of planning a city. Reducing car dependency is critical to the success of the approach to avoid streets that are congested, noisy and unpleasant to spend time in. It will also help to ensure that streets are safer with air that is clean to breathe. There will be further positive impacts in terms of healthcare costs: the ambitious programme of initiatives to clean up London's air are estimated to save the NHS and social care system almost £5 billion over the next 30 years.[33]

Health inequalities remain one of London's greatest challenges

One of London's greatest challenges is poor public health and the stark health inequalities that prevent many Londoners from reaching their full potential. London remains deeply

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[28] Laybourn-Langton, L., Quilter-Pinner, H., & Ho, H. (2016). Lethal and illegal: Solving London's air pollution crisis. *Institute for Public Policy Research*.
[29] Oldridge NB. Economic burden of physical inactivity: Healthcare costs associated with cardiovascular disease. Eur J Prev Card. 2008;15(2):130-9.
[30] https://content.tfl.gov.uk/mts-challenges-and-opportunities-report.pdf
[31] National Institute for Health and Care Excellence, 2012
[32] The Prince's Responsible Business Network, 2011
[33] https://www.london.gov.uk/press-releases/mayoral/ulez-to-save-billions-for-nhs

divided in terms of health and wellbeing, with health outcomes and inequalities varying considerably across London. Health inequalities are systematic, avoidable and unfair differences in mental or physical health between groups of people. These differences affect how long people live in good health. They are mostly a result of differences in people's homes, education and childhood experiences, their environments, their jobs and employment prospects, their access to good public services and their habits. There is a clear relationship between wealth and health which means that everyone but the very richest is likely to have some avoidable illness.

In 2016 we estimated that the most deprived communities were exposed to about a quarter more NO_2 pollution than the least deprived. It shows the potential power of Mayoral action that by 2019 we had halved this 'pollution gap'. However, it remains the case that if you're poorer you're still more likely to be exposed to more pollution. This is wrong and is why further action to improve air quality is needed.

The pandemic has highlighted the health inequalities that continue to persist in London's society and reinforced the need to take action. The London Health Inequalities Strategy (2018) sets out the Mayor's commitment to a healthier fairer city and to consider "health in all policies". With regards to transport, this means ensuring that all Londoners have access to clean air, are protected from road danger and noise, are supported to achieve the minimum physical activity required for good health and wellbeing through active travel, as well as being able to access key services.

The Strategy recognises the role that transport along with the Mayor's other statutory responsibilities can play and the opportunities it presents to make a difference to the wider determinants that affect the health of Londoners. Health and transport are inextricably linked, with London's transport system providing a lever to reduce health inequalities and improve Londoners' health and wellbeing. There are clear links between transport and health inequalities: transport can *directly cause* these inequalities (for example, an area with few opportunities for active travel can lead to poorer physical health); it can *directly exacerbate* existing inequalities (for example, exposure to poor air quality as a result of vehicle emissions can exacerbate lung conditions); and it can indirectly exacerbate inequalities (for example, lack of access to transport means that people may not be able to access jobs, education and other services which are essential to health).

An inclusive, low-emission transport system will help to reduce the negative impacts of transport on health, improve health inequalities and close the gap in life expectancy that exists between those who life in the most and least deprived areas of London. Reducing the persistent and in some cases widening health inequalities in London requires commitment and action from a range of organisations; tackling those caused by emissions from transport is a priority for the Mayor.

Further reducing road transport emissions will improve air quality in London and help to tackle wider health inequalities

The Health Inequalities Strategy and the MTS set out the important role that managing road transport plays in addressing air quality, road danger, noise, physical activity and wellbeing. The LES also commits the Mayor to taking firm action to improve air quality in London, with public health now more important than ever in the context of the pandemic and what we know about the disproportionate impact it has on particular groups.

The pandemic has spurred a greater focus on the need for cleaner air in the capital: higher Covid-19 mortality has been observed in areas of greater air pollution[34] and long-term exposure to air pollution may lead to increased risk of mortality from Covid-19.[35] There are also established links in London[36] between air quality and both deprivation and ethnicity, with those in more deprived communities being more likely to be exposed to high levels of air pollution. People in non-white communities were also more likely to be exposed to higher levels of air pollution than white populations, although the effect was less marked.

Significant progress has been made in terms of air quality (as described in section 2 of this paper), although there remains considerable work to be done to improve health outcomes and address inequalities for Londoners. A 2020 report modelling the long term impacts of changing air pollutants in London suggests that policies are effective in reducing air quality related disease, especially over the longer term as health benefits accrue over time.[37] However, it also notes that it is important that these policies continue to be implemented to their full effect, and that existing policies alone are not enough to eliminate all air quality related disease. In particular, more action is needed to reduce levels of $PM_{2.5}$ at a pan-London level. The report further notes that reducing air pollution even in lower pollution areas has an important impact in terms of disease cases avoided.

[34] https://www.ons.gov.uk/economy/environmentalaccounts/articles/doesexposuretoairpollutionincreasetheriskofdyingfromthecoronaviruscovid19/2020-08-13
[35] ONS, 2020 https://www.ons.gov.uk/releases/airpollutionandcovid19mortalityrates
[36] https://www.london.gov.uk/sites/default/files/air_pollution_and_inequalities_in_london_2019_update_0.pdf
[37] https://www.london.gov.uk/sites/default/files/modelling_the_long-term_health_impacts_of_changing_exposure_to_no2_and_pm2.5_in_london_final_250220_-4.pdf

4. Transport challenges created by the Covid-19 pandemic

Historically, London has been successful in increasing sustainable mode share, and reducing private car use

Over the past two decades, reducing car ownership and use and increased sustainable mode share have characterised London's travel trends. This has occurred as a result of policies to make public transport more attractive and efficient and disincentivise car use, including road user charging and land use policies.

Private transport mode share has decreased by 11.8 percentage points between 2000 and 2019 (in terms of journey stages); public transport mode share increased by 10.8 percentage points in terms of journey stages.[38] This took place in the context of an increasing population: between 2000 and 2019 London's population increased by 24 per cent. This switch from car journeys to more sustainable modes has taken three million car trips off the roads each day.

This is reflected in relatively low car ownership in London compared to the rest of the UK: around 56 per cent for London overall, and 40 per cent for households in inner London. In both inner and outer London, car ownership is correlated with income.[39] In inner London, for example, 80 per cent of households with annual income under £10,000 – and 70 per cent with annual income under £20,000 – do not have access to a car; while car ownership generally increases as household income increases.

The MTS sets a target of 80 per cent sustainable mode share by 2041. Achieving this brings a range of social, health, economic and environmental benefits. It also relates to other key objectives:

- for all Londoners to do at least 20 minutes of active travel a day by 2041 (Policy 2);
- a 10 per cent reduction in morning peak freight transport in central London by 2026 (Proposal 15);
- the Vision Zero aim, for no individuals to be killed or seriously injured on London's roads by 2041 (Policy 3); and
- at least 3m fewer daily car trips and 250,000 fewer cars owned in London by 2041 (Policy 5).

The pandemic significantly disrupted travel, with many fewer journeys made overall, and road traffic recovering more strongly than other modes

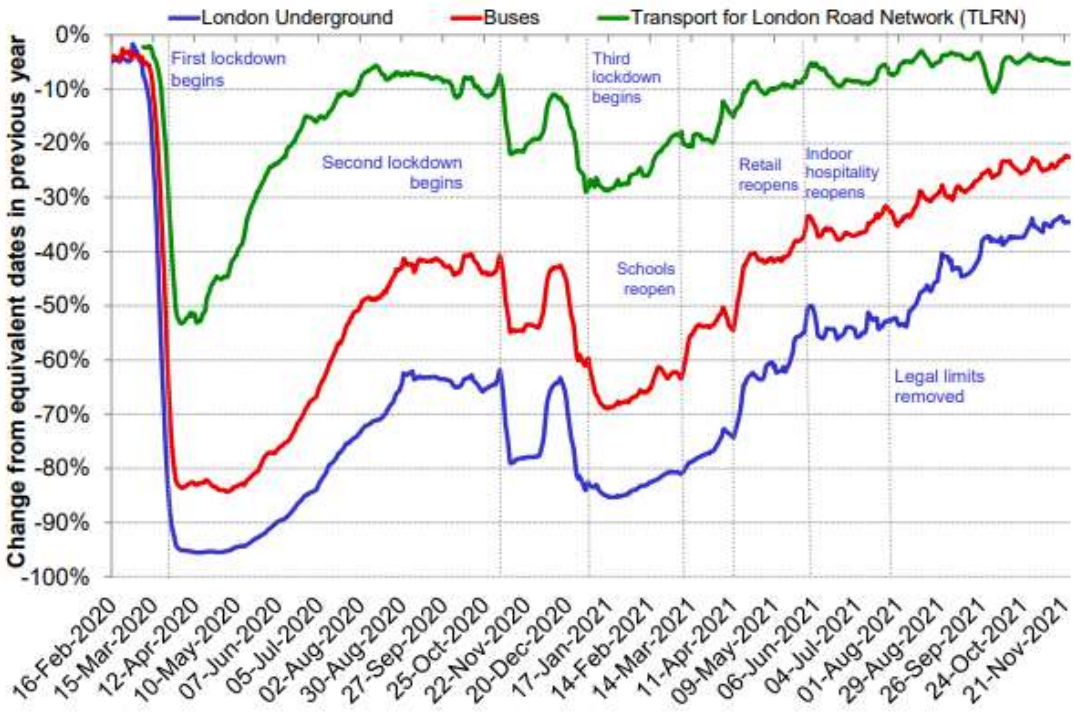
The pandemic had a sudden and dramatic impact on travel demand as a direct consequence of the shock to economic and social activity imposed by the March 2020

[38] Travel in London 13, TfL, 2019
[39] See Travel in London 12, TfL 2018 https://content.tfl.gov.uk/travel-in-london-report-12.pdf

lockdown and the associated social distancing requirements put in place to protect public health.[40]

Figure 2 shows the demand trends for London Underground, bus and traffic on the Transport for London road network (TLRN) since the start of 2020. The immediate pandemic impact from March 2020 is clearly visible. At the lowest point, London Underground demand was just four per cent of normal levels. Bus demand fell to 16 per cent of its normal level. These drops in demand are in contrast to road traffic demand, which was much more resilient, falling to just under half (47 per cent) of normal levels.

Figure 2: Change in demand on the main transport networks[41]



Following an upward trajectory from late 2020, there are now signs that public transport demand is falling off again as we feel the effects of the Government's Plan B restrictions in response to the Omicron variant. In the week commencing 13 December, there was a 20 per cent decrease in Tube passengers and a four per cent decrease in bus passengers week-on-week, and Tube journeys were at 51 per cent of pre-pandemic levels. Were there to be further restrictions imposed, this would be likely to reduce again. This highlights the continued uncertainty around demand for public transport that we currently face.

As well as a dramatic fall in demand, the timing and destination of many journeys changed, with a shift towards more local travel. Even when restrictions were lifted, it is apparent that people's attitudes to the different modes had changed, reflecting the challenges brought by the pandemic, and with that their travel choices and behaviours.

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[40] A nearly-full service ran from May 2020. Night Tube and Night Overground services resumed in December 2021

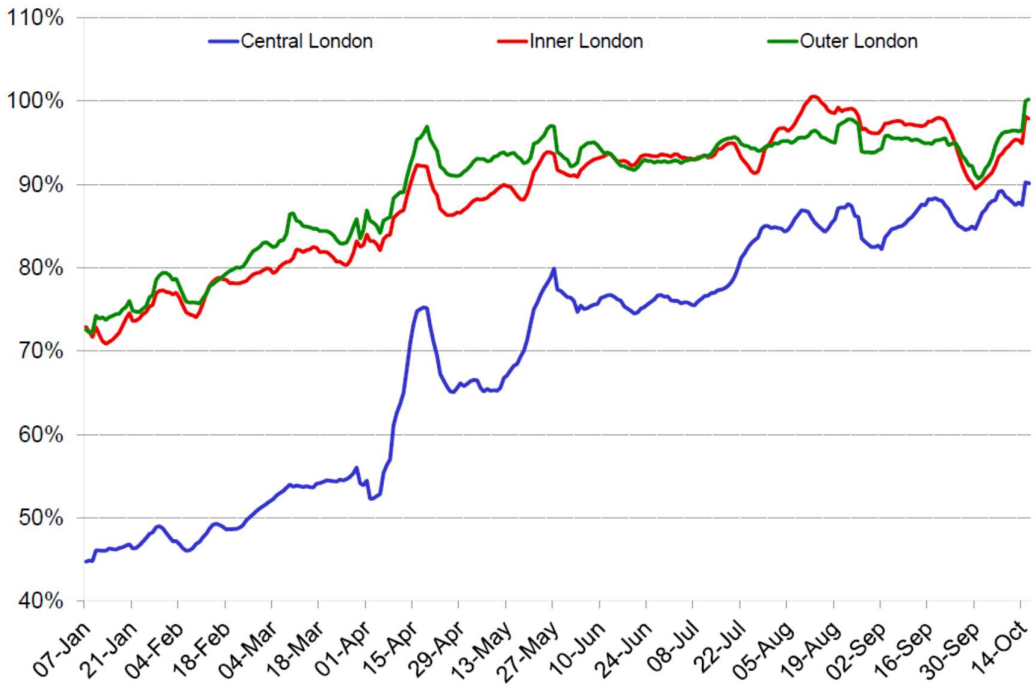
[41] Travel in London 14, TfL

Road traffic has been more resilient than other modes and is now close to pre-pandemic levels

While public transport demand is still significantly short of pre-pandemic levels, road traffic has been relatively more stable, with current levels at or close to typical pre-pandemic demand. Although the pattern is different in central, inner and outer London, the overall trend is for a relatively strong return to pre-pandemic levels in all areas.

By mid-October traffic volumes in inner and outer London had again returned to pre-pandemic levels, with traffic in central London at around 90 per cent of 2019 levels (see Figure 3).

Figure 3: traffic volumes recovery compared to equivalent dates before the pandemic by functional area, 7 day moving average[42]



Changed patterns including strong road traffic recovery could threaten achievement of ambitions, despite an increase in walking and cycling

A striking effect of the pandemic was the reduction in overall trips made. The number of trips made per person per day in 2020/21 was an average of 21 per cent lower than 2019/20 (1.7 trips per person per day compared to 2.3 trips before). Additionally, trip distances were much shorter than in a typical year, reflecting both restrictions placed on non-essential travel and people's preference to stay local. Related to this, there were increases in the number of journeys cycled and walked. In 2020, the proportion of journeys cycled accounted for 3.4 per cent of all journeys, up from 2.3 per cent in 2019 – a 48 per cent increase in the proportion of journeys made by bike. There was also a significant increase in the number of trips walked in London in 2020, with the proportion of journeys

[42] Travel in London 14, TfL

made on foot by Londoners increasing from 21 per cent of all journeys to 30 per cent – a 43 per cent increase.[43]

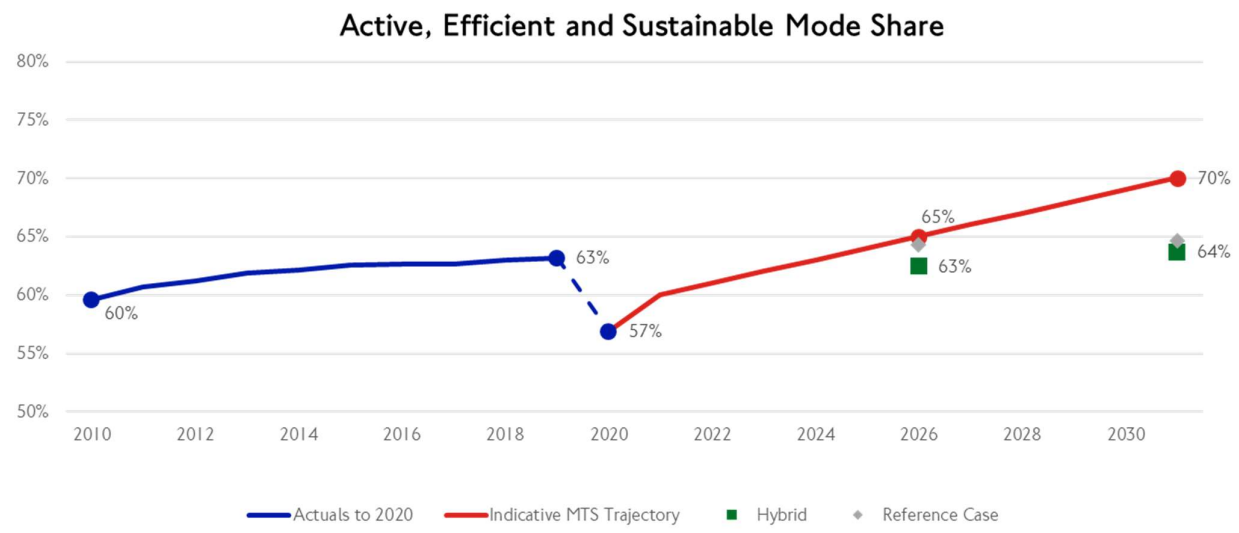
However, despite this welcome increase, we are still off-target for sustainable mode share now and in the future. There remains uncertainty about future travel demand and travel patterns in London.

We have developed five post-Covid-19 pandemic scenarios of different levels of travel demand. The scenarios enable us to plan in the face of increased uncertainty about how London will look in the future. To enable detailed assessments, we also have developed two forecasts. As is usual in transport modelling, there is a 'Reference Case', defined in a similar way to pre-pandemic forecasts it assumes no further restrictions are brought in and people start returning to their pre-pandemic routines so that by the time we reach the first forecast horizon (2026) behaviour has reverted back. There is also a 'Hybrid Forecast', which accounts for the latest evidence on London's recovery and maps a central position in the range of plausible outcomes as defined by the scenarios and is kept under regular review. The latest version assumes slightly slower population growth, more working from home and online shopping and a slower recovery in public transport usage than the Reference Case. In both the Reference Case and Hybrid Forecast, traffic levels, including car use, return to and in some areas increase from pre-pandemic levels, exacerbating the challenge we already face in meeting the sustainable mode share target (see Figure 4).

The trajectory presented here assumes in 2021 we recover half the impact of the pandemic, then pick up the MTS trajectory from that point. Forecasts of the Hybrid Forecast and our Reference Case are both below the MTS trajectory, with a significant gap opening up in the late 2020s, potentially threatening our continued progress on this measure as well as ultimate achievement of the 2041 aim. The Hybrid Forecast is lower than the Reference Case as it assumes less rail commuting and a slightly lower population.

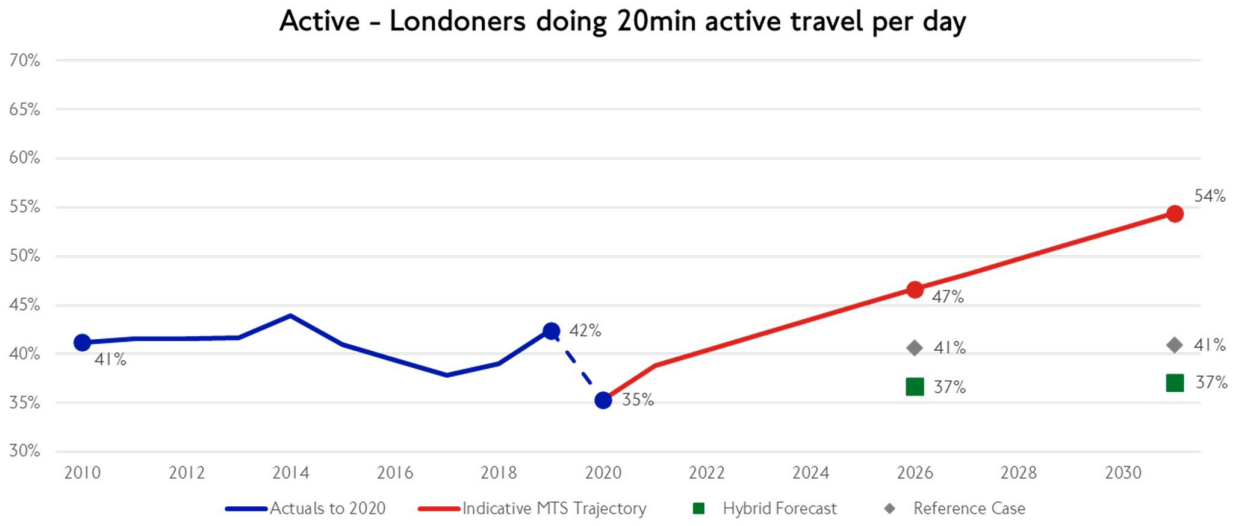
[43] Source: TfL press release 15 December 2021, figures from Travel in London 14
[44] TfL, City Planning

Figure 4: Trajectory on sustainable mode share[44]



A similar picture can be seen for the active travel target for Londoners (see Figure 5). While progress on this measure has been uneven since it was first measured, there is clearly a significant pandemic impact, and in the context of fewer trips overall there will need to be further interventions to close the gap between the target and the Hybrid Forecast.

Figure 5: Trajectory on active travel[45]



While the vehicle fleet is already shifting towards zero emission vehicles, this needs to accelerate given the emissions challenges we face

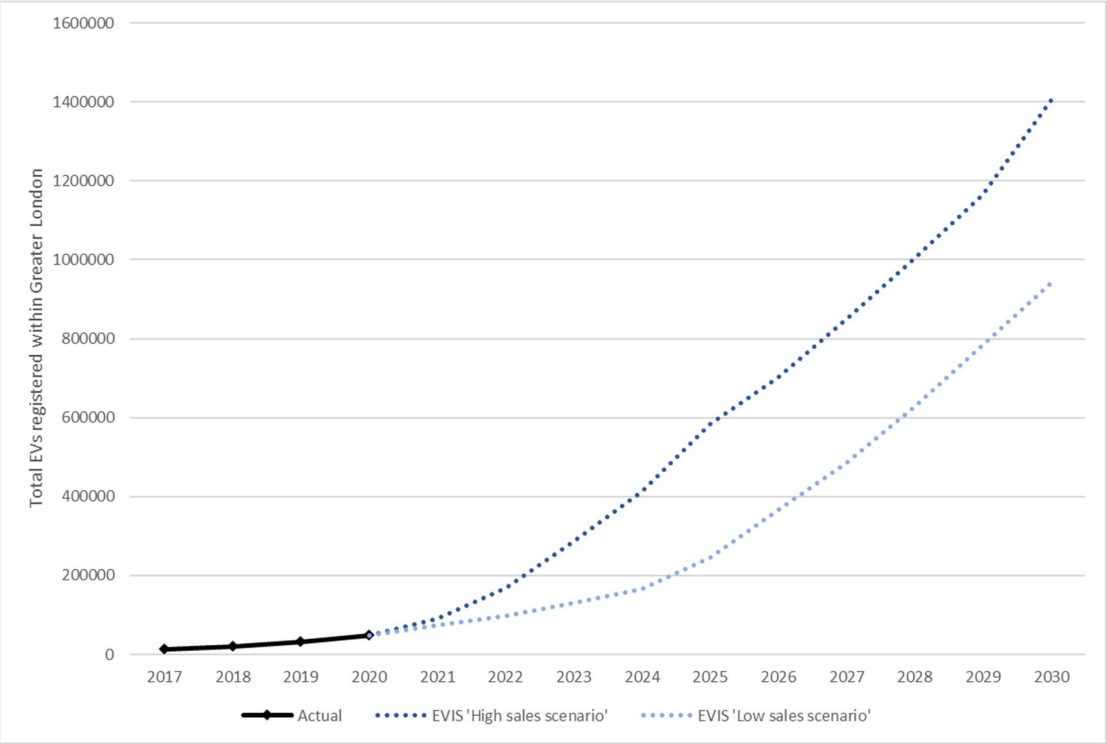
Although there is uncertainty about the volume of vehicle trips in London in the future, it is evident that there has been and will continue to be a shift away from conventional petrol and diesel vehicles. While this reflects Government policy on phasing these out vehicles

[45] TfL, City Planning

and increased consumer acceptance of EV technologies, greater affordability and choice of vehicles, the effect is also amplified in London, in large part due to the policies described in this note.

The current forecast for EV uptake is shown in Figure 6 below. At present approximately two per cent of vehicles registered to London residents are electric. See Appendix B for further information about EVs in London. The chart below shows a projection of between 0.3 and 0.6 million EVs in London by 2025 (between nine per cent and 21 per cent of London's total car and van fleet). By 2030, our projections estimate between 946,000 and 1.4 million EVs (between 34 per cent and 49 per cent of London's total car and van fleet). This reflects signs of increasing consumer acceptance of EVs and expected growth in EV manufacturing. In the past couple of years there has been a marked increase in the market share of plug-in vehicles, which encompasses plug-in hybrid and battery EVs.

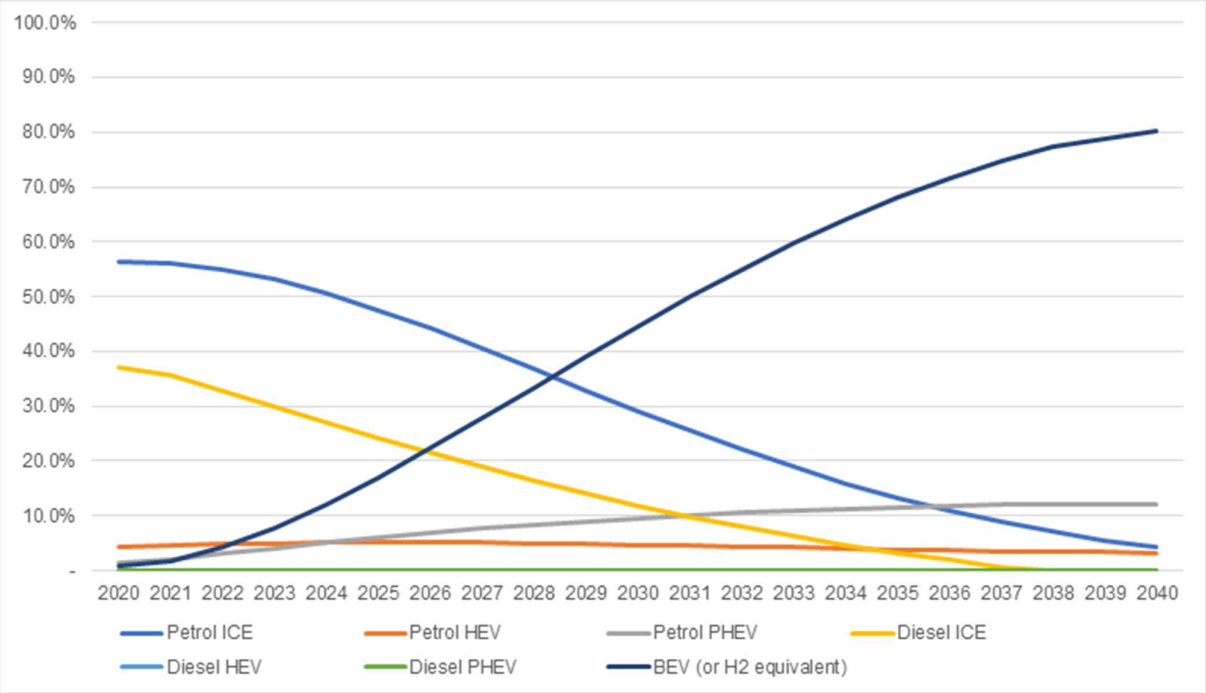
Figure 6: London EV sales growth scenarios[46]



In London, our estimates show that, for cars, battery electric vehicles are anticipated to surpass the proportion of petrol and diesel ICE vehicles as a percentage of the total fleet in 2028/2029, as shown in Figure 7 below, and then surpass all ICE (including hybrid) by 2031.

[46] Sources: Department for Transport, dataset VEH0131 for actuals to 2020; TfL taxi and private hire vehicle licensing and CoMo UK (car club data); 2019 EV Infrastructure Taskforce Delivery Plan; Element Energy Electric Car Consumer Model (for EVIS scenarios). Taken from Electric Vehicle Infrastructure Strategy, TfL, 2021

Figure 7: Future trajectory of vehicle technology types in London (passenger cars only)[47]



While these trajectories are encouraging in terms of moving to cleaner vehicles and suggest that emissions standards are working, they also indicate that it will be important to ensure that new standards keep pace with changes to the fleet, and continue to incentivise a shift to the cleanest vehicles, as well as a shift to more sustainable modes as EVs still produce non-exhaust particulate emissions (e.g. from tyre and brake wear).

The future is uncertain – but effective policy making can help shape a sustainable recovery

Travel demand is likely to continue to be volatile until we fully recover from the effects of the pandemic. What is clear from recent trends is that road traffic demand has recovered much more quickly than public transport demand, meaning that the challenge of achieving our mode shift and active travel targets is even greater.

Cars (regardless of their emissions) take up a lot of space relative to the number of people they move, and reliance on cars will only make congestion – the cost of which is estimated at around £5.1 billion[48] per year – worse. This has huge impacts on Londoners, causing pollution, making streets unpleasant places to be and delaying public transport and the

[47] Source: TfL modelling, based on ANPR data
[48] https://inrix.com/press-releases/2021-traffic-scorecard-uk/ This figure is based on the delay faced by people driving does not account for the cost of congestion on bus passengers and bus operating costs.

essential freight and commercial journeys that keep London running. The average commuter in London lost 148 hours a year to congestion in 2021.[49]

The success of London's future transport system relies on reducing non-essential car use. Pre-pandemic, one quarter of car trips could potentially be walked, and two thirds could potentially be cycled. Making alternative transport options accessible and appealing to all Londoners is therefore key to encouraging people to change the way they travel and reducing car dependency. This means improving street environments for more space efficient modes of transport to make walking and cycling the most attractive options for short journeys and providing more and better services to make public transport the most attractive option for longer ones. This approach will reduce health and economic inequalities by providing low-cost, accessible travel options for Londoners who are currently reliant on cars – or who cannot get around at all.

[49] https://inrix.com/press-releases/2021-traffic-scorecard-uk/

5. Potential approaches to address these challenges

We need to understand current travel behaviours and how these could be shifted to achieve MTS objectives to inform the most effective approach

To understand policy interventions that could help to achieve sustainable road use objectives, we have completed a high-level policy analysis exercise. This optioneering process included assessing different policy interventions against their ability to deliver traffic reduction, air quality improvements and CO_2 emissions reductions alongside other MTS objectives and feasibility criteria. This work identified that new RUC schemes or modifications to existing schemes could be effective in meeting strategic objectives.

In considering what approaches may be effective in addressing the challenges set out in this paper, we have considered the achievements of existing schemes in London and how they might be modified, the likely behavioural response, and other factors such as implementation cost and timelines. All of the approaches considered could be adjusted to achieve slightly different impacts.

Around 85 per cent of the car kilometres travelled in London are in outer London (Table 2).

Table 2: Percentage of London-wide car kilometres travelled across London[50]

Area	Percentage of London-wide vehicle kilometres
Central	2%
Inner	14%
Outer	84%
London-wide	**100%**

This means any scheme that extends into outer London can achieve a more significant London-wide impact as reduced vehicle kilometres will result in fewer emissions and other benefits. For this reason, we have assumed that all approaches could apply London-wide. The emissions-reduction impacts of any approach could also be enhanced by the level of charge applied and the compliance standards which are set.

A low-level charge to nudge behaviour in a similar way to a plastic bag charge could have an individually small but collectively significant impact (given the large scale) on the way people make their travel choices. If needed, the charge could evolve over time to respond to changing circumstances and as more alternative travel choices become available.

Focus box: Plastic bag tax – a small charge achieves a big impact

[50] TfL, City Planning

- The 5p charge on plastic bags in England was introduced in October 2015 with the aim of reducing single-use carrier bags and associated litter, by encouraging people to re-use bags.
- Since the introduction of the scheme, the number of bags used has decreased by more than 95 per cent.[51] There was an immediate impact following the scheme, with 0.6 billion single-use carrier bags given by main retailers in the first six months following its introduction compared to over 7.6 billion in 2014.
- The latest figures for 2019-20 suggest that around 564 million single use bags were provided by the main retailers.[52]
- Academic research suggests that all age, gender and income groups in England substantially reduced their plastic bag usage within one month of the charge and support for the charge also increased in the one month period after the charge was introduced.[53]
- This is mirrored by research from Wales which suggests that support for their bag charge, introduced in October 2011, increased from 59 per cent before it was introduced to 70 per cent following introduction.[54]
- England has now increased its charge from 5p to 10p with 74 per cent of the public who responded to the consultation in support, with the majority of those who did not agree reasoning that increasing the charge to 10p was insufficient to truly change behaviour.[55]

We have developed four broad potential approaches and modelled high-level impacts

Table ***3*** below shows a high-level description of the overall objective for different types of approaches and each could be adjusted to better target specific challenges in different areas or from particular types of vehicle. In developing any new scheme or expansion of an existing scheme, appropriate discounts and exemptions would need to be considered. Any new scheme would have to be effective, simple for customers to use and fair and proportionate to its aim.

Table 3: Approaches to emissions-based road user charging

	Description	**Earliest potential**

[51] https://www.gov.uk/government/publications/single-use-plastic-carrier-bags-why-were-introducing-the-charge/carrier-bags-why-theres-a-5p-charge#benefits-why-theres-a-charge
[52] https://www.gov.uk/government/publications/single-use-plastic-carrier-bags-why-were-introducing-the-charge/carrier-bags-why-theres-a-5p-charge#benefits-why-theres-a-charge
[53] https://www.frontiersin.org/articles/10.3389/fpsyg.2019.00266/full
[54] https://www.cardiff.ac.uk/__data/assets/pdf_file/0014/1320332/WSA-Working-Paper01-2012.pdf
[55]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/913093/carrier-bags-consultation-summary-of-responses-government-response.pdf

		implementation date
Approach 1: ULEZ expansion to outer London	An extension of the existing ULEZ standards to cover all areas within London	Late 2023
Approach 2: ULEZ expansion with a tighter standard	An extension of the existing ULEZ standards to cover all areas within London with the addition of a stricter emission standard to charge internal combustion engine (ICE) vehicles (i.e. vehicles that are not ZEC) at a low-level	Late 2023
Approach 3: Low-level emissions charge	A low-level daily charge applied to all ICE vehicles driving anywhere in London to act as a 'nudge' to behaviour change	Late 2023
Approach 4: Next-generation charging	A new charging mechanism based on distance (e.g. km or miles) travelled and other factors which could integrate existing / proposed schemes (including environmental RUC schemes) in a single simple, fair way	2025/26

Additionally, opportunities to use more sophisticated types of road user charging technology – as would be the case with next generation charging – could be appropriate for all types of scheme in the future, or indeed could replace any schemes in place at the time of implementation.

Any scheme would have implementation costs and recurring operational costs. Some initial work has been undertaken and the indicative implementation costs are as follows: expanding the ULEZ to outer London, around £225 to £275m; a low-level emissions charge around £325m; and a strengthened expansion of ULEZ to outer London, which contains elements of the other two approaches, would be around £375m. Next generation charging has been costed for a central and inner London scheme at around £270m. This would be considerably higher for a London-wide scheme.

These costs are indicative and the actual costs would depend on a number of factors related to, for example: the number and location of enforcement cameras; the extent of discounts and exemptions provided; the integration of systems with other RUC schemes in London; and the costs of mitigations such as scrappage schemes. Scrappage schemes were a key part of the delivery of the expanded ULEZ scheme and would be expected to be needed again if ULEZ were to be expanded. Such a scheme could cost in the region of £100m, in addition to implementation costs. In other cities, scrappage costs have been met by central Government, for example the £90m scrappage scheme for the Greater Manchester Clean Air Zone.

The following sections set out the potential impacts of each approach in terms of traffic, mode shift and emissions.

For the approaches considered in this paper, the traffic impacts are shown as both reductions to numbers of car trips and reductions to vehicle kilometres, compared to forecast traffic levels. As there is a large amount of uncertainty in future traffic volumes,

the pre-scheme number of vehicles has been assumed at pre-pandemic levels at this stage of assessment. Emissions forecasts are based on information available at the time from the previous LAEI 2016 and during preparation of the LAEI 2019 and forecasts. All estimates are based on an indicative level assessment of response and impacts on future projections which are subject to change. If any of the approaches is taken forward as a result of this work, further analysis would be required. For all approaches, it should be noted that modelling is based solely on the imposition of a new charge and does not incorporate other important factors such as mitigations, complementary measures and transport measures paid for by scheme revenues.

Approach 1: Extending the ULEZ to tackle more of the dirtiest vehicles

Description

Building on the success of the recently expanded zone, the scheme could be adapted to extend the existing ULEZ to cover all areas within London, thereby extending emissions benefits London-wide with reductions in NO_x, $PM_{2.5}$ and CO_2. This would mean that the zone would be over four times the size of the current extended ULEZ area. We have assessed this approach using the current charge level and emissions standards.

Impacts

This section will look at the impact of an extended ULEZ to outer London on London-wide car trips, vehicle kilometres, mode shift and air quality.

London-wide car demand

For any emissions-based charge there are two main responses. First, a daily charge may encourage people to change their non-compliant vehicle to a compliant vehicle. Second, if they choose to keep the non-compliant vehicle, a daily charge will influence whether they use this vehicle to travel and incur a cost or change their behaviour, for example shift to a sustainable mode. For the former, this assessment uses the observed response seen from the October 2021 ULEZ expansion regarding vehicle choices to inform the responses in outer London. It should be noted that to avoid double counting, this assumption does not account for any positive impact that ULEZ expansion has already generated in outer London. The ULEZ data is from the first month of operation and may change over time, which would mean refining analysis in any further work on such an approach.

A £12.50 Greater London ULEZ charge in 2023, could encourage outer London compliance to increase from 91 per cent to at least 94 per cent. This has a positive effect on London-wide compliance rates by around 2.5 per cent (from over 92 per cent to almost 95 per cent). While switching a vehicle to a compliant one doesn't reduce overall car travel, it could lead to around 60,000 to 70,000 of the most polluting cars from London's roads being replaced by ULEZ compliant vehicles. This would reduce the number of non-compliant cars in London from approximately 210,000 down to between 140,000 and 150,000.

Behaviour change i.e. shifting journeys to more sustainable modes from those who continue to own non-compliant cars (those not already affected by ULEZ expansion to

inner London) reduces the number of non-compliant cars in London by 20,000 to 40,000 every day (approximately one per cent of London-wide cars). It is worth noting that this assessment has been undertaken by looking at the number of unique cars.

Since one car on average makes around 2.2 car trips per day this is equivalent to between 45,000 and 85,000 fewer car trips every day (up to one per cent of daily London-wide car trips).

Overall, with both responses the total London-wide non-compliant cars would reduce from approximately 210,000 to between 100,000 and 130,000, a decrease of around 45 per cent.

Table 4: Estimated number of cars in London every day, 2023

2,800,000 cars every day

Without ULEZ expansion to outer London

210,000 non-compliant cars every day (91 per cent compliance rate)

With ULEZ expansion to outer London

~ 60,000 to 70,000 may shift to compliant cars (94 per cent compliance rate)

~ 20,000 to 40,000 may change behaviour away from car usage

100,000 to 130,000 daily non-compliant cars

*All figures are estimates that are based on forecasts of London car demand and future compliance rates, which may be revised.

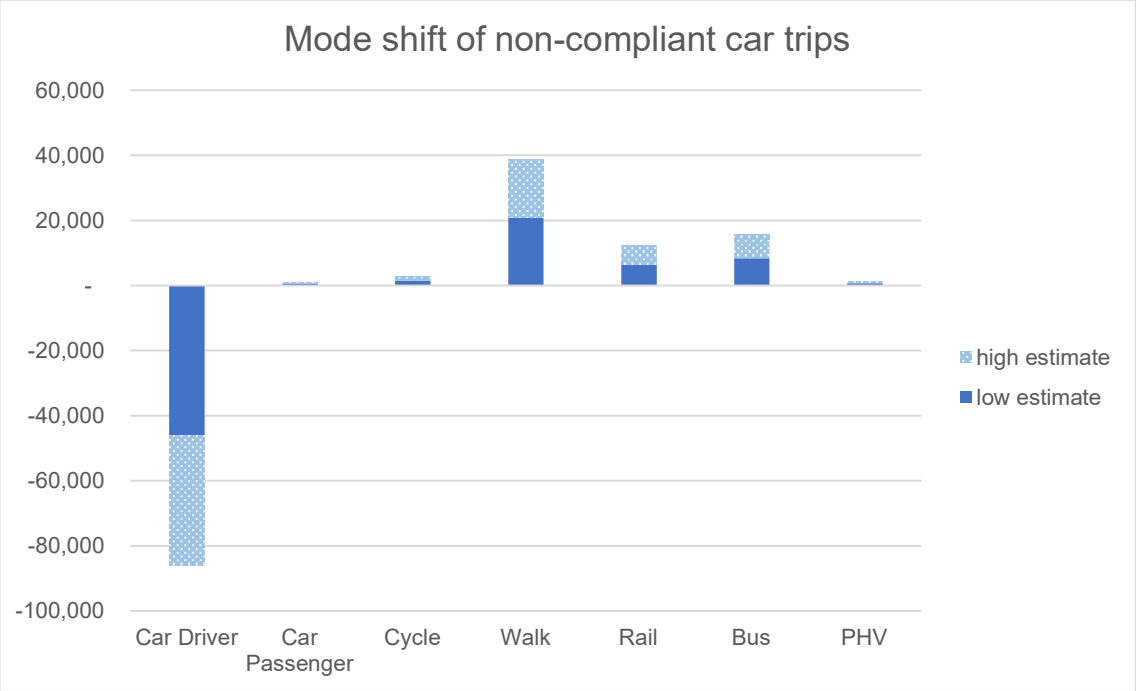
Vehicle kilometres

Expanding ULEZ to outer London could reduce London-wide vehicle kilometres by between 0.5 and one per cent. Since increasing compliance of cars would not have an impact on vehicle kilometres, all the reduction is as a direct result from charging the remaining non-compliant cars. For Light Goods Vehicles (LGVs) there is also approximately a one per cent reduction and despite there being fewer LGVs in London (around 300,000 every day) they typically travel longer distances. This vehicle kilometres analysis is highly indicative and is has been calculated using a number of assumptions that are likely to change with more detailed analysis.

Mode shift

Of the 20,000 to 40,000 reduction in daily non-compliant cars, which is equivalent to between 45,000 and 85,000 car trips, around half may switch to walking trips instead of driving and over a third could shift to bus and rail. This would have a small impact on London-wide sustainable mode share.

Figure 8: Mode shift of daily non-compliant car trips



Emissions

Expanding ULEZ to outer London could reduce NO_x emissions from cars and vans in outer London by around nine per cent and London-wide by around six per cent. The range of reductions is between 285 to 330 tonnes. This depends on the background level of uptake of electric vehicles in the fleet, where a higher level of uptake reduces the benefits which can be attributed to an emissions-based charging scheme over time (although the overall benefit remains the same). A reduction in CO_2 emissions of around 135,000 to 150,000 tonnes (equivalent to over six per cent reduction in car and van CO_2 emissions) in outer London is also expected as a result of cleaner vehicles and reductions in travel. Emissions savings could be enhanced further if vehicle owners change to EVs earlier than they might have done otherwise, particularly for vans where uptake to EVs is slower than for cars.

Table 5: Potential ULEZ emissions savings in outer London

		Excluding phase out of ICE cars and vans sales from 2030			Including phase out of ICE cars and vans sales from 2030		
		Reduction (tonnes)	% reduction emissions		Reduction (tonnes)	% reduction emissions	
			Outer London	London-wide		Outer London	London-wide
NO_x	Cars	195	7.5%	5%	150	7.4%	5%
	Vans	135	15%	10%	135	15%	10%
	Total	**330**	**9%**	**6%**	**285**	**9%**	**7%**
CO_2	Cars	125,000	6%	4%	110,000	6%	4%
	Vans	25,000	7%	5%	25,000	7%	5%
	Total	**150,000**	**6.3%**	**4%**	**135,000**	**6.5%**	**4%**

Summary of potential impacts of expanding ULEZ to outer London

Such an approach would build on the existing, proven and well-understood ULEZ scheme.

The impact of introducing ULEZ standards is clear – compliance with existing standards is improving rapidly especially due to the expansion to of the zone to inner London in October 2021. Currently, compliance is 82.5 per cent in outer London and in the ULEZ area it has increased 7.5 per cent to 92 per cent from September to November 2021. London-wide, compliance is expected to be around 91 per cent in outer London by late 2023 and expanding the ULEZ to outer London could accelerate levels of compliance to at least 94 per cent in the same timeframe. Challenges in meeting the more stringent 2021 WHO interim targets and guidelines (see Table 1) mean that significant reductions in NO_x and $PM_{2.5}$ emissions from road transport will be required, and approaches 1 and 2, both modifications to the current ULEZ scheme, are particularly effective in reducing NO_x and CO_2 emissions.

Approach 2: Modifying the ULEZ to make it even more impactful in reducing emissions

Description

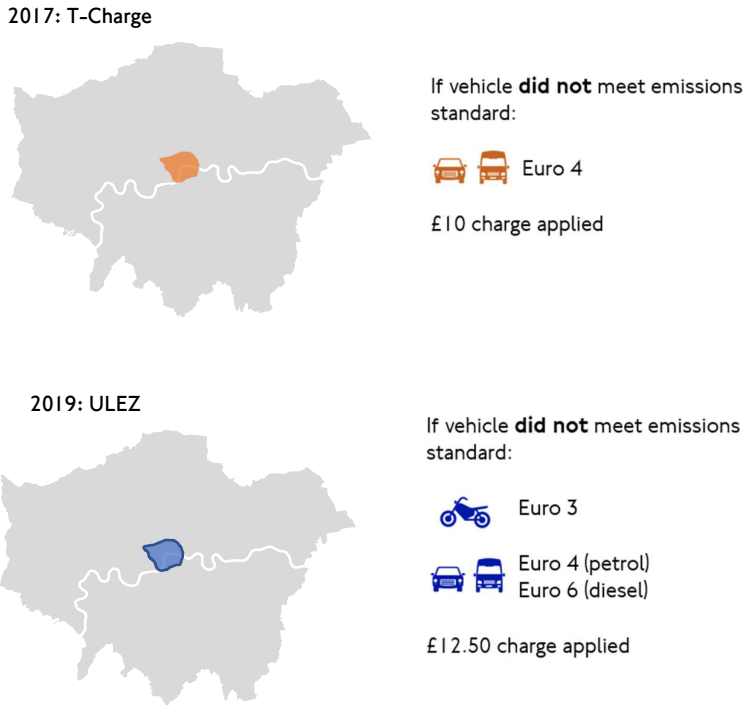
This approach would tackle the twin challenges of air quality and CO_2 emissions. It builds on the previous approach (a £12.50 charge for non-compliant vehicles) by adding a further low-level charge for conventionally-fuelled (ICE) vehicles (i.e. those that are not ZEC). This could help to accelerate the transition to zero emission vehicles and encourage mode shift.

Modifying ULEZ to include a stronger emissions standard could begin by focussing a small charge on ICE vehicles, with no charge applied to ZEC vehicles. As set out in section 4, these vehicles currently make up only two per cent of the London fleet, expected to increase to nine per cent by 2025. However, with the right conditions (such as increasingly bold sustainability goals in private companies), this could increase to 21 per cent.[56] Introducing stricter emissions standards aligns with and supports Government policy and the phasing out of ICE vehicles from 2030 and ZEC vehicles from 2035.

Under this approach, in 2023 the existing ULEZ standards would continue to apply, with a £12.50 charge for motorcycles not meeting Euro 3 standards, petrol vehicles not meeting Euro 4 standards and diesel vehicles not meeting Euro 6 standards.

Additionally, it could be proposed that a low-level charge would apply to ICE vehicles that meet the current ULEZ standards, but do not meet a potential new, tighter ZEC standard. Plug in hybrids, battery electric and hydrogen vehicles (i.e. ZEC vehicles) would not pay anything (neither the ULEZ charge nor the additional charge).

Figure 9: How ULEZ could modify to become more impactful



[56] London's 2030 electric vehicle infrastructure strategy 2021 https://tfl.gov.uk/modes/driving/electric-vehicles-and-rapid-charging

2021: ULEZ expansion to inner London

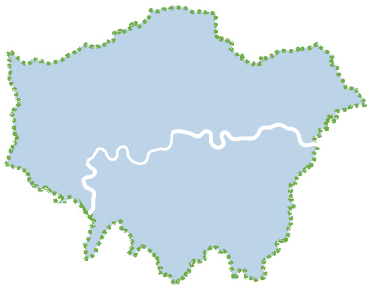
If vehicle **does not** meet emissions standard:

Euro 3

Euro 4 (petrol)
Euro 6 (diesel)

£12.50 charge applies

2023: ULEZ expanded London-wide



If vehicle **does not** meet emissions standard:

Euro 3

Euro 4 (petrol)
Euro 6 (diesel)

£12.50 charge applies

If vehicle **does not** meet emissions standard:

Zero Emission Capable
(plug-in hybrid or EV)

Low level charge applies

Impacts

This section will look at how this approach could enhance the impacts of the first approach of extending the current ULEZ standard to outer London.

The impacts set out below pertain to an indicative low-level charge of £0.50 for those vehicles which meet current ULEZ standards but are not ZEC. Different charge levels would give different levels of impact and other charge levels are considered under approach 3 below. As would be expected, a higher charge would result in a larger response and subsequent impacts on vehicle kilometres and environmental metrics.

London-wide car demand

With this approach it is forecast that there would be approximately a two to 2.5 per cent reduction in London-wide car trips. Combined with the up to one per cent decrease in daily London-wide car trips from ULEZ expansion, this means a London-wide ULEZ with a stronger emissions standard could decrease London-wide car trips by between three and 3.5 per cent. This translates into over 100,000 fewer cars every day, or 220,000 car trips, mostly in outer London.

Despite a low charge level, because there around 2.5 million cars affected, this aspect of the scheme has a bigger impact than the expansion of the existing standard.

However, for LGVs, the main influence of change is likely to be seen from the expansion of the existing standard. This is partly because the LGV London-wide compliance rate is lower (around 84 per cent) than cars (around 92 per cent). Expanding ULEZ could increase LGV London-wide compliance by around two percentage points up to 86 per cent. This equates to around 5,000 non-compliant LGVs being replaced by compliant vehicles. Similarly to cars, this response is based on the initial observed compliance changes seen with ULEZ expansion and this assumption may be revised with further analysis. In addition to this, it is also likely that the low-level charge would have a much smaller impact on LGV driver behaviour than it does for car drivers, as there are fewer alternative modes for the majority of LGV based trips and because of the nature of the trip they are less sensitive to costs.

Vehicle kilometres

This approach could result in a reduction in London-wide vehicle kilometres of around 0.8 per cent. This combined with the indicative 0.5 to one per cent reduction from a London-wide ULEZ charge means overall vehicle kilometre reductions could be in the order of 1.5 per cent. The level of traffic reduction is closely correlated with charge level – charging at higher levels would result in a larger reduction in vehicle kilometres.

Mode shift

Sustainable mode share could increase by around 0.5 per cent as a result of this approach: the majority of this impact would come from the low-level emissions charge. The mode shift response as a result of a low-level emissions charge is discussed in more detail in the assessment of approach 3 below.

Emissions

Expanding and adapting ULEZ to include enhanced emissions standards could increase emissions savings compared to expanding the current ULEZ standards because there is some additional reduction in vehicle kilometres for both cars and vans which reduces emissions further. The reduction in vehicle kilometres is subject to uncertainty but a conservative estimate of 0.8 per cent reduction in inner London (from low-level emissions charge) and 1.7 per cent in outer London could be expected from cars, and around one per cent from vans.

Table 6: Emissions savings from ULEZ expansion with a stronger standard

		Excluding phase out of ICE cars and vans sales from 2030		Including phase out of ICE cars and vans sales from 2030	
		Reduction (tonnes)	% reduction emissions in London	Reduction (tonnes)	% reduction emissions in London
NO_x	Cars	250	6%	190	6%

	Vans	140	10%	140	10%
	Total	**390**	**7%**	**330**	**9%**
CO_2	Cars	165,000	6%	145,000	6%
	Vans	28,000	5%	28,000	5%
	Total	**193,000**	**6%**	**173,000**	**6%**

Expanding ULEZ with a stronger standard is forecast to reduce NO_x emissions from cars and vans across London by between seven and nine per cent. The range of reductions is between 330 to 390 tonnes, depending on the background level of uptake of electric vehicles in the fleet where a higher level of uptake reduces the benefits of emissions schemes over time. A reduction in CO_2 emissions of around 170,000 to 190,000 tonnes (equivalent to over six per cent reduction in car and van CO_2 emissions) in London are also expected as a result of cleaner vehicles and reductions in travel. Emissions savings could be enhanced further if vehicle operators change to electric vehicles earlier than they might have done otherwise, particularly for vans where uptake of electric vehicles is slower than cars.

The overall emissions savings of NO_x from cars and vans are nearly a fifth higher (18 per cent) when expanding and strengthening ULEZ compared to expanding the current standards, whilst for CO_2, the emissions savings are nearly 30 per cent.

Summary of ULEZ expansion with a stronger standard

The approach of expanding and strengthening ULEZ builds on the first approach of expanding the current ULEZ standards. Both approaches encourage drivers to choose less-polluting vehicles or switch to other options, but the second approach brings in an additional incentive to accelerate the shift to zero emission vehicles. Compared to expanding current standards, the inclusion of a stronger emissions standard has the additional effect of reducing the overall number of cars by encouraging people to choose alternative sustainable options. This means that overall traffic could decrease and the traffic that is remaining is made up of lower polluting vehicles. The stronger emissions standard could support ULEZ expansion to outer London by reducing the total number of car trips by a further two per cent and improving London's sustainable mode share by 0.5 per cent.

In terms of emissions, this approach has a greater impact in reduction of NO_x and CO_2 emissions than expanding ULEZ, with a total reduction of 330 to 390 tonnes NO_x and 170,000 to 190,000 tonnes of CO_2. As will be seen, it also produces greater emissions reductions than the third potential approach, and for CO_2, at a similar level to next generation road user charging.

It could also be possible for schemes to adapt further in future to also account for tyre and brake wear emissions. Future phases could be designed to provide the foundation for a scheme using more sophisticated road user charging technology.

Approach 3: Low-level emissions charge

Description

This approach involves applying a low-level emissions charge (similar to the tighter emissions standard described in the second approach, expanding and strengthening ULEZ) and applies it as a stand-alone scheme. This would be a low-level daily charge to all ICE vehicles driving anywhere in London, with the objective of reducing emissions and the environmental impact of road traffic by providing a nudge to more sustainable travel behaviour including:

- Shifting more trips to sustainable modes; and
- Shifting remaining car trips to zero emission vehicles

As set out in section four, EV uptake in London is increasing but will need to accelerate further and faster to meet 2030 ambitions. A charge on ICE vehicles provides a further nudge towards EVs, in addition to their lower running costs.

For this approach, a range of low-level charges have been modelled.

Impacts

In this section we will look at the impact of a low-level emissions charge on London-wide car trips, vehicle kilometres, mode shift and emissions.

London-wide car demand

Table 7 shows how a low-level emissions charge could impact London-wide car trips. As expected, as the charge level is increased, London-wide car trips decrease further, with a £0.50 charge having around a two to 2.5 per cent impact. In practical terms, this could mean 60,000 to 70,000 fewer cars on London's roads every day, or 130,000 to 160,000 fewer car trips.

For the charge levels assessed, this relationship is fairly linear; double the charge results in nearly double the impact. For LGVs, the £0.50 charge can be placed in context of the daily LGV operating costs of around £175.[57] This combined with the lack of alternative modes for the majority of LGV trips means that for LGVs undertaking work related trips it is unlikely that an additional £0.50 charge by itself would have a significant impact on overall London trips. For some personal trips in an LGV there may be a modest impact.

Table 7: Impact of a low-level emissions charge on percentage reduction of London-wide car trips[58]

	£0.30	£0.50	£1

[57] https://consultations.tfl.gov.uk/roads/direct-vision-standard-phase2c/user_uploads/appendix-5-heavy-goods-vehicle-survey.pdf
[58] TfL, City Planning

% reduction in London-wide car trips	1.6%	2.3%	3.9%

Vehicle kilometres

An Emissions Charge of £0.50 could impact London-wide vehicle kilometres by around 0.8 per cent. When considering that 84 per cent of London's vehicle kilometres are in outer London this results in a significant absolute decrease in the overall kilometres travelled in outer London. Table 8 shows the effect on vehicle kilometres across charge levels and, for the charge levels tested, the relationship between charge level and impact seems linear.

Table 8: Impact of low-level emissions charges on percentage reduction in London-wide vehicle kilometres

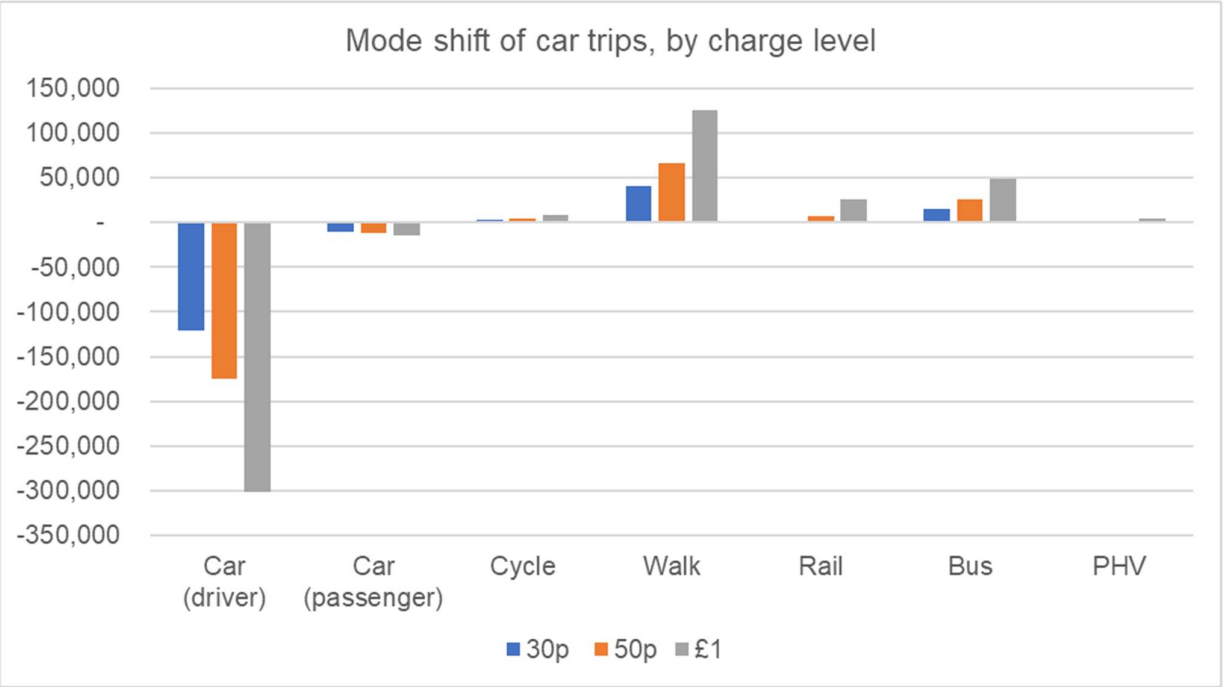
	£0.30	£0.50	£1
% reduction in London-wide vehicle kms	0.6%	0.8%	1.3%

Mode shift

Under this approach, some people may decide to switch to an alternative mode to avoid paying a charge. Figure 10 shows that most of the mode shift would be away from car and towards walking and bus. This suggests this approach would predominantly shift shorter distance car trips that are walkable with longer distance journeys switching to bus. Since rail is on average more expensive and caters for longer journeys than bus, there is less competition with rail travel.

[59] TfL, City Planning

Figure 10: Mode shift of car trips by charge level[59]



Emissions

Table 9: Potential emissions savings from a low-level emissions charge, London-wide

		Excluding phase out of ICE cars and vans sales from 2030		Including phase out of ICE cars and vans sales from 2030	
		Reduction (tonnes)	% reduction emissions in London	Reduction (tonnes)	% reduction emissions in London
NO_x	Cars	32	<1%	25	<1%
	Vans	3	<1%	3	<1%
	Total	**35**	**<1%**	**28**	**<1%**
CO_2	Cars	23,000	<1%	20,000	<1%
	Vans	1,000	<1%	1,000	<1%
	Total	**24,000**	**<1%**	**21,000**	**<1%**

Summary of low-level emissions charge

This approach could be implemented relatively easily and would deliver benefits. As would be expected, the scale of benefits is related to the charge applied, with car trips decreasing as the charge increases (and the scale of the shift to sustainable modes also increasing).

With a £0.50 charge, there would be between two and 2.5 per cent fewer London-wide car trips and a reduction of around 0.8 per cent London-wide vehicle kilometres. Mode shift

would be around 0.5 per cent (the same as in approach 2) and similarly to approach 2, the mode shift results in a strong shift to walking trips. This would result in an estimated reduction of 35 tonnes of NO_x and 24,000 tonnes of CO_2.

Approach 4: London-wide next generation charging

Description

Proposal 21 in the MTS commits us to investigating the most ambitious and bold next generation of road user charging, which could include different technology and functionality.

Ultimately, with this approach, all existing charging schemes in the city would be replaced, including the Congestion Charging scheme and ULEZ, and instead an entirely new and simple London-wide charging mechanism would be introduced based on distance (e.g. kilometres or miles) travelled and which could account for other impacts such as road danger.

Under this new and more sophisticated approach, drivers would have the option of opting in to using this new system or paying flat daily charges as currently if preferred. Ensuring the system is inclusive and accessible to all would need to be considered as part of scheme development.

This type of approach has been put forward in a number of independent studies (for example, Centre for London's Street Smarts[60] and Green Light[61]) and London stakeholders are increasingly advocating for the need to consider this approach in the future.[62]

This type of bold approach would be among the first of its kind in the world, which is why it is important to provide reassurance about how it could operate. For this reason, we have developed a set of principles that would apply to any future scheme of this type:

Simple: Integrates and simplifies existing charges into a single system

Smart: Incorporates time of day, area, emissions, distance

Effective: Creates a behavioural response to achieve MTS objectives

Fair: Clear, simple, fair, and accounts for the fact that Londoners have already paid VED

A scheme of this nature could incorporate and replace all existing RUC schemes in London and be taken forward for implementation in 2025/26 as a longer term aspiration in combination with any of the other approaches described in this note.

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[60] Street Smarts, Centre for London, 2017 www.centreforlondon.org/publication/street_smarts_report_of_commission_londons_roads_and_streets/
[61] https://www.centreforlondon.org/wp-content/uploads/2019/04/Next-Generation-Road-User-Charging.pdf
[62] Comments were made in response to the recent consultation on changes to the Congestion Charge. TfL's Report to the Mayor can be found here: https://haveyoursay.tfl.gov.uk/congestion-charge-changes

For this assessment, higher charges are assumed in central London than inner and outer London, partly to reflect the fact that the central London Congestion Charge is already in place in central London and would be replaced by this scheme. Higher charges have also been assumed for the first kilometre of each journey than subsequent kilometres as an extra incentive to switch modes for shorter journeys.

By the time a scheme like this could come into effect, which could be no earlier than 2025/26, it would replace all existing charges and it is assumed would be subject to a daily cap, under a similar approach to public transport daily capping. A higher first kilometre charge would also be needed. This charge level means that the overall charge per trip is higher than the other three approaches, even for the shortest journeys.

Impacts

This section will look at the impact of next generation charging on London-wide car trips, vehicle kilometres, mode shift and emissions.

London-wide car demand

Indicative modelling shows this could result in a reduction of around six per cent of London-wide car trips. This would be the equivalent to removing around 400,000 to 500,000 cars from London's roads every day, or between 0.9 and one million trips daily.

In Inner London the percentage response is larger compared to outer London. However, because there are more cars in outer London this contributes more to the overall reduction. The larger response in inner London could be due to the greater range of public transport alternatives. For LGVs, indicative assessments suggest a response of around 2.5 per cent reduction in number of trips, which equates to around 7,000 fewer LGVs on London's roads every day.

Vehicle kilometres

Vehicle kilometres could decrease by around five to six per cent. As you would expect, with a distance-based charge, the impact on vehicle kilometres is more significant than with an area-based charge. However, an area-based charge still has significant impact in the overall reduction.

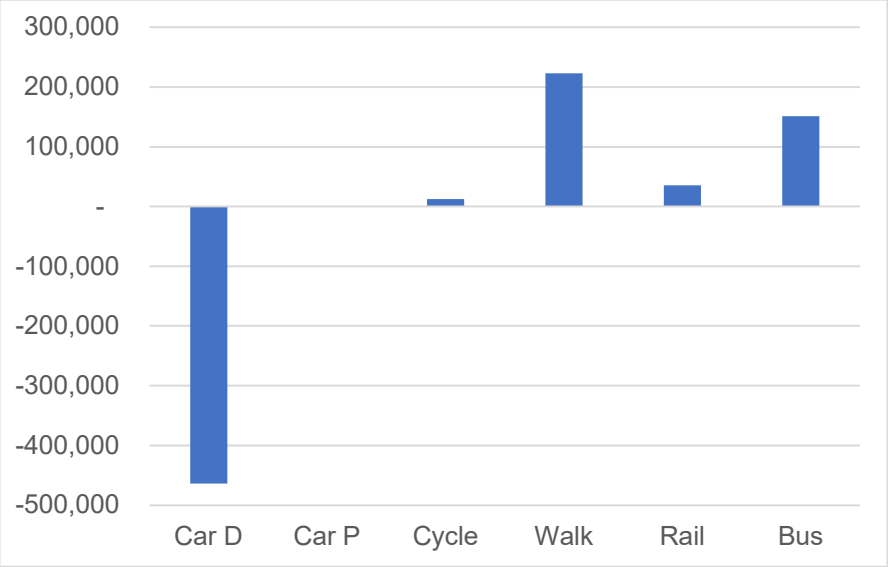
A distance-based charge comprises of two main components, an area-based charge (or first kilometre charge) and a per kilometre charge, and each can be adjusted to affect the overall impact. The overall impact of a distance-based scheme will ultimately depend on the base charge (first kilometre charge) as well as the per kilometre charge and these could be designed to generate the desired change in car trips compared to vehicle kilometres. The base charge could be increased to stimulate a higher overall reduction in car trips and consequentially vehicle kilometres; or the per kilometre charge could be increased to specifically stimulate a further reduction in vehicle kilometres.

Mode Shift

This approach could increase sustainable mode share by around 1.5 per cent across London. Of the trips that shift to other modes around half move to walking trips, which are typically short distance. As there is a higher first kilometre charge this is likely contributing

to the shift to walking. A per kilometre charge is likely to impact the longer distance trips more than other approaches, and this is likely why there is a greater shift to bus in this approach than the other approaches. There may also be some longer distance trips that redistribute to more local, shorter distance trips where they are more likely to use bus or walk to their new destination.

Figure 11: Mode shift for next generation charging in 2026



Emissions

Table 10: Next generation charging emissions savings across London, 2026.

To note: ***Emissions savings assume that further action has been taken by 2026 (for the purpose of this analysis, this has been assessed as equivalent to the expansion of ULEZ).***

Lower vehkm response (5%)		Excluding phase out of ICE cars and vans sales from 2030		Including phase out of ICE cars and vans sales from 2030	
		Reduction (tonnes)	% reduction emissions in London	Reduction (tonnes)	% reduction emissions in London
NO_x	Cars	140	5%	120	5%
	Vans	22	2%	19	2%
	Total	**162**	**4%**	**139**	**4%**
CO_2	Cars	120,000	5%	100,000	5%
	Vans	11,000	2%	10,000	2%
	Total	**131,000**	**4%**	**110,000**	**4%**

Summary of next generation road user charging

This approach, which would be a world first, is significantly different to the others presented in this paper; there are many possible variations of it but the main characteristic is capability to charge based on distance travelled (in addition to other variables such as emissions). It would use different technology to existing RUC schemes in order to charge on a 'per mile' basis. It is potentially fairer and could more effectively be tailored to objectives (and be flexed over time) and could be implemented from 2025/2026.

In terms of traffic reduction, this approach has the strongest effect, with a reduction of vehicle kilometres of between five and six per cent, equating to 400,000 to 500,000 fewer cars on London's roads every day. It is also the most effective in terms of mode shift, between one and two per cent.

Because of its later implementation date (compared to approaches 1,2 and 3), the emissions reductions are somewhat lower: 140 to 230 tonnes less NO_x and 110,000 to 181,000 tonnes less CO_2. However, these are still beneficial and could be developed over time.

6. High-level benefits of the assessed approaches

This paper demonstrates there are a range of potential approaches that could be taken in London within the next few years and which could help to address the continuing emissions challenges in London, aligned with Mayoral and national policy. Objectives to address these and other related challenges were set out in the MTS, and we were making good progress in achieving them, but the Covid-19 pandemic has set us back. As described in section 3 above, although we have made great gains in air quality, we need to go further to ensure legal compliance and protect public health, particularly in light of new WHO guidelines. There is also increased urgency to tackle the challenge of climate change. To set us on a trajectory to meet these goals, a new emissions-based scheme of the kind described in this note may be required.

The need to reduce both air quality pollutants (NO_x and PM) and CO_2 emissions is the primary scheme objective in order to protect the health of Londoners, reduce inequalities and tackle the climate emergency: the success of ULEZ and LEZ are testament to the

effectiveness of these schemes in tackling emissions from road-based transport. The Mayor's policies have helped to narrow the gap between the most and least deprived areas exposure to NO_2 by up to 50 per cent since 2016.[63]

Preliminary modelling on the four approaches considered in this paper indicates that a London-wide scheme could significantly reduce vehicle kilometres and their associated emissions. This is the case with even a relatively low charge applied to a large population. Reduced emissions will help to prevent Londoners developing diseases attributable to air pollution and reduce the cumulative cost to the NHS and social care system over the next 30 years.

In addition, congestion causes inconvenience and unreliability for motorised road users and has a significant cost to London's economy. The annual cost of congestion is estimated at around £5.1 billion[64] based on the delay faced by people driving. This figure does not account for the cost of congestion on bus passengers and bus operating costs. Improving air quality in London would also provide an economic benefit of almost £500 million per year to the local economy.[65]

While the most effective approach at this stage of analysis seems to be extending and strengthening the ULEZ, all approaches have been shown to result in positive impacts and could be further adapted as part of design and development work. A distance-based scheme, while not deliverable on the same late 2023 timeframe as other potential approaches could remain a longer term goal even if another approach is taken forward in the shorter term, given its potential benefits in terms of flexibility and fairness.

As this paper has summarised, a reduction in vehicle kilometres, particularly where trips are switched to sustainable modes or to cleaner vehicles, brings a range of wider benefits in terms of public health, freeing-up road space and increasing physical activity. And as a consequence of these, there is a lesser burden on the NHS, the street environment is more conducive to walking and cycling and health inequalities can be addressed. There can also be further positive effects in line with the MTS such as more reliable bus journey times and moving towards Vision Zero.

A mode shift to sustainable modes (public transport, walking and cycling) brings further health benefits in addition to those from reduced emissions. It is estimated that there would be a £1.7bn saving in NHS treatment costs over 25 years if every Londoner walked or cycled for 20 minutes a day.[66] This has direct knock on impacts on the economy where employees who are physically active take 27 per cent fewer sick days than their colleagues[67]; and 73 per cent of employees who cycle felt it makes them more productive at work.[68]

Revenue generated by road user charging must be spent directly or indirectly on implementing the MTS. The positive outcomes summarised above could be supported using revenue raised by one of the potential RUC approaches considered in this paper.

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[63] https://www.london.gov.uk/press-releases/mayoral/bame-and-poorer-londoners-face-air-quality-risk
[64] https://inrix.com/press-releases/2021-traffic-scorecard-uk/
[65] https://www.cbi.org.uk/media/5539/2020-09-cbi-economics-caf-report.pdf
[66] https://content.tfl.gov.uk/mts-challenges-and-opportunities-report.pdf
[67] National Institute for Health and Care Excellence, 2012
[68] The Prince's Responsible Business Network, 2011

For example, revenues could be used to make active and sustainable modes more attractive as an alternative to private vehicle use.

These outcomes could be further improved if additional net proceeds were available. Buses and street outcomes could be supported by, for example:

- maintaining borough LIP funding, including principal road maintenance and borough structures;
- increasing investment in outer London town centres;
- maintaining and protecting London bus services, and with sufficient net revenues, increasing outer London bus services;
- accelerating bus electrification (assuming government funding is provided for the necessary capital investment);
- creating a new scrappage scheme (building on the success of the ULEZ expansion scheme) or other support mechanisms; and
- enhancing sustainable alternatives, including bus services to provide an attractive and viable alternative to private car use. Attractive and viable alternatives to private car use will be a prerequisite to being able to introduce any new scheme.

Wider RUC schemes which incentivise the shift to EVs could also help fund the increase in supply of charging infrastructure to support this. The latest Electric Vehicle Infrastructure Strategy for London,[69] published in December 2021, highlighted that at present there are 8,600 public charging units in the capital and this needs to increase to between 40,000 and 60,000 by 2030.

[69] London's 2030 Electric Vehicle Strategy (2021) https://tfl.gov.uk/modes/driving/electric-vehicles-and-rapid-charging

7. Considerations for any new scheme

Simple, effective and fair

It is important that any new charging scheme is simple and easy to use, that where possible, adverse impacts have been mitigated, and that the objectives are fair and proportionate and the benefits are real and effective. In ensuring this we would pay attention to the precedents of existing RUC schemes with regard to discounts, exemptions and support schemes.

We already know that improved air quality is important to Londoners – 78 per cent[70] said that tackling poor air quality should be a priority – and surveys in advance of ULEZ expansion[71] showed that it was supported by a majority of Londoners. Depending on the design of a scheme, these benefits could include reduced traffic leading to better bus journey times, or more reliable journey times for essential freight, delivery and servicing trips. If a scheme is taken forward, we would monitor its effect, be open in sharing the data and be ready to make changes to the scheme on an ongoing basis, following consultation and proper processes, to improve its outcomes or further mitigate its effects if these are indicated.

One aspect of this would be ensuring there are appropriate discounts and exemptions in place for a suitable period. This could include, for example, a discount for disabled Londoners who may find it more difficult to shift away from the car, subject to impact assessments.

Mitigations, including consideration of low income households

Any scheme would be subject to a series of detailed impact assessments including an EqIA to assess and mitigate impacts on people with protected characteristics. For interventions which seek to affect behaviour change through levying a charge, particular consideration would also need to be given to those on low incomes and mitigating the direct impact of the cost of any charges. Options for mitigating this would need to be part of scheme development but could include, for example, the option to pay for trips at a reduced level or the opportunity to purchase annual unlimited trips at a lower rate. It may also be possible to offer residents, or residents meeting certain eligibility criteria the opportunity to qualify for a quota of free trips, potentially in conjunction with signing up to pay by account. Consideration will need to be given to how to make sure that low income households are able to benefit from such an offer.

As noted in section 4, car ownership is correlated with household income. The most recent pre-pandemic data (2019/20) shows that 71 per cent of low income households in London (annual household income less than £20,000) do not have access to a car, compared to only 28 per cent of high income households (annual household income greater than

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[70] London Councils poll, 2020 https://www.londoncouncils.gov.uk/our-key-themes/environment/air-quality-london/air-quality-public-polling

[71] YouGov polling for Client Earth in April 2021. 51% supported the ULEZ expansion, 68% agreed that higher-polluting vehicles should pay more https://www.clientearth.org/latest/press-office/press/majority-of-londoners-support-expansion-of-the-ultra-low-emission-zone/

£75,000), with car ownership rising through income bands. As a result, London residents living in low income households are less likely to use private modes for travel – 22 per cent of all trips, compared to 34 per cent of trips made by Londoners from high income households. Those living in low income households are more likely to use modes which would benefit from the congestion and road space improvements resulting from traffic reduction schemes – buses and active modes.

For the ULEZ scheme we introduced scrappage schemes which were prioritised to help the most vulnerable, meaning that they have been restricted to small businesses, low income and disabled Londoners and charities. This was a popular and effective supportive measure which enabled over 14,000 dirtier vehicles to be scrapped to date. To be eligible for the car and motorcycle scrappage scheme support for low-income residents you needed to be in receipt of one or more of specified benefits[72] and live within London.

Should one of the London-wide ULEZ approaches be taken forward, it is envisaged that a similar scrappage support package would accompany the scheme to support low income and disabled Londoners, small businesses and charities.

For the other approaches, including the low-level charge element of a strengthened ULEZ, additional support and mitigations would be considered as part of scheme design to ensure that any potential new scheme is fair and affordable alternatives are available. This would include consideration of discounts for disabled Londoners, informed by impact assessments.

Related to this we must also be clear on how the revenue raised from a RUC scheme supports the wider delivery of the MTS. The onus will be on us to demonstrate how this has led to a cleaner and fairer city for everyone; be that by improving bus services, by improving access to transport or mitigating the worst effects of climate change.

Complementary measures

As well as defining the rules and parameters of a scheme, final proposals should include an effective and targeted package of complementary measures, including for example investment in sustainable travel alternatives to driving. This will help to enhance the positive impacts of the scheme including public health benefits from behaviour change. Genuine and viable alternatives are critical to the successful implementation of a new road user charging scheme and will be key to public acceptability.

A package of complementary measures would provide alternatives to car use to support the scheme's objectives. It would need to take account of the varied circumstances in different areas around Greater London and especially outer London. An area of focus could be increasing active travel connectivity between residential neighbourhoods and town centres in outer London.

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[72] State benefit award letters provide a clear and uncomplicated process, which applicants will be familiar with. Criteria based on household income would be difficult to administer as we are unable to verify who is registered at a residential address and do not have access to income data. The eligibility criteria include working tax credit, which boosts the income of working people who are on a low income: https://tfl.gov.uk/modes/driving/ultra-low-emission-zone/car-and-motorcycle-scrappage-scheme

Interventions would be based on analysis, engagement with stakeholders and boroughs, and local circumstances to help identify the most appropriate and impactful measures by location. It will be important to consider these within the overall landscape of existing TfL and borough investment and transport plans.

Impact on London's businesses

The MTS sets a clear total traffic reduction target of 10-15 per cent by 2041 to tackle congestion and improve the efficiency of London's streets for the movement of people and goods. Congestion causes unreliable journey times for businesses and has a significant cost to London's economy, with the annual cost of congestion in London is estimated at around £5.1 billion[73] based on the delay faced by people driving.

A scheme that encourages a shift from car use to sustainable modes makes more efficient use of London's streets. Reducing car use provides economic benefits to businesses by freeing up road space and reducing journey times for essential trips that keep London's businesses and key services running. Support schemes for small businesses who need to use motorised vehicles such as scrappage schemes or other measures will be considered and included if appropriate, to help mitigate the impacts of a new scheme. Consideration will also need to be given to business models that rely on car use, such as car clubs, taxis and PHVs. This would be informed by impact assessments during scheme development.

Customer experience

It will be important to ensure that there is a good customer experience in terms of being able to understand how the charge works and offering options to pay the charge in a way which is integrated with other RUC schemes in London. Several channels already exist for customers to interact with road user charging schemes in London, described online as 'Pay to Drive.' The most popular channel is Auto Pay and 750,000 people are registered with this system. Over three-quarters of customers pay for the Congestion Charge by Auto Pay, which enables users to register for a payment account which has the advantage of meaning that payments cannot be inadvertently missed and lead to Penalty Charge Notices (PCNs) for non-payment**.**

In developing any RUC scheme proposal there are a number of data protection and privacy matters which would need to be taken into account. Data Protection Impact Assessments (DPIA) would be required to identify, assess and (where appropriate) mitigate, any privacy risks identified.

Next stages

RUC schemes have significant potential to achieve positive results in London. If one of the approaches discussed in this paper were to be taken forward, there would need to be work under the following broad themes:

- Option development

[73] https://inrix.com/press-releases/2021-traffic-scorecard-uk/

- Proposed scheme design for public consultation, including complementary measures, discounts and exemptions and support schemes and other mitigations, and the accompanying MTS revision
- Drafting a scheme order which would set out the rules of the scheme including defining the charging area and zone, when liability to pay the charge arises, the level of charge and discounts/exemptions criteria
- Preparation of an Integrated Impact Assessment (IIA), including an EqIA on the scheme; environmental report under Strategic Environmental Assessment rules for any required MTS revision
- Engagement and consultation
- Operational and implementation preparation including customer considerations
- Use of revenue / Ten Year Plan (for a wholly new scheme)

A high level timeline setting out this activity is included at Appendix C.

8. Conclusion

This paper provides a preliminary assessment of the potential of four approaches in terms of reducing vehicle kilometres and, in doing so, reducing air quality and CO_2 emissions. In addition, a GLBC has been considered and impacts are highlighted here for ease of comparison, though more detailed analysis can be found in the GLBC Feasibility Study. As Table 11 demonstrates, each approach has different merits and, should feasibility work be taken forward, these could be further investigated and other potential impacts identified. As set out in the previous section, there would be considerable further work before any scheme could be implemented, including the drafting of a new scheme order (or modifications to an existing one) and amendments to the MTS and undertaking impact assessments and public and stakeholder consultations. A potential high-level timeline is given at Appendix C.

Table 11: Summary of impacts of assessed approaches[74]

	1. ULEZ expansion to outer London	**2. ULEZ expansion with a tighter standard**	**3. Low-level emissions charge**	**4. Next generation charging (London-wide)**	**Greater London Boundary Charge**
Policy impacts					
MTS Objective: reaching compliance with UK and EU legal limits as soon as possible					
NO_x emissions*	▼ 285 to 330 tonnes NO_x	▼ 330 to 390 tonnes NO_x	▼ 28 to 35 tonnes NO_x	▼ 139 to 162 tonnes NO_x	▼ 50 tonnes NO_x
MTS Objective: net zero carbon					
CO_2 emissions	▼ 135,000 to 150,000 tonnes CO_2	▼ 173,000 to 193,000 tonnes CO_2	▼ 21,000 to 24,000 tonnes CO_2	▼ 110,000 to 111,000 tonnes CO_2	▼ 27,000 tonnes CO_2
*For NO_x and CO_2 emissions figures given above, the higher figure excludes a phase-out of ICE vehicles by 2030 and the lower figure includes this.					

[74] Note figures are early indicative findings

	1. ULEZ expansion to outer London	2. ULEZ expansion with a tighter standard	3. Low-level emissions charge	4. Next generation charging (London-wide)	Greater London Boundary Charge
MTS Objective: at least 3m fewer daily car trips and 250,000 fewer cars owned in London by 2041					
Traffic reduction	▼ <1% car trips ▼ 0.5 to 1% veh kms ▼ This equates to 20,000 to 40,000 fewer cars on London's roads every day	▼ 3% car trips ▼ 1.5% veh kms ▼ This equates to 100,000 fewer cars on London's roads every day	▼ 2.5% car trips ▼ 0.8% veh kms ▼ This equates to 60,000 to 80,000 fewer cars on London's roads every day	▼ 6% car trips ▼ 5.5% veh kms ▼ This equates to 400,000 to 500,000 fewer cars on London's roads every day	▼ 3% car trips ▼ 1% veh kms ▼ This equates to 60,000 to 70,000 fewer cars on London's roads every day
MTS Objective: 80 per cent sustainable mode share by 2041					
Mode shift	Marginal as 60,000 to 70,000 of the most polluting cars from London's roads are replaced with ULEZ compliant cars	▲ 0.5% With a strong shift to walk trips	▲ 0.5% With a strong shift to bus and walk trips	▲ 1.5%	▲ 0.5%
Implementation cost and date					
Implementation cost	£225-275m (+ c. £100m tbc scrappage fund)	£375m (+ c. £100m tbc scrappage fund)	£325m	£270m (based on central / inner London cost – London wide would depend on what else is in place in 2025/6)	£220m
Earliest date	Late 2023	Late 2023	Late 2023	2025/2026	Late 2023

Appendices

Appendix A: London Atmospheric Emissions Inventory Concentration Maps

The 2019 LAEI provides modelled concentration maps for NO_2, PM_{10} and $PM_{2.5}$. Previous LAEI maps from 2013 and 2016 are provided for comparison.

Figure 12: NO_2 Concentrations 2013

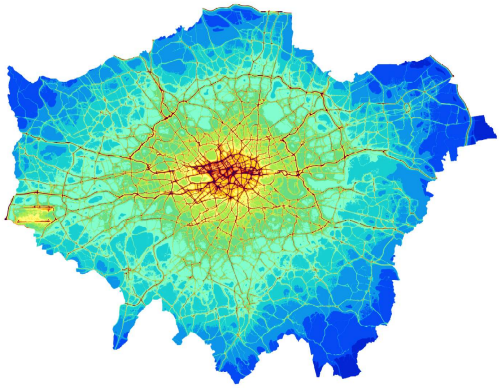


Figure 13: NO_2 Concentrations 2016

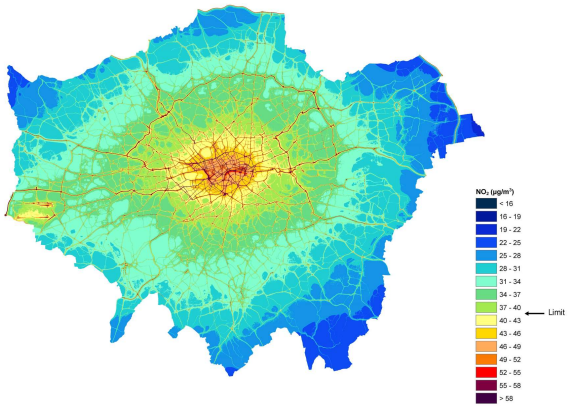
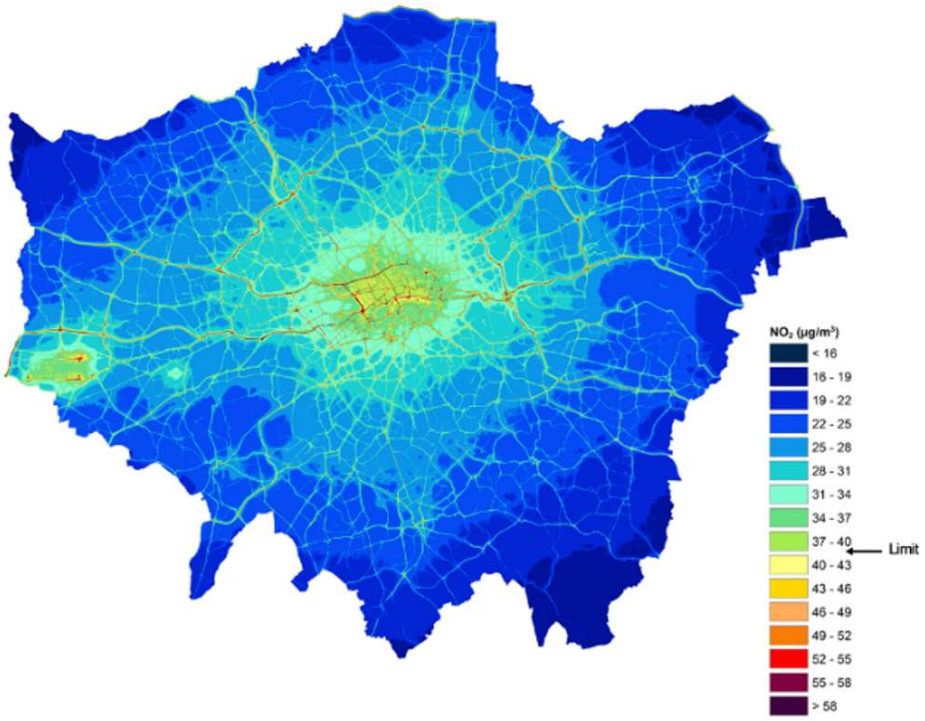


Figure 14: NO_2 Concentrations 2019



The NO_2 concentration maps show a significant reduction in concentrations across the whole of Greater London from 2016 to 2019 with the majority of the area meeting the legal limit for NO_2 in 2019. These improvements will continue with the recent expansion of the Ultra Low Emission Zone up to the North and South Circular roads on 25 October 2021. Average concentrations of NO_2 are approximately 22 per cent lower than in 2016.

Figure 15: PM_{10} Concentrations 2013

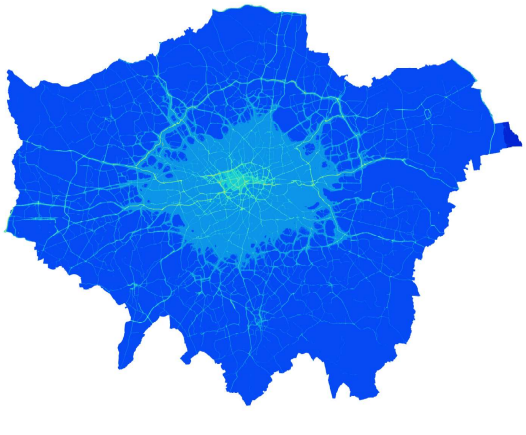


Figure 16: PM_{10} Concentrations 2016

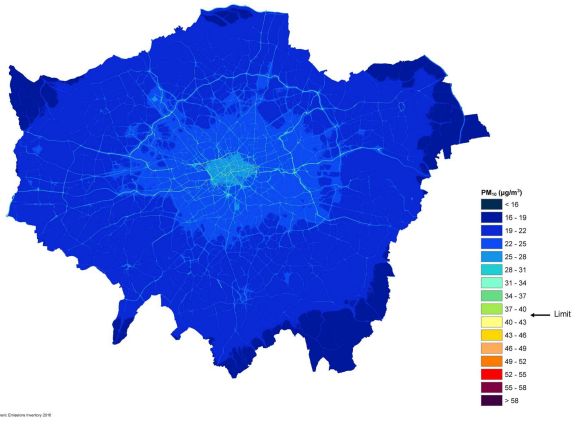
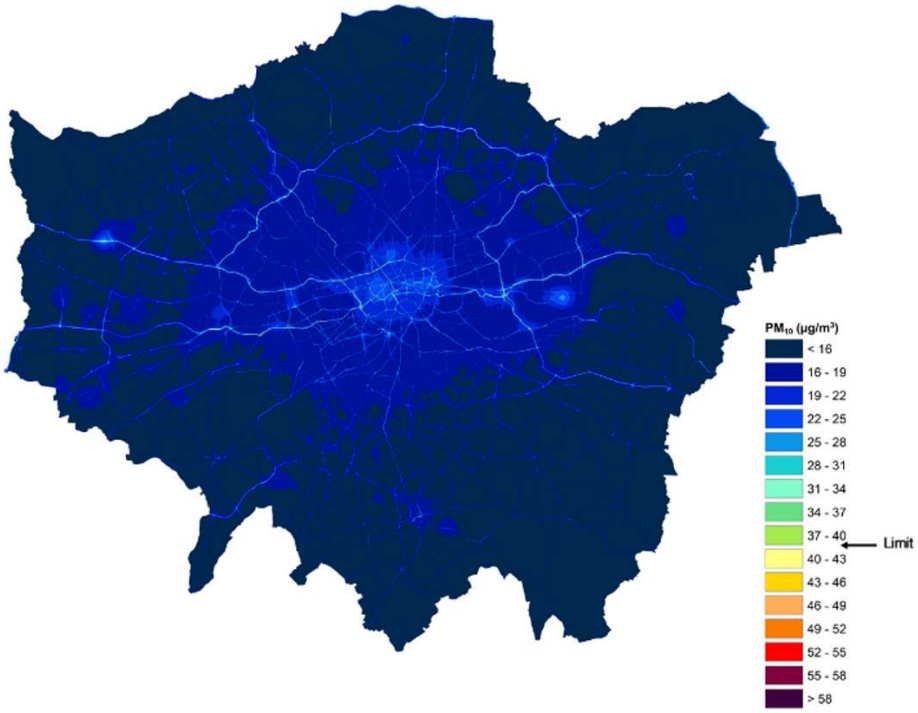


Figure 17: PM_{10} Concentrations 2019



The PM_{10} concentration maps show that the whole of Greater London has experienced reductions in PM_{10} concentrations from 2016 to 2019 with large areas of outer London now in the lowest category on the map for 2019. In addition to local reductions in emissions,

PM_{10} is a transboundary pollutant which is influenced by background concentrations and meteorology. Average concentrations of PM_{10} are approximately 24 per cent lower than in 2016.

Figure 18: $PM_{2.5}$ Concentrations 2013

Figure 19: $PM_{2.5}$ Concentrations 2016

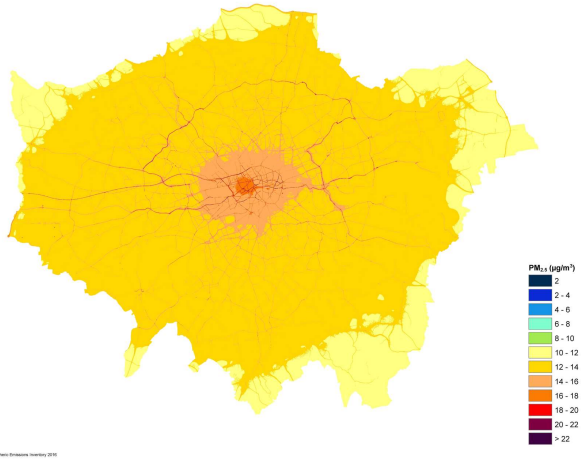
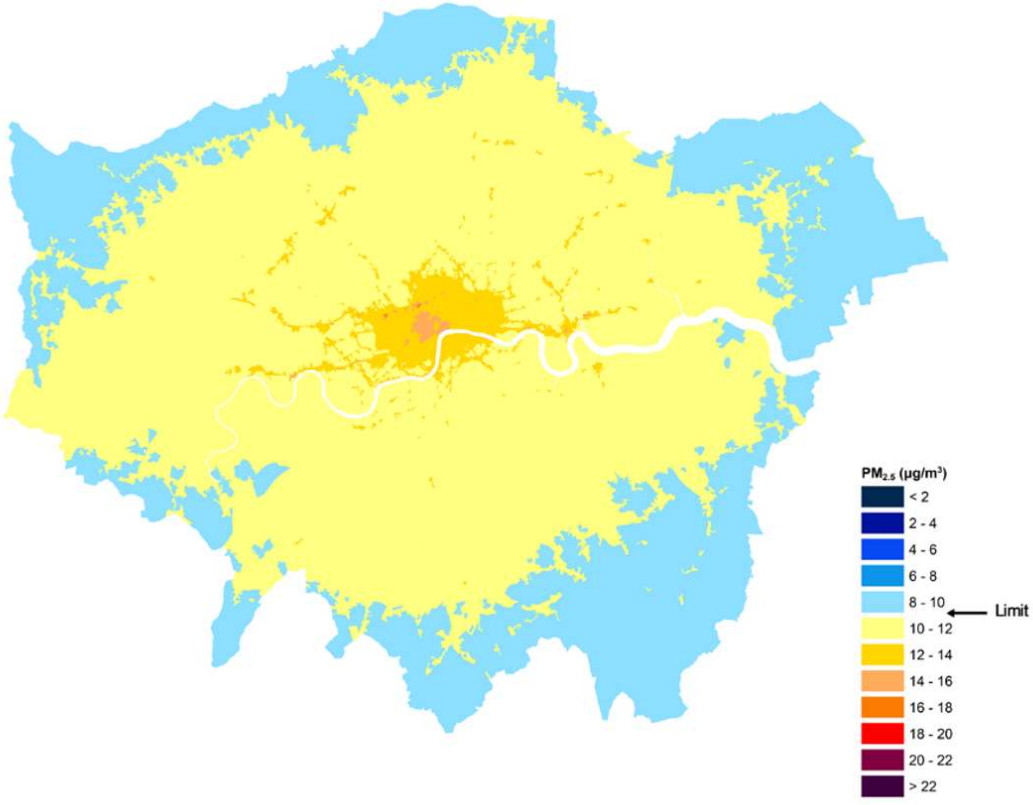


Figure 20: $PM_{2.5}$ Concentrations 2019



The $PM_{2.5}$ concentration maps show that there was a reduction in $PM_{2.5}$ across the whole of the city with many parts of outer London meeting the WHO interim guideline of $10\mu gm^{-3}$

for the first time in 2019. Average concentrations of $PM_{2.5}$ are approximately 19 per cent lower than in 2016 – this includes background and roadside locations. In addition to local reductions in emissions, $PM_{2.5}$ is a transboundary pollutant which is influenced by background concentrations and meteorology.

Appendix B: Data on Electric Vehicles and compliance levels

Data from the network of ANPR cameras in London for November 2021 indicates the following average daily captured volumes of unique vehicles, by zone and compliance status. Note that the central zone is the same as the congestion charging zone, inner London is the area between central and the North/South Circular Road, whilst outer London is the area outside the North/South Circular, up to the GLA boundary. The recently expanded ULEZ covers central and inner London combined (and de-duplicated) and LEZ is the whole of Greater London.

The volumes captured by ANPR are shown in Table 12 and

Table ***13*** below, one for all fuel types combined and one showing numbers of hybrid vehicles (according to DVLA fuel classifications - both plug-in and non plug-in types) and showing zero emission vehicles (primarily battery electric vehicles (BEV) with hydrogen included where they are seen).

Table 12: Vehicle captures by current ANPR cameras (all fuel types)

	All fuel types combined			
Zone	**Daily Non-Compliant**	**Daily Compliant**	**Daily Total**	**% ULEZ Compliant**
Central	18,391	125,148	143,539	87.2%
Inner	74,128	877,278	951,405	92.2%
Expanded ULEZ	80,076	897,647	977,722	91.8%

Outer	137,978	650,905	788,883	82.5%
LEZ	191,145	1,274,916	1,466,061	87.0%

Table 13: Vehicle captures by current ANPR cameras (hybrid and zero emission vehicles)

	Hybrid and zero emission vehicles	
Zone	**Daily Total Hybrid**	**Daily total zero emission vehicles (BEV and H2)**
Central	21,178	5,086
Inner	94,177	26,031
Expanded ULEZ	95,289	26,454
Outer	59,710	8,682
LEZ	120,595	29,893

Please note that the camera network in central and inner London has been upgraded significantly to support the existing ULEZ scheme. Since the network in outer London currently has a lower density of camera placements it captures a lower proportion of vehicles, so the data from respective areas are not directly comparable. The outer London data is therefore a low estimate for the volume of daily vehicles in outer London. Also, each zone is measured in isolation, so it is possible for a single vehicle to be captured in multiple zones on a given day. Where this occurs the data represents an upper estimate for vehicle volumes.

Appendix C: Timeline of how an MTS amendment and proposed scheme option could be taken forward