London electric vehicle infrastructure delivery plan

June 2019

Supported by

The Mayor's Electric Vehicle Infrastructure Taskforce

Contents

Mayor's foreword

London's air is so dirty and polluted it amounts to nothing less than a serious public health crisis. It breaches legal limits and blights the lives of Londoners, resulting in thousands of premature deaths every year and causing a range of lethal and debilitating illnesses, including cancer, heart disease and dementia. As an adult I developed asthma, which doctors tell me is likely to be linked to air pollution.

But what makes me most angry is the impact London's filthy air is having on the health of our children. To our shame, in some parts of our city there are children growing-up with stunted lungs and chronic respiratory conditions because of exposure to poor air quality. This is simply unacceptable.

The task of finding solutions to this scourge is urgent. So, at City Hall, we're taking action – not only in response to our dangerous air, but also to address the climate emergency that threatens the long-term security and wellbeing of every Londoner.

The action we've already taken includes: cleaning up our bus and taxi fleets, promoting walking, investing record sums in cycling, and encouraging more Londoners to use public transport by freezing fares and introducing more affordable bus tickets. We're working to a target of 80 per cent of trips to be walking, cycling or public transport by 2041.

We've also rolled out the world's first ever Ultra Low Emission Zone, which is the toughest emission standard in operation anywhere on earth. However, if we aspire to truly transform the quality of our air – and preside over a steep and meaningful reduction in our carbon emissions – we must move away from petrol and diesel cars, and towards electric and hydrogen vehicles. Bringing about this sea change won't be easy, but with the right political will and ambition I'm confident we can pull it off.

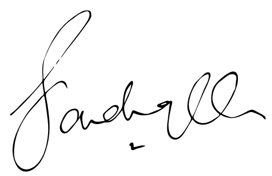
I'm proud that London is one of the first major cities in the world to publish a detailed and independently-assessed climate action plan that outlines how we will comply with the Paris Agreement. A big part of this plan is aiming for all new cars and vans on our roads to be zero emission from 2030.

This is a radical, but necessary step. Car ownership continues to decline in London, but we must do more now to help unleash an electric vehicle revolution across our city. Through our Electric Vehicle Infrastructure Taskforce, the public and private sector have worked side-by-side to expand London's public charge points and to make sure they are well used, in the right locations and future-proofed for tomorrow's technology.

The past year has seen more than 1,000 new charge points installed at petrol stations, town centres and retrofitted into street lighting columns. Our world-famous cabbies now drive more than 1,700 electric taxis and Transport for London runs Europe's largest electric bus fleet. We've also created a new multi-million-pound fund to support small businesses, charities and low-income Londoners switch to cleaner vehicles including electric.

There's no shying away from the fact that expanding our public charge points will be challenging. London's land is always in high demand, our streets are often narrow and we have to work with 35 different planning authorities. But we know there is a real appetite to cut harmful emissions and propel London towards a greener future. Thanks to our taskforce's hard work, we have tapped into the energy, enthusiasm and expertise of more than 140 organisations to plan for the cutting-edge infrastructure London needs. It is a world-leading piece of work that will ensure that London can continue to lead from the front, blazing a trail for others to follow.

With so much at stake, we simply can't afford to slip into reverse gear. In fact, now is the time to really put our foot down and accelerate our city's transition to zero emission vehicles. This plan will enable us to do just that. This is crucial because ultimately our efforts will mean cleaner air, a greener city and healthier lives for all Londoners, not to mention a better and more sustainable future for our planet and generations to come.



Sadiq Khan
Mayor of London

Executive summary

Through this delivery plan, we believe we can be confident there is a clear way to provide the right type and amount of charging infrastructure to serve London's needs.

Background

The Mayor's Transport and Environment Strategies set out a clear commitment to zero emission road transport, and to a zero carbon city by 2050. This is a priority given the significant impact London's toxic air has on health and social justice for Londoners. The Mayor has declared a climate emergency and his ambition is for every new car or van registered in London to be zero emission from 2030, meeting the ambition of the Committee on Climate Change and sooner than the national goal of 2040 as set out in the Government's Road to Zero.[1] To achieve this will require a significant shift in mindset, vehicles and infrastructure, supported by legislation.

London has a growing electric bus fleet, zero emission-capable taxis and other electric vehicles (EVs) such as private hire and vans already in use on London's roads, in greater numbers than any other UK city.

Numbers of EVs are increasing, with one in every 47 new cars registered in the UK now plug-in, and one in every 36 for London. However, barriers to more widespread uptake remain. Consumer awareness and perception, range, availability of vehicles and cost of vehicles are all factors, but the availability of charging infrastructure – real or perceived – is considered to be the most immediate barrier to tackle at the city level. The Committee on Climate Change has recently reported that the expansion of EV charging networks and grid capacity is key to facilitating growth of EVs.[2]

Private home (or workplace) charging is expected to be preferred for many car owners across the UK, as well as having some particular advantages as set out in Road to Zero. This is also the case in London, but there will also be an important role for public charging infrastructure, both because of car-owning homes without off-street parking, a rising gig economy, and high-mileage vehicles such as taxis and private hire that will require charging throughout the course of a day. Owing to the rapidly changing technology of the vehicles and charging infrastructure, the behaviour of drivers is still evolving, making it challenging to plan for future infrastructure needs.

1 The Road to Zero: Next steps towards cleaner road transport, HM Government, 2018 www.gov.uk/government/publications/reducing-emissions-from-road-transport-road-to-zero-strategy

2 www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf

3 www.theicct.org/publications/ev-capitals-of-the-world-2018

The London context

London is recognised as one of 25 EV capitals that together are home to around half of all EVs worldwide.[3] Sales of EVs, both pure battery electric (BEV) and plug-in hybrid (PHEV), in London are growing year on year. In 2018, EVs accounted for 2.81 per cent of sales in London – higher than the UK average of 2.13 per cent.[4]

EVs in London are supported by a range of charging infrastructure, ranging from rapid DC chargers, to slow to fast AC chargers.[5] The current mix of charging infrastructure helps to accommodate today's technology and to facilitate different uses. Rapid chargers are costly per unit but offer the fastest charge time, whereas slow to fast AC chargers cost considerably less to purchase and install, but take much longer to charge a vehicle. In both cases, on-street provision needs to be carefully balanced against concerns about meeting accessibility needs, and the density of street furniture and traffic on London's roads, in line with the Mayor's Transport Strategy.

There has been significant public investment in charge points in London from the origins of London's first public charging network, Source London in 2011 to the lamppost and freestanding charge points being installed today via the Go Ultra Low City Scheme.[6] Transport for London (TfL) has also committed to installing 300 rapid chargers by the end of 2020. The private sector is investing as well, and the commercial case is set to improve further, with growing zero emission fleets of taxis, private hire and other key user groups. However, initiatives to remove barriers and improve the conditions for accelerating investment are critical to facilitate and speed up growth in this sector.

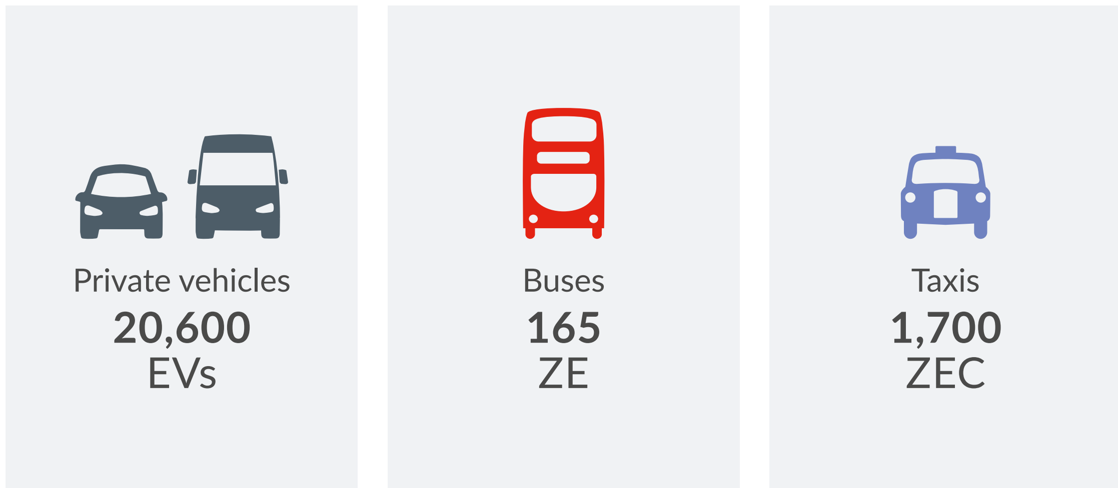


Figure 1
London's transition to zero emissions

4 Plug-in EV = Battery electric (BEV) + Plug-in Hybrid (PHEV); vehicle segments include cars, motorcycles and LGVs, DfT Statistics, Datasets VEH0130, VEH0131, VEH0150, VEH0260, VEH0354, VEH0454

5 Rapid DC is defined here as DC50kW+ (CCS + CHAdeMO/Supercharger) or AC 43kW+. Slow to fast AC is defined here as a 3-22kW charger. See Glossary for further details

6 www.londoncouncils.gov.uk/our-key-themes/transport/roads/gulcs

Image 1
The Mayor addressing delegates at the launch of the EV Infrastructure Taskforce

The Mayor's EV Infrastructure Taskforce

In May 2018, the Mayor established a world-first EV Infrastructure Taskforce with experts from both the public and private sector who collectively have the knowledge to help unlock barriers to expanding charging infrastructure and accelerating the switch to EVs in the Capital. The taskforce consists of representatives from business, energy, infrastructure, Government and London boroughs and, over the past year, they have been supported by contributions from more than 350 stakeholders from in excess of 140 different organisations.

The taskforce has been informing and steering the development of a delivery plan, to identify and deliver the level and type of charging infrastructure that London will need to accelerate the switch to EVs up to 2025. The focus is on the medium rather than the long term, as taskforce members agree that, due to rapid change in this industry, to make firm plans now for the longer term is not advisable. The decisions we take now, and the level and type of provision installed in the medium term, will help to shape the way the switch to EVs grows across London, and therefore influence the long-term requirements, progressing towards the Mayor's Transport Strategy goal of a zero emission transport network by 2050.

Since May 2018, we have held a series of taskforce workshops to inform the delivery plan, discussing user needs, land and energy issues, and financial models. We held further, more targeted, stakeholder meetings and round-table discussions to solidify our understanding of specific user needs and what stakeholder groups wanted the taskforce to deliver. These included:

- Individual meetings with groups of taxi stakeholders, private hire stakeholders, car manufacturers and EV infrastructure investors
- Round-table discussions with charge point manufacturers and operators, car and van sharing representatives, and a business leaders' round-table meeting organised by taskforce member, London First

The delivery plan

This report recognises that infrastructure is currently a barrier, be it real or perceived, to the switch to EVs, although it should be noted that there are other barriers that will have a large influence. Notably, EV supply in the UK is currently a constraint, and unless this issue is resolved, this will continue to be a limiting factor. It may mean that our low EV growth scenario, or even lower, is a real possibility.

The modelling for this plan gives us confidence the current delivery schedule in London by the private and public sector, consisting of over 300 rapid charge points and over 3,500 slow to fast chargers by the end of 2020, will be sufficient to deal with the expected uptake of electric vehicles. By 2020, using prudent EV uptake assumptions, we could need around 200 to 400 rapid charge points and 3,400 to 4,700 slow to fast charge points. By 2025, with EV uptake in line with the MTS and London's 1.5 degree plan, this could rise to between 2,300 to 4,100 rapid charge points and 33,700 to 47,500 slow to fast charge points. The expectation of the taskforce is that the numbers of points suggested in the report would be delivered primarily by the private sector but further support from the Government may be needed.

As it is likely there will be a mix of both types of chargers the numbers of chargers are likely to be somewhere in between these ranges. It is important to note that the wide range in the numbers of charge points is largely driven by commitments from the private hire sector to transform their fleets to be zero emission and other factors such as the cost and supply of vehicles improving. The total number of rapid charge points required would reduce further should charging speed capability of new vehicles increase to accommodate ultra-rapid charging (100-150kW+).

These estimates have been derived from a modelling exercise, which took into account uncertainties including the rate of the switch to EVs, charging behaviour and charger utilisation. Because of the uncertainties of these variables, and so to avoid the risk of 'predict and provide', the taskforce did not recommend a prescriptive, target-based approach to 2025. Instead, the focus is on addressing the barriers to scaling up existing infrastructure in a way that takes account of the need to ensure London's streets are 'Healthy Streets'[7] and do not contribute to congestion.

A common concern is that EVs will put too much strain on the power supply and will cause the system to fail. However, evidence provided by the National Grid and local distribution networks suggests that this can be effectively overcome through better coordinated and 'smarter' use of our power networks.

7 The Healthy Streets Approach is the system of policies and strategies to help Londoners use cars less, and walk, cycle and use public transport more (see content.tfl.gov.uk/healthy-streets-for-london.pdf)

Image 2
Shirley Rodrigues, Deputy Mayor for Environment and Energy, addressing delegates at the launch of the EV Infrastructure Taskforce

Table 1: Six central challenges to delivering more EV infrastructure:

Category	Challenge
Land and energy	1. Ability to secure suitable charge point locations given competing demands and London's limited land availability
	2. Long lead times and complexity of installation
	3. Cost of energy grid upgrades
Operational/users	4. Lack of confidence in the availability of convenient charge points (ie, perception that all are already in use or broken down, or not in convenient locations)
	5. Unfamiliarity with the experience of charging – perception that it is confusing, complicated and inconvenient
Investment uncertainty	6. Uncertainty about what type of charger is needed, concerns about obsolescence – reluctance to invest until there is more confidence in the charging model

We have identified six central challenges to delivering more EV infrastructure (see Table 1).

This delivery plan for EV infrastructure in London seeks to address these challenges. We must provide clarity for the medium term (to 2025), and inspire confidence that infrastructure will no longer be cited as a barrier to transition to EVs for those vehicles that need to use London's roads. This plan sets out the framework, clarifying where we should focus our efforts. It includes actions to facilitate installation, tackling the known challenges around land and energy issues, and finally it sets out the scale and type of likely infrastructure needed against a charter of commitments to roll out EV infrastructure and support for the industry.

A key aim of the taskforce is to consider what market conditions are needed to embolden a commercial market and maximise the value of public funding. London has already been subsidising EV infrastructure and the role of the public sector is now beginning to move towards providing strategic direction and facilitation. This is not about distorting business models, but rather unblocking a number of strategic barriers that have been identified.

The overall insights, findings and recommendations of the taskforce are:

- We are frontier planning, with many unknowns and rapidly changing technology. Our findings must be understood within this context. EV driver behaviour is evolving and we must be cautious to avoid stranded assets (out of date technology). This is the first time a city has undertaken such a comprehensive exercise to understand likely future EV infrastructure needs and it is hoped that others will also benefit from the work of the taskforce

- Public charge points should be open to all, with a few exceptions, notably for taxis in central London and other specific, priority groups that need extra support due to mandatory requirements and operational needs. This increases public confidence in charging infrastructure and also boosts utilisation, and therefore financial viability

- Different types of chargers currently suit different user needs, and a mix of rapid and slower chargers will continue to be needed to 2025. However, different approaches are suggested for rapid chargers and slower chargers:

  For rapid chargers
  – The proposed focus is on the development of rapid charging hubs,[8] which we see as serving primarily high-mileage/business users who need fast and available charging. Multiple charge points in known locations serve to increase consumer confidence that they will find a reliable and available charger

  – To improve the spread of these across London, the next phase of delivery should focus on at least five flagship rapid hubs, one in each sub region of London, with the first by 2020, subject to funding and EV growth. These would be in off-street locations, easily accessible and with high throughput

  – To improve overall coverage of rapid chargers, additional rapid chargers should be prioritised to serve London's town centres.[9] This could be in the form of hubs or single rapid chargers, to primarily serve commercial needs. As suitable sites along TfL's roads are increasingly difficult to find, we expect future sites to be on borough roads (or off-road)

  – The private sector should adopt these approaches going forward, and TfL will also be doing so for the remainder of the 300 rapid chargers it will install in London by the end of 2020

  For slow to fast AC chargers
  – The focus is on a) uplifting volume, b) reducing the streetscape impact of chargers, and c) exploring new models around deployment off-street (eg, car parks in or around residential areas)

  – The future favoured deployment model is strategic and demand-led, (not desire-led) in order to improve commercial viability and enable the private sector to take over delivery

8 Defined as 'a minimum of six rapid chargers enabling simultaneous charging of six+ vehicles' – further definitions of types of rapid hubs can be found in Chapter 4

9 Town centres as defined in the London Plan (approx. 200)

Image 3
Q&A session at the launch of the EV Infrastructure Taskforce

What can we do to make this happen?

The situation is complex, there are numerous stakeholders involved and the Mayor of London has limited powers and cannot impose infrastructure deployment. However, there are a number of ways we can help facilitate charge point installation and unblock the barriers identified above. The following set of 'enablers' has been developed and are summarised in Table 2. More detail on how they will be taken forward is set out in Chapter 5.

These activities will facilitate EV infrastructure by tackling current challenges to provision. However, if we are to meet the scale of infrastructure we might need in London – in any of the modelled scenarios – we also need investment and commitment from the private sector.

As part of this delivery plan, we set out a number of commitments from both the public and private sector, gathered in a charter. This demonstrates the ambition and commitment to support the delivery plan. However, more must be done, and the final purpose of this work is to initiate a call to action, requesting more private sector organisations based or working in London to come forward with their own commitments to be part of the EV revolution in London, making it the leading EV city both in the UK and globally.

We believe that this delivery plan, with the identified enablers, research and the charter of commitments, should provide confidence to fleets, businesses and London residents that there is a clear way forward to delivering the right type and amount of charging infrastructure to serve London's needs, accelerating the switch to zero emission transport.

Table 2: Enablers to facilitate charge point delivery

Category	Enabler	Date
Facilitate smoother installation and match supply with demand	1. Deliver London's first rapid charging hub and support the roll-out of additional rapid charging hubs – in collaboration with the private sector	From 2020
	2. Support shared business charging infrastructure	Ongoing
	3. New pan-London Co-ordination Body to facilitate and oversee charge point installation	Initiate in 2019
Reduce energy barriers	4. New online tool/ 'heat mapping' to identify energy grid constraints and where new charging capacity will be cheaper and easier	June 2019
	5. Explore alternative and smart power supply options, such as battery storage, mobile charging and private wire networks	Ongoing
Share knowledge and maximise potential of legislation	6. Publish guidance on charge point installation for both public and private sector	2019/20
	7. Publish guidance on future-proofing EV infrastructure to encourage investors	2019/20
	8. Promote better standardisation of charge points and vehicles, interoperability of systems and data sharing	Ongoing

1 Introduction and aims

The Mayor set up the EV Infrastructure Taskforce to address one of the key barriers to London's EV transition.

1.1 Introduction

In his transport and environment strategies, the Mayor has set out his ambition for London to be the greenest city in the world, alongside his vision for transitioning to a zero carbon future with a zero emission transport network by 2050. This is a priority given the significant impact London's toxic air has on health and social justice for Londoners, as well as the climate related to carbon emissions.

At the national level, the Government has set out its aims for zero emission transport in the Road to Zero, in which it calls for at least 50 per cent – and as much as 70 per cent – of new car sales and up to 40 per cent of new van sales to be ultra low emission[10] by 2030. By 2040, no new conventional petrol or diesel cars/vans will be sold in the UK.

The Mayor's ambition is to accelerate this target and to work towards all new cars or vans registered in London to be zero emission by 2030, meeting the aspirations of the Committee on Climate Change. This ambition lies in an overarching approach of encouraging sustainable travel. The Mayor's Transport Strategy sets the direction in terms of supporting sustainable travel and, in particular, efforts to reduce overall car use and to enable more people to travel by walking, cycling and public transport. The health benefits of this are multiple, from having more exercise and reducing health impacts, to cleaner air with reduced tailpipe exhaust emissions, as well as the city being a cleaner and more attractive place to live and visit.

For unavoidable trips, accelerating the switch to EVs is critical to delivering this vision. London is already making progress with its growing fleets of Zero Emission Capable[11] (ZEC) black cabs, electric buses and electric support fleets being used by Transport for London (TfL), the London Fire Brigade and the Metropolitan Police Service. Business innovation has also been forthcoming, with electric delivery services from Gnewt, UPS and DPD, and demonstration projects such as e-FLEX[12] to look at the vehicle to grid charging market. London boroughs are progressing innovative schemes such as variable parking charges, zero emissions streets, and Neighbourhoods of the Future trials.

A recent report by the International Council on Clean Transportation has recognised London as one of 25 prestigious EV capitals, which together are home to around half of all EVs in the world.

1.2 Supporting policies towards zero emission

The roll-out of charge points in the Capital requires clear strategic oversight, in the same way as the planning of an urban bus network or congestion charge scheme. However, the Mayor has very limited powers to deliver on the strategy as it would require designating existing premises and highway for the provision of charge points. The exception is that an elected mayor can make a request to the Secretary of State to set regulations that require large fuel retailers to provide charge points, but this was only enabled in the 2018 Automated and Electric Vehicles Act and is yet to be tested. Otherwise, powers are broadly limited to the Mayor's spatial development strategy, the London Plan, which can only set requirements for new developments.

10 Ultra low emission vehicles (ULEVs) are defined by OLEV as vehicles that emit less than 75g of carbon dioxide (CO_2) from the tailpipe, for every kilometre travelled

11 Zero Emission Capable taxis are defined by TfL as 'having CO_2 emissions of no more than 50g/km and a minimum 30-mile zero emission range' tfl.gov.uk/info-for/taxis-and-private-hire/

12 www.london.gov.uk/decisions/md2332-e-flex

Image 4
Zero Emissions Capable taxi pulling in to use a rapid charger

To facilitate new investment in charging infrastructure, Government is seeking to introduce a concept of charging infrastructure rights. The Act also seeks to improve the experience of using charge points by enabling Government to mandate a common minimum method of accessing public charge points, allowing charging without a pre-existing contract; to compel operators to make the geographic location of their charge points publicly available; and to mandate minimum technical specifications for connectors to ensure greater interoperability. This is strongly supported and we would like to see this carried out to improve EV driving and charging experience.

The draft London Plan sets out requirements for EV charging facilities in residential development to provide 20 per cent ‘active’ and 80 per cent ‘passive’[13] provision of electric charging. Retail car parks must provide rapid charge facilities, and operational parking must provide suitable charging infrastructure for EVs or other Ultra Low Emission Vehicles (ULEVs). New or re-provided petrol stations must provide rapid charge hubs or hydrogen refuelling facilities.

Further specific supporting policies by the Mayor of London include the introduction of the Ultra Low Emission Zone (ULEZ) in central London from April 2019 to incentivise cleaner vehicles, including electric. The ULEZ will be expanded to the rest of inner London in 2021. Emissions standards will also be tightened in 2020 for heavy goods vehicles via changes to the Low Emission Zone (LEZ) which covers most of Greater London. A van scrappage scheme has also been put in place to help support these initiatives.

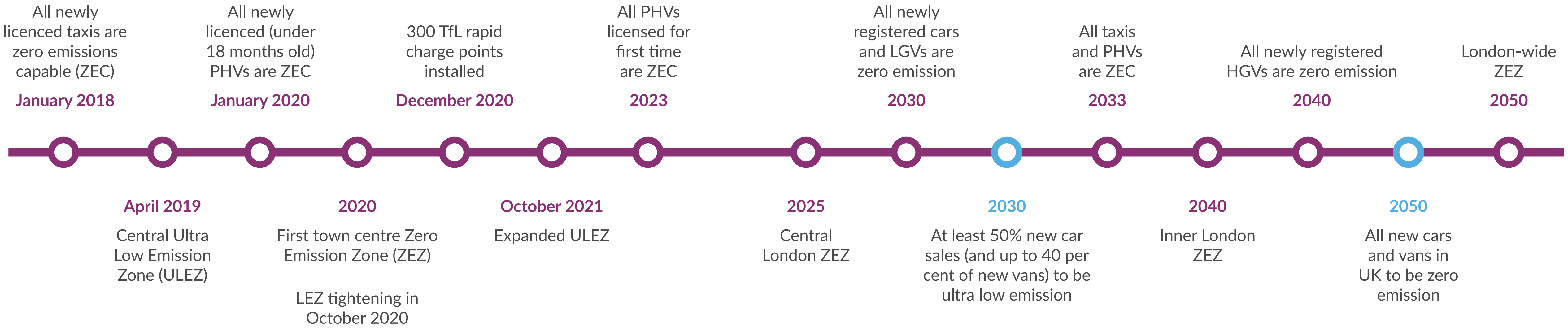
There is a commitment in the Mayor’s Transport Strategy and the London Environment Strategy to support boroughs wishing to implement Zero Emission Zones (ZEZs), and to create a ZEZ in central London by 2025. A new, phased, Cleaner Vehicle Discount to the Congestion Charge was also introduced in April 2019 and, by 2021, only full EVs will qualify. These policies strongly indicate the direction of travel in London and are already influencing travel and vehicle purchase choices.

Since January 2018, TfL has only been licensing new taxis (black cabs) that are ZEC and has offered a decommissioning fund – recently significantly enhanced – to take out of circulation some of the older cabs that are the most polluting. Soon, PHVs will also be subject to similar emissions-based qualifications to be issued licences – as detailed in the timeline below.

Figure 2
Timeline of key related policies

Mayor’s Transport Strategy 2018

Road to Zero Strategy 2018



13 Active spaces are fully wired and connected ready-to-use points at parking spaces. Passive provisions require the necessary underlying infrastructure to enable simple installation and activation of a charge point at a future date. See TfL website for further detail (tfl.gov.uk/info-for/urban-planning-and-construction/transport-assessment-guide/guidance-by-transport-type/electric-vehicle-charging-points)

1.3 What London is already doing to support EV charging infrastructure

Alongside the requirement that any new taxi being presented for licence would need to be ZEC from January 2018, TfL committed to putting in 300 rapid charge points by the end of 2020, using £17.8m[14] of funding from the Office for Low Emission Vehicles (OLEV). TfL reached an intermediate milestone late last year by achieving 150 rapid charge points in the ground in November 2018. Around half of these are dedicated to taxis, in support of ZEC taxis. The vast majority of this initial batch of rapid chargers have been sited along TfL's roads (TfL manages approximately five per cent of London's roads, known as the Transport for London Road Network or TLRN). This has enabled the speedy establishment of the core of a strategic network, and we are now beginning to see some rapid charge points go in along borough roads.

Historically, to provide slow charging for all, the 'Source London' EV charging scheme was established by TfL in May 2011. The scheme brought together a number of disparate public and private charging networks from across the Greater London area to form a single, publicly accessible charging network for EV drivers. TfL initially acted as the operator of the scheme, with responsibility for managing the Source London consortium and providing back office systems and services for members. Under the stewardship of TfL, the scheme grew from around 200 charge points in 2011 to more than 1,400 in 2014. The management and operation of the source London network was transitioned to the commercial operator IER Bolloré in September 2014 to enable improvement and expansion of the scheme without further reliance on public subsidy. TfL no longer manages the network.

Further expansion of public slow to fast charging has more recently been set up via the Go Ultra Low City Scheme (GULCS). GULCS is managed by TfL, the Greater London Authority (GLA) and London Councils, who are together rolling out even more street residential charge points, having received capital funding from OLEV (awarded in January 2016) which is match funded by boroughs. A total of £5.2m of the OLEV funding is allocated for residential slow on-street charge points and a new framework has been set up, including high standards for operators to meet. Much of the funding is going towards the smaller and more cost-effective lamppost charge points, and GULCS has already achieved its estimated target of 1,150 on street residential charge points by the end of 2020.

The GLA has also begun to provide charge points for its own fleets, and has committed in the Mayor's Transport Strategy for all cars in the GLA support fleets to be zero emission capable by 2025. The Mayor's Transport Strategy also set an objective for zero emission buses, pledging that TfL will have a 100 per cent zero emission fleet by 2037 at the latest (this includes more than 9,000 operator-run buses). The transition effort is well under way, with:

- All new double-deck buses procured for new contracts needing to be hybrid, electric or hydrogen by 2018
- 155 electric and 10 hydrogen fuel cell buses already on the network
- A further 90 electric buses due to join the fleet by the end of 2019
- From 2020, all new single-decker buses procured for new contracts will be zero emission

These funding streams have been key in supporting the public charge point network in London to date, but as numbers of EVs rise, we need to have a better understanding of how many more will be needed and who should deliver these.

1.4 The Mayor's EV Infrastructure Taskforce

We are now at a critical point in the delivery of EV infrastructure, where we need to look at implementation beyond the initial pump-priming that public funding can, or should, provide. This will require industry, businesses and the public sector to come together to develop a shared understanding of how, when and where the next phase of charging infrastructure will be delivered in the Capital. This can only be achieved with cross-sector expertise and partnership working, and this is the remit of the Mayor's EV Infrastructure Taskforce.

1.4.1 Who are the taskforce?

At a launch event on 31 May 2018, the Mayor of London invited industry leaders from 16 organisations to join the EV Infrastructure Taskforce, chaired by the Deputy Mayor for Environment and Energy, Shirley Rodrigues.

1.4.2 Taskforce remit

At the launch, it was agreed that the specific objectives of the taskforce would be to:

- Evaluate research and analysis regarding the level of charging infrastructure required in London, accounting for regional and national policies
- Explore the barriers and issues to delivering charging infrastructure in urban areas by contributing to, and analysing, the outputs from the workshops
- Consider the role of the public and private sector in facilitating a competitive market and partnership working, including land owners, charge point service providers and vehicle manufacturers
- Share any relevant knowledge or research with the wider taskforce group, and keep abreast of any pertinent industry developments
- Inform and steer the development of a shared EV infrastructure delivery plan (this document), explaining the most effective methods for delivery and the scale of infrastructure required
- Share, promote and gain stakeholder commitment to the delivery plan

Heavy goods vehicles (HGVs) were considered to be out of scope, as the technology for these vehicles is not well developed and therefore they are unlikely to be a significant user group over the next five years, which is the timescale the delivery plan considers. Their needs for charging

14 This funding pot is made up from OLEV grants under the following funding streams: National Infrastructure Plan, the Ultra Low Emission Zone (ULEZ) Taxi Competition and a contribution from the Go Ultra Low City Scheme (GULCS) scheme

Taskforce members:

- British Electrotechnical and Allied Manufacturers' Association (BEAMA)
- Cross River Partnership
- Energy UK
- Federation of Small Businesses (FSB)
- Freight Transport Association (FTA)
- London Councils
- London First
- Mayor of London
- Office for Low Emission Vehicles (OLEV)
- Ofgem
- Royal Automobile Club (RAC) Foundation
- Royal Institution of Chartered Surveyors (RICS)
- Society for Motor Manufacturers and Traders (SMMT)
- Shell UK
- SSE Enterprise
- Transport for London (TfL)
- UK Power Networks (UKPN)

Image 5
The Mayor of London and members of the EV Infrastructure Taskforce at the launch event at City Hall in May 2018

and space required means that they are unlikely to fit the charging models for cars and vans. The taskforce has however included engagement with the freight industry to understand their charging needs and barriers to take-up for a range of vehicles, which has informed the findings of the delivery plan.

Electric bicycles, scooters and alternative fuels have separate and distinct needs that are outside the core focus of the taskforce, which is about providing charging infrastructure for EVs. Also out of scope are autonomous vehicles, which are being considered separately from this workstream by TfL, as it was felt that within the timeframe (to 2025) it is unlikely that we will see significant change in London's vehicle make-up.

1.4.3 Stakeholder discussions

During 2018, TfL and the GLA organised a series of major EV Infrastructure Taskforce events, including three key workshops, round-table discussions and a range of one-to-one meetings to engage as widely as possible with stakeholder groups.

The three workshops were facilitated in London between July and October 2018 to consult a wider group of stakeholders on the need for public charging facilities in London to 2025, the current barriers and potential solutions for roll-out, and the associated business case challenges and opportunities they present.

Workshop 1 on understanding user requirements gave a greater understanding of typical user characteristics, revealing that private users mostly travelled under 10 miles a day whereas most commercial users travelled under 75 miles a day. Different users experienced different challenges such as parking and streetscape-related issues, and had varied commercial requirements (importance of depot as well as in-transit 'opportunity' charging).

Workshop 2 on land and power constraints discussed, in terms of land, the issues around planning consent, use of permitted development rights, shared land assets, utilising off-street spaces out of hours and the merits of partnerships or consortium approaches. In terms of energy, we explored the realities of smart charging and energy storage solutions, demand management and 'time of use' incentives, and issues around information regarding network capacity.

Workshop 3 on market models and financing focused on how important charge point utilisation is and how this could be maximised. We also covered the importance of reliability and minimising maintenance costs, the benefits of delivering alongside existing services, realistic payback periods, including lease terms, as well as future-proofing. The audience felt that public funds should be used primarily where little commercial opportunity exists – for social provision, equality and good coverage.

Figure 3
Example of the breadth of stakeholders consulted for the EV Infrastructure Taskforce

Car Share

zipcar, ecar, BVRLA

Consultants

ZERO CARBON FUTURES, energy saving trust, cenex, ARCADIS, wsp, Deloitte., INNOGY CONSULTING, ARUP, elementenergy, Grant Thornton – An instinct for growth, www.evdigest.co.uk EV Digest – Driving eVolution – Electric Vehicle Consultancy, RICARDO, HUBJECT

Charge Point suppliers / operations

allego, ESB, pod POINT, Marubeni, bp chargemaster, chargepoint, eo, engenie – electric vehicle rapid charging, urban electric, source LONDON

Finance

Triodos Bank, optimeyes – innovative energy solutions, Downing, NatWest, octopus – A brighter way, AMBER INFRASTRUCTURE GROUP

Lease / land owners

CitiPark, LONDON LEGACY DEVELOPMENT CORPORATION, LONDON CITY AIRPORT, Reliagen, OPDC – OLD OAK AND PARK ROYAL DEVELOPMENT CORPORATION

London boroughs

Camden, CROYDON www.croydon.gov.uk, Haringey LONDON, The Royal Borough of KINGSTON UPON THAMES, CITY OF LONDON, h&f hammersmith & fulham, Sutton, Hackney

Suppliers

GILBARCO VEEDER-ROOT, TRITIUM, SIEMENS, offgrid energy, FGE FACTS GLOBAL ENERGY, nationalgrid

Users

gnewt by Menzies Distribution, ups, RAC, try ev, dpd, O'DONOVAN WASTE DISPOSAL, Uber, ADDISON LEE GROUP, GLH, GMB LONDON REGION, LTDA

Vehicle technology solutions

LEVC, Ford, NISSAN

Other

ADDLESHAW GODDARD, REA RENEWABLE ENERGY ASSOCIATION, BOSCH, Energy & Climate INTELLIGENCE UNIT, C40 CITIES

Smaller, more focused, stakeholder workshops included taxi and private hire operators, charge point manufacturers, LoCITY members,[15] Distribution Network Operators (DNOs), existing charging network operators in London and vehicle manufacturers and operators (see Table 3).

Over the course of this work, we have involved 350 stakeholders from more than 140 different organisations, across a broad range of areas including financing, manufacturing, academia, consultancy and private business, retail and public sector. This has enabled us to gather information from the broadest possible base and shape the development of this work.

1.4.4 Modelling potential demand for charge points in London

A unique feature of the taskforce work has been the development of an innovative quantitative model which aims to provide new insight into how many chargers of which type may be needed in London up to 2025. For the first time, the scale of these needs has been modelled for London and this forms a key part of the evidence base used to move the understanding of London's EV needs forward. The model may also provide a means to examine future activity against projections and revisit these if EV sales follow a different path to what has been assumed.

The model has been based on the best current understanding of EV trajectories, vehicle/charging technology, range of likely user behaviour and charger utilisation. It has been formed from a range of research, and stress tested with a range of experts, including several members of the taskforce. However, it must be stressed that, consistent with the nature of predictive modelling, it cannot forecast with certainty and its results should not be treated as such.

Key insights from the model are provided in Section 3.2, with full details provided in Appendix A.

15 LoCITY is a TfL industry engagement programme helping the freight and fleet sector improve air quality and reduce carbon emissions https://locity.org.uk

Table 3: A selection of key meetings and stakeholder events beyond the core workshops, which fed into this report

When	What and who with	Engagement summary
June 2018	LoCITY working groups	Presented on taskforce and offered for stakeholders to join workshops
Aug 2018 – Feb 2019	Meetings with vehicle manufactures	Invited input and insight into EV user needs from their customers, discussion around future market and models coming out
Sept 2018	E-mobility Charging Conference – Milton Keynes	Presented on taskforce and its key activities. Invited to feed in and comment
Oct 2018	Taxi trade representatives workshop	Discussed taxi drivers' charging needs for ZEC taxis
Oct 2018	Private hire representatives workshop	Meeting to discuss private hire drivers' needs, including specific mix of PHEV and BEV needs, and typical PHV driver requirements
Oct 2018	Infrastructure Projects Authority (IPA) meeting	Discussed the process for the IPA's Charging Infrastructure Investment fund (£200m fund, to be match funded to make £400m)
Oct 2018	Round-table discussion with London Climate Business Leaders	High-level commitments from members were discussed and how they could help each other. Keen to convince investors and those 'up' the supply chain, the leasing companies and the 'parent' banks
Nov 2018	Round-table discussion with London First members	Update on taskforce and high-level outcomes from workshops. Introduction of Charter of commitments
Nov 2018 – Feb 2019	Zap-Map meetings	A number of meetings to discuss data held by Zap-Map and how we can use this to further our understanding of charge points in London
Dec 2018	Siemens round-table meeting: 'Opportunities to develop the London EV ecosystem'	Discussions on the likely future for EV charging and key influences on the need for public infrastructure
Dec 2018	BP round-table discussion 'Whole of value chain initiative on high-powered charging'	Discussions around high-powered charging
Jan 2019	Round-table meeting with car- and van-sharing providers	Gave an update on taskforce process and discussed unique charging needs and possible solutions for vehicle sharing
Mar/April 2019	Meetings with investors in EV tech and infrastructure and other selected stakeholders to talk through delivery plan findings	Overview of top-level findings and enablers
May 2019	Charge point manufacturers and operators round-table	Comments on delivery plan and initial discussions on futureproofing
May 2019	Stakeholder workshop to present the findings from the delivery plan	Overview of top-level findings and enablers

2

The current situation in London

This chapter provides a review of the latest insights regarding electric vehicles and charging infrastructure, with emphasis on developments in London.

2.1 Electric vehicles

2.1.1 Categories and definitions

For the purpose of this delivery plan, an electric vehicle (EV) is taken to mean a vehicle with a battery that can be recharged by plugging into mains electricity. This definition is taken to refer to both:

- **Battery electric vehicles (BEVs)**, also known as 'pure' or '100 per cent' EVs, which are always powered by the battery
- **Plug-in hybrid electric vehicles (PHEVs)**, which combine a small plug-in battery with an internal combustion engine (ICE). Includes both parallel and series plug-in hybrids (also know as range extenders)

As BEVs can only run on the battery, they do not emit tailpipe emissions and are dependent on charging, whereas the extent to which PHEVs are zero emission depends on the extent they are driven in zero emission mode. Some reports have highlighted concerns regarding low actual use of zero emission mode by PHEVs.[16]

2.1.2 London EV registrations

As of the end of Quarter 4 2018, a total of approximately 20,622[17] EVs were registered in Greater London, reflecting around 0.69 per cent of the total vehicles registered in London. As indicated in Figure 4, new EV registrations have been growing year on year across London and the UK, representing 2.81 per cent of new registrations in 2018 in London, higher than the 2.13 per cent average for the UK.

In the UK, PHEVs currently make up a higher proportion of new registrations than BEVs, with a ratio of around 70:30.[18] However, the BEV market in London is already well ahead of that of other parts of the UK – with BEVs comprising 48 per cent of new EVs registered in London.[19] The type of charging infrastructure can also influence the type of EVs being used, as most PHEVs can only use slower AC chargers.[20]

The higher proportion of BEVs in London is likely to increase further for the following reasons:

- The cost and range difference between hybrid and fully electric vehicles is reducing – with batteries getting cheaper and battery sizes in BEVs increasing[21]
- PHEVs are more complex and expensive to maintain due to having both electric and internal combustion powertrains[22]
- The removal of the Government grant for most PHEV purchases from November 2018[23]
- Strong intentions have been communicated via London's recent policies around establishing ZEZs in the Mayor's Transport Strategy, and removing the discount to the Congestion Charge for all but pure EVs from 2021[24]

Registration data for London provides important context for charging infrastructure requirements, however there is also significant use of London roads by non-London registered vehicles and vice versa. Analysis by TfL indicates that, on average, 74 per cent of the vehicle kilometres driven on London's roads are driven by London residents, whilst 62 per cent of vehicle kilometres driven by London's residents are on London's roads.[25]

Image 6
On-street charger in use in London

16 New analysis of plug-in hybrid car mpg and emissions is expected to spark debate on their suitability for fleet operation, The Miles Consultancy, 19 September 2017

17 Total EV registration, London, DfT Statistics for London, Dataset VEH0131 Vehicles include: Plug-in cars, LGVs and quadricycles

18 Data provided by the SMMT, 2018

19 Data provided by the SMMT, 2018

20 However, the most popular Mitsubishi Outlander can charge rapidly

21 EV costs, Parliament Publications: https://publications.parliament.uk/pa/cm201719/cmselect/cmbeis/383/383.pdf

22 PHEV engine, Making the Connection, The Plug-In Vehicle Infrastructure Strategy, OLEV https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/3986/plug-n-vehicle-infrastructure-strategy.pdf

23 EV grant changes, Government website, www.gov.uk/government/publications/plug-in-car-grant-changes-to-grant-level-november-2018/upcoming-changes-to-the-plug-in-car-grant

24 Changes to the Congestion Charging exemptions: tfl.gov.uk/modes/driving/congestion-charge/discounts-and-exemptions

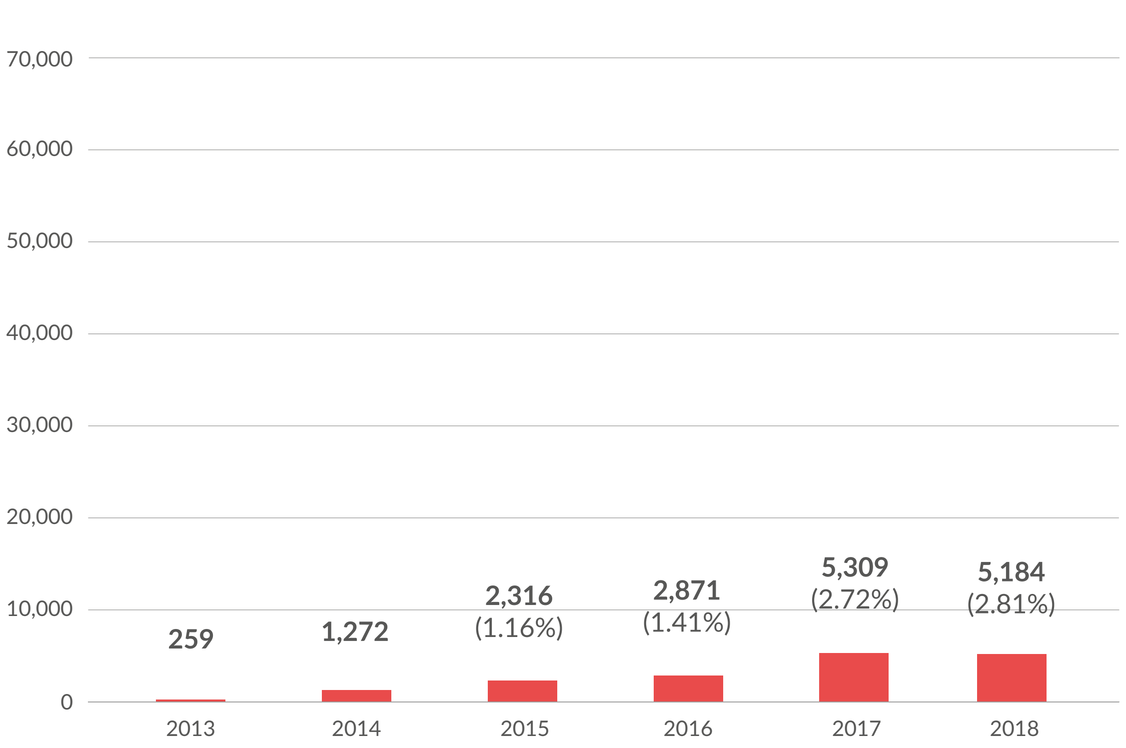
25 Source for percentage of residents using London's roads from Analysis of Project Edmond data, City Planning, TfL

Figure 4
Plug-in vehicles registered for the first time in London and UK[26]

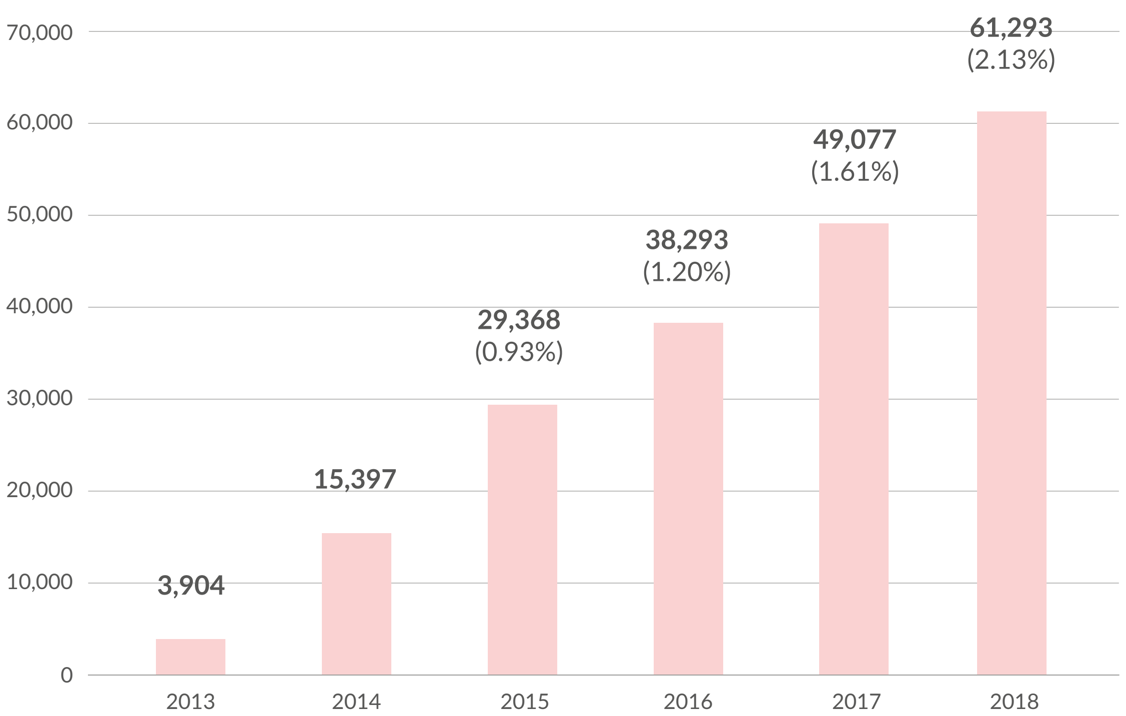
London

UK

First time registrations in London (% of total first time registrations)



First time registrations in the UK (% of total first time registrations)



26 DfT Statistics, Datasets VEH0130, VEH0131, VEH0150, VEH0260, VEH0354, VEH0454

2.1.3 Market offering

Model availability

The number of EV models available has expanded significantly in recent years. For passenger vehicle segments, most mainstream car manufacturers now offer an EV model, with more than 60 BEV or PHEV models available to buy or lease in the UK across all vehicle segments.[27] The notable trends among new models coming to market and upcoming launches are the increasing battery capacities and capabilities to support faster charger rates. While the breadth of electrified models continues to increase, this does not yet correspond to availability of supply, with continued evidence of limited production runs and long waiting times[28] although this is beginning to change as manufacturers catch up.

For the light goods vehicle (LGV) sector, the choice of EVs has been limited for vehicle buyers until recently, although a number of new product launches in 2018, or announced for 2019, have created greater breadth in the marketplace. The market for LGVs is very price sensitive, so take-up of vehicles with a price premium tends to be slow.

Vehicle range and battery size

Vehicle battery sizes and range of BEVs have been increasing over recent years, with earlier models of small and medium cars typically having <30kWh capacity, corresponding to 150-200km of range, whereas recently released models and near-term planned releases typically are featuring 40-60kWh batteries and ranges greater than 250-300km. Premium segment vehicles have a further step up in range, with Tesla Model S and Model X having 75-100kWh capacity, corresponding to >500km of range.

Vehicle price

For both passenger vehicles and LGVs, EVs have operational cost advantages over traditional internal combustion engine (ICE) vehicles due to lower energy and therefore running costs. However, the upfront price is higher and still a considerable barrier to adoption.

Figure 5 demonstrates this price differential with a review of the prices of most popular passenger vehicle models for the different powertrains for different vehicle segments. There is a move by car manufacturers to shift from purchase price to Total Cost of Ownership (TCO).[29] This is to reflect tax and other penalties, as well as the cost of electricity (fuel).

While the upfront price of EVs is currently higher than equivalent ICE vehicles, prices are expected to continue to decline, with some analysts suggesting cost parity of EVs in the early 2020s.[30]

27 EV database https://ev-database.uk/

28 www.drivingelectric.com/kia/niro/e-niro/865/kia-e-niro-nearly-sold-out-lead-times-set-increase

29 From various meetings with individual manufacturers

30 Battery Electric Vehicles, Deloitte, 2018

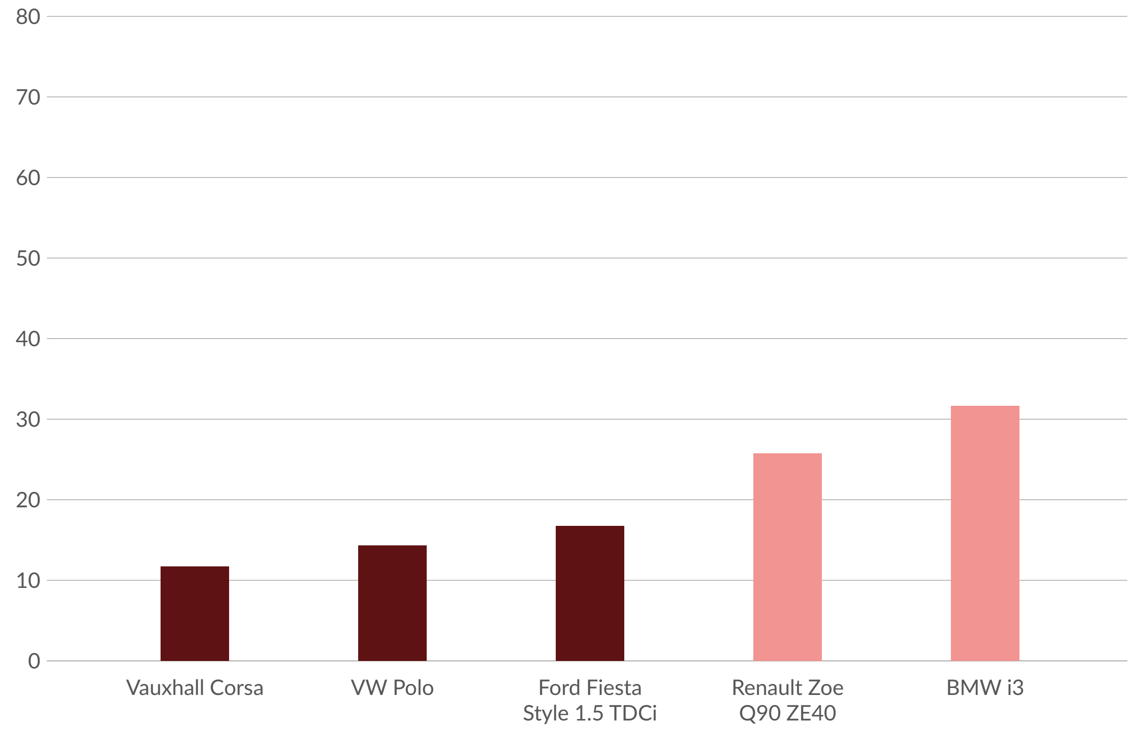
Figure 5
Review of approximate vehicle prices for popular models across different vehicle classes and powertrain types. Prices shown in £000s[31]

ICE

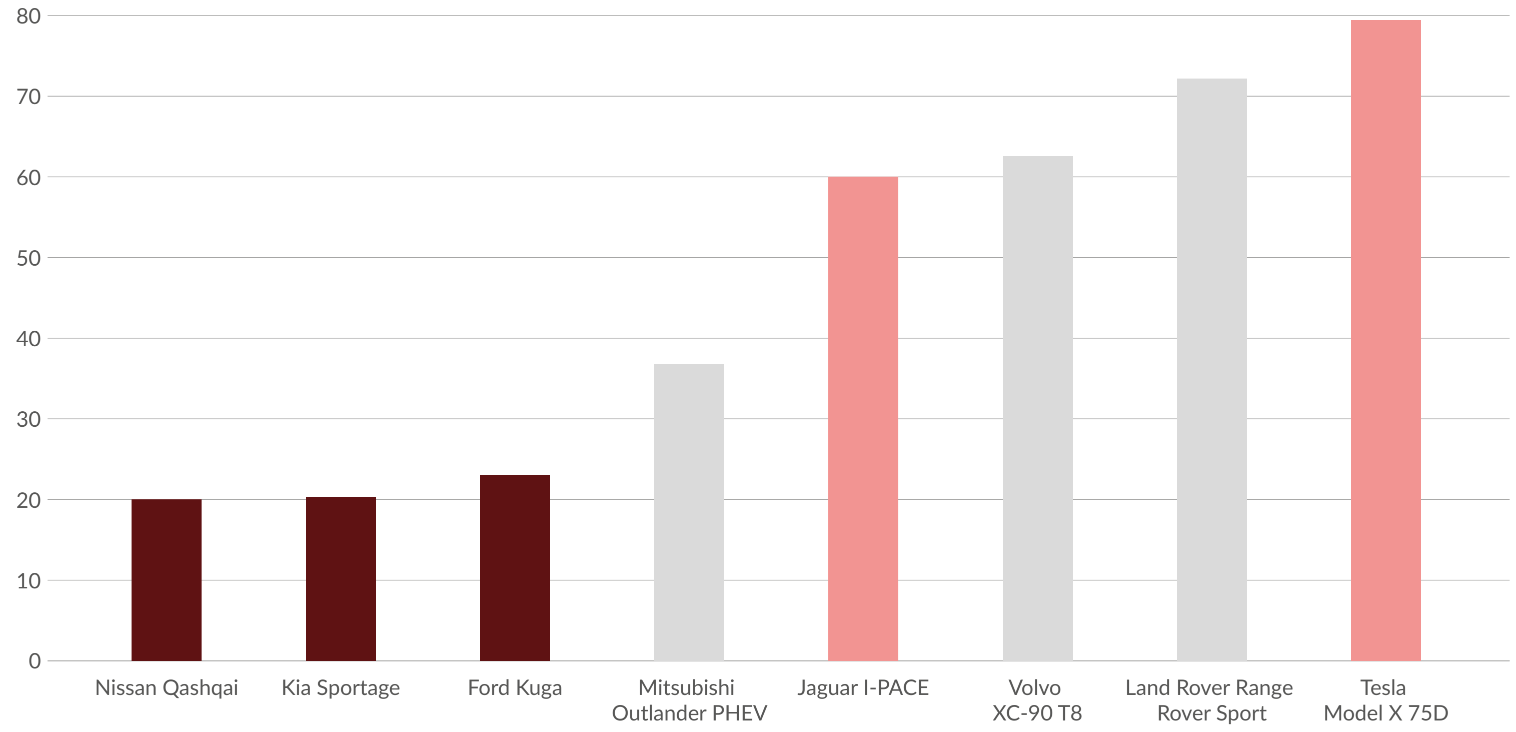
BEV

PHEV

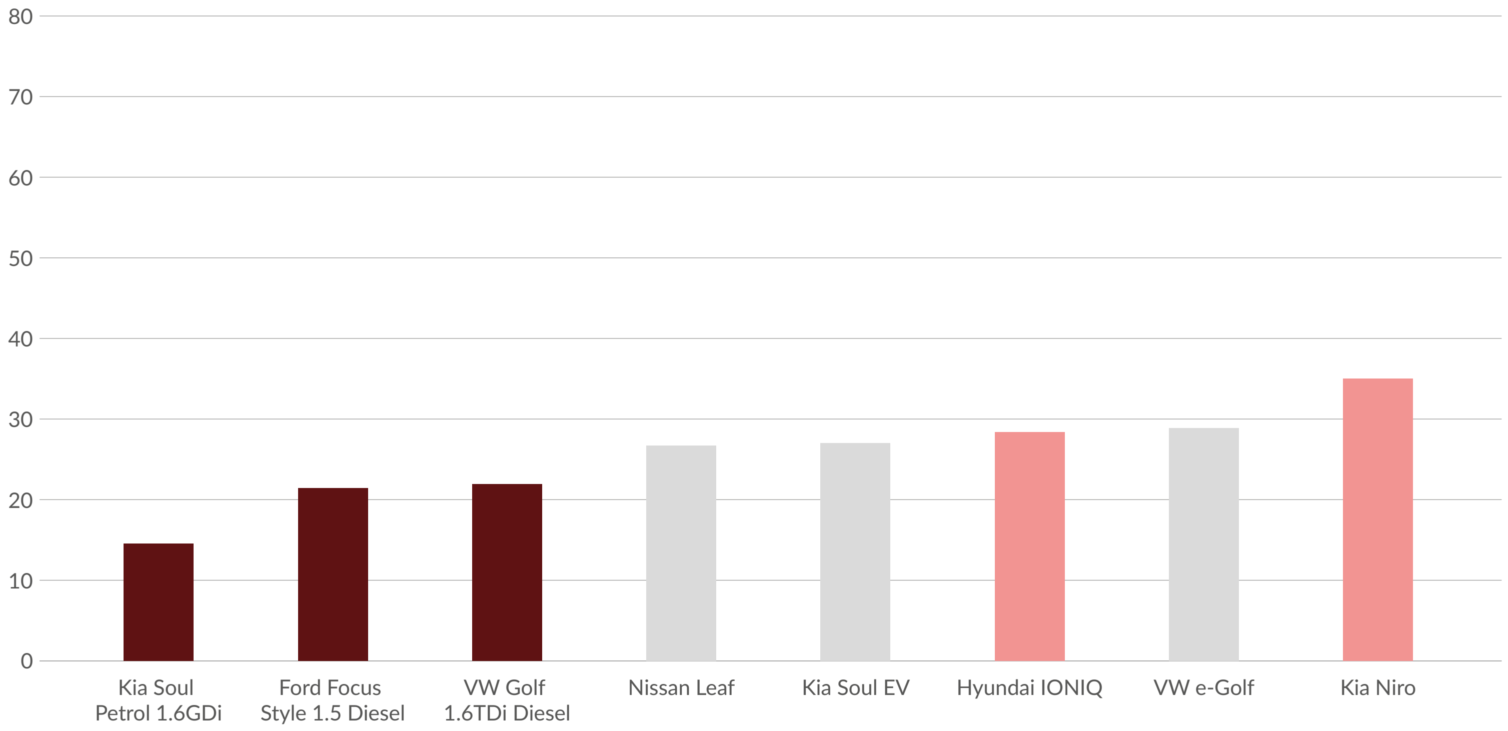
Popular supermini cars



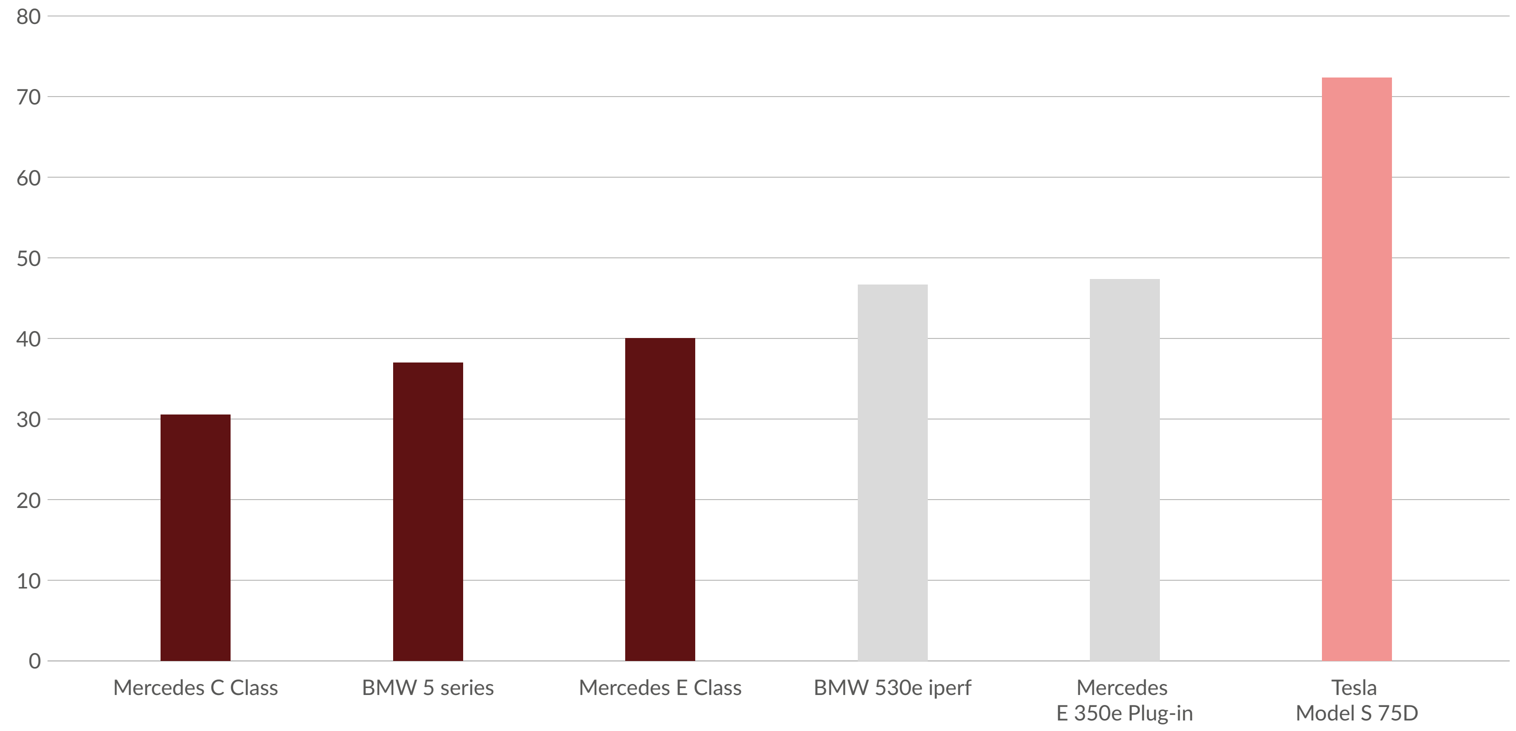
Popular SUVs



Popular medium cars

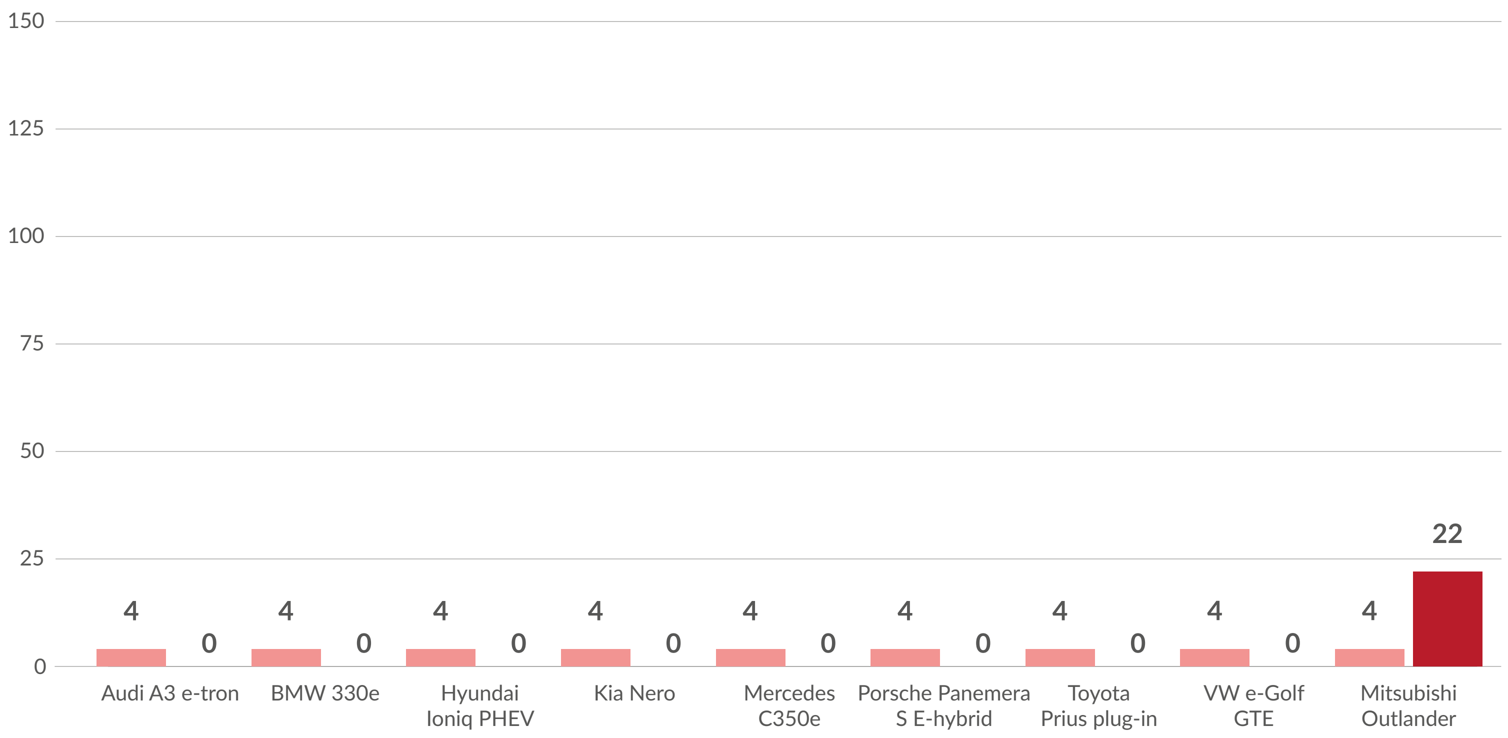


Popular executive cars



31 TfL market review, 2019

PHEV charge capability (kW)



BEV charge capability (kW)

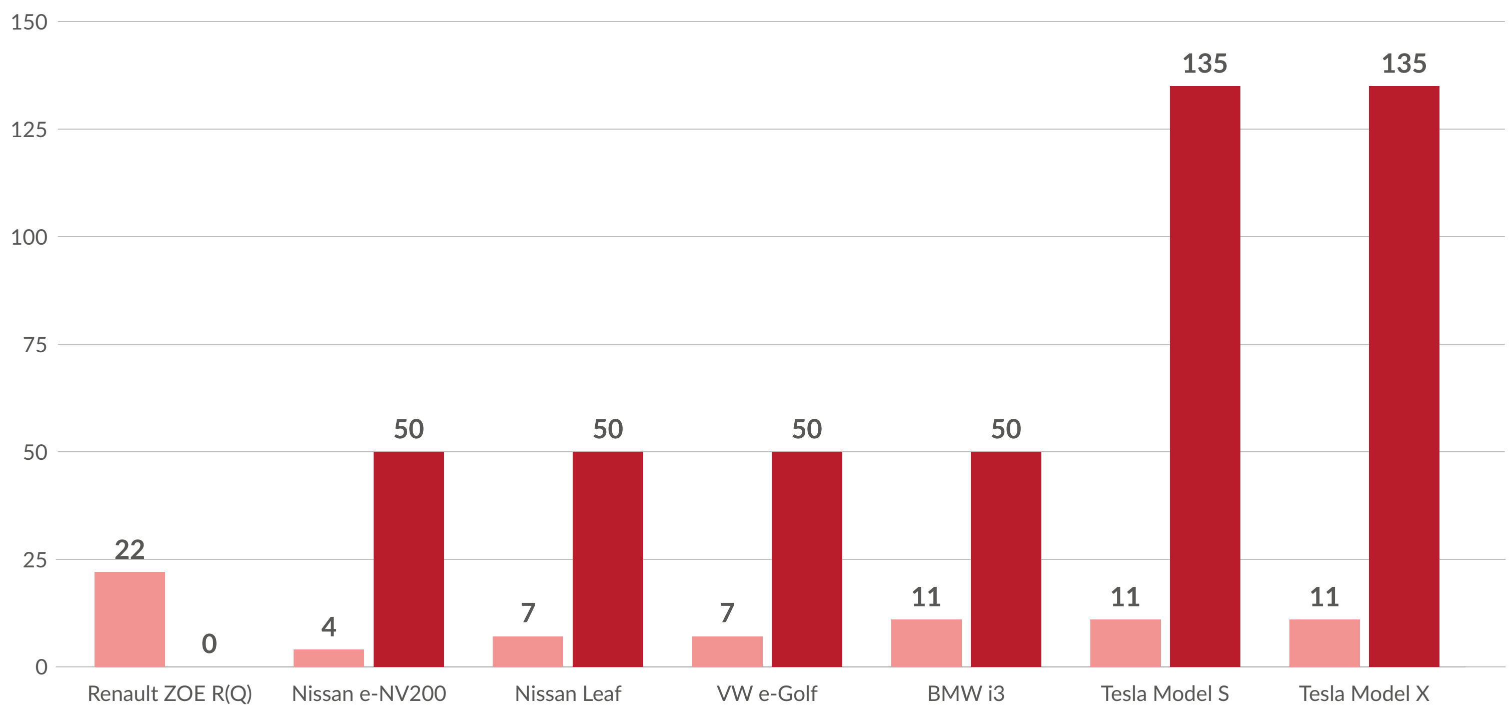


Figure 6
Review of charging capabilities of selection of currently available EVs[32]

Max AC charge capability (kW)

Max DC charge capability (kW)

2.1.4 Vehicle-charging capability

AC and DC charging for BEVs and PHEVs

It is critical to note that the speed of charging for both AC and DC charging is not solely dependent on the potential charging speed of the charger, but also on the vehicle and its state of charge. The variety of charging capability is indicated across a range of current EV models in Figure 6.

AC charging requires an on-board rectifier to convert AC power to DC required for battery storage. The size of the on-board rectifier limits the maximum AC charge rate to 11kW or less for many current BEVs and to 3.6kW or less for many current PHEVs.

Battery size, chemistry and battery management systems determine the potential for DC charging, meaning that vehicles rated for use of 50kW DC rapid chargers would be unable to draw the maximum power potential of the higher powered 100kW+ DC chargers. This has implications for the future-proofing of infrastructure, which results in cautious investment.

The rate of DC charge is also dependent on the battery's state of charge on arrival and power acceptance curve of the vehicle. For example, a battery at 15 per cent, a low state of charge, will typically charge at a higher rate than one at 60 per cent.

A review of planned new EV model launches over the coming years indicates the majority of future BEV models facilitate a maximum AC charging power of 11kW, and typically at least 50kW DC charging, with a number of post-2019 launches also supporting ultra-rapid charging (100-350kW).

32 Abstracted from RAC Foundation, 2018

Image 7
Rapid charge point in use in London

Battery degradation concerns
There has been considerable debate over the impact of rapid charging on battery life, with concerns raised over potential for accelerated degradation. These concerns have been compounded by vehicle manufacturers including caveats in battery warranties, often limiting the use of rapid charging or otherwise potentially compromising warranted repairs. However, research has indicated that the negative impact of such charging behaviour is largely over-stated. Authoritative studies in the USA, UK and Europe, as well as well-documented open source information from EV owners, have demonstrated that battery management systems with appropriate charging protection strategies are effective at limiting incremental battery degradation due to rapid charging.[33, 34]

EV manufacturers are continually improving battery performance and reducing the impacts of degradation and loss of capacity. This is important for the potential role of rapid charging and the next generation of ultra-rapid chargers (100kW+) for EV users. This is because, as charging power increases, all other things being equal, more potential stress is imposed on EV batteries, which could lead to accelerated ageing. Technical challenges posed by ultra-rapid charging can be mitigated by proportionally increasing battery capacity, designing more effective thermal management (heating/cooling of the battery pack) or implementing more sophisticated protection when necessary.

33 SAE Technical Paper 2015-01-1190, Effects of Electric Vehicle Fast Charging on Battery Life and Vehicle Performance, Shirk, M. and Wishart, J., 2015

34 On the possibility of extending the lifetime of lithium-ion batteries through optimal V2G facilitated by a flexible integrated vehicle and smart-grid system, Energy, 133, pp. 710-722, Uddin, Kotub, Jackson, Tim, Widanage, Widanalage Dhammika, Chouchelamane, Gael, Jennings, P.A. (Paul A.) and Marco, James, 2017

Image 8
Slow charge point being installed in London

2.2 Charging infrastructure

2.2.1 Categories and definitions

There are many ways to categorise charging infrastructure, including charge speed, connector compatibility, electrical current type (AC/DC) and location type (such as on-street/off-street residential, fuel station, retail, leisure and car parks).

In this delivery plan, we have categorised what we believe the dominant charging formats are for London in Table 4. The three categories of publicly accessible charging include elements of both charging speed and location (for slow to fast chargers). The fourth category, private charging, is critical in its effects on the demand for public chargers, but is not the focus of this report.

Table 4: Categories of charging infrastructure

Category Type of power kW Type of connector	**Typical formats**	**Points to note**
Rapid DC 50+ (CCS/ CHAdeMO/Supercharger) AC 43+ (Type 2)	• Rapid charge hubs • Fuel stations • Taxi rest ranks	• Fastest charge speeds (~22kWh in 30mins providing ~120km of range for 50kW rapid) • Higher capital cost (~£50,000) and higher prices (20-40p/kWh)* – Most new BEVs can use rapid DC chargers – Maximum DC charge for majority of new BEVs is 50kW – Some premium models allow 100kW+ – Maximum DC charge of some PHEVs is 22kW – No DC charging for many PHEVs/older BEVs Concerns regarding battery degradation owing to use of rapid chargers are easing
Destination Slow to fast AC 3-22 (Type 2)	• Retail / public car parks • Urban centre streets • Leisure centres • Hospitality	• Slower speeds (~22kWh/~120km of range in 3 hours for a 7kW fast charger and 6 hours for a 3.6kW slow charger) • Lower capital cost ~£4-6,000 for a fast charger and as low as £1,000 for a slow charger • Lower prices (9-15p/kWh) • Streetscape impact will limit on-street mass deployment • All EVs can use a form of AC charging, however – Maximum AC charge of many PHEVs is ~3.6kW – Maximum AC charge of many BEVs is 11kW – Some exceptions allow 22kW
Residential Slow to fast AC 3-22 (Type 2)	• Charge pillars • Lampposts • Pop-up/ kerb chargers	
Private Varies	• Home • Workplace • Depot	

Publicly accessible | Not publicly accessible

*Indicative pay as you go price range

Figure 7
Examples of the different categories of charging infrastructure as set out in Table 4

2.2.2 Myth-busting power network concerns

A common concern of many is that EVs will put too much strain on the power network and will cause the system to fail. However, the evidence provided by National Grid and local distribution networks indicates that these concerns are either not material or can be mitigated with planning and introduction of coordinated smart response.

The power system involves four main components. First, generation ie, where electric power supply originates from power stations. Secondly, transmission ie, where power is delivered in very high volumes and voltages from power stations to substations in urban centres; this component is managed by the National Grid. Thirdly, the distribution network, where power is delivered from these substations to final customers at lower voltages; this component is managed by Distribution Network Operators (DNOs) such as UKPN and SSE in London. Fourthly, consumption ie, where power is used by households, businesses and public bodies.

In addressing the concern that EVs will put too much strain on the power network, it is first important to distinguish between power and energy. Put simply, energy provides the ability to do something, and power is the rate at which energy is delivered. Energy can be stored, whereas power cannot.[35]

Overall, energy is not considered a concern. It can be shown that the scale of increased total energy demand is relatively minimal, with modelling described later in this report suggesting an increase of the order of 1.3–2.5 per cent associated with publicly accessible EV charging infrastructure in London in 2025.

Power is a different concern as this introduces a timing consideration, with potential for different levels of impact across the power system. Both the National Grid and the DNOs must ensure there is sufficient ability to deliver power above the demand of users at any given time. This concept is referred to as 'headroom' and when a part of the network is exposed to more and more incremental demand at a given time, the headroom decreases to a point that the operator needs to upgrade that part of the network. This assumes everyone getting home from work and plugging in their EV simultaneously at 6pm on weekdays.

DNOs are typically more exposed to this than the National Grid as there is a statistically greater chance that one of the larger number of smaller distribution substations could experience a loss of 'headroom' than the larger transmission-level substations, where a much greater number of vehicles would have to charge at once.

Network operators monitor activity and work to forecast demand to anticipate potential 'headroom' hotspots to ensure upgrades can be performed in advance, but this is not the only mitigation tactic available. Smart charging, which is already being introduced to charging systems, enables controlled timing of charging to occur through two-way communication between the car battery system and the grid. This would ensure demand from EVs is shifted to a less popular time of day, such as overnight between 22:00 and 06:00, which would mean no net increase in power demand and no concerns for the grid.

These mitigations are most relevant for home- and office-based charging and potentially for overnight on-street-based charging, but less so for on-demand, high-powered publicly accessible charging such as rapids, where sufficient grid capacity is established with installation.

Image 9
Slow charge point being installed in London

35 In the context of electricity, energy is typically measured in kWh (or MWh, GWh, TWh), whereas power is measured in kW (or MW, GW, TW)

Image 10
Rapid charger screen

2.2.3 Deployment in London

As of December 2018, London has 2,400 publicly accessible charge point devices spread across 1,230 locations.[36] Of these, approximately 200 are rapid DC chargers and 2,200 are slow to fast AC chargers.

Figures 8 to 11 graphically represent the publicly accessible chargers in London. Outer London has 56 per cent of rapid chargers and 51 per cent of slow to fast chargers. Charger provision is typically denser in inner London boroughs.

Deployment of charging infrastructure has been increasing across all types over the last five years. Figure 12 indicates the deployment ramp-up since 2015 for the different charger types, shown in numbers of connectors (sockets) rather than numbers of charge points or devices.

Rapid chargers

Rapid deployment is seen to be a recent feature, with the majority of rapid chargers attributed to the TfL Rapid Cap Charging Infrastructure project (TfL RCI project), which has achieved installation of over 175 rapid chargers as of May 2019, of which approximately 40 per cent are taxi dedicated. Figure 9 provides a graphic representation of rapid chargers in London, showing a reasonable spread already of rapid chargers, especially in central London.

As indicated in Figure 13, much of the programme to date has involved installation on TfL land, on the red routes and private land, because of the need to ensure sufficient infrastructure ahead of the requirement for ZEC taxis, and these sites were easier to bring forward quickly. To help speed up roll-out of more rapid charge points on the borough road network, London Councils' Transport and Environment Committee has formed a member-level sub-group to oversee borough activity, including the setting and monitoring of targets for the identification of possible sites in each borough. To date, boroughs have identified more than 500 additional potential rapid charge point locations across London.

Slow to fast chargers

Figures 10 and 11 provide a graphic representation of the current distribution of slow to fast charge points in London.

36 Zap-Map, December 2018: www.zap-map.com

Figure 8
Map of publicly accessible EV charge points in Greater London[37]

Slow Chargers
Fast Chargers
Rapid Chargers
TLRN

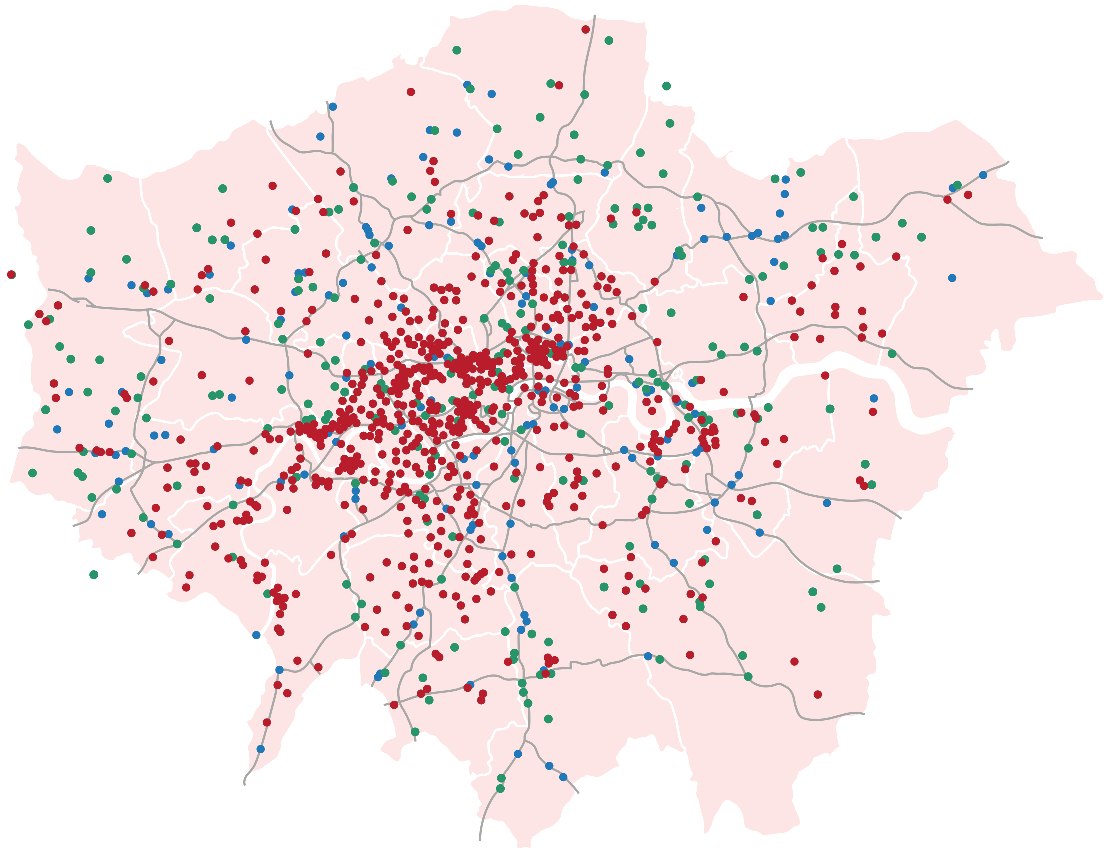


Figure 10
Map of devices with fast connectors in Greater London[39]

Fast connectors
TLRN

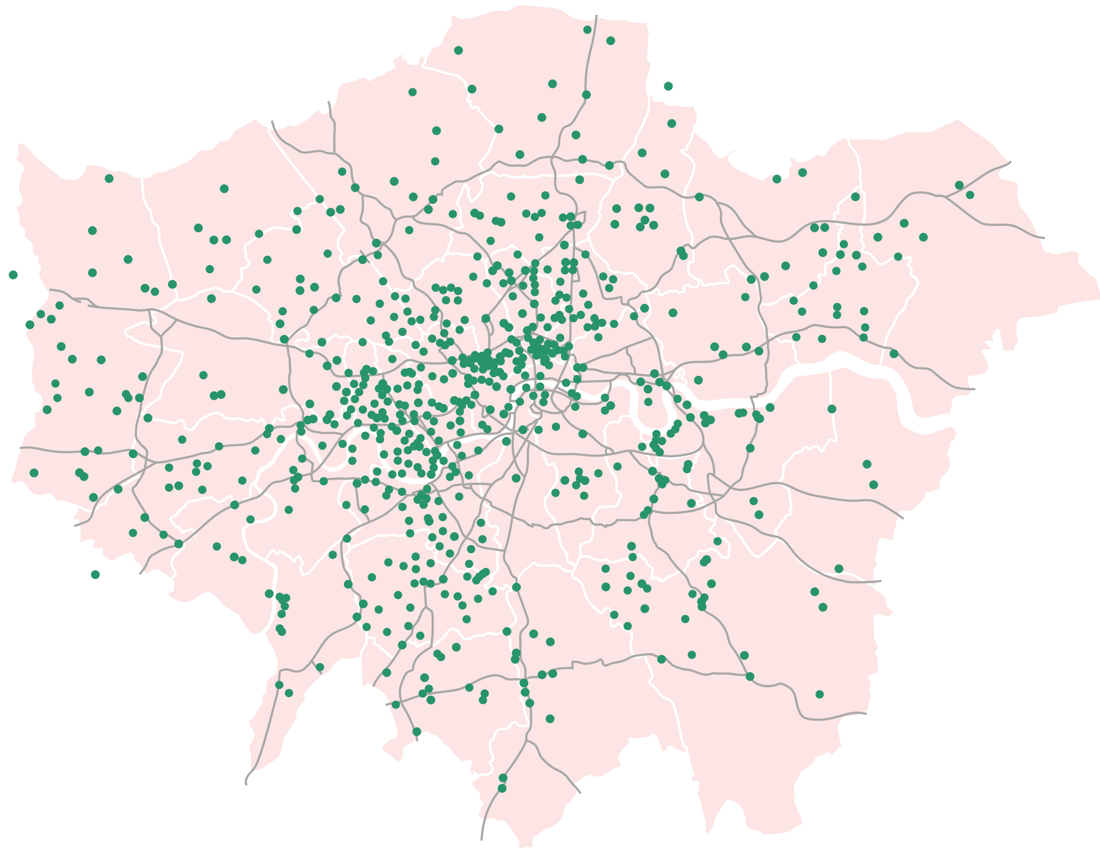


Figure 9
Map of current rapid charge points in Greater London[38]

Rapid Chargers
TLRN

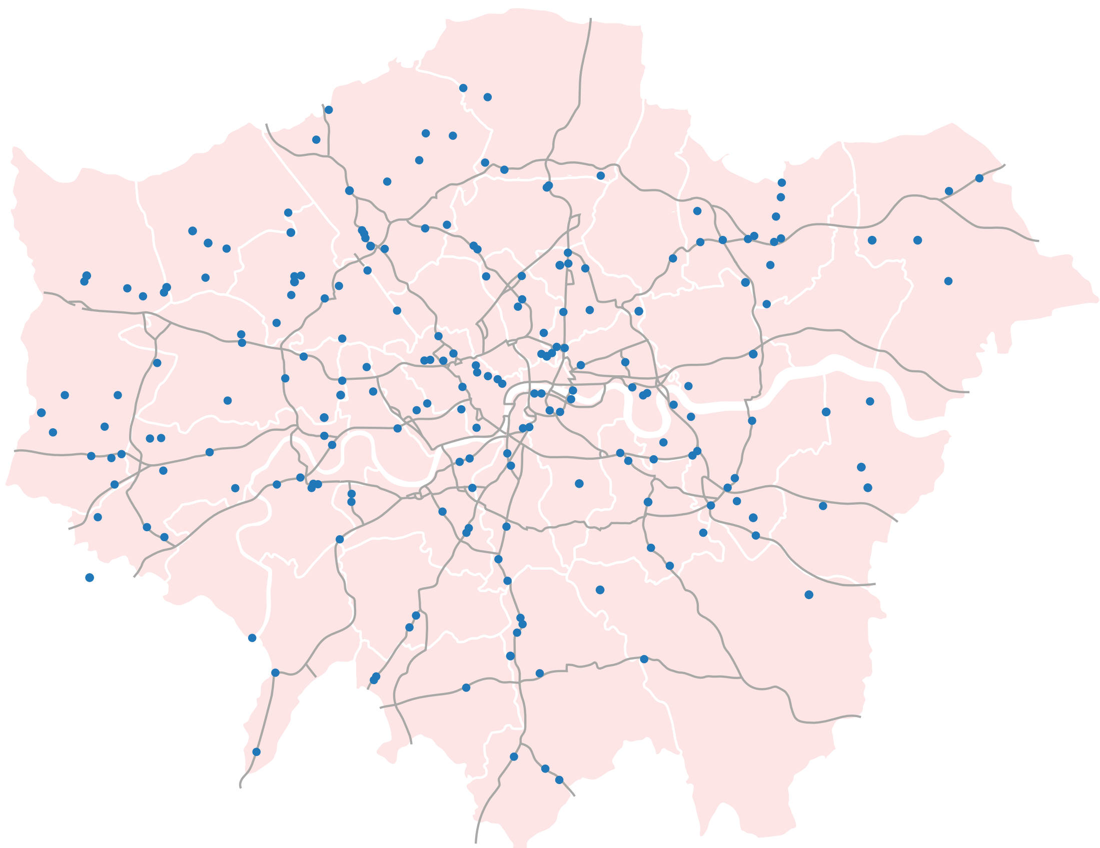
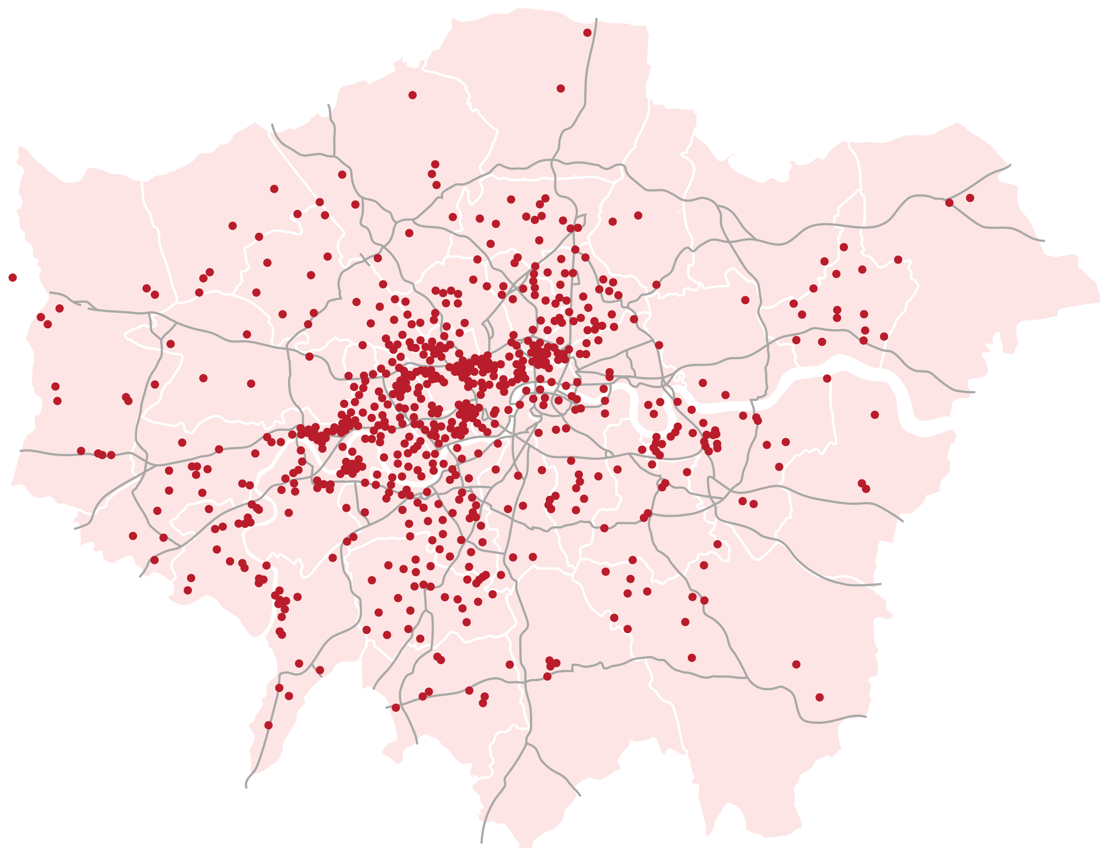


Figure 11
Map of devices with slow connectors in Greater London[40]

Slow connectors
TLRN

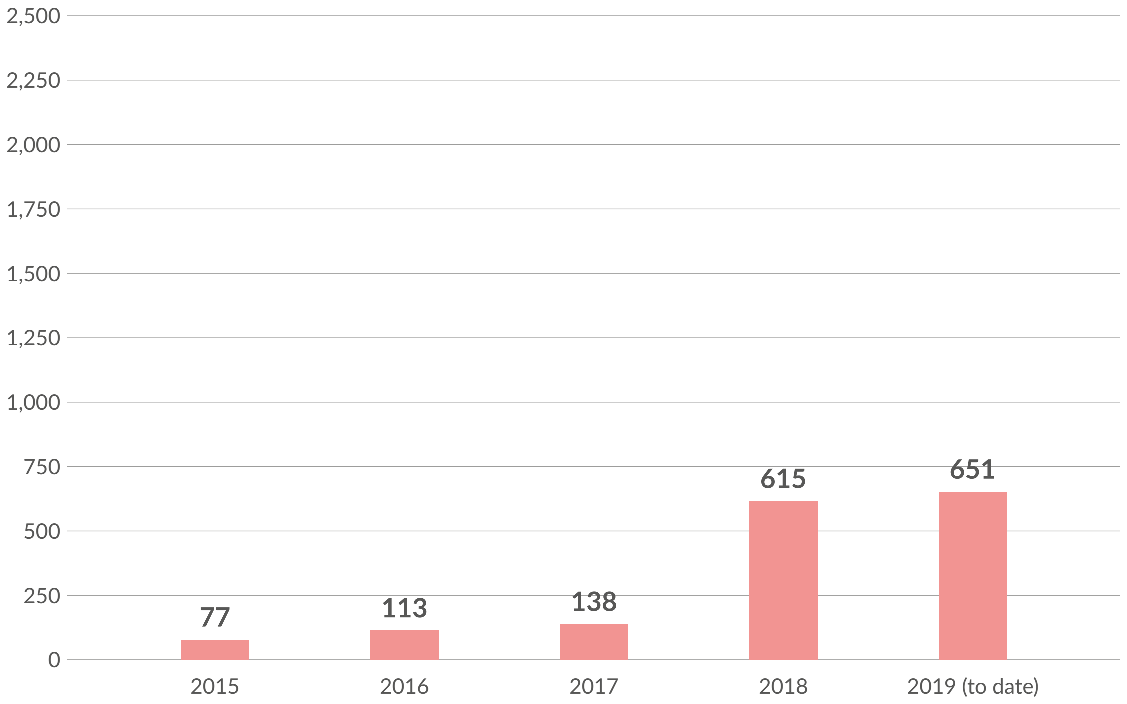


37 Zap-Map database, February 2019: www.zap-map.com
38 Zap-Map database, February 2019: www.zap-map.com
39 Zap-Map database, February 2019: www.zap-map.com
40 Zap-Map database, February 2019: www.zap-map.com

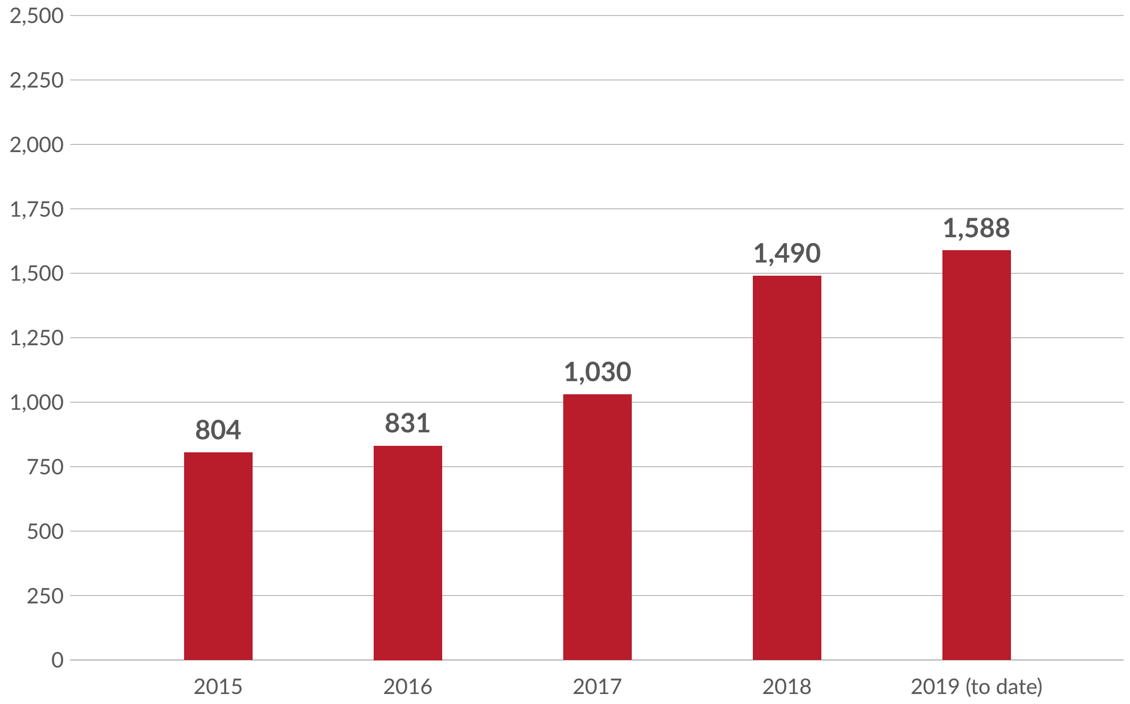
Figure 12
Deployment of charging infrastructure connectors, 2015-Feb 2019[41]

- Rapid connectors
- Fast connectors
- Slow connectors

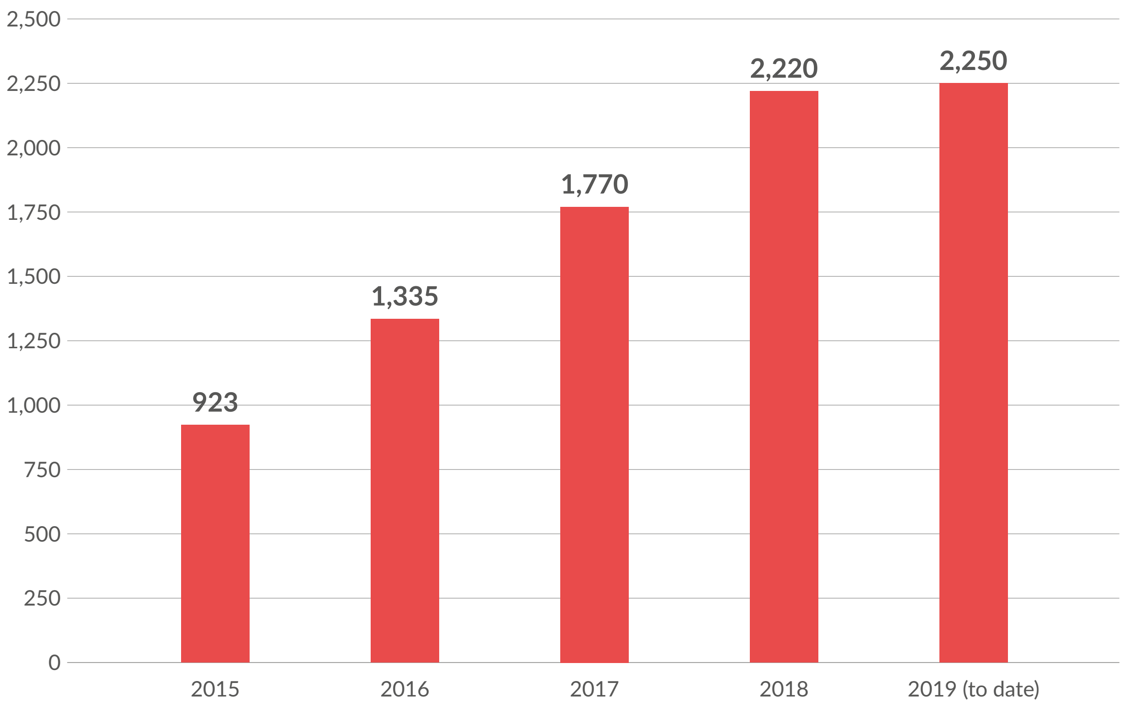
Rapid connectors



Slow connectors



Fast connectors



41 Note data is cumulative over time. Connectors differ from charger devices as a charging device may have multiple charger connection types. For example, rapid charge point devices typically have three connectors per device and this does not correspond to the number of vehicles that could charge from a single device at the same time.
Source: Zap-Map, February 2019

TfL rapid devices by location type

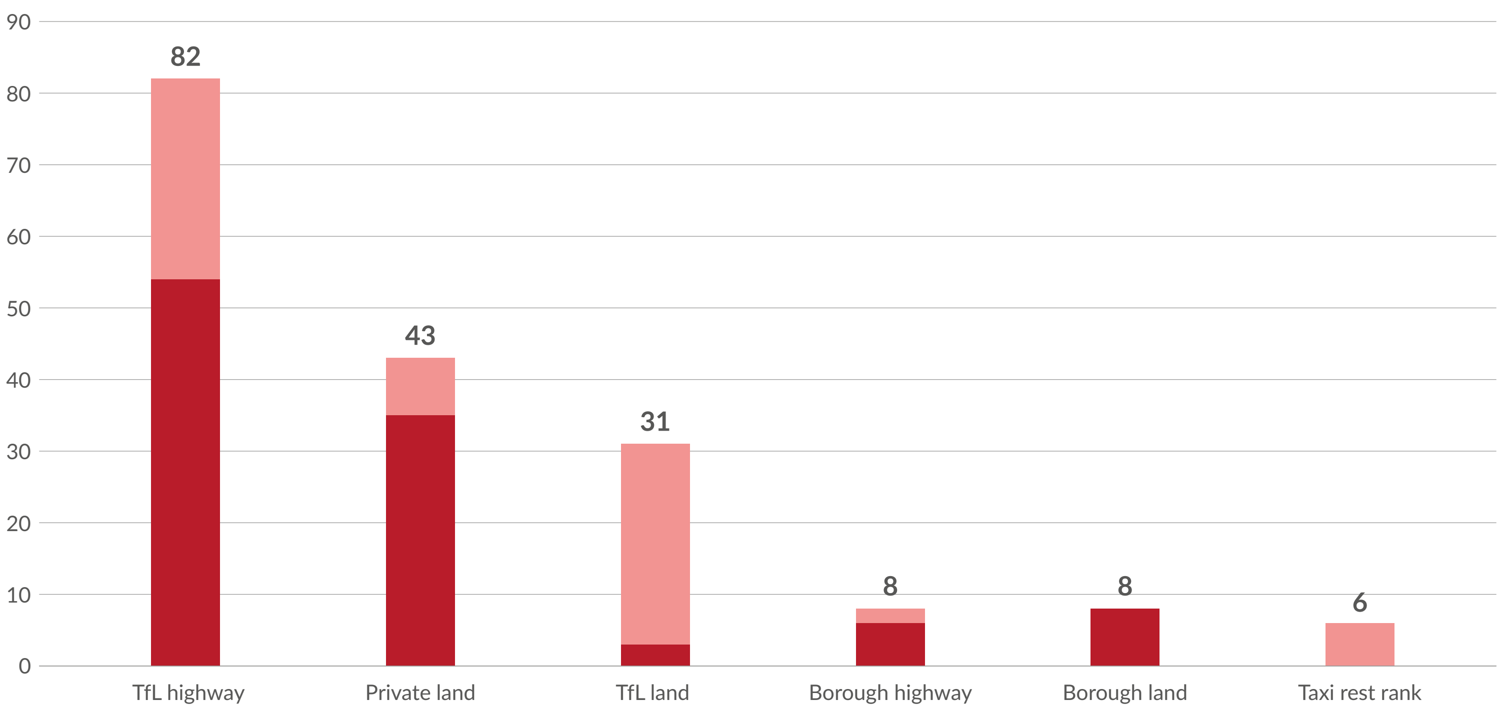


Figure 13
TfL rapid devices by location type, as of May 2019[42]

Taxi only

Public

Total number of TfL rapid devices

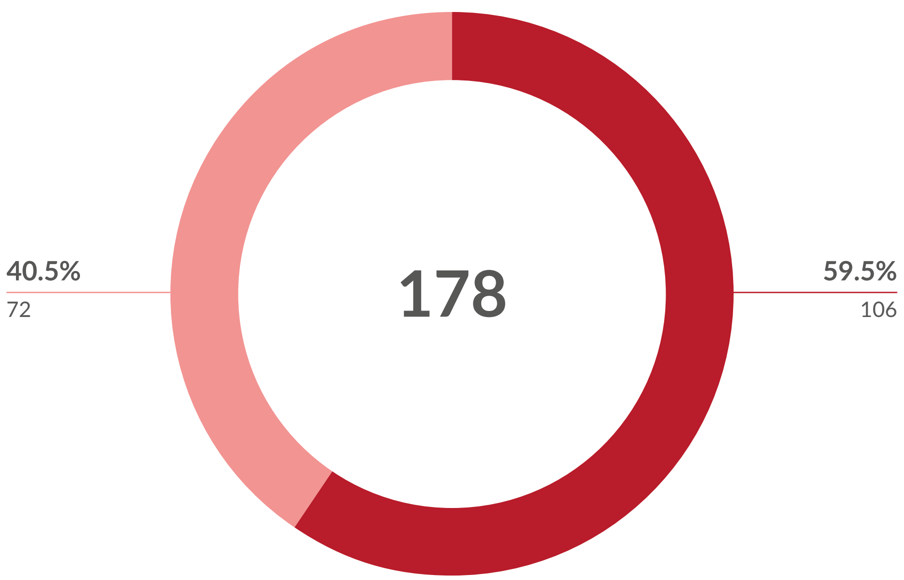


Image 11
Rapid charge point

42 Analysis of TfL rapid chargers in March 2019

Figure 14
Comparison of utilisation for different publicly accessible charger types in London[43]

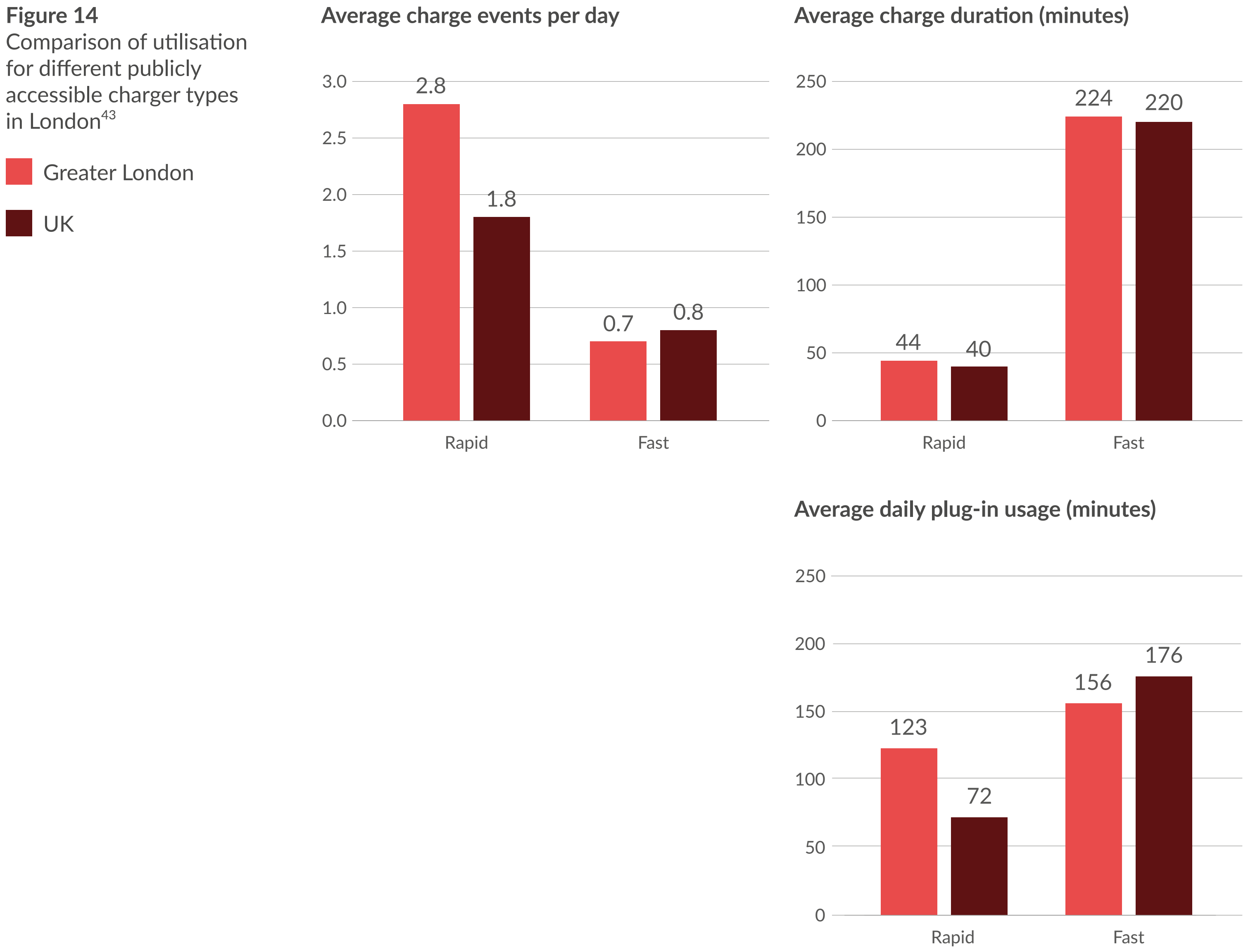
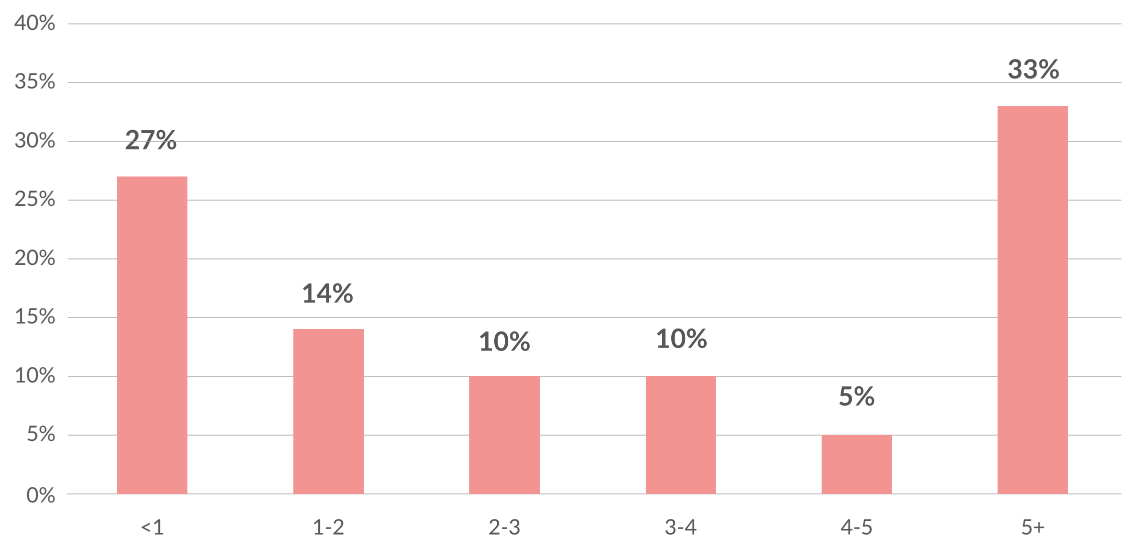


Figure 15
Average number of charges per day at TfL rapid charge points[44]



43 Zap-Map Quarter 4 2018: www.zap-map.com

2.2.4 Charger utilisation

Utilisation is a key determinant of economic viability of charging infrastructure and can be considered in a number of ways:

- **Number of charges:** this considers the number of visits by vehicles, but does not consider visit duration and energy consumed, which can vary significantly
- **Plug-in time:** this considers the average duration a vehicle is connected for in a given charge event

It should be noted that, for the reasons described in the section on vehicle charging capability, actual charge rates are often less than maximum charge rates and therefore actual electricity transfer is dependent on the state of charge on arrival and duration of the charge.

Figure 14 shows the current utilisation between fast and rapid charger types in terms of average number of daily charges and average charge duration.

The spread of use for the chargers that are part of the TfL RCI project can be seen in Figure 15. A wide spread is observed, with 27 per cent of chargers currently averaging less than one charge per day. There are a significant number of chargers that are used very frequently, with 33 per cent averaging five or more charges per day, with the most popular chargers being used up to an average of 17 charges per day or 10.5 hours of plug-in time. Utilisation data indicates higher demand for chargers in central and inner London. This can most likely be linked to core taxi operating areas as a core current user group. It is also noted that utilisation across chargers has been steadily increasing since deployment of TfL rapid chargers began in September 2017.

44 Analysis of TfL rapid chargers for March 2019

2.2.5 Emerging trends in charging infrastructure

Through the work of the taskforce over the past year, a number of key emerging trends have come to light which will influence the switch to EVs and the use of charging infrastructure. Change in this arena is happening fast, and having this knowledge and understanding will help us in forming our approach, ensuring it is 'no regrets' and can be flexible should the market take an unexpected turn. Overall, what we set out here has not changed our expectation that rapid chargers will meet user needs to 2025, but that we should try to ensure that we invest in adequate power supply to enable upgrades soon after. Technologies such as mobile charging may help with identifying gaps in the infrastructure, but are not a long-term solution in themselves. We will be continuing to horizon scan, testing and piloting some of the technologies below to ensure that the most appropriate solutions for London's charging infrastructure are found.

Ultra-rapid charge points

Progress is being made in the development and deployment of ultra-rapid public chargers, with 100kW units already being installed, and plans for 150kW ultra-rapid chargers, which are effectively expected to become the new 'standard' rapid charge point. A number of the newest generation of EVs can all charge at between 100kW and 150kW. In addition, the pan-Europe 'Ionity13' network of 350 kW CCS chargers is due to begin being deployed in the UK in 2019.[45]

The time at which 150kW charging will generally be accepted as 'standard' depends on EV model availability and sales, but this is unlikely to be before 2025. Arguably, any switch to such capable EVs in London may generate customer expectation of charging infrastructure capable of delivering such power. While this deployment will grow throughout the early to mid-2020s, existing rapid charge infrastructure rated at 50kW would still be accessible by the next-generation EVs (just not charging at their maximum potential) and, of course, the existing fleet. Some rapid charger manufacturers are now future-proofing by pre-equipping today's 50kW chargers with 150kW-capable transformers, thereby mitigating some of the future upgrade impacts.

Alternative power supply and energy storage

Connecting power to supply a new charge point with electricity is normally facilitated by a DNO. In many cases, this is straightforward. However, in situations of high costs of grid upgrade and long lead times, there are alternative opportunities such as private wire[46] or energy storage, which may result in a lower cost power supply and shorter lead times. There are emerging examples of these working in practice.

Private wire can have advantages including cost, speed and commercial flexibility. Direct connection to large-scale electricity generation, such as solar, avoids additional levies, resulting in potentially cheaper energy costs. Stationary energy storage is a complementary approach, used to store and buffer energy behind the meter using a lower power supply than otherwise required. An example of this is the UPS depot in Camden, where an expandable battery storage and active network management system was installed to support electrification of the depot's 170 delivery vehicles, avoiding costly upgrades to the incoming power supply.[47]

Smart charging and vehicle to grid

Smart or managed charging of an EV involves a system that enables EV charging to be automatically controlled with minimal user input.[48] This provides the EV with the ability to integrate into the whole power system in a grid-friendly and user-friendly way, allowing for adaptive charging habits.

Managed charging requires either the charge points or the EVs to be able to communicate current charging conditions and respond to third-party control commands. This communication capability is already built into some charge points and EVs, and potential systems are in trial phase and expected to become more widespread during the 2020s. The Automated and Electric Vehicles Act 2018 empowers Government to mandate smart charging by way of secondary legislation, and from July 2019 all newly installed home EV charge points in the UK must feature such communication-enabled technology to receive Government grant funding.

Vehicle to grid (V2G) extends the concept of managed charging to include bi-directional power flow, whereby a vehicle's battery can be both charged and discharged while plugged into a charge point. As the numbers of EVs increase significantly, in aggregate – even with perhaps modest amounts of power being transferred back into the grid – this technology creates a 'virtual power plant', providing energy in lieu of generation during periods of peak demand or when renewables are unable to provide the amount of power required at any time. Demonstration of the technology is currently under way in London[49] and across the UK to understand how this would work in practice and its likely benefits – including value streams, potential incentives and possible payments to EV users for participating in V2G.

Battery swap

EV battery swap technology has been trialled in a number of countries and across different vehicle types. The well-known tech start-up, Better Place – formed in 2007 – attracted significant global investment and developed a network of battery swap stations, designed initially for the Renault Fluence. The company closed in 2013, having tried to establish toeholds and run pilots in probably too many markets. Key challenges were the significant cost of battery swap stations, and of establishing a sufficiently standardised and readily-removable battery across enough vehicle manufacturers and different EV models to sustain their business model. In China, a number of cities have trialled battery swapping for fleets of electric buses, but recent advances in ultra-fast charging and better battery management appear to have largely consigned battery swap to history.

45 https://ionity.eu/

46 Private wire refers to connecting to networks other than the local DNO; examples include TfL (LU), Crossrail, Network Rail, local generators or directly to National Grid's transmission-level substations

47 www.edie.net/news/6/UPS-to-bolster-London-charging-infrastructure-with-ex-EV-batteries/

48 Recharging the Future, UKPN, 2018

49 See www.e-flex.co.uk/v2g/ and www.london.gov.uk/decisions/md2332-e-flex#

New charging formats: wireless charging

Wireless charging is a technology successfully employed in low-power consumer products and specialised industrial environments. It uses the principle of electromagnetic induction – where a magnetic field generated by a high-frequency alternating current in a primary coil (or charging pad) induces the flow of electrical current in a secondary coil. In a vehicle, the receiving coil would typically be located under the floor – and when stationary over a charging plate embedded in a road or parking space, the vehicle's battery is automatically charged without any driver intervention.

Wireless charging for EVs has been in development for a number of years and demonstrated in several pilot projects (including on TfL's bus route 69 in east London, as part of the EU funded 'ZeEUS' project). Retrofit induction charging kits are available for a number of EVs in markets such as the USA, but have not been offered by the car manufacturers themselves. The cost associated with testing and validating such technology in an automotive environment, issues with efficiency of energy transfer, plus lack of standards, have meant that the time to introduce wireless charging as a mainstream offering has been far longer than anticipated. However, the market is now moving closer to commercialisation, with premium car makers (Daimler/Mercedes-Benz, BMW) among the first planning to soon have wireless charging as a factory-fitted option on certain of their EVs – initially expected to be a home charging convenience package.

TfL is a partner in one of Innovate UK's wireless charging feasibility studies,[50] looking at the opportunities, benefits and obstacles to this technology potentially becoming a part of the EV charging ecosystem. One of the first possible applications is for taxis, which is the focus of the study to which TfL is contributing. Among the challenges to overcome is the business case, and whether the convenience and automated nature of induction charging is more attractive than any cost premium versus conventional (plug-in) charging. However, for some sensitive urban locations, the benefit of unobtrusive (or less obtrusive) wireless charging infrastructure can have large streetscape benefits.

New charging formats: mobile charging

An emerging, alternative form of deployment involves non-fixed infrastructure where energy is stored in mobile battery units. The units are essentially batteries-on-wheels, which are pre-charged, then trailered and wheeled to a vehicle in need of charging. Example of this type of deployment include BP, which in 2018 invested in the US-based FreeWire Technologies, a manufacturer of mobile charging units; more recently, Volkswagen has announced that it will begin production of mobile EV charging units. Volkswagen has indicated that these mobile units will theoretically be able to charge up to 100kW, taking a vehicle around 17 minutes for a full charge.[51]

Given the relative economics of large battery storage and logistics of moving units, this category is not considered a large-scale, long-term substitute for fixed charging infrastructure. However, such units provide several potential advantages, including:

- **Emergency charging:** increasing options for charging to be brought to consumers will help provide confidence and reduce range anxiety

Image 12
Example of a mobile rapid charge unit. Not yet in use in the UK[52]

- **Business model experimentation:** the flexible deployment nature of the units could enable businesses to test the viability of deployment at different sites before making the capital commitment of fixed infrastructure
- **Power requirements:** the storage element of this category creates opportunity for power to be drawn from less constrained areas of the network and at less busy times. Mobile units still need charging, but this can be done at convenience. They could feasibly also deal with local grid constraints while waiting to install increased power capacity
- **Battery second life:** at current battery prices, it is anticipated that the relative economics of this option will be at a significant disadvantage relative to fixed charging, but this could be reduced should lower-cost batteries, such as second-life batteries, prove an adequate alternative

50 https://apply-for-innovation-funding.service.gov.uk/competition/198/overview
www.cenex.co.uk/press-releases/world-leading-wicet-project-launches-to-advance-wireless-charging-for-electric-taxis/

51 Mobile EV charging, Volkswagen to produce 'mobile' EV charging units, https://airqualitynews.com/2019/01/04/volkswagen-to-produce-mobile-ev-charging-units/

52 www.current-news.co.uk/news/bp-to-test-mobile-electric-vehicle-chargers-in-the-uk#close

Image 13
Example of slow charge point

2.3 User experience

Charging an EV requires a significantly different approach to how drivers currently refuel their vehicles. There are many misconceptions about owning and driving an EV, which often mean that infrastructure is seen more of a barrier to take-up than it needs to be. People often assume they will need to plug a vehicle in overnight or fully charge it each time, but these are myths that need to be overcome.

As behaviours adjust, providing sufficient access to infrastructure remains a key issue. As well as ensuring there is sufficient infrastructure available, it is essential that this is easy to locate, access and be affordable if growth in EVs is to be achieved.[53]

At each stage of the charging process, there are potential 'pain points' for users, which can each undermine confidence in the adequacy of charge point infrastructure and lead to a poor overall experience. Some examples of these are illustrated in Table 5.

Discussions within the taskforce workshops and subsequent engagement with key stakeholders have identified a number of issues that are already experienced for those using charge points in London. Many of these are not unique to London and can be common to anyone relying on public charging networks in the UK. Examples of the issues that will require a national approach include mapping charge points, tariffs, common payment platforms and interoperability, as well as standardisation of charge point connectors and cables.

2.3.1 Finding a charge point

There are currently very limited sources from which EV drivers can obtain basic information on the location of charge points, the type of charge and connectors they offer and the current and future availability (during the day) of charge points from multiple operators. Zap-Map is currently the only service to offer this, with EV drivers otherwise needing to rely on information provided by specific operators. With the number of charge points increasing quickly, it is important that this information is accurate and up-to-date.

The most commonly used mapping tools by drivers currently contain only partial and often out-of-date information. This can lead to drivers being unable to find charge points, or being unaware of nearby charging options.

2.3.2 Accessing a charge point

A key challenge is that drivers currently lack confidence in the availability of convenient charge points. Having located a charge point, two of the major concerns for drivers are whether they will be able to physically access it and whether it will be in full working order.

In a densely populated city like London, on-street parking is often in high demand. Parking adjacent to many on-street charge points is not restricted to EV drivers (for instance through a marked charging bay) and access can be blocked by other vehicles that are not charging. For those where there are parking restrictions, there are concerns that these are not always adequately enforced. Similarly, EV users complain of others leaving their vehicles plugged in after the vehicle is fully charged. There may be mechanisms that we could encourage, such as time-based tariffs and booking systems raising the tariff beyond a set period, to control this better.

Table 5: Examples of user 'pain points' when charging an EV

Charging stage	Potential 'pain points' for users
Finding a charge point	• Not being able to locate charge points using common mapping tools • Not knowing if it will be available when you need it • Not being able to find it easily
Accessing it	• Finding it is already in use, or is blocked out by a vehicle that is not charging • Discovering it is out of service or not working properly • Not being able to connect to it
Charging from it	• Not knowing how to use it • Not having the right account or payment method • Being unable to get help or support when needed • Not knowing how much it will cost to charge • Feeling vulnerable or unsafe • Not having anywhere to wait in comfort (if charging during a journey)

53 The Road to Zero: Next steps towards cleaner road transport, HM Government, 2018

The number of installed charge points that are not maintained in good working order has also been of concern across the UK, albeit with some recent signs of improvement. Analysis by Zap-Map in 2017 suggested that, at the time of its research, nearly 15 per cent of all UK chargers were either out of service or only partially operational. The situation has improved, with the equivalent figure from 2018 analysis being 8.5 per cent of chargers (of which nearly 7.5 per cent are entirely out of service).[54] But this continues to fall well short of the 99 per cent charge point availability reported for EV users in the Netherlands.[55]

Charge points out of service represent a significant challenge to user confidence, which is further undermined by limited up-to-date data on whether a charge point is working. TfL's rapid charger framework has set standards around faults and repairs and we have found the average proportion of units typically out of service is lower than five per cent.

The 2018 Automated and Electric Vehicles Act provides the UK Government with new powers to set reliability standards for charge point operators and this is one of the measures set out within its 'Road to Zero' strategy.

2.3.3 The charging experience

Each of the five largest charge point networks in the UK operates differently, with customers typically needing to obtain an a Radio-Frequency Identification (RFID) card,[56] or to download an app before they can access a charge point. They also differ in their payment models, with some requiring initial charges and many offering a range of monthly subscription and pay as you go charge options (now mandated through the Automated and Electric Vehicles Act). Some operators also offer pre-booking for charge points (for example, Source London charge points can be booked at least 40 minutes in advance).

Within London, where there are multiple operators, users may need to hold multiple accounts if they are able to use their most convenient charging option. While some operators offer a pay as you go option using a contactless payment, this is not presently a universal option and registration is still required.

The tariffs for charging from different networks also vary and there are concerns from taskforce members and other stakeholders that the cost to users is not always sufficiently transparent. This, coupled with the multiple operating models, can add to confusion, as it is not always clear which charging options offer the best economy.

These differences in payment models is viewed as being a particular issue for commercial fleet operators and those who rely on their own vehicles for business as it adds uncertainty to charging costs and makes it more difficult to charge from a public charge point during a working day.

It is also an issue that has been identified by Government as an area of concern. Among the new powers to Government from the Automated and Electric Vehicles Act is the ability to ensure there is greater standardisation in how charging payments should be made, and should lead towards standard payment mechanisms, although this has not yet been fully realised.

The experience of the driver while charging their vehicle is also an important consideration – particularly when the driver is at a site for the sole purpose of charging. As a recent report by the RAC Foundation highlights,[57] a reasonable charging experience for a user stopping to charge during their journey is likely to include having somewhere warm and dry they can wait (other than in the vehicle) and having access to toilet, food and drink facilities. The hub model (discussed in Chapter 4) is one way in which this could be delivered in London.

It is also important to ensure that users feel confident about the security of their vehicle and themselves when they plug in to charge while away from home. Examples could include ensuring charge points are located in well-lit areas and ideally located close to other activities.

Image 14
Rapid charge point

54 www.zap-map.com/zap-map-survey-reveals-top-ev-charging-networks/, Zap-Map, August 2018

55 Development of the UK Public Chargepoint Network, RAC Foundation, 2018

56 RFID uses electromagnetic fields to automatically identify and track tags attached to objects. These have traditionally been used for EV charging

57 Development of the UK Public Chargepoint Network, RAC Foundation, 2018

3

User needs

The purpose of this chapter is to examine what is needed in terms of publicly accessible charging infrastructure.

Developing such a perspective requires consideration of how demand may grow, identifying the prime users with the most imminent need, what those users of EV infrastructure will require and how these needs vary across London.[58]

We must also find the right balance between the potentially conflicting objectives of: i) providing sufficient charging infrastructure to stimulate confidence to switch to EVs; ii) planning for a less congested and less car-dependent future for London and iii) ensuring charge points are well utilised and commercially viable beyond public sector subsidy (with limited stranded assets).

3.1 Understanding charging needs

Accelerating the switch to EVs will require potential users to feel confident that there are adequate charge points to meet their needs, that these will be conveniently located and that they will be available when needed.

To date, the vast majority of those in the UK who have been early adopters of EVs are able to charge their vehicle off-street (typically from home).[59] Their charging needs can mainly be met by charging from home (or from a depot) – where overnight charging is a convenient and low-cost option.[60]

For many businesses and residents in London, though, this is not an option. An estimated 24 per cent of all London households have a car but don't have access to off-street parking.[61] There is also significant variation between boroughs. As illustrated in Figure 16, this falls to under 15 per cent of households in boroughs such as Bromley, Bexley and Havering, while reaching more than 30 per cent in boroughs such as Waltham Forest, Wandsworth and Hillingdon.

Therefore, access to nearby public charging, or shared use of private charging, is essential if we are to ensure that charging is neither a perceived nor real barrier to the switch to EVs, particularly in inner and central London.

Learning from current EV users, we recognise it is important that public charging facilities meet the volume, location, time of use and power delivery requirements of EV users. While overnight charging is likely to remain the prominent method for most London residents who own an EV and can park at home, different users are likely to look to a different blend of charging methods to meet their needs.

The key factors that influence charging needs and charging behaviour of different user groups are:

- The nature of vehicle use (including daily mileage, routes, destinations, stationary time, frequency and predictability)
- The type of EV (whether this is a BEV or PHEV)
- The battery range and charging capabilities of the vehicles used
- The availability of private charging options (eg, charging at home, workplace or depot)

58 A study that seeks to better understand charging behaviour and the associated implications is the Optimise Prime Project Location Suitability Study. This project has been formed by UK Power Networks, Centrica, SSE Networks, Uber Technologies and Hitachi, and endorsed by the GLA, with the aim to find the optimal charge point network. The project will involve an injection of 3,000 electric vehicles on to London's streets and then to assess drivers' habits to determine the best number of charge points, the most ideal locations and the peak times of charging. The consortia intend to share the insights from this study with others from the automotive and technology sectors and Government officials to provide insights about the most efficient way to expand the EV network within London

59 Research by Systra for the Committee on Climate Change in January 2018 found that 93 per cent of EV owners had access to off-street charging

60 A review of consumer preferences of and interactions with electric vehicle charging infrastructure, Transportation Research Part D 62, Hardman et al, 2018, p508-523

61 London Travel Demand Survey (LTDS), TfL, 2015/16 to 2017/18

62 LTDS, TfL, 2015/16 to 2017/18 (data for City of London and Westminster were collected as one small sample size in City of London)

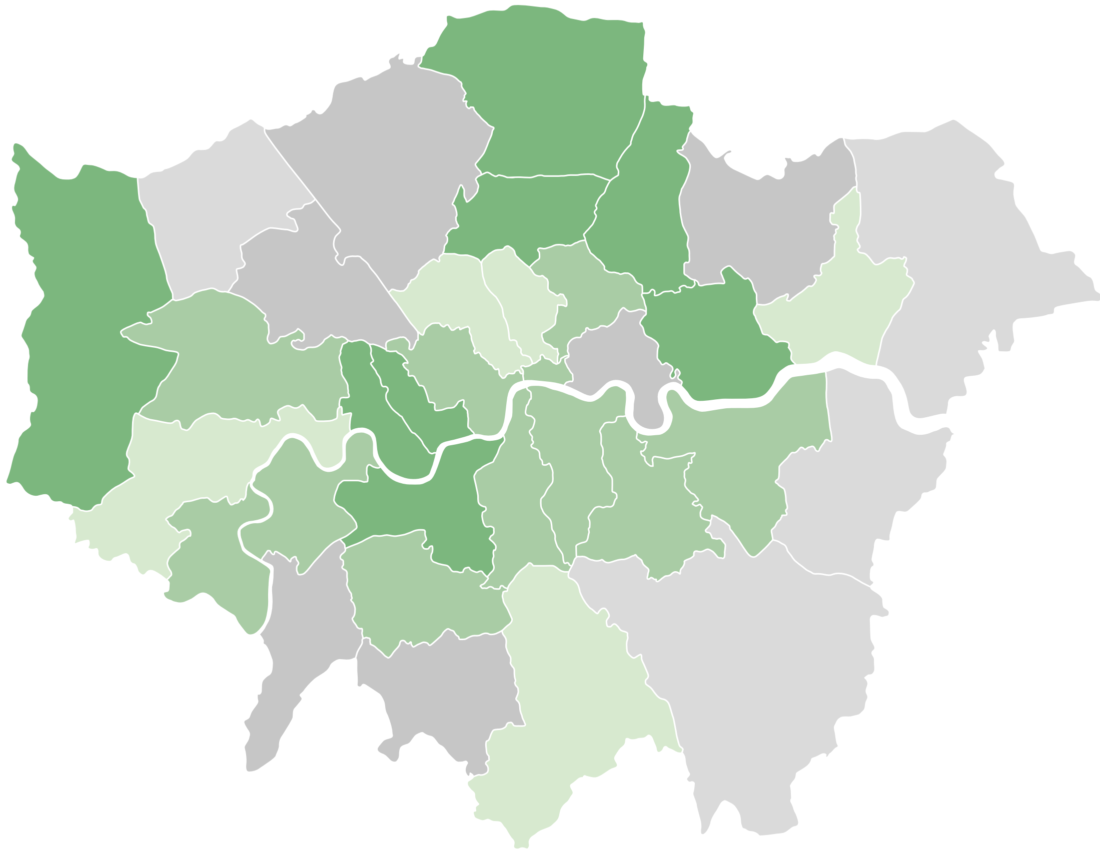


Figure 16
Households with a car and no off-street parking across London Boroughs[62]

We recognise that the charging behaviour of early adopter users results from the vehicle and charging technologies available at that time. As technology develops and new EV models are introduced, we expect the relative importance of these factors will change. For example, recent research by UKPN[63] suggests that drivers are more inclined to plug their car in when the battery level reaches low, rather than plugging in every night. This behaviour supports the charging advice of vehicle manufacturers, but contradicts the current perception of non-EV users. The capacity of the battery is therefore a key factor in determining how regularly a vehicle is charged. As behaviours normalise, over time range anxiety will become range awareness.

Summary of key user needs
We have identified six key groups of users of EVs in London and examined their specific charging needs in greater depth (see Table 6). These have been determined through engaging stakeholders in Workshop 1, and with the taskforce members, as well as being supported with evidence from TfL and wider studies of EV use in London and beyond.

User needs are summarised in Table 6, which shows typical charging behaviours for each user group:

- From/near home – slow charging from home, or from a nearby slow charging point (eg, a lamppost charger)
- At workplace/depot – off-street charging at a depot location or charging at a workplace car park charge point during the day
- 'Grazing' charging – charging a vehicle whenever the opportunity arises (eg, while parked to go shopping, on business or making a delivery)
- 'On-the-go'/in transit – where the primary purpose is to charge the vehicle, so speed and availability are very important – either during a journey or as needed to ensure there is adequate charge to complete daily activities (eg, at a rapid charge hub or rapid charge point)

For each behaviour, we then present how regularly we expect each group will generally charge in this way:

- Daily – used most days/nights
- Regularly – used at least once per week
- Occasionally – used on an ad-hoc basis, less than once per week on average

In the discussion that follows, we explore the needs of these groups in greater depth, including the implications on charger requirement as a result of their individual user need.

63 Recharge the Future Project, UK Power Networks, 2018 www.smarternetworks.org/project/nia_ukpn0028/documents
64 Findings from EV Infrastructure Taskforce Workshop 1, June 2018

Table 6: Summary of charging behaviour assumptions by user.[64] Further detail on how these assumptions have been used to inform the modelling undertaken for this plan can be found in Section 4 of Appendix A

User category	Vehicle type	From or near home or at depot (Slow/standard charge)	While 'grazing' or at the workplace (Any charge speed)	'On-the go' or in-transit (Typically rapid charge)
Company fleet LGVs	BEV	Regularly to nightly (during working week)	Rarely to occasionally (depending on mileage and access to depot charging)	Occasionally to daily (depending on mileage)
	PHEV		Rarely or never	Occasionally (where vehicle supports)
Privately owned LGVs (including the 'gig economy')	BEV	Regularly to nightly (during working week)	Occasionally to regularly (depending on the nature and length of the stop and access to home charging)	Regularly (depending on daily mileage and ability to charge from or near home)
	PHEV			Occasionally (where vehicle supports)
Taxi	Any	Nightly (during working week)	Rarely or never	Regularly to daily (depending on daily mileage and ability to charge from or near home)
Private hire	Any	Nightly (during working week)	Rarely or never	Regularly to daily (depending on daily mileage and ability to charge from or near home)
Shared vehicles (eg. car clubs)	BEV	Regularly to daily	Occasionally to regularly (although dependent on business model)	Regularly (dependent on vehicle and business model)
	PHEV			Regularly (where vehicle supports)
Private cars	BEV	Regularly	Occasionally (depending on use of vehicle and ability to charge from or near home)	Occasionally to regularly (depending on use of vehicle and ability to charge from or near home)
	PHEV	Regularly	Occasionally to regularly (depending on use of vehicle and ability to charge from or near home)	Occasionally (where vehicle supports)

Image 15
Electric van in use in London

3.1.1 Light goods vehicles

LGV traffic in London has been steadily increasing since the 1970s and now represents one fifth of all road traffic. This is driven in part by demand for quicker and more flexible deliveries and servicing, and reducing nearby storage space.[65] Tackling the rise in LGV traffic is one of the major policy goals of the Mayor's Transport Strategy, which includes measures to improve the efficiency and alter the timing of deliveries in London. It is important that investment in charging infrastructure reflects this priority – especially in congested areas.

There are a wide range of different users who drive LGVs on a daily basis. These can be broadly split between the drivers of vehicles that are part of a company fleet, and those who own their own vehicles and use these commercially. The majority of vans (56 per cent) are in private ownership rather than company owned.[66]

The distances travelled and private charging options available to these different LGV user groups will vary considerably. There is limited up-to-date data available on the specific travel behaviours and different types of van user, so much of the discussion here is derived from insight from the taskforce workshops.

i) Company fleets

Larger fleet owners are likely to seek their own depot-based private charging solutions and minimise the use of public charge points. The use of company fleets during working hours will vary depending on the organisation. Typically, there is expected to be sufficient time for an overnight charge.

Higher-mileage delivery vehicles, however, are likely to require some access to public charging throughout the day (for instance those delivering from stores or warehouses in outer London to customers across the city), with little stationary time during a shift. With businesses wishing to minimise time lost to charging during a shift, they are likely to prioritise access to rapid charge points.

Smaller businesses are likely to be most price-sensitive in their charging decisions and are expected to require greater access to public slow charging. Those taking advantage of the Mayor's new scrappage scheme for 'micro-businesses' for diesel vans that do not meet the new central London ULEZ[67] (who are interested in going electric) are likely to need confidence that there are sufficient options available to charge between shifts and the ability to charge opportunistically during the day. For small company service vehicles, this could mean charging while they are parked on business (for example, in a client's car park, or driveway, or in a residential street).

Key implications for the delivery plan: private charging (eg, from a depot) is likely to be desirable for most companies' needs, but grazing opportunities during the day (eg, at fast or rapid chargers) will be needed for some.

ii) 'Gig economy'

With the growth of the 'gig economy', an increasing number of privately owned vehicles are being used commercially for deliveries and servicing. Owners of these vehicles will face similar charging challenges to owners of private cars. Vehicles are often parked at or near home overnight and many owners will be equally as dependent on public charging to meet their requirements.

With many of these vehicles being used for higher daily mileages than private cars, they are likely to require more regular overnight charging. Time pressures will apply to high-mileage delivery users who need to charge during their working day so rapid charge points will be required. Servicing drivers may seek to top up their vehicle charge levels opportunistically (as described above) when at work.

Key implications for the delivery plan: access to public charging will be important for many private goods vehicle owners, along with access to grazing and short rapid charge opportunities during the day.

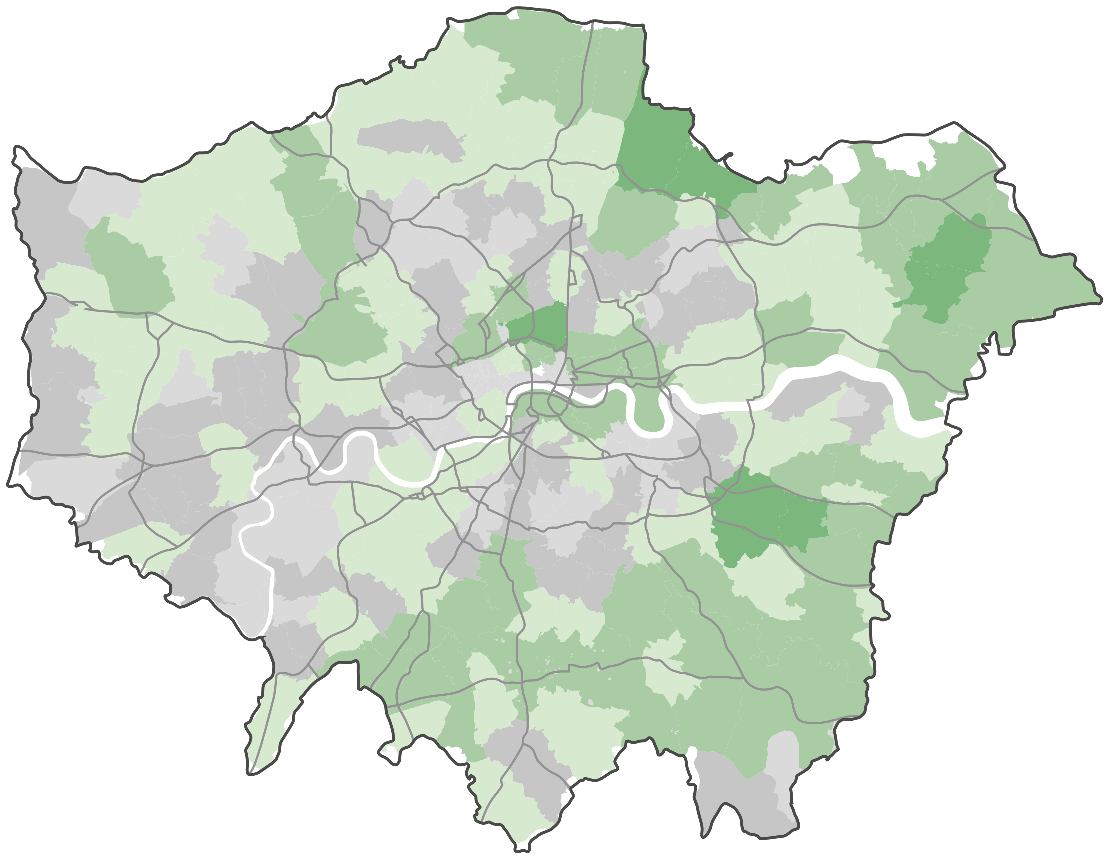
65 Mayor's Transport Strategy

66 Roads Task Force – Technical Note 5: What are the main trends and developments affecting van traffic in London?, TfL, 2013 http://content.tfl.gov.uk/technical-note-05-what-are-the-main-trends-and-developments-affecting-van-traffic.pdf

67 GLA press release on scrappage scheme, 18 December 2018: www.london.gov.uk/press-releases/mayoral/mayor-announces-scrappage-scheme-for-vans-0

Figure 17
Taxi driver licence registrations by postcode district[68]

1-25
25-50
50-100
100-250
250+



3.1.2 Taxis (black cabs)

As with most vehicles that are individually owned, taxis are typically parked at or near to the driver's home between shifts, providing an ideal time to charge. It is expected that most drivers will seek (both for convenience and the relative cost) to charge daily at home, or near home using on-street charging.

Two-thirds of London taxi drivers live within the GLA boundary. Many also live in less densely populated areas of outer London (see Figure 17), where more households have off-street parking, and home charging is a viable option. However, an estimated four in 10 taxi drivers do not have the ability to charge from home and will therefore need daily access to either public or designated taxi-only charge points.[69]

Taxis typically have a high daily mileage. A survey of drivers conducted for TfL in 2016 found that drivers travelled on average 98 miles per work day (including commuting distances), with two-fifths of drivers travelling more than 100 miles.[70] By comparison, the LEVC TX taxis currently in use in London have a battery range of around 80 miles (with a petrol range extender increasing the range to more than 350 miles)[71] and may therefore require a charge during each shift. However, taxi drivers require minimum downtime with minimal impact on ability to earn money and the potential to coordinate with rest breaks, so rapid charging represents an ideal solution for these users.

New models of taxi are likely to offer a higher battery range, but rapid charging is expected to remain particularly important to support high daily mileage – not least for the third of drivers who commute into Greater London from outside.

Convenient access to rapid charge points for taxi drivers is needed across London, but is likely to be especially important within central and inner London. Recent taxi customer surveys suggest that over three quarters of taxi journeys begin here, and two thirds have a destination here.[72] Taxi stakeholders identified to us the particular need for rapid charge points in the Congestion Charge zone as this is their main area of operation.

Access to charge points is key, so multiple rapid chargers in easily accessible locations will be required in the future as EV taxi use increases to avoid queues. It is important to remember that as EV use becomes more mainstream, behaviours will change and drivers will get used to thinking ahead, topping up for shorter periods and using apps to ensure they do not have to waste any time.

Key implications for the delivery plan: taxis are a priority user of rapid charge points. Convenient access to rapid charging while working will be an important requirement for taxi drivers.

3.1.3 Private hire vehicles (PHVs)

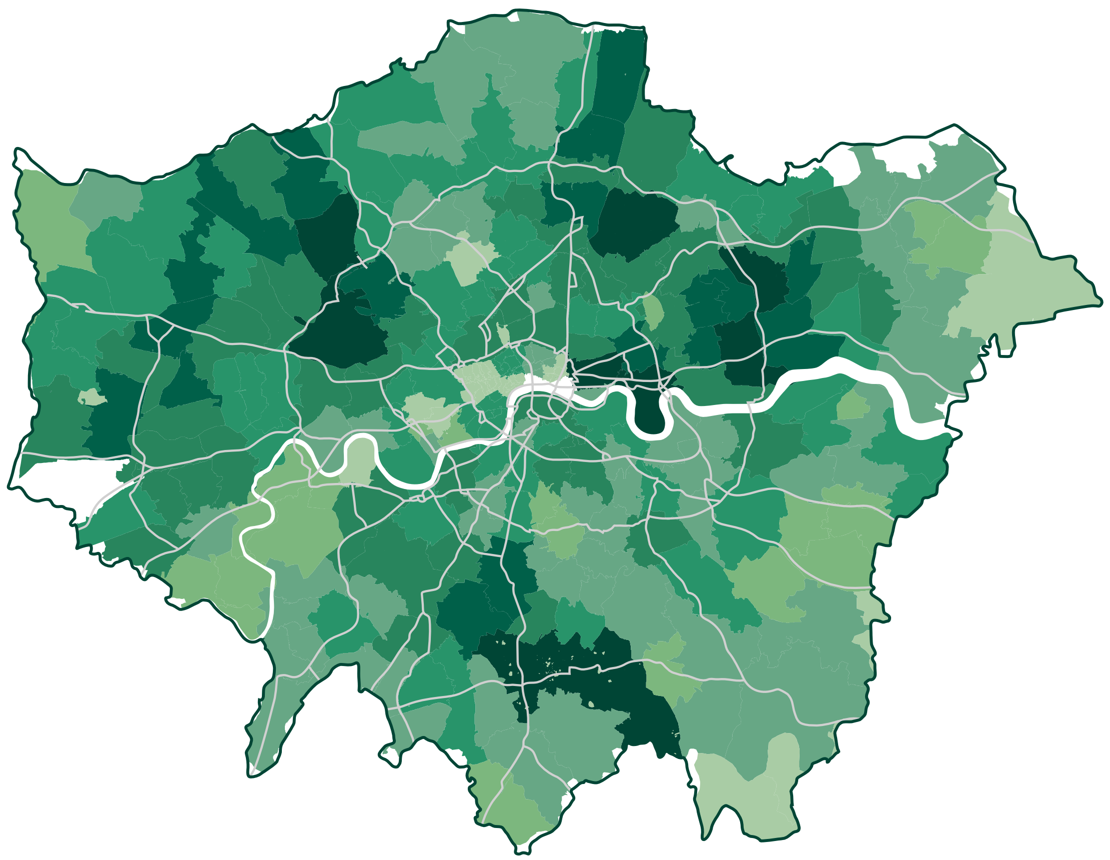
Private hire drivers switching to EVs share similar charging needs to taxi drivers, but with some notable differences.

The number of PHVs licenced in London has increased dramatically in recent years, from approximately 50,000 in 2012/13 to nearly 90,000 by 2017/18.[73] Private hire drivers are likely to be earlier adopters of EVs than many car users, with a new requirement from January 2020 that all PHVs licensed for the first time in London will need to be zero emission capable. Local operators are therefore already planning for the replacement of vehicles with EVs. The largest of these, Uber, recently stated that its ambition is to have 20,000 EVs in London by the end of 2021 and for all vehicles to be EVs by the end of 2025.[74]

A greater proportion of PHV drivers (when compared to taxi drivers) live in areas of London where only a minority of homes have off-street parking (Figure 18). The majority of private hire drivers will therefore not be able to charge their vehicle at home, so public charging provision will be required in residential areas to enable charging near home between shifts. This may be a combination of slow/fast charging on residential streets, fast/rapid charging at local

68 TfL, 2018
69 London Taxi Company survey of 1,200 drivers, 2016
70 A feasibility study into a rapid chargepoint network for plug-in taxis, Energy Saving Trust for TfL, 2016 http://content.tfl.gov.uk/rapid-charging-for-taxis-feasibility-study-draft.pdf
71 LEVC reported range of 81 miles
72 On Street Taxi and Minicab Usage Survey, TfL, 2016 http://content.tfl.gov.uk/on-street-passenger-surveys-nov-2016.pdf
73 Travel in London report 11: tfl.gov.uk/travel-in-london-report-11.pdf
74 Uber's Clean Air Plan to help London go electric, October 2018 www.uber.com/en-GB/newsroom/uber-helps-london-go-electric

Figure 18
Private Hire Vehicle driver licences by postcode district[75]



- 1-50
- 50-100
- 100-250
- 250-500
- 500-1,000
- 1,000-1,500
- 1,500+

facilities such as supermarkets, leisure facilities and service stations, and rapid charging stations on frequently travelled routes.

The distribution of trips made by PHVs is also more evenly distributed across the city than those trips made by taxi drivers. Private hire trips can typically be around London's many town centres, and at stakeholder meetings the trade representatives confirmed that rapid charging facilities at these locations would be preferred. While serving central London businesses represents an important market for a number of firms (in particular Uber), TfL modelling data shows two-thirds of PHV trips are made outside the Congestion Charge zone.

Access to rapid charging outside central areas is therefore likely to be equally as important.

Furthermore, PHV drivers generally travel greater daily distances than taxi drivers, so in-transit charging facilities will be just as important for both groups.

Private hire stakeholders commented that PHVs are generally second-hand vehicles between three and 10 years old. However, the second-hand EV supply chain of vehicles that will satisfy PHV needs is extremely limited currently, limiting public charging demand. When appropriate EV supply increases, demand for public charging facilities will increase accordingly.

Key implications for the delivery plan: access to convenient public charging (and especially rapid charging while working) will be highly important to support PHV drivers.

3.1.4 Car/van sharing

The number of car clubs (offering shared cars and vans) operating in London continues to grow and the reach of the organisations is expanding across the city. Car/van sharing can play a role in enabling Londoners to give up their cars and free up space for more active, sustainable and efficient modes, while still providing access to cleaner cars for infrequent travel in inner and outer London.

Car clubs typically rely on offering a convenient solution for customers, which can create a challenge if there is a need for the vehicle to be charged. Car club operators that are incorporating EVs into their fleets have thus far relied either on customers to charge the vehicles themselves, or removing the vehicles from service while taking them to be charged.

There are two main operational models for car clubs, which have different charger needs:

- A 'round trip' hire – which involves a vehicle being collected and dropped off from the same location (typically in a dedicated parking bay)
- A more flexible model where vehicles can be picked up and dropped off anywhere within the service operating area

For the former, slower AC charging is suitable in car club bays, with vehicles largely being charged between hires. To date, the roll-out of car club bay-only charge points using public funds has been limited by legal considerations – limitations around State Aid rules which restrict the use of Government funds to support private businesses. We are seeking to overcome these.

For the latter, rapid charge points are likely to be a key source of charging. If car club members are to play an increasing role in ensuring that vehicles remain available for use at a reasonable level of charge, convenient and quick charging is essential in areas of car club use. Increased access to rapid charge points is therefore needed.

Key implications for the delivery plan: a mix of charging options is needed to support car/van sharing, with rapid chargers in particular demand.

3.1.5 Private cars

Overall, London residents are becoming increasingly less dependent on cars to meet their mobility needs and it is a key aim of the Mayor's Transport Strategy to significantly reduce car dependency.

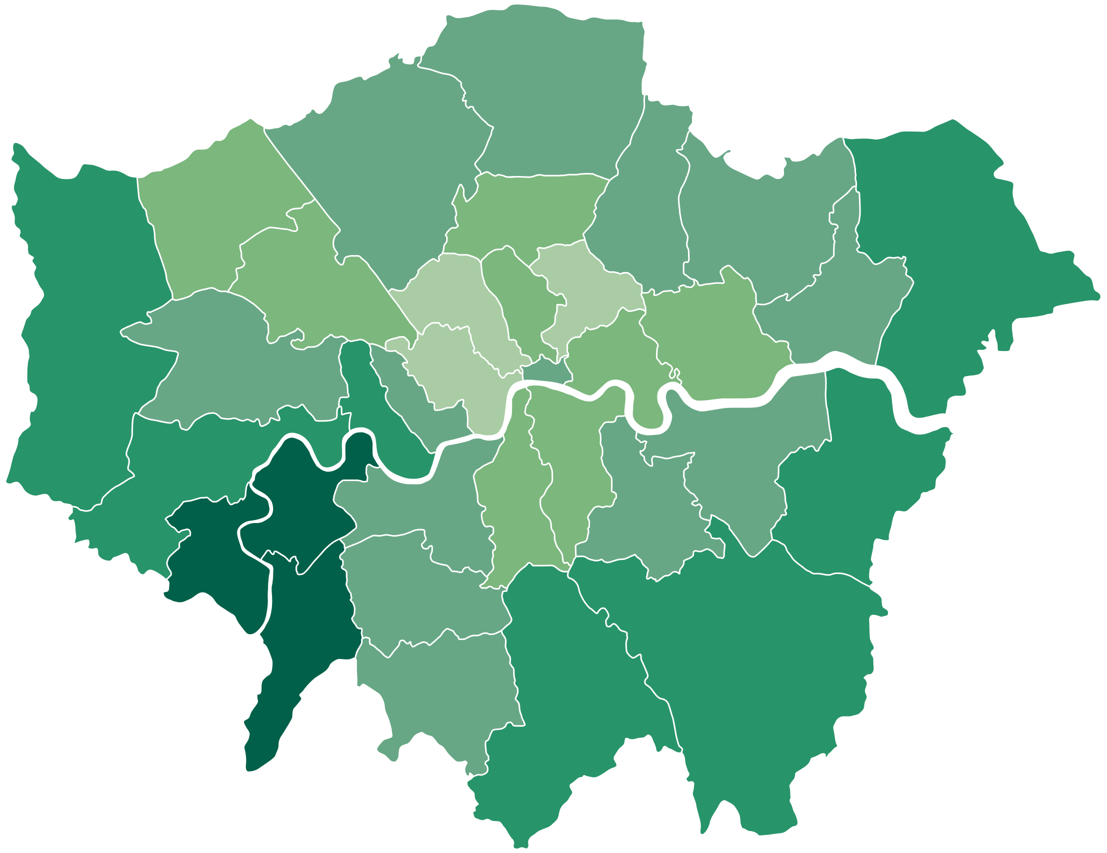
As mentioned above, a large proportion of London households do not have access to a car and the long-term trend has seen levels of car use significantly decrease. The average Londoner now makes fewer than one trip by car per day.[76]

Car ownership does vary significantly across London, with only 40 per cent of inner London households having access to a car, compared to 70 per cent in outer London.

75 TfL, 2018
76 LTDS, TfL, 2018

Figure 19
Car usage by borough – average distance (km) driven per day, per driver[77]

- 2 to 3.5
- 3.5 to 5
- 5 to 6.5
- 6.5 to 8
- 8 to 9



Greater levels of car ownership require more charging provision to facilitate a switch to EVs, although in many outer London boroughs levels of off-street parking are higher, helping to cater for this greater need. Figure 16 shows how car ownership without off-street parking varies across different boroughs.

Few private EV drivers are likely to need to charge their cars more than once or twice per week, although car use also varies considerably between different areas. On average, car owners drive slightly more than six kilometres on a typical day, but those living in outer London travel, on average, nearly 2km further per day (close to 7km) than those from inner London (5km per day). A substantial majority of car owners (around 70 per cent) travel less than 20km each day. Residents within inner London who tend to drive less will not need to charge as often, particularly as battery capacity increases.

In areas where Londoners tend to travel further and more frequently by car (as shown in Figure 19), they are likely to require convenient access to charging more regularly. This means for these drivers, as well as expanding the availability of charging at or near home, grazing charging (ie, whenever the opportunity presents – for instance at supermarkets, or leisure facilities) could offer an additional source to meet their charging needs. There are clear climate and air quality benefits of electrifying this travel. It will be important, though, to ensure that the appeal of grazing charging does not encourage trips to be made by car that could otherwise be easily made by walking, cycling or public transport.

On-the-go (or in-transit) charging can also play an important role in enabling private car owners to switch. For those without access to off-street parking, it could represent a quick and convenient charging option. It will also help to reduce the range anxiety that can be perceived as a barrier to switching to an EV by existing car owners. However, the relative cost of different charging solutions will be an important factor in private users' charging decisions.

Key implications for the delivery plan: a range of charging options will be needed for private cars – particularly in the short term.

3.2 Modelling potential demand to 2025

To support our understanding of London's EV charging needs, we have undertaken a detailed quantitative modelling exercise. This has used a range of scenarios to reflect the significant uncertainty around how EV demand will evolve in the short to medium term. In particular, we have modelled alternative scenarios for:

- Future EV sales – with a 'high sales' scenario where EVs represent 30 per cent of new vehicle registrations by 2025 (in keeping with the Mayor's Transport Strategy aim for zero emissions and the Government's 'Road to Zero' ambitions) and a 'low sales' scenario where this is closer to six per cent

- The preferred charging behaviour of different EV users – where we have considered different scenarios ranging from a high preference for rapid charging, to a high dependence on private or residential charging

The model also includes assumptions regarding vehicle mileage, energy efficiency and charger utilisation. The detailed assumptions and mechanics of this model are provided in Appendix A.

It is important to note that these represent the 'in extremis' positions, and are shown here to illustrate the possible range of infrastructure needs. They are not 'targets' but serve as a guide to illustrate the minimum and maximum levels of infrastructure that could be needed towards 2025.

Actual demand will also be influenced by wider societal, economic factors that we have not sought to examine at this stage within the modelling (including uncertainty about the supply of EVs to the UK market, or the impact of Brexit on demand for EVs). Furthermore, we have not given consideration within our modelling to needs beneath a London-wide level, or to the availability of suitable land for charging.

77 LTDS, TfL, 2018

Image 16
Rapid charge point

Our modelling has provided us with the following key insights:

i) The number of EVs registered in London is forecast to grow from 18,500 in 2018 to between 145,000 and 335,000 vehicles by 2025

This growth is largely forecast to come from:

- Private cars and vans, accounting for up to 62 per cent of EVs – where the range of EV adoption reaches between six per cent (low) and 31 per cent (high) of new private car and van registrations by 2025
- PHVs, up to 24 per cent of EVs – where the low/high range is dependent on the rate of replacement of combustion engine vehicles in response to new PHV emissions standards and industry targets

The 'high sales' scenario for PHVs would mean replacing more than 80,000 vehicles; there remains, therefore, significant uncertainty as to whether this is achievable, or likely. It is included here as the 'in extremis' position and should be viewed in that context.

ii) In 2020, an estimated 230 to 700 rapid chargers and 3,400 to 8,000 residential slow to fast chargers will be needed to service projected levels of EV adoption

The summarised range above is wide, but can be narrowed down depending on scenario of charger preference is realised. Our modelling estimates that:

- If there is a higher emphasis on rapid charging, there will be a need for between 400 and 700 rapid and 3,400 and 5,700 residential slow to fast chargers
- If there is a higher emphasis on residential charging, the need is for between 230 and 400 rapid, and 4,800 and 8,000 residential slow to fast chargers

iii) In 2025, the range of model estimates varies significantly, with the upper estimates particularly dependent on the targeted replacement of PHVs being met

Our modelling estimates that, by 2025:

- In a high rapid charging scenario, there will be a need for between 2,500 and 4,100 rapid and 20,000 and 34,000 residential slow to fast chargers
- For a high residential charging use scenario, the need is for between 1,400 and 2,300 rapid and 28,000 and 48,000 residential slow to fast chargers

The upper ranges of the modelled estimates are only likely to be reached if the current aims for the near-full replacement of PHVs (especially from Uber) are achieved by 2025. It will therefore be particularly important to track growing demand for EVs in this sector to avoid the risk of over- or under-supply.

It should be noted that modelling of rapid assumes nominal charge rates of 50kW. The number of rapid chargers required would reduce proportionally should charging speed capability of the majority of vehicles increase further to accommodate ultra-rapid charging (100-150kW+).

iv) The estimated electricity demand for London's public charging infrastructure in 2025 is equivalent to 1.3-2.5 per cent of London's current electricity consumption (~38TWh in 2017).[78, 79]

This represents a significant range of between 520 and 920GWh, with the dominant user groups being the taxi and private hire fleet (comprising around 80 per cent of the estimated public charger electricity consumption).

It should also be noted that the model is derived from electricity demand and supply and does not reflect what geographic coverage of charge points would be needed to enable easy access to a charger. It is also based on existing rates of vehicle energy consumption, although with improvement in the effective charge rates from current chargers.

78 Sub-national electricity and gas consumption summary report 2017, DBEIS, 2018

79 Note that public charger electricity demand attributed to taxis and PHVs is disproportionate to vehicle numbers as these vehicles travel significantly greater distances compared with private cars and are more dependent on a public charging network given the lower proportion of drivers with access to off-street charging

4

The delivery plan

In response to the challenges, we set out the future focus for different types of chargers.

Having understood the current situation in London, the different user needs and the scale of infrastructure London may need, we can summarise the key challenges to delivering the required amount of infrastructure to 2025. We can then set out how we plan to tackle these using a no-regrets approach ie, one that applies irrespective of whether a high, medium or low scenario is taken, and one which can pivot easily to accommodate the fast-changing nature of this sector.

4.1 Challenges

4.1.1 Land and energy challenges

Suitable space for charge points is at a premium and is often subject to competing demands including:

- Space for private vehicles on London's streets is already in high demand and much of it is required for bus lanes, cycle lanes, red routes, parking facilities, loading/unloading or access. In particular, suitable space on the TLRN has largely been exhausted
- Many streets are unsuited to current charging mechanisms/ equipment owing to narrowness, one-way restrictions and the size of the charger and cables. On-street charging can increase conflict between drivers and pedestrians by adding to street clutter
- High land values, unfavourable lease arrangements and the limited availability of suitable sites in appropriate locations can be prohibitive to off-street charger investment

Installing new charge points can be a long and complex process:

- The experience of installing new charge points can vary considerably across different parts of London owing to different approaches to the planning requirements, levels of resource and experience with installation:
  - Possible surveys/reports required include townscape (listed buildings, conservation areas), arboriculture report, parking loss survey, highway safety audit, etc
  - Boroughs can use 'Permitted Development'[80] rights to install charge points without needing planning permission, but many are reluctant to do so
  - Approvals sometimes required for highway closures – eg, where installation of a feeder pillar (to connect to the electricity network) classifies as major works, causing time delay (the delivery of a TfL rapid charger at Highgate Station was delayed by six months, owing in part to the approvals required for highway closures)
- Those putting charge points in often lack knowledge to specify the correct infrastructure, or lack clarity on what is likely to be required for a successful application
- Streetscape impacts – currently, most charge points remain relatively bulky and intrusive, particularly rapid chargers, leading to concerns from residents and accessibility groups about pavement obstruction and in some cases planning application rejections

The cost of energy grid upgrades can be prohibitive where capacity is low:

- The peak demand for electrical networks is already at capacity in many locations and upgrades to the electrical supply can be costly[81] so alternative solutions, including the role of smart charging in the longer term, will need to be considered
- DNOs will be cautious about investing in network reinforcement, with uncertainty around the level of need and key locations to focus on
- Customers requiring a connection want to link to the electricity network and obtain connections at the lowest possible cost and as quickly as possible. However, these vary by location and time[82]
- The current regulatory arrangements mean that customers are required to partly fund network upgrade costs if they want to connect in an area with no spare capacity, leading to customers being concerned at the upfront costs[83]
- Stakeholders need more choice in their connection journey. In Great Britain there is already a competitive connections market, with more than 100 connection providers offering a range of services and commercial terms to meet customer needs alongside the local DNO

80 Permitted Development rights are a national grant of planning permission that allow certain building works and changes of use to be carried out without having to make a planning application

81 Providing power to supply a new charge point with electricity is normally facilitated by a DNO, installing a connection. Depending on the level of power needed, this can be from the low- voltage supply, which typically runs from a distribution transformer along streets and under footpaths to serve domestic properties and light commercial users. For very significant power requirements, such as a rapid charging hub, a dedicated on-site transformer is likely to be required – necessitating a high-voltage cable connection to the nearest high-voltage substation

82 Previously, the level of network capacity was not visible before starting a connection application process, but now DNOs have maps that show this information on their websites

83 Ofgem has confirmed: there are rules in place to ensure that connection customers pay a fair price to get connected to the network. These rules include the Electricity (Connection Charges) Regulations (ECCR) – also known as the 'second comer regulations'. The ECCR provides that where a person connects to, and benefits from, electricity infrastructure that was paid for by an earlier party, the earlier party should be reimbursed for a share of the costs by the subsequent connecting customer

4.1.2 Operational/user challenges

Drivers lack confidence in the availability of convenient charge points:

- Many car owners in London would not be able to charge from home and will therefore need to rely on easily and publicly accessible charging – there is lack of certainty on where and how this would work for individuals
- There is a fear that chargers would not be available, either through already being in use or being out of service (concerns raised particularly by taxi drivers)
- As coverage across London is not currently consistent, drivers in some areas will have concerns over supply of infrastructure

Drivers find the experience of charging confusing and complicated:

- Customers' experience of using different charge points (and operators) can vary considerably from poor to excellent
- There is poor interoperability between charge points and charge point providers, creating confusion around which chargers drivers can use and how much they can expect to pay
- Poor information on the location of charge points, and whether the charge point closest to the customer is in use or out of service
- Confusion/lack of clarity about how a different model of 'refuelling' would work in practice among those with no experience of anything other than conventional engines

4.1.3 Challenges around investment uncertainty

Investors remain wary of backing the wrong type of charger, concerned about obsolescence:

- While growing fast, the switch to EVs is still in its infancy, with a range of different vehicles and charging models that have developed in an uncoordinated way
- The availability of data for public authorities to undertake long-term planning has been limited and it lacks consistency – for the first time this taskforce has worked across industry to increase understanding of available data to build a model that can help plan for a range of future scenarios. This is especially important in planning enhancements to the grid. Further insights will be possible if we can obtain access to the charge point data
- Upfront capital costs and initial low numbers of users mean that it can take a number of years before charging is profitable, which is compounded if the type and location are not effective. Having a better understanding of future needs will help maximise the efficiency of charge points and charge point investment
- Ongoing advances in technology raise concerns that what is installed now will become quickly obsolete

4.2 Guiding principles

It is vital that the delivery of charging infrastructure is aligned with Mayoral strategy, and that we are aligned with the wider aim of reducing dependence on private vehicles for travel – and especially car travel – within London.

To ensure this, we have defined a set of 'guiding principles' (see Table 7) for EV charging infrastructure. These specifically address the key related transport and environment policy aims for London.

Table 7: Guiding principles for delivering EV charging infrastructure in London

Mayoral policies (from Mayor's Transport Strategy and London Environment Strategy)	Guiding principle
Reduce Londoners' dependency on cars in favour of active, efficient and sustainable modes of travel (Mayor's Transport Strategy Policy 1) Reduce emissions from London's road transport network by phasing out fossil- fuelled vehicles, prioritising action on diesel, and enabling Londoners to switch to more sustainable forms of transport (London Environment Strategy Policy 4.2.1)	1. Charge point provision must not make travelling by car for non-essential trips more attractive in parts of London where trips can be made conveniently by walking, cycling or public transport
Make London a city where people choose to walk and cycle more often by improving street environments (Mayor's Transport Strategy Policy 2) The Mayor will promote and prioritise more sustainable travel in London, including walking, cycling and public transport, as part of the Healthy Streets Approach (London Environment Strategy Proposal 4.2.1.a)	2. On-street charge points should complement the street environment and ensure streets are highly accessible/prioritised for pedestrians and cyclists
Adopt Vision Zero for road danger in London (Mayor's Transport Strategy Policy 3)	3. New charge points must not impact on the safety of other road users
Prioritise space-efficient modes of transport to tackle congestion and improve the efficiency of streets for the movement of people and goods (Mayor's Transport Strategy Policy 5)	4. Charge point provision should be consistent with an overall reduction in space allocated to cars and private vehicles 5. Vehicles should not be travelling into congested areas (and especially Central London) to charge, or park on-street for long periods

Image 17
Visualisation of a rapid charging hub

4.3 Defining what is needed

As indicated in Chapter 2, rapid chargers and slow to fast chargers have different advantages and disadvantages relative to each other across key features such as capital cost, charging speed/convenience and streetscape impact. It is clear that, towards 2025, each charger type will still be needed, as they each suit the different user needs.

While the modelling exercise has suggested the scale of charging infrastructure required, with different scenarios for the dominant charger type, given the infancy of this sector, the taskforce does not believe that setting a target number of charge points now for 2025 is practical. Instead, this section sets out below the strategic focus areas for each of the charger types towards 2025, to guide the roll-out of charge points in London.

4.3.1 Rapid chargers

Priority focus – hubs

Recommendation: insight from the work of the taskforce has shown the need to focus on rapid charging hubs going forward. This will not only be more beneficial for EV drivers but will help expedite a step change towards a zero emission future.

The full rationale for this is:

- With their faster charge times (typically 20–30 minutes), rapid chargers are well suited for 'on-the-go' charging
- Knowing that there are multiple charge points at a single site increases customer confidence – another key barrier to take-up – and provides highly reliable availability and minimum wait times
- The hub is similar to the fuel station model with which drivers have existing familiarity
- Typical dwell time provides an increased footfall, justifying additional provision of facilities such as toilet facilities, food and retail offerings, which may increase the commercial viability of sites, another concern holding operators back from investing
- Provision of facilities and high expected reliability is likely to create a virtuous circle, increasing utilisation, confidence and good customer experience, facilitating further switching to EVs and local demand and therefore increasing commercial sustainability of the chargers

A rapid hub can simply be defined as 'a minimum of six chargers enabling simultaneous charging of six+ vehicles'. However, it is helpful to further define the types of rapid hubs we currently have and would like to see in London towards 2025. These are detailed below.

Figure 20
Virtual hub, Southwark Street

- Taxi only rapid charge points
- General use rapid charge point

A. 'Virtual' rapid hub (eg, Southwark Street)
This describes a grouping of rapid chargers along a street in a popular location, offering increased certainty of charger availability. A virtual hub can manifest itself as a grouped cluster of on-street chargers with no further facilities, for example the rapid charger provision along Southwark Street.

Image 18
Dedicated rapid hub – opened in Milton Keynes in December 2018

Image 19
Visualisation of a dedicated rapid hub (K:Port by Hewitt Studios)

B. Dedicated rapid hub
This type of hub is simply dedicated to recharging vehicles. One of these recently opened in Milton Keynes (see Image 18), and TfL is already progressing several dedicated hubs within London as part of the TfL RCI project. It is expected that these will form part of a transitionary move towards commercial rapid charging hubs (see hub type C), and will suit areas with limited space.

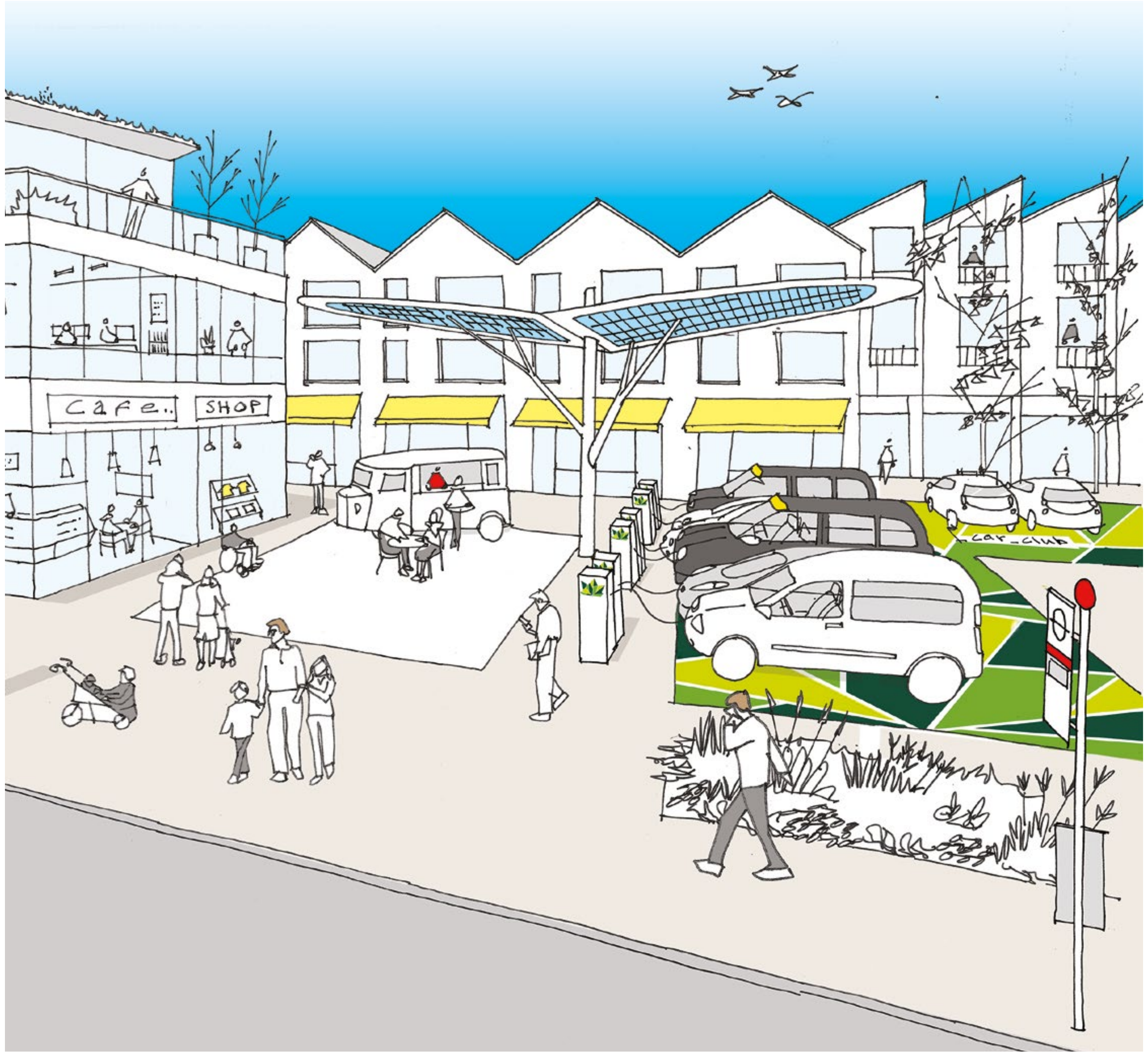


Figure 21
Visualisation of a commercial rapid hub

C. Commercial rapid hubs
Unlike the dedicated hub, this off-road cluster of rapid chargers is not just about charging vehicles. Some have a high commercial focus, situated in supermarket or retail car parks and including nearby shops, food and drink, toilet facilities and potentially on-the-go working facilities. At the other extreme are some rapid chargers within fuel stations, which are primarily for recharging, but will provide shop facilities.

The more commercially focused hubs have potential for mutual benefit for consumers and land-owners/operators, providing a range of services for consumers to access, and driving increased footfall to local businesses.

As EVs become more popular, it is expected that fuel retailers will roll out more EV charging infrastructure to their fuel forecourts. Some fuel retailers – such as Shell – are already committing to increased roll-out of such infrastructure. Shell Recharge will be available on approximately 30 Shell forecourts across the UK by the end of 2019, including a mix of rapid 50kW and 150kW charge points.

D. Shared access (eg, depots)
As commercial fleets are increasingly electrified, the installed charging infrastructure in depots and garages is typically underutilised in periods when the fleet is deployed, eg, during business hours. This can present an opportunity for a new revenue stream by opening access for charging to the public or specific user groups such as taxis and private hire. There would be issues of access and privacy to resolve but the potential gains are large. There are currently no known examples of this in London.

Priority focus – good coverage
Having set out the types of rapid charger hubs we have or expect to see in London, the question of what is needed, by when, arises.

Recommendation: to improve the spread of rapid hubs across London, the next phase of delivery should focus on at least five flagship rapid hubs, one in each sub-region of London. The first hub should be operational by 2020 (subject to funding and EV growth).

A map to indicate how this may look is shown in Figure 23. TfL is already progressing a number of hubs, of the virtual or dedicated type, and is also looking into facilitating a commercial hub, to test how these will work.

Beyond this broad distribution, to provide a good spread, the following series of questions can help guide rapid hub placement:

1. Is it a densely populated urban area or highly transient route?
2. Are other facilities available on site (eg, existing fuel station shop, retail park)?
3. What other competition is there in the area (eg, are there nearby rapid hubs that would result in too much traffic and competition)?
4. Does it provide good overall coverage?
5. Does it comply with Mayoral Policy? (see Table 7)
6. Would it create adverse public transport or active travel network impacts?
7. Is the cost of the connection reasonable?
8. Is there accessible land?
9. Is there energy capacity available?

Figure 22
To improve overall coverage, additional rapid chargers should be prioritised to serve London's town centres

Town centre

Figure 23
Moving towards rapid charging hubs, the next phase of delivery should focus on at least five flagship hubs, one in each sub region of London

Rapid charging hub – indicative location only

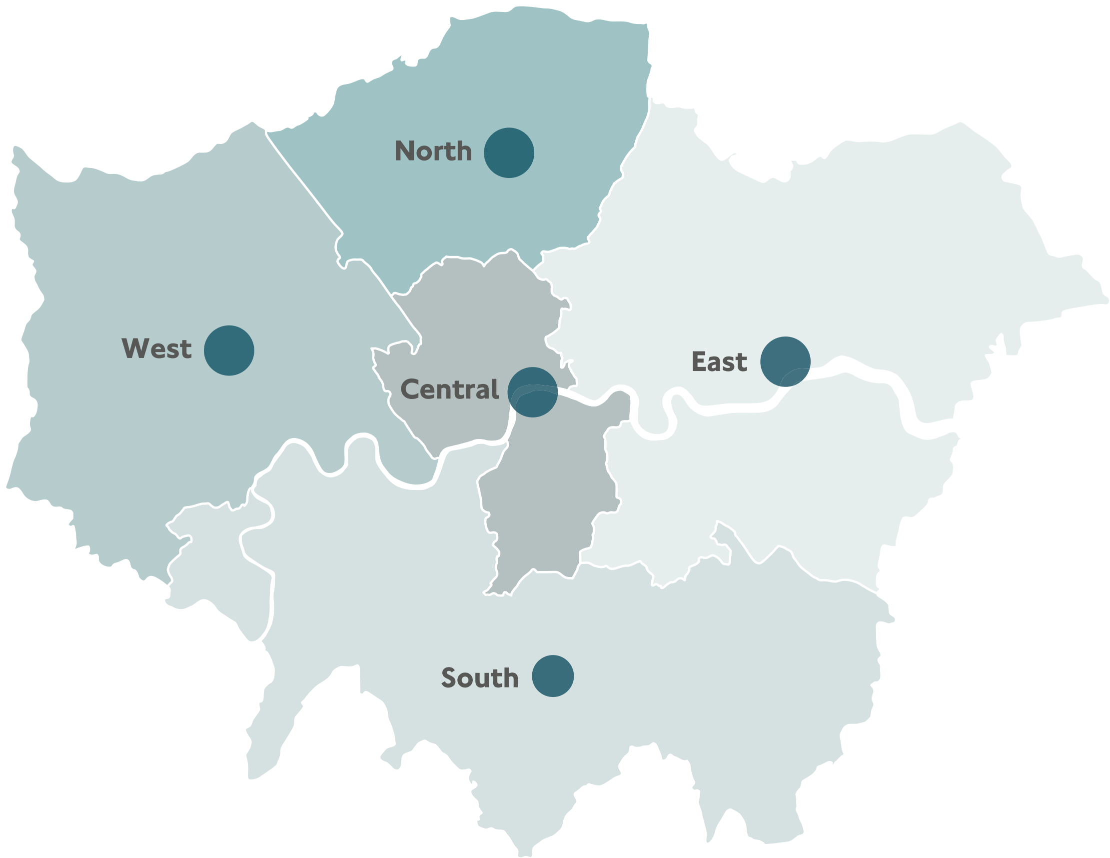
North

East

South

West

Central



A secondary area of focus beyond the roll-out of rapid hubs is for there to be consistent geographic coverage of rapid charge points for all Londoners.

Recommendation: to provide overall coverage, additional rapid chargers should be prioritised to serve London's town centres. This could be in the form of hubs or single rapid chargers, to primarily serve commercial needs.

If all 200 of London's town centres (as defined in the London Plan) could be served by at least one rapid charger, this would provide a consistent level of access to rapid chargers across London to give commercial EV drivers (eg, taxi and private hire drivers) confidence that London's charging infrastructure is city-wide. In order not to clog up space-restricted town centre high streets, the best locations for these rapid chargers would be along or off highly transient routes that are in close proximity to the town centre. TfL is already beginning to prioritise the remainder of its roll-out of 300 rapid chargers in locations that serve town centres. As there are few remaining suitable sites along TfL's roads, we expect future sites to be on borough roads (or off road). The criteria in use for selection include:

- Population of the town
- Geographical size
- Existing rapid charger provision
- Relative number of high-mileage users
- Through traffic
- Available energy capacity

Once the publicly accessible network of chargers reaches a consistent level of provision across London (bringing poorly served areas up to the standard of areas that are currently well served), the provision method can then rely more on a demand-led model, with a focus on those that are more commercially viable.

Where will they come from?
Chapter 1 sets out how TfL has committed to putting in 300 rapid chargers by the end of 2020, supported by funding from OLEV, and has led the way by installing 153 by the end of 2018, largely on the TfL road network. The remainder of the TfL RCI project will focus on increasing consistency of the geographic coverage and creation of hubs. However, with only five per cent of the road network, boroughs will have a significant role to play in increasing coverage on the 95 per cent of roads that they control. Boroughs have committed to identify 20 sites each for rapid charging and these sites will be vital in facilitating widespread take-up of EVs. Taskforce member UKPN has committed to proactively steer/signal the GLA towards positions for rapid chargers serving the town centres, based on network capacity.

Beyond the initial support the public sector is giving to rapid deployment, it is the expectation of the taskforce that the commercial market should be well placed to drive future deployment with little to no additional public funding. This means involvement by commercial market players such as charge point operators, fuel retailers, garage/depot operators, automotive manufacturers, car park operators and other retail businesses and land owners. This will also require partnership working with public bodies to identify and facilitate sites on publicly owned land, and potentially facilitate grid upgrades.

Testing demand – mobile rapid charging

As indicated in Chapter 2, while not a long-term substitute for fixed charging infrastructure, mobile battery units have advantages including: potential for emergency charging, business model experimentation, power requirements and battery second-life applications. It will be important to manage any unintended consequences such as increased vehicle mileage from moving the units around.

Recommendation: mobile rapid charging could be a useful short-term solution to plug gaps and test business models, but is unlikely to form a significant part of the long-term future of charging infrastructure.

4.3.2 Slow to fast AC chargers

The merits of rapid chargers and in particular rapid hubs have been set out above. We are clear that this is a preferred direction of travel above slower types of charger (in particular, for commercial uses such as taxi and PHV), yet there is still a place for slower chargers towards 2025. Within this timeframe, there are a few areas where we would like to focus action for these types of charger.

Priority focus – shift to demand-led distribution

The first mass roll-out of slow to fast chargers in London was by Source London between 2011 and 2014, when the number of EVs was much smaller, and behaviours and habits unknown. The chargers were not always placed in the right location for users, and many have since been replaced or relocated. Lessons have been learnt from this, but it was successful in terms of kick-starting a base level of charger distribution, helping to reassure potential EV users that there was the necessary infrastructure to help them make the switch to EVs.

The current public funding of slow to fast charge points is via the GULCS programme, which is managing the delivery of more than 1,150 publicly funded on-street slow to fast chargers for residential use. The funding is allocated to London boroughs that apply and meet the criteria set by GULCS, not necessarily based on demand. Boroughs determine individually what chargers are needed locally and where these should be located.

While some boroughs install on a more demand-led basis, the approach is inconsistent and may limit confidence that prospective EV buyers will be able to access nearby charging facilities. There is a risk that a demand-led approach may result in inconsistent geographic coverage, but we will seek to minimise this and have strategic overview. Such a roll-out will serve to build confidence in EVs in the period to 2025. It will also enable chargers to be more commercially viable which, given there is no further significant public funding on the horizon towards the capital costs of slow to fast charger implementation, is prudent.

The management of a demand-led system needs to be consistent and systematic. Although we recommend demand-led this should not be seen as desire-led – we do not want to raise the expectation that anyone who wants a charger to be installed outside their house will be able to have one. It is recommended that this function is overseen by a pan-London co-ordination body – this is expanded on in Chapter 5.

Recommendation: the future favoured deployment model is strategic and demand-led (not desire-led), in order to improve commercial viability and enable the private sector to take over delivery.

Priority focus – uplifting volume, reducing streetscape impact and exploring off-street models

Volume must continue to increase to enable the switch to EVs, but while doing this, we must take particular care over the impact this type of charger has on the streetscape, given the locations and numbers they may be needed in.

With their slower charge rates but lower costs, slow to fast AC chargers are well suited for overnight or destination charging, where dwell times are long. However, it is critical that they are in locations where they can be used for those purposes. Installing chargers in the wrong location so that they are underutilised or stranded does not improve confidence in the scale of infrastructure. It has to be based on demand, or accepted as a social need.

Streetscape space is at a premium, with competition from a large number of sources of street furniture. Bulky chargers and cabinets, when located on the footway, can have a detrimental impact on pedestrians, particularly for larger scales of deployment. As well as locating charge points in the carriageway where safe to do so, creative, low-cost and low street-impact charger options are beginning to come to market with designs encompassing lamppost chargers, pop-up chargers, hidden sockets in the ground and small charging mounds. Innovation in design can also reduce cost, which should facilitate accelerated uptake in desired locations. To hide cables, discreet kerbside channels could also provide a low-impact/low-cost option.

Recommendation: the key focus areas for slow to fast AC chargers include installing more in the correct locations, reducing their streetscape impact and exploring new models of deployment.

Image 20
Trojan Energy model of residential charger, flush with the pavement[84] (not yet in use)

How will slow to fast chargers be deployed in London?
This section details three categories of slow to fast AC charger expected to make up the scale required to 2025, along with examples of commercial market initiatives and commitments.

A. Residential on-street chargers
Residential on-street chargers can provide a convenient form of charging for EV owners without off-street parking, taking advantage of extended periods of time when vehicles are not in use and the relatively lower cost of infrastructure compared with rapid chargers.

Where conditions are appropriate, charging provision can be made in the carriageway on build-outs of footpath. In addition to this, there have been a number of examples of charging infrastructure innovations that serve to reduce streetscape impact in this category. One such example is lamppost charging, which leverages existing streetlight infrastructure. Other organisations such as Connected Kerb and Urban Electric are pursuing innovative low impact solutions and Trojan Energy (see image above), which is partnering up with Innovate UK funding to trial its flush socket.

B. Residential hubs/ Community chargers
The concept of community chargers is a grouped hub of slow to fast AC chargers in off-street, residential areas designed for open access, ideally based on a booking model. This model has potential to provide local access in a way that reduces impact on local streetscapes. This model is of interest to many owing to the opportunity it raises with energy management, as vehicles will be plugged in for a long time and could spread the draw on the grid using grid management techniques.

C. Off-street, destination chargers
Destination charge points will be in places where people stay for a few hours such as gyms, supermarkets and shopping centres. This will enable EV owners to incorporate charging into their usual routine.

In addition to rapid deployment described in an earlier section, Tesco, VW and Pod Point committed to installing 2,500 charge points at more than 600 stores across the UK by 2020.[85] The majority of these chargers will be slow to fast.

Image 21
Destination slow to fast charger example[86]

84 Image courtesy of Trojan Energy: www.trojanenergyltd.com/

85 www.carmagazine.co.uk/electric/electric-charging-stations-uk-find-nearest-ev-charging-point-best-journey-planner-for-electric-cars/

86 Image reproduced courtesy of Volkswagen UK

5

What can we do to make this happen?

The decisions and action we take now are essential to shaping the way the switch to EVs accelerates across London.

The learning to date has moved our understanding along in strides, and has helped clarify what we still need to do to help facilitate the provision of London's charge points.

In order to provide confidence that infrastructure is not going to be a barrier to EV adoption to 2025, the taskforce looked for what possible solutions, or 'enablers', could be actioned in the short term, to overcome some of the challenges identified. These solutions have come from the workshops, stakeholder and taskforce meetings, and have been developed with taskforce members.

Taskforce members are committed to taking these forward as a result of this year of research and joint working. Many members have signed up to lead or be involved in these, using their skills, connections and knowledge to accelerate success. These enablers fall into three categories (see Table 8).

5.1 Facilitate smoother installation and match supply with demand

Enabler 1. Deliver London's first rapid charging hub and support the roll-out of additional rapid charging hubs – in collaboration with the private sector
Building on what has been set out in Chapter 4, TfL will continue the development of two dedicated rapid hubs within the TfL RCI project, at Glass Yard and Baynard House, which are expected to be delivered as part of the 300 target by the end of 2020.

Following on from this, TfL will take the next step by bringing London its first commercial rapid hub. TfL's role in this could range from assisting with land acquisition, energy supply or charge point provision, but it is not expected that TfL takes this forward alone. Taskforce member UKPN has also committed to collaborate in the selection of the rapid hub sites to best manage customer requirements and network impact, exploring the possibility of providing land and power requirements. TfL also welcomes collaboration with the private sector to progress this, and asks commercial businesses interested in working with us to step forward and engage. This will be a fundamental requirement of this type of hub site.

Taskforce members: TfL lead, input from Federation of Small Businesses, London Councils, Shell, SSE Enterprise and and UK Power Networks

Table 8: Enablers to facilitate charge point delivery

Category	Enabler	Date
Facilitate smoother installation and match supply with demand	1. Deliver London's first rapid charging hub and support the roll-out of additional rapid charging hubs – in collaboration with the private sector	From 2020
	2. Support shared business charging infrastructure	Ongoing
	3. New pan-London coordination body to facilitate and oversee charge point installation	Initiate in 2019
Reduce energy barriers	4. New online tool/ 'heat mapping' to identify energy grid constraints and where new charging capacity will be cheaper and easier	June 2019
	5. Explore alternative and smart power supply options, such as battery storage, mobile charging and private wire networks	Ongoing
Share knowledge and maximise potential of legislation	6. Publish guidance on charge point installation for both public and private sector	2019/20
	7. Publish guidance on future-proofing EV infrastructure to encourage investors	2019/20
	8. Promote better standardisation of charge points and vehicles, interoperability of systems and data sharing	Ongoing

Enabler 2. Support shared business charging infrastructure
To increase utilisation and the number of available charge points in London, charge points installed by a public or private sector organisation could be opened up for shared use with agreed partners only (or indeed for open access use). This is already being explored by some private sector organisations and we want to support a number of trailblazing schemes in London, for example by linking up relevant organisations and helping to overcome security and access concerns.

Typical issues raised when considering such options are around security and space. Bus operators are considering potential for broadening access to their depots or alternatively using spare capacity from the power upgrade required to support electric bus charging, to power a number of rapid chargers outside the bus depot. This would need to have minimum interference with bus movements and address security concerns, but would make use of spare energy capacity at the site.

For similar reasons, businesses that are adding EVs to their fleets are looking at locating their charging infrastructure in their car parks rather than inside the depot. This will mean others can use it without the security risk to their operations.

We are also following the learnings of a charging operator that is trialling a shared private network of chargers for business fleets and may be able to roll this out at scale in the near future.

Taskforce members: TfL lead, input from Cross River Partnership, Freight Transport Association, London Councils, London First, Office for Low Emission Vehicles and SSE Enterprise

Enabler 3. New pan-London coordination body to facilitate and oversee charge point installation
Through the extensive consultation and information gathering of the taskforce activity, it is very clear that there is strong support for the setting up of a new pan-London coordination body, to provide a service that will save money, pool resources and ensure a consistent approach for public charging infrastructure is adopted across London. This would build on the existing GULCS project, be a focus for activity, and the voice of authority and advice on the provision of EV infrastructure in London. Stakeholders have recommended that this service should centrally facilitate pre-installation, installation and business-as-usual activities.

Further work needs to be done in planning the functions of the body and how it would work in practice. It is proposed that it focuses on being a public interface and a central place to share best practice and analyse data. The taskforce work to date has come up with the following potential activities:

- Manage public charge point requests from Londoners via a one-stop-shop website, to provide a consistent approach across all of London's boroughs for its residents
- Assist with maximising the utilisation of existing infrastructure, by providing people with information on where nearby sites are located when they enquire, minimising the risk of stranded assets
- Navigate the planning processes, to allow those who are trying to install a charge point to better understand what permissions they may need, help promote the quickest and best routes to installation, and determine who else they may need to involve
- Collect and share data on charge point usage, identify patterns of use to help understand current and future demand in consultation with operators
- Provide procurement and contract management support, helping fill gaps in resource and knowledge and a consistent approach to be adopted
- Monitor customer experience and charging behaviour, reporting network reliability and providing reassurance around capacity
- Lead communications including myth-busting and awareness raising, supporting marketing by Go Ultra Low and any specific information from London boroughs and TfL
- Facilitate sharing of best practice regarding charge point installation and management

The first step would be to establish a one-stop-shop website, where Londoners could submit requests for an on-street slow to fast charge points. The intention would be for the remit of the body to be wider than just facilitating on-street slow to fast charge points, however. TfL has a lot of learnings and experience to offer in the delivery of rapid charge points in London, for both singles and hubs.

An indicative timeline is set out in Table 9.

Taskforce members: London Councils lead, input from BEAMA, CRP GLA, London First, OLEV, RAC, SMMT, SSE Enterprise, TfL and UKPN

Table 9: Indicative timeline for new pan-London coordination body

2019	• Scope out with key stakeholders over the summer the full remit of the body • Launch at the end of 2019 – one-stop-shop website will go live • Begin data collation and analysis
2020	• Use new TfL guidance to support boroughs and others in installing infrastructure • Customer experience and market research
2021	• Expand coordination body to facilitate deployment of rapid charge points

5.2 Reduce energy barriers

Enabler 4. New energy network constraints online tool/'heat mapping'
The role of DNOs is to facilitate connections within their regulatory framework. This can be achieved either through procuring flexibility or building new infrastructure. One way to help, and reduce potentially unnecessary investigation, is 'heat mapping' of the electricity distribution network. Such geographic information could indicate areas of constraint, and therefore locations where connections could be problematic. Even in a constrained area of the network, however, it does not prevent connection, but involves the need to reinforce the network for the increased load.

In London, UKPN has made a commitment to publish heat maps of potential future flexibility requirements in response to low voltage (LV) constraints. To support UKPN's pledge to be more transparent, the DNO has developed a roadmap to deliver London's future flexibility needs – which by inference is where UKPN predicts constraints on its network over the coming years. One end result is that it helps customers wanting to connect EV charge points to understand where constrained (and by exception unconstrained) parts of the network may be, which will enable them to choose more cost-effective locations for placing charge points.

UKPN plans to release a forecasted EV-driven LV constraint map covering the GLA area, and offer it via the same access conditions currently offered for their Distributed Generation (DG) mapping tool (with controlled access). This map will identify LV transformer sites and general network radii that are likely to be constrained without deployment of any Smart or managed charging. This will be a forecast and should be treated as such, and is made available with the intention to provide customers with more information than currently available in order to make more informed decisions.

Image 22
DPD's electric vans

UKPN will additionally introduce an EV-specific 'ask the expert' service to help customers navigate the connections process, providing the ability to discuss any charge point installations ahead of submitting formal applications.

Taskforce members: UKPN lead, input from Cross River Partnership, Energy UK, Ofgem and SSE Enterprise

Enabler 5. Explore alternative and smart power supply options, such as battery storage, mobile charging and private wire networks
As described in Chapter 2, connecting power to supply a new charge point with electricity is normally facilitated by a DNO. In situations of high costs of grid upgrade and long lead times, there are alternative opportunities such as private wire or energy storage, which may result in a lower-cost power supply and shorter lead times.

This work would be to explore, pilot, showcase and subsequently provide advice on the benefits and costs of alternatives to accessing the grid via the DNO, including battery storage and private wire networks. It is to be presented in a report including case studies with good practice from companies such as UPS (see Chapter 3).

Taskforce members: Energy UK lead, input from Cross River Partnership, Ofgem, Shell, SSE to SSE Enterprise and TfL

5.3 Share knowledge and maximise potential of legislation

Enabler 6: Publish guidance on charge point installation for both the public and private sectors
Building on the latest EV charging update to the TfL Streetscape guidance (March 2019) and a number of other new related guidance produced by others, TfL will revise and update its 2010 'Guidance for implementation of electric vehicle charging infrastructure'. This new document (to be published on TfL's website) would be a central source of information, serving as a practical guide to installing infrastructure and offering best practice. Aimed at both public sector (London Boroughs and others) and private sector, this guidance could include:

- Streetscape design principles, including accessibility and safety
- Criteria on site selection and design drawings for off- and on-street
- Guidelines and principles on charging hubs
- Town Planning and other consents considerations
- Installation checklist. Living Streets has also offered to contribute to this element
- Operation and maintenance considerations
- Safety, crime and disorder issues

Taskforce members: TfL lead, input from London Councils, RAC Foundation, SMMT and UKPN

Enabler 7. Publish guidance on EV infrastructure future-proofing to encourage investors
The purpose of this advice/guidance would be to help those interested in installing infrastructure to select the correct type of infrastructure, which will endure. The target audience for this guidance would therefore be charge point and infrastructure providers, procurement teams of charge points and other infrastructure, and any organisation (public or private) involved in financing or planning/installing EV infrastructure manufacturers. BEAMA will lead this work, and has proposed that the document includes:

- What future-proofing means
- Interoperability and interchangeability of charge points
- Different energy suppliers/other service providers
- Energy management systems
- Information on long-term energy infrastructure investments planned
- Different vehicles
- Data and data management services and software
- Access
- Cyber security

Taskforce members: BEAMA lead, input from TfL and UKPN

Image 23
Charging an electric vehicle

Enabler 8. Promote better standardisation of charge points and vehicles, interoperability of systems and data sharing
This enabler is intended to improve consumer experience and to support the rollout of the Automated and Electric Vehicles Act. It covers issues that have been highlighted by electric vehicle users where the public sector may need to facilitate solutions with industry partners or seek to regulate.

These issues include reliability standards, standardisation of connectors on charge points, cable types and locations on vehicles and payment platforms. It also covers an emerging priority regarding the attainment of charge point data and the delicate interplay between the public and private sector in an emerging market. In particular, how to ensure the public sector is kept fully informed of the installation of charge points, including the location and use patterns of charge points, without compromising commercially sensitive information.

The GLA, with support from taskforce members, will facilitate discussions with charge point operators and lead an exercise to collate data on the London Datastore so that it can support future planning by the public and private sectors.

Taskforce members: GLA to lead, input from Federation of Small Businesses, FTA, London Councils, OLEV, SMMT, TfL, and UKPN

5.4 Charter of commitments

The delivery plan sets out actions for the near term to ensure that the availability of publicly accessible charging infrastructure will no longer be a barrier to, and in fact will help accelerate the switch to EVs towards 2025.

A number of new cross-industry initiatives have been launched and multiple commitments have been made to support the switch to EVs and implementation of charging infrastructure in London. The taskforce welcomes these actions and examples are set out in Table 10.

However, in order to meet the likely scale of charging infrastructure required in London, further action that goes beyond the list in Table 11 is needed. The taskforce encourages other industry players/delivery partners to make their own pledges, aided by the findings contained in this report.

Table 10: Commitments on EVs

Company	Commitments
Addison Lee	Addison Lee Group aims to have a zero-emissions capable fleet by 2022[87]
British Vehicle Rental and Leasing Association (BVRLA)	Has launched a 'plug-in-pledge' to encourage its members' EV fleet size to grow from 50,000 in 2018 to 720,000 by 2025[88]
Chestertons	Will replace its entire fleet of around 60 company cars with EVs that produce no emissions, with the first 30 vehicles hitting the streets in July[89]
Clean Van Commitment	Launched its pledge to move to zero emission vans in cities by 2028[90]
DriveNow	DriveNow's fleet in London is already 18% electric, and they plan to grow this to 50% by 2025[91]
GLA group	Will work towards: All cars in GLA group support fleets being ZEC by 2025 at the latest; all newly purchased or leased cars and vans (less than 3.5 tonnes) in GLA group fleets to be ZEC from 2025; and the entire GLA fleets moving to zero emission by 2050[92]
Honda	Has committed to only sell EVs in Europe by 2025[93]
IKEA	Aims for 100 per cent of home deliveries by EVs (or other zero-emission solutions) by 2025, with an aim of 25 per cent by 2020[94]
Jaguar Land Rover	Commits that from 2020 all new models will be EVs[95]
John Lewis Partnership	Commits to creating a zero-carbon fleet by 2045[96]
Mazda	Will only produce BEVs and PHEVs by 2030[97]
Mitie	Commits to 20 per cent of its small van and car fleet to be electric by 2020[98]
Nissan	Aims to sell one million EVs a year by 2022 and develop eight new BEVs[99]
Optimise Prime	Launched to trial commercial EVs – involves Hitachi Vantara, UK Power Networks, Centrica, Uber, Scottish and Southern Electricity Networks, Hitachi Europe and Hitachi Capital Vehicle Solutions[100]
SEAT	Aims to develop six EV models by 2021[101]
Uber	Aims for all cars using the app to be fully electric in London in 2025, with the 20,000 drivers upgrading to EVs by the end of 202[102]
UPS	Over 30 per cent of UPS's central London fleet, based in Kentish Town, is now electric. The company has recently deployed a world-leading power supply infrastructure solution and is developing state of the art vehicle solutions to enable electrification of the entire Kentish Town delivery fleet[103]
Volkswagen	Will launch 70 BEVs by 2028 and expects 40 per cent of sales to be EVs by 2030[104]
Vattenfall	Commits to replacing its whole car fleet with EVs by 2022 (globally 3,500 vehicles)[105]
Volvo	Has committed to making every new car model launched from 2019 onwards electrically powered in part, and for up to 50 per cent of all sales to be fully electric cars by 2025[106]
Zipcar	Zipcar UK aims to transition to a fully electric fleet by 2025. It has started that process with the launch of 325 fully electric e-Golfs which, in only the first 9 months, have already been used by over 15,000 Londoners

Table 11: Commitments on charging infrastructure

Company	Commitments
BP Chargemaster	BP Chargemaster will install 400 ultra-fast (150kW) chargers on BP forecourts by the end of 2021, with the rollout beginning in summer 2019. In Greater London, this will include at least 20 ultra-fast chargers on 10 BP forecourts by the end of 2021, in addition to around 100 rapid 50kW chargers that it already operates within and around the M25[107]
ChargePoint	ChargePoint commits to delivering the hardware and software solutions for at least one rapid charging hub, in addition to the 5 public rapid charging stations it already operates in central London[108]
DPD	Has committed to open a network of eight all-electric micro depots across London (the first of these, DPD Westminster, opened in 2018[109]), using a range of different EVs for final mile delivery and trunking[110]
EDF Energy and Nuvve	Will install 1,500 vehicle-to-grid charge points in the UK[111]
GRIDSERVE	To build a UK-wide network of more than 100 Electric Forecourts for rapid charging[112]
IKEA	To provide access to charge points across all IKEA Group touchpoints (such as stores, office, and distribution centres) by 2020[113]
London Boroughs	Committed to installing over 1,700 slow and fast charge points by the end of 2019 (as part of the GULCS project) and providing 20 potential sites for new rapid charge points[114]
Morrisons, in partnership with ChargePoint Services	Will install 100 rapid chargers across supermarkets in 2019 with 17 being installed in London. These will form part of the GeniePoint Network[115]
Renewable Energy Association (REA)	The REA, whose EV sector group represents over 75 companies manufacturing, installing, operating and financing EV charging infrastructure across the UK, commits to advancing 'interoperability' across public charging networks. Greater interoperability means easier access to charging infrastructure for consumers and fleets. The REA commits to holding workshops for the industry to facilitate this[116]
Shell	Shell intends to extend its electric vehicle charging service, Recharge, to approximately 30 Shell forecourts in the Greater London Authority area by the end of 2019, as part of a wider national roll out. This will include a mixture of 50kW and 150kW charge points. Beyond this, Shell plans to further increase its UK network of charge posts substantially in and around London during 2020[117]
Source London	Will grow its network of slow to fast chargers from 1,000 to 2,000 charge points by the end of 2020. This includes 100 22kW charge points, primarily in central London[118]
Tesco	In partnership with Volkswagen, will install 7kW charge points (usage will be free) and rapid charge points for 2,500 charging bays at 600 stores by 2020[119]
TfL	Will have installed 300 rapid charge points by the end of 2020
Vattenfall	Commits to installing in excess of 1,500 InCharge public charge points in the UK by the end of 2020[120]

87 Source: Addison Lee
88 www.bvrla.co.uk/resource/bvrla-pledges-to-rapidly-increase-plug-in-vehicle-take-up.html Accessed February 2019
89 Source: Chestertons
90 www.globalactionplan.org.uk/clean-van-commitment-signatories Accessed February 2019
91 Source: DriveNow
92 www.london.gov.uk/sites/default/files/mayors-transport-strategy-2018.pdf
93 www.hondanews.eu/eu/en/cars/media/pressreleases/162328/geneva-international-motor-show-20191 Accessed April 2019
94 www.ikea.com/us/en/about_ikea/newsitem/091318-IKEA-group-zero-emissions-targets-home-delivery-2020# Accessed February 2019
95 www.jaguarlandrover.com/news/2017/09/every-jaguar-and-land-rover-launched-2020-will-be-electrified Accessed April 2019
96 www.edie.net/news/6/John-Lewis-Partnership-targets--net-zero--operational-carbon-emissions-by-2050/ Accessed April 2019
97 www2.mazda.com/en/publicity/release/2018/201810/181002a.html Accessed February 2019
98 https://news.mitie.com/news/mitie-reinforces-its-electric-vehicle-pledge-by-signing-up-to-the-clean-van-commitment-and-achieving-go-ultra-low-company-status Accessed February 2019
99 http://nissaninsider.co.uk/nissan-aims-sell-1-million-electrified-vehicles-year-2022/
100 http://news.ssen.co.uk/news/all-articles/2018/november/optimise-prime/ Accessed February 2019
101 www.seat-mediacenter.com/newspage/allnews/company/2019/SEAT-will-launch-six-electric-and-plug-in-hybrid-models-and-develop-a-new-platform-in-Spain-for-electric-vehicles.html Accessed April 2019

102 www.uber.com/gb/en/u/ride-journey-to-electric Accessed February 2019
103 Source: UPS
104 www.volkswagen-newsroom.com/en/press-releases/volkswagen-plans-22-million-electric-vehicles-in-ten-years-4750 Accessed February 2019
105 Source: Vattenfall
106 https://group.volvocars.com/news/electrification/2018/volvo-aims-for-half-of-our-sales-from-2025-to-come-from-fully-electric-cars
107 Source: BP Chargemaster
108 Source: Chargepoint
109 www.dpd.co.uk/content/about_dpd/press_centre/news.jsp Accessed February 2019
110 Source: DPD
111 www.edfenergy.com/media-centre/news-releases/edf-energy-and-nuvve-corporation-announce-plans-install-1500-smart Accessed February 2019
112 www.gridserve.com/post/breaking-news-1 Accessed April 2019
113 www.ikea.com/us/en/about_ikea/newsitem/091318-IKEA-group-zero-emissions-targets-home-delivery-2020 www.ikea.com/us/en/about_ikea/newsitem/091318-IKEA-group-zero-emissions-targets-home-delivery-2020# Accessed February 2019
114 Source: London Councils
115 www.edie.net/news/6/Morrisons-to-install-100-rapid-EV-chargers-in-2019 Accessed April 2019
116 Source: BP Chargemaster
117 Source: Shell
118 Source: London/BPL
119 www.bbc.co.uk/news/business-46386858 Accessed February 2019
120 Source: Vattenfall

Glossary

Alternating Current (AC) Charging
An AC charge point supplies the EV's on-board device (usually called the charger) which in turn converts the AC power to direct current (DC), allowing the battery to be charged. The on-board charger controls the charging process and may put a limit on the rate of charge (this limit will depend on the EV).

Battery electric vehicle (BEV)
A vehicle powered by a battery, which can be plugged into an electricity source to recharge. Also known as 'pure' or '100 per cent' EVs, they have zero tailpipe emissions.

Car club
A short-term car rental service that allows members access to cars parked locally for a per-minute, per-hour or per-day fee.

Car sharing/shared cars
Cars that are not owned by the people who use them to travel. This includes car clubs, taxis and PHVs.

Central, Inner and Outer London
These definitions can vary depending on the context in which they are being used. For the purposes of analysis (and future monitoring), this delivery plan has used the following definitions:

- Central London: an area broadly equivalent to the Central Activities Zone (CAZ), as defined by the London Plan
- Inner London (excluding central London, as appropriate): the boroughs of Camden, City of London, Hackney, Hammersmith & Fulham, Haringey, Islington, Kensington & Chelsea, Lambeth, Lewisham, Newham, Southwark, Tower Hamlets, Wandsworth and the City of Westminster, as defined by the Office for National Statistics
- Outer London: the boroughs of Barking and Dagenham, Barnet, Bexley, Brent, Bromley, Croydon, Ealing, Enfield, Greenwich, Harrow, Havering, Hillingdon, Hounslow, Kingston upon Thames, Merton, Redbridge, Richmond upon Thames, Sutton and Waltham Forest, as defined by the Office for National Statistics

Charge point connector
The socket on the charge point through which the EV is connected to the electrical supply using a charging cable, in order to charge the EV's battery.

Charge point device
A single freestanding or lamppost/wall-mounted structure offering one or more connectors suitable for charging EVs.

Congestion Charge
The charge applied to vehicles entering a defined area of central London, introduced to reduce congestion. Some vehicles are currently exempt from the Congestion Charge.

Direct Current (DC) Charging
A DC charge point directly charges the battery and the rate of charge is controlled by the EV's battery management system.

Distribution Network Operator (DNO)
A company licensed to distribute electricity in the UK. They are responsible for distributing energy and maintaining the electrical supply system.

Electric vehicle (EV)
A vehicle that uses an electric motor for propulsion, comprising ones that run solely on batteries, as well as plug-in hybrids (PHEVs) that have an attached petrol or diesel engine to power the battery engine.

Fast charge point
A charge point that provides power from 7kW to 22kW AC, and typically fully charges an EV with a 22 kWh battery in three to four hours. Common fast connectors are a tethered Type 1 or a Type 2 socket (via a connector cable supplied with the vehicle).

GIG economy
A labour market characterised by the prevalence of short-term contracts or freelance work, as opposed to permanent jobs.

Healthy Streets Approach
The Mayor and TfL's approach to prioritising people and their health in decision-making to create a healthy, inclusive and safe city for all. The approach makes London a more attractive place to walk, cycle and use public transport, and reduces the dominance of motorised transport.

Heavy goods vehicle (HGV)
A motor vehicle (such as a truck or lorry) with a maximum gross vehicle weight of more than 3.5 tonnes.

Hydrogen fuel cell
A cell that acts like a constantly recharging battery, electrochemically combining hydrogen and oxygen to generate power. Vehicles powered by hydrogen fuel cells produce only water and heat as by-products.

Internal Combustion Engine (ICE)
An engine that generates motive power by burning petrol, diesel, oil, or other fuel with air inside the engine, the hot gases produced being used to drive a piston or do other work as they expand.

Light goods vehicle (LGV)
A motor vehicle (such as a van) with a gross vehicle weight of less than 3.5 tonnes.

LoCITY
An industry-led programme helping the freight and fleet sector lead the way in improving air quality and reducing carbon emissions.

London Environment Strategy
The Mayor's environment strategy for London.

London Plan
The Mayor's spatial development strategy for London.

Londoners
Permanent and temporary residents of London and, where also applicable, commuters from outside London, visitors and tourists.

Low Emission Zone (LEZ)
A charging zone across most of Greater London for vehicles that do not meet emission standards for particulate matter.

Mayor's Transport Strategy
The strategy that sets out the Mayor's policies and proposals to reshape transport in London over the next two decades.

Plug-in hybrid electric vehicle (PHEV)
An EV that combines a small plug-in battery with an internal combustion engine (ICE). These typically use the battery to drive the wheels at low speeds, or for a limited range, with the petrol- or diesel-fuelled ICE used for greater speeds and longer distances.

Private Hire Vehicle (PHV)
Any vehicle that seats up to eight passengers and is available for hire with a driver. These vehicles require a PHV licence to operate in London.

Rapid chargers
Rapid charge points are one of two types – AC or DC. Current rapid AC charge points are rated at 43 kW, while most rapid DC charge points provide 50kW power. Both will charge the majority of EVs to 80 per cent in around 30–60 minutes (depending on battery capacity). Tesla Superchargers are also rapid DC charge points and charge at around 120kW.

Rapid AC charge points use a tethered Type 2 connector, and rapid DC charge points are fitted with a tethered CCS, CHAdeMO or Tesla Type 2. The rapid charging protocol is dictated by the vehicle manufacturer, therefore different vehicles require different rapid connectors. So rapid charge points are usually deployed with at least two and sometimes all three connectors (referred to as multi-standard charge points).

Slow chargers
A charge point that provides power from around 3kW AC. They typically take between six and 12 hours to fully charge a BEV with a 22kWh battery, or two to four hours to fully recharge a PHEV with a 7.6kWh battery. EVs charge on slow charge points using a cable that connects the vehicle to a three-pin or Type 2 socket.

Town centres
Places in London that provide access to a range of commercial, cultural and civic activities, including shopping, leisure, employment, entertainment, culture, and social and community facilities. Town centres are classified in the London Plan according to their existing role and function in light of characteristics such as scale, mix of uses, economic performance and accessibility.

Transport for London Road Network (TLRN)
Described in the GLA Act 1999 as the Greater London Authority Road Network, this is now known as the Transport for London Road Network. It comprises 580km of London's red routes and other important streets.

Ultra Low Emission Vehicle (ULEV)
Since 2009, OLEV has considered an ultra low emission vehicle to be a car or van that emits fewer than 75 grams of CO_2 from the tailpipe per kilometre driven, measured against the European test cycle. Recognising advancements in technology, from 2021 OLEV expects to define an ultra low emission vehicle as a car or van that emits fewer than 50 grams of CO_2 from the tailpipe per kilometre driven, measured against the relevant test cycle.

Ultra Low Emission Zone (ULEZ)
Charging zone in which vehicles that do not comply with emissions standards for air pollutants will be subject to a daily charge.[121]

Vision Zero
An approach to road danger reduction that works towards the elimination of road traffic deaths and serious injuries by reducing the dominance of motor vehicles on London's streets.

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

Zero Emission Zone (ZEZ)
A zone within which vehicles not capable of operating with zero-pollutant exhaust emissions are subject to road user charges (similar to ULEZ or LEZ) and/or other vehicle prohibitions or restrictions.

121 The Road to Zero: Next steps towards cleaner road transport, HM Government, 2018 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/739460/road-to-zero.pdf

Appendix A

Detailed modelling assumptions and approach

Overview

This section of the appendix provides the detailed assumptions behind the modelling outputs described in the delivery plan.

The purpose of this modelling was to quantify the sense of scale for EV charging infrastructure to 2025 based on feasible demand scenarios. Scenario development is an established technique, commonly used when exploring uncertain futures.

It should be noted, that for the purposes of the model, our scenarios have been limited to those linked to the sale of vehicles and demand for charging. We have not specifically modelled scenarios linked to different economic growth projections, or to societal or emerging technological trends.

Disclaimer
The following key points need to be considered regarding the modelling:

1. To date, the vast majority of EV adoption forecasts have been optimistic and inaccurate

2. A major factor is lack of supply. This has been due to the lag involved in making the transition to establishing the required manufacturing capacity. In addition, vehicle manufacturers for commercial reasons will not declare actual volumes, product mix or technology to be employed

3. Battery capacities have been increasing. While it is thought that this will now stabilise around an average of 40–50kWh, there are multiple offerings of greater capacity, including some potential mass market models

4. Charge points started at 3kW power and now machines with a theoretical output of 350kW are being tested. It is still unclear, however, what proportion of vehicles may be able to use these

5. There is significant uncertainty regarding future driver behaviour. Current low volumes, evolving vehicle and charging products and different charging locations mean that behaviour has not normalised as it has for diesel/petrol via a filling station.

It is against these uncertainties and others that the following modelling has been developed.

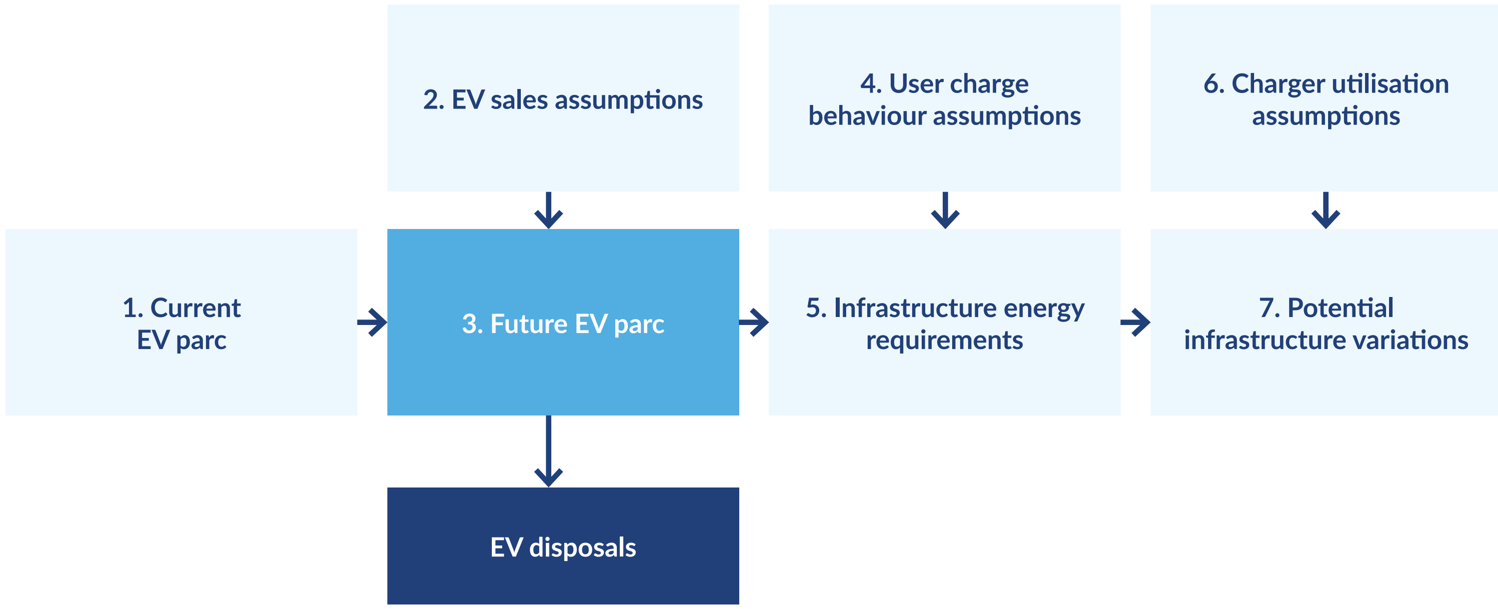


Figure 24
Basic conceptual model for EV infrastructure requirements toward 2025

Model structure
The model has seven key components, linked together as indicated in Figure 24, which also forms the structure of this section of the appendix. Infrastructure requirements are a function of infrastructure energy demand and charging utilisation. Infrastructure energy demand is a function of future EV 'parc' (the total number of vehicles) and charging behaviour. Future EV parc is a function of current parc, and future sales and disposals.

The basic underlying mechanics of the model are further captured in the equations in Figure 25. The calculation of the number of chargers required at any point in time is modelled as a function of the total energy demand for a given charger type, divided by the average energy supplied for that charger type.

1. Current EV parc

As of the end of 2017, there were approximately 3.1m vehicles registered in London, of which approximately 84 per cent were cars/LGVs and approximately four per cent were taxi/private hire. Only 14,000 of these were EVs (Figure 26).

For simplicity, the modelling has assumed that miles travelled for calculation of charging energy demand is based on miles travelled by vehicles registered in London. It is noted that two errors occur by using registration data as a proxy for the relevant vehicle parc. First, there are vehicles registered in London that do not operate in London (eg, registered to head office address). Second, there are vehicles registered elsewhere that travel into London.

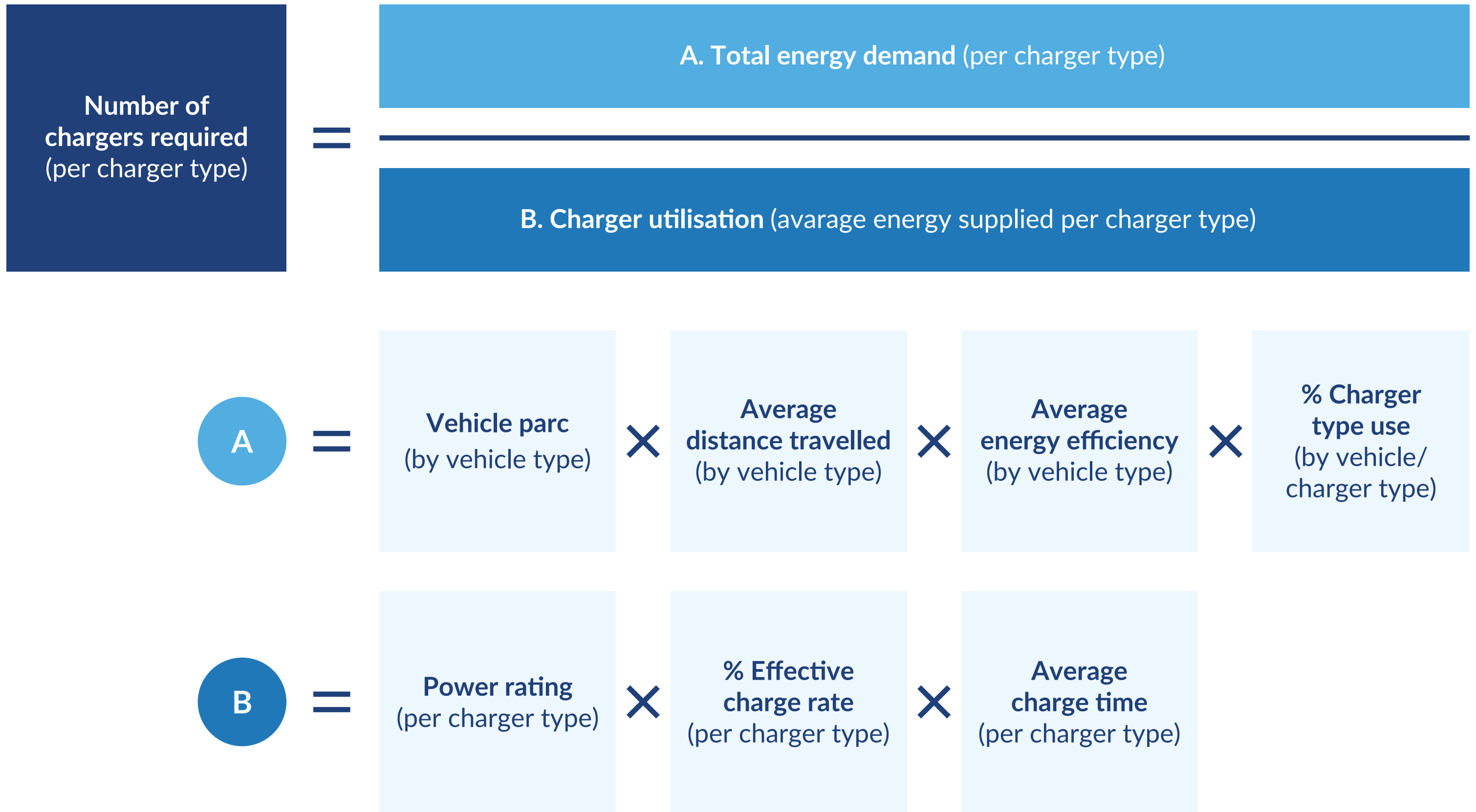


Figure 25
Basic logic-derived equations used in model for the number of chargers required to 2025

Analysis by TfL indicates that, on average, 74 per cent of the vehicle kilometres driven on London's roads are driven by London residents, while 62 per cent of vehicle kilometres driven by London's residents were on London's roads.[122] Therefore the scale of actual mileage travelled in London is 83 per cent of the baseline assumption (62 per cent/74 per cent). However, the modelling also assumes all vehicles are travelling average mileage for London, which is approximately 60 per cent of UK average mileage (12,500km/year[123] v 7,500km/year). When proportioned out, using London registrations only results in a roughly equivalent scale of mileage for use in calculation of estimating electricity demand.

2. EV sales assumptions

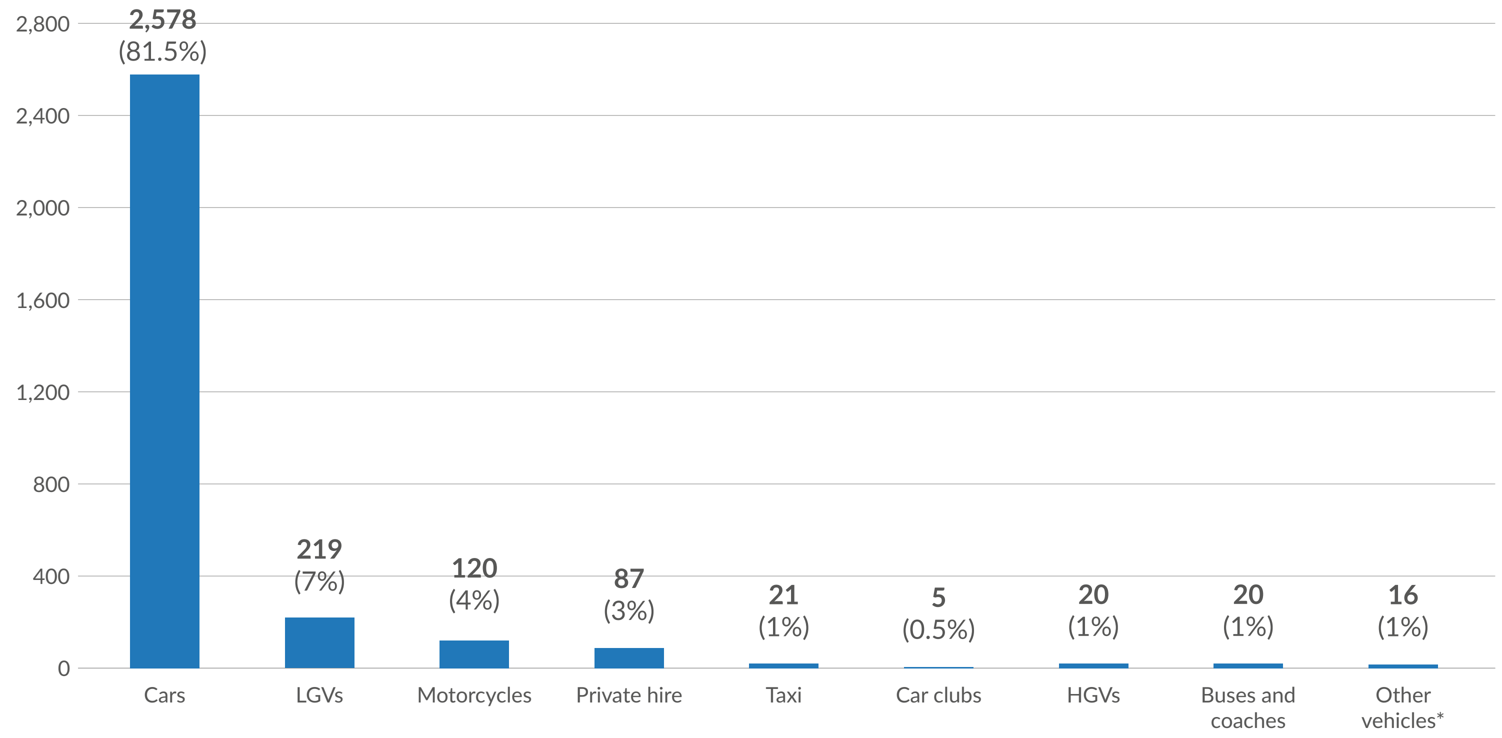
Future EV sales represent a key uncertainty and were identified as variable for high- and low-scenario development. This reflects considerable uncertainty in both the supply of, and demand for, EVs. Growth scenarios have been tested and developed in conjunction with taskforce and external industry experts.

For vehicle classes of private cars, LGVs and motorcycles, the low scenario represents slow growth of sales, increasing 10 per cent every year from the current low base to approximately six per cent in 2025. The high scenario represents a faster pace of growth, increasing 35 per cent every year to

122 Source for percentage of residents using London's roads from Analysis of Project Edmond data, City Planning, TfL

123 National Travel Survey, RAC, www.racfoundation.org/motoring-faqs/mobility#a24

Figure 26: London vehicle registrations, split by segment, 2017[124] (% total registrations in London)



represent approximately 30 per cent of sales by 2025, as indicated in Figure 27. This higher scenario aligns with Mayor's Transport Strategy modelled objectives for zero emission and a trajectory that meets the Department for Transport's Road to Zero objective of at least 30 per cent of sales to be zero emission by 2030.

These EV growth rate assumptions are applied to total vehicle sales (EV and ICE) from 2017,[125] assuming overall zero per cent annual vehicle sales growth. This is deemed reasonable as car sales have roughly plateaued in London in the years 2015–2017 (one per cent annual decline) after a period of greater annual growth since 2011.[126] This is also aligned with Mayor's Transport Strategy forecasts for population growth and road vehicle kilometres to 2025.

Adoption rates for taxi and PHV segments are determined separately.

* Other vehicles include rear diggers, lift trucks, rollers, ambulances, three wheelers and agricultural vehicles. Hackney carriages have been removed from this category to make up the 'taxi' category

124 DfT Statistics for London, Dataset VEH0105. An estimated 4,500 car club vehicles have been included in the data above, however this is not sourced from DfT

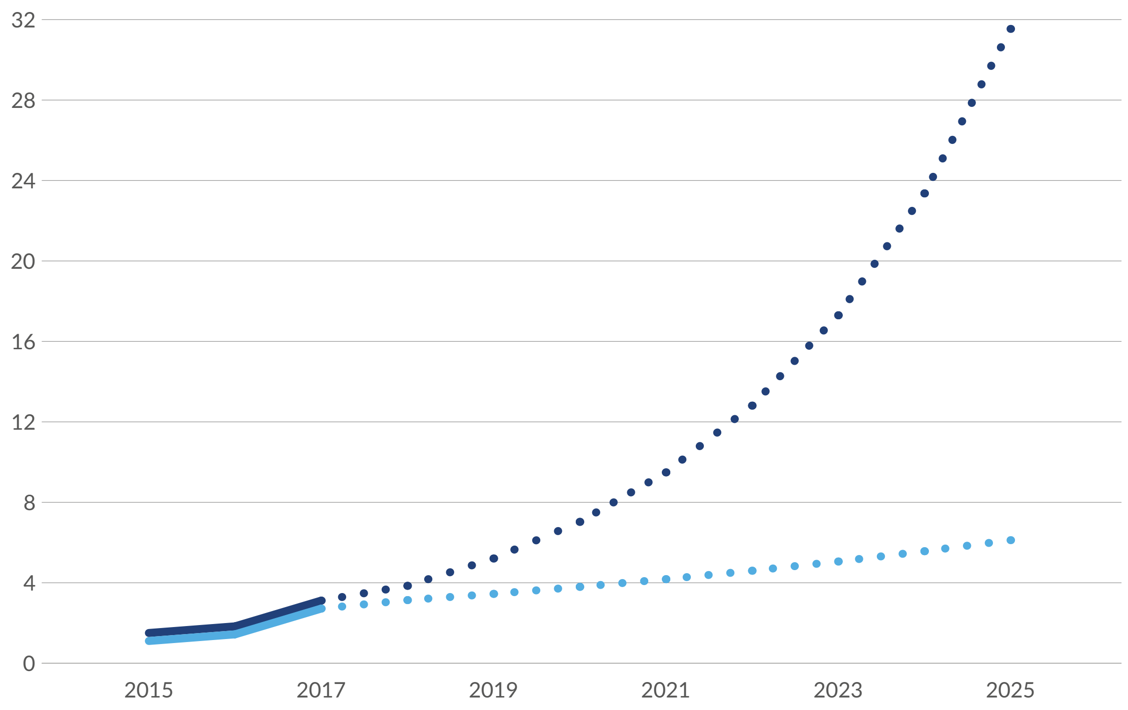
125 DfT Statistics for London, Dataset VEH0131

126 DfT Statistics for London, Dataset VEH0130

Figure 27
EV sales growth rate scenarios for cars, LGVs and motorcycles, percentage per year

High sales scenario: 35% year-on-year sales growth

Low sales scenario: 10% year-on-year sales growth



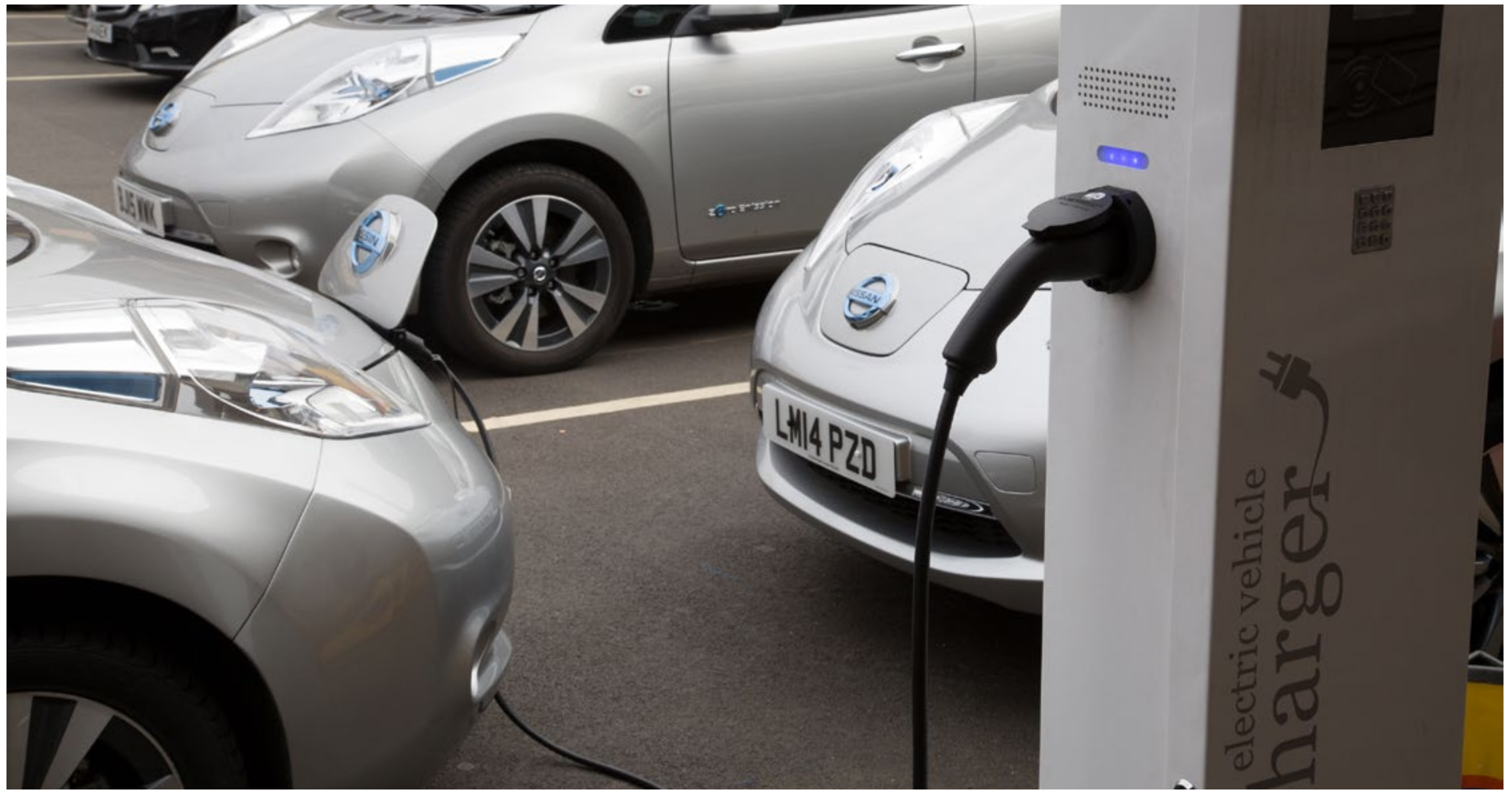


Image 24
EVs charging

This is as a result of the requirement for all new taxi registrations in London to be ZEC from 2018 and all new (under 18 months old) PHVs licensed for the first time to be zero emission from 2020.[127]

For taxis, stakeholder and industry information has indicated a reasonable assumption would be for 1,000 ZEC taxis per year from 2018–2025, with an additional 1,000 each year for 2019 and 2020.

The largest PHV fleet is Uber, which has stated an ambition for 20,000 of its drivers to switch to EVs by the end of 2021, and 100 per cent of its drivers to have done so by the end of 2025. This has been reflected as a gradual ramp-up in the high scenario along with an assumption that the rest of the PHV sector will have an annual turnover of one sixth of the fleet from 2021, and that its replacement fleet will comply with the new PHV emissions standards. In the low scenario, it is assumed that all PHVs will have a slower annual turnover of one eighth of the fleet to comply with the new PHV emissions standards for London. The low scenario also assumes that Uber reaches 50 per cent of its targeted ambition for 2025, feasibly due to more gradual driver uptake and/or limited vehicle supply.

For car clubs, an annual growth rate of 10 per cent has been assumed for the overall car club fleet. This reflects growth in the size of the fleet by close to 20 per cent annually over the past five years. While this is expected to continue, it is unclear to what extent. This, however, is not a sensitive input due to the relatively small starting base. The total number of new registrations is taken as the overall fleet increment plus the replacement rate of the existing fleet, assuming a five-year replacement period. The proportion of electric new car club vehicles has been modelled as 40 per cent in 2018, increasing to 100 per cent by 2025 in the high EV sales scenario, and 20 per cent, increasing to 80 per cent, in the low EV sales scenario. This is considered reasonable as the two largest car club fleets in London, Zipcar and DriveNow, have both added a significant number of EVs to their fleets in 2018.

127 TfL Taxi and Private Hire: tfl.gov.uk/info-for/taxis-and-private-hire/emissions-standards-for-phvs

Figure 28
EV new registrations growth scenarios for high-mileage user categories (taxis, PHVs and car clubs), percentage per year. Uber vehicles have been separated out to show what a large proportion of the expected PHV EV sales they represent

Car clubs
PHV (non-Uber)
PHV (Uber)
Taxis

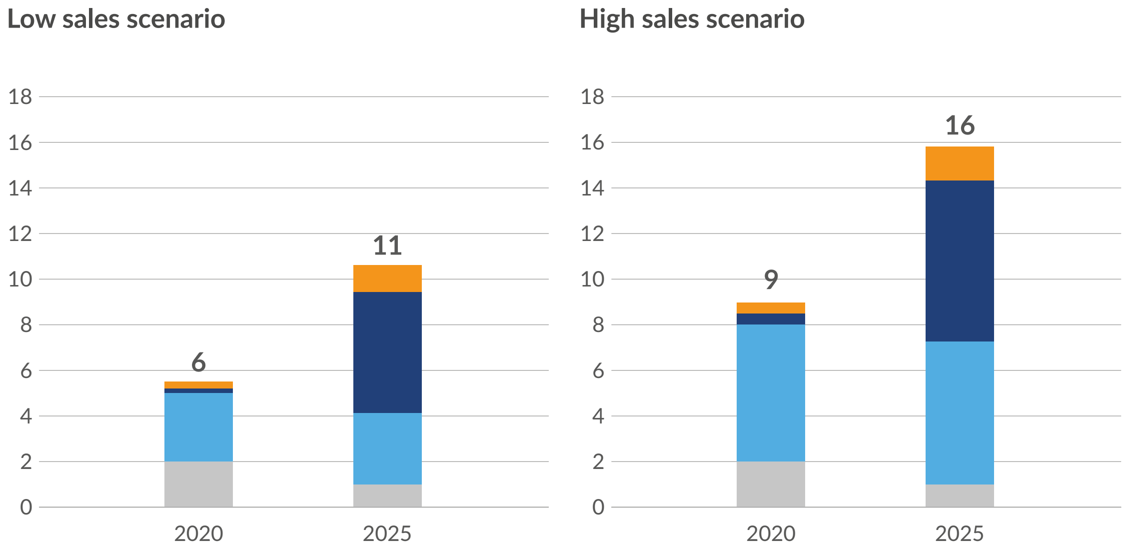
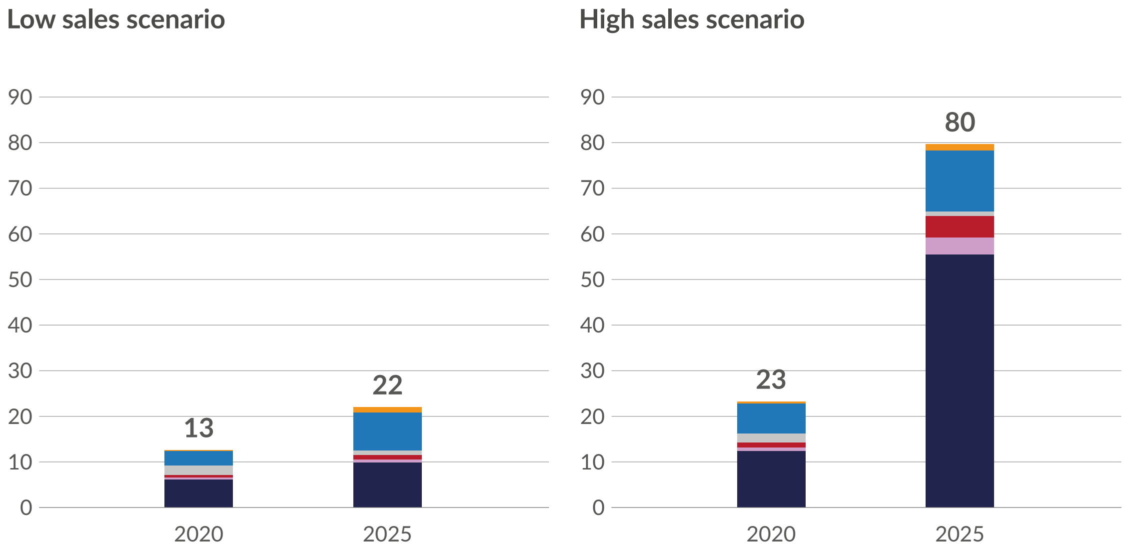
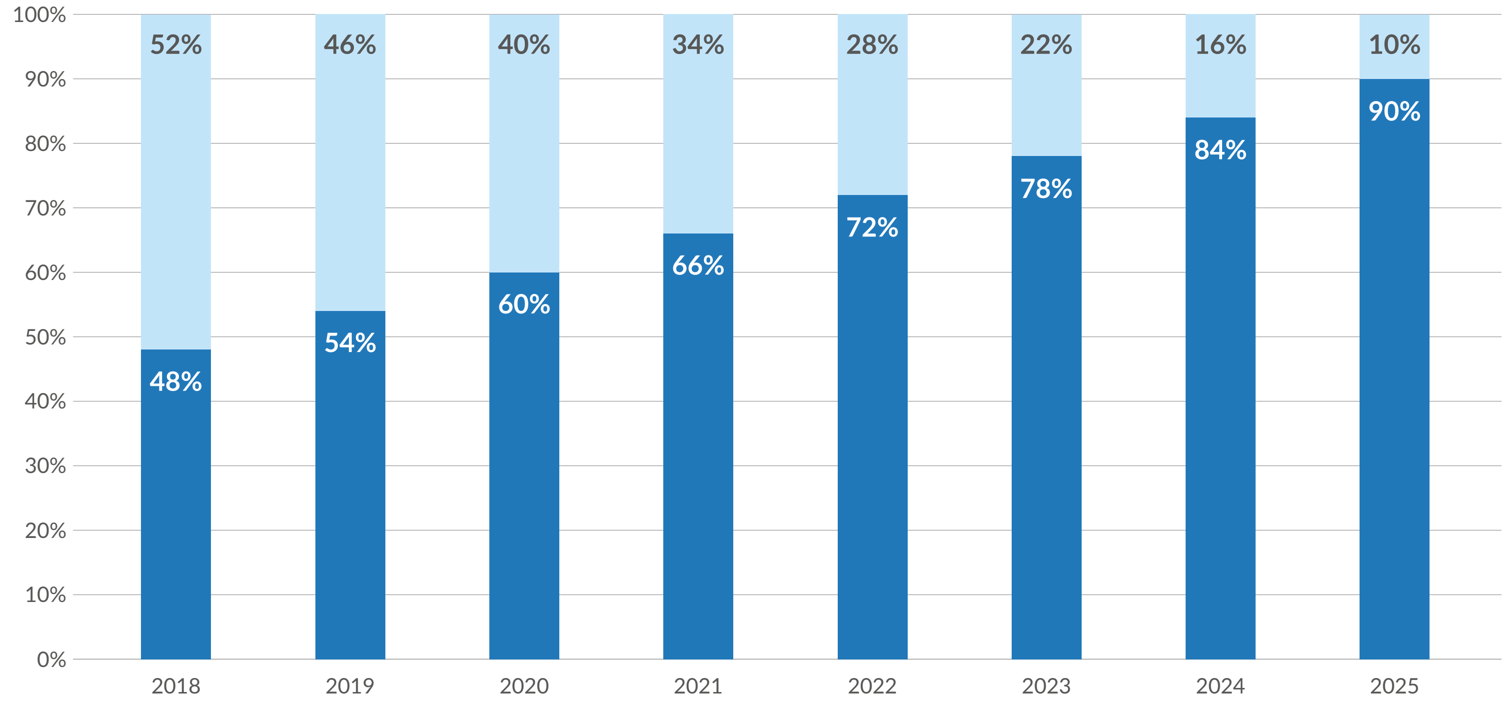


Figure 29
Scenarios of new registrations of EVs in London, by year, thousands

Car clubs
PHV
Taxis
LGVs
Motorcycles
Cars





A summary of taxi, private hire and car club EV new registrations is shown in Figure 28.

The combined EV sales scenarios are provided in Figure 29 and indicate a range of 20,000 to 77,000 EVs in 2025.

A further element of future EV sales modelling is consideration of the split between BEVs and PHEVs. This has been modelled to allow for different potential charging behaviours across the vehicle types. A simple assumption has been adopted, starting with the current split of 52 per cent PHEV to 48 per cent BEV.[128] The proportion of BEVs is then assumed to linearly increase to 90 per cent by 2025, based on the reasons outlined in Chapter 2.

The exception to this has been for taxis, Uber PHVs and car clubs. For Uber, all EVs are assumed to be BEVs (in line with Uber's public announcements). For taxis, the current available model is a PHEV, with initial deliveries of a BEV model later in 2019. The proportion of BEVs is therefore assumed to be 10 per cent in 2019, with a gradual increase to 90 per cent by 2025. For car clubs, the high EV sales scenario has assumed all new EVs will be BEVs and the low EV sales scenario has assumed 50 per cent of new EVs will be PHEVs.

As this is a potentially sensitive assumption for end outputs, it is revisited at the end of this appendix.

Figure 30
Modelled split of sales between BEV and PHEV for cars, motorcycles, LGVs and non-Uber PHVs in London

BEV
PHEV

128 PHEV and BEV split, SMMT data

Image 25
LEVC Taxi charging at rapid charge point

3. Future EV parc

The future EV parc is simply the cumulative sum of the annual EV sales to 2025. Figure 31 provides the modelled outcomes of EV parc and indicates a range of between approximately 130,000 and 330,000 EVs in 2025. For simplicity (and given the relatively short timespan of the modelling), no EV disposals have been incorporated into the model.

4. User charge behaviour assumptions

User charging behaviour is the second key uncertainty identified in the model and therefore has also been selected as a variable for scenario generation. As we remain at the early stages of EV adoption and behaviours are not yet established, a number of assumptions have had to be developed.

To make the assumptions contained in this appendix more insightful, the user groups have been split into three levels.

The first level divides by vehicle category:

1/ Cars and motorcycles

2/ Taxis and private hire vehicles

3/ LGVs

4/ Car clubs

The second level is based on what is assumed to be the most differentiating additional feature of each category.

For categories 1 and 2 this is access to off-street parking, which is the key enabler of private charging.

For category 3, different features reflecting likely charging differences have been used between:

- Depot-based fleets
- Private fleets (non-depot based) – delivery focused
- Private fleets (non-depot based) – service/trade focused

Car clubs (category 4) have been modelled uniformly (although there is some variance for type of powertrain – see below).

The third level relates to the vehicle's powertrain, where the difference in charging behaviour between PHEVs and BEVs is assumed to be significant.

To reflect the inherent uncertainty associated with user group behaviour, scenarios have been developed to reflect high and low potential usage range for different charger types.

Table 12 captures the input assumptions regarding proportion of charge time for each of the user groups. While there is a somewhat arbitrary nature in some assumptions, they are based on a set of reasoned principles, set out in Table 13.

5. Infrastructure energy requirements

Charger energy demand can be modelled by combining the vehicle parc/user charging behaviour scenarios and the assumptions on annual distance travelled and fuel consumption for the different vehicle categories provided in Table 14.

Table 15 provides the modelled output of electricity demand across the two sales scenarios. This is followed by Table 16, which provides the same modelled output data, but split per user subgroup and by the modelled split between publicly accessible and private charging. It indicates that, by volume of electricity, the taxi and private hire fleet, particularly those without off-street charging, is the dominant user group in the timeframe between now and 2025.

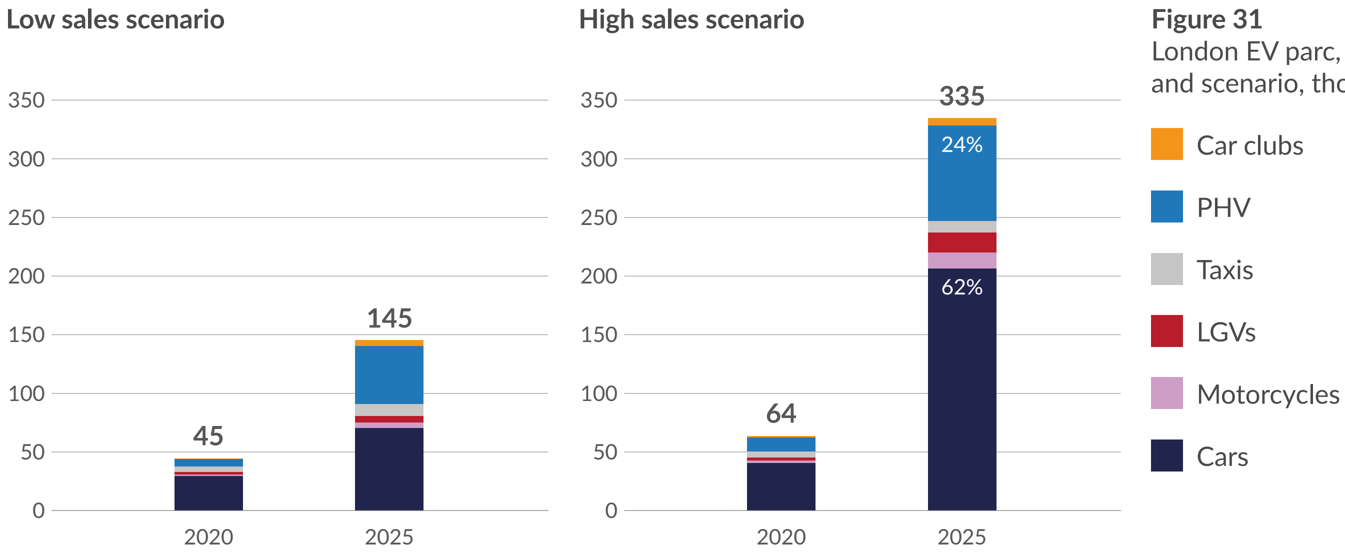


Figure 31
London EV parc, by year and scenario, thousands

Table 12: Proportion of energy attributed to charger category types, per user group and charging scenario, percentage per user group

Vehicle category	Basic archetype	% vehicle category	EV type	High private/ residential (%)				High destinaton /slow to fast (%)				High rapid charging (%)			
Cars and motocycles	Off-street parking	60%	PHEV[1]	95	0	5	0	85	0	15	0	90	0	10	0
			BEV	95	0	3	0	85	0	10	5	85	0	5	10
	No off-street parking	40%	PHEV[1]	20	75	5	0	20	50	30	0	20	50	30	0
			BEV	20	70	5	0	20	50	25	5	20	45	5	30
Taxis and private hire	Off-street parking	25%	PHEV[2]	90	0	0	0	80	0	5	15	80	0	0	20
			BEV	85	0	0	0	80	0	5	15	80	0	0	20
	No off-street parking	75%	PHEV[2]	0	70	0	0	0	70	5	25	0	50	0	50
			BEV	0	70	0	0	0	70	5	25	0	50	0	50
Vans	Depot-based fleets	33%	PHEV[1]	100	0	0	0	85	5	10	0	90	5	5	0
			BEV	95	0	0	0	85	0	5	10	80	0	0	20
	Private owned delivery	33%	PHEV[1]	80	15	5	0	70	15	15	0	55	20	20	5
			BEV	60	15	0	0	60	20	10	10	45	15	0	40
	Private owned trade	33%	PHEV[1]	70	25	5	0	60	25	15	0	45	40	10	5
			BEV	50	30	10	0	50	30	15	5	40	30	10	20
Car clubs	–	100%	PHEV[1]	0	60	20	0	0	40	30	30	0	40	20	40
			BEV	0	60	20	0	0	40	30	30	0	40	20	40

6. Charger utilisation assumptions

An assumption regarding average energy provided per charger is required to attempt linking energy demand to the scale of infrastructure chargers. Figure 32 indicates what may be considered a reasonable range of average utilisation by plug-in time. While maximum theoretical utilisation may be 24 hours per day, this is considered impractical and would be likely to involve unreasonable levels of queuing. The light-blue bar instead indicates what may be a reasonable upper bound utilisation. The hours for on-street residential are assumed higher than other charger types due to the nature of overnight charging. The navy bar indicates currently observed levels of average charger utilisation observed by TfL and Zero Carbon Futures (ZCF). The orange bars indicate the nominal utilisation assumptions adopted for the model. These are assumed to be higher than the currently observed levels

Table 13: Principles for user charging behaviour assumptions

1	The proportion of EV sales for those with access to off-street parking is assumed to be the same as the proportion of all vehicles that have access to off-street parking. ie, 60 per cent of EVs for private cars and motorcycles have off-street parking[129]
2	The proportion of EVs for taxis and private hires with access to off-street parking is assumed to be the same as the proportion of all taxis and private hires that have access to off-street parking. ie, 25 per cent of taxis and PHVs have off-street parking
3	Those with access to off-street parking will use home charging for the vast majority of charges, taxi/private hire will draw a slightly lower proportion due to their greater electricity requirements and absence of dedicated workplace chargers. ie, cars/motorcycles with off-street parking will draw 85–95 per cent of electricity needs from private (home/workplace) chargers, taxi/private hire 80–90 per cent
4	Depot-based LGVs will use depot charging for the vast majority of charges. For non-depot-based vehicles, service/trade vehicles will use a higher proportion of residential slow to fast chargers than delivery vehicles, owing to the longer average duration of their stops. ie, 80–100 per cent of charges are private for depot-based vehicles
5	Smaller batteries and ability for PHEVs to use petrol means a significant proportion of their energy requirements will continue to be provided by hydrocarbon fuels (eg, petrol/diesel). For taxis and private hire PHEVs, larger batteries, ability to take rapid charge and relative financial importance mean that a higher proportion will use electricity over petrol/diesel. ie, 30 per cent of distance travelled to be powered by electricity for private PHEV cars, motorcycles and LGVs, and 50 per cent for taxi/private hire PHEVs
6	Use of rapid chargers for PHEVs should reflect charging ability of PHEVs as many PHEVs cannot use rapid chargers. The exception is taxis and private hires where use of rapid chargers is possible and also more likely owing to high mileage and need for high vehicle availability. ie, for private PHEVs, assumed use is zero to five per cent and 10-50 per cent for taxis/PHVs
7	For public charging of BEVs, residential slow to fast or rapid chargers will dominate a large proportion of charging, destination slow to fast charger use will be more limited as this type combines length charge times with scenarios where the vehicle is typically parked for shorter periods of time (eg, 30–60-minute shopping trips). Taxis and private hire will use a higher proportion of rapid chargers than private vehicles owing to high mileage and need for high vehicle availability. ie, rapid use of five to 30 per cent for private car without off-street parking, 25–50 per cent for taxis/private hire
8	Car clubs will not charge privately but instead require a mix of either residential/destination slow to fast chargers or rapid charging. ie, zero per cent private charging, 30–60 per cent residential slow to fast, 20–30 per cent destination and 20–40 per cent rapid charging

129 For categories (1) and (2), the split of access to off-street parking is assumed proportional to our current understanding of access for such user groups based on an earlier study for private cars and insights provided by taxi and private hire user groups. This is a key assumption, which could vary outcomes significantly if one was to assume EV sales would disproportionately represent those with off-street parking, which would be a reasonable assumption where publicly available charging infrastructure is a significant barrier to adoption. However, given the purpose of the taskforce and delivery plan is to ensure that infrastructure is effectively not considered a barrier, this has been modelled as such

as current levels are considered underutilised. These numbers are also considered to be adequate for an economically sustainable commercial return on the infrastructure.[130]

As covered in Chapter 2 of the delivery plan, plug-in time is only one component of utilisation as, in many instances, the charge rate during the time plugged in will not equal the nominal charge rate of the charger. Given this, it is necessary to make assumptions on the effective average charge rate.

Using the same categories as Figure 31, Table 17 describes the effective charge rates used in the model and, combined with plug-in time assumptions, how this translates to energy supplied per charger per day. Rapid chargers have assumed a higher effective charge rate given that likely pricing structures will incentivise effective time use.

7. Potential infrastructure variations

The final component of the model provides potential scale of required infrastructure and builds on all previously developed assumptions within the model. Numbers are highly dependent on actual EV sales, actual user charging behaviour and actual utilisation levels. For this reason, they should not be treated as targets, but rather to provide a sense of scale for a number of 'what if' scenarios.

Figure 33 provides the range of modelled outputs for rapid chargers, Figure 34 for destination slow to fast and Figure 35 for residential slow to fast. Each of these charts provides modelled number of chargers for the different user behaviour scenarios (down the page), for two time periods 2020 and 2025 (across the page) and for low and high EV adoption scenarios (within each behaviour scenario/time period block).

Two coloured segments are provided to differentiate the charger demand associated with Uber and non-Uber to indicate the relative importance of this user group and their ambitions toward 2025.

130 Based on high-level calculations of current commercial pricing per kWh, infrastructure capital costs, some operational and maintenance allowance and 10-year payback periods

Table 14: Annual distance and energy consumption rate assumptions per vehicle category

Distance travelled per segment, km/year

Segment	Distance travelled	Comment
Cars	7,500	Calculated by dividing total London fleet vehicle kilometres travelled from Emissions Factor Toolkit (LAQM) by total London fleet (DfT)
Motorcycles	5,000	Calculated by dividing total London fleet vehicle kilometres travelled from Emissions Factor Toolkit (LAQM) by total London fleet (DfT)
Vans	15,000	Calculated by dividing total London fleet vehicle kilometres travelled from Emissions Factor Toolkit (LAQM) by total London fleet (DfT)
Taxis	45,000	Based on taxi survey data that drivers travel an average 70 miles per day (~110km) for an estimated 300 days per year
PHV	60,000	Provided by large PHV operator, includes personal distance travelled for an average full-time driver

Energy consumption rates per segment, kWh/km

Segment	Energy consumption	Rationale
Cars	0.18	Consumption ranges from 0.13-0.23, with 0.18 selected as a mid-range reference point[131]
Motorcycles	0.06	Consumption ranges from 0.05-0.08 for models of 'Zero Motorcycle'[132]
Vans	0.25	Consumption ranges from 0.18-0.28, with 0.25 selected as a representative mid-range reference point
Taxis	0.22	Calculation estimates for the LEVC ZEC taxi based on quoted EV range and assumptions about total/usable battery capacity. Expected that given size, weight and passenger loading, taxis will be closer to LGVs (vans) than cars
PHV	0.20	Selected as an interim value between private cars and taxis as PHVs are skewed towards Multi-Purpose Vehicles (MPVs)

131 TfL analysis of popular models
132 spritmonitor.de

Table 15: Total electricity demand scenarios by vehicle category, GWh per year

	2020		2025	
	Low sales	High sales	Low sales	High sales
PHV	71	141	544	908
Taxis	28	28	69	69
Cars	26	37	74	232
LGVs	5	8	18	56
MCs	0	0	1	3
Car clubs	3	3	11	15
Total	134	218	717	1,283

Table 16: Total electricity demand by key sales and public/private charging scenario, split per user subgroup, GWh per year

		2020		2025	
Vehicle category	Basic archetype	Low sales and high private	High sales and high public	Low sales and high private	High sales and high public
Cars and motocycles	Off-street parking	16	22	45	141
	No off-street parking	11	15	30	94
Taxis and private hire	Off-street parking	25	42	153	244
	No off-street parking	74	127	459	733
Vans	Depot-based fleets	2	3	6	18
	Private owned delivery	2	3	6	18
	Private owned trade	2	3	6	18
Car clubs	–	3	3	11	15
Total		134	217	717	1,282

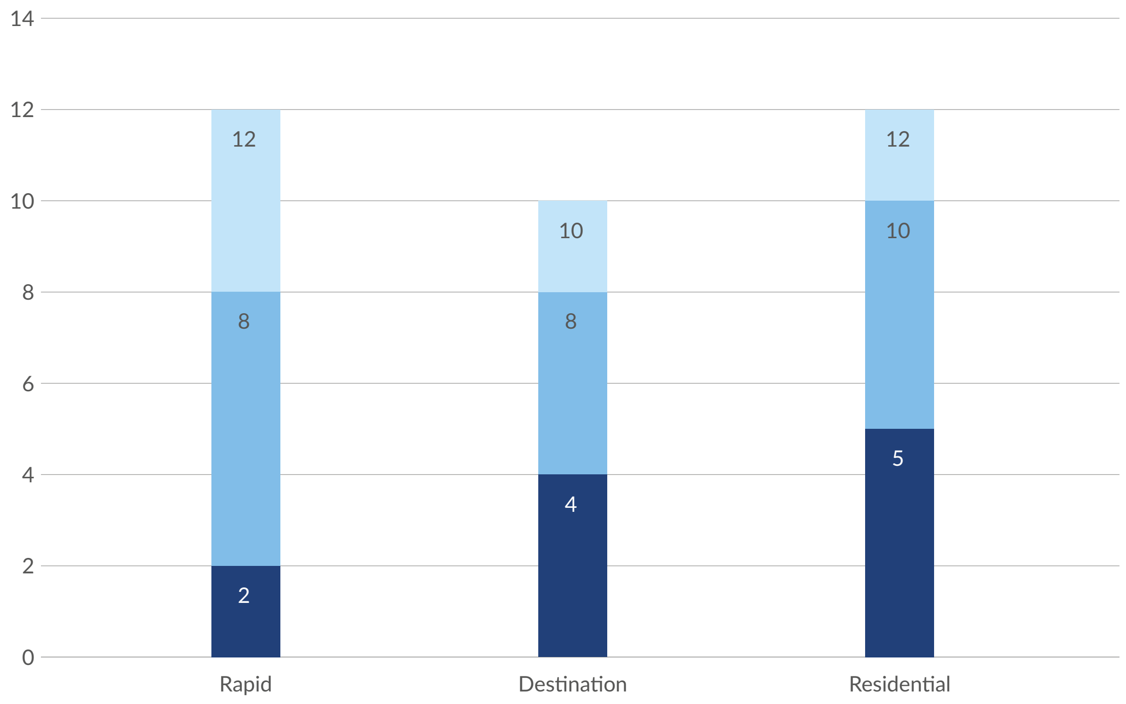


Figure 32
Range of average utilisation plug-in time per charger type, hours per day

Assumed max average utilisation

Value used in model

Empirical Zero Carbon Futures (ZCF) observations of current UK infrastructure

Table 17: Assumed effective charge rates per charger type and average energy per day

Charger type	Rapid	Destination slow to fast	Residential slow to fast
Assumed capacity kW	50	11	7
Effective charge rate – observed Source: ZCF and TfL	50%	23%	19%
Effective charge rate – modelled Assumed to increase over time	75%	50%	50%
Average energy per day – modelled kWh/day	150	44	32

Figure 33
Modelled number of rapid chargers by charge behaviour and sales scenario for 2020 and 2025

Low sale:

- Uber
- Non-Uber

High sale:

- Uber
- Non-Uber

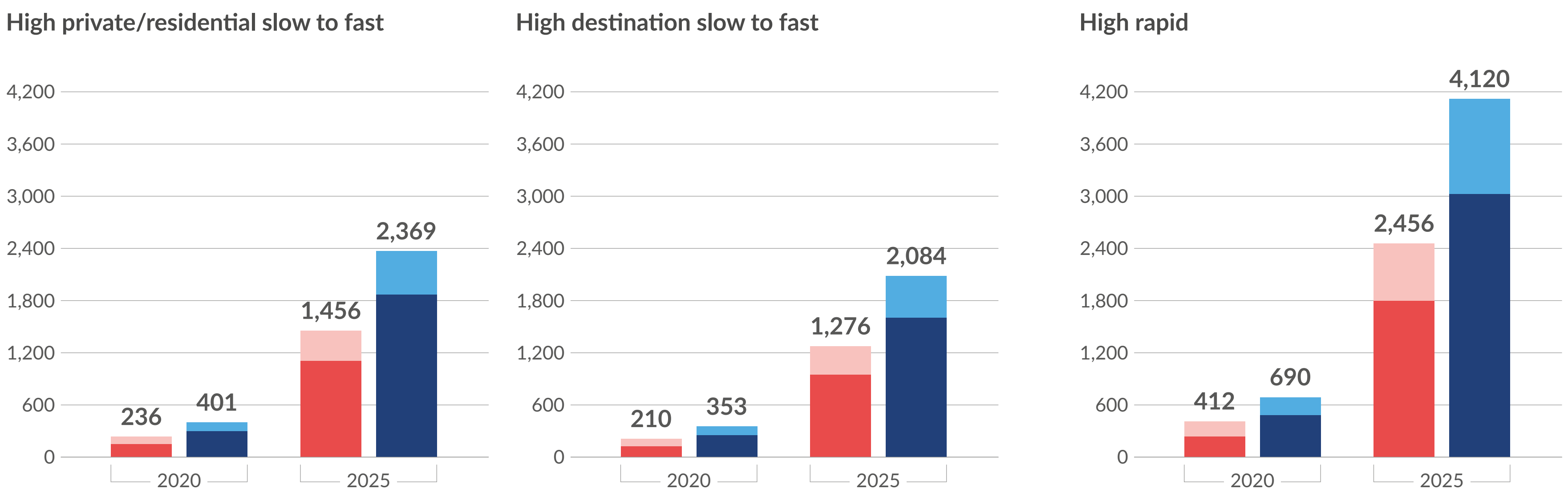


Figure 34
Modelled number of destination slow to fast by charge behaviour and sales scenario for 2020 and 2025

Low sale:

- Uber
- Non-Uber

High sale:

- Uber
- Non-Uber

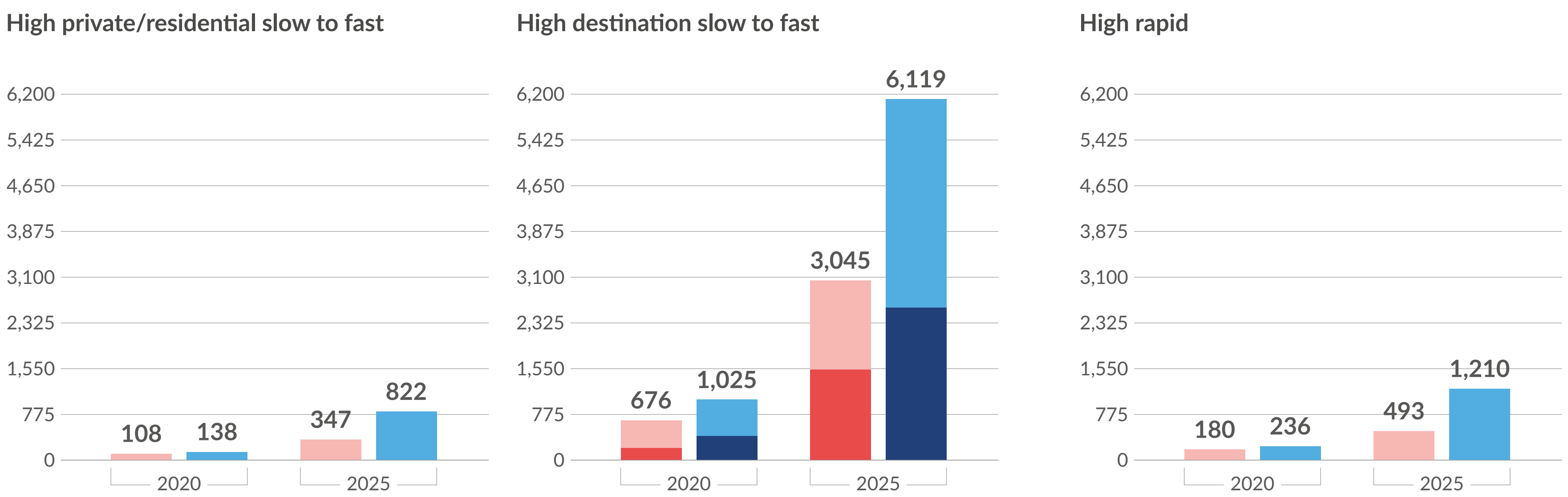


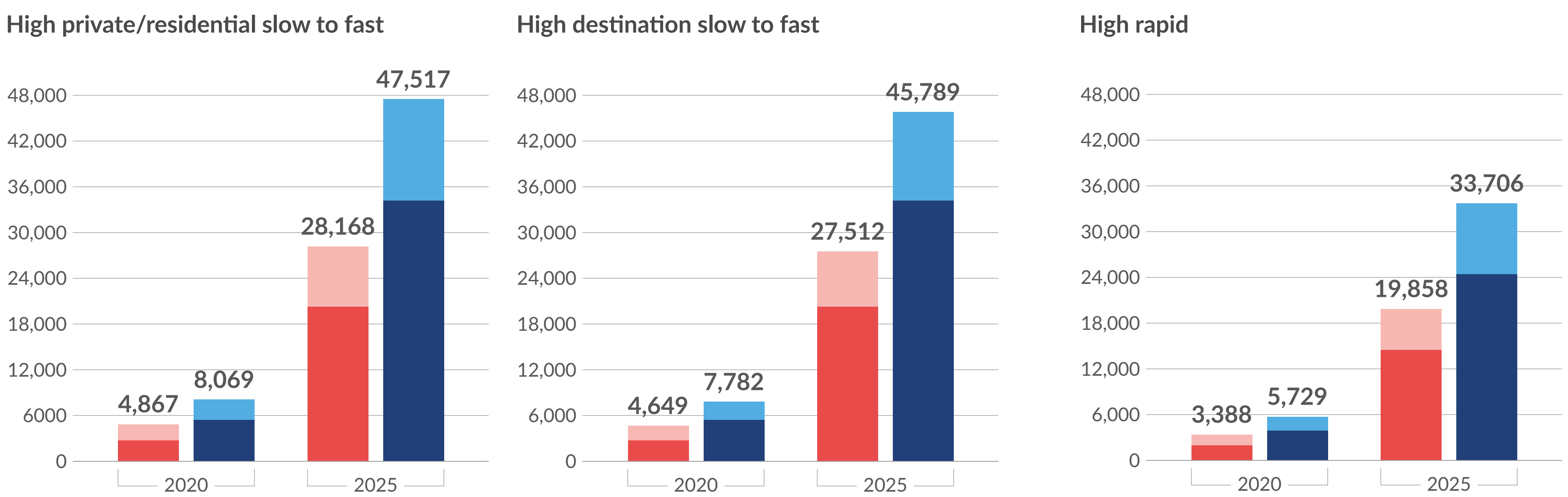
Figure 35
Modelled number of residential slow to fast by charge behaviour and sales scenario for 2020 and 2025

Low sale:

- Uber
- Non-Uber

High sale:

- Uber
- Non-Uber



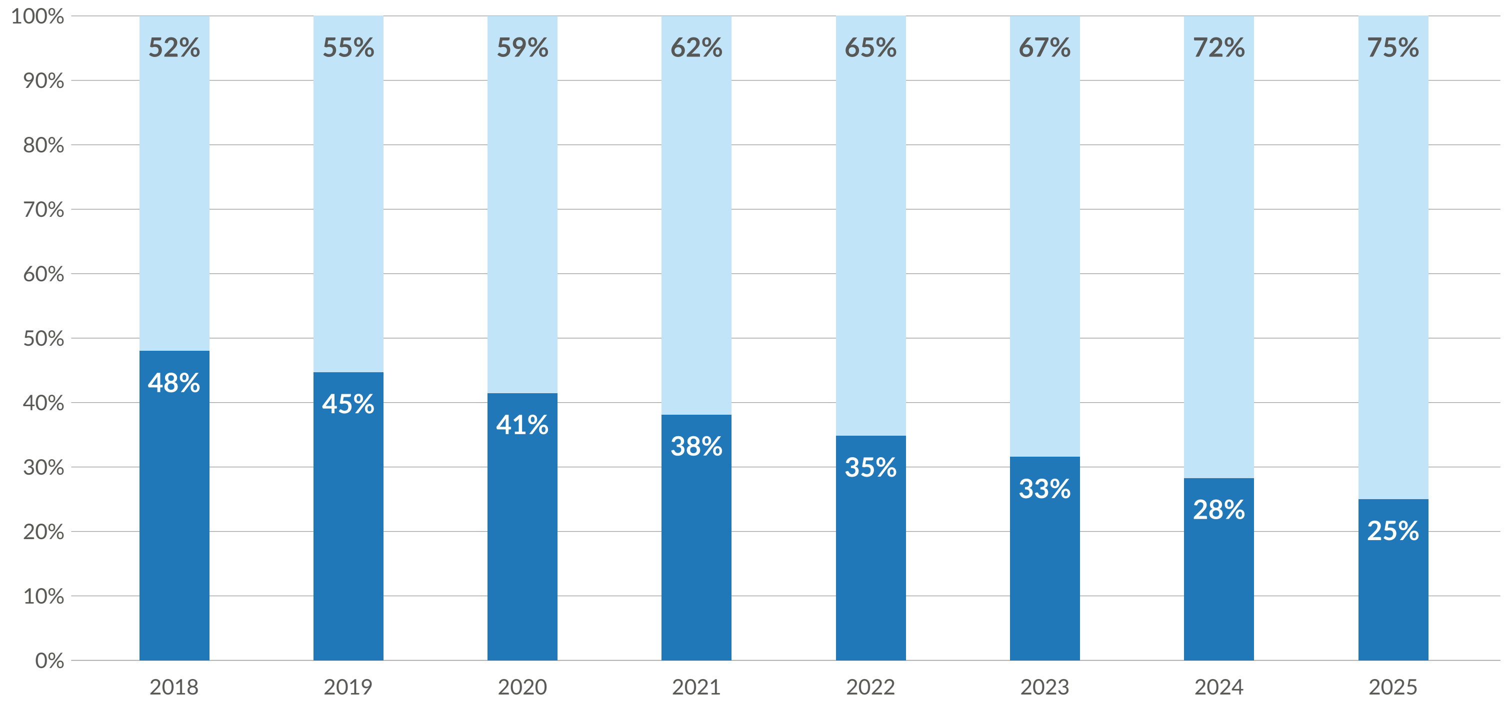


Figure 36
Alternative projection between PHEV and BEV

BEV

PHEV

Sensitivity testing: BEV v PHEV

As indicated in the description of component 2 of this model (EV sales assumptions), the split between BEV and PHEV sales is a potentially sensitive input and is tested in the section below for impact on end potential infrastructure variations. The Uber EV fleet was earlier assumed to be 100 per cent BEV. In this scenario testing, the EV adoption assumptions are kept but only 50 per cent are assumed to be BEVs.

As can be seen in Figures 37, 38 and 39, the impact of this change is significant, indicating a potential reduction in the need for rapid and residential on-street chargers of the order of 30–40 per cent. This is due to PHEVs' lower use of rapid chargers and lower overall electricity demand due to the significant proportion of distances travelled using the traditional combustion engine.

Image 26
EV charge point connector in use

Figure 37
Modelled number of rapid chargers by charge behaviour and sales scenario for 2020 and 2025

Low sale:
- Uber
- Non-Uber

High sale:
- Uber
- Non-Uber

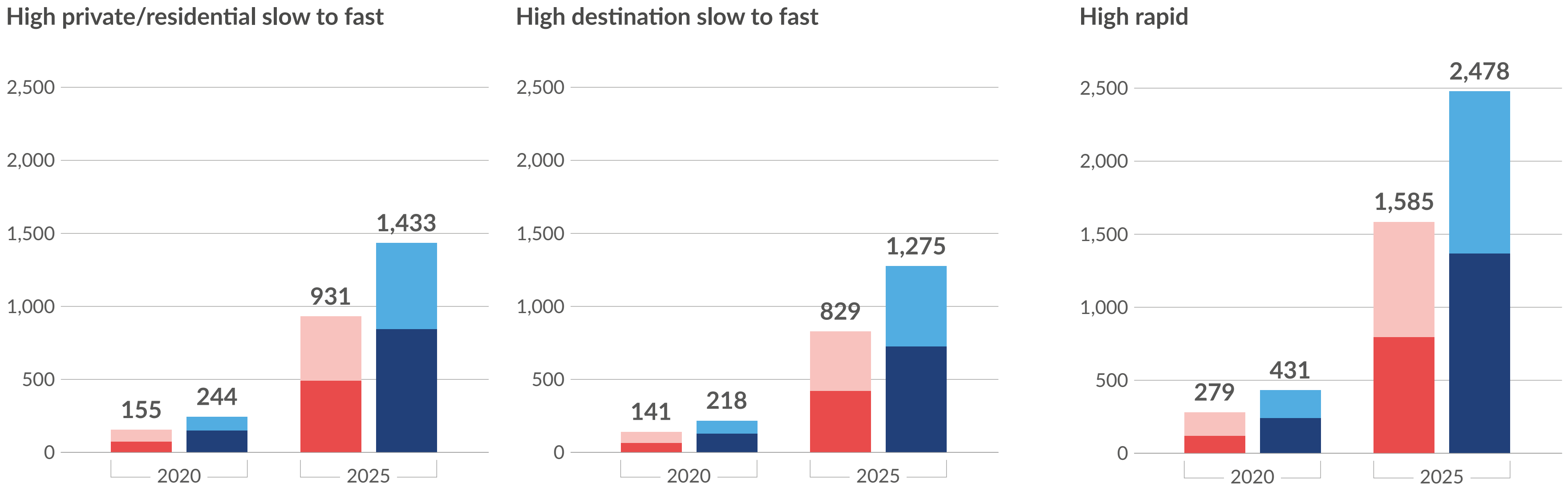


Figure 38
Modelled number of destination slow to fast by charge behaviour and sales scenario for 2020 and 2025

Low sale:
- Uber
- Non-Uber

High sale:
- Uber
- Non-Uber

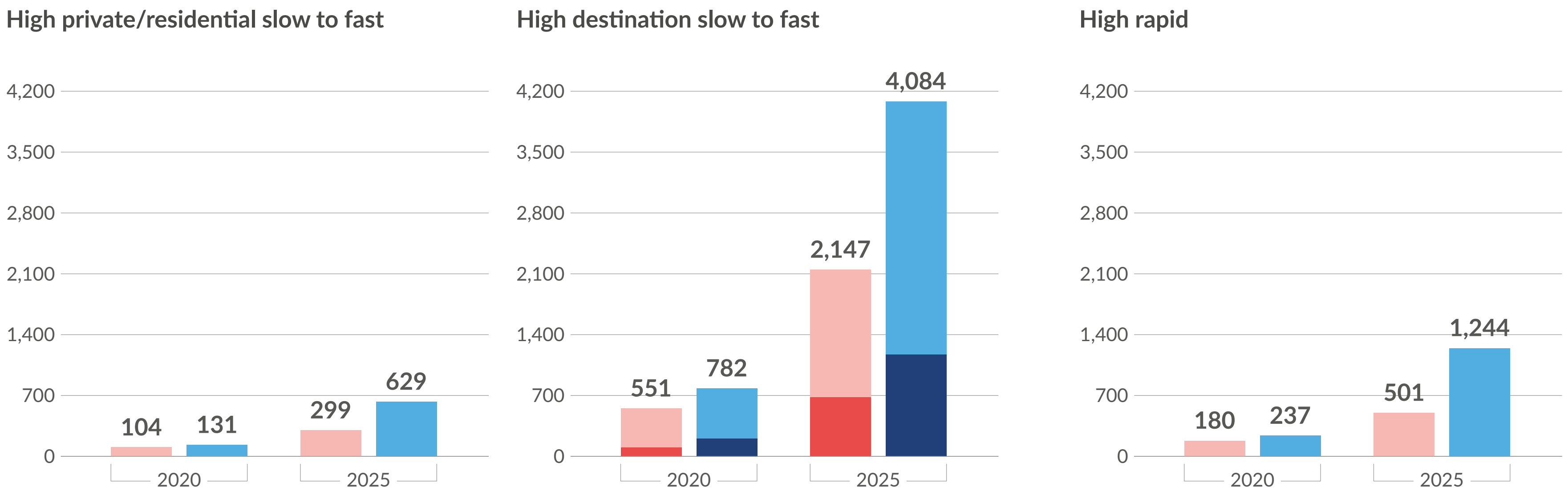
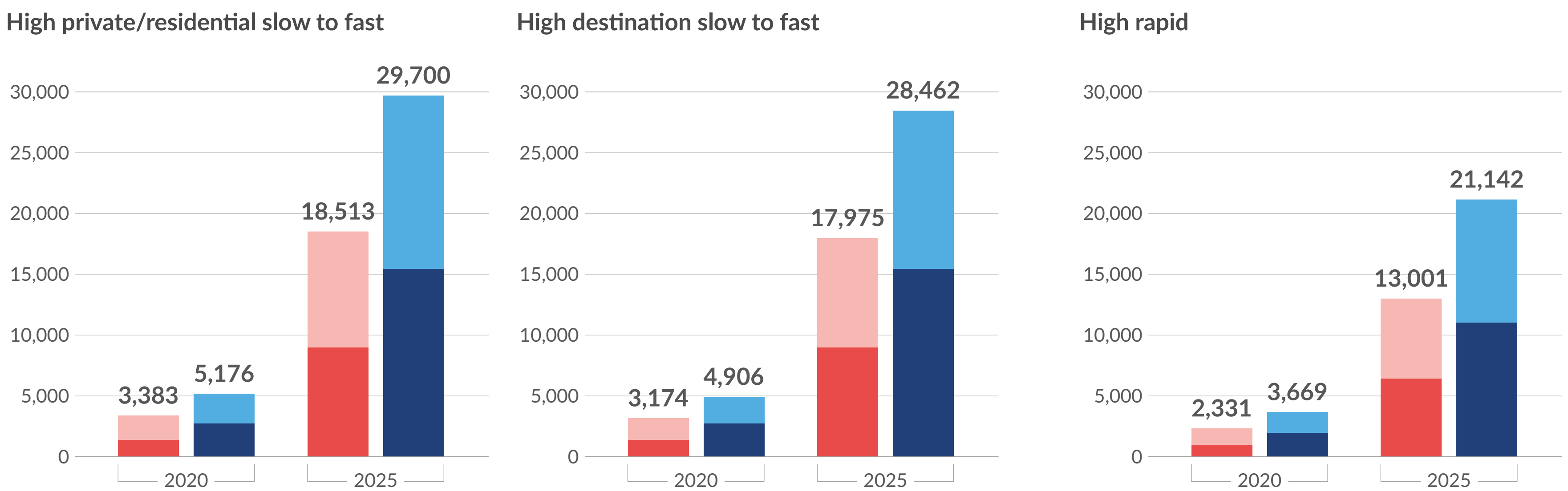


Figure 39
Modelled number of residential slow to fast by charge behaviour and sales scenario for 2020 and 2025

Low sale:
- Uber
- Non-Uber

High sale:
- Uber
- Non-Uber



Appendix B

Principal author: Zero Carbon Futures

Introduction

Three workshops were conducted in London between July and October 2018 to consult with knowledgeable stakeholders on the need for public charging facilities in London to 2025, the current barriers and potential solutions, and the associated challenges and opportunities they present. The information gathered was used to inform the EV infrastructure taskforce's delivery plan for London to 2025.

A broad cross-section of stakeholders was invited to attend three workshops, including current and potential EV users, charging network operators and charge point suppliers, vehicle manufacturers, national Government, boroughs, DNOs, energy suppliers and solution providers, land owners and investors.

Some stakeholders were consulted separately in addition to these workshops to gain greater insight into current conditions and future requirements. This included taxi and PHV operators, Lo-CITY members, DNOs, existing charging network operators in London, vehicle manufacturers and operators.

Each workshop focused on a separate topic, beginning with presentations regarding London's current position, which were used to introduce the topics for further discussion. Discussions were led in small mixed groups of stakeholders by TfL, the GLA and ZCF staff, focusing on questions key to the information required to create an appropriate delivery plan. Each group discussed the same questions to gain a wider cross-section of responses capturing the varied views of stakeholders with different roles and objectives in this marketplace. Note-takers documented the discussions in each group, enabling a summary record to be prepared of each workshop's findings. Each workshop ended with a question and answer session, providing attendees with the opportunity to make wider comments for consideration.

Results of the workshops and wider stakeholder engagement activities were presented to the taskforce members at regular meetings and discussed in order to agree appropriate delivery plan actions.

Workshop 1 – User requirements to 2025 – 17 July 2018

Purpose
The workshop was designed to ascertain stakeholders' views about likely EV user driving and charging behaviour in London to 2025, to identify different types of EV user, their journey characteristics and public charging needs. This information fed into the requirements modelling exercise that informs the delivery plan.

Method
This half-day workshop representing users, suppliers, Government and consultants interested in public EV charging solutions for London was attended by 64 stakeholders. Attendees were split into eight groups for break-out discussion, of which five groups focused on the requirements of commercial users and three groups on private users' needs. Attendees were assigned to specific groups, enabling a wide variety of stakeholders' views to be discussed and responses gathered. Representatives of diverse commercial users included delivery and servicing fleets, police and ambulance services, boroughs and car-club operators, whose views were complemented by vehicle lease and manufacturer organisations.

Presentations were provided on barriers to EV adoption, modelling of EV charging requirements, vehicles and use in London, and private and commercial EV user examples.

A central question was then posed to frame the group discussions – 'Users wish to charge wherever and whenever they want. What does this mean for London?' – followed by seven questions that were designed for group discussion to ascertain stakeholders' views regarding likely EV user driving and charging behaviour in London to 2025, covering:

- Different types of EV user (user characteristics, journey types)
- Their journey characteristics (distance, frequency, predictability, destinations, parking duration)
- Their public charging needs (frequency, energy, location types, charger speeds) with:
  - Current 130 miles EV range
  - Future 250 miles EV range (next-generation vehicles)

Responses were captured using post-it notes on templates prepared for each group, and were supplemented by comments recorded by the note-taker for each group.

Outcomes
This workshop highlighted many potential EV users in London. It also identified that public charging facilities are important in inner London to facilitate commercial users and in residential areas without off-street parking to support private and home-based commercial users.

EV user types and travel behaviour:

- Many types of potential EV user were identified by stakeholders. Characteristics such as distance, frequency and destination types may be used to define user archetypes for modelling of charging requirements
- The many use cases identified for private and commercial EV users can be aligned with National Travel Survey (NTS) trip definitions.[133] This enables average trip characteristics to be used for modelling charging requirements
- Most private users travel fewer than 10 miles per day, with only occasional daily journeys above 100 miles. This suggests that charging is only required once per week
- Most commercial users travel fewer than 75 miles per day, suggesting that charging is required every second day
- Only a few taxi and PHV users, and some supply chain deliverers, travel more than 150 miles per day. This suggests that quick turnaround rapid charging solutions are required to support these use cases
- Many and varied destinations were identified in London, dependent upon journey purpose that can be linked NTS data
- Most private and commercial vehicles are stationary for more than four hours per day, typically near home, at work including depots and at long-stay destinations, suggesting that slow/fast (up to 22 kW) charging may be adequate in many situations

Private users' charging requirements at current 100-130 miles EV range:

- Most private users in London require only one charge per week, preferably near home
- Slow to fast chargers provide an adequate solution in London near home, work and destinations with a minimum of four hours' stay duration
- Rapid chargers are required at in-transit locations for the few high-mileage private users and occasional longer private journeys

Rapid charging hubs may also be an alternative solution for those without off-street parking, depending upon location, availability and cost.

Commercial users' charging requirements at current 100-130 miles EV range:

- Commercial users' requirements vary from one charge per week to more than one charge per day
- Appropriate charger type depends on cost, availability and location but convenience is key for commercial users
- Slow/fast (up to 22 kW) chargers are adequate near home and work but the certainty of rapid chargers is vital during business hours

Private and commercial users' charging requirements at next-generation 250 miles range:

- EV users won't necessarily travel any further on a daily basis, except for making occasional longer journeys
- Private users still prefer to charge near home or work
- Slow to fast (up to 22 kW) chargers are still adequate for most users' needs
- Cost and convenience factors become even more important for the utilisation of public charging infrastructure. Public charging facilities must be cheap, in suitable locations and reliable

Specific challenges highlighted for London:

- Demand for public charging depends upon the relative convenience, availability and pricing of alternative charging solutions eg, at homes, depots, workplaces and privately operated destinations which are outside TfL or borough control
- Continuing demand for near-home charging in London from both private users and commercial users with a home base, in spite of local parking and streetscape challenges
- Commercial charging requirements vary greatly between delivery and service use- cases, and both journey distance and destination can be unpredictable so public in-transit charging solutions are required to provide certainty
- Commercial public charging requirements depend upon the availability and relative cost of alternative depot, home and in-transit charging opportunities

Workshop 2 – The enablers for charging to 2025 – 30 August 2018

Purpose
The workshop was designed to gain insight into the challenges encountered in London to date for the roll-out and operation of EV charging solutions regarding land, energy and operational barriers, to invite ideas for solutions and to identify the organisations necessary to enable them to 2025.

Method
This workshop was attended by 59 stakeholders with experience of charging infrastructure roll-out, representing charging equipment suppliers and installers, charging network operators, energy suppliers and technology solutions, DNOs, vehicle manufacturers and fleet operators. Attendees were assigned

133 NTS trip definitions can be found on page 11 of the following document produced by the DfT: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/729523/nts-2017-notes.pdf

to six discussion groups to provide a broad cross-section of views. This all-day workshop was split into three topic sessions, with presentations and a facilitated break-out group discussion for each. The three topics discussed were:

- Land
- Energy
- Operations

Presentations were provided on location suitability, London rapid charger roll-out experience, the London Plan, London-specific town planning considerations, energy constraints and opportunities, and operational factors from both the operator's and customer's perspective.

The break-out groups were asked to discuss each of the three topics in turn, to provide the following information:

- The issues experienced in London
- Potential solutions to those difficulties
- Who can enable those solutions?
- The role of policymakers in those solutions

Outcomes
This workshop highlighted that the challenges are interlinked between the three topics.

EVs and charging infrastructure are clearly relevant to many of the policy areas covered in the London Plan,[134] but stakeholders have difficulty understanding its relative importance to public transport, cycling, walking, freight, parking and better streets policies.

Further guidance and education is required from central Government regarding how to achieve OLEV's Road to Zero strategy.

Stakeholders believe that EV driving and charging behaviour is not normalised yet and that a short-term outlook is currently hindering business model development for public charging solutions.

Topic 1. Land

Challenges identified

- Land is expensive and scarce, both above and below ground
- Existing parking capacity issues
- Competing priorities eg, streetscape, public transport
- Long, difficult planning process due to multiple stakeholder involvement
- Landowners uncertain of business case
- Data available reflects early adopters' behaviour only
- Land leases vary from 8 to 80+ years, generating much uncertainty regarding future demand for charging infrastructure
- Many stakeholders in the land ownership chain, making process lengthy and costly

Possible solutions

- Sharing of existing land assets
- Utilise off-street parking spaces in residential areas (eg, schools, workplaces, etc) for overnight public charging
- Deploy chargers on streets and in car parks without dedicating EV-only parking bays to them, until demand justifies this with the necessary enforcement activities
- Promote the importance of EV and charging provision in wider environmental and social context
- Prioritise and streamline the planning process, provide more guidance to applicants, explore zoning opportunities to designate land use for charging, educate planners on wider priorities, redesign charging equipment to suit London's historic streetscape, and better position chargers to minimise streetscape implications for other road users
- Develop different asset accounting methods to value the social and environmental benefits of charging infrastructure
- Realistic forecasts of future public charging demand are required to inform charger roll-out quantities and locations
- Provide incentives for landowners to encourage them to permit and enable chargers to be deployed on their land
- Encourage wider partnership/ consortium approaches to public charging provision

Topic 2. Energy

Challenges identified

- Only a power capacity problem at peak use times of day
- High cost and long lead-times for DNO grid connections
- Little data available on where power capacity exists in London
- Complicated DNO application process
- Additional agreements required with landowners governing access (wayleaves)
- Limited space available below ground for new energy and grid infrastructure
- Poor business case for energy storage solutions

Possible solutions

- Use smart charging and energy storage solutions to minimise peak capacity issues, plus explore usefulness of demand management and time-of-use incentives
- Requires support of Ofgem regulatory framework
- Use competition where appropriate to reduce cost and time for connections, and explore real possibilities of sharing capacity between multiple users
- Link charging equipment to renewable energy generation and storage solutions
- Encourage the introduction of network capacity maps by DNOs
- Enable discussion about potential charging sites with DNOs, encourage a partnership approach to meet London's objectives and ease the application process

134 www.london.gov.uk/what-we-do/planning/london-plan/current-london-plan

- Encourage the development of charging hubs where power capacity exists and users wish to go

- Value energy assets in financial accounts

- Provide incentives for energy generation and storage linked to charging services

Topic 3. Operations

Challenges identified

- Lack of interoperability between multiple charging networks in London

- Confusion and a lack of information at point of use regarding fees for charging

- Charging payment systems are incompatible with fleet operating procedures

- Poor maintenance and dependability of existing chargers, poor customer service, and security while charging in some locations

- Charging bays are blocked by non-EVs or by EVs overstaying their charging time

- Mixed views on the benefits of current charging apps, generally too many of them causes confusion for customers

Possible solutions

- Charge, pay and go functionality is now required by Automated and Electric Vehicles Act 2018. Explore European payment models for alternative solutions, provide one centralised charging information system to customers

- Clarify/standardise terms and penalties for parking and overstay at chargers to reduce confusion, display charging fees/fines at each charger, enforce parking regulations at charging bays

- Adopt an equivalent to fuel card system for EV fleet charging, enabling automatic payments. Multiple payment mechanisms may be required to suit different users' needs

- Introduce a 'kite mark' to encourage reliability and good customer service from charging operators. Implement a good practice guide (eg, default to free charging when General Packet Radio Services (GPRS) communications fail, response times). Change public procurement lowest cost view and standards

- Enforcement and parking sensors (additional cost), fines, reservation

- Mixed use (transport solutions), market likely to consolidate

Workshop 3 – Market models and finance to 2025 – 30 October 2018

Purpose

To obtain information from stakeholders on challenges and solutions related to market models and the financing of EV charging infrastructure in London to 2025.

The workshop was designed to gain information regarding best practice financing solutions for public charging provision, ideas to increase utilisation, reduce costs and increase revenues, and the best uses of limited public funding and support.

Method

This final half-day workshop was attended by the most stakeholders, with 95 attendees contributing to the discussions. Attendees were split into eight groups for break-out discussion, providing mixed groups of stakeholders with interests in financing, sponsoring, installing, operating and using public EV charging solutions in London.

Presentations were delivered providing an introduction to the economics of public charging and infrastructure financing methods, followed by an invitation for comments from attendees regarding how to reduce costs, increase revenue and utilisation.

A facilitated panel discussion was then presented to discuss novel methods of funding public charging. The panel was made up of experts from electricity and fuel suppliers who have diversified into charging services (Ecotricity and Shell), the Government's Infrastructure and Projects Authority, National Grid and a representative of the many services that connect to it BEAMA. This session provided attendees with a lively debate highlighting the need for energy and transport providers to work together to provide charging services where users want them and costs allow. It also stressed the importance of increasing utilisation and the immediate opportunity presented by fleet charging. The need for better data on where, when and how much customers will wish to charge in the future was also identified as a key requirement for effective infrastructure business planning.

Break-out group discussions were then used to gather information on the best uses of public support and limited public funding to drive market models forward for public charging provision.

Outcomes

Topic 1. Utilisation

Both the introductory presentations and panel discussion highlighted the need to increase utilisation of charging infrastructure in order to deliver an acceptable financial business model for investors.

Possible solutions to increase utilisation:

- Significant increases in plug-in vehicle sales are required to increase public charger utilisation

- Realistic plug-in vehicle supply forecasts are essential to build effective business plans

- Tools required to grow the second-hand plug-in vehicle market eg, scrappage schemes for ICE vehicles to accelerate the switch to plug-in vehicles

- Charging operators should target guaranteed/predictable high users eg, taxis, fleets above low use or unpredictable personal users

- Processes required to manage public charger use eg, reservation systems, maximum duration, separate parking facilities, with enforced penalties for misuse. This should increase availability, leading to increased confidence for users

Topic 2. High costs, low revenue
High costs of charging equipment, DNO connections, stakeholder engagement and installation works in London were identified as barriers to infrastructure roll-out. Furthermore, limited revenue opportunities resulting from current low utilisation and narrow service offerings compound this challenge.

Possible solutions to improving the cost/revenue balance:

- Identify good value-for-money charging locations combining grid capacity, high predictable user demand and economies of scale in infrastructure installation

- Define and deploy appropriate charging solutions for each use case using the least cost equipment, connection and installation solutions to meet users' needs

- Deploy multiple chargers in locations where grid capacity exists, to benefit from economies of scale in costs and provide certainty of supply to increase utilisation

- Identify realistic payback periods in business models, using realistic plug-in vehicle sales forecasts and willingness to pay for data, and realistic operating costs including land lease terms, maintenance, future-proofing and customer service costs

- Reliability is essential so focus on warranty while minimising maintenance costs by delivering this with existing services

- Acceptable user pricing is key as customers compare public charging fees with home electricity costs

- Investigate the provision of additional services, including marketing opportunities using charging infrastructure services

- Develop valuable service bundles with other products and loyalty schemes to attract and keep users

- Maximise revenue opportunities by exploring advertising, grid services, revenue sharing and partnership investment routes

Topic 3. Charging infrastructure deployment process
Building on discussions at Workshop 2, the challenges presented by the current charging infrastructure deployment process in London were again highlighted by stakeholders. A number of solutions were suggested:

- Provide consistent, long-term London-wide policies and targets for charging infrastructure, which investors can rely on to inform business models

- Agree and communicate common charging objectives and priorities across all London boroughs, linking environment, transport, energy and business strategies

- Ease the planning process by standardising parameters, process and guidance across all boroughs and reducing the time taken for application and approval

- Promote the common need for, and benefits of, charging infrastructure to citizens, fleets, landowners, investors and borough representatives across London

Topic 4. Best use of public support
Given the limited availability of public funding but opportunities for use of TfL and borough policy and planning roles, the stakeholders suggested a number of ways in which public support could be most effectively provided:

- Use public funds only where little commercial opportunity exists eg, for social provision to ensure equality and coverage for all citizens across London, based on likely demand

- Underwrite private sector investment to offset utilisation risks in certain areas and uses

- Contribute to the largest-cost components eg, grid connections, grid reinforcement and energy solutions

- Ease access to land in good locations through policy and possibly incentives

- Ease access to information about grid capacity, charging demand, investors, land owners and partnerships

- Incentivise good charging network performance

Taskforce members:

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