

Electric Vehicles: leading the way on public EV charging Infrastructure

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Executive Summary

As the deployment of electric vehicles (EV) accelerates across the UK, it is vital that drivers can rely upon a comprehensive public charging network to charge their vehicles. Last year we launched our landmark EV Infrastructure Strategy which set out our plans to accelerate the rollout of a world-class charging network and to make EV charging more convenient than refuelling at a petrol station. We must ensure public chargepoints are in place to support those without off-street parking and to enable long-distance journeys. We expect at least ten times more public chargepoints to be needed across the UK by the end of the decade than were in place at the start of 2022, bringing the lower bound of estimated requirements to around 300,000 by 2030. This not only highlights the scale of the challenge that we face but also provides more clarity to the market around likely future infrastructure requirements, and confidence of expected returns on investment.

Keywords: BEV (battery electric vehicle), electric vehicle (EV), infrastructure, electricity, mass market

1 Abstract

In June 2019 the UK became the first major global economy to pass a law that requires us to achieve 'net zero' greenhouse gas (GHG) emissions by 2050. Transport has a huge role to play in the economy reaching net zero. In the UK, transport is the largest contributor to domestic GHG emissions, contributing 27% of domestic emissions in 2019.

In July 2021 we published the Transport Decarbonisation Plan [1] – the first such Plan in the world – which sets the transport sector on a path to net zero by 2050, in line with the Paris Agreement. This is the biggest piece of work we have ever done to tackle greenhouse gas emissions from transport. It takes a holistic and crossmodal approach and sets out a credible and ambitious path for the sector.

As part of this, the UK Government has committed to phasing out the sale of new petrol and diesel cars and vans by 2030 and from 2035, all new cars and vans must be zero emissions at the tailpipe, the first G7 country to do so. The UK has been a global front-runner in supporting provision of charging infrastructure through both public and private sector investment. Therefore, our vision is to continue to have one of the best infrastructure networks in the world for electric vehicles. We want chargepoints to be accessible, affordable and secure.

In March 2022, we published a landmark strategy [2] setting out our plans to accelerate the rollout of a world class charging network. Our strategy sets out our vision and commitments to make EV charging more

convenient than refuelling at a petrol station. Of the £2.5 billion of Government funding committed to the EV transition since 2020, over £1.6 billion will be used to support charging infrastructure.

We know that the majority of EV drivers charge at home, and we expect this trend to continue. We recognise that we must ensure public chargepoints are in place to support those without off-street parking and to enable long distance journeys. We expect at least ten times more public chargepoints to be needed across the UK by the end of the decade than were in place at the start of 2022, bringing the minimum number to around 300,000 by 2030.

Within the strategy we announced new regulations for public chargepoints to improve confidence in the charging network and make the user experience truly seamless. Drivers will benefit from easier payment methods as well as the ability to compare prices and access real-time information about chargepoints. We will ensure there is a 99% reliability rate across rapid chargepoint networks, and all public chargers will need to present open data so that they are easy to find using maps and apps.

To ensure the transition to electric vehicles takes place in every part of the country, the Local Electric Vehicle Infrastructure (LEVI) fund will support local authorities in England to work with industry and transform the availability of charging for drivers without off-street parking. The LEVI pilot, launched in August 2022 and expanded in February 2023, provided over £57m in public and private investment to deliver 4,400 chargepoints and gullies.

We have stepped up the delivery of high-powered rapid chargers on the strategic road network (Britain's A roads and motorways) for people making longer journeys. We already have a well-developed rapid charging network, but we aim to go further and have at least six high powered, open access chargepoints at all motorway service areas in England by the end of 2023, with some larger sites having ten to twelve. By 2035, we expect the number to increase to around 6,000 high powered chargers across the network.

We are also working with Ofgem, the regulator for the electricity and gas markets in Great Britain, to ensure that charging a vehicle is completely integrated with our smart energy system. This will deliver benefits to the grid and lower cost electricity tariffs for those willing to charge flexibly. This has taken on additional significance given wider world events which have increased the price of gas and electricity to consumers.

The public chargepoint demand estimates presented in the EV Infrastructure Strategy were constructed using the Chargepoint Demand Model (CDM).

The CDM estimates annual electric vehicle (EV) chargepoint requirements out to 2030 across three key broad public charging categories.

1. On-street – Slow chargepoints typical installed in residential areas
2. Destination – Slow/Fast chargepoints typically installed at supermarkets, leisure centres, hotels etc.
3. Transit– Rapid chargepoints typically installed in refuelling stations and motorway service areas.

It was estimated that between 280,000 and 720,000 public chargepoints could be required in 2030 to support the charging needs of all electric car and van owners. The estimates are based on a wide range of scenarios which capture key uncertainties of future charging behaviour, preferences and vehicle mileage. The scenarios were based on the best available evidence (2021) and will evolve over time as the market matures and more evidence around consumer behaviour, preferences and technology emerges.

2 Main Paper

In 2020, the UK Government confirmed its intention to phasing out the sale of new petrol and diesel cars and vans by 2030 and from 2035, all new cars and vans must be zero emission at the tailpipe. At the time it was the first G7 country to do so. This was a huge step for a nation and laid the ground for the Transport Decarbonisation Plan. The Transport Decarbonisation Plan was the first plan in the world to set out a credible and ambitious pathway to a net zero transport sector. Collectively this gave a strong message to vehicle manufactures and industry that electric vehicles were the future.

Following these announcements, it was clear that the next step had to be presenting a clear ambition for the infrastructure to accompany these new vehicles. The UK recognises that a focus on vehicles is only half of the challenge. A world-class charging infrastructure is absolutely fundamental to delivering net zero road transport. The EV Infrastructure Strategy set out the UK Government's plans to accelerate the rollout of a world-class charging network. The Strategy did this in three key ways:

- Stating and highlighting progress that had been made but crucially outlining existing barriers that were holding back installations of EV chargepoints across the energy and transport sectors.
- Clearly communicating roles and responsibilities across all actors and stakeholders in these sectors, including central Government and local authorities. Removing uncertainty and confusion.
- Establishing clear commitments across industry and government to remove barriers and accelerate rollout of infrastructure.

This approach has provided certainty to industry and investors alike that the transition to EVs in the UK is serious and has been well planned. Providing the sector with this level of detail has provided confidence and assurance to the market in order to draw in private sector investment to accelerate EV infrastructure across the country.

The EV Infrastructure Strategy was the catalyst for us to remove charging infrastructure as both a perceived, and a real, barrier to the adoption of electric vehicles (EVs). As part of our vision for 2030, in any scenario, rollout must progress at pace to provide sufficient chargepoints ahead of demand and to ensure that the UK is a place where:

- Everyone can find and access reliable public chargepoints wherever they live – be that city centre or rural village, urban flat or suburban house, in the north, south, east or west of the country. Charging opportunities will not be limited by income or location.
- Effortless on and off-street charging for private and commercial drivers is the norm – easy overnight charging is, and will remain, the default for those with driveways. However, charging should be just as convenient and stress-free for those who currently park on street. This must extend beyond privately owned cars; those who drive vans and commercial vehicles must also have access to chargepoints that meet their needs.
- Fairly priced and inclusively designed public charging is open to all – there will be vibrant competition across the charging sector with choice in provider and type of charging, and open data on pricing and availability.
- Market-led rollout for the majority of chargepoints delivers a thriving charging sector – the sector is booming now with smart UK small to medium sized enterprises (SMEs) driving the pace of change and forcing big corporations to adapt. By 2030, this will represent a huge global opportunity for UK Plc. A thriving competitive market will help to drive down costs for consumers.
- Infrastructure is seamlessly integrated into a smart energy system – to minimise the impact of the EV transition on the grid (both distribution and generation), but also to offer the lowest cost tariffs to consumers and to capitalise on the exciting opportunities of 'Vehicle-to-Grid'.
- Continued innovation to meet drivers' needs lowers cost and increases convenience – because although the fundamentals of delivering electricity to charge batteries will not change, the charging landscape of 2030 will be very different. We are already seeing startling innovation in both technology (speed, smartness and delivery method) and business models (from peer-to-peer charging to portable tariffs).

At the time of the Strategy being published progress had been acceptable, but there were significant challenges, to delivering our vision for 2030:

- The pace of rollout was too slow – even the recent surge in chargepoint deployment is not at a pace consistent with what is needed for a wholly zero emission new car fleet in 2035. This is particularly true for local, low power, on-street charging which is so crucial for drivers without driveways. Many fleet drivers also rely on this type of charging. Planning arrangements can be complex to manage. Chargepoint installers can sometimes need multiple permissions, consents and licences, which adds time and cost to deployment.

- Too often, public charging lets people down – although many EV drivers with driveways discover that they can meet almost all of their charging needs at home, every EV driver wants access to a plentiful, reliable and fairly priced public charging network. Too often though, they experience poor customer service, opaque or excessive charging costs, poor reliability and complex access regimes involving numerous apps and smartcards.
- The business case for commercial deployment can be challenging – this can be particularly true in areas of potentially low utilisation or high connection costs or needing to upgrade the grid. In 2022, there are significant regional disparities in deployment. This uncertainty creates a market deadlock, with potential EV purchasers, at both individual and company fleet level, being reluctant to buy until there is more visible infrastructure.
- Connecting new chargepoints to the electricity system can be slow and expensive – this is a particular issue in remote areas, where new high power connections might be required, or locations where there is insufficient capacity in the existing distribution network, such as for charging of vehicle fleets in depots. Numerous chargepoint operators have brand new chargepoints installed but are waiting for a grid connection so that they can be turned on.
- We need more local engagement, leadership and planning – local authorities are fundamental to successful chargepoint rollout, particularly for the deployment of widespread on-street charging. They are ideally placed to identify the local charging needs of residents, fleets and visitors. But the current picture is mixed. Some are driving the agenda forward at pace, others are short of dedicated resource and expertise. Planning permission delays are often cited as a major brake on the speed of deployment, and the interaction between local parking and charging policies is not fully resolved.

Our approach to addressing these challenges, and to delivering our vision of a world-leading public charging offer where ‘range anxiety’ is a thing of the past, will be based on the following strategic framework.

Government will focus our intervention on two crucial sectors where we most need an accelerated pace of rollout, and where the business cases can be particularly challenging: high powered chargers on the strategic road network and local on-street charging. We will target our intervention at these two areas, addressing the key challenges:

The Rapid Charging Fund (RCF) will future-proof electrical capacity at strategic locations to prepare the network for a fully electric car and van fleet. This will unlock current barriers to deployment, enabling provision where the commercial case will not add up. Confidence in the ability to undertake longer journeys is fundamental to EV adoption. We will ensure that every motorway service area has at least six rapid chargers by the end of 2023, with some having more than 12. There will be over 6,000 high powered chargers along our strategic roads by 2035. Electricity network capacity at motorway service areas will be ready to meet demand to 2035 and beyond.

We will transform local on-street charging by putting an obligation on local authorities (subject to consultation) to develop and implement local charging strategies to plan for the transition to a zero-emission vehicle fleet. These strategies should identify how to provide affordable, convenient charging for residents, businesses including fleets, and visitors without causing pavement disruptions that could discourage walking and cycling. They will also need to consider charging opportunities for other vehicles, including e-bikes and motorbikes. Different funding streams for EV infrastructure will be consolidated to ensure clarity, simplicity and efficiency for local authorities. We have set up a dedicated local authority support programme to ensure they have the resource and expertise they need to work out their specific local challenges and plan accordingly.

We will continue to enable thriving sectors to flourish and address barriers to private sector rollout. Certain areas of the charging infrastructure market are already growing at pace. Here, the role of the Government is simply to remove any existing barriers and step out of the way, so:

- Government does not plan to financially intervene in the destination charging sector, and
- We will help to reduce the costs to businesses by tackling barriers to investment and delivery of public chargepoints. Where barriers are slowing down private sector deployment, we will address them: for example, we have consulted on measures to make Traffic Regulation Orders (part of the process to install on-street chargepoints) more straightforward.

We will give people confidence in the public network. We will regulate to ensure chargepoints are reliable and easy to use. This will include specific requirements on open data, price transparency, payment methods and reliability. We also have developed chargepoint design standards to improve accessibility and improve signage to chargepoint locations.

We have been working with Ofgem to ensure chargepoints can seamlessly integrate with the energy system. The EV transition is both an opportunity and a risk to the UK energy system and is part of wider changes needed to deliver net zero across the whole economy. We will ensure that the opportunities are grasped, and the challenges mitigated. This will include making sure that the bulk of charging is ‘smart’ and ideally off-peak, that connection costs do not avoidably deter chargepoint deployment (including through the use of Ofgem’s £300m Green Recovery Scheme), and that EV charging infrastructure makes the most efficient use of the electricity system. This will help ensure that charging costs are fair for both consumers and businesses.

We have been supporting innovation in business models and technology. As the automotive sector increasingly shifts its focus to electrified cars, the pace of technological development has become ever quicker. Battery packs are becoming more energy dense, enabling longer ranges. Previously unimagined rates of charging are now possible and wireless charging is nearing commercial deployment. At the same time, the economic potential from the integration of the energy and transport systems is still in the early stages. There is huge scope for chargepoint operators to gain by selling services to the grid, and for the grid to gain by increasing flexibility. Ultimately consumers will benefit through cheaper, and potentially even negative, tariffs if they agree to cede some control over charging or even share some of their vehicle’s battery capacity. We are continuing to facilitate this innovation and encourage new business models to deliver the charging we need. This could be through local community charging companies, longer-term on-street concessions, remote charging, cable guttering, lamppost chargers or peer-to-peer charging services.

2.1 Post Strategy

Since publishing the strategy, we have been keen to continue to monitor how new business models and technologies are being adapted by the private sector in the UK. Within Government, we have been actively driving forward the commitments that we tasked ourselves in the Strategy whilst encouraging other stakeholders in the sector to do so as well.

Some of our achievements since the publication include:

- Influencing Ofgem to socialise a further proportion of the cost of network reinforcements among billpayers, reducing the upfront cost of connecting to the grid for customers. These changes are expected to come into effect from April 2023.
- In August 2022, the Government and Ofgem jointly published the Electricity Networks Strategic Framework. This sets out a shared vision for the transformation of the electricity network, that will ensure it can act as an enabler for a clean, secure and low-cost energy system.
- Government published a call for evidence (summer 2022) to establish how the land rights and consent processes for network infrastructure affect stakeholders and to inform whether reform is required. We are considering all responses and plan to publish a response to the call for evidence in 2023. This will set out whether reform to the current consenting system is required and government’s next steps.
- We have amended the Workplace Chargepoint Scheme to support small accommodation businesses and the charity sector to install workplace charging for guests and visitors. These businesses are often in rural areas, and we have seen provision in these areas low compared to similar urban ones. This will help support rural communities and allow those staying at or working for these businesses to charge either overnight or during the day.
- From June 2022, we introduced regulations requiring all new homes and workplaces with associated parking, including those undergoing major renovation, to have chargepoints installed at the point of construction.
- We reformed the Electric Vehicle Homecharge Scheme to focus on support for home charging at flats and rented accommodation, rather than the more established market for people with their own driveways and garages.

- The Government co-sponsored PAS 1899 alongside national disability charity Motability. PAS 1899 provides, for the first time, specifications on designing and installing accessible public EV chargepoints, meeting the industry need for standardised guidance on what accessible public chargepoint design consists of and how it can be deployed. PAS 1899 covers specifications including: the location, placement and spacing of chargepoints, along with aspects such as kerb height, the height of the chargepoint, and the force required to lift the charger cable and insert the charge connector. The standard also considers chargepoints in the context of their wider built environment, to ensure pedestrians' and other road users' needs are reflected.
- We laid regulations in October 2021 to mandate that private chargepoints sold in Great Britain must be smart and meet minimum device-level requirements from June 2022. We have made advice on smart charging available via the Energy Savings Trust.
- We launched a pilot for the LEVI Fund in August 2022, expanding it further in February 2023, to support the development of the full fund. The pilot provides over £57m in public and private investment to 25 different local authorities across England to deliver almost 4,400 chargepoints and gullies for drivers without off-street parking.
- We will maximise the opportunities for flexibility from EVs while protecting the electricity grid and consumers, publishing a joint Government-Ofgem Electric Vehicle Flexibility Action Plan.
- We will set out our overall approach to transforming the electricity network to achieve our Net Zero goal in our electricity networks strategy: [Electricity Networks: Enabling the Transition to Net Zero.] This will include our approach to enabling cost effective and timely connections.
- Accelerate the widespread deployment of vehicle-to-everything (V2X) technologies, working in close collaboration with Ofgem and industry. We have published a summary of our recent Call for Evidence and outline next steps.

3 Chargepoint Demand Model (CDM)

The public chargepoint demand estimates presented in the EV Infrastructure Strategy have been constructed using the Chargepoint Demand Model (CDM). The CDM estimates annual electric vehicle (EV) chargepoint requirements out to 2030 across three key broad public charging categories.

1. On-street – Slow chargepoints typical installed in residential areas
2. Destination – Slow/Fast chargepoints typically installed at supermarkets, leisure centres, hotels etc.
3. Transit – Rapid chargepoints typically installed in refuelling stations and motorway service areas.

Workplace and private home charging have also been considered within the modelling framework but are not included in the definition of public chargepoints. It was estimated that between 280,000 and 720,000 public chargepoints could be required by 2030 to support the charging needs of all electric car and van owners. The estimates are based on a wide range of scenarios which capture key uncertainties of future charging behaviour, preferences and vehicle mileage. The scenarios were based on the best available evidence (2021) and will evolve over time as the market matures and more evidence around consumer behaviour, preferences and technology emerges.

The modelling utilises a top-down approach, based on a calculation of the future energy requirements of electric car and van owners across the United Kingdom. The projection of EV sales assumed in the model is in line with the Office for Zero Emission Vehicles (OZEV) 2035 delivery plan range and the Net Zero Strategy transport scenario. This uptake projection represents one potential trajectory to achieving road transport decarbonisation ambitions. This corresponds to battery electric vehicles (BEVs) comprising 24% of total cars on the road and 14% of total vans on the road by 2030.

A detailed model map is presented below, outlining key inputs and calculation steps that underpin the chargepoint projections:

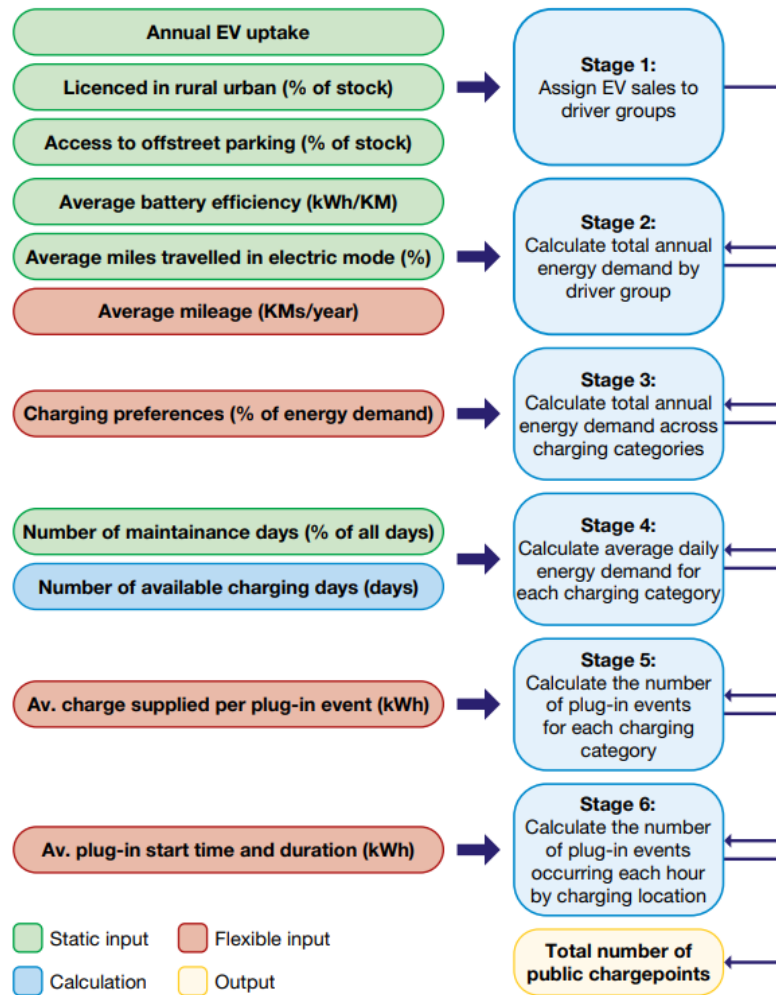


Figure 1 – Chargepoint Demand Model Map

A set of scenarios have been produced to underpin the estimates illustrating the scale of infrastructure rollout needed under credible 2030 outcomes. As illustrated above in Figure 1, four key assumptions have been adjusted to reflect the areas of major uncertainty:

1. Vehicle mileage
2. Where drivers prefer to charge
3. How frequently drivers charge
4. How long drivers occupy a chargepoint.

These assumptions have been selected due to significant uncertainty around how they may change over time as the market develops from its current early stage, as well as the potential scale of impact on modelling outputs. All other assumptions have been kept constant across the scenarios.

3.1 Mileage

Annual mileage is a key factor in determining the energy requirements of EV owners. At Stage 2 of the model map above, three mileage levels have been tested and are displayed in Table 1 below. An additional assumption is then applied to plug-in hybrids (PHEVs) to account for the fact that only a proportion of their annual miles will be driven in electric mode.

| | Cars | Vans |
|---------|-------|--------|
| Low | 7,700 | 11,500 |
| Central | 8,500 | 12,700 |
| High | 9,400 | 14,000 |

**Table 1 – Annual mileage in 2030
(miles per year)**

3.2 Charging preferences of drivers without off-street parking

As set out in the EV Infrastructure Strategy there will be a variety of suitable locations for an EV owner to charge in the future – at home, at work, on a residential street, at a destination or on-route to a destination. Anticipating where drivers without off-street parking will charge is very difficult as it will depend on several variables such as the price or convenience of charging at each location. These factors will become more certain once more EVs are adopted by drivers without off-street parking. To account for this uncertainty the impact of three illustrative sets of charging preferences have been tested at Stage 3 of the modelling.

- a. **Existing behaviour / High workplace** – EV owners without off-street parking charge at a broad mix of public chargepoints. It is assumed these drivers source approximately 60% of their energy from a combination of residential on-street, destination and rapid chargepoints with the remainder at workplaces.
- b. **High on-street** – Over time, on-street charging becomes more prevalent. By 2035 it is assumed EV owners without off-street parking source 80% of their charging demand from on-street chargepoints.
- c. **High destination / on-route** – Over time, destination and on-route charging becomes more prevalent. By 2035 EV owners without off-street parking source 80% of their charging demand from a combination of these two locations.

3.3 Amount of electricity supplied per plug-in event

Stage 5 of the modelling factors in the number of plug-in events required over the course of an average day to satisfy energy demand. A ‘plug-in event’ is defined as the entire period a chargepoint is occupied and includes the time the EV is charging and any remaining time the driver spends occupying the chargepoint after the charging is complete.

As it is unrealistic to assume that all drivers fully charge their battery from 0% to 100% every time they plug-in, an assumption is required to define the amount of electricity that is supplied to the battery on average every time an EV plugs-in. This notion has also been backed up by some of the latest research of consumer trends as displayed in the Britain Thinks publication [2]. Assumptions are expressed below as the amount of charge that is added to the battery (as % of total capacity) per plug-in event. As illustrated in Table 2 below, it is assumed that on average each EV adds 55% to their battery every time they charge at an on-street chargepoint.

Given the significant uncertainty around future charging behaviour, the impact of reducing the amount of charge supplied (reflecting more frequent charging) and increasing the amount of charge supplied (reflecting less frequent charging) has been tested.

| | On-street | Destination | Rapids |
|---------|-----------|-------------|--------|
| Low | 40% | 20% | 45% |
| Central | 55% | 30% | 55% |
| High | 70% | 40% | 65% |

Table 2 – Average additional charge supplied per plug-in event (% of battery capacity)

3.4 Plug-in duration

Stage 6 of the modelling involves distributing plug-in events throughout the hours of the day. This stage of calculation is important as it accounts for public chargepoints being shared amongst EV drivers and potentially used more than once per day.

Plug-in events are distributed in line with the charging patterns observed by existing EV owners and differ across charging categories. For example, it is assumed that the greatest proportion of plug-in events at destination chargepoints begin at 08:00 (13%), whilst the greatest proportion of plug-in events at on-street chargepoints begin at 17:00 (11%). Distributing plugin events across the day enables us to calculate the number of plug-in events occurring each hour. By observing the hour with the greatest number of plug-in events taking place, it is possible to estimate how many chargepoints are occupied during the peak hour and therefore the number of chargepoints required.

A key assumption influencing the number of plug-in events taking place in any hour is how long drivers occupy a chargepoint, including time plugged-in and not actively drawing charge. Table 3 below shows the assumptions that have been used for each chargepoint location. The ‘Low’ captures a scenario where drivers plug-in for a shorter period relative to the ‘Central’ whilst the ‘High’ captures a scenario where drivers plug-in for longer.

| | On-street | Destination | Rapids |
|---------|-----------|-------------|--------|
| Low | 08:45 | 01:59 | 00:24 |
| Central | 10:45 | 02:59 | 00:29 |
| High | 12:45 | 03:59 | 00:34 |

Table 3 – Average plug-in duration (hh:mm)

It is important to note that this assumption alone does not alter the active charging time which is determined in Stage 5.

4 Conclusion

Transport is the UK’s largest emitting domestic sector and 91% of UK transport emissions come from road transport. If the UK economy is to achieve net zero emissions by 2050, it has to decarbonise road transport. The recent rapid increase in both the supply of, and the demand for EVs means that charging infrastructure now stands as the single biggest challenge to that decarbonisation. Delivering that requires commitment and investment across the energy, chargepoint, automotive and public sectors which is something that following the EV infrastructure strategy we are starting to get a hold of.

Despite all this work on EV infrastructure taking place there are still some barriers that remain stubborn. Our work continues on these to ensure we remain at the very forefront of the transition to Electric Vehicles. We


are determined to continue to welcome new technologies and innovation to the sector whilst working to provide a network that is fast, reliable and accessible for everyone.

Building a world-leading charging network will enable EV drivers to plug in and charge anywhere, be it on the street where they live, where they shop, or on route to their destination. This won't happen overnight, nor without challenges along the way. But the benefits of the zero emission motoring will be felt everywhere, with improved air quality in our towns and cities, economic growth through our automotive industry, and ultimately cleaner driving for all.

References

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Presenter Biography



Chloe is Deputy Head of Stakeholder Engagement and International in the Office for Zero Emission Vehicles (OZEV), supporting the team's liaison with industry stakeholders and international Governments. She also leads on accessibility policy in OZEV, supporting an inclusive charging infrastructure rollout across the UK. Chloe joined OZEV in August 2021, initially supporting policy for the UK's Plug-in Car Grant until the scheme was closed in June 2022. Prior to joining OZEV, Chloe worked for a local authority highway department, leading the team responsible for statutory consultations and legal agreements.