energy taskforce

Charging the Future: Drivers for Success 2035

Office for Zero Emission Vehicles

CATAPULT Energy Systems

Zemo Partnership

Foreword

The rapid electrification of cars and vans on our roads is starting to be viewed as a given in terms of the UK's transition to net zero. The trajectory for electric vehicles sales is pretty much set, and the Sixth Carbon Budget has committed the UK to a zero carbon electricity system by 2035. Buying an electric vehicle is going mainstream and we see more and more chargepoints on our streets, forecourts, carparks and driveways each week. Job done? Time, surely, for the focus to shift to the even harder-to-decarbonise sectors of the economy?

It may be tempting to view the job as already done, but it would be a grave mistake to disregard the chicken-and-egg relationship between the number of electric vehicles on our roads and the development of charging infrastructure needed to support them. Potential electric vehicle drivers do worry about their ability to charge when, where - and at a price - they like. Potential investors in infrastructure do worry that the demand won't be there to give the returns they need. Those that invest in, operate and regulate the electricity system do worry that we won't have the right capacity in the right place at the right time, that we have too much - or too little – copper in the ground.

One of the key challenges has been to define the type and scale of infrastructure that we'll need. If we can agree a coherent view of the goal and the order and priority of the steps needed to get us there with greater certainty, we can build the confidence of those thinking of buying an electric vehicle, investing in a chargepoint or reinforcing the distribution network. Developing such a view is not straightforward. The complexity of the relationships between the many components of our transport and energy systems is daunting. The work must account for consumer wants and needs as well as the physics, economics and politics involved. It must address supply and demand and have spatial and temporal coherence. Above all, the desired outcome needs to be deliverable.

This report covers a significant range of work that aims to meet this challenge. The good news is that it shows what an infrastructure that addresses consumer needs, integrates into the energy system, is investable and good value, could look like. It also highlights the key enablers required if it is to be delivered and to perform as needed.

It doesn't cover all the angles – there is more work to be done, especially on the challenges of inclusiveness, equity, connectivity and the interplay with truck and bus decarbonisation. Models reflect aggregated conditions and assume relatively well-functioning markets – and there are some feedback loops that haven't been fully captured. No one should claim perfect foresight. There are significant uncertainties, or course; some but not all have been captured as sensitivities in the analysis. The opportunities for innovation are tremendous, and not all innovation can be foreseen. People change – attitudes, expectations and behaviours shift with experience. As the current situation in Ukraine amply and tragically testifies, the scope for massive shifts in the external context is always there.

But even given these caveats, and even though there is no shortage of views about the future of our infrastructure, there are three key reasons why this work is distinctive:

- It is based on a very rich whole-system view of the challenge, synthesising a wide range of models and expert analysis.
- It offers both a quantitative view of future infrastructure and consideration of the steps needed to deliver it.
- Most importantly, it is the result of intense collaboration and scrutiny across the breadth of organisations and interests represented in the EV Energy Taskforce.

The assumptions used and the conclusions drawn are based on representative expert consensus, delivered through working groups and collective scrutiny. The assumptions, and the key data sets used by and generated from the modelling work, are publicly available and accessible.

A key objective of the EV Energy Taskforce was to help establish a consensus on a no regrets path to electrifying road transport. I believe this report will help to deliver this.

On behalf of everyone involved in the Taskforce over the past few years, I hope you find the work interesting and the conclusions useful.

Philip New
Chief Executive Officer,
Energy Systems Catapult

Acknowledgements

This report is the culmination of a year's intensive work involving a wide range of stakeholder organisations from across the different sectors involved. The Taskforce Steering Group would like to thank everyone for their valuable contribution to producing this report.

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The Taskforce undertook a number of specific workstreams led by: Sarah Chisnall (Ombudsman Services), Jason Doran (Zemo Partnership), Stephen Skippon (Energy Systems Catapult), Jonathan Murray (Zemo Partnership), Catherine Bowen (BVRLA), Daniel Brown (REA) and Roy Williamson.

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Executive Summary

2035 is a key year in the UK's journey to net zero. It is when the commitment in the Sixth Carbon Budget to a 78% reduction in emissions economy-wide, underpinned by the complete decarbonisation of the electricity system, falls due – as does the cessation of sales of internal combustion-powered cars and vans, a necessary condition for meeting this target.

The urgency of action reflected in these goals is compounded not only by the succession of ever bleaker reports from bodies including the IPCC but also by the radical shift in geopolitical context in the last few months. Reducing dependency on fossil fuels and improving our energy resilience are necessities, now driven by the likely impacts of sustained high oil and gas prices as well as by our need to avoid the consequences of climate change.

The electrification of transport responds directly to these imperatives. The UK has made good progress in decarbonising the grid and maintaining reliable electricity supply (the carbon intensity of the grid fell from nearly 500 gCO_2/kWh in 2009 to 200 gCO_2/kWh in 2019). Sales of plug-in cars and vans are growing rapidly – now one in five of new car registrations. UK chargepoint provision has grown fast - at the end of 2021 there were an estimated 300,000 private [1] and around 27,000 public [2] chargepoints.

The market is going mainstream and, as it does, awareness of the importance of developing effective public charging infrastructure, whether to serve the needs of those without access to domestic charging or to build the confidence of the majority of drivers who are able to charge at home, grows. This is a market involving a diverse range of stakeholders and likely to touch the lives of the vast majority of UK citizens. But it is one which is not only fast growing, but very immature. Like many such markets it carries opportunity, risk and uncertainty.

The EV Energy Taskforce was established to bring together the many industry, governmental and consumer groups with interests in this space to build consensus around the way forward. The initial focus was on enabling smart charging, improving energy system resilience and engaging consumers. Over the past two years the Taskforce has also focused on broader charging infrastructure questions – in particular the major issues surrounding the delivery of a domestic, workplace and public charging infrastructure that works for EV drivers, is deliverable by industry and investors, is good value for money (at both system and user level) – and is fair and inclusive.

This report sets out, for the first time, a quantification of the infrastructure required by 2035 and a summary of the characteristics of that network along with the Taskforce's perspective on the actions necessary to enable this outcome. The recommendations are based upon the most comprehensive, integrated analysis of the energy system, infrastructure provision, vehicle capabilities and consumer preferences undertaken to date in the UK.

Key modelling insights

In developing its analysis, the EV Energy Taskforce employed the Energy Systems Catapult's latest transport-focused framework to model the interplay between zero emission vehicles, users and the energy system that serves them. The analysis drew upon the collective know-how of the Taskforce's wide range of stakeholders to agree underlying assumptions and scrutinise the outputs.

The work describes outcomes consistent with the goals of the Sixth Carbon Budget. It is predicated on the assumption that private sector investment is fundamental, that the preferences of consumers (both private and commercial) are reflected, that provision is adequate to meet their needs and that whole system costs are minimised. The analysis explored a range of cases and reflects possible conditions in a mature and balanced market and provides some clear messages which should inform the development of government policy and decisions about industry investment.

1 Bold and aggressive rollouts are needed to meet the Sixth Carbon Budget and net zero emissions targets and deliver the ambition to end the sale of internal combustion engine vehicles:
   - **2.5 million BEV cars** will need to be sold per year in the UK by 2030; a rate **13 times greater than the record-breaking levels seen in 2021**, consuming as much as **7% of forecast global BEV car production**.
   - Electricity demand from the transport sector will increase to **55 TWh per year** by 2035 making up 14% of total demand, **enough to power two-thirds of homes in the UK today**.
   - In the central case **500,000 public chargepoints** need to be deployed by 2035 – from fewer than 30,000 in place today – to provide drivers with the confidence to buy electric vehicles and the means to charge them.

2 Near home charging provision is a critical part of the mix:
   - As many as **50% of public chargepoints** need to be targeted at providing charging for **drivers in homes without dedicated parking**.
   - To ensure the widest possible uptake this **near home charging must not solely focus on on-street residential charging**.
   - **Local rapid hub charging** has the potential to be an investable, **competitive** and **desirable** solution for near home charging. **In a mature market, charging prices**[1] **at local rapid hubs could converge towards domestic prices**.

3 **Higher throughput enables lower charging prices** at public charging locations. This requires there to be enough EVs on the road using them while occupancy times also need to be managed. **Doubling the amount of time the average vehicle spends at a chargepoint** more than triples the number of chargepoints needed and **more than doubles charging prices**.

4 En route rapid charging is essential to support long-distance journeys. By 2035 **60,000 such chargepoints** will be needed along the strategic road network, more than **10 times the number in place today**.

5 Domestic charging prices will be **25% higher without smart charging**.

Creating a UK charging infrastructure fit for the future

The Taskforce's analysis shows that it is possible to deploy a charging infrastructure that delivers good value for EV drivers, that is investable, that is accessible and available enough not just to meet drivers needs but to build confidence and overcome any concerns with the ability to charge when needed. But to deliver this a number of critical enabling conditions need to be met – requiring action from both industry and government. These enabling conditions were developed in consultation with a wide range of stakeholders and build upon the previous work of the Taskforce. They constitute the key recommendations of the work. A full discussion of these is provided in Section 4 of this report and can be summarised as:

1 **Public charging needs to be built ahead of need to gain consumer confidence**
Delivering a universally accessible public charging infrastructure across the UK, ahead of the mass market transition, is critical in gaining EV user confidence and creating the conditions for the transition to take place in the timescale required. To do this, government and the financial sector must develop targeted financial support including blended public and private capital funding and explore mechanisms to share risk, supporting investment in public chargepoints ahead of demand growth while also offering affordable prices to EV drivers. Utilisation-linked loans to chargepoint providers are a possible mechanism. Anticipatory investment in distribution networks, underpinned by Local Area Energy Plans, is critical. Planning guidelines and consent protocols need to be streamlined and simplified.

2 **It is essential that local authorities have the tools, capabilities, powers and resources to ensure integrated energy and transport planning**
Local authorities have a pivotal part to play in the effective deployment of public charging infrastructure through their role in control of planning, consents and access, their responsibility for the road network and transport planning, as well as through other aligned activities including measures to tackle air pollution and climate change. However, local authorities (LAs) are often underpowered, poorly informed and uncertain of their options. To tackle this, Government must ensure that LAs have the resources, the mandate and the obligation to develop and deliver local charging strategies. Distribution Network Operators (DNOs) must also provide mechanisms for sharing knowledge, materials and learnings across LAs in their region to develop local transport energy plans.

[1] On an equilibrium price basis.

3 **Public chargepoints have to be used and usable – visible, accessible, connected, secure and interoperable to gain consumer confidence.**
Confidence in the charging infrastructure is critical to enabling EV market demand and accelerate the transition. Government and industry must work together to deliver high-quality public charging services and ensure that charging is integrated as effectively as possible into the energy system. To enable this, the Government and Ofcom need to develop a wholistic strategy to deliver national data connectivity with an architecture that supports EV charging requirements. They should publish detailed maps of mobile signal connectivity to aid chargepoint network planning. Chargepoint operators must ensure a minimum level of service which includes accessibility, uptime and repair completion targets, and be held to account. Local authorities should include minimum performance criteria in their chargepoint procurement processes. Relevant chargepoint, network and vehicle data should be presumed open and accessible whenever possible. The emergence of chargepoint reservation services will aid consumer confidence.

4 **Smart charging, wherever appropriate, is essential if system cost is to be managed.**
Utilising the generation, network and charging infrastructure capacity is vital in delivering a cost effective and low embedded carbon energy system. The impact on peak demand and the need for network reinforcement must be minimised. This offers opportunities for UK leadership in the development of innovative business models for smart charging and potential application in electrification of heat. To do this any public chargepoint requiring a sufficiently long charging time should be smart charging-enabled to reap the significant benefits to users and to the efficient functioning of the grid. Further reform of electricity market arrangements to better reflect the system value of flexibility is encouraged. Data sharing standards and protocols will need to be developed and applied across the energy system, charging infrastructure and vehicle.

5 **Informing, educating and protecting EV users is critical to create the understanding necessary for mass market uptake.**
With the adoption of any new technology requiring behaviour change, there is resistance and caution. Confidence in the performance and attributes of electric vehicles and in the availability and useability of the chargepoints, combined with clarity and transparency about the costs and benefits is crucial.

Consumers will need to adopt new practices in terms of how and where they charge their vehicles. To enable this, extensive and consistent public information messaging across public and private sectors will be needed, although this also provides an opportunity for the development of innovative consumer propositions and services that make charging easier.

Support for disadvantaged consumers without access to domestic charging must be explored, with a range of charging options appropriate to their locality. Consistent consumer protections and complaint handling processes across the consumer journey, as well as bundled support packages for vehicles, chargepoints, tariffs and associated finance will be needed.

These points have been collated into a list of 15 key recommendations to industry and government which are detailed in the conclusion to this report.

1 Introduction

Introduction

EV Energy Taskforce Background

The Electric Vehicle Energy Taskforce was established in September 2018; an initiative announced at the Prime Minister's Zero Emission Vehicle Summit. The Taskforce was initially set up to make suggestions to government and industry to ensure that the energy system is ready for and able to facilitate and exploit the mass take up of EVs.

Phase One of the Taskforce concluded in January 2020 with the publication of the 'Energising our Electric Vehicle Transition' report [3], which contained 21 proposals describing what's needed to successfully electrify our road transport system by no later than 2050.

Phase Two delved into the detail of making the 21 proposals actionable, with the publication, in October 2020, of the in-depth report 'Moving from Proposals to Actions'[4]supporting the initial range of findings and recommendations.

Phase Three of the Taskforce's work focuses on defining the conditions required to deliver the EV charging infrastructure we need and to capture the potential benefits to our energy and transport systems as the transition progresses.

Charging The Future

The aim of this study was to identify the essential elements of a functioning ecosystem that will meet the requirements of EV users over the next ten years. Achieving this aim required the development of an aligned, evidence-based view, shared between participants in the EV Energy Taskforce (who represent the widest range of stakeholder perspectives).

As we are at an early stage in this transition and given the rapid pace of change necessary over the coming decade there is, inevitably, uncertainty about many aspects of the EV ecosystem that will emerge. To ensure this is fully functioning, however, will require separate sectors with limited past experience of working together, to build complementary and compatible products, systems and services; and to do so urgently. Establishing the essential requirements of EV users, as EVs proliferate and technology and drivers' expectations evolve, provides the common foundations for these separate sectors to build on.

Charging The Future Scope

With the requirements of EV users at its heart, this work sets out the actions and conditions needed to bring about the desired ecosystem to successfully deliver the electrification of all new cars and vans by 2035.

To inform this report, the EV Energy Taskforce created an analytical framework to quantify the complex interplay between a wide range of factors. These include the impact on consumers of the EV transition as well as on, vehicle procurement and use, charging infrastructure investment and deployment and the overall energy system. It has been informed through broad, expert stakeholder engagement encompassing consumer groups, the automotive sector, chargepoint network operators, the energy sector along with regulators and representatives of local and central Government.

This report builds upon earlier work of the Taskforce, undertaking both a qualitative and quantitative assessment of the implications of meeting the Sixth Carbon Budget and electrifying the car and van market to the targeted timescale.

In attempting to identify the quantity and nature of the infrastructure that will be required (including chargepoints, electricity networks and electricity generation) the study considers a wide range of factors. These include: the needs of private and fleet drivers of cars and vans; the impacts of evolving EV technology; the potential for different types of public and private charging; the upstream electricity networks; generation, storage and supply (including what's required to serve other energy demands) and different emissions and vehicle sales policies.

The enabling conditions identified focus on:

- public charging deployment
- what LAs and distribution network operators need to do to support the EV rollout
- public charging operation and maintenance
- the implementation of smart charging
- the information needed for mass market uptake

EV charging infrastructure modelled assumptions

Central to the task is the development, under Taskforce auspices, of a common, data-driven understanding between stakeholders of EV user needs and related factors which will impact on the future requirements for the charging and energy system infrastructure. These common assumptions, challenged, scrutinised and agreed by EV Taskforce members, provide the data required to model the charging and energy system infrastructure and its evolution over time (to 2050).

The EV Energy Taskforce model outputs were required to be compatible with the decarbonisation of the transport system in line with the 2050 Net Zero target as well as ensuring that energy generation and usage align with the Sixth Carbon Budget as defined by the Climate Change Committee[5].

Assumptions were made in terms of the requirements for government interventions. These included:

- That the transition to both BEVs and FCVs is supported by central Government via vehicle grants, phased-out by 2030, and that there is continuing targeted support for the deployment of chargepoints.
- That government leverages private investment in distribution network infrastructure, providing regulated returns.
- That a coordinated rollout of infrastructure opens opportunities for demand management via both time-of-use and delegated control tariff schemes for home charging.

Assumptions were also made with regard to the types of cars and vans that will be available – and when – within the future assessment, to align with Government ambitions as set out in the Transport Decarbonisation Plan [6]. In particular with:

- The phase out of ICE and PHEV vehicles, aligned with the Government ambition of 2030 and 2035, respectively.
- The suggestion that fuel cell vehicles (FCVs) become more widely available when and if the large-scale production of hydrogen from electrolysis is in place.

Consumer needs are described by 'use cases' considering different user groups and their varied travel and charging behaviours. These groups included:

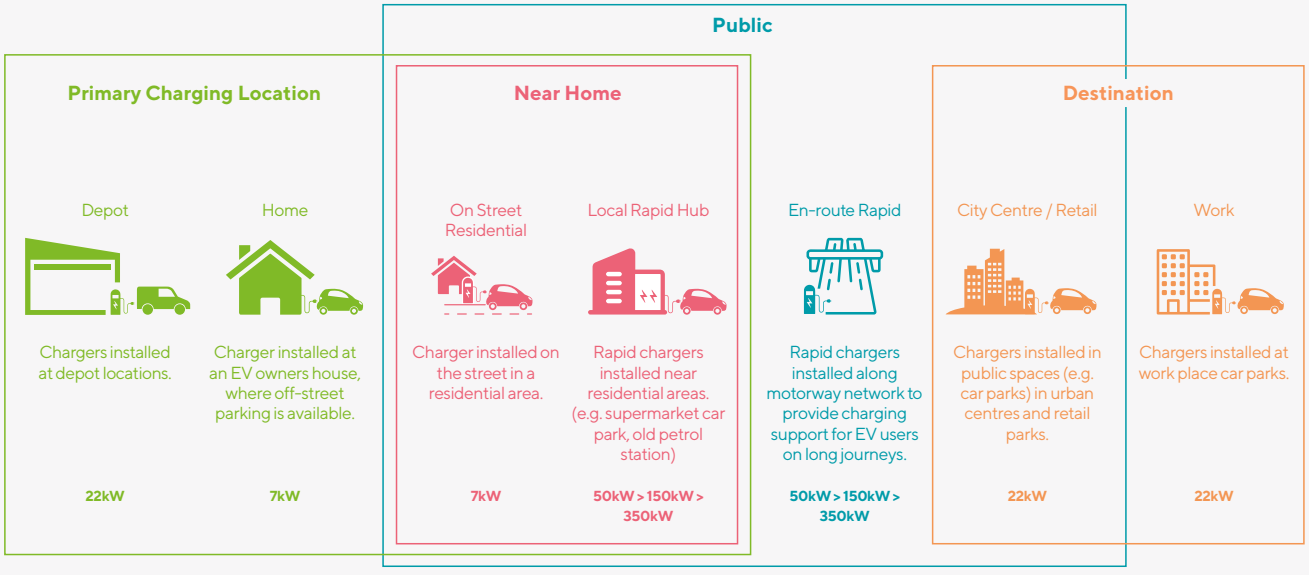
- private consumers;
- users of company-owned cars where the users themselves have free choice over their purchase decisions and;
- users of company-owned vehicles where the purchase decision lies with the company or fleet manager.

Within some of these user groups there are further sub-groups allowing for further differentiation in terms of behaviours and preferences.

In addition to home-based chargepoints, six other chargepoint types are included in the assessment (see Figure 1). These are categorised in terms of how they would be used, from a user's perspective, as:

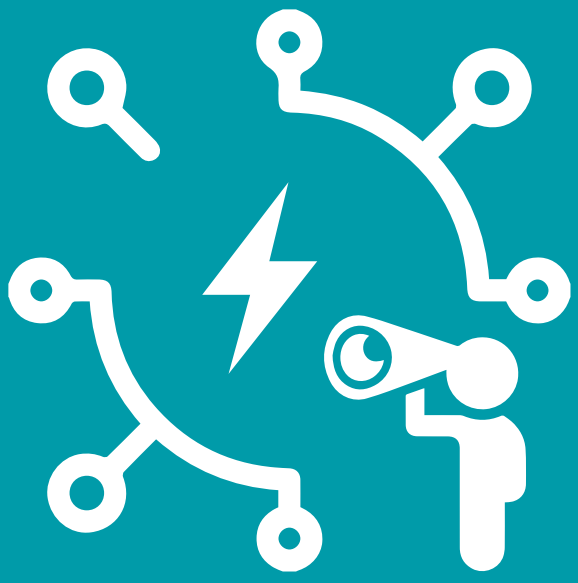
- On-street residential
- Local rapid hub
- En route rapid
- Publicly accessible chargepoints for opportunistic charging, referred to as city centre/retail
- Workplace charging; and
- Depot-based charging.

Figure 1: Chargepoint types examined within the analysis



The EV Energy Taskforce modelling outputs also include charging prices to 2035 at each chargepoint type. The prices used are projected equilibrium pricing in an open and competitive market, where supply and demand for each charging service has reached stability.

2 What does an effective EV charging network look like from a user perspective?



What does an effective EV charging network look like from a user perspective?

Introduction

Cars and vans play a vital role in UK transport for both households and businesses. In 2020 there were over 35 million cars and 4.6 million vans on the road. 79% of households have access to a car or van and 3.4 million people use or depend on a van for their work. The roles these vehicles play, and the uses to which they are put, are hugely diverse, but all will need to be catered for by charging infrastructure if we are to successfully electrify this market.

The Taskforce's modelling analysis is based on three broad types of user:

- Private users: Private consumers, who have free choice over their purchase decisions
- Company car drivers: Users of company-owned cars where the users themselves have, at least some, free choice over their purchase decisions and
- Fleet users: Users of company owned vehicles where the purchase decision lies with the company or fleet manager.

User requirements, however, differ for reasons that go well beyond the type of user. The Taskforce's work with both fleets and private motorist groups identified use cases based on where the vehicle is kept, how it is used, what it is used for as well as a variety of specific requirements of the user. Each user group and each different use case implies different charging requirements. The following discussion explores these requirements for each group.

Private users & company car drivers

For private and company car users, the distinction between use cases can be further segmented in terms of:

- Where the vehicle is kept
- Type of use
- Accessibility

Where the vehicle is kept

Private users and company car drivers typically charge their car (or, sometimes, van) at their home. In the UK, nearly two-thirds of households have access to off-street parking, although this varies regionally and between city centre, suburban and rural areas. Access to off-street parking is, unsurprisingly, highest in rural areas and lowest in city centres.

Of Britain's 27.6 million households, it's estimated that 18 million (65%) either already have or have the potential for off-street parking for at least one car or van [7]. Research has consistently shown that when home charging is available the majority of charging needs will be covered there [8]. Off-street parking is considered a safe, convenient and cost-effective option for charging.

However, for the remaining 35% of households without access to off-street parking, charging at home is not an option. This is clearly a barrier to EV adoption so alternative charging solutions need to be made available.

Type of use

Journey type and duration will affect the types of charging infrastructure needed. The National Travel Survey [9] provides detailed information on the reason for trips in terms of the number of journeys and mileage covered. Trips are divided between personal, commuter and business purposes.

The most common purpose for a trip by car in 2020 was personal use[2], accounting for 73% of journeys. (Personal use includes leisure, shopping, education and driving others.) Journeys by car for commuting accounted for 15% of trips, while business use accounted for 12%.

Journey length is also important and will affect charging needs and patterns. Provision of public charging infrastructure will need to account for the types of journeys users make and how likely they will be to charge after each type of journey. 98% of trips made are under 50 miles. For 2019 the average journey length by car was 8.4 miles [10].

In 2019[3], the average car in the UK drove 7,400 miles, a reduction of 24% on 2002 [11]. British motorists have been driving less in recent years; a result of lower demand for both business and private uses. (Data from 2020 onwards was impacted by the Covid pandemic and so is excluded.) Commuting, however, has been more resilient, between 2002 and 2019, as shown in Table 1. The long-term implications for commuting patterns resulting from the Covid pandemic have not been examined here.

Table 1: Chargepoint types examined within the analysis[13]

Change in UK Driving Habits	Business Miles	Commuting Miles	Other Private Miles	Average Total Miles
2002	1,300	2,700	5,100	9,200
2019	400	2,700	4,400	7,400

Accessibility

For some groups - such as the disabled, the elderly and infirm and parents with young families - the proximity of a chargepoint to their home is particularly important.

There are predicted to be 2.72 million Blue Badge holders in the UK by 2035. These will be made up of disabled drivers, passengers and carers, of whom 1.35 million will be partially or wholly reliant on on-street charging infrastructure [12]. It is vital that public chargepoints are accessible to Blue Badge holders and other user groups described earlier. Currently, 71% of Blue Badge holders are concerned about accessibility in terms of their ability to manoeuvre around the vehicle, chargepoint, kerbs and trip hazards and to connect and operate the chargepoint [13] .Furthermore, according to SSEN's Equal EV project [14], very few public chargepoints are located in disabled parking bays.

[2] This is travel for private purposes or for work or education, provided the main reason for the trip is for the traveller themself to reach the destination.

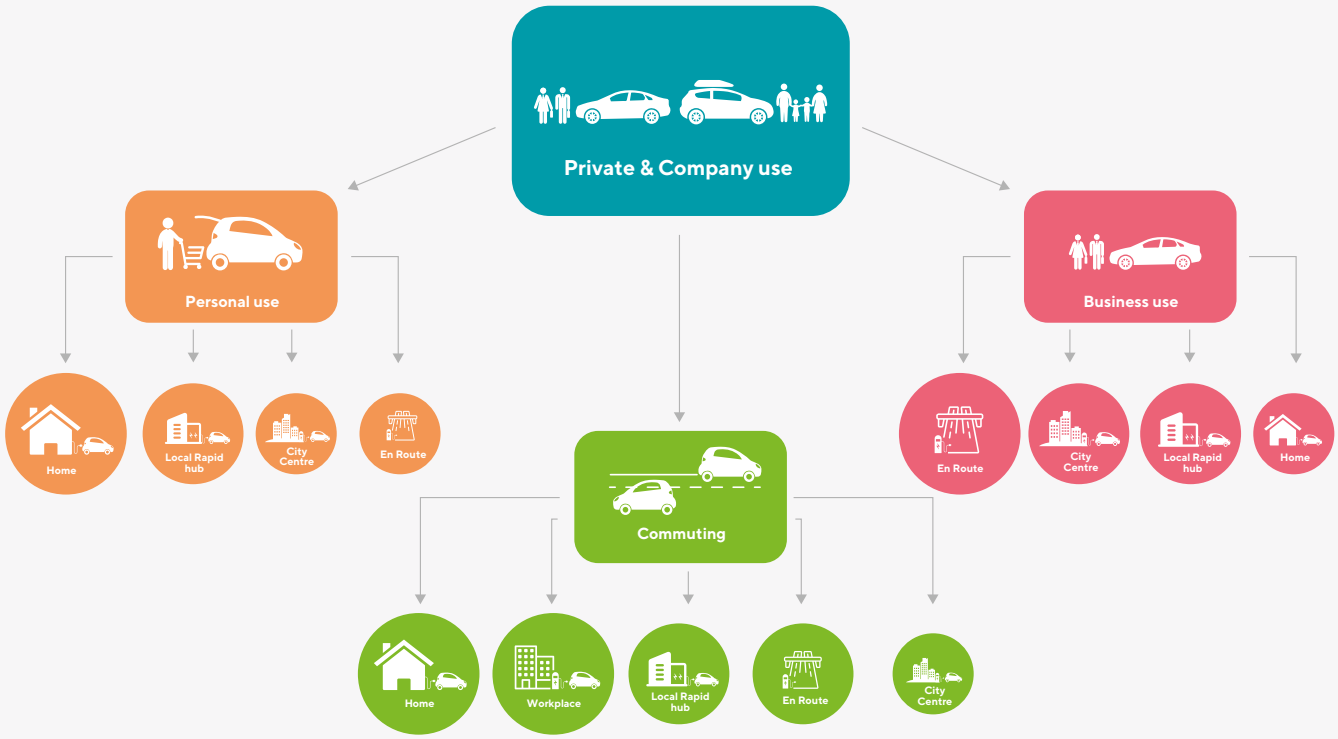
[3] 2020 statistics were not presented due to the effects of the global pandemic


HYPERVOLT

EV charging preferences

Most car or van user groups will require near home charging when their own or shared (peer-to-peer) off-street parking is not available. To further understand the needs and preferences of drivers without access to off-street parking, Energy Systems Catapult carried out extensive consumer engagement work with this user group.

Figure 2 – Private Car Use Cases



Two main studies were undertaken; the first involved qualitative research to explore user knowledge of and attitudes towards EVs and the second was a choice experiment exploring the preferences of users without access to off-street parking for different forms of public charging.

The first study engaged focus groups comprised of car users in households without off-street parking. In addition to the usual barriers to EV adoption they faced an additional barrier: the perception that EVs are impractical for them as they have nowhere to charge. Fast charging hubs were seen by most participants as convenient; they generally felt that they would be able to do something useful while charging, such as shopping, if the hub were located at a supermarket. There was less enthusiasm for on-street charging due to the potential for it to exacerbate existing conflicts over parking, as well as posing some safety concerns (such as cables being a trip hazard for pedestrians).

The choice experiment study involved a sample of car users from households without off-street parking. Existing EV users generally showed a preference for slower overnight charging solutions close to their homes, whereas non-EV owners were more likely to favour local fast charging solutions.

Responses from non-EV owners who said they were not likely to buy an EV in the next five years showed an equal split between those favouring overnight and fast hub charging. However, those who said that they're likely to buy an EV in the next five years expressed a greater preference for fast charging solutions (around 65%:35%).

The findings from Energy Systems Catapult's consumer engagement studies were used as a basis for some of the assumptions made in the modelling work discussed in Section 3.

A recent study by EVA England [15] found that drivers with access to off-street parking will also utilise public charging. Based on the report, only a third of current electric vehicles drivers confine their charging to their home, the rest using a combination of public and private charging. Surprisingly, 10% of drivers indicated that they performed all their charging using public chargepoints7. Currently, only 5% of all drivers use designated workplace charging as the primary location for charging their vehicles4. New workplace charging propositions could shift charging demand from near home to workplace charging[4].

Fleet Users

The charging requirements of fleet vehicle users can be further broken down by identifying:

- Where the vehicle is kept
- Type of operation / duty cycle
- Vehicle size

Where the vehicle is kept

Business premises, depots and drivers' homes offer convenience as vehicles are stationary for long periods, making smart charging attractive. These are expected to be the dominant locations for charging fleet vehicles into the future.

However, there are a limited number of fleet use cases where vehicles are kept either on-street or at other public locations and these will have specific charging requirements.

Stakeholder feedback also revealed that for fleets with branded vehicles, especially vans, there already exists some hostility towards them in locations where there is pressure on parking. This could be exacerbated by the introduction of electric fleet vehicles competing for limited on-street charging points.

Type of operation / duty cycle

In many cases the time a vehicle is stationary is sufficient to recharge the battery to ensure sufficient range for the next day's duty cycle.

However, there are a number of fleet use cases where (due to operational range or turnaround time requirements) there isn't sufficient dwell time to recharge the vehicle. These drivers will depend on rapid public charging to provide the primary charge and/or additional charge to extend range during the vehicle's daily operation.

These use cases include car club vehicles, car rentals (in particular, those at airports), double-shifted taxis where the turnaround of the vehicle may be as little as 30 minutes, and vehicles with a duty cycle requiring top-up charging to extend range. Rapid charging hubs in accessible locations will be needed to support these use cases where home or depot charging is not an option [16].

Emergency service vehicles also have a very specific duty-cycle. These vehicles can spend a significant time stationary, while waiting for a call, which allows for slow charging, or they may require rapid charging during a shift. For example, a specific requirement for NHS ambulances is to have complete technical interoperability across all NHS locations [17].

Vehicle Size

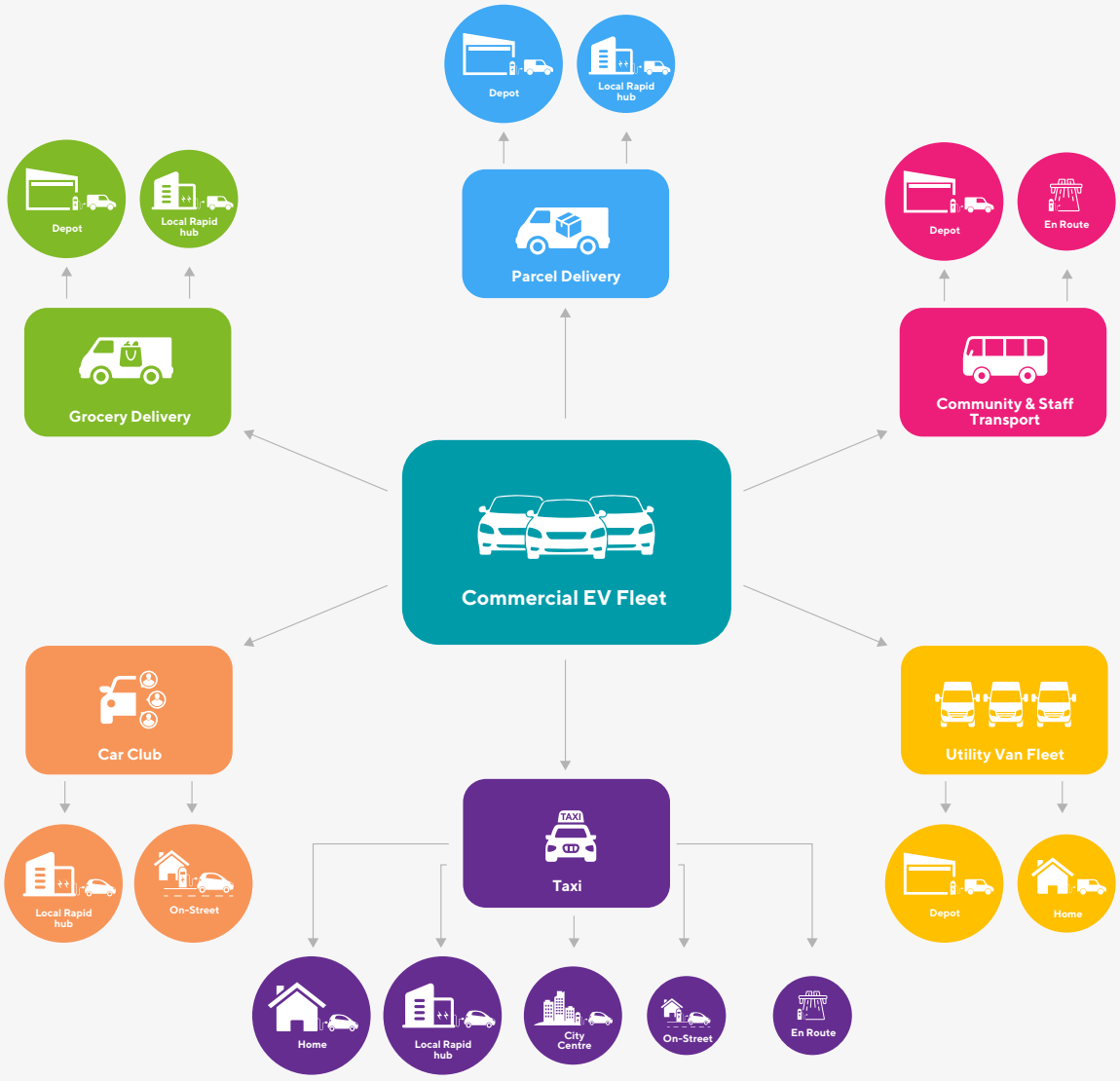
There are a range of specialist fleet vehicles which create particular demands on charging infrastructure. These include larger vehicles with a long wheelbase, high-roof, or specialist-bodied vans. Along with vehicles towing trailers, these need access to charging stations with larger bays and turning circles, as well as longer cables to enable ease of connection. These vehicles may require specialist charging stations allowing drive-through access.

Fleet operators who are under time pressure need reliable access to chargepoints, implying greater emphasis on their maintenance as well as the ability to schedule charging at public sites and/or allow priority and top-up charging at hubs.

[4] It should be noted that the behaviour of future EV drivers might be different compared to current EV drivers.

Implications for fleet EV Charging

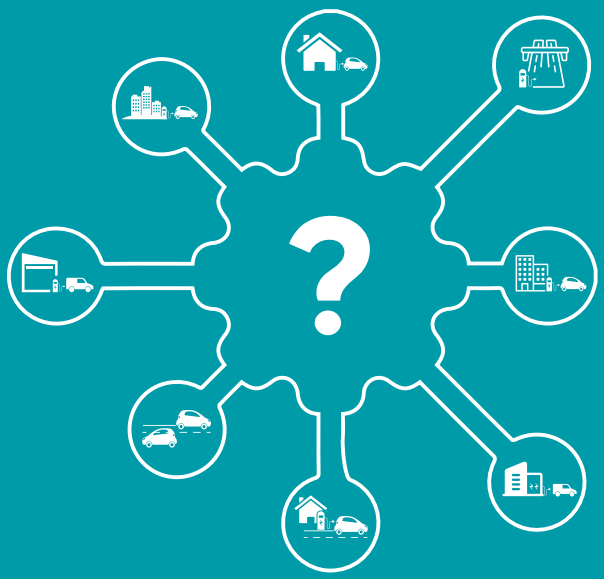
Figure 3 – Commercial Fleet Use Cases



Vehicle fleets - in particular public and large private sector fleets - are in the vanguard of EV adoption. While depot, business premises and drivers' homes will remain preferred locations for charging, a number of use cases will rely on developing the public charging infrastructure. There are opportunities to support both fleets and chargepoint networks, by ensuring the right charging infrastructure is present in the right places [17].

Local authority planners, in association with DNOs, have a critical role to play in the provision of appropriate charging infrastructure for fleet operators as well as meeting the requirements of other EV users.

3 What infrastructure will we need to meet EV user requirements?



What infrastructure will we need to meet EV user requirements?

3.1 Methodology

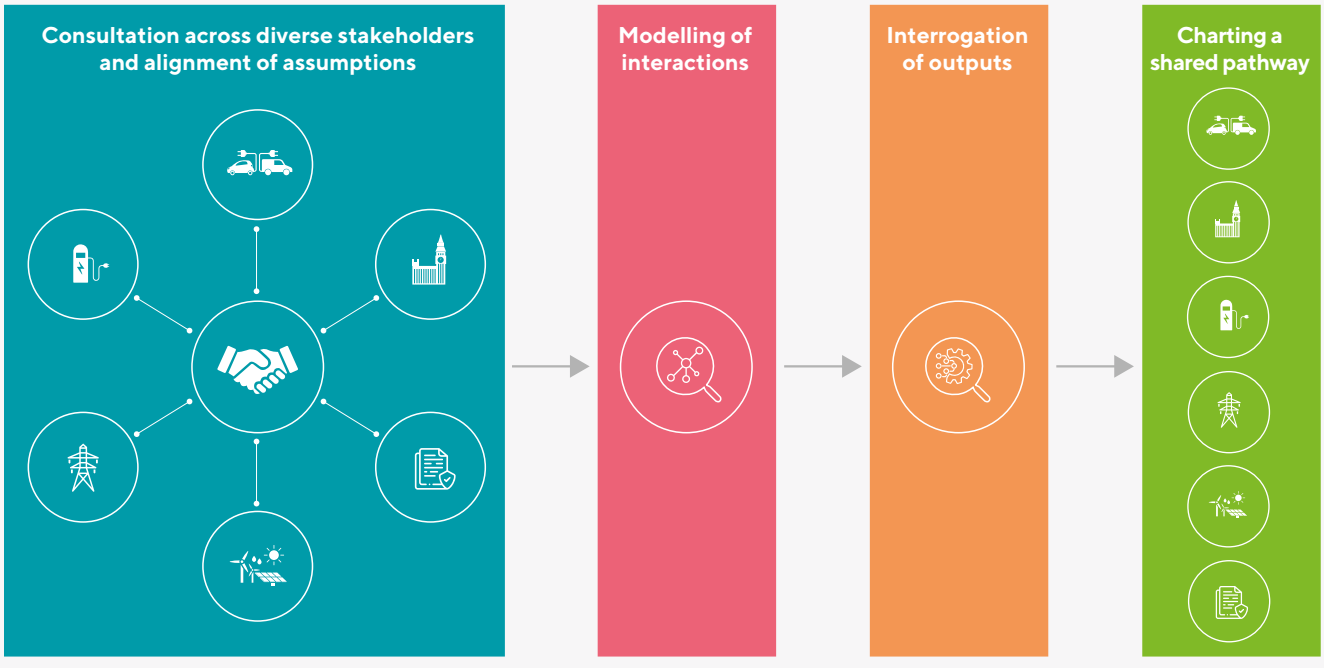
A key focus of the work was to develop a consensus view - aligned between the diverse range of stakeholders involved in the EV Energy Taskforce - of the infrastructure that will be required to deliver the ambition of phasing out internal combustion engine vehicles by 2030 (and hybrids by 2035).

This brought with it notable challenges. There are a wide range of stakeholders, from the automotive and energy industries as well as chargepoint providers, multiple branches of government (central and local), regulators and others. Each brings a unique and valuable perspective to the core issues. Yet these diverse views also resulted in substantially differing expectations about what might be possible or, indeed, necessary.

Many of the prior assessments undertaken had provided critical insights but it has been typical for these to be limited to a narrow portion of the ecosystem and for some of the crucial interactions between sectors, for example, to be overlooked. Where wider elements of the ecosystem are included, it has not been uncommon for out-of-date or inconsistent assumptions to be used.

However, the number and diversity of perspectives available to the Taskforce presented opportunities in terms of the breadth and depth of up-to-date know how that could be drawn upon. Channelling this effectively to amplify collective understanding required a bespoke approach, using robust and comprehensive tools.

Figure 4 - Stages of the approach adopted for this work



The first stage involved consultation with as many stakeholders from each relevant sector as possible to develop agreed assumptions about, for example: the nature of the vehicle and charging technology that would be available in the coming decade; the costs of network upgrades; and the potential for travel and purchasing habits to change and evolve. This stage also sought to establish where the biggest areas of uncertainty remained.

The next stage utilised a sophisticated modelling suite[5] to analyse the interactions in potential, emergent ecosystems to establish the size of the changes that will be required. The effects of, for example, changing travel habits, parking behaviours and varying attitudes towards certain charging options were explored.

The outputs were interrogated by specialist analysts and the Taskforce's expert stakeholders, ensuring their credibility and accuracy, whilst at the same time allowing those involved to challenge each other's - and their own - preconceptions.

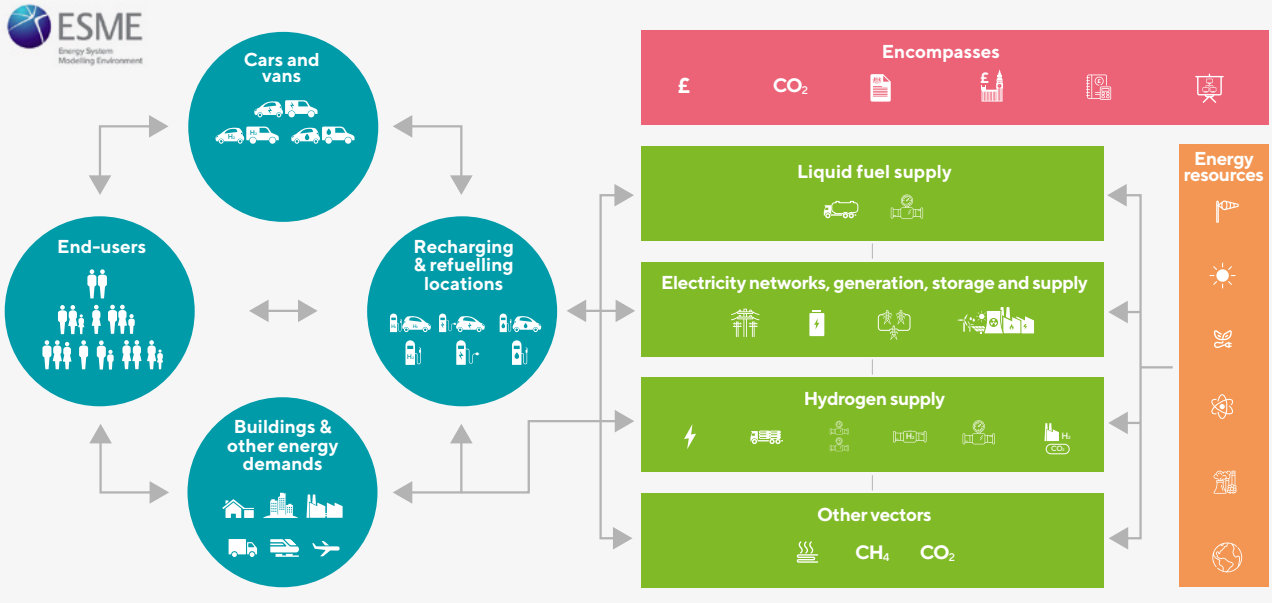
The final stage was to build on the collective understanding of the scale of the changes needed for each part of the ecosystem that was emerging; to define the conditions that need to be created for an ideal EV charging network (see Section 4) and develop recommendations for the actions necessary to achieve them.

3.2 The ESME:Transport Analytical Framework

The ESME:Transport Analytical Framework encapsulates the whole energy system, covering the different forms of energy supply, network infrastructure and end-use sectors. It has a particularly detailed representation of the transport sector and provides an integrated, holistic means of quantifying and qualitatively assessing the impacts on and from infrastructure, consumers, vehicle uptake and use, policy measures and commercial models across the system.

The Analytical Framework also allows for different user groups to be represented, each having different travel patterns and charging requirements.

Figure 5 - Overview of the ESME:Transport Analytical Framework



[5] See Section 3.2 **The ESME:Transport Analytical Framework**

3.3 Vehicle parc and energy system impact

The modelling outputs show that a dramatic uptake of electric vehicles is needed to deliver the UK's transport decarbonisation ambitions [6]. (Note that all the data shown in this Section is the output of the Energy System Catapult's modelling.)

In order to encourage wider adoption of both private and fleet vehicles, a significant increase in vehicle availability plus a broader selection of models, improved vehicle range, lower vehicle prices, along with the roll-out of a user-friendly public charging infrastructure will be required.

To meet the UK's decarbonisation targets, annual BEV sales will need to reach 2.5 million by 2030. To put this in context, Deloitte forecasts that global electric car production capacity will be 35 million units in 2030 [18], so sales of electric cars in the UK would represent over 7% of global production capacity in that year.

By 2035, this could mean 26.8 million BEVs on the road, compared with 337,718 battery electric cars and vans today[6] [19].

Figure 6 – UK Vehicle parc by powertrain in 2030 and 2035

From 2030 through 2035, the scale of the electrification of the vehicle parc will put pressure on the automotive industry to deliver 18.5 million BEVs to enable their uptake.

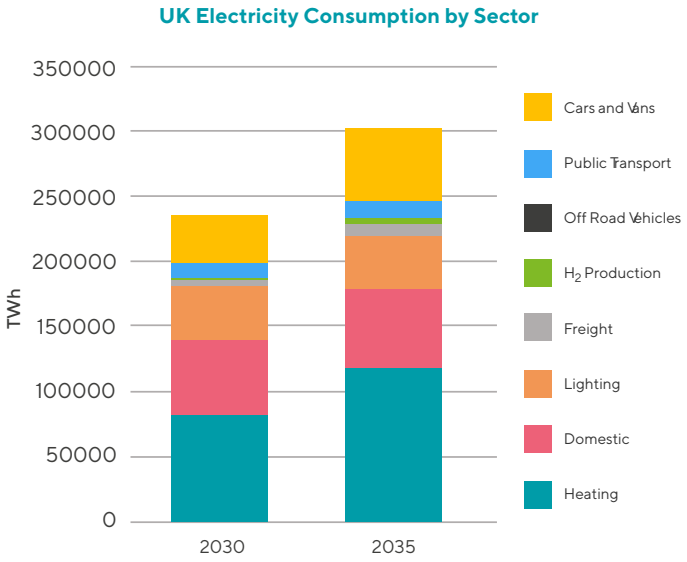
[6] As of the end of Q3 2021 according to data published by the Department for Transport.

Figure 7 – New battery electric car and van sales in the UK between 2025-2035

The rapid electrification of the vehicle parc will clearly add to demands on the electricity system. At 55 TWh per year by 2035, it is forecasted that car and van charging will make up 14% of total UK electricity demand.

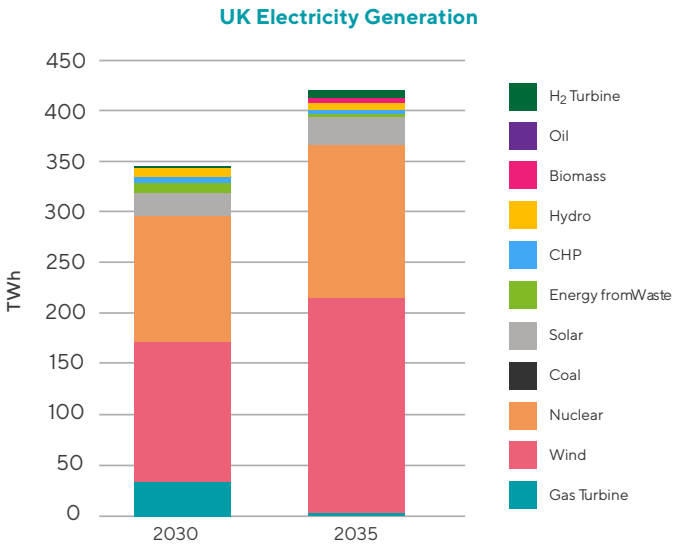
With electricity demand from other sectors (particularly domestic heating) also expected to increase over the same period, annual UK electricity consumption will grow from 287.4 TWh [20] in 2020 to just over 300 TWh in 2030 and 379 TWh in 2035. Demand from heating electrification is expected to grow from 70 TWh in 2020 to 199 TWh in 2035 whilst public transport, road freight and the production of hydrogen also add to the projected growing consumption of electricity.

Figure 8 – UK electricity consumption by sector (2030 and 2035)



While electricity consumption is projected to increase and change rapidly in its composition over the next two decades, the electricity supply mix will also evolve rapidly. Higher penetration of decentralised, weather-dependent (and, therefore, intermittent) renewable energy (particularly wind power) will drive changes to the electricity system, though nuclear energy is also expected to play a significantly greater role. Innovation-friendly and consumer-focused electricity market design [21] will maximise the opportunity for demand to match low-cost variable supply and for EVs to provide system services with fair rewards.

Figure 9 – UK electricity generation by source (2030 and 2035)



3.4 Delivering charging infrastructure aligned with user needs

To support the uptake of EVs, a diverse charging infrastructure will be required (as shown by the modelling outputs). Charging and travel behaviour and user preferences (discussed in more detail in Section 2) will influence the types and location of chargepoints needed. It is assumed that charging infrastructure will mainly be delivered by the private sector, sometimes leveraged by public investment. (Note that all the data shown in this Section is the output of the modelling for this study.)

Accurately identifying current and future user requirements and ensuring that charging infrastructure is investable will be keys to delivering the diverse EV charging ecosystem we need.

The following sub-sections look at different types of charging infrastructure in detail. Modelling outputs[7] show that:

- A mix of charging types and locations will be needed to provide drivers with the confidence to buy electric vehicles and the means to charge them.
- To ensure the widest possible uptake of EVs, near home charging solutions should not focus only on slow on-street residential chargepoints.
- Higher throughput enables lower charging prices.
- Chargepoint utilisation is critical: there must be enough EVs on the road and the length of time they are occupied must be managed.
- Home charging demand is projected to remain stable as a proportion of total charging, as it meets most charging requirements for those it is available for and is independent of the types of public charging available.
- En route rapid charging plays a stable role in supporting long distance journeys.
- Higher uptake of smart charging tariffs reduces charging prices. Further savings are likely to be possible with more advanced designs. The role, within the electricity system, and design of smart charging offerings will need to evolve as electrification of the vehicle parc increases.

Public charging

Public charging infrastructure provision is critical in supporting EV uptake. It will need to be investable and meet consumer needs. The volume and type of public charging needed will depend on how people's travel patterns develop, how they use their vehicles and how they choose to charge them.

When considering the various influences, the modelling outputs suggest that the number of chargepoints needed ranges from 253,000 to 661,000 by 2035 with a central estimate of 490,000. In reaching these numbers, the modelling assumes that chargepoints are built ahead of need to encourage uptake, whilst allowing the chargepoint operators to gain a return over the lifetime of the installations[8].

The rapid deployment of chargepoints at this scale (central estimate) implies total UK charging infrastructure investment[9] of £7 billion by 2035.

[7] The analysis focuses on Home, Near Home, En-Route Rapid and Depot chargepoints. For all types of chargepoints included in the modelling see Section 1.

[8] This can mean that chargepoints operators face a shortfall in returns initially.

[9] Investment refers to installation and capex of chargepoints. Distribution network connection costs are accounted at system level and reflect not only EV uptake but electrification of other demand loads.

Figure 10 – Total number of UK public chargepoints (2030 and 2035) and impact of variations to: availability of near home charging; journey lengths; overall vehicle mileage; and upfront costs of on-street residential chargepoints.

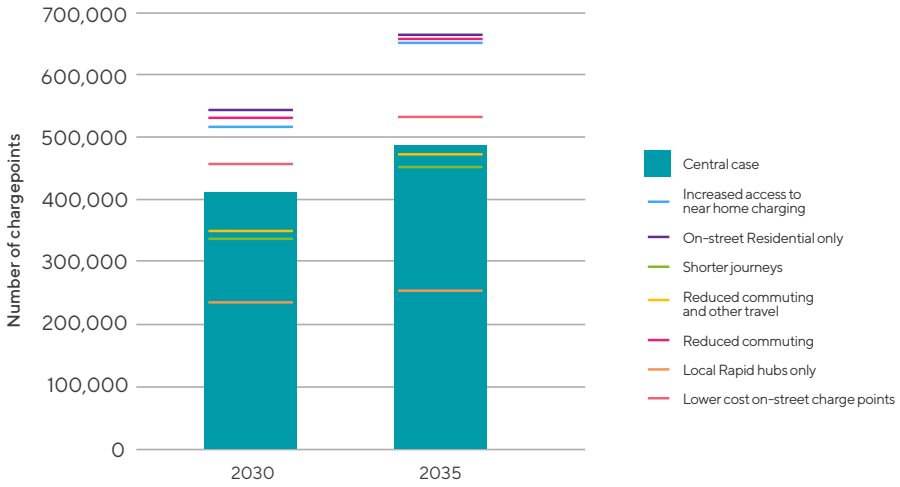
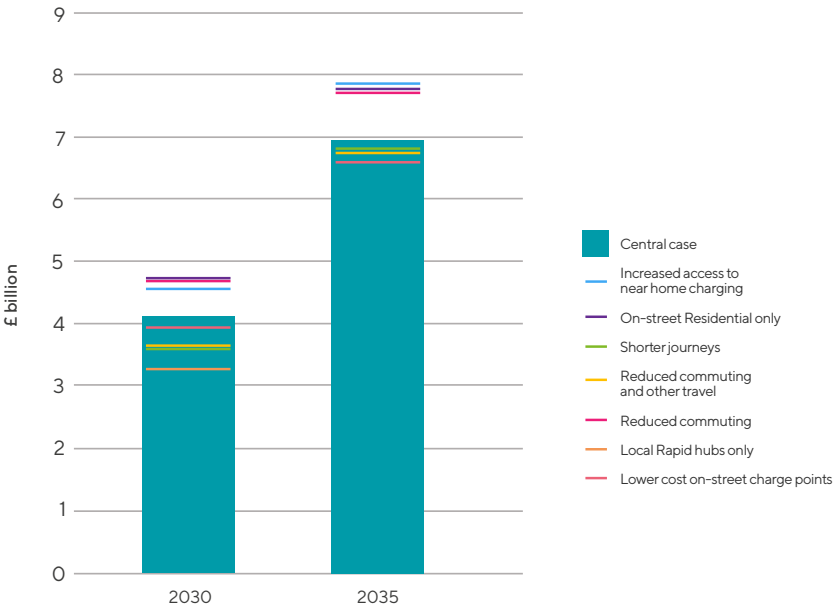


Figure 11 – Cumulative CAPEX on UK public chargepoints (2030 and 2035) and impact of variations to: availability of near home charging; journey lengths; overall vehicle mileage; and upfront costs of on-street Residential chargepoints.



Investment needs and charging prices depend on expectations of throughput[10]. It is therefore important to understand the factors that will affect this. The higher the throughput of a chargepoint, the sooner its investment costs can be recovered, the more its ongoing costs can be covered and, ultimately, the lower the prices EV users can be offered.

It's clear that hundreds of thousands of public chargepoints will need to be deployed to provide drivers with the confidence that they will be able to charge their electric vehicles having bought them. How many, exactly, and what mix of different types of public chargepoint are needed is most heavily influenced by user behaviour and preferences. (These preferences were explored through consumer engagement work and are discussed in more detail in Section 2.) The preference effect is very clear; if more people want to use a specific chargepoint type, then more of them will be required. It's important to note that the amount of time vehicles are parked at a chargepoint (beyond that necessary for charging) will also drive up the number of chargepoints required.

[10] For the purposes of this report, throughput is defined as the average amount of energy a chargepoint serves in a year.

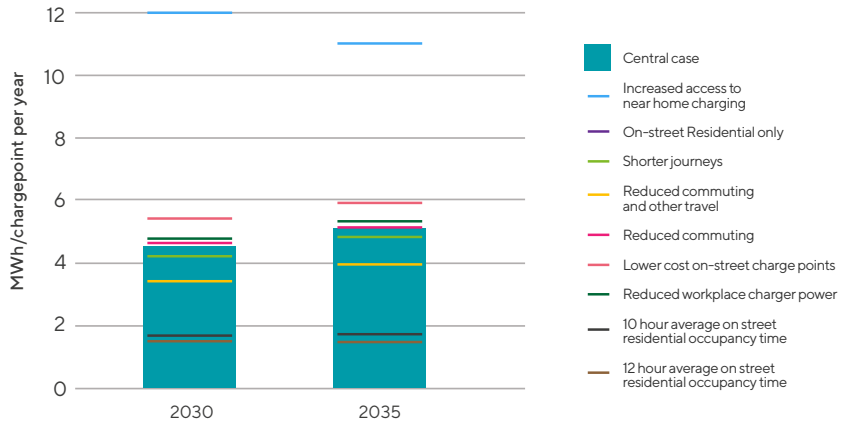
Behaviour not only affects the number of chargepoints but the energy demand they serve as well. Travel behaviour dictates the quantity and frequency of energy demand at each charging location. Less travel, for example due to reduced commuting and a modal shift away from personal vehicle use, drives down electricity demand at all charging locations. Shorter journeys, meanwhile, reduce the energy demanded at city centre and retail locations as users have less need to charge opportunistically as more of their charging needs can be met at, or close to, home.

It's clear, with all these factors at play, that a significant variability in throughput at public chargepoints is likely and that this will have significant knock-on effects for the viability and investability of different types of charging and location.

To understand the impact of changes in these factors on charging infrastructure requirements, several potential sensitivities were examined in the modelling analysis undertaken. Figure 12 provides an example of the impacts, showing the effect on throughput at on- street residential chargepoints in 2030 and 2035.

A summary of the impacts on the various forms of public charging is shown in the following sub-sections.

Figure 12 – On-street residential chargepoint throughput (2030 and 2035) and impact of variations to: availability of near home charging; journey lengths; overall vehicle mileage; and upfront costs of on-street residential chargepoints.



En route rapid charging

By 2035, around 60,000 en route rapid chargepoints will be needed. Sited along the strategic road network these are critical to enable drivers to undertake longer journeys. The modelling work carried out for this study showed that total EV numbers are the dominant influence in terms of en route rapid charging requirements. As an illustration, if the overall car parc contracted by 1% from the central projection and with further reductions in travel demand, (including less commuting) 1,700 fewer en route rapid chargepoints would be needed by 2035. In comparison, if there were an increase of 360,000 BEVs in the parc by 2035 (1% increase in the number of BEVs), the model shows that 3,200 more en route rapid chargepoints would be needed by that year.

Figure 13 – Annual UK electricity demand at en route rapid chargepoints from 2025 to 2035 (central case)

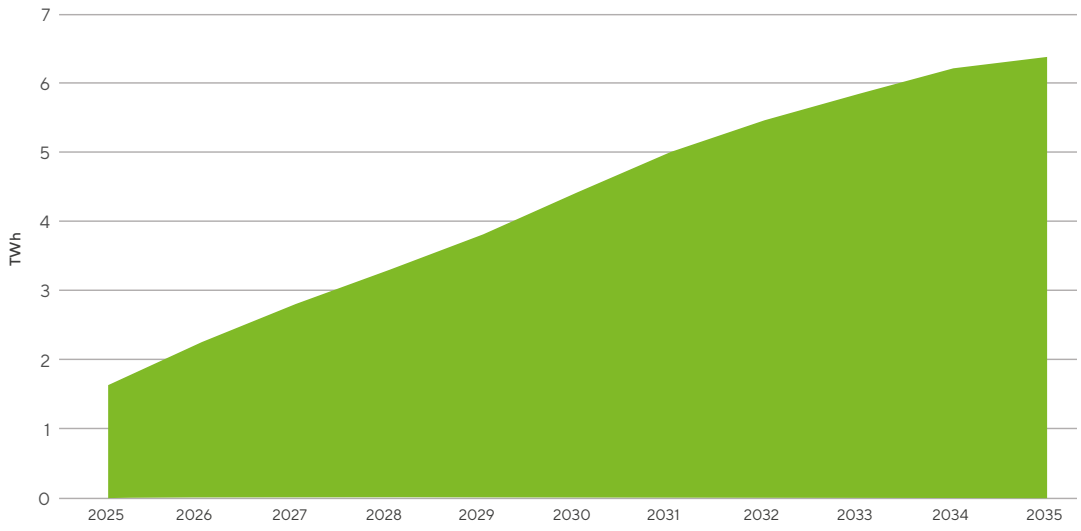
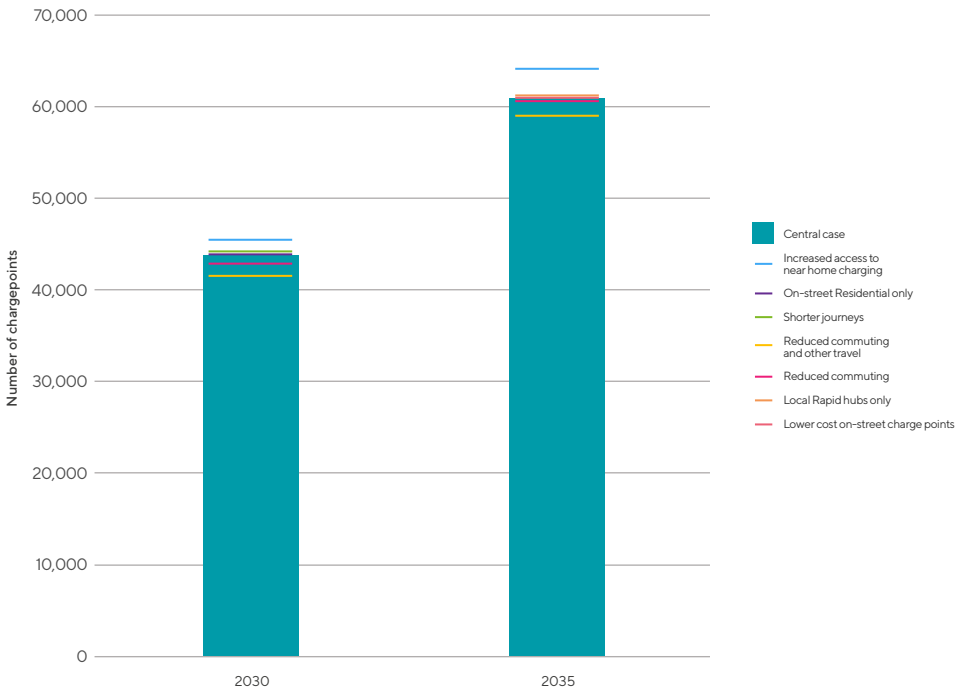


Figure 14 – Number of UK en route rapid chargepoints (2030 and 2035) and impact of variations to: availability of near home charging; journey lengths; overall vehicle mileage; and upfront costs of on-street residential chargepoints.



Near home charging

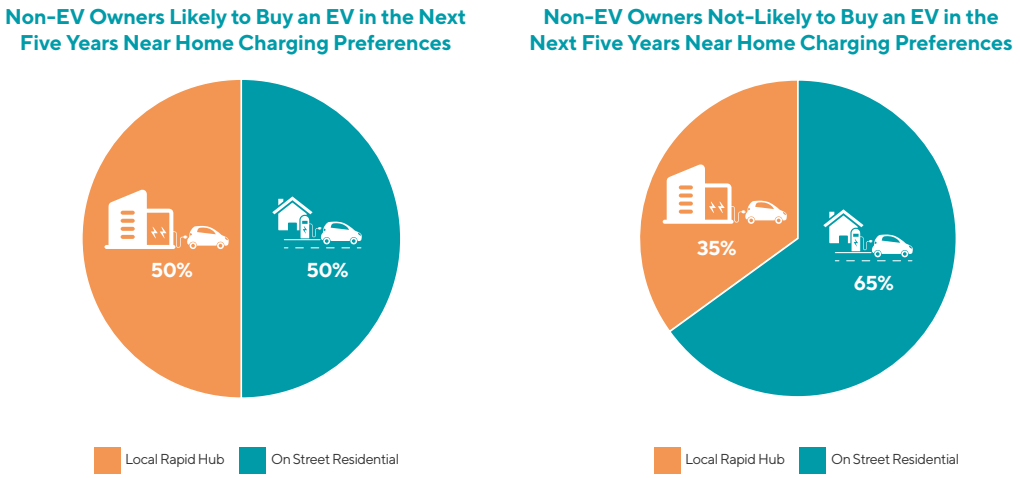
Drivers who cannot charge at home[11] need access to alternative forms of charging. Near home charging solutions provide options for this. Building on findings from recent consumer studies[12], two forms of near home charging were assessed in this work: on-street residential charging and local rapid hub charging.

In delivering the aforementioned ambition and targets, as much as 50% of the total number of public chargepoints will need to be near home charging options, specifically to serve drivers without access to off-street parking. The availability of near home charging will be a key enabler in terms of the wider adoption of EVs, able to serve the needs of both private users and fleet vehicles. Capturing consumer preferences and understanding fleet requirements in this context will be essential to providing charging solutions that are usable, accessible and investable.

To ensure the widest possible uptake of EVs, near home charging solutions should not solely focus on slow, on-street residential chargepoints. On-street residential charging is currently in most circumstances the de facto solution when home charging is not available.

It is evident, though, from the consumer engagement work described in Section 2, that households without off-street parking vary in their preferences for charging solutions near home and that there will be a role for both slow on-street residential charging and local rapid hubs. Current EV owners show a stronger preference for slow overnight charging, but non-EV owners' preference is split between slow overnight charging and local rapid hubs[13]. The evidence gathered suggests that the preferences of late EV adopters, could be different from those of early adopters.

Figure 15 – Assumed EV user preferences towards on-street and Local Rapid Hub charging options, based on consumer research (see Section 2 for more details)



Taking account of these evolving consumer preferences, by 2035 over 200,000 chargepoints are projected to be needed near home to support users without access to off-street parking. They will, in total, need to serve 1.7 TWh of electricity annually.

[11] If they do not have access to off-street parking, for example.
[12] See Section 2 for more details.
[13] Energy Systems Catapult EV Charging Consumer Survey 2022

Figure 16 – Number of near home chargepoints needed from 2025 to 2035 (central case)

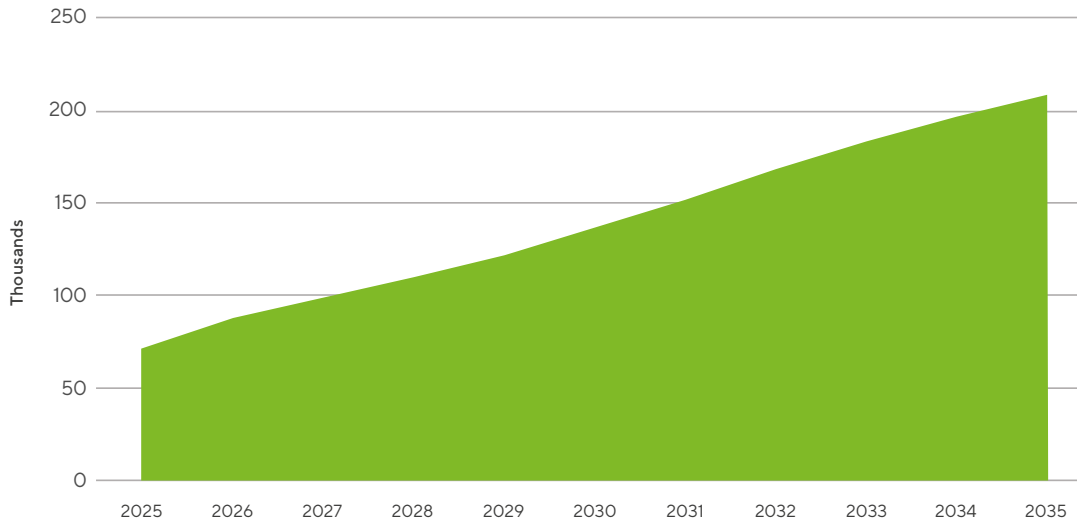
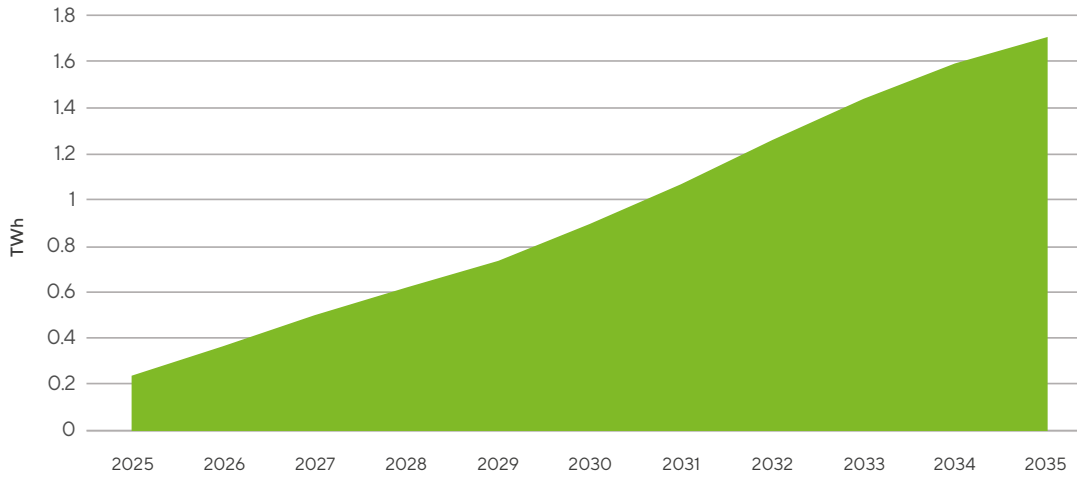


Figure 17 – UK electricity demand from near home chargepoints (central case)



As discussed, throughput has a large effect on charging prices, and this can be seen in the projected price difference of electricity delivered from on-street residential chargepoints compared with local rapid hubs (see Figure 18). Local rapid hubs will be able to serve a larger volume of vehicles, attain higher throughput and therefore (providing the market works as it should) offer lower prices[14].

[14] A 15-year economic life is assumed for both charging solutions.

Figure 18 - Near home charging solutions - overview of modelling outputs

	Number of chargepoints	Energy Served (MWh)	Throughput (MWh/ chargepoint)	Charging price (p/kWh)
On Street Residential	204,500	1,060,000	5	41
Local Rapid Hubs	4,100	650,000	158	22

As well as influencing charging prices, throughput will also affect the appetite for investment in charging infrastructure. The levels of public charging infrastructure needed will require major investment and the backing of major financial investors (see Section 4.1).

Dedicated financial modelling [22] revealed that, without intervention, the financial returns on faster charging solutions significantly outweigh those for slow residential charging. Even at similar levels of utilisation, returns improve with speed of charging.

Chargepoints being occupied whilst they are not charging also, of course, reduces the opportunity for throughput. Occupancy times will have to be managed to avoid an increase in charging prices at on-street residential chargepoints as a result of reduced throughput. A dramatic increase in the number of chargepoints required and low utilisation can be expected with longer occupancy times. This would result in higher charging prices.

The average occupancy time[15] was varied between 5 and 12 hours in the model to understand the impact such a change would have on the number of chargepoints needed, their utilisation and the price levied to charge at them[16].

[15] An average occupancy time is used to reflect varying occupancy durations throughout a 24hr period, for example, longer overnight occupancy periods and shorter occupancy events during the day.

[16] https://evenergytaskforce.com/reports/encouraging-investment-in-public-ev-charging/

Figure 19 – Number of UK on-street residential chargepoints required in 2035, for a variety of average occupancy times

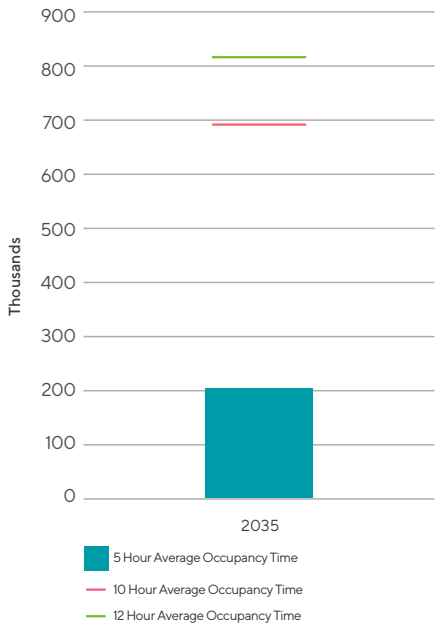
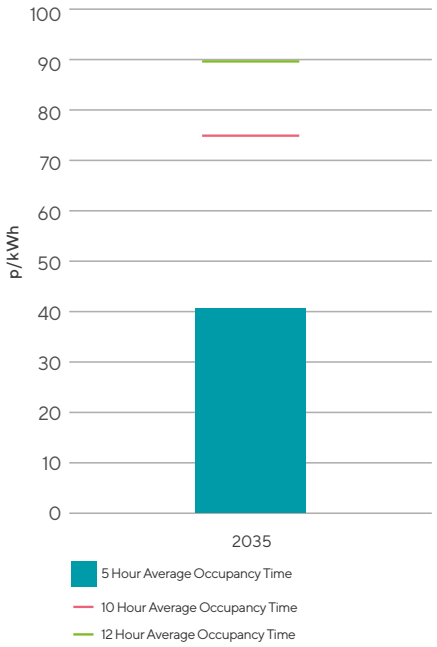


Figure 20 – Prices at on-street residential chargepoints in 2035, for a variety of average occupancy times



It was also evident that lowering the up-front costs of on-street residential chargepoints can reduce the price gap compared with local rapid hub charging. Reducing the up-front costs to install on-street residential chargepoints, reflecting higher penetration of cheaper solutions (e.g. lamppost charging), by 65% can reduce the price of charging at them by 25%, from 39p/kWh to 29p/kWh in 2035, under the same utilisation assumptions. This is still higher compared to the price projected for local rapid hubs (22 p/kWh in 2035).

To ensure the widest possible uptake of EVs, near home charging solutions should not focus solely on on-street residential charging. Many (particularly prospective) EV drivers state a preference for local rapid hubs.

There are, of course, other factors that could affect investment decisions and charging prices that have not been considered as part of this assessment. Those that have been specifically identified to explore in future work, include:

- The fact that further reductions in charging prices at on-street residential chargepoints might be possible with the implementation of smart charging.
- For both near home charging solutions there is the potential for charging revenues to be supplemented by other forms of income. Examples could include parking fees or amenities.
- Local factors are very likely to make one form of near home charging more appealing than the other for that area. Land and network connection costs, parking availability and local resident preferences are among these factors. This highlights the need for local area assessments that consider both transport and energy elements to deliver the required infrastructure.
- Demand for both charging solutions could be affected by price elasticity effects or competitive pricing strategies, for example.

Home charging

For drivers with access to off-street parking, home charging can supply the majority of their charging needs and do so at the lowest prices. Many of these drivers are still expected to make occasional use of public and/or workplace charging for longer journeys and as opportunities arise.

As with en route rapid charging, the use and deployment of home charging is closely linked to the overall uptake of EVs. In the period to 2035, the number of home chargepoints is forecast to grow in line with the penetration of EVs in the car market, reaching around 15.7 million by 2035. By this stage, it's expected that home charging will account for almost three-quarters of total charging demand in the UK.

Figure 21 – Number of UK home chargepoints required from 2025 to 2035 (Central case)

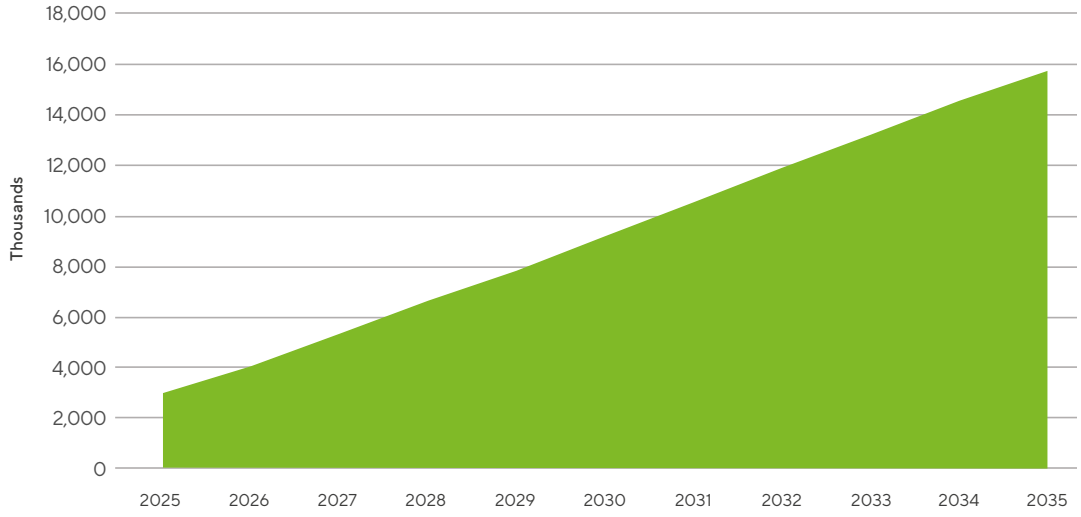
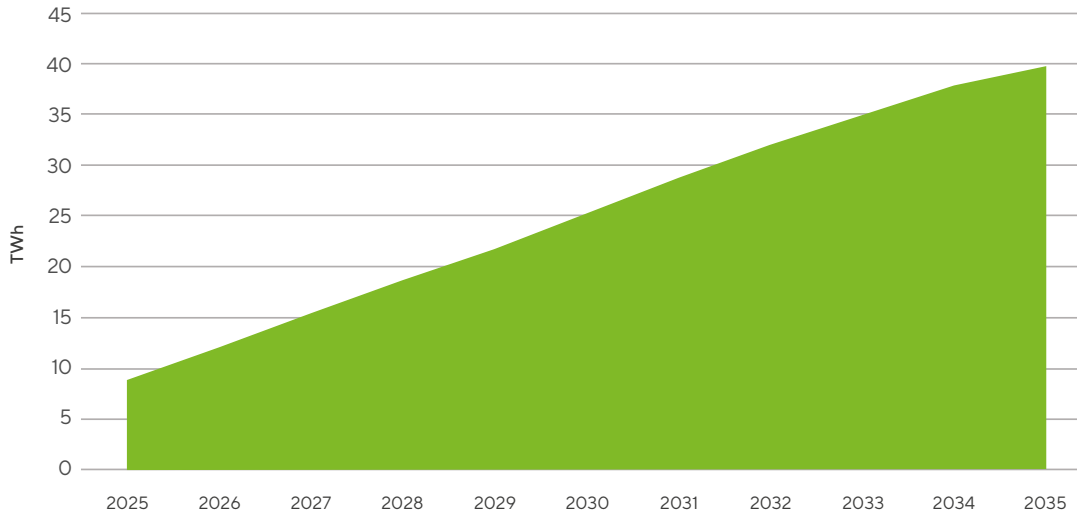


Figure 22 – UK annual electricity demand delivered through home chargepoints (Central case)



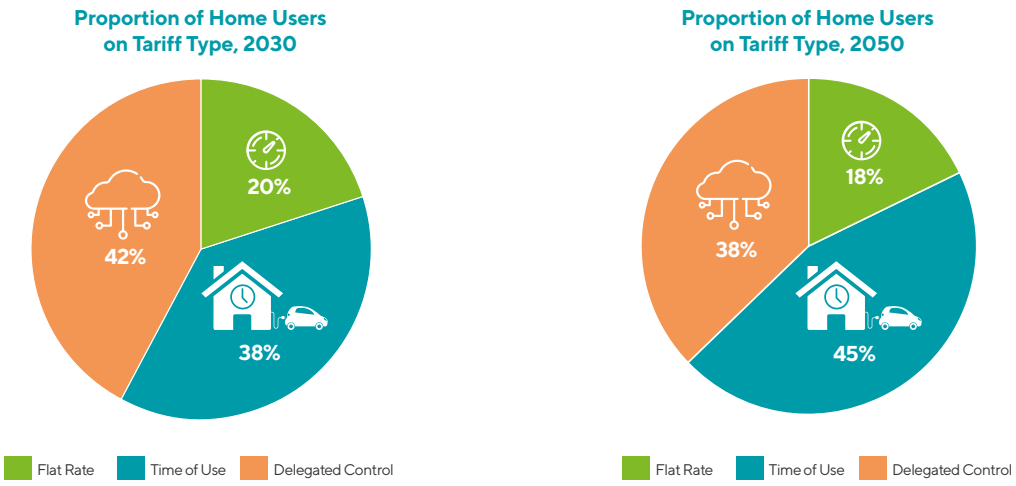
With UK electricity supplies increasingly dominated by intermittent, renewable power, there will be growing benefits to EV users, other electricity consumers and to the energy system if the timing of vehicle charging is managed 'intelligently', taking into account when electricity supply is abundant and the electricity price consequently low. Throughout this analysis 'smart charging' is assumed to be available, in addition to flat rate tariffs, to be deployed at home, either in the form of time-of-use (ToU) or delegated control tariffs.

Time-of-use tariffs incentivise users to charge during off-peak demand hours (and/or when supply is abundant) whilst delegated control tariffs enable third parties (e.g. an energy supplier or flexibility aggregator) to manage a user's demand, making charging responsive to static, hourly electricity price changes. Both tariff types typically result in charging being moved predominantly to the overnight period.

The model assumes that by 2030, around 80% of users that can charge at home are either on a ToU (43%) or delegated control (36%) tariff. Driven by consumers being better informed and more receptive of smart charging tariffs, by 2050 higher uptake of delegated control tariffs is expected (45%) as users move from ToU or flat rate tariffs. It is assumed that EV users will have a good understanding of the benefits of smart charging, enabling higher rates of smart charging to be achieved.

Smart charging is expected to bring significant benefits to the electricity system; £2bn can be saved in distribution network reinforcement costs by 2050.

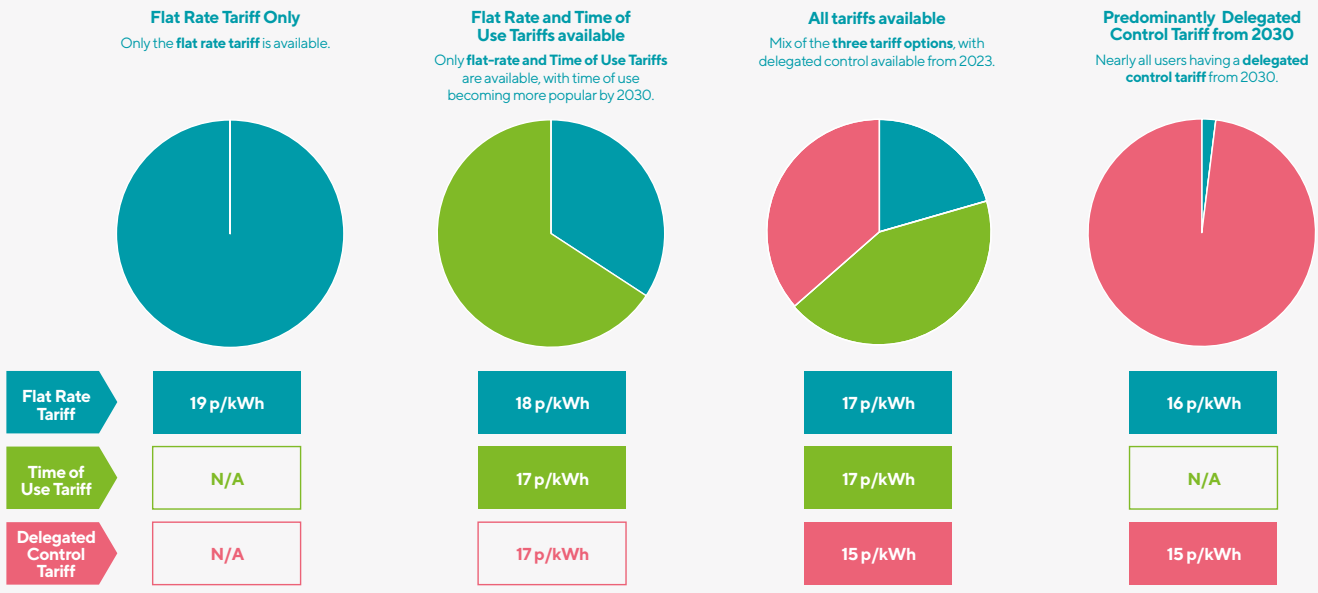
Figure 23 – Proportion of drivers on each tariff type at home (2030 and 2050)



Users on delegated control tariffs benefit from lower charging prices. Compared with flat rate tariff customers, they can gain advantage from lower wholesale electricity prices, reducing their average annual spending on charging.

In 2030 users on delegated control tariffs are expected to be able to save, on average, 13% on their EV charging bills. Higher uptake of delegated control tariffs can also reduce charging prices for all users, with the larger volume of EVs offering flexibility services to the electricity network resulting in a reduction in wholesale electricity prices (Figure 24).

Figure 24 - Average annual price for different home charging tariff options under four different cases



Further savings for both users and the electricity system are likely to be possible with more advanced designs of this form of tariff. When designing delegated control tariffs, it is necessary to understand changes in electricity markets and the role smart charging offerings will play, especially in the context of the increased electrification of the vehicle parc. Data access and sharing will be critical in delivering new smart charging propositions.

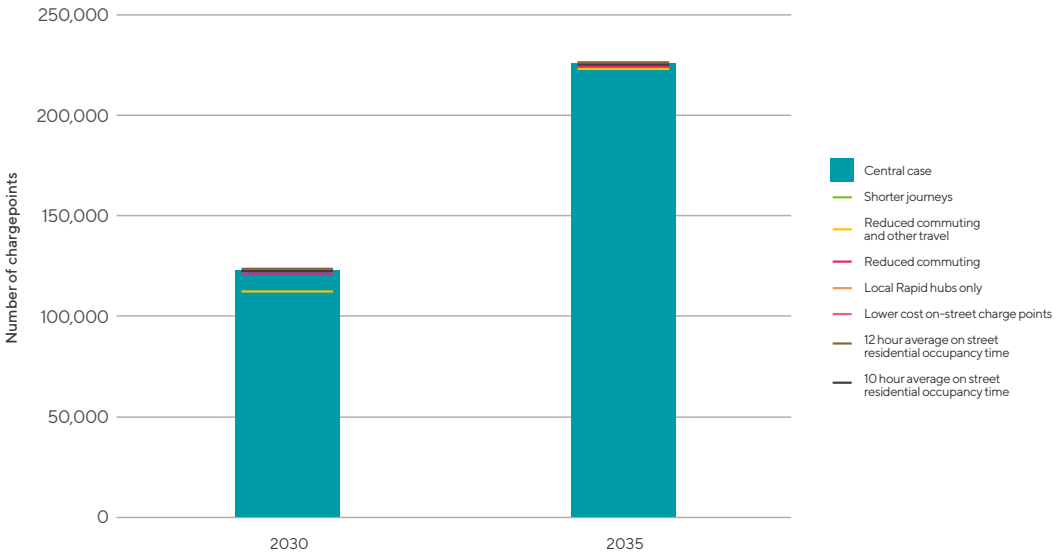
Considerable progress has already been made in terms of enabling smart charging at home. To achieve a widespread uptake of smart charging, technical requirements and governance arrangements will need to be in place and adopted to ensure interoperability, cyber security, data privacy and grid stability.

Depot charging

In common with en route rapid and home charging, the modelling outputs show that there will be a steadily rising need (at least until the early 2030s) for charging facilities installed to meet the requirements of depot-based fleet vehicles. Depots will need to serve around 5 TWh of electricity from 200,000 chargepoints in 2035, growing from just over 2 TWh in 2025. Changes to the number of depot-based electric vehicles and the mileage they undertake will naturally alter this.

As discussed earlier, the minority (around 14%) of fleet vehicles are based in depots. Home and near home charging will play a key role in supporting the charging needs of certain fleet EV users such as company car drivers whose charging behaviour is more akin to that of a private consumer.

Figure 25 – Number of UK depot chargepoints required in 2030 and 2035 under different market conditions



4 What do we need to do to create the conditions for an effective EV charging network?

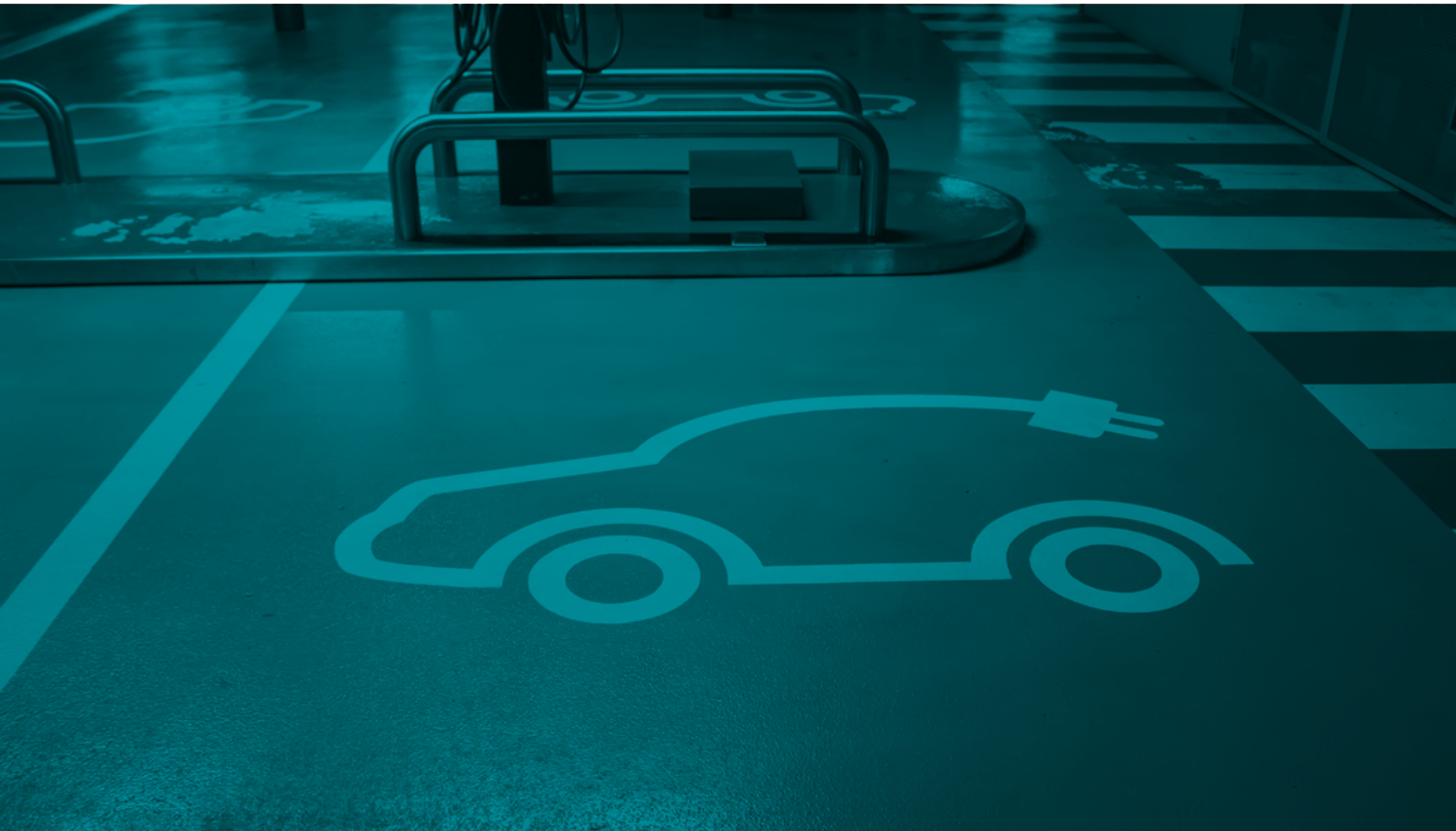
What do we need to do to create the conditions for an effective EV charging network?

The work of the EV Energy Taskforce has highlighted five key 'enabling conditions' which are required to ensure the successful deployment of the charging infrastructure the UK requires to decarbonise transport.

The Taskforce's 'EV Landscape Review' (an associated publication of this document) [23] recommends new actions needed to continue to ensure the energy system is ready and able to facilitate the accelerating uptake of EVs over the next, crucial decade.

This process included a comprehensive review of new activity across energy system stakeholders. The five key conditions identified that:

- Public charging needs to be built ahead of need to gain consumer confidence.
- Local authorities need to have the tools, capabilities, powers and resources to ensure integrated energy and transport planning.
- Public chargepoints have to be used and usable – visible, accessible, connected, secure and interoperable to gain consumer confidence.
- Smart charging, wherever appropriate, is essential if system cost is to be managed.
- Informing, educating and protecting EV users is critical to create the understanding necessary for mass market uptake.



4.1 Public charging needs to be built ahead of need to gain consumer confidence

Introduction

The adoption of electric vehicles at the scale necessary to deliver net zero by 2050 will require a level of confidence in the charging infrastructure that is not present today. Hundreds of thousands of public chargepoints will need to be deployed to provide drivers with the confidence to buy electric vehicles, knowing they have the means to charge them. A range of charging solutions will be required to meet user needs and expectations.

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- Charging infrastructure is delivered by the private sector, leveraging private capital. Risk sharing mechanisms are in place to deliver diverse charging infrastructure ahead of need.
- Targeted financial interventions, including blended public and private capital funding and utilisation-linked loans are deployed to support low density/unprofitable locations.
- Targeted government interventions while the market matured, have helped to ensure equality of access and a strategically capable system for all, where conventional private sector business cases are weak.
- The efficient and coordinated deployment of network infrastructure has been established. Local authorities, DNOs and chargepoint operators are working closely together to enable infrastructure roll-out and provide transparent information, widely shared.
- Data about traffic flows, chargepoint utilisation and, power availability support and encourage investment decisions. Shared data also enables comprehensive smart charging leading to savings for consumers and benefits to chargepoint operators. A range of new products and business models have been developed.
- Clear and transparent information around processes is also available and it is encouraging investment. This includes information on DNO processes, site availability and suitability and planning permissions. EVs are widely deployed by fleets. Coordination between fleet and chargepoint operators enables access to public charging networks and improved utilisation and use of depot and workplace chargepoints.
- As the market matured, steps were taken to address inequality in charging prices and accessibility and to enable users without off-street parking to access affordable charging solutions. Lower prices are seen at local rapid hubs which are much closer to home flat rate tariffs.

Key recommendations

- Government and the financial sector must develop targeted financial support including blended public and private capital funding and explore mechanisms to share risk such as utilisation-linked loans to chargepoint providers.[17]
- Ofgem and government should ensure there are network investment incentives, linked to Local Area Energy Plans, to stimulate investment.
- Central and local government need to streamline and simplify planning guidelines and consent protocols.

[17] Utilisation-linked loan financing would provide investor assurance against slower than anticipated utilisation rate improvements and would de-risk demand-side impact on returns.

Other specific recommendations:

- A common template local government tendering structure should be established to bundle high- and relevant low-usage locations as investment opportunities.
- Education of LAs and a centrally-funded and supplied expert resource should be established to support and enable efficient local tendering. This would help provide templates, frameworks and best practices for developing charging infrastructure.
- Greater data transparency is needed to drive better decision making. This includes pricing data and signals, traffic flows and power distribution availability. Regional or local forums should be established to allow the sharing of data between fleet operators, DNOs and LAs to assist in transport and energy planning.
- Additional practices can be adopted by chargepoint operators as well as depot and workplace providers to further improve utilisation. Practices such as sharing chargepoints between fleets with different usage patterns, establishing private and public partnerships to develop charging hubs, providing access to the general public and scheduling of charging into fleet operations should be explored.
- Investigations around pricing and forms of targeted support are needed to ensure households without access to off-street parking and, especially, low-income households are not faced with unfair charging costs while the market is maturing.

Background and Discussion

The scale of public charging required has been described in Section 3. Around 490,000 public chargepoints (central estimate) will be needed by 2035 to meet the requirements of the electric vehicles expected to be in use by that date. Chargepoints will need to be highly utilised to minimise charging prices.

The poorly judged placement of chargepoints by providers not well-versed in charging demand profiles and unit economics can lead to stranded, largely redundant and/or poorly maintained assets. This is a clear waste of resources and could reduce, rather than increase, driver confidence in terms of the provision of infrastructure [19].

A combination of improved investment efficiency (transparency of data, speed of deployment, better educated/informed decision makers) and appropriate market-sensitive financial interventions (e.g. policy consistency, bundling low utilisation public good and high utilisation assets; public private investment frameworks) can make a significant difference to investment appetite and lead to a public charging infrastructure that is built to serve user needs.

To achieve the levels of public charging infrastructure required, it has been estimated that £21bn will need to be invested by 2035[19]. The EV Energy Taskforce modelling outputs corroborate this finding. The number of public chargepoints (and the consequent level of investment required) could, however, be higher or lower depending on user behaviour and preferences. The level of investment required will not be met under the investment conditions prevailing today.

Progress to date

The Progress Report [23], an associated publication of the EV Energy Taskforce, reflects on the current state of the UK's charging infrastructure, highlighting progress made since the Taskforce published its original proposals. Some progress has been identified in terms of developing the most conducive environment for investment.

- Profitable business models clearly already exist for some public charging solutions and strategic investors and venture capital-backed players have started to invest in position-building.
- Public interventions are under way to drive on-highway rapid charging [24] and support already exists for slow on-street charging [25]. In addition, changes introduced by RIIO2 allow for public investment ahead of need [26].
- Ofgem's Green Recovery Scheme [27] has been mobilised and the consultation on the distribution connection charging review looks at further reducing barriers to investment. Participating projects will aim to accelerate low regret network investment to stimulate economic recovery, accelerate decarbonisation of the electricity system and bring benefits to consumers.

Though progress is being made, additional steps need to be taken to improve the attractiveness of investment in chargepoint infrastructure.

Key barriers to the provision of public charging infrastructure identified through discussions between expert stakeholders in the EV Energy Taskforce and extensive further stakeholder engagement included[19]:

- The risk profile (commercial utilisation, technology, credit) associated with the EV charging market today has mostly suited earlier stage venture capital-type investors and corporates who already participate in the energy delivery sector (oil and gas and utilities). Major financial investors shy away from demand-side merchant risk (associated with low utilisation assets) and technology risk (fast-changing technologies with risk of obsolescence) in particular.
- Lack of data transparency to support the development of viable business models.
- The EV charging market is diverse and the financial returns profile of different charging formats does not reflect the dimensions of charging as a public good. A previous report published by the Taskforce[11] found that without intervention, the financial returns on faster charging solutions significantly outweigh those for slow on-street charging.
- Non-financial barriers to investment: A survey conducted by the Green Finance Institute [29] revealed that financial barriers are not the only issues limiting EV infrastructure provision. There are significant non-financial obstructions to the smooth flow of investment at scale into the UK's charging infrastructure. Barriers identified included:
  - a lack of understanding of the EV charging business by LAs
  - the length of time taken by DNOs to process chargepoint-build applications
  - suitable site availability and grid access
  - the complexity of planning and permission processes for the installation of infrastructure adds to uncertainty around investor business models
  - motorway service area monopolies preventing new entrants and competition

To address these barriers the Taskforce, in collaboration with the Green Finance Institute's Coalition for the Decarbonisation of Road Transport, undertook complementary studies [28], [29] proposing financial and non-financial mechanisms to encourage investment in public electric vehicle charging. Financial and non-financial mechanisms that were proposed included:

- Revenue guarantees to mitigate utilisation risk. (These will need to be carefully considered to avoid artificially supporting chargepoint deployment in areas that are well-served.)
- A blended finance fund designed to lower the cost of capital for competitive market entrants. Public and private capital is combined for supporting chargepoint rollout where needed, e.g. high grid connection costs, less affluent and rural areas.
- Utilisation-linked loans. These could provide chargepoint operators with low interest rates for up-front investment. Repayment will be linked to utilisation.
- Community municipal investments. Promotion of community-funded chargepoints that can allow residents to share in the benefits of the growing charging infrastructure.
- Best practice frameworks for deployment including education for LAs and procurement frameworks to help LAs understand how they can use financial models to install chargepoints. Furthermore, enabling competitive tenders for long-term contracts (over 10 years) could also reduce demand risk for operators.
- Local authority education and support to build an understanding of the charging infrastructure and funding models. This could be delivered by either a knowledge hub and/or dedicated expert resource.
- Transparency of opportunities and grid connections. Improve network connection processes and provide transparency of connection costs associated with available charging sites.
- Shared municipal assets. Charging infrastructure can serve, for example, both private and fleet vehicles, such as buses. Sharing assets can improve investment attractiveness.
- Considering battery storage as an alternative to reinforcing grid connections could lower costs.

During the initial development phase of the UK's charging infrastructure in particular, there is a risk of large variations in the prices customers pay to charge. Low-income households without access to off-street parking may, as a result of being dependent on the public network, be faced with prices significantly higher than home charging tariffs, which is exacerbated by the differential VAT applicable to electricity supplied via domestic and public charging infrastructure. (With the opportunity for resident users already benefiting from lower VAT on electricity supplied as well as the potential for them to benefit from smart charging the price difference could become even greater.)

Modelling outputs also included an assessment of future charging prices when EV ownership and chargepoint utilisation increase to a sustainable equilibrium level and an open and competitive market is established (as petrol prices are today).

What is clear is that adopting the higher utilisation public charging format (such as local rapid hubs) could enable prices at a level reasonably close to the average prices paid by people charging at home. High utilisation could, however, also result in queues forming, especially at busy times of the day. It will be important to manage queuing, and (as discussed in Section 4.3) to utilise data for better visibility of chargepoints and booking systems.

For on-street residential charging, prices are reflecting lower utilisation rates and longer occupancy times, resulting in higher prices than both home chargers and local rapid hubs. While the market matures, targeted government interventions are likely to be required to ensure equality of access in situations where the business case for private investment is weak.

Potential interventions to support users without access to off-street parking include:

- The use of domestic tariffs at public chargepoints.
- Targeted support, similar to the home heat allowance.
- The addition of a social premium on domestic charging.
- Addressing the VAT anomaly between electricity levied on home vs public charging.
- Enabling smart charging at long-duration charging locations could reduce prices by allowing users to harness the flexibility offered by EVs.
- Capturing other revenue streams such as advertising revenue and attracting customers (e.g. at supermarkets) could also impact charging prices.

Alternative charging solutions should also be explored. Workplace charging could be an attractive alternative for users without access to off-street parking, as could peer-to-peer sharing of domestic chargepoints and/or enabling public access to shared depot facilities.

Policymakers need to be mindful that inequality in terms of access to chargepoints and to reasonably priced charging could undermine progress and buy-in to the necessity of the EV transition.

4.2 Local authorities need to have tools, capabilities, powers and resources to provide integrated energy and transport planning

Introduction

Local authorities are lynchpins and key enablers in terms of the deployment of public charging infrastructure. They have control over local planning, consents and access rights as well as responsibility for the road network and local transport planning. They also have responsibilities relating to local air quality and decarbonisation.

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- Local authorities have received well-targeted funding that, when coupled with access to the human resources and technical expertise, has enabled them to develop strategic plans for the effective deployment of EV charging infrastructure within their region. Consistent and structured funding approaches from central Government have enabled LAs to make plans for chargepoint deployment based on the predicted needs of local people and businesses.
- Strong relationships across regional authorities, particularly with regards to housing authorities and the sub-national transport bodies, has provided the mechanisms for knowledge-sharing and streamlined delivery of EV charging infrastructure.
- The sharing of knowledge and materials between LAs providing access to better data, including market data, chargepoint location modelling, delivery model choice), easy to understand technology guidance as well as potentially joint procurement procedures, has greatly improved the efficiency of any infrastructure planning.
- Platforms for collaboration between regional authorities have been provided at a national, or even DNO (regional) level reducing the risk of individual LAs being outmanoeuvred by suppliers and have helped to identify criteria for selecting the best technology for a particular location.
- The growth in electricity demand beyond EV charging – for domestic heating and other uses – has increased dramatically. LAs, working in collaboration with regional DNOs have been able to plan effectively for these wider energy system demands. The stakeholders involved have had access to the necessary support, tools, and powers to better integrate energy and transport plans and support charging delivery. DNOs have proactively led work with LAs and other local stakeholders, forecasting EV uptake and other energy consumption trends to deliver effective and coordinated transport and energy investment plans for their regions.

Key recommendations

- Government must ensure that LAs have the resources and have both the mandate and obligation to develop and deliver local charging strategies,
- DNOs must provide mechanisms for sharing knowledge, materials and learnings across LAs in their region to develop local transport energy plans.

Other specific recommendations:

- A national roll-out strategy for EV charging including frameworks, toolkits and guidance should be provided to LAs, as well as the regional Energy Hubs, for local area energy mapping and planning for the delivery of smart local energy systems.
- The regulator should facilitate efficient, anticipatory electricity network investment by network operators informed by common assumptions and local area energy plans through RIIO 2.
- Government and LAs should review their planning guidance and consent protocols to support rapid deployment, once projects have been accepted into the local area energy plan.
- Central Government should ensure LAs are provided with sufficient support to effectively plan and procure a high-quality public EV charging infrastructure in the right places at the right time as part of the wider energy and transport system, with the option to make this a mandated duty of the local authority if required.
- Capacity and capability within LAs should be improved with the provision of funding and resources. There should be a move away from stop-start, short-term funding arrangements to a longer-term 'outcome' based approach, with the potential for this to be allocated based on predicted need. Relationships between the housing authorities and the sub-national transport bodies should be strengthened.
- Mechanisms for sharing knowledge, materials and project learnings across different LAs within a DNO region will be required to provide better data (including market data, customer demographics, location modelling, delivery model choice, procurement and technology guidance). This would most efficiently be provided at a national or regional level to reduce the risk of LAs being outmanoeuvred by suppliers. Support should be provided enabling LAs to understand the criteria for selecting the best technology for a particular location.
- DNOs should ensure consistent approaches are developed across the multiple LAs within their area of operation; providing guidance to LAs in developing charging infrastructure plans and to provide forums for fleets to engage with LAs to plan electric vehicle deployment.

Background and Discussion

As more responsibility for the deployment of charging infrastructure is passed to LAs, it is essential that LAs understand the needs not only of local residents and visitors, but also of small businesses and fleets and how they should be considered within public EV charging infrastructure plans.

Local authorities should be focused not only on existing use cases for EVs, but also hard-to-transition elements within fleets which could delay wider electrification. Local authorities will need support to do this effectively and will require information on the diversity of fleet uses to enable a better understanding of fleet operations and charging requirements as well as supporting direct engagement with fleet operators. DNOs should also engage with fleets to identify areas on their network where there will be demand for fleet charging as part of developing their plans for grid reinforcement.

Key barriers to the provision of public charging consistently raised by LAs and expert stakeholders in the EV Energy Taskforce included:

- The need for strategic direction at a national level; including an articulation of the vision for the future and clarity over what role authorities are expected to play in delivering EV charging infrastructure.
- Funding and resource constraints; current funding structures are too short-term to allow for any strategic planning. As they're based on competitive allocation, they do not focus on delivery where infrastructure will be needed most.
- Lack of data to support the decision-making process; including not having modelling of future demand, as well as access to current grid capacity mapping.
- Difficulties engaging with DNOs on energy planning and grid connection and, as with other areas, a lack of and an overall, strategic approach to energy planning.
- Concerns over procurement approaches, with questions over whether authorities have the right commercial skills and whether best practice is being shared across the sector as each authority is developing new contracts and documents.
- Concerns over current market constraints and the extent to which this was driving commercial arrangements and decision-making.
- Questions over the appropriate technology to invest in and apprehension about future technology obsolescence.

With no current targets in place for delivery of EV charging infrastructure, nor specific powers or duties prescribed to LAs in relation to the provision of EV charging, it is challenging to get these resource-constrained institutions to prioritise EV charging.

The majority of LAs are, however, planning future involvement in the procurement or deployment of public EV charging infrastructure, and some already have legacy chargepoints that have been in place for some time. Coventry City Council for example, has been proactive in working with local businesses and the regional DNO, producing a strategic plan [30] for deployment as well as actively monitoring chargepoints which has resulted in an impressive 98% reliability.

However, a significant minority of LAs have decided that, in the absence of a mandated requirement from central government - and in light of uncertainty and constrained resources - that the development of EV charging infrastructure is not currently a priority for them. Without a clear mandate (accompanied by the necessary resources), some LAs will choose to take different approaches.

While the role for local government in the delivery of EV charging infrastructure is not yet fully clear, many LAs feel that they lack the appropriate skills and data to make investment decisions in what is seen as a fast-paced and evolving technological landscape.

There is widespread concern that the market alone will not be able to meet the needs of all their residents, visitors and businesses.

Role for Distribution Network Operators

Ofgem has set out a plan to prepare the electricity network for the transition to electric vehicles describing priority areas for action in its report 'Enabling the transition to electric vehicles' [31].The priority areas Ofgem has identified are:

- Ensuring the network is prepared for EV adoption
- Reducing barriers to network connections by ensuring efficient and timely processes and proposals to reduce EV connection charges
- Enabling rapid development and maximising the uptake of smart charging and V2X technology
- Consumer participation and protections

As part of the actions to prepare the network for electric vehicles, Ofgem requires DNOs to prepare forecasts of electric vehicle adoption across their networks. The aim is to minimize the network investment required by focusing investment where it is needed, especially on the local networks.

To achieve this, the DNOs will need to work with stakeholders to drive the location of the charging infrastructure and determine where the additional load will appear on the network. Local authorities will have an important role as they are responsible for transport and land-use planning, as will large fleet operators in decisions about the location of their charging depots.

The DNOs are starting to engage with stakeholders to develop their network plans. Currently a number of approaches are being trialed and no settled approach has developed. However, DNOs operate across multiple LAs, all of which they will need to engage with, to develop their network investment plans. The DNOs are, therefore, in an advantageous position to ensure that consistent approaches are developed, to provide guidance to LAs in developing charging infrastructure plans and to provide forums for both fleets and LAs to help plan electric vehicle deployment.

Progress to date

The Progress Report [23], published by the EV Energy Taskforce in association this report, reflects on the current state of the UK's charging infrastructure, highlighting progress made since the Taskforce published its original proposals [3] and subsequent actions [32].

- A number of pilot schemes have been carried out to ensure better coordination between DNO's and LAs. For example, Charge Collective [33] - a pilot project launched by UK Power Networks in partnership with local councils in Cambridge, Norwich and London, and also Project PACE [34], which brings together SP Energy Networks and LAs across Lanarkshire, are looking at encouraging chargepoint installers to invest in areas where the market is struggling to deliver today in a way which is fair to customers and addresses high connection costs. If successful, this model could be scaled-up across the country.
- BEIS's customer guidance [35] relating to the registration of energy devices in homes or small businesses will enabled a standardised process necessary for increasing network visibility for DNOs.
- The Local Government Association (LGA) commissioned Local Partnerships to undertake research [36] to understand the role LAs should take in the delivery of EV charging infrastructure, focusing on charging of private EVs, largely in residential areas with no off-street parking (rather than destination or rapid charging).
- Cenex and IET produced new guidance [37] that offers a single point of reference to LAs across the UK to assist them with EV infrastructure implementation.

4.3 Public chargepoints have to be used and usable – visible, accessible, connected, secure and interoperable to gain consumer confidence

Introduction

Consumer confidence in charging infrastructure is a critical building block to enabling the EV market to grow according to the trajectory required for the energy transition. A fundamental component of this if for motorists to have easily accessible, real-time information telling them where and when they can charge on the public network. To enable this, chargepoint operators need to ensure that relevant chargepoint data is openly available and in a format that enables easy collation.

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- Chargepoints are operational for approaching 100% of the time and any faults rapidly repaired. They are fully connected to deliver the communication services needed.
- The UK mobile data network has comprehensive coverage, is fully functional and ufficiently reliable to enable the data transfers required.
- There is easy and convenient interoperability between chargepoint payment systems which consumers can chose between. A variety of popular payment mechanisms underpinned by common design approaches (adopted across the EV and CPO sector) have been rolled out to ensure drivers benefit from convenience and fair choice. Full payment interoperability between chargepoints creates an EV charging ecosystem that encourages competition, provides a better deal for consumers and offers greater functionality to support the grid.
- Chargepoint pricing is clear and transparent, even when bundled with other services.
- New, and innovative practices in the EV charging marketplace are flourishing while the complex regulatory landscape of standards, specifications, protocols, and codes of practice has evolved in alignment with international requirements. Government has monitored and encouraged developments in the right direction.
- Public chargepoints are physically safe, secure and accessible to the widest range of vehicles and users. In any given locality the public charging network supports vehicles of diverse dimensions as well as catering to drivers with differing abilities and requirements.
- Government, industry and other stakeholders continue to work iteratively together to align procedures around the need for device-level interoperability, cyber security, data privacy and grid stability for all types of chargepoint.

Key recommendations

- Government and Ofcom need to develop a strategy to deliver national data connectivity with an architecture that supports evolving EV charging requirements. As an interim measure they should publish detailed maps of mobile signal connectivity to aid chargepoint network planning. The data communications network needs to allow for real time transactional & operational data across the network.
- Chargepoint operators must ensure a minimum level of service which includes accessibility, uptime and repair completion targets, and be held to account for these.
- Local authorities should include minimum performance criteria in their chargepoint procurement processes.
- Industry must make relevant chargepoint, network and vehicle data open and accessible whenever possible to facilitate smart charging.

Other specific recommendations:

- Government and industry must work together to make relevant chargepoint data open and accessible for a high-quality public charging service, (consistent with the proposals made by the EDiT [38]), ensuring that charging forms a connected part of the energy system. Public chargepoint data must be available to meet the needs of different types of vehicle and people of different abilities with quick, stable, and secure connectivity.
- Government and industry need to develop a common perspective about what is needed to deliver seamless roaming between chargepoints and data sharing, based on common and agreed assumptions.
- Government and industry must ensure 'system resilience by design' to mitigate against both physical and cyber system vulnerabilities relating to the digital integration of EVs and charging infrastructure. The UK should aim to lead the way on international standards relating to interoperability.
- Chargepoint innovation should be encouraged to ensure EV users are able to unlock new revenue streams and provide a range of grid applications in flexibility markets.
- Chargepoint operators must ensure public chargepoints are physically accessible, connected, well-maintained, reliable, and easy to use for all types of users and vehicle.
- Government should define the legal and regulatory basis for chargepoint operator obligations regarding cyber security and propose a workable compliance/enforcement scheme, while supporting industry to develop cyber security mechanisms in live trial situations.
- Industry should converge around standards for communications, data, and security protocols with appropriate feedback mechanisms in place to measure progress. These need to be developed in close coordination with international standards to ensure the consistency of data language and protocols between chargepoints across the sector.

Background and Discussion

As Section 3 of this report explained, a public EV charging network aligned with consumer needs is an essential requirement to deliver the transition needed in road transport. The discussion below highlights some of the key issues, identifying what has already been done and what still needs to be done in this area.

Transactional, physical and technical interoperability of public EV networks

The Alternative Fuels and Infrastructure Directive (AFID), as implemented in the UK in 2018, ensured that all new chargepoints must offer 'ad-hoc' access, enforced by Office for Product Safety and Standards (OPSS) (backed up by £1,000 penalties per non-compliant chargepoint).

However, issues remain; for example, in some situations customers must still install and 'app' in order to pay rather than use a contactless bank card or other simple method. Customers are still unable to access all chargepoint networks and must sign up with different operators and/or electricity mobility service providers for full, roaming access to public chargepoints. Also, payment receipts are not always transparent or easy to access and their formats are not standardized. In some cases, EV drivers are even locked into charging arrangements by chargepoint providers.

Payment systems providing universal access to public chargepoints, utilising a variety of payment mechanisms and providing transparent pricing need to go beyond 'ad hoc' to achieve full interoperability. The AFID Directive on ad hoc charging represents a solid first step but doesn't equip chargepoint operators and mobility service providers with the ability to fully communicate with each other. More guidance and support is needed to enable full interoperability and position the industry to properly exploit the potential for value-added and energy sector services.

"Full interoperability entails a network of chargepoints enabling customers to access any public charging station without entering a subscription, offers non-discriminatory access for customers with existing subscription with other EMPs, facilities value added services to customers, and allows for customers to roam using a single identification or payment method"

– REA, 2019 [39]

Full (transactional) interoperability, as defined above, will create an EV charging ecosystem that encourages competition, provides a better deal for consumers, and offers greater functionality to support the grid (where appropriate). Apps such as Zap-Pay in the UK, roaming agreements agreed between some of Europe's largest networks, and the development of interoperable cloud-based back-office systems are all positive developments in this direction.

Future guidance should take a wide perspective on the development of new standards to ensure future interoperability arrangements meet consumer needs. This will help to prevent any consumer 'lock-in' to particular suppliers and enable a range of competing commercial offerings.

In addition to the development of standards for new technologies and data provision, standards taking a more holistic view will be needed to allow future integration of higher electricity loads into smart energy management platforms. Generally, a wider, agreed integration of standards to facilitate information flows between energy system operators and distributed assets, will be needed for the energy system to deal with increased transport electrification.

Enabling differential offerings such as pre-booking on public networks may improve the consumer experience, and are likely to increase data flow requirements, further supporting more open collection of chargepoint network data.

Underpinning transactional, physical and technical interoperability is sufficient data communications connectivity for both EVs and chargepoints. This will be a key enabler of progress in this area for public and home charging, as further discussed in a separate part of this Section below.

Vehicle and user charge-station accessibility

As seen in Section 2, disabled customers (including passengers and carers) who do not have access to off-street parking will require on-street charging solutions as they transition to EVs. Prior research [40] has shown that Blue Badge holders, have specific needs when it comes to on-street charging infrastructure, and require access close to their homes.

Of the 2.72 million disabled users predicted to be living in the UK in 2035, it's estimated that 1.35 million will be partially or wholly reliant on on-street charging infrastructure. UK Power Networks' (UKPN) partnered with Motability (a national disability charity) in the Enable Project [41] to better understand the role DNOs can play in supporting disabled EV users reliant on on-street parking.

The research, which involved surveys of disabled drivers, passengers and carers identified many barriers to adoption. The most significant limiting factor (cited by 76% of respondents) was concern about battery capacity on longer journeys. Other leading limiting factors were all related to a perceived lack of charging infrastructure (73%), and the accessibility of charging infrastructure (71%).

The Enable Project allows distributed network operators to advocate for the on-street charging needs of disabled customers, ensuring that chargepoint accessibility is a prominent feature as the sector develops. This might, for example, take the form of engagement with third-party service aggregators to consider the inclusion of accessible on-street charging bays in their flexibility services and also ensuring that related services are designed with disabled users in mind.

Data sharing also has a role to play in ensuring adequate provision for the disabled and this needs to include active engagement with LAs. Data about the demand from disabled customers, related network connection challenges and timelines for infrastructure provision are aspects of information that will be required by various stakeholders.

In support, DNOs need to proactively engage with local authority plans for on-street charging provision for disabled customers, including this in their future demand modelling, whilst ensuring that support teams are available to customers to offer guidance.

Accessibility challenges are not limited to the requirements of disabled customers. A survey of BVRLA members [42] highlighted that van users often require a larger space to be able to charge, depending on the vehicle involved. This is a particular challenge in residential areas where charging bays are typically constructed with passenger cars in mind. Chargepoint providers need to keep this, and related, accessibility challenges in mind when investing in new provision.

Using data to make public chargepoints simpler to use

A recent report by the EV Energy Taskforce [43] has shown how the use of open EV data can improve the customer charging experience, including by:

- making it easier to find somewhere to charge
- making it simpler to use the chargepoint
- improving access to information about chargepoint restrictions and amenities
- simplifying the payment process
- improving integration with the energy system

The Taskforce recommends encouraging or incentivising the publication of specific data items (such as opening times, real-time operating status, price per kWh e) where available, via a modern, publicly accessible, open chargepoint data mechanism.

It also proposes the development of an industry-agreed chargepoint vocabulary to enable effective data transfer. (It is also encouraging the publication of data such as photos, amenities, additional capabilities etc.) Semantic web techniques should ideally be used to allow data to be shared and reused across many communication channels.
Having open EV data will be crucial when mediating the trade-offs between maintaining the high utilisation rates needed to drive chargepoint return-on-investment (as discussed in Section 4.1), and the possibility of untenable queueing emerging that could inhibit EV uptake.

A readily available open chargepoint data mechanism that EV users have confidence in will, in addition to improving the customer charging experience, provide the digital infrastructure to enable greater chargepoint utilisation, helping to unlock investment efficiency and, in turn, the appetite for the private investment needed to expand the public network.


CHARGING STATION

Progress to date

The Progress Report [23], published by the EV Energy Taskforce in association with this report, reflects on the current state of the UK's charging infrastructure, highlighting progress made since the Taskforce published its original proposals. Some of the positive steps that have been identified include:

Transactional, physical and technical interoperability of public EV networks

- Renewable Energy Assurance Limited (REAL) [44] set up EV ROAM in October 2020. 25 MSP IDs and 16 CPO IDs have since been issued, encompassing 22 different organisations.
- The Government consultation on the Consumer Experience at Public Chargepoints [45] will inform impending regulations to enable access to public chargepoint data, improve the reliability of the network, streamline the payment methods offered to drivers and increase pricing transparency.

Vehicle and user accessibility

- DfT and national disability charity Motability commissioned the British Standards Institute (BSI) to develop accessibility standards for EV chargepoints across the country [46] .
- The Enable Project (UKPN & Motability) and the Equal EV project (Scottish and Southern Electricity Networks, Energy Systems Catapult & Disabled Motoring UK) have further informed understanding about the barriers to people living with disabilities who would like to switch to EVs [47].

Using data to make public chargepoints simple and easy to use

- The Open EV chargepoint data discovery project (initiated by OZEV) has enhanced understanding about how chargepoint data can be integrated with the Modernising Energy Data Principles [48].
- The Government has signalled its willingness to further the Open Charge Point Interface (OCPI) data standard in the chargepoint sector across the UK.
- The Future of Transport Regulatory Review seeks primary powers to mandate aspects of chargepoint design such as familiarity, look and feel. It will include accessibility and safety features [49].

Data coverage for EVs and chargepoints

As the transport sector evolves, reliance on communications networks is increasing. From home to public charging, communications networks will be essential to deliver user and system requirements. For smart charging, communication networks will be vital.

The outputs of the modelling work provided a clear indication of the likely scale of future demand. With 26.8 million BEVs on the road by 2035, 15.7 million home chargepoints and around 490,000 public chargepoints (central case) there will be tremendous demand for data exchange over communication networks.

For home charging, communication networks will be required to support smart charging. Users will also require connectivity for remotely starting their charge session. Data flows between the user, chargepoint, vehicle, load management platforms and energy supplier are needed and will be enabled by a reliable communications network.

Smart charging at public charging locations will also rely on communication networks. By 2035, around 200,000 on-street residential chargepoints will be needed[18]. As outlined above other services that public chargepoints will need to deliver will also rely on communication networks, therefore those networks will need to be both more sophisticated and resilient.

Network connectivity will also be a key enabler of progress in this area for both home and away from home charging. Combined with appropriate data exchange, progress in this area will improve chargepoint visibility and availability, enable pre-booking, payments, and, potentially, charging control/ smart charging.

The chargepoint infrastructure will therefore not be fully fit-for-purpose without considerable action taken to develop the accompanying communications system architecture that will provide reliable and resilient connectivity. How the geographical distribution of chargepoints evolves and the differences in configuration of their deployment (single units, clusters etc), will determine the need for a variety of different connectivity services to evolve in parallel, each with their own bandwidth/latency requirements, depending on the nature of the specific data exchange interfaces.

Other applications emerging in transport (mobility as a service, connected and autonomous vehicles and smart road systems) [50] will also heavily depend on communication network coverage and must be integrated in the development of connectivity services. New requirements and potential synergies from flexible control of other low carbon technologies will also have to be considered.

Trade-offs between investment costs and network capabilities will shape the portfolio of solutions needed over time. Fixed-line connections can offer speed and reliability, but they can be difficult and costly to install and maintain, with network operators unable to achieve the economies of scale necessary to justify large capital investments. Alternatively, wireless connections using 4G, LTE and mobile networking require no additional cables and provide the flexibility to be added to, or integrated into, EV charging points with relative ease and at a far lower cost. However, these are dependent on cellular network connectivity which may be limited in some areas, particularly rural locations. They may also introduce the risk of stranded assets with hardware potentially becoming obsolete when standards or network connectivity requirements update, such as was the case with the 2G access phase-out. Clarity on timescales and migration towards 5G or other ancillary communication networks that can sufficiently manage large numbers of EVs, chargepoints and other smart energy devices (heat-pumps etc.) will also be essential to ensure future system costs are minimised.

Whether it's public investment, communications, electricity or chargepoint companies, EV providers or specialist networks, the questions about who provides the communication infrastructure, who performs the system integration and, fundamentally, who pays for it are central points of debate when defining the connectivity strategies that support EV charging.

Ensuring communication connectivity across the nation will be crucial if we are to enable an equitable transition and minimise total system costs.

A whole system view is necessary to understand the evolving requirements of the transport sector and beyond, addressing the risks and challenges captured above, to define a strategy for the communications system architecture that will provide reliable and resilient connectivity for EV charging.

[18] Based on the central modelling case.

4.4 Smart charging, wherever appropriate, is essential if system cost is to be managed

Introduction

The transition to EVs will require the electricity system to supply a very significant new demand. The EV Energy Taskforce modelling outputs show the scale of the new demand.

Our charging system in 2035 – a postcard from the future

- 55 TWh of electricity is needed for car and van charging in the UK – 14% of total system demand (EV Energy Taskforce model output).
- Total electricity demand has grown from 287.4 TWh in 2020 to 379 TWh in 2035. Demand from the electrification of heating alone has increased from 70 TWh in 2020 to 199 TWh in 2035, to make up 31% of total demand.
- A much higher proportion of decentralised, renewable electricity is present in the UK's supply mix.
- Innovation-friendly and consumer focused electricity markets have maximised the opportunity for demand to match low cost, variable supply and for EVs to provide system services with fair reward. EV users have benefited from access to smart charging tariffs.
- EV charging offers flexibility through demand-side response and smart charging. Charging infrastructure is designed and operated as an integral part of the electricity system, offering cost savings to both networks and consumers. Smart charging delivers savings to the energy system worth £2bn by 2050 by cutting distribution network reinforcement costs.

Key Recommendations

To enable smart charging, at residential and small business, commercial and public locations, additional technical standards are expected to be required in four distinct areas: interoperability, security, privacy and grid stability.

New standards may also be required to ensure the safe installation, operation, decommissioning or disposal of EV charging infrastructure as a result of new smart charging requirements, but these have not yet been identified [51]. Different charging solutions may have different requirements in terms of standards so these should be acknowledged and addressed.

- Chargepoint operators should ensure that any chargepoint at a location with a sufficiently long occupancy time is smart charging-enabled to reap the significant benefits to both users and the most effective functioning of the grid that smart charging allows.
- Ofgem and government should further reform electricity market arrangements to ensure that the system value of flexibility is encouraged.
- Industry must develop data sharing standards and protocols to be applied across the energy system, charging infrastructure and vehicle parc.

[19] The figures presented here are modelling outputs.

Other specific recommendations:

- Government, industry and other stakeholders should work together to align expectations for interoperability, cyber security, data privacy and grid stability, taking a whole systems approach to ensure a seamless integration of cross-sector data services.
- Good governance of data access and data sharing is needed to guarantee safe operation of the electricity system, the EV charging infrastructure and the vehicles at all times, with best practice being adopted to ensure the resilience of national strategic infrastructure and connected managed assets.
- Markets and price signals should maximise the opportunities and incentives for consumers to utilise their flexible resources, including EVs, and sufficiently reward them for offering demand flexibility services that support optimised network operations and investment, emission reductions and whole electricity system efficiency.

Background and Discussion

The EV Energy Taskforce modelling outputs showed the benefits that can be achieved from smart charging at home. The modelling was based on the assumption that technical requirements will be formulated and adopted by industry to ensure seamless operation and user experience.

Smart charging at public locations could bring benefits to both users - as they will be rewarded for the services they provide - and to the electricity system. The grid stability outcomes that public smart charging will aim to deliver will have to be agreed.

The technical and regulatory framework should allow the development of a wide range of innovative flexibility services and tariffs and support the effective operation of flexibility providers such as EV aggregators, while protecting consumers and the energy system.

However, smart charging at public locations could potentially require vehicles to be plugged in for longer times to allow for greater flexibility to be offered from EVs. In this situation, the Taskforce's modelling outputs indicate that if access levels are to be maintained to ensure user satisfaction, the number of public chargepoints needed could dramatically increase.

Services could also be provided by other charging solutions. Rapid hubs, charging forecourts and depot charging could offer demand-side response through on-site storage and generation.

It will also be important to take a whole system approach to ensure seamless integration of cross-sector data services, looking at how transport sector services will integrate with services provided for other sectors such as electricity.

Ensuring the safety of all actors involved in the charging system should also be a priority. Improved visibility of cyber security risks is needed to ensure protections are integrated into smart chargepoints, giving consumers the confidence to engage and protecting the energy system.

The EV Energy Taskforce has identified challenges related to the development of the best technical standards and specifications for smart EV charging under various scenarios [51]:

- Firstly, the complexity of the system means that there are many different stakeholders with different roles, responsibilities and needs. These include network operators and providers of network infrastructure as well as providers of flexibility services; chargepoint operators and building energy managers; manufacturers and providers of smart charging systems and devices and their electrical and communications connections; and vehicle manufacturers.
- There is a complex regulatory landscape consisting of many different standards, specifications, protocols, codes and other regulations that is further influenced by the need for alignment with international requirements and with the electrification of heating and other purposes.
- Many of the requirements and expectations are still to be determined, which means that smart EV charging infrastructure is being rolled out at pace even as technical requirements are being developed.
- High urgency. There is a rapidly growing market for smart electric vehicles and related infrastructure.

Progress to date

Some positive steps have already been taken to enable smart charging at home and at other, long duration, charging locations. The Progress Report [23], published by the EV Energy Taskforce in association with this report, reflects on the current state of the UK's charging infrastructure, highlighting progress made since the Taskforce published its original proposals. Positive steps already taken include:

- Government has (following the 2019 Smart Charging consultation [52]) legislated to mandate that all new private home and workplace chargepoints under 50kW have smart functionality. It also aims to 'nudge' users to charge off-peak through personalised default charging, (Phase 1 legislation also requires that chargepoints retain their smart functionality following a change of energy supplier) [53].
- Ofgem has placed responsibility on industry to deliver the Market-Wide Half Hourly Settlement (MHHS) Programme and made Elexon the Senior Responsible Owner (SRO). This programme will facilitate the uptake of smart charging through market incentives, in addition to removing barriers for V2X, and developing enablers such as data and communications for dynamic smart charging [54].
- BEIS' Smart Systems and Flexibility Plan outlines the first iteration of a monitoring framework for flexibility markets, with key monitoring indicators relating to EV uptake including the number of ULEV registrations, unit capacity of demand-side response available and the percentage of domestic consumers with smart meters. This document includes the range of actions Government is taking to drive consumer uptake of smart charging and encourage innovation [55].

4.5 Informing, educating and protecting EV users is critical to create the understanding necessary for mass market uptake

Introduction

Having engaged, well informed and protected EV users is a vital component if we are to stimulate and sustain the mass market uptake of electric vehicles. Critically, the population needs to have confidence in the performance and attributes of electric vehicles, in the availability and reliability of charging infrastructure, combined with clarity about the operational costs and financial benefits that can be achieved.

There is cross-sector consensus that if electric vehicle users, whether consumers or fleets, are confused, ill-informed or lack confidence in the vehicles, then the speed of the UK's EV roll-out will be limited and the key objectives associated with it – as outlined in this report – will be undermined.

Our charging system in 2035 - a postcard from the future

- EV users are well informed and confident in the performance of their EVs. They know they can rely on the availability and reliability of the chargepoint infrastructure and are aware of the opportunities accessible to them from smart charging.
- A majority of chargepoints (home, on-street and at hubs) with long occupancy times offer smart charging, providing greater flexibility to the electricity network. EV users are aware of these opportunities and regularly utilise them, having been fully informed by effective public information campaigns and associated communications.
- The EV ecosystem is operating efficiently and effectively, enabled by the timely introduction of a suite of regulations around vehicle information, financing and chargepoint labelling (mandating clear, comprehensive and comparative information to purchasers and users).
- Clear point of sale information is provided to EV users and relevant staff have been appropriately trained. Importantly, this information is supplemented by freely available, independent consumer advice from impartial and trusted sources.
- There are integrated complaint-handling processes coupled with a comprehensive suite of consumer protections. Standards for complaint handling and redress for the entire electric vehicle consumer journey (covering all relevant sectors and industries) have been widely adopted by industry. Consumer protections have been developed to ensure data privacy and consumers have a full understanding of their data rights and the ability to access and share.

Key recommendations

- Government and industry should develop an extensive and consistent public information campaign to support consumer confidence and engagement with smart charging and how to engage with public charging effectively.
- Government, LAs and chargepoint operators will need to support disadvantaged consumers without access to domestic charging, by exploring and deploying a range of charging options appropriate to the locality and the use of home and roam tariffs.
- Government must ensure that there are consistent consumer protections and industry must deploy complaint handling mechanisms across the consumer journey, particularly to address issues with bundled packages including vehicle, chargepoint, tariff and finance.

Other specific recommendations:

- Government, industry and regulators should work together to ensure that sector boundaries do not constrain effective complaint handling for EV charging under the auspices of the EV Energy Taskforce. Industry should adopt consistent complaint handling standards across market boundaries.
- Government and Ofgem should clarify rights/obligations around consumer data, including issues concerning privacy, access and portability.
- Government (DCMS) should outline how the transparency of AI/algorithms that are involved in all related EV decision-making processes will be monitored, as part of data protection reforms [56].
- Government and industry need to work together to implement a consumer data accessibility and privacy framework for all EV products and services, underpinned by the principles already identified by the EV Energy Taskforce [57].

Background and Discussion

Improving awareness and understanding of electric vehicle charging

Consumer concerns about electric vehicle charging remain an important barrier to adoption. Particular concerns relate to range anxiety, the availability of public chargepoints, payment mechanisms and the implications of smart charging. Allaying drivers' concerns around all forms of charging ('smart' or not) is therefore critical – not just to enable the uptake of smart charging but, more fundamentally, to accelerate the mass adoption of EVs themselves.

The promotion of smart charging, along with all forms of charging, and the organised provision of trusted, impartial information to consumers, timed according to the readiness of the market, will play an important role in allaying concerns.

With the cessation of the Go Ultra Low campaign there is no obvious single body to take this forward. This could be achieved through a government-endorsed umbrella campaign to be adopted by third parties. (The EV Energy Taskforce will be publishing a report detailing how this can be achieved in Spring 2022 [58].)

New products and added value services are likely to emerge. These could include management of the occupancy of chargepoints, as well as systems to enable virtual queuing and book a charge slot. These services could aid consumer confidence but will themselves require behavioural change. The challenges involved in educating users about how such new systems work and ensuring the energy system works as a whole shouldn't be underestimated.

Some factors to consider around consumer awareness and understanding of EV charging were identified through workshops, convened by the EV Energy Taskforce, with consumers and were also informed through other discussions with expert stakeholders. They include the suggestions that:

- Many organisations might play a role in promoting, informing and advising users about smart charging at the point of enquiry. However, few have an obligation to do so and those that do (such as energy suppliers' obligations with regard to their customers) risk not being able to do so in a timely manner, as they aren't involved in the EV purchase.
- While not all users want, or seek to find, complete information before purchasing products, digesting the diversity and volume of information available is difficult. It's important that all users should have access to consistent information, whether from car dealers, chargepoint operators, the electricity industry or other independent, impartial sources.

- Consumers' ability to absorb information varies; innovators and early adopters have a greater propensity to research information. As EVs move into the mass market, the chances of misconceptions, leading to consumers making ill-informed decisions, increases. Information needs to be easily accessible and provided both proactively and reactively in response to individual queries from consumers.
- Industry-led marketing and sales activity will be vital in terms of informing, educating and advising consumers on specific products and services, and innovative business models may help with consumer engagement. Independent and impartial consumer advice will also be important in providing support to consumers as the market matures.
- The point of sale is an important opportunity to inform consumers about charging options. The purchase of a vehicle is likely to (and should) be closely linked by the consumer to having a viable charging solution in place. The level of expertise about EVs and charging solutions that is currently provided at the point of sale varies greatly and the challenges will be compounded by the development of the used electric vehicle market as the first point of contact for mainstream consumers in future.

Consumer protections, data access, and privacy.

Important to a successful mass uptake of EVs will be the provision of robust consumer protections. Embedding consumer protection into smart charging from the outset must be a priority for policymakers and industry alike. While existing protections cover the automotive and energy sectors, the changing nature of EV services raises new questions and challenges, which need to be tackled. EV users need to be confident that there are robust protections in place, that any problems will be resolved quickly and fairly, that their data is safeguarded and that their EV can be charged as needed.

There are a large number of potential risks in the EV journey for consumers related to data access and privacy. The EV Energy Taskforce's Data Access and Privacy [56] report showed how existing and upcoming work might cover these risks. It identified areas where protections are lacking and suggests areas where the government and the regulator should focus their efforts.

Complementing this EV Energy Taskforce report, workshops with consumers and discussions with expert stakeholders helped to identify the key barriers to improving consumer protections, data access and privacy in the EV charging sector. They include:

- Consumer exposure to EVs and smart charging cuts across a range of sectors, from those that are tightly regulated and established to new, largely unregulated ones. This means that many EV services are currently only covered by general consumer and privacy laws, such as General Data Protection Regulation (GDPR), which brings risks in terms of the protection of consumer rights.
- EV tariffs and smart charging do not fit neatly into the conventional rules and obligations which energy suppliers are required to comply with under the electricity supply licence. This brings a risk that providers may not be aware of all the applicable obligations, responsibilities, and protections or that new services fall between the cracks, leaving consumers unprotected.
- Consumers are not aware of the options available to them should they have a problem. There are likely to be differences in protection for consumers when there's sectoral regulation compared with when this falls under general consumer law.
- It's important that the Government and Ofgem take the lead to deliver the best outcomes for domestic demand-side response and smart charging. Industry and government (at different levels) should seek to educate, inform and advise at the point of enquiry, guarantee safety, provide a quality service, be inclusive by considering vulnerability and access and provide confidence over charging levels. The role and responsibilities to deliver each of these 'outcomes' can be vague, leaving gaps in provision. As such, it is proposed that a full review is undertaken to develop a comprehensive picture of consumer protections relating to smart charging and EV services.
- Protecting consumers in the event of emergency charge limitation; in certain scenarios, there may be a conflict of interest between an electric vehicle receiving a full level of charging during a period of time and the need to assure all customers' supply. If enabled by Ofgem, emergency charge limitation should only be allowed in exceptional circumstances, must be time-limited, protect vulnerable users and ensure that consumers are informed on a timely basis.
- Consumers need confidence in terms of the data used in connection with smart charging and EV services. There should be protections in place relating to how often industry can access this data and what for; and, crucially, consumers should own the data relating to their charging usage and transactions. Consumers will need to be confident that any data they agree to release will be maintained according to agreed rules. Decision-making risks, particularly involving algorithms and artificial intelligence (AI), are poorly understood – more consumer protections could be needed in this area.

Consumer complaints handling

Trust and confidence can be won if consumers' complaints are dealt with swiftly and fairly...or lost, otherwise. The bundling of home energy, public charging, and vehicle services as well as the range of actors involved in the customer journey could create complex interdependencies within service provision. In such circumstances, users need to be confident that any problems will be resolved quickly and fairly, with clear boundaries in terms of who is responsible and how the process will work.

Consumers must not be forced to navigate between different companies and agencies to resolve a problem. To prevent this, clear responsibilities for resolving consumer complaints must be defined and allocated between different market participants. Industry will need to agree to cooperate and work closely, jointly establishing processes to diagnose problems and assign them to relevant parties to create consumer confidence in fast, effective complaint resolution.

The EV Energy Taskforce is currently convening the different consumer complaint handling bodies to investigate the nature and prevalence of current complaints and assess how that might grow and develop as the uptake of EVs enters the mass market phase.

The group intends to arrive at a set of industry standards for complaint handling and redress during the EV consumer journey, covering all relevant sectors and industries (including but not limited to energy suppliers, aggregators, chargepoint operators and installers, and vehicle manufacturers) along with a set of guiding principles and standards that follow an ideal consumer complaint journey about any aspect of their EV experience. It is proposed that this will be shared with any bodies (new and existing) that are responsible for implementation.

Establishing complaint handling standards should be industry-led in the first instance, to reflect the fast-changing nature of the EV sector. However, government needs to closely monitor implementation of the standards and, if insufficient progress is made, keep open the option of intervention.
Procedures must also aim at delivering a high level of service to consumers, with the onus being on the organisations involved to provide as smooth a complaint-handling journey as possible for the consumer should things be escalated.

As the standards will cut across many different industries and organisation types, they are intended to be principles-based. However, access to an independent Alternative Dispute Resolution (ADR) body is considered essential. Whether a new body is established to handle this new independent ADR or if it be integrated into an existing body will need agreement across the sector.

Progress to date

Some positive steps have already been taken towards informing, educating, and protecting EV users to create the shared understanding necessary for mass market uptake. The Progress Report [23], published by the EV Energy Taskforce in association with this report, reflects on the current state of the UK's charging infrastructure, highlighting progress made since the Taskforce published its original proposals. Some of the positive steps identified include:

Improving engagement, awareness and understanding of electric vehicle charging

BEIS (in collaboration with Energy Saving Trust and Cabinet Office) launched a trial EV smart charging advice page [59] on Energy Saving Trust's website.

Consumer protections, data access, and privacy

A voluntary demand side response (DSR) Code of Conduct for aggregators was introduced in 2019 by the Association for Decentralised Energy (ADE) through the Flex Assure scheme [60]. This gives DSR customers assurance that they will receive good quality service and sets minimum standards. The scheme has been well received by industry and government, but it only applies to aggregators in the non-domestic sector and does not offer protections to householders for smart charging and EV services.

Consumer complaints handling

Electric Vehicle Energy Taskforce's consumer complaints handling group intends to arrive at a set of industry standards for complaint handling and redress along the EV consumer journey. It will also produce a set of guiding principles and standards that follow an ideal consumer complaint journey about any aspect of their EV experience, shared with any bodies (new and existing) that are responsible for implementation.

5 Conclusion & Recommendations

5. Conclusion & Recommendations

The primary motivation for the electrification of transport remains the achievement of net zero by 2050. A key milestone on that journey is the end of sale of internal combustion powered cars and vans in 2035.

Reducing our dependence on fossil fuels, however, has become even more urgent in recent months to improve our energy security and mitigate against what looks likely to be a period of sustained high oil and gas prices.

The EV Energy Taskforce believes the underlying analysis and recommendations remain sound despite these altered circumstances, and although the electrification of transport remains challenging there are huge economic as well as environmental benefits that will accrue from this transformation.

The Taskforce in developing this report has, for the first time, brought together unparalleled expert analysis combined with detailed analytical modelling to assess the impact of the electrification of cars and vans and how this should best be achieved. The Taskforce employed Energy Systems Catapult's latest transport-focused modelling framework to assess the interplay between zero emission vehicles, users, charging infrastructure and the energy system that serves them.

The Taskforce's wide range of stakeholder experts agreed underlying assumptions, scrutinised outputs and developed the Taskforce's recommendations for delivering a charging infrastructure that works for EV drivers, is deliverable by industry and investors, is good value for money – at both system and user level – and is fair and inclusive.

The report demonstrates the size of the task in terms of number of electric vehicles, public chargepoints and the increase in the demand for electricity. It also highlights the need to make best use of smart charging wherever possible to minimize network reinforcement costs as well as provide consumer benefits.

Achieving the objectives outlined, however, depend on consumers having confidence that the vehicles, charging infrastructure and charging tariffs are available to fulfil their requirements. This means building a charging network that provides good value to users, is investable and accessible.

To deliver the conditions necessary for the deployment at pace of the charging infrastructure required, the EV Energy Taskforce has made the following recommendations to industry and government.

Public charging needs to be built ahead of need to gain consumer confidence

Delivering a universally accessible public charging infrastructure across the UK, ahead of the mass market transition, is critical to gaining EV user confidence and creating the conditions for the transition to take place to the timescale required.

Key Recommendations:

- Government and the financial sector must develop targeted financial support including blended public and private capital funding and explore mechanisms to share risk such as utilisation-linked loans to chargepoint providers.[20]
- Ofgem and government should ensure there are network investment incentives, linked to Local Area Energy Plans, to stimulate investment.
- Central and local government need to streamline and simplify planning guidelines and consent protocols.

[20] Utilisation-linked loan financing would provide investor assurance against slower than anticipated utilisation rate improvements and would de-risk demand-side impact on returns.

Other specific recommendations:

- A common template local government tendering structure should be established to bundle high- and relevant low-usage locations as investment opportunities.
- Education of LAs and a centrally-funded and supplied expert resource should be established to support and enable efficient local tendering. This would help provide templates, frameworks and best practices for developing charging infrastructure.
- Greater data transparency is needed to drive better decision making. This includes pricing data and signals, traffic flows and power distribution availability. Regional or local forums should be established to allow the sharing of data between fleet operators, DNOs and LAs to assist in transport and energy planning.
- Additional practices can be adopted by chargepoint operators as well as depot and workplace providers to further improve utilisation. Practices such as sharing chargepoints between fleets with different usage patterns, establishing private and public partnerships to develop charging hubs, providing access to the general public and scheduling of charging into fleet operations should be explored.
- Investigations around pricing and forms of targeted support are needed to ensure households without access to off-street parking and, especially, low income households are not faced with unfair charging costs while the market is maturing.

It is essential for local authorities to have the right tools and resources to provide integrated energy and transport planning.

Local authorities have a pivotal part to play in the effective deployment of public charging infrastructure through their role in control of planning, consents and access, their responsibility for the road network and transport planning, as well as through other aligned activities including measures to improve local air quality and contribute to decarbonisation. However, LAs are often underpowered, poorly informed and uncertain of their options.

Key recommendations:

- Government must ensure that LAs have the resources and have both the mandate and obligation to develop and deliver local charging strategies,
- DNOs must provide mechanisms for sharing knowledge, materials and learnings across LAs in their region to develop local transport energy plans.

Other specific recommendations:

- A national roll-out strategy for EV charging including frameworks, toolkits and guidance should be provided to LAs, as well as the regional Energy Hubs, for local area energy mapping and planning for the delivery of smart local energy systems.
- The regulator should facilitate efficient, anticipatory electricity network investment by network operators informed by common assumptions and local area energy plans through RIIO 2.
- Government and LAs should review their planning guidance and consent protocols to support rapid deployment, once projects have been accepted into the local area energy plan.
- Central Government should ensure LAs are provided with sufficient support to effectively plan and procure a high-quality public EV charging infrastructure in the right places at the right time as part of the wider energy and transport system, with the option to make this a mandated duty of the local authority if required.
- Capacity and capability within LAs should be improved with the provision of funding and resources. There should be a move away from stop-start, short-term funding arrangements to a longer-term 'outcome' based approach, with the potential for this to be allocated based on predicted need. Relationships between the housing authorities and the sub-national transport bodies (STBs) should be strengthened.
- Mechanisms for sharing knowledge, materials and project learnings across different LAs within a DNO region will be required to provide better data. This would most efficiently be provided at a national or regional level to reduce the risk of LAs being outmanoeuvred by suppliers. Support should be provided enabling LAs to understand the criteria for selecting the best technology for a particular location.
- DNOs should ensure consistent approaches are developed across the multiple LAs within their area of operation; providing guidance to LAs in developing charging infrastructure plans and to provide forums for fleets to engage with LAs to plan electric vehicle deployment.

Public chargepoints have to be used and usable – visible, accessible, connected, secure and interoperable for consumer confidence.

Confidence in the charging infrastructure is critical to enabling EV market demand and accelerate the transition. Government and industry must work together to deliver high-quality public charging services and ensure that charging is integrated as effectively as possible into the energy system.

Key recommendations:

- Government and Ofcom need to develop a strategy to deliver national data connectivity with an architecture that supports evolving EV charging requirements. As an interim measure they should publish detailed maps of mobile signal connectivity to aid chargepoint network planning. The data communications network needs to allow for real time transactional & operational data across the network.
- Chargepoint operators must ensure a minimum level of service which includes accessibility, uptime and repair completion targets, and be held to account for these.
- Local authorities should include minimum performance criteria in their chargepoint procurement processes.
- Industry must make relevant chargepoint, network and vehicle data open and accessible whenever possible to facilitate smart charging.

Other specific recommendations:

- Government and industry must work together to make relevant chargepoint data open and accessible for a high-quality public charging service, (consistent with the proposals made by the EDTF [38]), ensuring that charging forms a connected part of the energy system. Public chargepoint data must be available to meet the needs of different types of vehicle and people of different abilities with quick, stable, and secure connectivity.
- Government and industry need to develop a common perspective about what is needed to deliver seamless roaming between chargepoints and data sharing, based on common and agreed assumptions.
- Government and industry must ensure 'system resilience by design' to mitigate against both physical and cyber system vulnerabilities relating to the digital integration of EVs and charging infrastructure. The UK should aim to lead the way on international standards relating to interoperability.
- Chargepoint innovation should be encouraged to ensure EV users are able to unlock new revenue streams and provide a range of grid applications in flexibility markets.
- Chargepoint operators must ensure public chargepoints are physically accessible, connected, well-maintained, reliable, and easy to use for all types of users and vehicle.
- Government should define the legal and regulatory basis for chargepoint operator obligations regarding cyber security and propose a workable compliance/enforcement scheme, while supporting industry to develop cyber security mechanisms in live trial situations.
- Industry should converge around standards for communications, data, and security protocols with appropriate feedback mechanisms in place to measure progress. These need to be developed in close coordination with international standards to ensure the consistency of data language and protocols between chargepoints across the sector.

Smart charging wherever appropriate, is essential if system cost is to be managed.

Utilising the generation, network and charging infrastructure capacity is vital in delivering a cost-effective and low embedded carbon energy system. The impact on peak demand and the need for network reinforcement must be minimised. This offers opportunities for UK leadership in the development of innovative business models for smart charging with applications also applicable to the electrification of heat.

Key recommendations:

- Chargepoint operators should ensure any chargepoint at a location with a sufficiently long occupancy time is smart charging-enabled to reap the significant benefits to both users and the most effective functioning of the grid that smart charging allows.
- Ofgem and government should further reform electricity market arrangements to ensure that the system value of flexibility is encouraged.
- Industry must develop data sharing standards and protocols to be applied across the energy system, charging infrastructure and vehicle parc.

Other specific recommendations:

- Government, industry and other stakeholders work together to align expectations for interoperability, cyber security, data privacy and grid stability, taking a whole systems approach to ensure a seamless integration of cross-sector data services.
- Good governance of data access and data sharing is needed to guarantee safe operation of the electricity system, the EV charging infrastructure and the vehicles at all times, with best practice being adopted to ensure the resilience of national strategic infrastructure and connected managed assets.
- Markets and price signals should maximise the opportunities and incentives for consumers to utilise their flexible resources, including EVs, and sufficiently reward them for offering demand flexibility services that support optimised network operations and investment, emission reductions and whole electricity system efficiency.

Informing, educating and protecting EV users is critical to create the understanding necessary for mass market uptake.

With the adoption of any new technology requiring behaviour change, there is resistance and caution. Confidence in the performance and attributes of electric vehicles and in the availability and performance of the chargepoints combined with clarity and transparency regarding the costs and benefits is crucial. Consumers will need to change their behaviour with regard to vehicles, including how and where they are refuelled (charged) in order to deliver the ambition of electrifying transport. Innovative business models will need to effectively engage consumers.

Key recommendations:

- Government and industry should develop an extensive and consistent public information campaign to support consumer confidence and engagement with smart charging and how to engage with public charging effectively.
- Government, LAs and chargepoint operators will need to support disadvantaged consumers without access to domestic charging, by exploring and deploying a range of charging options appropriate to the locality and the use of home and roam tariffs.
- Government must ensure that there are consistent consumer protections and industry must deploy complaint handling mechanisms across the consumer journey, particularly to address issues with bundled packages including vehicle, chargepoint, tariff and finance.

Other specific recommendations:

- Government, industry and regulators should work together to ensure that sector boundaries do not constrain effective complaint handling for EV charging under the auspices of the EV Energy Taskforce. Industry should adopt consistent complaint handling standards across market boundaries.
- Government and Ofgem should clarify rights/obligations around consumer data, including issues concerning privacy, access and portability.
- Government (DCMS) should outline how the transparency of AI/algorithms that are involved in all related EV decision-making processes will be monitored, as part of data protection reforms [51].
- Government and industry need to work together to implement a consumer data accessibility and privacy framework for all EV products and services, underpinned by the principles already identified by the EV Energy Taskforce [56].

Modelling - future work

The ESME:Transport Analytical Framework[21] has been used to build a numbers-based picture of future ecosystems that support the mass adoption of EVs. This assessment has been developed from a set of central assumptions agreed between the Taskforce's stakeholders, as well as several variations to these where some of the biggest areas of uncertainty lay. Further work to enhance the current findings and provide additional insights around the implications of decarbonising the car and van sector include:

- The **availability of smart charging at on-street residential locations** to assess the impact on charging prices and potential benefits to the electricity system.
- **Enhancement of fleet travel patterns and charging preferences** to provide additional insights into how fleet vehicles will use public chargepoints.
- **Additional revenue streams for near home charging solutions** to assess how these could affect charging prices and the viability of associated business models.
- The **potential of sharing (peer-to-peer) access to private off-street residential chargepoints** to assess any impact on charging prices and impact on the need for other types of near home charging
- The **availability of workplace charging schemes** that encourage higher usage, to assess their impact on near home charging provision.
- The **availability of vehicle-to-grid for home and other long duration charging locations** to assess the impact on charging prices and the potential benefits to the electricity system.
- Sensitivity analyses to assess the **impact of future battery technologies** on the number of chargepoints and charging electricity demand.
- The potential for **competitive pricing** and **price elasticity** to alter the demand for each form of charging.

Modelling conclusions

The modelling carried out as a part of this study sought to quantify the impacts on the energy ecosystem arising from the mass uptake of EVs. Insights were focused on four areas: the scale of EV uptake; future electricity demand from cars and vans; the diversity of chargepoints that will be needed; and near home charging solutions for users without off-street parking.

- Scale of EV uptake
  - By 2035 there will need to be a greater than **50-fold increase in the number of battery electric cars on the road**.
  - Getting to this level means that by 2030 **2.5 million battery electric cars** will need to be sold per year in the UK, at a rate **13 times greater than the record-breaking levels seen in 2021**.
  - Doing so will mean consuming as much as **7% of the global battery electric car production** that is currently forecast for that year.

- Electricity demand from charging
  - Electricity demand from the transport sector will reach **55 TWh per year** by 2035.
  - This is **enough to power two-thirds of the homes in the UK today**.
  - By 2035 it would represent 14% of total demand

- Diversity of chargepoint types
  - Chargepoints of various types and at a variety of locations will be needed to serve drivers' needs
  - In the central case **500,000 public chargepoints** will need to be deployed by 2035 to provide drivers with the confidence to buy electric vehicles and the means to charge them
  - Up to **50% of all public chargepoints** will be needed to provide charging near home for **drivers without dedicated parking**.

- Near home: both solutions are needed
  - Different options for near home charging exist
  - On-street residential charging and local rapid hub charging are two of the clearest options. EV users have differing views on their attractiveness.
  - To reach the ambitious levels of EV uptake set out, a variety of options for private users without off-street parking will be needed.
  - Local rapid hub charging appears likely to be able to offer more competitive prices for drivers than on-street residential charging
  - The high potential throughput of local rapid hubs can enable good investment returns and commercially viable operation without public subsidy.
  - Lowering the cost of up-front investment in on-street residential chargepoints and managing occupancy times could reduce the price gap compared with local rapid hub charging.
  - Further savings for on-street charging may well be possible through smart charging and public subsidy but the implications of both need to be tested.
  - The suitability of each solution will also have to be assessed at a local area level. Local factors, such as consumer preferences, land prices or network connection costs, are likely to make one solution more appealing than the other.

[21] See section 3.2 The ESME:Transport Analytical Framework

Glossary

BEV	Battery electric vehicle
Consumer Interoperability	Ability for consumers to switch between both different commercial offers and technology choices.
Commercial Interoperability	Aligned incentives across the energy system to ensure that value can flow where it needs to, driven by market forces.
CPO	Chargepoint operator
Data Interoperability	Sharing and portability of data between different systems.
Device Interoperability	Devices are swappable, replaceable and exchangeable as needs change and technologies develop and to allow consumers to make informed choices between open and closed eco-systems.
DNO	Distribution network operator
En route rapid charging	Sited along the strategic road network, these are critical for drivers undertaking long, cross-country journeys. (50-350kW)
EV	Electric vehicle
Depot charging	Charging facilities at commercial fleet depot (22kW)
FCV	(Hydrogen) fuel cell vehicle
Home and roam	Tariff which allows you to use public charge points and be charged to your home tariff
ICEV	Internal combustion engine vehicle (petrol/diesel)
Interoperability	Ability of the components of a system to work together comprising: consumer, commercial, data, device, physical.
LA	Local authorities
Local rapid hubs	Public rapid charging at local forecourt with high throughput located near residential areas (e.g. former petrol stations) (50-350kW)
Off-street residential	Domestic chargepoints on private residential property (garages, driveways etc) (7kW)
On-street residential	Slow charger installed on the street in a residential area (7kW)
Physical Interoperability	End-to-end systems function as changes happen to parts of the system.
Smart charging	Shifting the time of day when an EV charges, or modulating the rate of charge at different times, in response to a signal to the chargepoint.
Near home charging	Charging solutions for drivers who do not have access to private home charging, namely on-street residential and local rapid hubs
PHEV	Plug-in hybrid electric vehicle
RIIO-2	Ofgem price control for period 2023-28
RTTC	Road Transport Transition Council
TOU	Time-of-use (tariff)

References

1 "Electric vehicle charging device grant scheme statistics: January 2022 - GOV.UK." https://www.gov.uk/government/statistics/electric-vehicle-charging-device-grant-scheme-statistics-january-2022 (accessed March 2022).

2 "Electric vehicle charging device statistics: January 2022 - GOV.UK." https://www.gov.uk/government/statistics/electric-vehicle-charging-device-statistics-january-2022 (accessed March 2022).

3 "EV Energy Taskforce: Energising Our Electric Vehicle Transition | Reports | Electric Vehicle Energy Taskforce." https://evenergytaskforce.com/reports/phase-one-report/ (accessed March 2022).

4 "EV Energy Taskforce: Moving from Proposals to Actions | Reports | Electric Vehicle Energy Taskforce." https://evenergytaskforce.com/reports/moving-from-proposals-to-actions/ (accessed March 2022).

5 "Sixth Carbon Budget - Climate Change Committee." https://www.theccc.org.uk/publication/sixth-carbon-budget/ (accessed March 2022).

6 "Transport decarbonisation plan - GOV.UK." https://www.gov.uk/government/publications/transport-decarbonisation-plan (accessed March 2022).

7 "Cars parked 23 hours a day." https://www.racfoundation.org/media-centre/cars-parked-23-hours-a-day (accessed March 2022).

8 "Electric Vehicle Association England Improving Drivers' Confidence in Public EV Charging" https://www.evaengland.org.uk/wp-content/uploads/2021/04/EVA-England-Consumer-Charging-Survey-Report.pdf (accessed March 2022).

9 "National Travel Survey: 2020 - GOV.UK." https://www.gov.uk/government/statistics/national-travel-survey-2020/national-travel-survey-2020#recent-trends-in-trips-miles-and-hours (accessed March 2022).

10 "Mode of travel - GOV.UK." https://www.gov.uk/government/statistical-data-sets/nts03-modal-comparisons (accessed March 2022).

11 "Vehicle mileage and occupancy - GOV.UK." https://www.gov.uk/government/statistical-data-sets/nts09-vehicle-mileage-and-occupancy#car-mileage (accessed March 2022).

12 "UK Power Networks Innovation - Enable." https://innovation.ukpowernetworks.co.uk/projects/enable/ (accessed March 2022).

13 "Electric Vehicle Project | Motability." https://www.motability.org.uk/impact-and-innovation/innovation/electric-vehicle-project/ (accessed March 2022).

14 "SSEN first electricity network to explore EV accessibility for people with disabilities - SSEN." https://www.ssen.co.uk/news-views/2021/2021-ssen-first-electricity-network-to-explore-ev-accessibility-for-people-with-disabilities/ (accessed March 2022).

15 "EVA England launches drivers' survey to improve confidence in the EV public charging experience" https://www.evaengland.org.uk/2021/02/22/eva-england-launches-drivers-survey-to-improve-confidence-in-the-ev-public-charging-experience/ (accessed March 2022).

16 "BVRLA Road to Zero Report Card 2021." https://www.bvrla.co.uk/resource/road-to-zero-report-card-2021.html (accessed March 2022).

17 "EV Energy Taskforce: Commercial EV Fleet Charging Requirements | Reports | Electric Vehicle Energy Taskforce." https://evenergytaskforce.com/reports/commercial-ev-fleet-charging/ (accessed March 2022).

18 "New market. New entrants. New challenges. Battery Electric Vehicles Contents" https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/manufacturing/deloitte-uk-battery-electric-vehicles.pdf (accessed March 2022).

19 "Average number of trips made and distance travelled - GOV.UK." https://www.gov.uk/government/statistical-data-sets/nts01-average-number-of-trips-made-and-distance-travelled (accessed March 2022).

20 "Electricity consumption in the UK 2021 | Statista." https://www.statista.com/statistics/322874/electricity-consumption-from-all-electricity-suppliers-in-the-united-kingdom/ (accessed March 2022).

21 "Rethinking Electricity Markets – The case for EMR 2.0 - Energy Systems Catapult." https://es.catapult.org.uk/report/rethinking-electricity-markets-the-case-for-emr-2/ (accessed March 2022).

22 "EV Energy Taskforce: Encouraging Investment in Public EV Charging in the UK | Reports | Electric Vehicle Energy Taskforce." https://evenergytaskforce.com/reports/encouraging-investment-in-public-ev-charging/ (accessed March 2022).

23 "Reports | Electric Vehicle Energy Taskforce." https://evenergytaskforce.com/reports/ (accessed March 2022).

24 "Government vision for the rapid chargepoint network in England - GOV.UK." https://www.gov.uk/government/publications/government-vision-for-the-rapid-chargepoint-network-in-england/government-vision-for-the-rapid-chargepoint-network-in-england (accessed March 2022).

25 "On-street Residential Chargepoint Scheme - Energy Saving Trust." https://energysavingtrust.org.uk/grants-and-loans/street-residential-chargepoint-scheme/ (accessed March 2022).

26 "Network price controls 2021-2028 (RIIO-2) | Ofgem." https://www.ofgem.gov.uk/energy-policy-and-regulation/policy-and-regulatory-programmes/network-price-controls-2021-2028-riio-2 (accessed March 2022).

27 "Decision on the RIIO-ED1 Green Recovery Scheme | Ofgem." https://www.ofgem.gov.uk/publications/decision-riio-ed1-green-recovery-scheme (accessed March 2022).

28 "EV Energy Taskforce: Encouraging Investment in Public EV Charging in the UK | Reports | Electric Vehicle Energy Taskforce." https://evenergytaskforce.com/reports/encouraging-investment-in-public-ev-charging/ (accessed March 2022).

29 "CDRT Report | Road to Zero: Unlocking public and private capital to decarbonise road transport." https://www.greenfinanceinstitute.co.uk/news-and-insights/cdrt-report-road-to-zero-unlocking-public-and-private-capital-to-decarbonise-road-transport/ (accessed March 2022).

30 "TTF commits to supporting local authorities with rolling out public EV charging networks - TTF." https://ttf.uk.net/community/the-ev-infrastructure-working-group/ttf-commits-to-supporting-local-authorities-with-rolling-out-public-ev-charging-networks/ (accessed March 2022).

31 "Electric vehicles: Ofgem's priorities for a green fair future | Ofgem." https://www.ofgem.gov.uk/publications/electric-vehicles-ofgems-priorities-green-fair-future (accessed March 2022).

32 "EV Energy Taskforce: Moving from Proposals to Actions | Reports | Electric Vehicle Energy Taskforce." https://evenergytaskforce.com/reports/moving-from-proposals-to-actions/ (accessed March 2022).

33 "UK Power Networks Innovation - Charge Collective." https://innovation.ukpowernetworks.co.uk/projects/charge-collective/ (accessed March 2022).

34 "PACE - SP Energy Networks." https://www.spenergynetworks.co.uk/pages/pace.aspx (accessed March 2022).

35 "How to register energy devices in homes or small businesses: guidance for device owners and installation contractors - GOV.UK." https://www.gov.uk/government/publications/register-energy-devices-in-homes-or-small-businesses-guidance-for-device-owners-and-installation-contractors/register-energy-devices-in-homes-or-small-businesses-guidance-for-device-owners-and-installation-contractors (accessed March 2022).

36 "Scoping the role of local authorities in the provision of electric vehicle charging infrastructure | Local Government Association." https://www.local.gov.uk/publications/scoping-role-local-authorities-EV (accessed March 2022).

37 "OZEV to release EV charging infrastructure guide for Local Authorities." https://electrical.theiet.org/wiring-matters/years/2021/88-november-2021/ozev-to-release-ev-charging-infrastructure-guide-for-local-authorities/ (accessed March 2022).

38 "Energy Data Taskforce | A Modern Digitalised Energy System." https://es.catapult.org.uk/report/energy-data-taskforce-report/ (accessed March 2022).

39 "The Interoperability of Public EV Charging Networks in the UK - REA." https://www.r-e-a.net/resources/the-interoperability-of-public-ev-charging-networks-in-the-uk/ (accessed March 2022).

40 "Electric Vehicle Project | Motability." https://www.motability.org.uk/impact-and-innovation/innovation/electric-vehicle-project/ (accessed March 2022).

41 "UK Power Networks Innovation - Enable." https://innovation.ukpowernetworks.co.uk/projects/enable/ (accessed March 2022).

42 "BVRLA Fleet Charging Guide 2022." https://www.bvrla.co.uk/industry-campaigns/decarbonisation/fleet-charging-guide-2022.html (accessed March 2022).

43 "EV Energy Taskforce: Data Accessibility and Privacy | Reports | Electric Vehicle Energy Taskforce." https://evenergytaskforce.com/reports/phase-two-working-group-4/ (accessed March 2022).

44 "Renewable Energy Assurance Ltd - REAL." https://www.realschemes.org.uk/ (accessed March 2022).

45 "The consumer experience at public chargepoints - GOV.UK." https://www.gov.uk/government/consultations/the-consumer-experience-at-public-electric-vehicle-chargepoints/the-consumer-experience-at-public-chargepoints (accessed March 2022).

46 "UK government partners with disability charity to set standards for electric vehicle chargepoints - GOV.UK." https://www.gov.uk/government/news/uk-government-partners-with-disability-charity-to-set-standards-for-electric-vehicle-chargepoints (accessed March 2022).

47 "UK Power Networks Innovation - Enable." https://innovation.ukpowernetworks.co.uk/projects/enable/ (accessed March 2022).

48 "Open Electric Vehicle (EV) chargepoint data - Digital Marketplace." https://www.digitalmarketplace.service.gov.uk/digital-outcomes-and-specialists/opportunities/15132 (accessed March 2022).

49 "Future of transport regulatory review: zero emission vehicles - GOV.UK." https://www.gov.uk/government/consultations/future-of-transport-regulatory-review-zero-emission-vehicles (accessed March 2022).

50 "Department for Transport Innovation Programme - Case Studies." https://cp.catapult.org.uk/project/dft-innovation-programme-2/ (accessed March 2022).

51 "EV Energy Taskforce: Cyber Security and Smart Charging | Reports | Electric Vehicle Energy Taskforce." https://evenergytaskforce.com/reports/phase-two-working-group-3/ (accessed March 2022).

52 "Electric vehicle smart charging - GOV.UK." https://www.gov.uk/government/consultations/electric-vehicle-smart-charging (accessed March 2022).

53 "Electric vehicle smart charging consultation: summary of responses - GOV.UK." https://www.gov.uk/government/consultations/electric-vehicle-smart-charging (accessed March 2022).

54 "Home - MHHS Programme." https://www.mhhsprogramme.co.uk/ (accessed March 2022).

55 "Transitioning to a net zero energy system: smart systems and flexibility plan 2021 - GOV.UK." https://www.gov.uk/government/publications/transitioning-to-a-net-zero-energy-system-smart-systems-and-flexibility-plan-2021 (accessed March 2022).

56 "EV Energy Taskforce: Data Accessibility and Privacy | Reports | Electric Vehicle Energy Taskforce." https://evenergytaskforce.com/reports/phase-two-working-group-4/ (accessed March 2022).

57 "EV Energy Taskforce: Energising Our Electric Vehicle Transition | Reports | Electric Vehicle Energy Taskforce." https://evenergytaskforce.com/reports/phase-one-report/ (accessed March 2022).

58 "We don't seem to be able to find the page that you're looking for | Electric Vehicle Energy Taskforce." https://evenergytaskforce.com/reports/phase-two-working-group-2/ (accessed March2022).

59 "Smart charging for electric vehicles - Energy Saving Trust." https://energysavingtrust.org.uk/advice/smart-charging-electric-vehicles/ (accessed March 2022).

60 "Flex Assure." https://www.flexassure.org/ (accessed March 2022).

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