element energy

Analysis to identify the EV charging requirement for vans

Final report

for

Climate Change Committee

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Executive Summary

The number of electric vans on UK roads is set to grow rapidly over the next 10 to 15 years. Past studies analysing charging needs of the future electric vehicle (EV) fleet have assumed that the diverse charging needs of cars will also meet the needs of vans. However, recent survey data and case studies suggest that vans differ from cars in several important areas which will impact charging needs. Charging infrastructure predominantly designed for cars could therefore act as a barrier to electric van uptake.

The aim of this study is to look at the differences in usage patterns and charging needs between cars and vans to calculate and cost of the total additional charging infrastructure needed for vans above the network deployed for cars, in addition to the cost of charging faced by van drivers. This study was carried out in parallel with the On-street Charging Study carried out by Ricardo Energy and Environment on behalf of the CCC, and assumptions are aligned. This report sets out the key findings around the optimal charging strategy for the electric van fleet in the UK and recommendations developed to overcome the charging barriers to the uptake of electric vans.

Key findings and recommendations

There will be a variety of optimum charging solutions for the UK's electric van fleet, depending on their operating profile. Operating profiles are highly varied across the UK's van fleet, with differences in daily mileage, radius of operation, stopping behaviour, and overnight parking locations. Actors including government, distribution network operators, charge point operators, and fleet operators must act to alleviate barriers and facilitate the charging of electric vans. Key recommendations include:

Recommendations to central government:
• Policy makers should encourage fleet operators to carry out overnight charging of their fleet at depots, where possible, instead of shifting the focus to charging at drivers' homes as this reduces charging costs and alleviates congestion at on-street charging points. • Policy makers should encourage the development of business models for sharing of private charging infrastructure and support investment in platforms that provide a quick, seamless infrastructure sharing experience. • Specific policy should support small businesses as they transition to electric vans, as these small fleets are more likely than other groups to face higher average charging costs due to frequent use of rapid charge points and limited access to private charging infrastructure. • Policy should encourage smart charging of vans overnight to limit impact on the grid and reduce reinforcement costs. • Regulation should be put in place to prevent large disparity in the availability or cost of infrastructure. • If current plans to regulate minimum reliability requirements of rapid infrastructure are put into place, policy should consider extending the regulation to ensure reliability of under-utilised/rural charge points. • Regulation should be introduced to ensure vans and other larger commercial vehicles can access charge points.
Recommendations to local government:
• Policy should facilitate vans' access to low cost on-street charging infrastructure as current first come first serve models are insufficient to support van users who are likely to want to charge every day.

Recommendations to fleet and/or charge point operators:
• Fleets and charge point operators should consider the needs of vans when designing the roll-out of charging infrastructure for other commercial vehicles, HGVs, taxis etc. • Modelling in this study assumes constant charge point utilisation rate and demand throughout the year from van fleets. In reality, demand will be much higher in winter months, and particularly around the Christmas period, as a result of higher consumer demand for home delivery, maintenance, and medical services. Fleet and charge point operators should collaborate to develop a strategy for charging of vans during concentration of 'worst days' in winter months, which could involve mobile charging infrastructure, use of back-up vehicles, or sharing of depot infrastructure.

Usage patterns and charging behaviour of vans

A comprehensive review of van usage patterns was carried out to develop van archetypes with distinct operational profiles and therefore charging behaviour. Macro level analysis of van use, based on data from the DfT van survey[1], found that the distribution of average daily mileages and typical road use of vans can be determined by their operating types, defined as a van's typical driving range from base: 1) Local – within 15 miles of base (54.6% respondents), 2) Regional – within 50 miles of base (32.8% respondents), or 3) National – over 50 miles from base, but still within UK (12.5% respondents).

Surveys and interviews with van drivers and fleet operators were then used to understand the practicalities of operating an electric van, including charging opportunities. Vans expect to charge at a range of locations, which can be categorised as either being used overnight (residential or depot) or topping up in the daytime, as shown in Table 1. Drivers that charge residentially overnight without access to off-street parking are likely to make use of a mixture of charging locations, including overnight charging at on-street charging and other daytime charging locations, particularly rapid hubs. Vans typically visit a wide range of sites during operation, which are likely in the future to have private charge points installed. Vans could make use of this infrastructure to top-up charge during the day, however, business models to facilitate sharing of private infrastructure are still emerging.

Table 1: Potential charging locations for vans by time of day and preference category

	Category	Location	Definition
Overnight	**Depot**	**Depot**	Fleet-owned location, likely to house multiple vehicles and require significant charging infrastructure, likely to be slow 7 - 12 kW chargers
	Residential	**Private**	Privately-owned off-street, likely to be slow 3 – 7 kW, used overnight
		On-street residential	Public on-street, generally near to homes, either lamppost (ca. 3 – 5.5 kW) or fast charging on-street (7 – 22 kW), used overnight
Daytime	**Public**	**En-route rapid**	Public rapid chargers (50 kW+) on driving route, used during the day
		Forecourt rapid	Public rapid chargers (50 kW+) in urban areas, used during the day
		On-street residential	Daytime shared use of public chargers on-street close to customer home, where off-street not available (3 – 22 kW)
	Private	**Commercial zone**	Depots and warehouses in UK are clustered in commercial zones/ districts. This will contain many depots and client sites

[1] Van Statistics: 2019 to 2020 underlying data, DfT

		which could be opened up to third party charging – likely to be 'spare' high speed infrastructure (50 kW+)
	Client site	Privately-owned off-street charging belonging to client, likely to be slow 7 – 12 kW chargers
	Private residential	Daytime shared use of privately-owned off-street charging belonging to customer, likely to be slow 3 – 7 kW.

Twelve van charging archetypes were developed, categorised by their operating type (local, regional, or national) and their overnight and daytime charging preferences (Residential or Depot, and Public or Private respectively), as identified from stakeholder engagement and analysis of DfT survey data. A charging distribution model was developed to calculate the proportion of each archetype's charging demand occurs at the different charging locations, as shown in Figure 1.

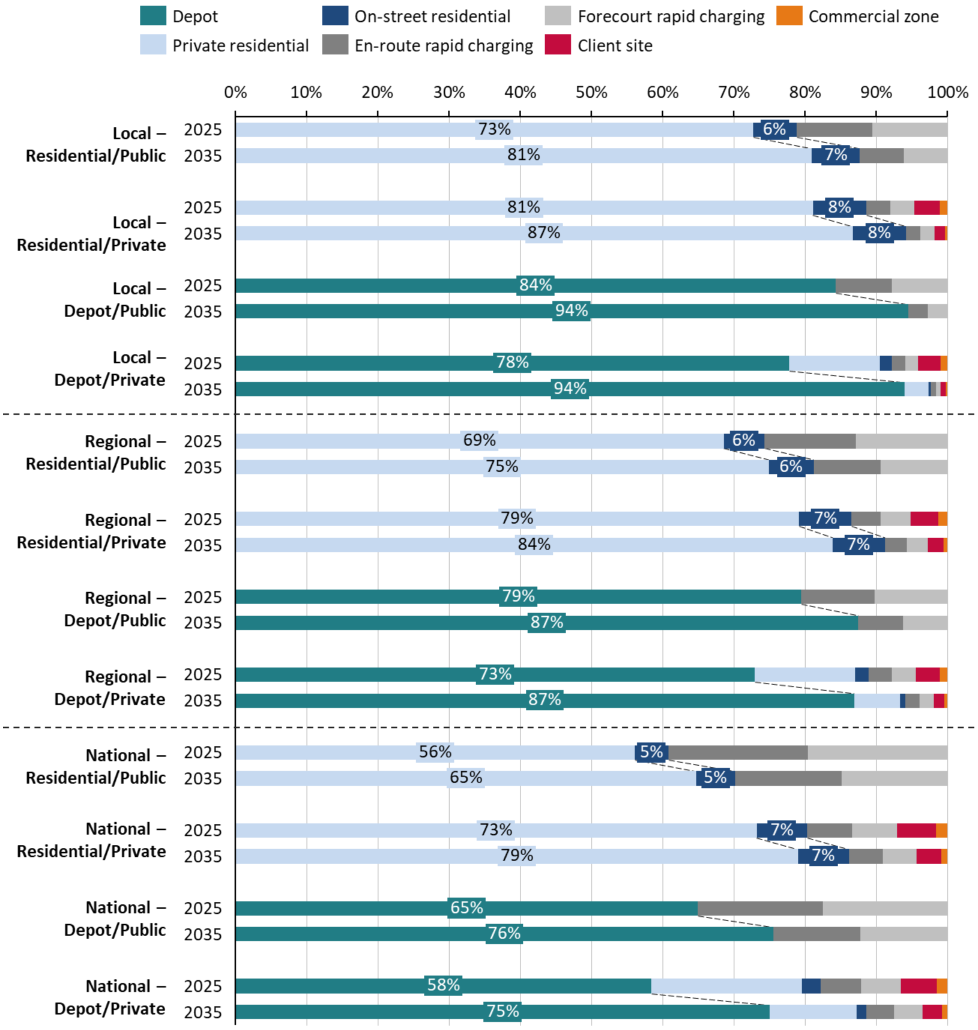

Figure 1: Baseline charging mix distribution across van archetypes, 2025-35

Across all archetypes, most charging demand (54 – 84% in 2025) can be met overnight. Over 2025-35, projected improvement in van range further reduces the need for daytime top-up charging. A sensitivity on the availability of on-street residential charge points was carried out, leading to the proportion of public residential charging demand met on-street to vary from 70% (with high availability of on-street charge points) to 30% (with low availability). This was found to have a limited impact on the overall charging mix of archetypes that charge residentially overnight (see Figure 17 in main report), largely due to the prevalence of off-street parking and the spread of demand over daytime charging locations. An additional sensitivity on the level of adoption of business models for sharing private infrastructure was carried out (see Figure 18 in main report). This was found to have a high impact on the projected use of public infrastructure, with much lower expected use of rapid hubs when ability to share private infrastructure is high as a result of the lower cost and higher convenience of shared private infrastructure compared to rapid hubs.

The ICCT sets out charging behaviour assumptions for electric cars[2], which differs from the van charging mix shown in Figure 1 due to the differing operational profiles, which are not expected to have access to client infrastructure during the daytime or be based at depots overnight. Cars are additionally expected to have a higher share of time not in use, so there is more opportunity for slow, long duration charging.

Additional charging infrastructure needs for vans

The total charging demand at each location over 2025-35 was used to calculate total charge point needs for charging of vans. The total number of charge points required is expected to grow by 309% from 0.95 to 3.89 million over this period, as shown in Figure 2. In 2030, out of the 2.5 million charging points, only ca. 160,000 (6.5%) are projected to be public charging points.

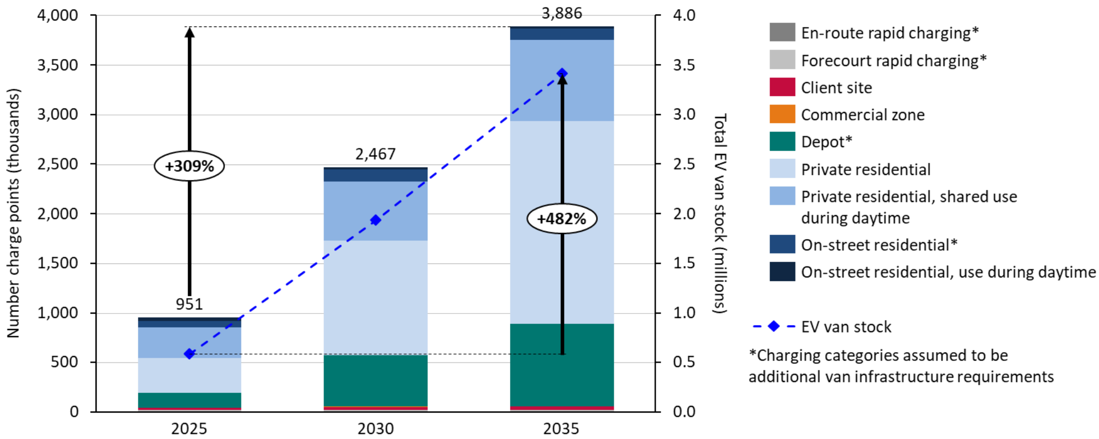

Figure 2: Baseline charging infrastructure needs by charging location in the UK

The total charge point requirement is not representative of the additional infrastructure needed for vans on top of infrastructure installed for cars or other purposes. The infrastructure shared at commercial zones and client sites is likely to be depot infrastructure of other fleets. Residential infrastructure used during the day by vans visiting customers are likely to have been installed for overnight charging. Furthermore, van drivers are likely to own a private car for personal use. Therefore, private residential infrastructure is likely to be accounted for in other studies' modelling of charging infrastructure needs for cars. As a result, only the following categories are considered additional van infrastructure: 1) depot (520k charge points needed by 2030), 2) on-street residential used overnight (116k charge points needed by 2030), 3) en-route rapid charging (10k charge points needed by 2030), 4) forecourt rapid charging (10k charge points needed by 2030).

[2] Quantifying the electric vehicle charging infrastructure gap in the UK, ICCT, August 2020

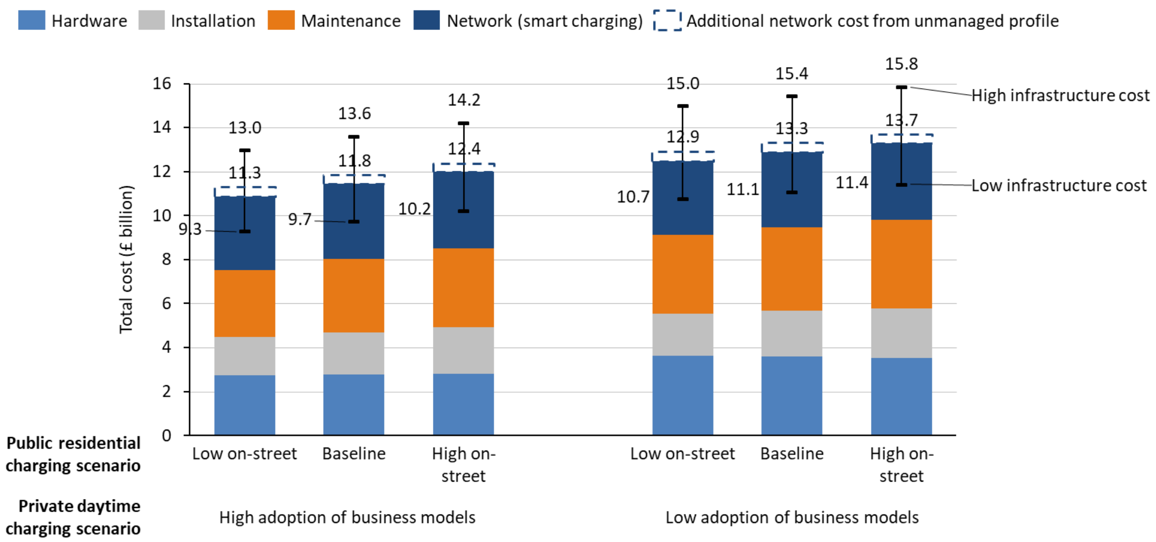

Figure 3: Cumulative total cost of required van charging infrastructure in 2030 in the UK, across charging preference and charging infrastructure cost scenarios.

The cumulative total cost of the additional infrastructure hardware, installation, and maintenance, and the network reinforcement from van charging demand was calculated as between £9.2 – £15.8 billion in 2030, as shown in Figure 3. This cost will mostly be met by private investment, in particular businesses installing depot infrastructure and charge point operators investing in rapid hubs. For fleet operators installing depot infrastructure, it is likely that there will be a compelling business case for this investment as a result of the lower running costs of electrifying their fleet. As set out in the On-Street Charging Study[8], the business case for rapid hub operators will be dependent on factors including utilisation of infrastructure and grid upgrade costs on-site. The impact this may have on infrastructure availability for van drivers is explored in more detail in Section 4.3.

The total cost of additional charging infrastructure is reduced by high adoption of business models for sharing of private infrastructure, as improved sharing of existing infrastructure leads to a lower required number of additional charge points for vans. Low use of on-street residential charging overnight also results in a lower total infrastructure cost, due to the increased use of high power, high utilisation rapid charge points again leading to a lower required number of additional charge points. Van charging demand without use of smart charging technology could create a total demand peak of 8.5 GW between 8 – 9pm, aligning with the evening peak in national electricity demand. Smart charging at depots, private residential, and on-street charge points flattens the peak demand to 7.6 GW and away from the evening peak, leading to savings of ca. £400 million in network reinforcement costs across all Charging Scenarios.

Cost to van drivers

Average cost to van drivers for each charging location was used to calculate an overall average charging cost per kWh. The average cost of charging varies by archetype, with the extent of variation increasing over time (21 – 29 p/kWh in 2025 and 18 – 26 p/kWh in 2030). The overall cost of charging for each archetype decreases over time, largely due to expected improvements in van range leading to higher proportion of demand met at cheaper overnight charging locations.

Drivers charging residentially overnight were found to benefit significantly (34 – 51% fall in average cost) from off-peak EV tariffs if they have access to off-street parking. Drivers expected to charge residentially overnight without access to off-street parking see high charging costs – high availability of on-street charging infrastructure lowers the cost of charging to these consumers, as they are less expensive than rapid charging, the next preferred option. High levels of sharing of private infrastructure during the day lowers charging costs to drivers, again due to lower use of costly rapid hubs.

As shown in Figure 4, the cost of charging to van drivers is similar but slightly lower than cost of charging to car drivers, with some range in values observed across both. The highest cost to van drivers is observed for national drivers that charge residentially overnight and publicly during the day, which makes up ca. 7% of the total van fleet and is often drivers that are self-employed or belong to small fleets. These groups would still expect savings when transitioning away from ICE vans to electric, but savings would be lower than seen for other drivers. Widespread availability of easy-to-use and convenient infrastructure is likely to be a more significant factor in the decision to transition to EVs.

There may be variation in availability and cost of public charging infrastructure across the country. For example, the introduction of utilisation-based pricing schemes at public networks would impact the cost to drivers, in particular drivers that rely on rapid charging. This has largest impact on archetypes with high use of public infrastructure, leading to up to a 17.5% increase in average charging costs. Low utilisation of charging infrastructure is typically seen in minor road networks or rural areas. However, analysis of DfT traffic count data[3] found that van drivers will not be more disadvantaged than car drivers. EV drivers (cars and vans) operating in rural areas with under-utilised infrastructure may face disproportionately higher charging costs if reliant on public networks. Current rapid networks do not appear to make use of utilisation-based pricing model and therefore higher prices are not currently observed at infrastructure with low utilisation. It is likely that a more key concern for drivers reliant on public infrastructure when transitioning to electric vans will be the widespread availability of easy-to-use and convenient charge points.

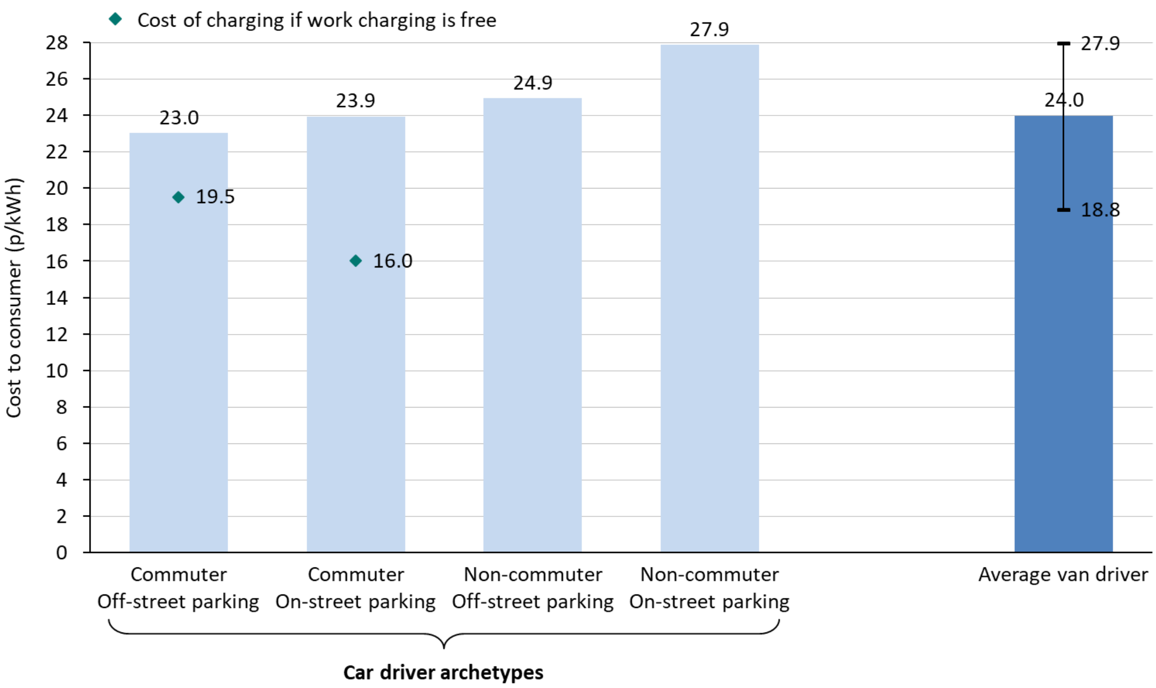

Figure 4: Cost of charging to car drivers across different archetypes and average, min, and max cost of charging across van archetypes to van drivers in 2030

[3] DfT Road traffic statistics: https://roadtraffic.dft.gov.uk/downloads

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Note about key assumptions

Cost to consumers of charging at different locations is subject to large variation and is therefore challenging to predict. This analysis aligns cost of charging with broader modelling assumptions of the Climate Change Committee, and in particular the On-Street Charging Study carried out by Ricardo Energy and Environment on behalf of the CCC in May 2022. These costs are based on electricity prices prior to the recent energy crisis leading to high prices, however, comparison between charging solutions and average costs to consumers remain valid. Costs to consumers are also dependent on emerging commercial models.

Acronyms

BEIS	Department for Business, Energy & Industrial Strategy
BEV	Battery electric vehicle
CCC	Climate Change Committee
CPO	Charge point operator
DfT	Department for Transport
EE	Element Energy
EV	Electric vehicle
EVCP	Electric vehicle charging point
HGV	Heavy goods vehicle
ICCT	International Council on Clean Transportation
ICEV	Internal combustion engine vehicle
IRR	Internal rate of return
OZEV	Office for Zero Emissions Vehicles
PAYG	Pay as you go
PHEV	Plug-in hybrid electric vehicle
SMMT	Society of Motor Manufacturers and Traders
TCO	Total cost of ownership
VAT	Value added tax

1 Introduction

1.1 Background and context

The number of electric vehicle (EV) vans on UK roads is set to grow rapidly over the next 10 to 15 years, with the government's plan to phase out the sale of pure petrol and diesel vans by 2030 and plug in hybrids by 2035. This rapid growth is necessary for the UK to meet its net zero targets and previous modelling the Climate Change Committee (CCC) has carried out for the Sixth Carbon Budget suggests that sales of petrol and diesel vans must end by 2032 at the latest to meet the Balanced Net Zero Pathway. Following this rapid uptake trajectory is required to achieve net zero by 2050 and would lead to 35% of all vans on the road being battery electric vehicles (BEVs) by 2030, rising to 87% by 2040. Currently, 14,000 BEV and PHEV (plug-in hybrid electric vehicles) vans are in operation on the UK's roads[4], representing just 0.3% of the total fleet, highlighting the scale of the challenge to decarbonise this segment.

Most BEVs sold to date have been cars and have been bought by consumers with off street parking. This has led to charging infrastructure which is mostly on driveways at home for private use, supported by public charging along the major road network for longer trips. As the number of BEVs grows the diversity of charging needs will grow to include more residential on-street charging, destination charging and rapid charging hubs off the major road network. Past studies have mostly assumed this diversification of car charging will meet the charging needs of vans as well. However, recent survey data from DfT and case studies from early electric van fleets suggest vans differ from cars in several important areas which will impact charging needs. These include van daily mileages, van destinations, off-street access, van specifications, and road network use. Early adopters of BEV vans include major fleets such as British Gas and Ocado, able to make use of charging in depots. As the van fleet electrifies, demand for charging infrastructure will diversify, and the difference between car and van charging needs will become more important.

The knock-on impact of these differences between the car and van fleet means that charging infrastructure predominantly designed for cars could act as a barrier to battery electric van uptake and vans with a higher reliance on public charging infrastructure may see much higher charging costs than home charged cars, impacting the electric van Total Cost of Ownership (TCO) and delaying their roll-out. To sustain the high levels of BEV and PHEV van uptake needed to meet the 2030 emission targets, charging infrastructure will be required that meets the specific needs of all van drivers.

1.2 Project aims and approach

The aim of this study is to look at the differences in usage patterns and charging needs between cars and vans through review of literature and engagement of stakeholders. Vans' charging needs in the UK was used to calculate and cost the total additional charging infrastructure needed for vans above the network deployed for cars, in addition to the cost of charging faced by van drivers. These analyses were brought together to understand the optimal charging strategy for the electric van fleet in the UK, and recommendations were developed to overcome significant barriers to uptake of electric vans.

This study for the CCC divides the work across three work packages, as set out in Figure 5.

[4] SMMT, 2021, Van growth drives UK commercial vehicle parc to record highs, https://www.smmt.co.uk/2021/05/van-growth-drives-uk-commercial-vehicle-parc-to-record-highs/

WP 1: Difference in usage patterns and charging behaviour between vans and cars

> Carry out comprehensive review of van usage patterns and charging opportunities in order to build a van charging matrix
> Set out a car charging matrix based on the existing literature
> Define the electric vehicle uptake and charging behaviour scenarios to be taken forward to WP2

WP 2: Modelling the additional charging infrastructure needs for vans

> Calculate the additional charging infrastructure needed to support van electrification
> Determine the impacts to charging demand on the electricity network
> Estimate costs of the charging infrastructure and the impact on the electricity network
> Evaluate cost of charging to van drivers in comparison to car drivers

WP 3: Recommendations

> Draw together findings to form a series of concise conclusions regarding optimal charging solution specific to the van sector
> Set out the barriers and policy needed to overcome them in order to support rapid electrification of the van market

Figure 5: Project approach and work packages

1.3 Report structure

This report sets out the key findings from the study. Following this section, the report is structured as follows:

Section 2: Usage patterns and charging behaviour of vans sets out the calculation of van charging demand at different locations (charging mix) for a number of defined archetypes based on literature review and stakeholder engagement.

Section 3: Additional charging infrastructure needs for vans describes the calculation of van infrastructure needs, based on the modelled charging demand profiles.

Section 4: Cost of van charging to consumers compares the average cost of van charging to drivers, in comparison with cost to car drivers.

Section 5: Conclusions and recommendations draws together the findings from the study to form conclusions on the optimal charging solution and recommendations to overcome the barriers to uptake of electric vans.

2 Usage patterns and charging behaviour of vans

This section of the report looks at the differences in usage patterns and charging behaviours between vans and cars, setting out the calculation of van charging demand at different locations (charging mix) for a number of defined archetypes based on a review of data from the DfT van survey and interviews and surveys of van drivers and fleet operators.

2.1 Review of van usage patterns and charging opportunities

A comprehensive review of van usage patterns from literature and stakeholder engagement was carried out in order to develop archetypes to produce a van charging matrix (ratios of demand at different charging locations). Archetypes, with distinct operational profiles and therefore charging behaviour, were defined to capture the variation in operational behaviour across the UK's van fleet.

Macro level analysis of van use, based on data from the DfT van survey[1], was used to develop archetypes and understand the range of behaviours within a single archetype. This was followed by micro level analysis of van behaviour within each archetype, carried out through review of data collected during surveys and interviews. This micro level analysis was used to understand the practicalities of operating an electric van, including charging opportunities.

Summary of key findings:

- Distribution of average daily mileages and typical road use can be determined by vans' operating types (typical driving range from base), with no clear statistical differences in the distributions of mileages observed by vans used for different business activities
- Van drivers and fleets expect to charge at a range of locations, which can be categorised as either overnight or daytime locations, in particular – overnight: depot, private residential, public residential; daytime: fleet sites, client sites, public rapid hubs

2.1.1 Macro level analysis of DfT van survey data

DfT carried out a survey of van drivers in 2020 and have published the raw response data[1]. Data was provided for 19,876 respondents from across the UK. This data included:

1. Total fleet size
2. Van's primary usage activity and category of business activities
3. Average annual mileage
4. Frequency of travel on motorways, dual carriageways, A road, local/rural roads
5. Typical driving pattern
6. Number of stops made per day

The response data was analysed to understand patterns in van driving behaviours and operational profiles, with the aim of developing van operating archetypes.

The underlying mileage data from the survey respondents were analysed to understand the distributions of average daily mileages across potential archetypes.

First, the distribution of average daily mileages across the respondents' primary usage categories were considered. Respondents with the two most relevant primary usage categories were analysed – 1) Carrying equipment, tools, or materials, or 2) delivery/ collection of goods. The distributions are shown in Figure 6.

Comparison of the distributions of respondents' average daily mileages across these primary usage categories indicates that there is no clear statistical difference. There is significant overlap in the distributions, therefore it is not possible to estimate daily mileage based on vans' primary usage category.

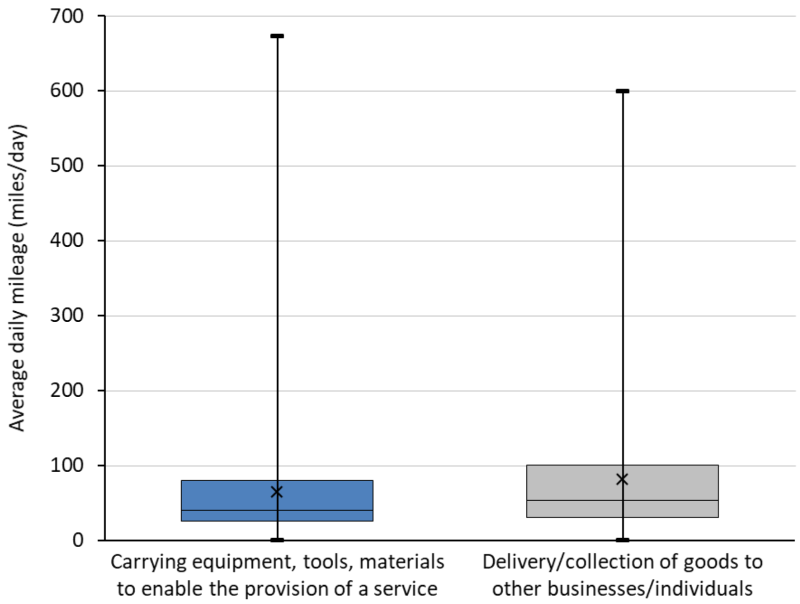

Figure 6: Box and whisker diagram showing the distribution of average daily mileages across van primary usage categories. Note: box and whisker diagram shows minimum, lower quartile, median, mean, upper quartile and maximum values in distribution.

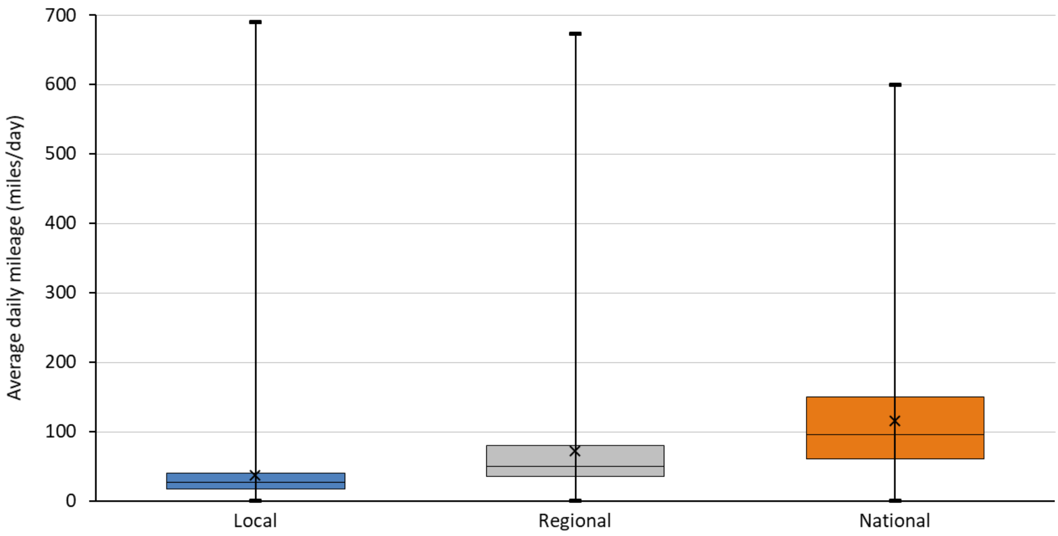

Figure 7: Box and whisker diagram showing the distribution of average daily mileages across operating types. Note: box and whisker diagram shows minimum, lower quartile, median, mean, upper quartile and maximum values in distribution.

The DfT van survey additionally asked respondents to categorise their operating behaviour according to typical driving range from base, defined in this study as their operating type:

1. **Local**: within 15 miles of base (54.6% total respondents)
2. **Regional:** within 50 miles of base (32.8% total respondents)
3. **National:** over 50 miles from base, still within UK (12.5% total respondents)

Excluding respondents with international driving behaviours, the average daily mileages across these operating types show distinct distributions, with clear differences in average, upper, and lower quartile values. The average daily mileage distributions across operating types are shown in Figure 7.

The DfT van survey looked at the typical frequency of driving on different road types, asking drivers to indicate how regularly they drive on local/rural roads, other main/A roads, dual carriageways, and motorways.

Figure 8 shows the proportion of respondents in each operating type that indicated that they drive either regularly or with high frequency on each road type. This indicates that all operating types regularly use local/rural roads and A roads, but the use of motorways and dual carriageways is dependent on operating type, with significantly higher proportion of national drivers making use of motorways than local drivers. Road type usage indicates likely charging preferences and fuel consumption.

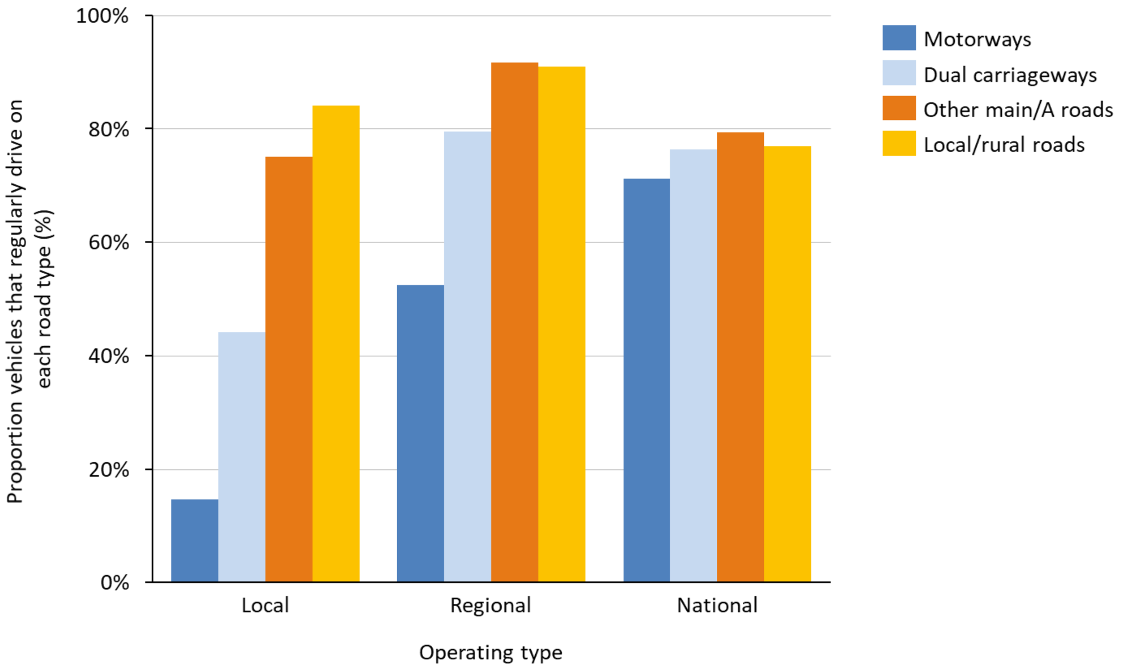

Figure 8: Proportion of vehicles within each operating type driving with either high or regular frequency on each road type

The charging preferences of different van's operational profiles identified through the surveys and interviews will be used in the development of the archetypes for modelling of the charging mix, as set out in Section 2.2.1.

2.1.2 Stakeholder engagement

A total of 17 van drivers and fleet operators were interviewed and surveyed, including large fleets, small and medium companies, and drivers of single van operations. The full list of fleets and drivers surveyed and interviewed are in Appendix 6.1. The complete list of survey questions is shown in Appendix 6.2.

The interviews and surveys were used to gain a more in-depth understanding of different van operations and needs. Operators of large fleets were asked about typical behaviour of vans in their fleets, and often provided information on archetypes within their fleet. For example, a large parcel delivery company provided typical mileages and operation of vans operating in towns and separate operational information for vans operating in cities.

Drivers and fleet operators were asked about their average daily mileages and their 'worst day' mileages. This analysis defined worst day mileages as mileages vans observed regularly (ca. 5 – 10 times per year), rather than extreme mileage events that occur very rarely and would therefore not have a major impact on overall charging needs. The distribution of average day and worst day mileages for the interviewed/surveyed vans are shown in Figure 9.

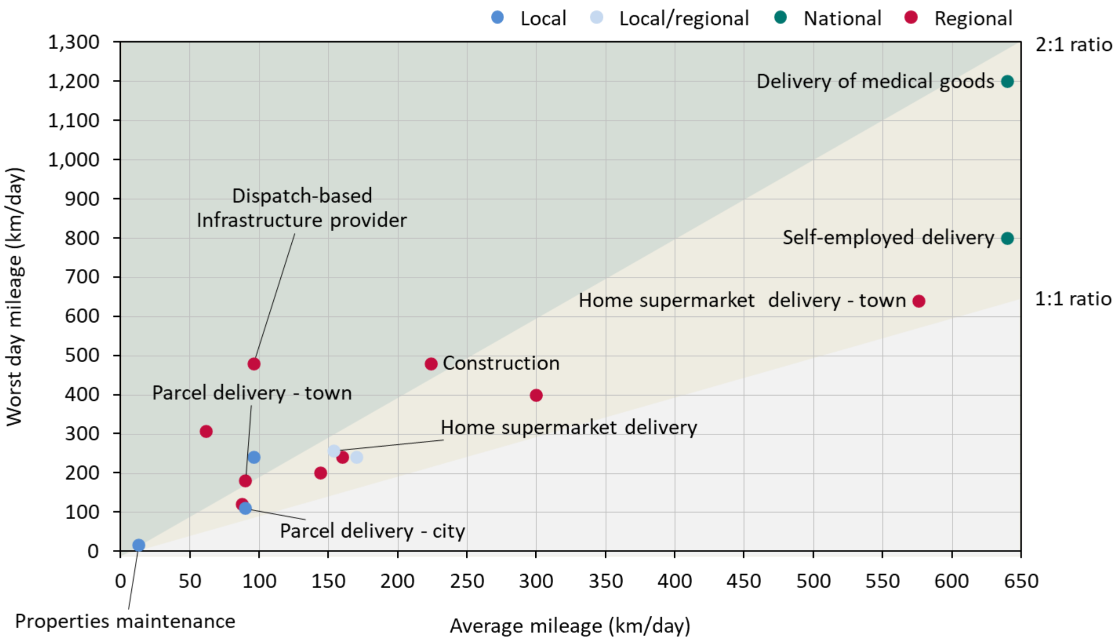

Figure 9: Distribution of average and worst day mileages reported by fleets across interviews and surveys

The majority of interviewed/surveyed vans' drive under 300 km on an average day, with most typically observing occasional high mileages under 500 km. The ratio of worst day to average day mileage for respondents is generally between 1 – 2. However, fleets with highly variable, dispatch-based services, such as infrastructure providers, have significantly higher ratios of worst day to average daily mileage, up to approximately 5.

Current or potential suitable charging locations based on operational profile were additionally discussed during interviews and surveys. Respondents typically distinguished between overnight charging, expected to be the bulk of charging, and top-up charging during the day. The following key overnight charging locations were identified:

1. **Depot:** Fleet-owned location, likely to house multiple vehicles when not operating and therefore may require significant charging infrastructure
    - Cost, operational, and spatial considerations would inform infrastructure decisions, but likely to be slow 3 – 7 kW chargers
2. **Residential:** Residential charging, both on and off-street
    - Off-street likely to be slow 3 – 7 kW chargers
    - Residential charging for drivers without off-street parking likely to take place at a number of locations, including on-street infrastructure near to homes or rapid hubs.

Identified key daytime charging locations are as follows:

1. **Fleet site:** Fleet-owned location, either depot where vehicle is based, or alternative site, e.g., railway station

- Likely to be slow 3 – 7 kW chargers or fast 11 – 22 kW

2. **Client site:** Customer or client location, may be residential charging (on or off-street) or at a workplace/destination
    - Likely to be slow 3 – 7 kW chargers or fast 11 – 22 kW
3. **Public rapid charging:** Rapid hubs at strategic locations on vehicles' routes
    - 50 kW+ chargers

The charging preferences of different van's operational profiles identified through the surveys and interviews will be used in the development of the archetypes to model the charging demand at each location, as set out in Section 2.2.1.

2.2 Method for modelling van charging mix

Summary of key findings:

- Twelve van charging archetypes were developed, categorised by their operating type (local, regional, or national) and their overnight and daytime charging preferences (Residential or Depot, and Public or Private respectively)
- Charging distribution model was developed to calculate the proportion of each archetype's charging demand at different charging locations, according to year, proportion of off-street parking and defined charging scenarios

2.2.1 Van charging archetypes

Archetypes were developed to encompass the varied operational behaviour of vans across the UK fleet. Archetypes split the van fleet according to their operating type (local, regional, or national – as defined in section 2.1.1), and then define their overnight and daytime charging preferences. The resulting 12 archetypes are summarised in Table 2 with example fleets for each. The full list of numbered archetypes is set out in Appendix 6.3.

The defined archetypes show subtle differences across preferred charging locations within their overnight and daytime charging categories. For example, vans that use private charging infrastructure for daytime charging may charge at commercial clients' sites, or alternatively could charge at the homes of their residential customers (private residential).

The DfT survey data[1] provides the weighted split of the national fleet by the three operating types. The findings of the DfT and the additional surveys and interviews, as set out in section 2.1.2, were used to determine the split within these categories of charging preferences.

Table 2: Examples of fleets that fit within each of the 12 defined archetypes

	Operating type		
Overnight / daytime charging category	**Local**	**Regional**	**National**
Residential / Public	**Archetype 1,** Example: Urban postal Outside Service Providers (OSPs) – high density stops in local area, relying on on/off street residential charging overnight and public charging during the day	**Archetype 5,** Example: Roadside assistance – regional operation, with majority of vehicles charged overnight drivers' homes, some use of public charging during day	**Archetype 9,** Example: Self-employed medical goods delivery – high daily mileages across country, will rely on on-street residential charging overnight and charging at public rapid hubs during day
Residential / Private	**Archetype 2,** Example: Properties maintenance provider – low mileage around local area, relies on on-street residential charging overnight and on/off street residential charging at client sites	**Archetype 6,** Example: Home infrastructure service provider – regional operations, relies on on-street residential charging overnight and on/off street residential charging at client or fleet sites	**Archetype 10,** Example: Specialist maintenance (e.g., maintain hospital equipment) – national coverage with opportunity to charge at clients' sites.
Depot / Public	**Archetype 3,** Example: Postal delivery in city centres – low mileage around local area, with high density short stops. Rely on public charging during the day.	**Archetype 7,** Example: Delivery service – operates around region, with van charging overnight at workplace, public charging used during the day	**Archetype 11,** Example: Furniture removals – high daily mileages across country, will rely on depot charging overnight and charging at public rapid hubs during day
Depot / Private	**Archetype 4,** Example: Supermarket home delivery in London – low mileages with high density stops in local area. Charge overnight and during day at depot between shifts	**Archetype 8,** Example: Major travel infrastructure provider – operations split across 5 operating regions, will rely mainly on depot charging with some use of daytime private charging (+ public where necessary)	**Archetype 12,** Example: Specialist maintenance (e.g., maintain hospital equipment) – national coverage with opportunity to charge at clients' site

2.2.2 Charging distribution model

The charging distribution model calculates the proportion of each archetype's charging demand at a number of different locations, defined as the archetype's charging mix in this study. The potential charging locations were identified through analysis of fleet surveys and interviews, and an overview is provided in Table 3.

Table 3: Potential charging locations for vans by time of day and preference category

	Category	Location	Definition
Overnight	**Depot**	**Depot**	Fleet-owned location, likely to house multiple vehicles and require significant charging infrastructure, likely to be slow 7 – 12 kW chargers
Overnight	**Residential**	**Private residential**	Privately-owned off-street, likely to be slow 3 – 7 kW, used overnight
Overnight	**Residential**	**On-street residential**	Public on-street, generally near to homes, either lamppost (ca. 3 – 5.5 kW) or fast charging on-street (7 – 22 kW), used overnight
Daytime	**Public**	**En-route rapid charging**	Public rapid chargers (50 kW+) on driving route, used during the day
Daytime	**Public**	**Forecourt rapid charging**	Public rapid chargers (50 kW+) in urban areas, used during the day
Daytime	**Public**	**On-street residential**	Daytime shared use of public chargers on-street close to customer home, where off-street not available (3 – 22 kW)
Daytime	**Private**	**Commercial zone**	Depots and warehouses in UK are clustered in commercial zones/ districts. This will contain many depots and client sites which could be opened up to third party charging – likely to be 'spare' high speed infrastructure (50 kW+)
Daytime	**Private**	**Client site**	Privately-owned off-street charging belonging to client, likely to be slow 7 – 12 kW chargers
Daytime	**Private**	**Private residential**	Daytime shared use of privately-owned off-street charging belonging to customer, likely to be slow 3 – 7 kW.

Figure 10 shows an overview of the charging distribution model, which results in a full charging profile for each of the 12 defined archetypes. The charging profile can be calculated across different charging preference scenarios (defined in section 2.3) and considering van specifications and BEV/PHEV projections over 2022 – 2035[5].

As shown in Figure 10, the charging distribution model has a number of inputs. These are summarised in Table 4, with more detail on key inputs provided in Appendix 6.4.

[5] Climate Change Committee's 6th Carbon Budget, Balanced Pathway scenario, set out in Appendix 6.4.3

Table 4: Summary of inputs to the charging distribution model

Input name	Description
Charging category preferences by archetype	For each archetype, sets out the proportion of charging demand met at each overnight category (residential or depot) and daytime category (public or private).
Charging location preferences by category	Charging location preferences within each overnight/daytime categories. Dependent on the chosen scenarios for public residential charging and private daytime charging. Different input values for BEVs and PHEVs, as assumed that PHEVs do not use rapid chargers[6].
Van range by operating type	Vehicle range based on year selected, and calculated for local, regional, and national operating types, based on EE's cost and performance model. Van range differs across local, regional, and national archetypes as a result of choice of battery size and typical driving behaviour. This is explored in more detail in Appendix 6.4.2.
Mileage distribution by operating type	Distribution of average daily mileages for local, regional and national operating types based on DfT van survey 2020 data.
High vs. average mileage distribution	Distribution of daily mileages on high mileage days, calculated by applying triangular distribution to average mileage distribution defined above.
Average no. potential PHEV charging stops	Average number of daily stops where PHEV likely to be able to charge, depends on archetype behaviour. Assumed to be 4 per day on average days, 3 on worst days.
Proportion days with high mileage	Proportion total days that are worst day mileage rather than average mileage, to calculate overall charging demand mix. Assumed ca. once per month or 10-12 times per year, equating to 4% of days
BEV/PHEV ratio	Proportion total EV fleet that are BEVs vs PHEVs, to calculate charging demand mix. Based on CCC's 6th Carbon Budget, Balanced Pathway[5].

The model additionally includes several control variables, to allow selection of various scenarios. These are as follows:

1. **Year**: year to calculate charging mix for, 2022 – 35. Determines van specification and ratio of BEV/PHEV powertrains.
2. **Off-street parking proportion:** determines residential charging mix at private residential, rather than on-street residential. Assumed that 85.6%[7] of van drivers have access to off-street parking.
3. **Public Residential Charging Scenario:** different scenarios to meet overnight charging demand with public infrastructure.
4. **Private Daytime Charging Scenario:** different scenarios to meet daytime charging demand with private infrastructure.

[6] PHEVs assumed not to make use of rapid charging due to small battery size and very limited PHEV models on the market able to take rapid charging speeds

[7] Average proportion of cars and vans in England with off-street parking, based on Element Energy's Off-street parking model

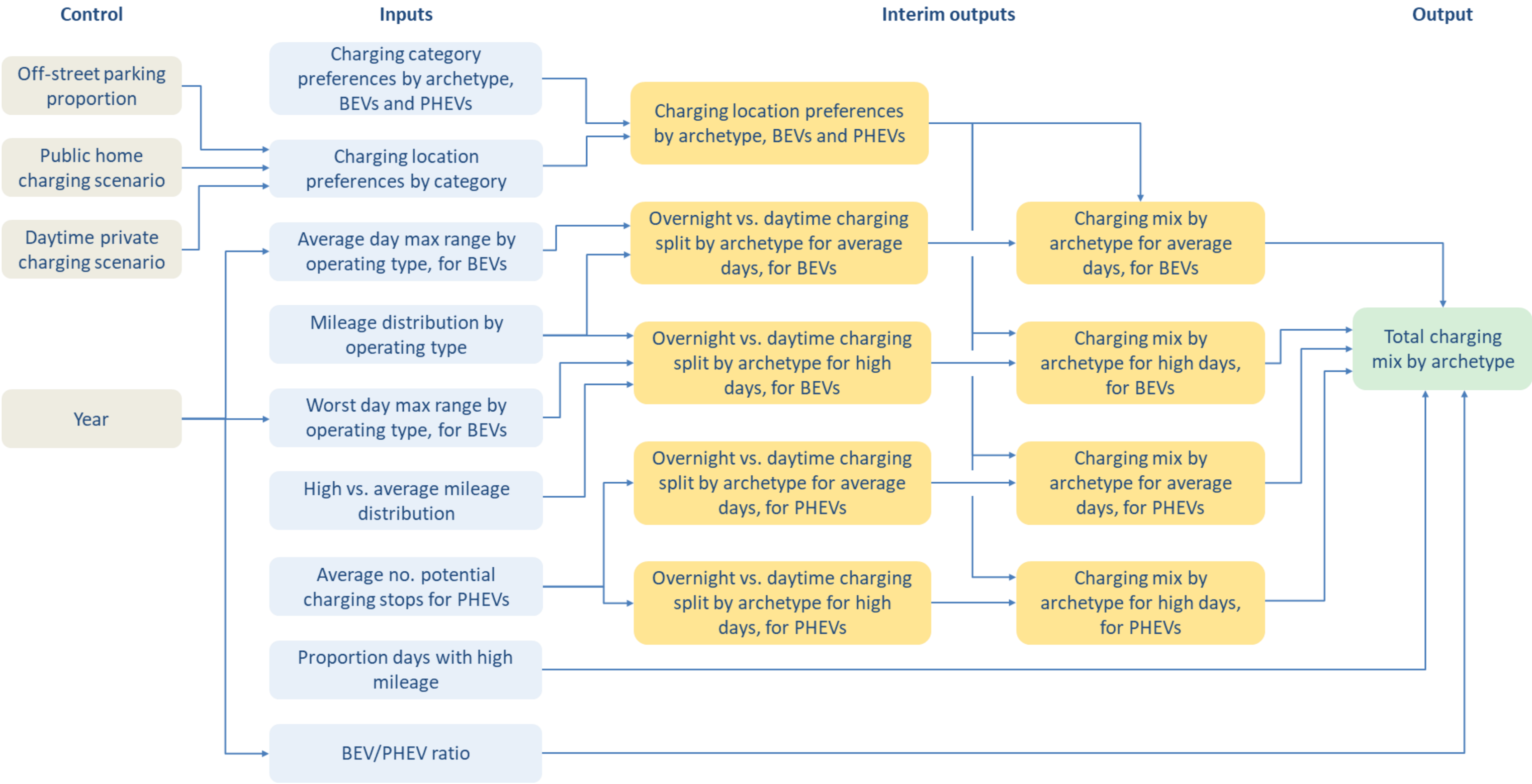

Figure 10: Diagram of the charging distribution model

2.3 Development of scenarios for van charging mix

Two sets of charging preference scenarios were developed, to indicate archetypes' preferences for public residential charging locations, and for private daytime charging locations. The developed scenarios indicate the range of preferences for charging across different locations, which is not expected to vary over time as EV uptake increases. The sensitivities are used to represent the uncertainty in future charging preference and how these could change as a result of different technology and business model developments.

Summary of key findings:

- Van drivers without access to private residential charging from off-street parking are likely to make use of a mixture of charging locations, including overnight charging at on-street charging and other daytime charging locations particularly rapid hubs.
- Vans typically visit a wide range of sites as part of their daily operating profiles, which are likely in the future to have private charging infrastructure installed. Vans could make shared use of this infrastructure to top-up charge during the day, however, business models and platforms for sharing of private infrastructure are still emerging.

2.3.1 Public Residential Charging Scenarios

Scenarios were defined to indicate the charging location preferences of public residential charging carried out overnight, relevant for archetypes that charge residentially overnight (1, 2, 5, 6, 9 and 10). A proportion of vehicles within each of these archetypes do not park off-street overnight and therefore will not be able to make use of private residential charging infrastructure. The charging distribution model assumes that 85.6% of vans can park and charge off-street[7], which assumes that if a van driver has access to off-street charging they will choose to do so. However, during stakeholder engagement (see section 2.1.2), some fleet operators reported that drivers may be unable to fit large vans in their private driveways or garages, or may choose to prioritise privately owned cars in off-street parking, which may reduce the number of vans able to access off-street charging. However, if private residential charging is an option, van drivers may be more motivated to choose to park their van off-street to charge when required. This study therefore assumes that if off-street, private residential charging is available to vans that charge residentially overnight, they will make use of this option.

The On-street Charging Study carried out by Ricardo for the CCC[8] has identified a number of potential charging locations for drivers without off-street residential charging:

1. **On-street residential:** lamppost chargers or fast charging on-street, close to drivers' homes.
2. **Destination:** E.g., shopping centre, or car park.
3. **En-route rapid charging:** Use of rapid chargers during the day, at strategic locations on driving route.
4. **Forecourt rapid charging:** as above, but in urban settings.

The On-street charging study found that it is unlikely that a single uniform solution will emerge for drivers without off-street parking. Instead, drivers are expected to make use of a mixture of locations, with speed, reliability, and ease of use important factors when choosing a charging location. However, investment by local authorities and charge point operators (CPOs) may over

[8] Final Report: Understanding the costs and impacts of potential approaches to providing electric vehicle charging for households without private off-street parking, Ricardo Energy and Environment for the Climate Change Committee, 2022

time be focused on a particular technology, such as on-street infrastructure or rapid hubs, increasing availability of that infrastructure and driving down costs.

Analysis of the car charging scenarios developed by the ICCT[2] (Figure 11) suggests that 50% of overnight residential charging demand for drivers without off-street parking is met by on-street residential charging infrastructure overnight. The remaining demand is distributed across different charging locations over the drivers' daytime operation. For the cars considered by the ICCT, this is a mixture of destination and rapid charging. This charging mix is based on current charging preferences of different types of car drivers, which is not expected to change significantly over time.

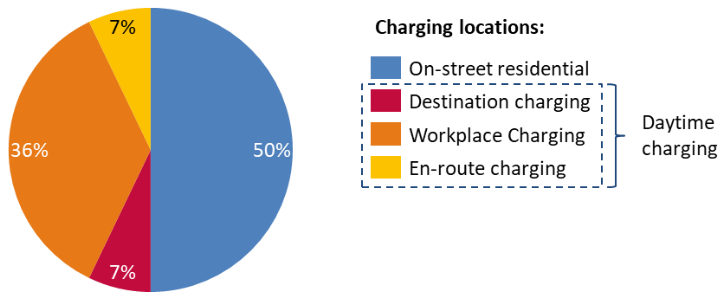

Figure 11: Split of public residential charging demand for cars across locations as defined by the ICCT.

However, van drivers' behaviour differs from that of car drivers. Therefore, the modelling of vans' public residential charging demand brings together the findings of the Ricardo On-street Charging Study and the ICCT car charging mix. The Public Residential Charging Scenarios assume that a proportion of public residential charging demand will be met by on-street residential chargers, with the rest of the demand met by various locations during the day. The demand met during the day will be distributed across charging locations according to each archetype's daytime preferences and the selected Private Daytime Charging Scenario.

To account for the potential of a dominant technology emerging as a result of investment, 3 Public Residential Charging Scenarios have been defined, as shown in Figure 12 and defined below:

1. **Baseline:** 50% public residential charging demand met by on-street charging, rest distributed across daytime charging scenarios – based on ICCT.
2. **High on-street:** Investment leads to widespread availability of on-street charge points at competitive pricing. As a result, high proportion of public residential charging demand met by on-street infrastructure.
3. **Low on-street:** Low investment in on-street charge points, focused on other technology such as development of rapid hubs, leading to low availability of on-street charge points. As a result, a low proportion of public residential charging demand met on-street, and most is spread over daytime charging events.

Note that in distributing the additional daytime charging demand for PHEVs, the modelling assumes that no charging is met at public en-route or forecourt rapid charging hubs as these powertrains are unlikely to be capable of charging at rapid rates.

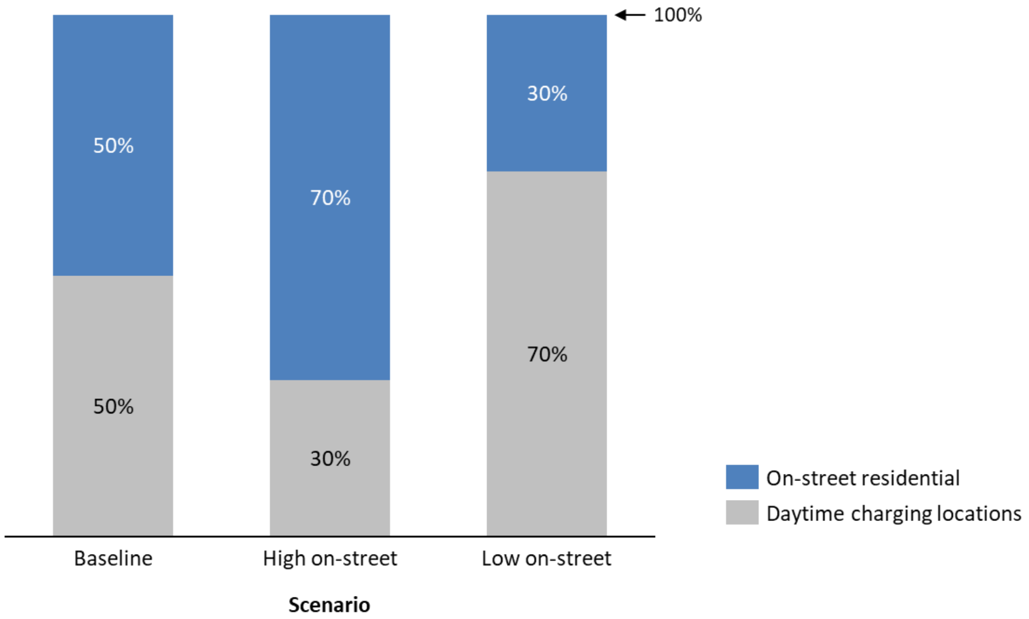

Figure 12: Split of public residential charging demand by location across 3 defined Public Residential Charging Scenarios

2.3.2 Private Daytime Charging Scenarios

Scenarios were defined to indicate the preferred locations of daytime charging for archetypes that prefer to charge at private locations during the day (archetypes 2, 4, 6, 8, 10, 12).

Private daytime charging is expected to be carried out at client infrastructure. These clients may be residential customers, and therefore the charging will be carried out at private residential or on-street charging. Alternatively, the clients may be larger commercial customers, such as warehouses, manufacturing sites, or large commercial zones. Based on analysis of DfT van survey data, the modelling assumes that 75% of van drivers' clients are classified as residential (homes, small shops, or restaurants).

For all archetypes that prefer private daytime charging, some daytime charging is distributed in modelling to public charge points. This is because not all clients will have charging infrastructure and therefore van drivers cannot make use of this.

Furthermore, the potential for vehicles to make use of private daytime charging is uncertain as many of the necessary business models do not yet exist, such as payment for charging at a client's house or depot, or charging at an open depot of an unrelated company. It is uncertain if these business models will be developed at all and, if they are developed, the extent to which the models will be adopted. A review of existing private infrastructure sharing platforms is set out in Appendix 6.7.3, and a discussion of emerging business models is set out in Section 4.2.4.

As a result, two scenarios have been defined for modelling of the charging mix:

1. **High** adoption of infrastructure sharing business models (considered baseline)
2. **Low** adoption of infrastructure sharing business models

The two scenarios are shown in Figure 13. Note – the model assumes that PHEVs are unable to charge at either rapid charging categories (en-route or forecourt).

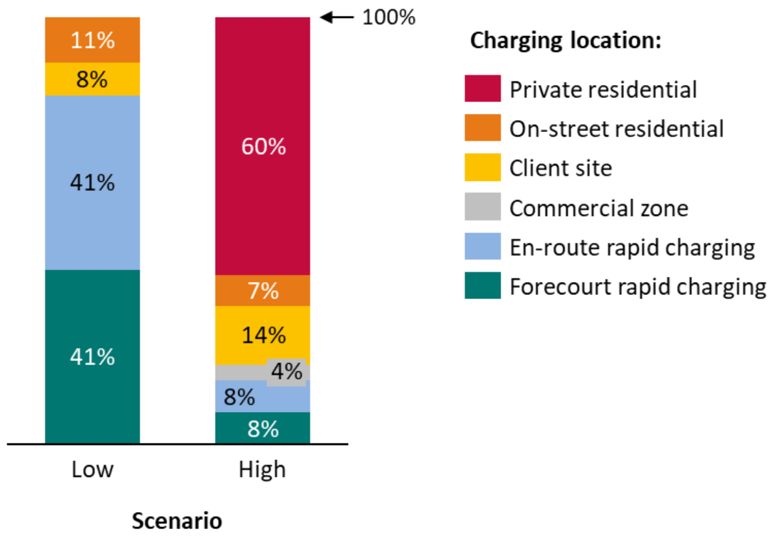

Figure 13: Split of private daytime charging demand by location across 2 defined scenarios

2.4 Results of modelling van charging mix

Summary of key findings:

- Across all archetypes, the majority of charging demand (54 – 84% in 2025) can be met by overnight charging. Over 2025 – 2035, the projected improvement in van range reduces the need for daytime top-up charging.
- Public Residential Charging Scenario (low, baseline, or high availability of on-street charging infrastructure) has limited impact on the overall charging mix of archetypes that charge residentially overnight, due to the prevalence of off-street parking and the spread of demand over daytime charging locations.
- The Private Daytime Charging Scenarios (low or high adoption of business models for sharing private infrastructure) impacts the use of public infrastructure, with high adoption leading to lower use of rapid hubs as a result of the lower cost and high convenience
- Comparison of resulting charging mix with car charging mix indicates that cars typically charge in different locations from vans and have a higher share of time not in use, with more opportunity for slow, long duration charging than vans. The increased operational periods for vans, relative to cars, means they are likely to struggle to use on-street overnight charging, especially when supply is limited, as they need the infrastructure more frequently and have less flexibility to choose when to charge. Sharing models which unlock daytime charging and reduce reliance on night time on-street charging is therefore important to allow all users to transition.

Figure 14, Figure 15, and Figure 16 show the baseline output charging mix for each of the archetypes operating locally (54.6% of fleet), regionally (32.8% of fleet) and nationally (12.5% of fleet), in 2025, 2030 and 2035. The figures show the overall charging mix across BEV and PHEV powertrains, considering both average and worst days. The baseline Public Residential Charging Scenario is used with the high Private Daytime Charging Scenario.

The overall baseline charging mix shows that across all archetypes, the majority of charging demand (54 – 84% in 2025) can be met by overnight charging, and in particular using depot or private residential charging infrastructure. Moving from archetypes operating locally to nationally the ability to rely on overnight charging reduces, as average and worst day mileages increase (average daily mileages for local, regional, and national drivers are 63, 128, and 240 km respectively). The demand met at public rapid infrastructure is significant across all archetypes (ca. 4% - 39% in 2025).

Across archetypes that charge residentially overnight, the proportion of on-street charging is low, as some residential charging demand is shifted to daytime charging locations instead when drivers do not have off-street parking.

Over time, van range is expected to improve across all operating types, from ca. 300 – 330km in 2025 to ca. 420 – 435 km in 2035 as a result of increased battery size and improved fuel efficiency (as set out in Appendix 6.4.2). The projected improvement in van range increases the proportion of charging that can be met overnight, reducing the need for daytime top up charging across all archetypes.

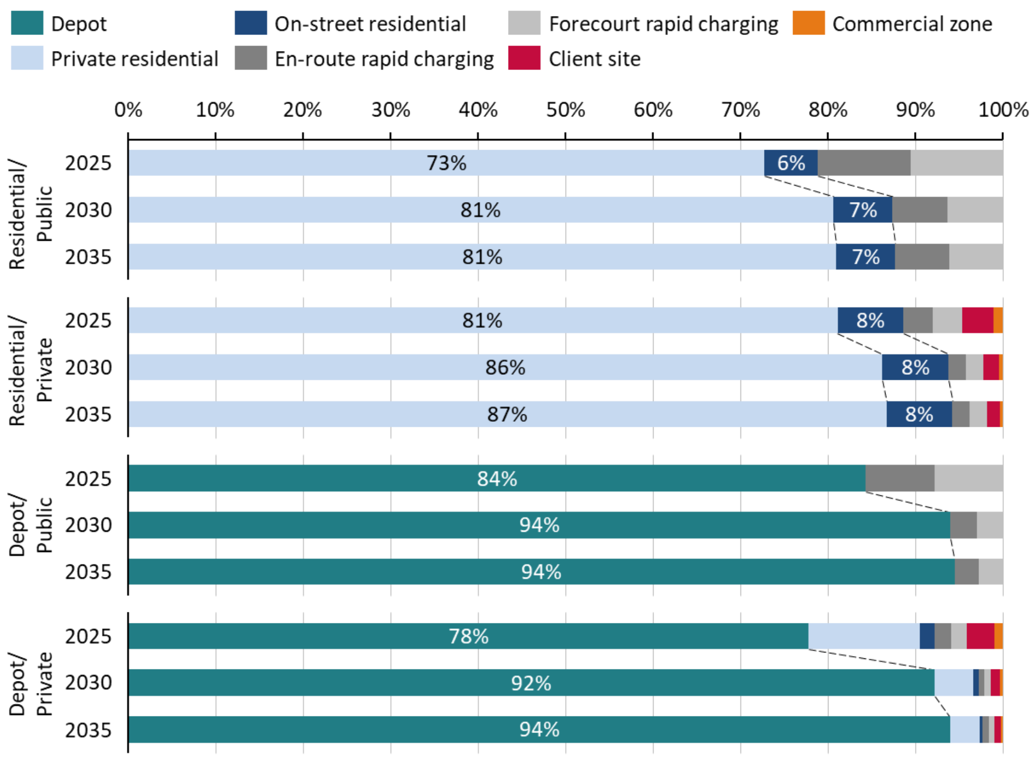

Figure 14: Baseline charging mix distribution for archetypes operating locally over 2025 – 2035

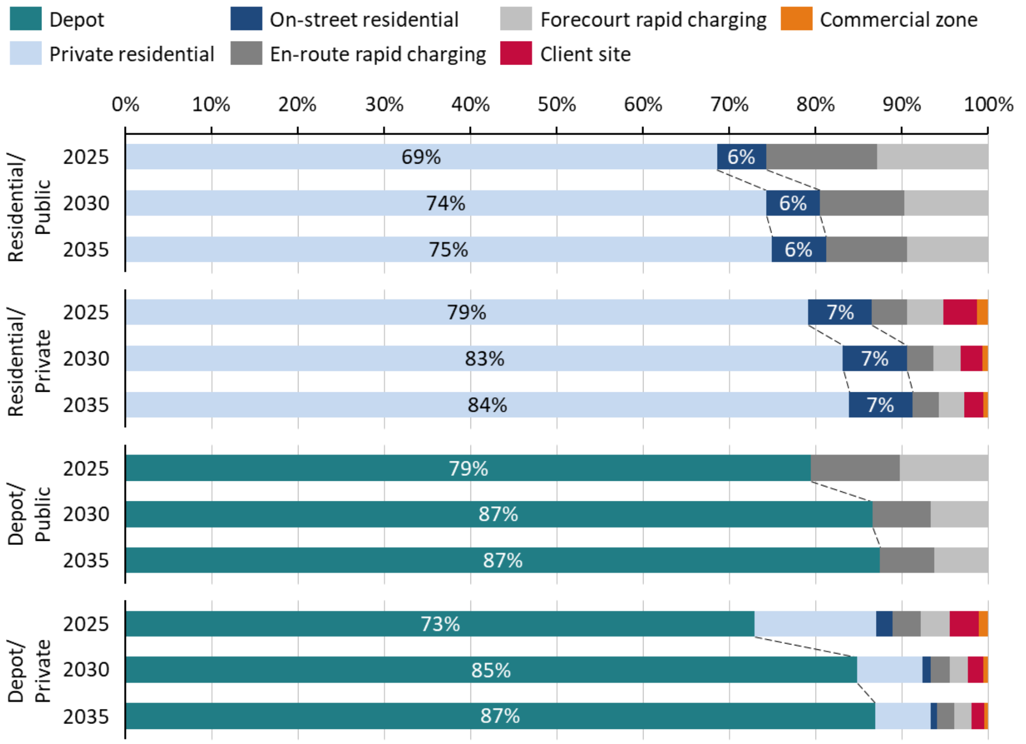

Figure 15: Baseline charging mix distribution for archetypes operating regionally over 2025 – 2035

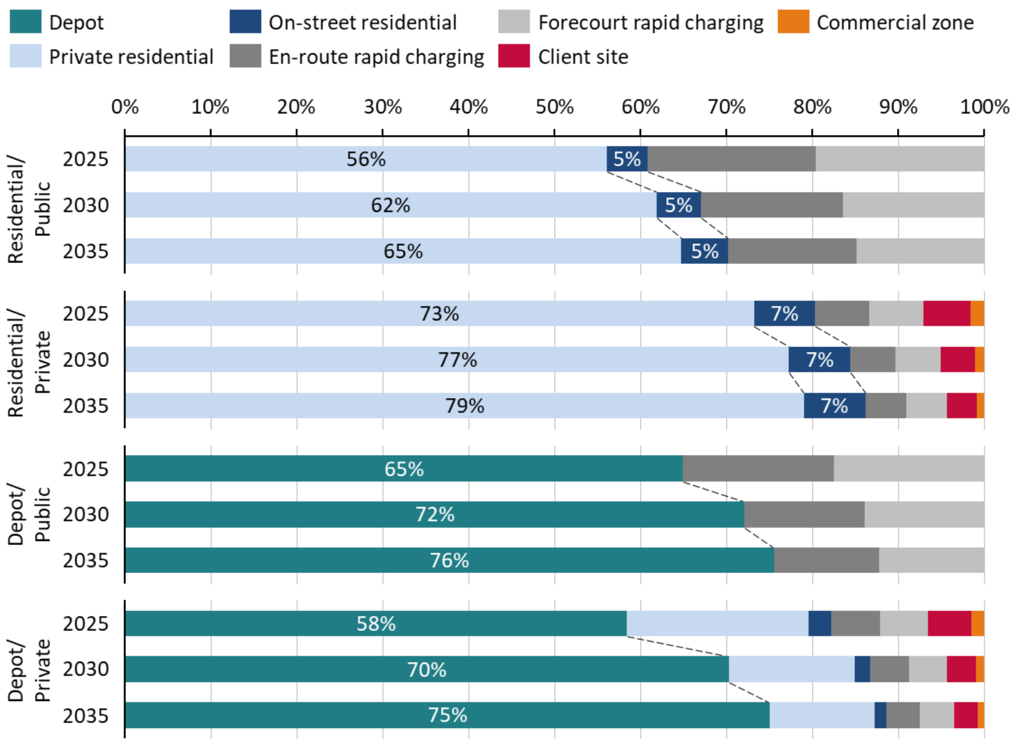

Figure 16: Baseline charging mix distribution for archetypes operating nationally over 2025 – 2035

2.4.1 Impact of charging preference sensitivities on charging mix

Sensitivities were carried out to understand the impact of the charging preference scenarios on the overall charging mix for each archetype.

Figure 17 shows the impact of the selected Public Residential Charging Scenario (low, baseline, or high, as defined in Section 2.3.1) on the overall charging mix. The overall charging mix includes the needs of both BEVs and PHEVs across both average and worst days. The two extreme cases are shown – high availability of on-street charging infrastructure (leading to 70% public residential charging demand being met on-street) and low availability (only 30% met on-street).

The ability to charge at on-street residential infrastructure impacts all archetypes that carry out residential overnight charging, or private daytime charging. The selected Public Residential Charging Scenario impacts the proportion demand met at on-street infrastructure rather than other public or private locations – either residential overnight charging or daytime charging when visiting clients. As a result, the selected Public Residential Charging Scenario only impacts archetypes that charge residentially overnight or privately during the daytime (not those with Depot/Public charging preferences – 4, 8, and 12). As the vast majority of charging demand is met overnight, the scenarios' most significant impact is the proportion of overnight demand that can be met by on-street residential infrastructure, rather than spread over daytime charging locations and rapid charging hubs. However, the Public Residential Charging Scenarios do not lead to significant variation in overall charging mix, which is still dominated by either depot or private residential charging across all archetypes. The charging distribution model assumes that 85.6% of van drivers have access to off-street parking[7], and if drivers that charge residentially overnight have access to off-street, private residential charging they will choose to do so.

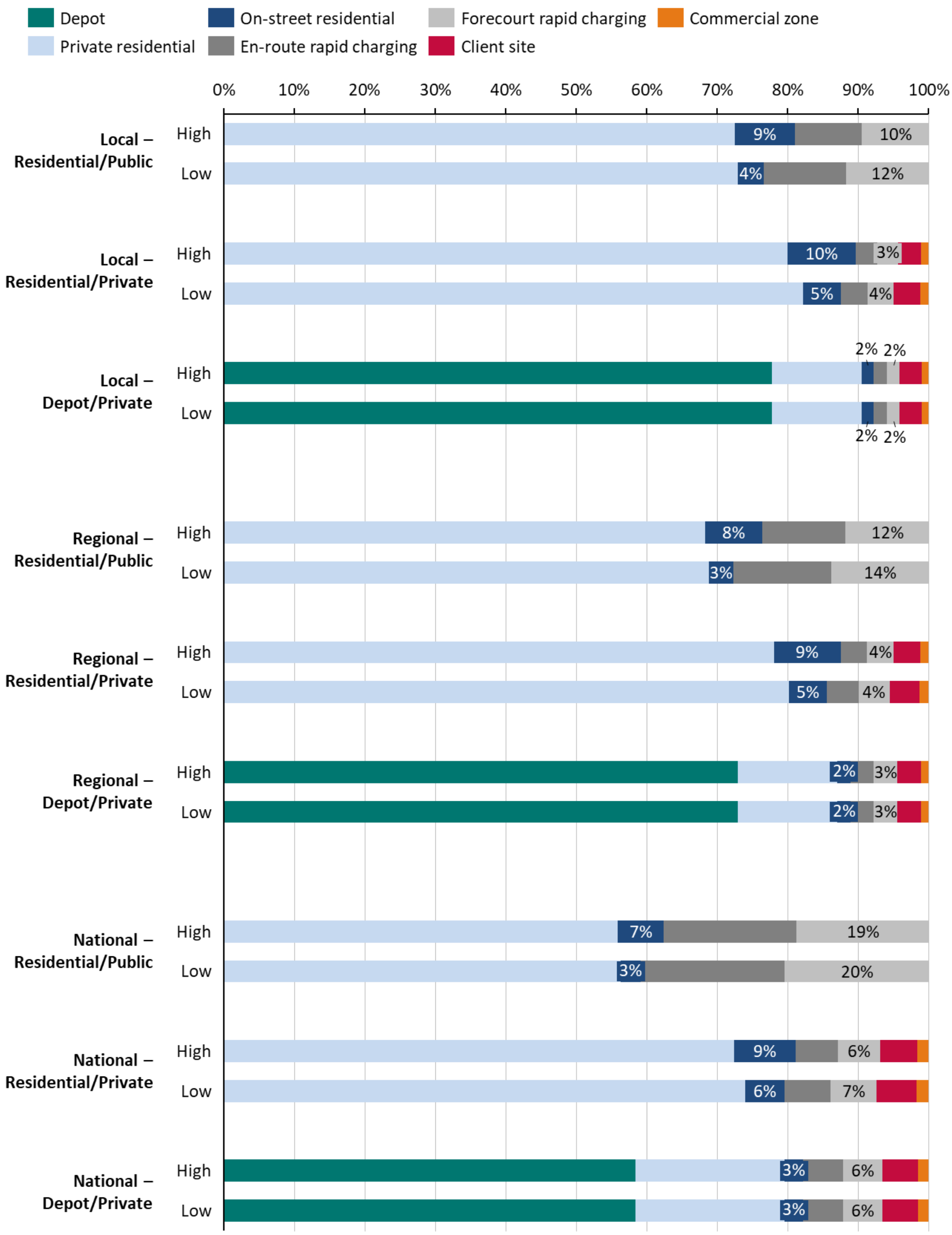

Figure 17: Charging demand met at different locations across 9 impacted archetypes over high on-street and low on-street Public Residential Charging Scenarios in 2025

An additional sensitivity was carried out looking at the impact of the two Private Daytime Charging Scenarios (low and high, as defined in section 2.3.2). Figure 18 shows the overall charging mix across both low and high adoption of business models for sharing private infrastructure. The overall mix includes consideration of the charging needs of both BEVs and PHEVs and across average and worst days. As expected, the low adoption of business models for sharing private infrastructure leads to more public infrastructure use, in particular rapid charging hubs.

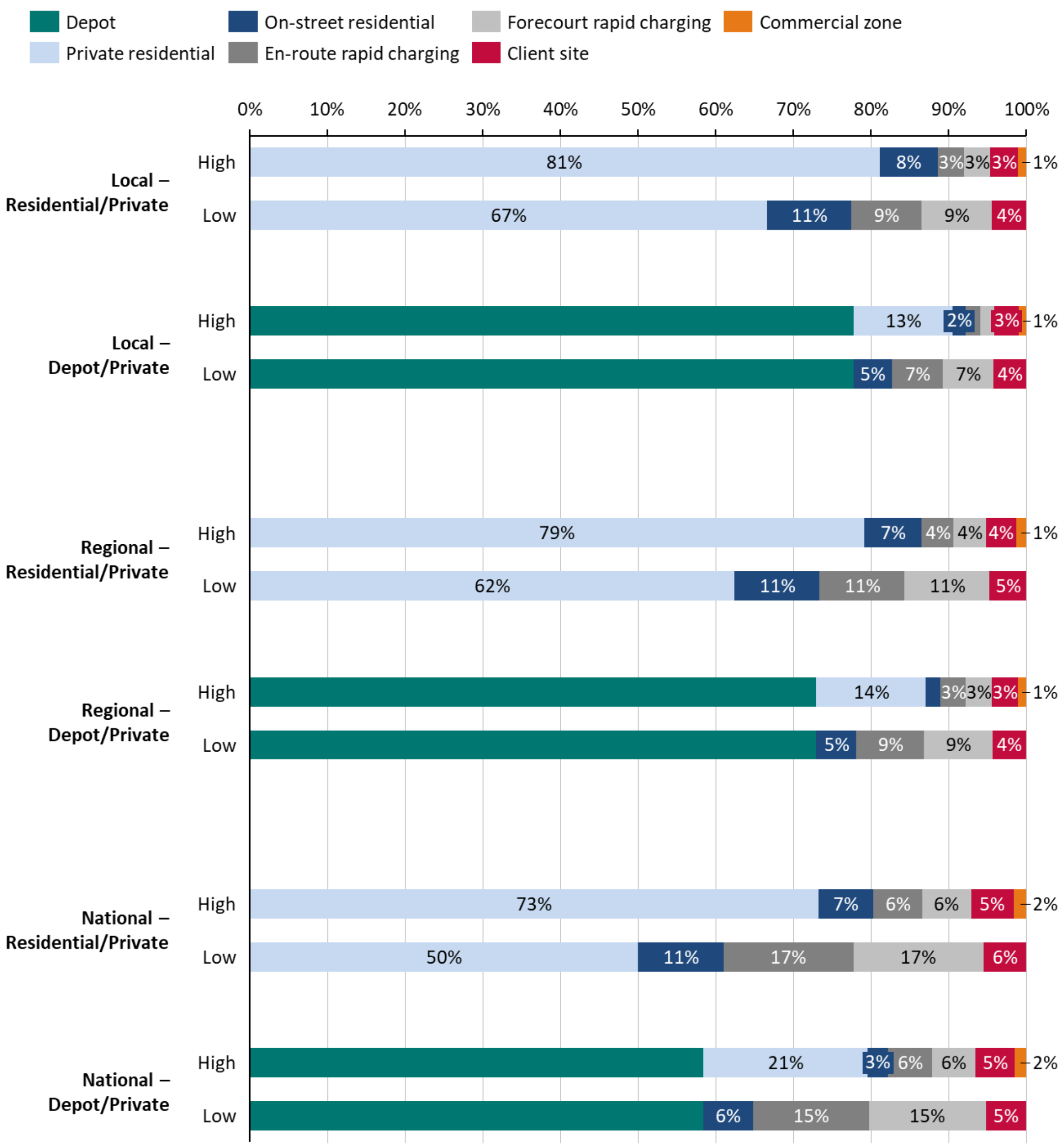

Figure 18: Charging demand met at different locations across 6 private daytime archetypes across 2 Private Daytime Charging Scenarios in 2025 – high adoption of sharing business models and low adoption of sharing business models

2.4.2 Comparison with car charging mix

The ICCT sets out the charging behaviour assumptions for privately owned commuting and non-commuting car drivers, both with and without off-street parking[2], as set out in Figure 19 and in Appendix 6.5. Passenger cars' charging locations are different from those of van drivers, as a result of their differing operational profiles which are not expected to share client infrastructure during the daytime or be based at depots overnight. Private cars are additionally expected to charge at a number of different locations, including at their workplace, or at destination chargers, such as supermarkets or shopping centres, and are expected to have a higher share of time not in use, so more opportunity for slow, long duration charging.

Comparison of cost of charging to car drivers as a result of the car charging mix, compared to cost of charging to van drivers is explored in Section 4.3.

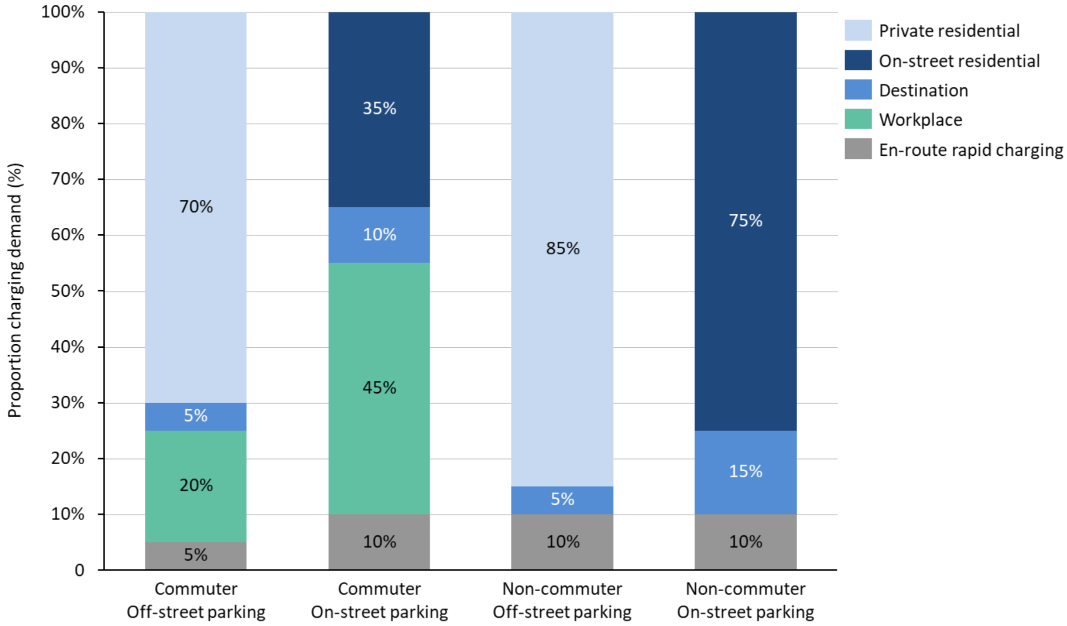

Figure 19: Charging mix distribution for battery electric cars across a number of archetypes

3 Additional charging infrastructure needs for vans

This section of the report looks at the modelling of the additional charging infrastructure needs for vans over and above the charging infrastructure requirements for cars, based on the calculated charging mix for each archetype, including roll-out cost and grid impact.

3.1 Method for modelling of additional charging infrastructure needs for vans

The total charging demand at each charging location in 2025, 2030 and 2035 was used to determine total infrastructure needs for charging of vans. The total charging demand across each charging location in 2025, 2030 and 2035 is shown in Figure 20.

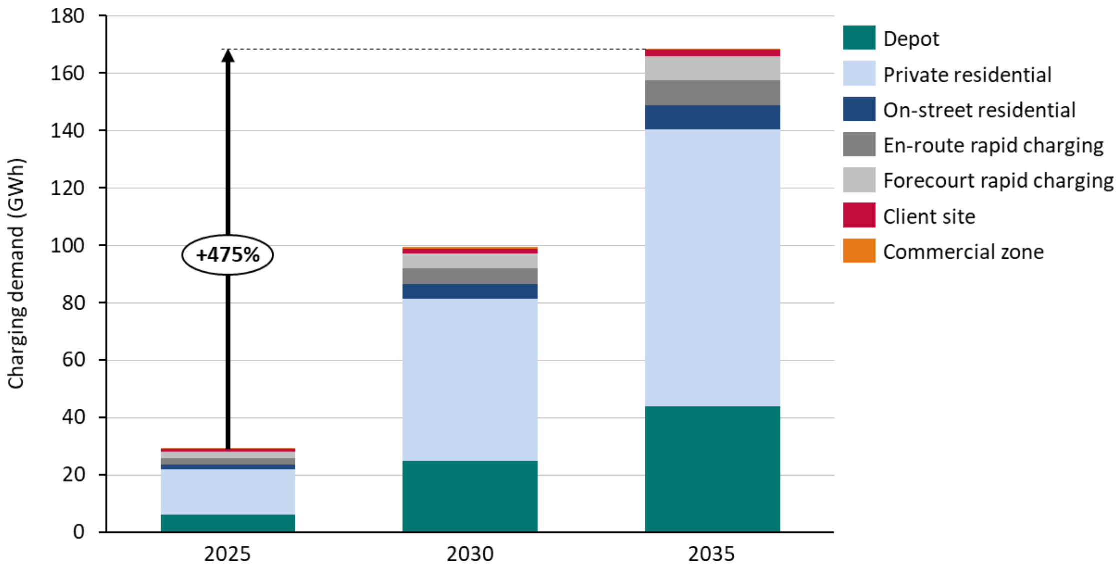

Figure 20: Van fleet charging demand by location in the UK, with baseline charging mix

To calculate the required number of charge points of each charging location and power, daily utilisation assumptions were defined for each charging location category in 2025, 2030 and 2035. Power and daily utilisation assumptions were based on the findings of the On-street Charging Study[8] or Element Energy's database of charging infrastructure specifications. Full charge point power and utilisation assumptions are summarised in Appendix 6.6.1.

The average charge point power[9] and daily utilisation assumptions were used to calculate the total daily energy delivered by each charge point. This can be used alongside total daily demand for each charge point category to calculate the total number of each charge point category required. Charge point reliability was assumed to be sufficiently high[10] that extra charge points for redundancy were not required.

$$Energy\ delivered\ per\ charge\ point\ (kWh/day) = Average\ charge\ point\ power\ (kW) \times Charge\ point\ utilisation\ (hours/day)$$

[9] Note that energy delivered is calculated considering the average power the charge point provides during charging session, rather than its peak rated power. Average charge point power is assumed to be 80% of the peak rated power, based on EE analysis of charging curves.
[10] UK government plan to mandate 99% reliability for rapid (over 50 kW) charge point network: https://www.gov.uk/government/consultations/the-consumer-experience-at-public-electric-vehicle-chargepoints

$$Required\ number\ charge\ points = Fleet\ charging\ demand\ (kWh/day) \div Energy\ delivered\ per\ charge\ point\ (kWh/day)$$

This charger utilisation method is not used to calculate the required number of chargers used privately overnight residentially. These are instead calculated based on the number of vans that make use of these locations. It is assumed that for each van that expects to use an overnight private residential charger, one is installed.

3.2 Results of modelling additional charging infrastructure needs of vans

Summary of key findings:

- Total number of charge points needed by the electric van fleet is expected to grow by 309% from 0.95 to 3.89 million over 2025 – 2035.
- Total charge point requirement is not representative of the additional infrastructure that will need to be installed on top of infrastructure installed for cars or other purposes, with only infrastructure in depots, on-street charge points used overnight, and rapid infrastructure (en-route and forecourt) classified as additional in the analysis. Additional infrastructure required for vans is expected to grow from 241k charge points in 2025 to 962k in 2035.
- High Public Residential Charging Scenario requires installation of a higher number of additional charge points, due to the lower daily energy delivery capabilities of on-street infrastructure.
- High adoption of business models for sharing private infrastructure (Private Daytime Charging Scenarios) reduces the additional infrastructure requirements, as it increases the utilisation of existing infrastructure.

The total charging infrastructure needs (with baseline charging mix) over 2025 – 2035 is shown in Figure 21. The total number of charge points required grows over 2025 – 2035 by 309% from 0.95 to 3.89 million, while the projected electric van stock grows by 482%[5]. The required number of charge points per electric vans decreases from 1.62 in 2025 to 1.14 in 2035, as a result of expected improvements in charge point utilisation and power.

DfT's EV infrastructure strategy[11] projected that between 280,000 and 720,000 public charge points (residential on-street, destination, and en-route) will be required by 2030 for electric cars and vans. The modelling suggests that vans will need ca. 160,000 public charge points (on-street residential, en-route and forecourt rapid charging) by 2030, with baseline charging mix. It is difficult to compare these values, as the EV infrastructure strategy considers car and van charging demand together and assumes that 14% of van stock by 2030 is battery electric[12]. In contrast, this analysis uses the CCC's 6th Carbon Budget Balanced Pathway projections, which predicts 39% of the van stock will be battery electric by 2030[5]. The DfT projections are significantly lower than the CCC's projections, and therefore the total charge point need is likely to be lower than modelled in this analysis.

[11] Taking charge: the electric vehicle infrastructure strategy, DfT, March 2022
[12] DfT's EV infrastructure stock projections based on the sales scenarios set out in Transitioning to zero emission cars and vans: 2035 delivery plan, OZEV, 2021, and Net Zero Strategy: Build Back Greener, BEIS (2021), Technical Annex, Table 10

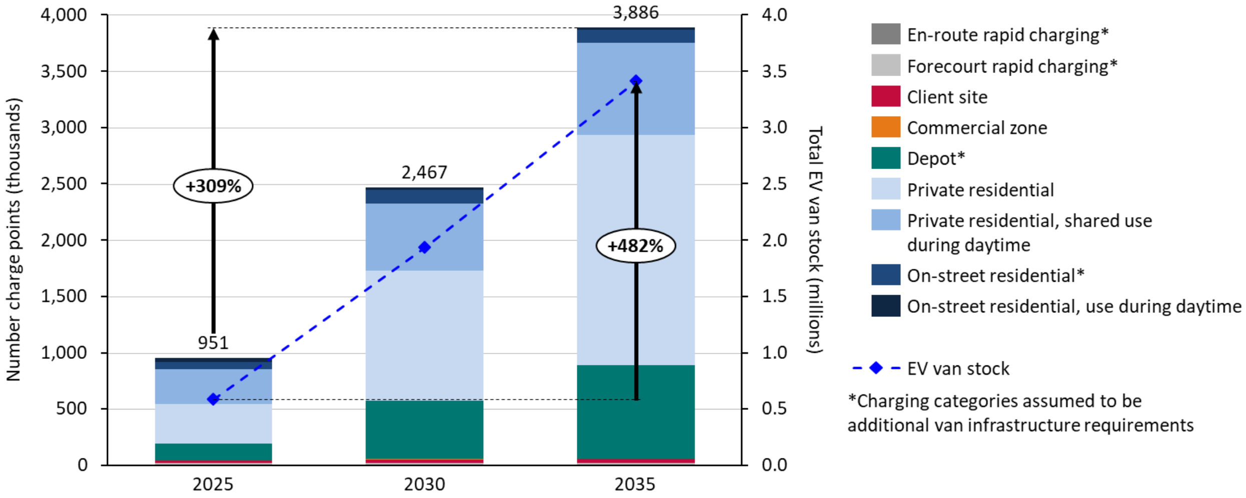

Figure 21: Charging infrastructure needs by charging location in the UK, with baseline charging mix, over 2025 – 2035

Charge points needs shown in Figure 21 have been calculated assuming high reliability of charge point networks, so that further installation of infrastructure is not required to compensate for charge points not working. The UK government is currently planning to mandate minimum 99% reliability across rapid charging networks (50 kW and over)[10] in the UK. However, this mandate is expected to apply as an average across a charge point operator's entire fleet of charge points rather than at each individual charge point. As a result, there could be charge points in areas of the UK that are not maintained, particularly in rural or hard to reach areas. This could lead to a requirement for further installed infrastructure to ensure EV drivers in these areas are not left behind.

Figure 21 shows total number of charge points in each category that is required to charge van fleet over 2025 – 2035, however, this is not representative of the additional infrastructure that will need to be installed to meet van demand. The infrastructure shared at commercial zones and client sites is likely to be depot charging infrastructure of other fleets. Therefore, the charge point needs within these categories overlap. This category makes up 1 – 2% of the total need and therefore this overlap is unlikely to be significant.

Additionally, private and on-street residential infrastructure used during the day by vans visiting customers are likely to either belong to or have been installed for car drivers. The infrastructure needs in these categories are therefore not assumed to be additional, as van use assumed to be simply increasing the utilisation of the charge points. Currently, typical utilisation of residential on-street charge points is observed to be between 2 – 4 hours charging per day and private residential ca. 2.5 hours charging per day[8], mostly concentrated overnight. Given the current low utilisation, the infrequent nature of maintenance service visits to homes, and the fact that these visits fit within the normal working day, this additional charging demand could easily be accommodated by this existing infrastructure installed for cars.

Furthermore, many van drivers are likely to also own/someone in their household will own a private car for personal use in addition to the van. As ownership of private battery electric cars becomes more common, drivers with vans based at home overnight will share their private residential infrastructure between their car and their van. The private residential infrastructure need shown in Figure 21 may therefore be accounted for in other studies' modelling of charging infrastructure needs for cars. Therefore, private residential charge point needs will not be considered as additional in this study, to prevent double counting.

The required infrastructure for depots, on-street used overnight, and rapid infrastructure (en-route and forecourt) can be considered as additional van charging infrastructure to meet the additional charging demand of vans on top of that of cars, as shown in Figure 22. This infrastructure is assumed to be additional as either vans cannot access these sites (depot) or van and car charging demand is expected to overlap in terms of the time of the day that the charging occurs (on-street residential used overnight, en-route rapid and forecourt rapid). In all the other cases it is assumed van charging can occur at a different time to the charging of other vehicles and the infrastructure can be shared, increasing the utilisation but not increasing the number of charge points.

Table 5 summarises the classification of each charging infrastructure category, as either additional or shared.

Table 5: Split of charging categories, considered as additional infrastructure installed for van charging, or shared with car charging

Additional	Shared
Depot	Private residential, used overnight
On-street residential, used overnight	Private residential, used during daytime
En-route rapid charging	On-street residential, used during daytime
Forecourt rapid charging	Client site
	Commercial zone

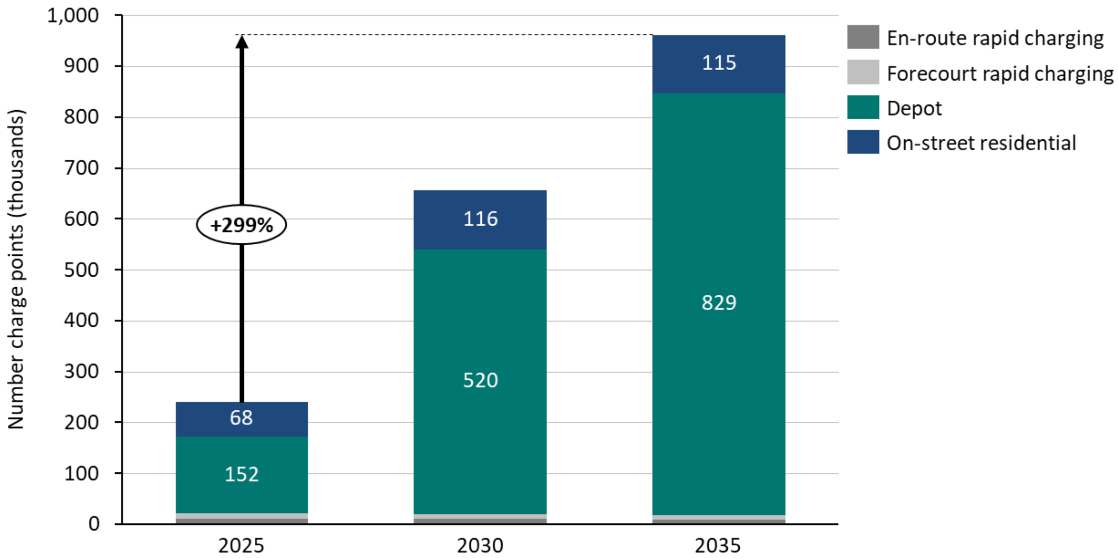

Figure 22: Additional charging infrastructure required to meet van charging demand in the UK, with baseline charging mix over 2025 – 2035

Depot chargers are the most significant category of additional van charging infrastructure, making up 63% of total needs in 2025, and over 86% in 2035. This is a result of the high and increasing proportion of van charging demand that can be met overnight due to improvements in vehicle range (27 – 40% improvement from 2025 – 2035 across all operating types, from improvements in fuel efficiency and increase in battery size as set out in Appendix 6.4.2).

3.2.1 Charging preference sensitivities

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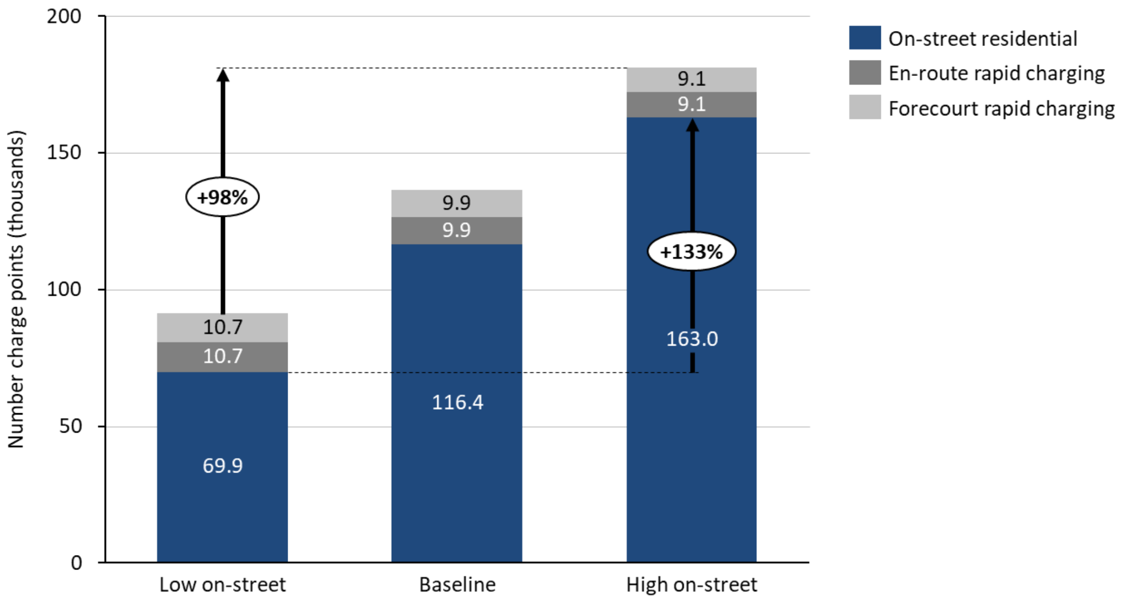

Figure 23: Additional van charging infrastructure needs in the UK across the three Public Residential Charging Scenarios in 2030

A sensitivity was carried out to understand the impact of the selected Public Residential Charging Scenario (low, baseline, or high, as defined in Section 2.3.1). The additional van charging infrastructure needs in 2030 across baseline, low on-street and high on-street scenarios is shown in Figure 23.

The sensitivity indicates that as the preference for on-street residential charging increases, a higher number of on-street residential chargers is required, increasing 98% across the low to high Public Residential Charging Scenarios. Across all charging preference scenarios, the remaining demand is split out across daytime charging locations, including rapid and shared infrastructure. There is not a one-to-one substitution of charge points due to the differing power and utilisation assumptions. As a result, the total number of required additional charge points in the high on-street public residential charging preference scenario is ca. 133% higher than in the low on-street scenario.

A sensitivity was additionally carried out on the impact of the adoption of business models for sharing of private infrastructure (Private Daytime Charging Scenario), as shown in Figure 24 for charge points used during the daytime in 2030. Figure 24 includes infrastructure needs across all daytime charging locations, not just the additional infrastructure required.

High adoption business models for sharing private infrastructure leads to lower need for public charging infrastructure. Therefore, although a higher total number of charge points are needed by vans for daytime charging in the high adoption scenario, 97% of these charge points are not considered additional van infrastructure – they are assumed to be installed already for cars or other fleets, as set out above. Additional van infrastructure requirements are 35% lower in the high adoption scenario than the low scenario, due to the lower reliance on rapid public charge points.

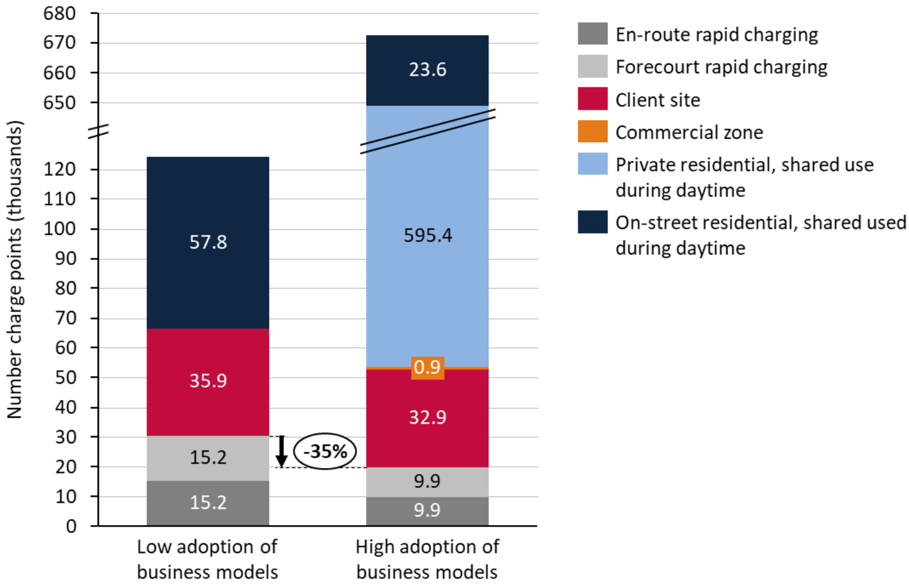

Figure 24: Daytime van charging infrastructure needs in the UK across the two Private Daytime Charging Scenarios in 2030 – high adoption of business models for sharing private infrastructure and low adoption. Note: additional and shared infrastructure are shown

3.3 Impact of van charging needs on the electricity distribution network

Summary of key findings:

- Unmanaged van charging across all locations leads to a total demand peak of 8.5 GW between 8 – 9pm, aligning with the evening peak in national electricity demand when network congestion is expected – national demand peaks at ca. 34-35 GW at this time
- Charging preference scenarios (both Public Residential and Private Daytime) do not have a large impact on the peak charging demand from van charging.
- Smart charging at depots, private residential and on-street charge points flattens peak demand to 7.6 GW and away from the evening peak.

The potential impact of each charging scenario on the electricity distribution network was assessed.

The expected peak load on the distribution network as a result of the van charging network was calculated using the total demand at each charging location and charge point load profiles[13]. The load profiles, including assumed plug-in times, are set out in Appendix 6.6.2.

[13] Load profiles based on Element Energy's database from ongoing work with distribution network operators and charge point operators.

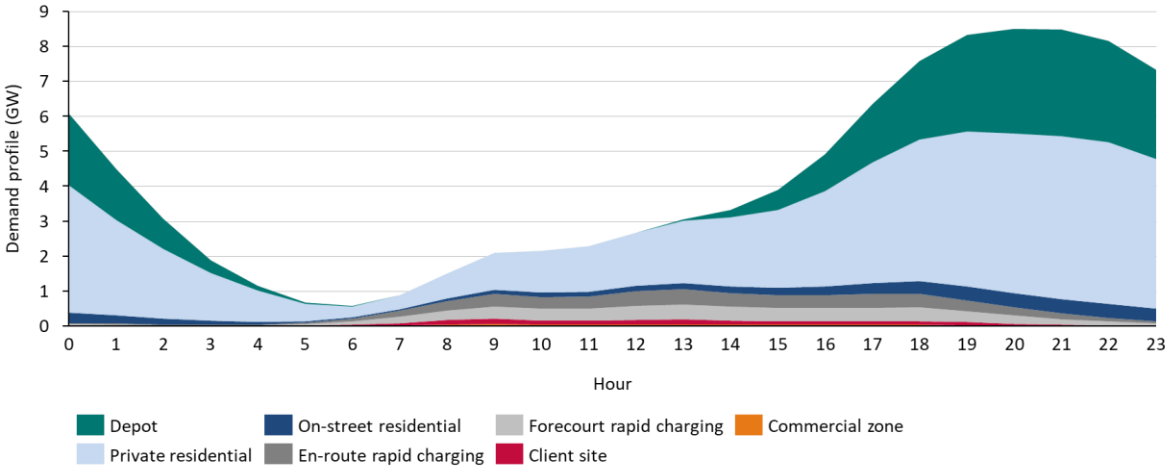

Figure 25: Unmanaged van charging demand profile in 2030 in the UK, with baseline public residential charging and high adoption of shared business models

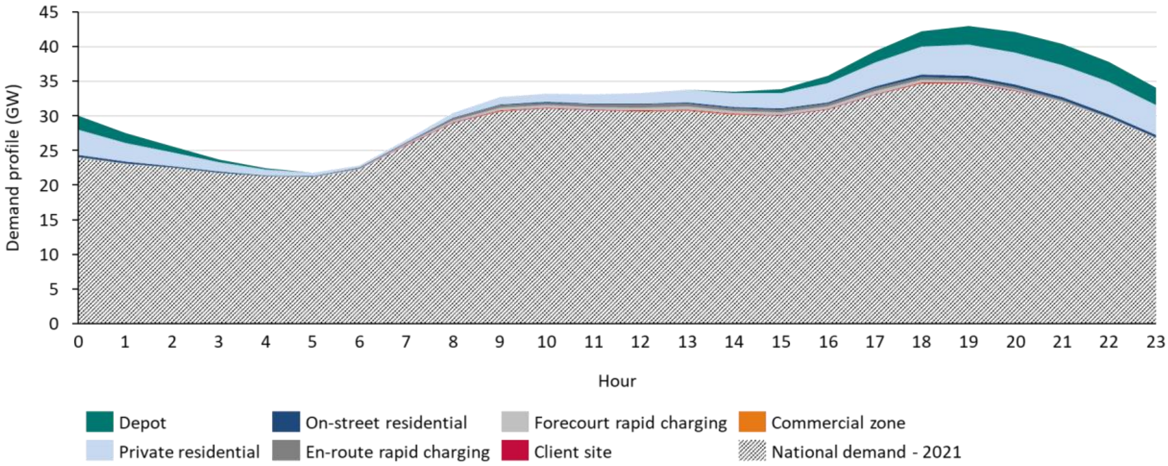

Figure 26: Unmanaged van charging demand profile in 2030 in the UK, with national demand as an average of historic demand over 2021[14]

The demand profile from van charging in 2030 is shown in Figure 25, separated by charging location. Unmanaged van charging across all locations leads to a total demand peak of 8.5 GW between 8 – 9pm. Typically electricity distribution networks observe high congestion during the evening, 5 – 9pm. As shown in Figure 26, the significant van charging demand in this evening period contributes to the existing peak on the national network at this time and is likely to lead to expensive network reinforcement requirements.

As a result of the high proportion of demand, private residential charging (specifically overnight use of private residential infrastructure) has the largest impact on the total load profile, making up 54% of the peak demand between 8 – 9pm. The private residential charging takes place at this peak time as a result of unmanaged charging profiles with vans beginning to charge as soon as plugged in at the end of their operational time.

[14] National demand based on Historic Demand Data 2021, from National Grid. https://data.nationalgrideso.com/demand/historic-demand-data/r/historic_demand_data_2021

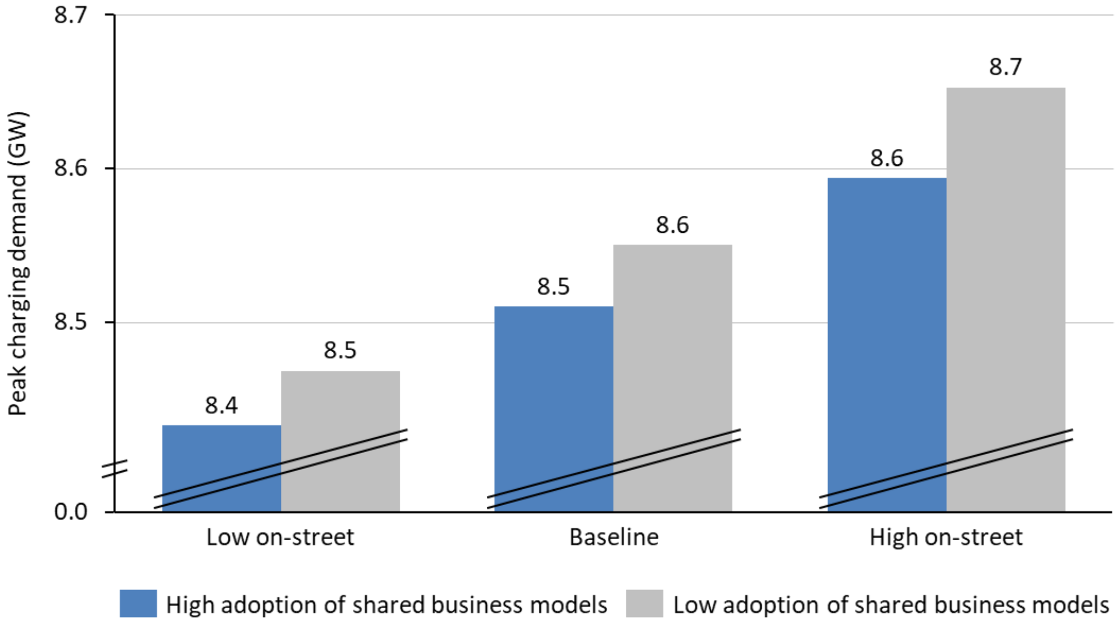

Figure 27: Peak charging demand from van charging in the UK over charging preference sensitivities, with unmanaged charging profile

As shown in Figure 27, the public residential charging and private daytime charging preference scenarios does not lead to a large variation in peak charging demand. Varying the preference scenarios results in ca. 0.2 GW difference in peak demand, all occurring between 8 – 9pm with unmanaged load profiles. The highest peak demand is observed with high on-street charging preferences. This is a result of less charging demand occurring during the day, and high charging overnight on-street. High overall grid impact is unlikely to drive up the cost of using this infrastructure to consumers, as grid reinforcement costs are expected to be socialised[15] and individual on-street charge point grid connections will be small (ca. 7 – 22 kW) and therefore usually inexpensive. Time of use tariffs could be introduced for on-street charge points to make charging at evening peaks more expensive, therefore encouraging demand to be shifted away from these times. The impact of this smart charging is explored in more detail in Section 3.3.1.

The low adoption of business models for sharing private infrastructure also increases public charging infrastructure use, including use of on-street overnight charging raising the demand peak. However, the on-street charging may be managed, as discussed in Section 3.3.1, which would limit the impact on the grid.

3.3.1 Impact of smart charging

A sensitivity was carried out to look at the impact of smart charging on the electricity distribution network. Smart charging load profiles are available for depot charge points and residential chargers (both private and on-street) used overnight (see Appendix 6.6.2). Other charging locations are generally not suitable for smart charging. During the day, charging events generally have shorter plug-in times, leading to less potential to shift the charging demand. Furthermore, the distribution network typically needs demand flexibility during the evening peak, 5 – 9pm, and therefore there is less potential for smart charging during the daytime to benefit the electricity network.

[15] Access and Forward-Looking Charges Significant Code Review: Final Decision, Ofgem, May 2022

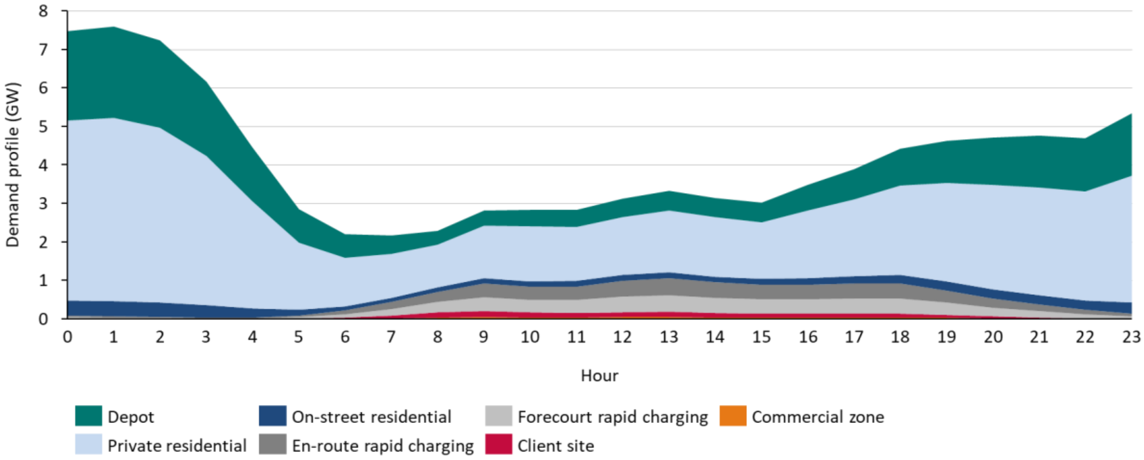

Figure 28: Total van charging demand profile in 2030 in the UK with smart charging, with baseline public residential charging and high adoption of shared business models

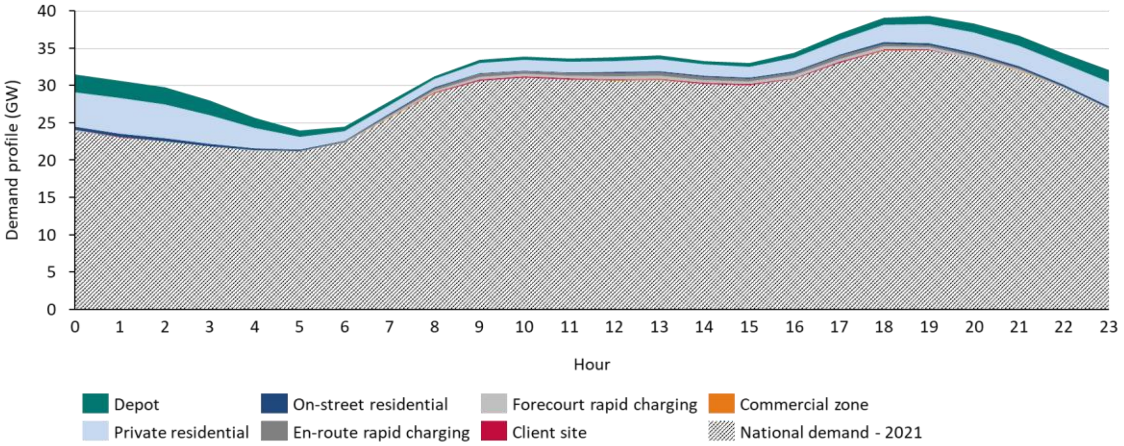

Figure 29: Van charging demand profile with smart charging in 2030 in the UK, with national demand as an average of historic demand over 2021[14]

As shown in Figure 28, the use of smart charging leads to a significant shift in the total van charging demand profile. The peak is flattened to 7.6 GW and is shifted away from the typical distribution network congestion period to 1am, when there is generally less congestion on the distribution network, as shown in Figure 29. As a result, smart charging at private overnight infrastructure is beneficial to the electricity network.

3.4 Cost of additional charging infrastructure needs of vans

Summary of key findings:

- Cumulative total costs of additional infrastructure hardware, installation, and maintenance, and the network reinforcement from van charging demand was calculated as between £9.2 – £15.8 billion in 2030. Majority of this cost will be met by private investment, in particular businesses installing depot infrastructure, likely to have a positive associated business case.
- Smart charging can save ca. £400 million across all Charging Scenarios. Given limitations of looking at one source of demand in isolation, this should be considered an indicative value and in practice savings could be much higher due to the shifting of the demand peak as well as the flattening.
- Total cost of additional charging infrastructure is reduced by high adoption of business models for sharing of private infrastructure (High Private Daytime Charging Scenario), and by low use of on-street residential charging overnight (Low Public Residential Charging Scenario)

3.4.1 Method for calculating the cost of additional charging infrastructure for vans

Several aspects relating to the installation of the required charging infrastructure was calculated, including the cost of hardware, installation, maintenance, and network cost.

1. **Hardware cost:** cost of additional charge point hardware by charging location, based on the On-street Charging Study[8] and Element Energy's extensive research with charge point operators
2. **Installation cost:** cost of additional charge point installation by charging location, based on the On-street Charging Study[8] and Element Energy's extensive research with charge point operators
3. **Maintenance cost:** cost of maintaining additional charge points by charging location, based on annual maintenance cost from the On-street Charging Study[8] and Element Energy's extensive research with charge point operators, and a 15-year lifetime of infrastructure
4. **Network cost:** cost of required network reinforcement based on predicted peak load increase from van charging (all charging categories, including shared), as identified in section 3.3. Reinforcement cost is based on typical cost per MW of upgrade at both primary and secondary substations, which in reality is likely to vary significantly depending on specific circumstances and free capacity on the network at the time of the peak load.

There is variation in hardware and installation cost across the charging categories. Hardware cost is dependent on manufacturer, purchase volume, and charge point power. Installation cost is also dependent on manufacturer, installation volume and location. For each charging category, high and low infrastructure costs are defined. Full assumptions are in Appendix 6.6.3.

3.4.2 Results of modelling the cost of additional charging infrastructure for vans

The cumulative total cost of van charging infrastructure in 2030, across charging preference scenarios and charging infrastructure cost scenarios, is shown in Figure 30. This total cost does not include the hardware and installation of charge points that are not considered as additional infrastructure required for vans, as set out in Section 3.2. The network cost shows the cost of the reinforcements required as a result of van charging demand across all charging locations, including shared infrastructure. This cost will mostly be met by private investment, in particular businesses installing depot infrastructure and charge point operators investing in rapid hubs. For fleet operators installing depot infrastructure, there will likely be a compelling business case for this investment as a result of the lower running costs of electrifying their fleet. As set out in the On-Street Charging Study[8], the business case for rapid hub operators will be dependent on factors including utilisation of infrastructure and grid upgrade costs on-site. The impact this may have on infrastructure availability for van drivers is explored in more detail in Section 4.3.

All cost components are significant, although the network reinforcement cost is 31 – 32% of the total, and maintenance 28 – 37% of the total. Figure 30 shows the high impact of the infrastructure cost scenarios on the total cost of additional van charging infrastructure. The high infrastructure cost scenario (as defined in Appendix 6.6.3 to represent the variation in hardware and installation cost across manufacturer, purchase and installation volume and location) leads to a total cost ca. 1.4 times higher than the low infrastructure cost scenario, showing the importance of infrastructure choice when installing charge points.

As shown in Figure 30, smart charging can save ca. £400m across all charging scenarios through reduced network impact and reduced reinforcement requirements. This saving is a simplification based on typical cost of reinforcement per MW peak demand, which is lower with smart charging than with unmanaged profiles. In reality, the cost of reinforcement is highly complex and likely to be dependent on other demand seen on the network at the time and existing capacity on the network. As smart charging additionally shifts the peak in van charging demand away from the evening peak when other demand on the network is high (as explored in Section 3.3.1), potential savings may actually be higher than found in this analysis.

Charging Scenarios have a significant impact on the total infrastructure cost. High adoption of business models for sharing of private infrastructure leads to a lower requirement for additional infrastructure, and therefore lower overall cost. Low use of on-street charging infrastructure in the Public Residential Charging Scenario leads to a lower overall infrastructure cost. This is again due to the lower total number of additional charge points as a result of the higher daily energy delivered by rapid charging infrastructure compared to on-street charge points.

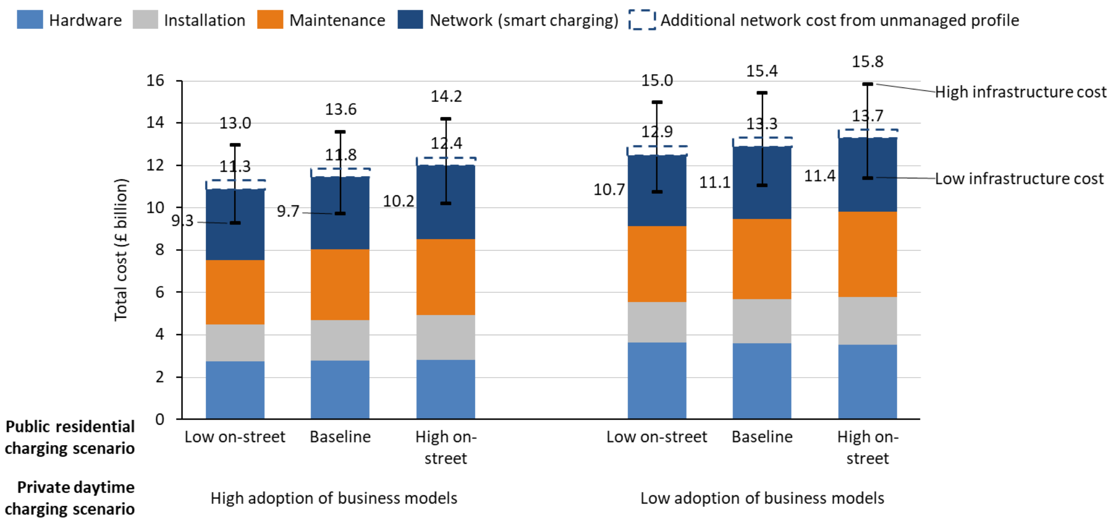

Figure 30: Cumulative total cost of required van charging infrastructure in 2030 in the UK, across charging preference scenarios and charging infrastructure cost scenarios.

4 Cost of van charging to consumers

Van users within each archetype could face different charging costs to the average car user, as a result of using a different ratio of charging locations. This section of the report looks at the calculation of the cost to the consumers across the defined van charging archetypes and charging preference scenarios.

Analysis was carried out in Section 4.3.2 looking at the impact of low utilisation on the cost of charging at rapid infrastructure, to determine if it was necessary to adjust charging price to account for van driving in urban vs. rural areas (highly utilised vs. low utilisation respectively). However, this analysis found that vans do not use rural major roads more frequently than cars. Additionally, rapid charge point prices are currently generally kept constant across networks. As a result, van drivers are not disproportionately disadvantaged by high use of infrastructure with low utilisation.

4.1 Method for modelling cost of van charging to consumers

The exact price for charging faced by van users is challenging to predict as the charging cost is impacted by a range of factors including charge point operators' business models, contract length and charge point utilisation level. There will be variation in the cost of charging faced by consumers across the same van archetypes and the values presented here should be viewed for the purpose of comparison between archetypes rather than an exact prediction of what will be paid by a specific user in each archetype. The costs of charging across all locations are also highly dependent on the price of electricity, which are based on BEIS central scenario[16]. These assumptions do not reflect the recent spike in electricity prices, which is expected to lead to long term increases in electricity prices above BEIS' projections. These long-term rises are expected to lead to higher absolute costs of charging across all charging locations, and therefore will not lead to changes in relative cost of charging across archetypes and locations allowing comparison between costs to consumers.

Average cost to van drivers for each charging location was combined with the charging mix for each archetype, as shown in section 2.4, to produce an overall average charging cost per kWh. The average cost to van drivers for charging at each location, as shown in Figure 31, is based on either the findings of the On-street Charging Study[8], analysis of market values, or a calculation of electricity mark-up value based on Internal Rate of Return (IRR) and up-front infrastructure cost. Full cost assumptions are set out in Appendix 6.7,

[16] BEIS 2020 electricity price scenarios, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1024043/data-tables-1-19.xlsx

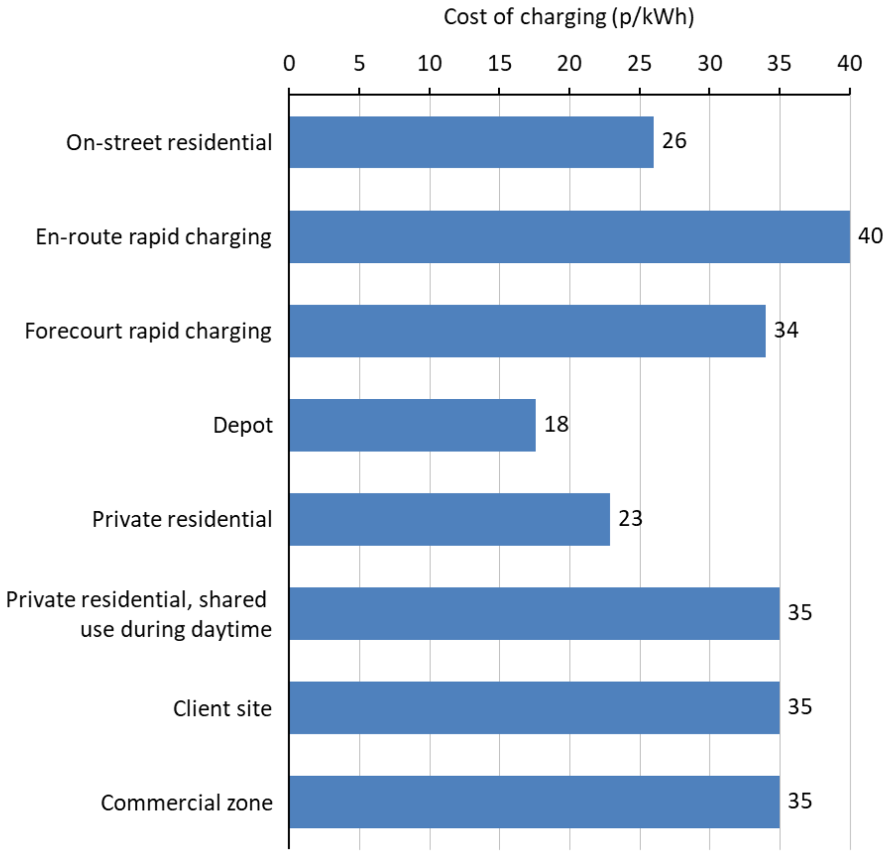

Figure 31: Cost of charging at each charging location (p/kWh) in 2025 with baseline infrastructure cost and utilisation, electricity-based cost for daytime shared infrastructure

4.2 Results of modelling cost of van charging to consumers

Summary of key findings:

- Average cost of charging to van drivers varies by archetype, with the extent of variation increasing over time (21 – 29 p/kWh in 2025 and 18 – 26 p/kWh in 2030), with highest costs observed for high mileage national drivers without access to depot charging.
- The overall cost of charging for each archetype decreases over time (ca. 10 – 23% decrease between 2025 – 2035), largely due to the expected improvements in van range leading to higher proportion of demand met at cheaper overnight charging locations. Largest fall in cost observed for archetypes that charge in depots overnight.
- Drivers who charge residentially overnight could benefit significantly (34 – 51% fall in average cost) from off-peak EV tariffs if they have access to off-street parking.
- Use of on-street charging infrastructure lowers cost of charging to consumers, particularly for consumers without access to off-street parking
- In addition to the level of adoption of business models for sharing of private infrastructure, the type of adopted business model is also uncertain. Session-based business models, where infrastructure owners set a p/min rate leads to the highest costs to consumers.

4.2.1 Baseline charging mix

The calculated cost to consumers across the van driver archetypes over 2025 – 2035 is shown in Figure 32. The average cost of charging to van drivers varies across archetypes, with the extent of variation increasing over time – in 2025, costs range between 21 – 29 p/kWh in 2025 (26% difference), and in 2035 a range of 18 – 26 p/kWh (44%) is observed. This fall in cost is largely a result of the higher proportion of charging demand met at cheaper overnight charging locations due to the projected 27 – 39% improvements in van range across all operating types (as set out in Appendix 6.4.2), in addition to projected falling cost of electricity (Appendix 6.7.2).

Van archetypes operating nationally (archetypes 9, 10, 11, and 12) observe higher average charging cost than local drivers. This is a result of the higher daytime charging needs of national drivers, which leads to higher demand for costly public charging as shown in Section 2.4. Additionally, van driver archetypes that charge residentially overnight rather than in a depot (archetypes 1, 2, 5, 6, 9, and 10), see higher average cost of charging. This is a result of the lower commercial electricity prices used by depots, as shown in Appendix 6.7.2. These groups of van drivers may be less willing to transition to EVs, as a result of the higher cost of charging. In particular, van drivers who operate nationally, making regular use of costly rapid charge points during the day, and are unable to make use of commercial electricity rates at depots overnight (archetype 9 – ca. 7% of the total fleet) may be left behind in the transition to electric vans. These groups could be supported by maximising availability of lower cost on-street charging infrastructure and measures to ensure cost-effectiveness (such as introducing off-peak tariffs), as explored in Section 4.2.3.

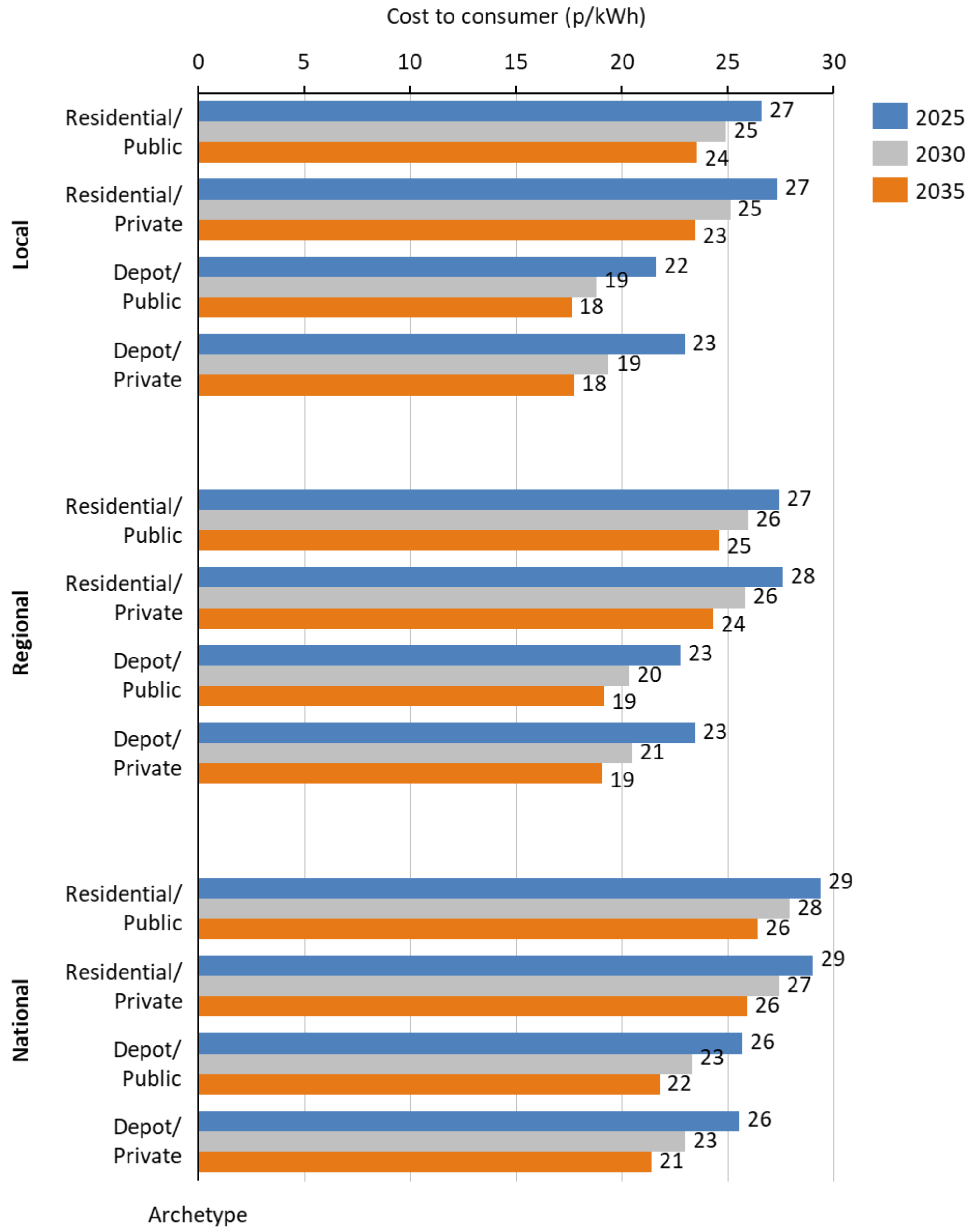

Figure 32: Average cost of charging to van drivers over 2025 – 2035, with baseline charging mix

4.2.2 Impact of off-peak electricity tariffs on residential charging cost

All vans able to charge overnight with private residential chargers may be able to make use of off-peak electricity tariffs to further reduce cost of charging.

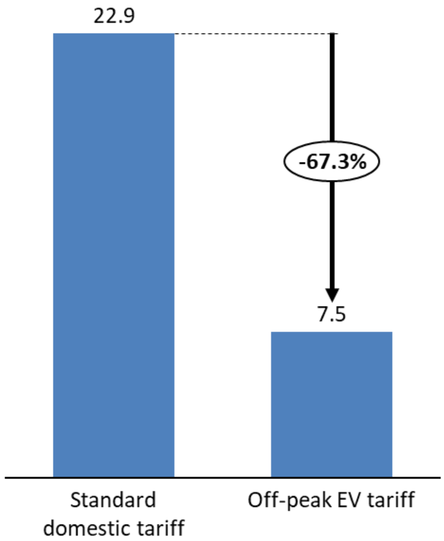

Figure 33: Comparison of cost of charging at private residential charge point in 2030, using a standard domestic electricity tariff and an off-peak EV tariff

To understand the impact, the cost of charging at a private residential charge point with an off-peak tariff was calculated, using Octopus Energy's Octopus Go tariff (calculation set out in Appendix 6.7.2). The cost of charging at a private residential charge point in 2030, including electricity mark-up, with an off-peak EV tariff is 67% lower than with a standard domestic tariff (BEIS 2020 central scenario), as shown in Figure 33.

The cost of charging at a private residential charge point with an off-peak tariff was used to calculate the overall average cost of charging for archetypes that charge residentially overnight in 2030 (archetypes 1, 2, 5, 6, 9, 10) as shown in Figure 34. Van drivers who charge residentially overnight could significantly benefit from off-peak EV tariffs, if they have access to off-street charging. This could not benefit van drivers without access to off-street parking.

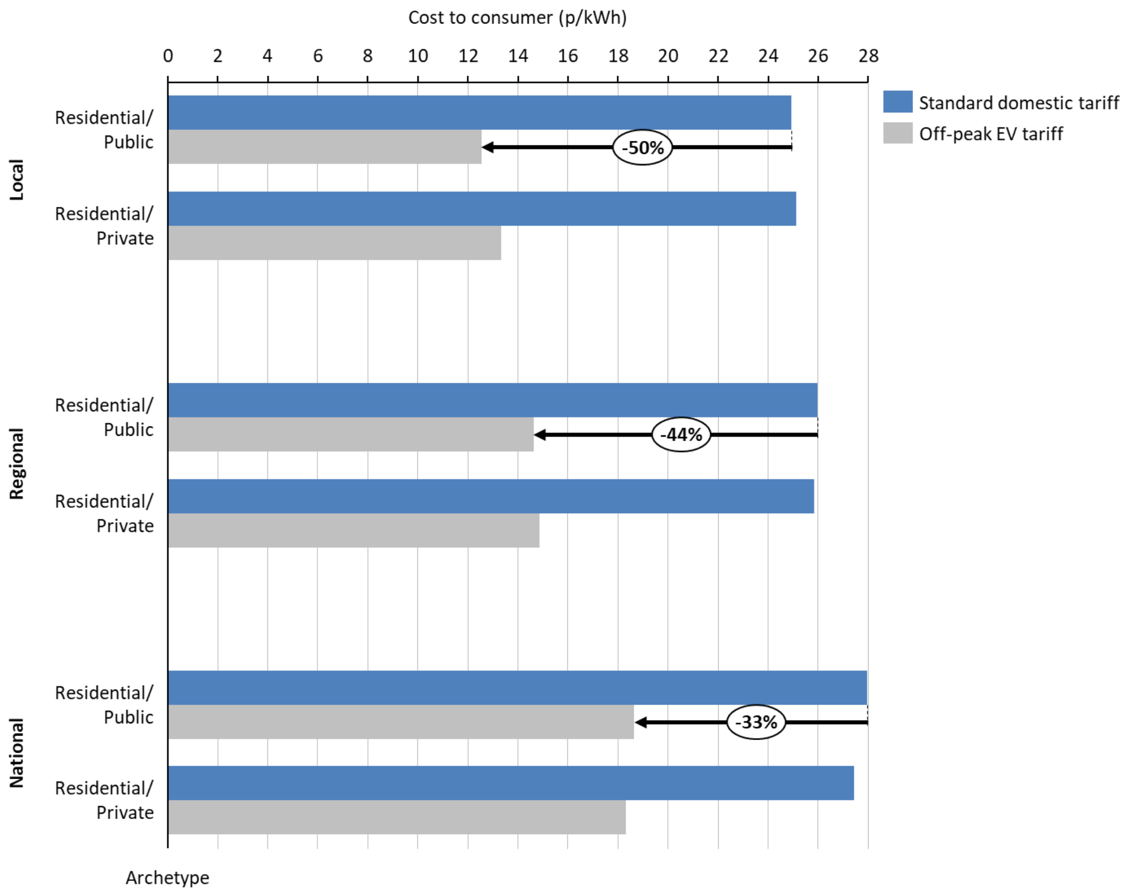

Figure 34: Average cost of charging to van drivers that charge residentially overnight in 2030, using either standard domestic electricity tariff or off-peak EV tariff

4.2.3 Impact of Public Residential Charging Scenario on van charging cost

A sensitivity was carried out to understand the impact of the selected Public Residential Charging Scenario low, baseline, or high, (as defined in Section 2.3.1), as shown in Figure 35. The cost of charging was calculated for average archetype demand, with a mixture of on and off-street parking as indicated in Section 2.4. An additional sensitivity was carried out assuming that overnight charging at private residential charge points was not possible, leading to higher average cost of charging.

The cost of charging is higher for drivers without access to off-street parking, due to the reliance on the public charging network. This disadvantages all EV drivers (both cars and vans) without access to off-street parking. Van drivers typically have a higher charging demand than typical car drivers and so are likely to be frequent users of the public charging network if no access to off-street parking. They are therefore likely to be more significantly impacted by inconvenience and reliability of this infrastructure.

The high on-street charging scenario reduces the average cost of charging to archetypes that charge on-street residentially by ca. 2% (average archetypes) – 12% (no overnight private residential charging), compared to the cost of charging in the low on-street charging scenario. This is a result of the high cost of rapid charging that is the preferred alternative to on-street charging in the low on-street charging scenario. A lack of investment in on-street charging infrastructure is likely to lead to a large cost disadvantage to EV drivers without access to off-street parking, as they will be forced to rely on more expensive, rapid charging infrastructure.

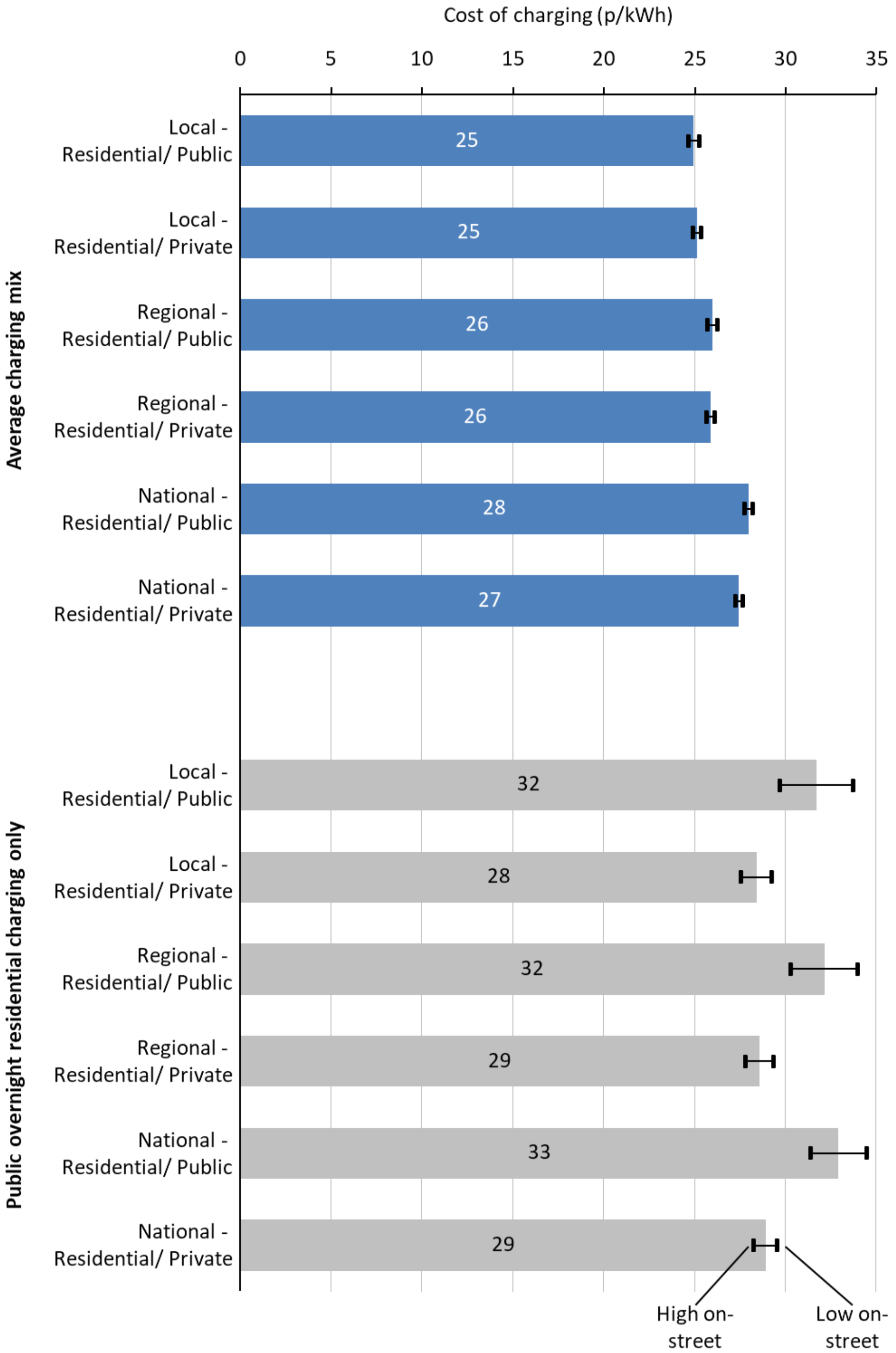

Figure 35: Average cost of charging to van drivers in 2030, over the three Public Residential Charging Scenarios and the 6 van charging archetypes that charge residentially overnight

4.2.4 Impact of sharing of private infrastructure on van charging cost

A sensitivity was additionally carried out to understand the impact of the adoption of business models for sharing private infrastructure. The cost of charging to van drivers in 2030, over high and low adoption of business models for sharing of private infrastructure, is shown in Figure 36.

Across all archetypes, sharing private infrastructure during the day makes up a small proportion of overall charging demand (as shown in Section 2.4.1) and as a result the extent of adoption of business models for sharing of private infrastructure does not have a large impact (< 1%) on the average cost to consumers.

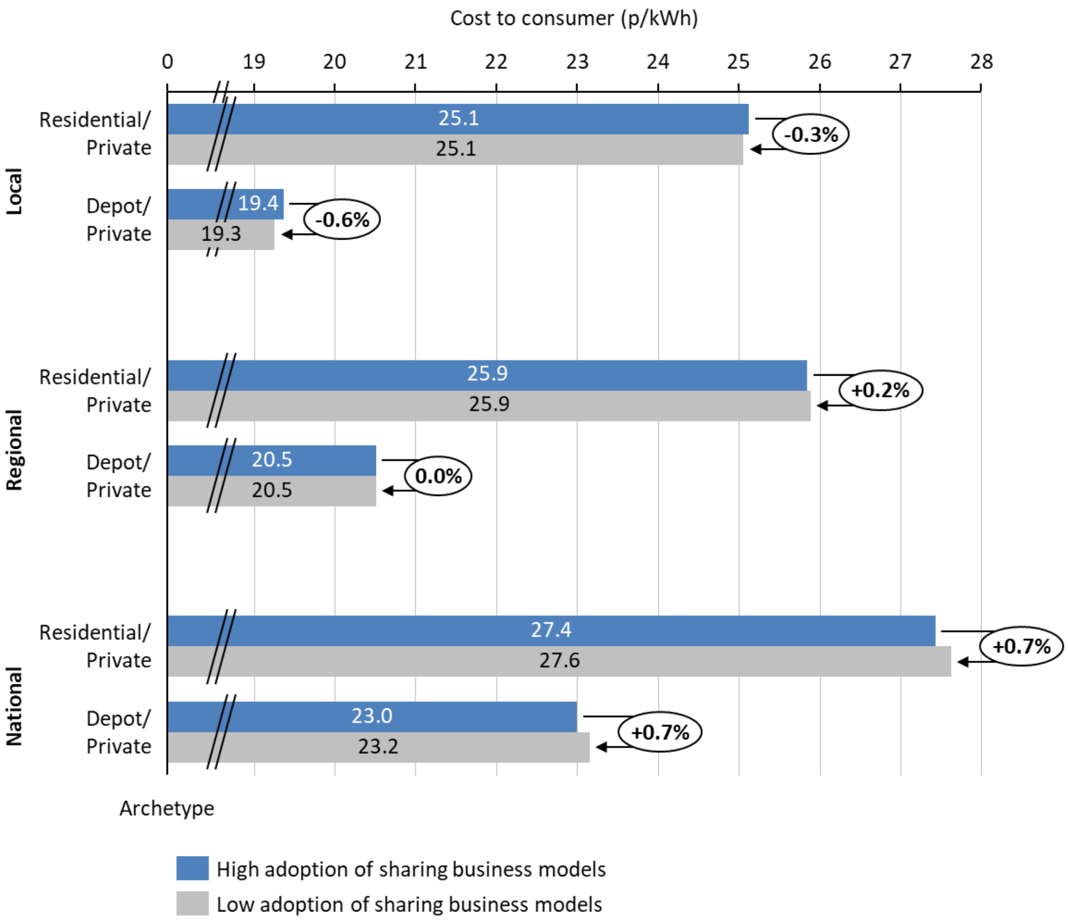

Figure 36: Average cost of charging to van drivers in 2030, over high and low adoption of business models for sharing of private infrastructure. Note: small differences in values are hidden by the rounding of numbers

In addition to the uncertainty around the adoption of business models for sharing of private infrastructure, it is also unclear what will emerge as the dominant business model for sharing of infrastructure.

Several platforms currently exist for sharing of private infrastructure, including Zap-Home[17], Zap-Work[18], and Bookmycharge[19]. A review of these platforms, as set out in Appendix 6.7.3, suggests that 3 key business models are emerging:

1. **Electricity-based:** Owners of charge points set a price in p/kWh, so that EV drivers pay for the electricity charged at the shared infrastructure.
2. **Session-based:** Owners of charge points set a flat rate for use, so that EV drivers pay a fixed amount for using shared infrastructure regardless of electricity charged.
3. **Cost recovery:** Owners do not plan to make a profit from offering shared use of charging infrastructure, but suggest a contribution towards the cost of electricity and infrastructure.

Figure 37 shows the impact of these business models on the average cost to van drivers that share private infrastructure. The cost recovery business model is represented in modelling by determining an electricity mark-up price, based on IRR and up-front infrastructure cost. Assumptions are set out in more detail in Appendix 6.7.3.

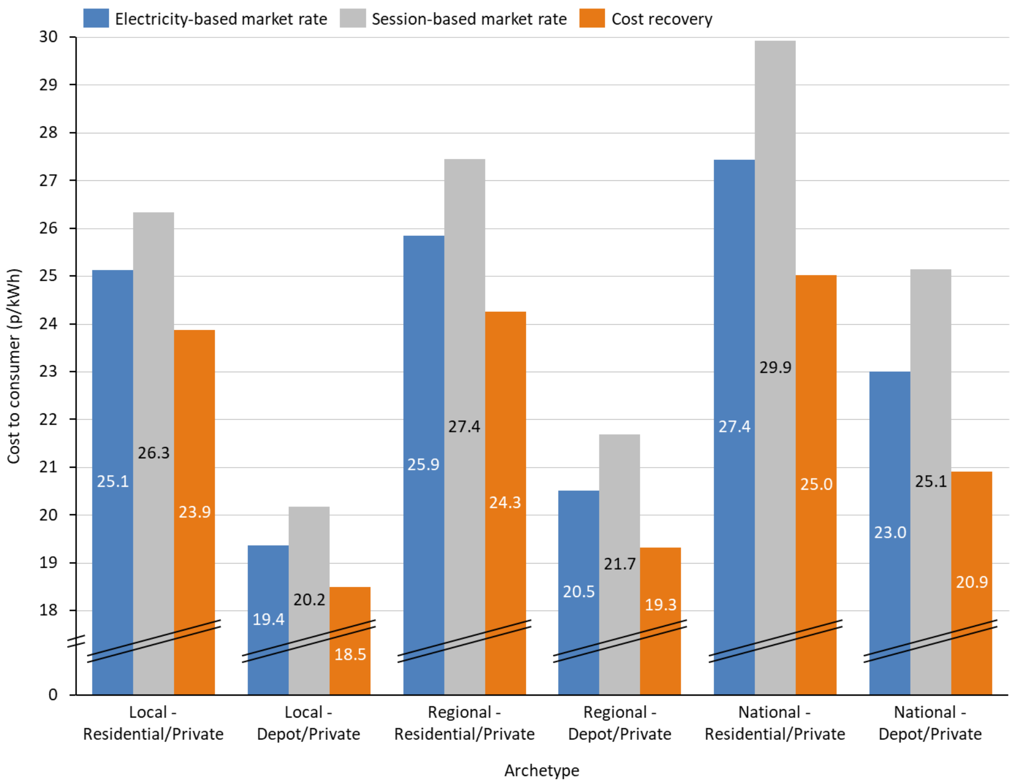

Figure 37: Average cost of charging to van drivers in 2030, over different business models for sharing of private infrastructure (Private Daytime Charging Scenarios), with overall adoption of sharing business models high

Session-based business model results in the highest cost to consumer, with consumers paying ca. 10 – 20% more than if cost recovery business models emerge as dominant. The UK

[17] Zap-Home network shows home charge points of users that have decided to share with other EV drivers: https://www.zap-map.com/charge-points/public-charging-point-networks/zap-home-network/

[18] Zap-Work network shows small business charge points that owners have decided to share with other EV drivers: https://www.zap-map.com/charge-points/public-charging-point-networks/zap-work-network/

[19] National network of EV charge points, owned by private individuals and businesses: https://bookmycharge.com/

government is proposing to mandate all public charge points to offer prices in p/kWh[20]. It is unclear if this mandate would extend to cover sharing of private infrastructure, however, this would lead to lower cost of charging for drivers and therefore could further encourage sharing of private infrastructure.

4.3 Comparison with cost to car drivers

Summary of key findings:

- The cost of charging to van drivers is similar but slightly lower than cost of charging to car drivers, with some range in values observed across both.
- Highest cost to van chargers is observed for national drivers that charge residentially overnight and publicly during the day, which makes up ca. 7% of the total van fleet and is often drivers that are self-employed or belong to small fleets. These groups would still see cost savings from transition to EVs, but these may not be as significant as for other groups.
- There may be variation in availability and cost of public charging infrastructure across the country. For example, utilisation-based pricing schemes could lead up to a 17.5% increase in average charging costs in low utilisation areas.
- Low utilisation of charging infrastructure is typically seen in minor road networks or rural areas, and could lead to higher costs and/or a lack of available infrastructure. However, van drivers will not be more disadvantaged than car drivers. EV drivers (both cars and vans) operating in rural areas with under-utilised infrastructure may face disproportionately high charging costs if reliant on public infrastructure.

4.3.1 Overall comparison

Van users within each archetype could face different charging costs to the average car user, due to the different ratio of charging locations. The average cost of charging for different BEV car archetypes have been calculated, considering the car charging mix defined in Appendix 6.5 and the cost of charging at each location as set out in Appendix 6.7.4. The cost of charging is shown for commuters and non-commuters, and car drivers with and without off-street parking. Figure 38 shows the resulting costs of charging to car drivers, with the average cost of van charging in 2030[21]. Overall, the cost of charging to van drivers is similar to cost of charging to car drivers, with some range in values observed across both.

The average cost of charging for van drivers is lower than the average cost of charging across most car driver archetypes, with the exception of commuters with off-street parking. This is largely a result of the low cost of van specific charging locations, such as depots that make use of commercial electricity rates and the potential for lower costs through shared infrastructure use during the day.

[20] Consultation outcome: The consumer experience at public chargepoints, DfT, OZEV, March 2022, https://www.gov.uk/government/consultations/the-consumer-experience-at-public-electric-vehicle-chargepoints/the-consumer-experience-at-public-chargepoints#executive-summary
[21] Calculated considering fleet mix of van archetypes, and assumes baseline public home charging, high adoption of sharing business models, baseline infrastructure and utilisation cost, and electricity-based market rates for sharing of infrastructure

Figure 38: Cost of charging to car drivers across different archetypes and average, minimum and maximum cost of charging across van archetypes to van drivers in 2030. Note: assumes baseline charging mix, baseline infrastructure and utilisation cost, and electricity-based market rates for sharing of infrastructure

The lowest charging cost for van drivers is seen with low mileage, local drivers, that are able to mostly rely on depot charging overnight (92% of total demand in 2030) making use of low-cost, commercial electricity rates. Lowest charging costs to car drivers are seen with commuters, a significant proportion of whose charging demand is met at their workplace. It is unlikely that workplaces will choose to make a profit from their employees' charging and may even offer free charging as a benefit. As a result, Figure 38 shows the cost of charging considering baseline workplace charging cost (cost recovery model, as set out in Appendix 6.7.2) and with a sensitivity of free charging at workplaces. Free workplace charging greatly reduces the overall cost of charging for commuters. In particular, commuters without off-street parking meet 45% of demand at work, and their average cost of charging is lower than the minimum cost of charging for van drivers as shown in Figure 38. However, it is unlikely that all workplaces will offer free charging to employees (in particular, small companies may be unable to offer this benefit to employees).

Non-commuting car drivers without access to workplace charging nor off-street parking, see the highest average charging costs due to complete dependence on public charging. Similarly, as discussed in Section 4.2, the highest cost to van drivers of 27.9p/kWh is observed for national drivers that charge residentially overnight and publicly during the day (archetype 9), as a result of the high use of expensive rapid charge points during the day, and being unable to make use of commercial electricity rates at depots overnight. This cost is close to the most expensive car charging mix. From stakeholder engagement (see Section 2.1.2), a large proportion of drivers that fit into this archetype are self-employed, small fleet operations. This group faces two equity related issues. Firstly, they may not be in a position to buy a new van, let alone a new BEV van, and their high mileage requirements may mean that second hand BEV vans do not meet their range needs for some time. They therefore may be some of the last to switch to a BEV. At this time diesel is expected to be expensive and possibly hard to find. Switching to a BEV would save these drivers money, and support may be needed to allow this group to access the savings of the switch to a BEV. Secondly, once they have switched to a BEV, they will pay more for charging per kWh than other users, although their costs will still have fallen relative to using diesel. The cost of charging for this group could be lowered by making use of off-peak overnight tariffs, as set out in Section 4.2.2, although this would not generally benefit drivers without off-street parking unless business models can be designed to include off-peak pricing, as discussed in the On-street Charging Study[8]. This group would also disproportionately benefit from regulation to stop value pricing at motorway service stations where a lack of choice or competition will keep prices high.

Both car and van drivers who are expected to charge residentially overnight and are unable to make use of low-cost charging from large employers may face lower savings than other drivers in the transition to EVs, however, savings are still expected in comparison with refuelling and operation of ICEVs. Widespread availability of easy-to-use and convenient infrastructure is likely to be a more significant factor in the decision to transition to EVs.

4.3.2 Impact of differential pricing schemes at public charging networks

There is concern that in addition to the different mix of locations van drivers charge at compared to car drivers, the cost of charging at public networks across the country may be variable, e.g. a lack of competition and choice for public charge points in some locations may result in higher prices. This would lead to different charging costs faced by van drivers despite similar operating profiles and charging preferences.

Another example of this is the possibility of charge point operators introducing utilisation-based pricing schemes, as explored in the On-street Charging Study[8]. To ensure profitability of public charging infrastructure for CPOs, the level of infrastructure utilisation could be used to set the cost to consumer, as shown in Figure 39. High utilisation of public charging infrastructure leads to a 5 – 15% decrease in cost. Low utilisation increases the cost to consumer by 10 – 40% above baseline, with en-route rapid charging seeing the largest impact of 40% in 2030.

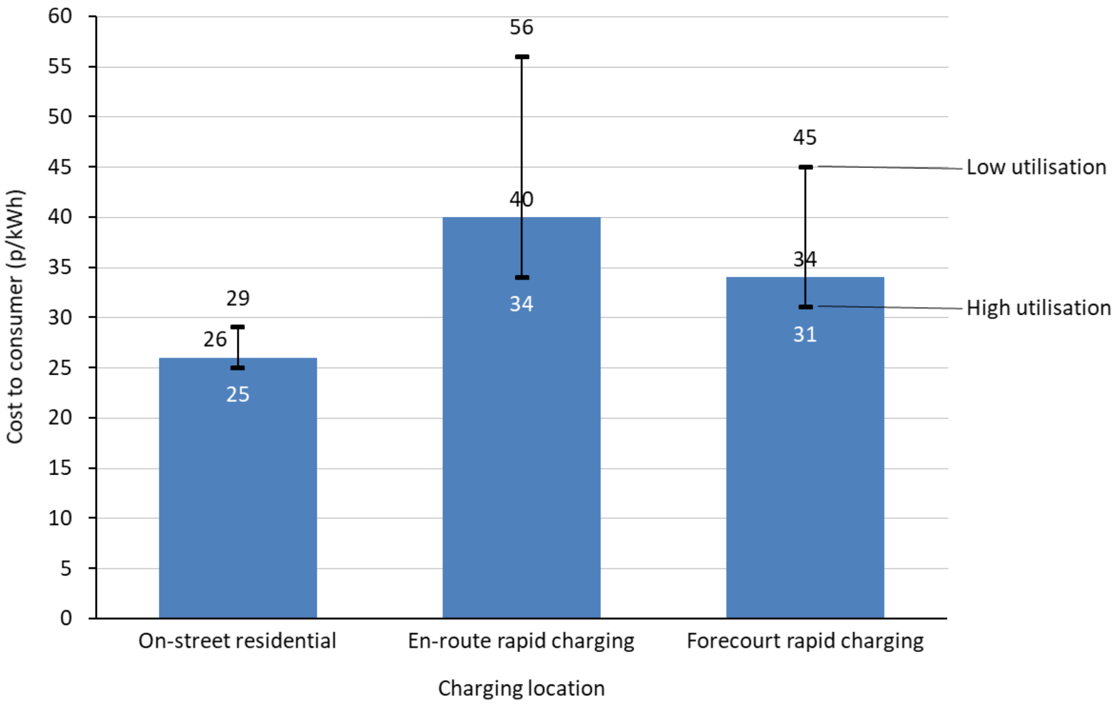

Figure 39: Cost of charging at public charging locations, with low, baseline, and high utilisation in 2030

Figure 40 shows the impact of infrastructure utilisation on the cost of charging to vans drivers. The largest impact is observed with archetype 9 – a national driver using public charge points to top up during the day. Low infrastructure utilisation leads to a 17.5% increase in the average cost of charging to archetype 9, reaching costs over 32 p/kWh.

Infrastructure utilisation has very little impact on drivers that prefer to charge privately during the day (archetypes 2, 4, 6, 8, 10, and 12). Some impact on overall cost is observed, as these archetypes make some use of public charging infrastructure (either overnight on-street, or during the day when private infrastructure not available). However, in the scenario of high adoption of business models for sharing of private infrastructure, public charging demand is low, and leads to 1 – 6% difference in charging cost.

If van drivers disproportionately charge at public rapid chargers with low utilisation, they will be significantly disadvantaged. Vans using on-street chargers with low utilisation would be disadvantaged, but not as significant an impact on cost as use of rapid chargers – both en-route and forecourt.

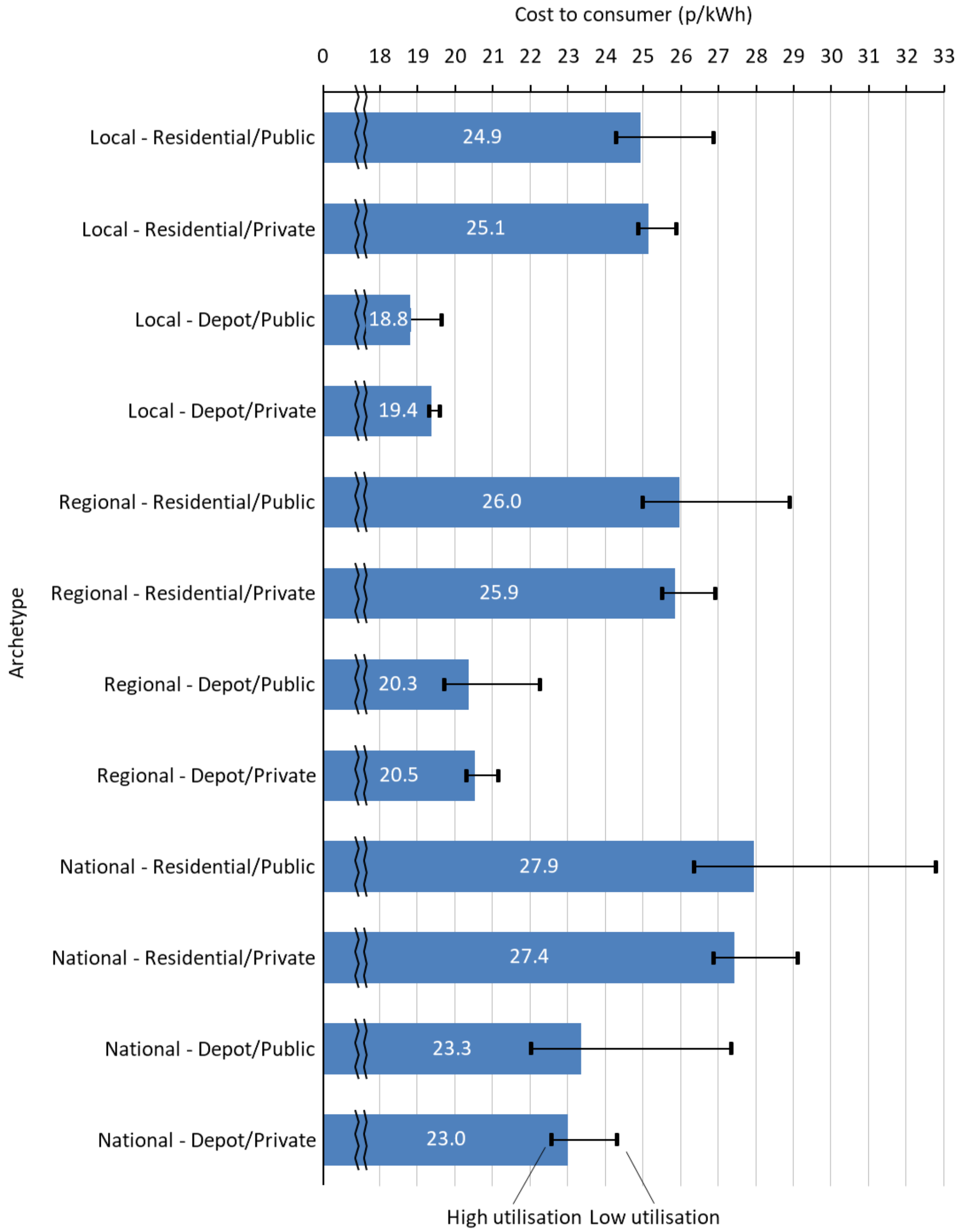

Figure 40: Cost of charging to van drivers in 2030, across low, baseline, and high utilisation

Low utilisation of charging infrastructure is typically seen in areas with lower traffic flow, such as minor road networks or rural areas. Analysis of DfT traffic count data[3] indicates that the ratios of cars to vans on both major and minor road networks remain approximately constant across rural and urban areas, as shown in Figure 41. Both car and van drivers may be disadvantaged by frequently charging at rural or off major road network chargers, where infrastructure may be more expensive. However, it does not appear that vans are more frequently driven in these locations and van drivers are therefore unlikely to be more significantly disadvantaged than car drivers.

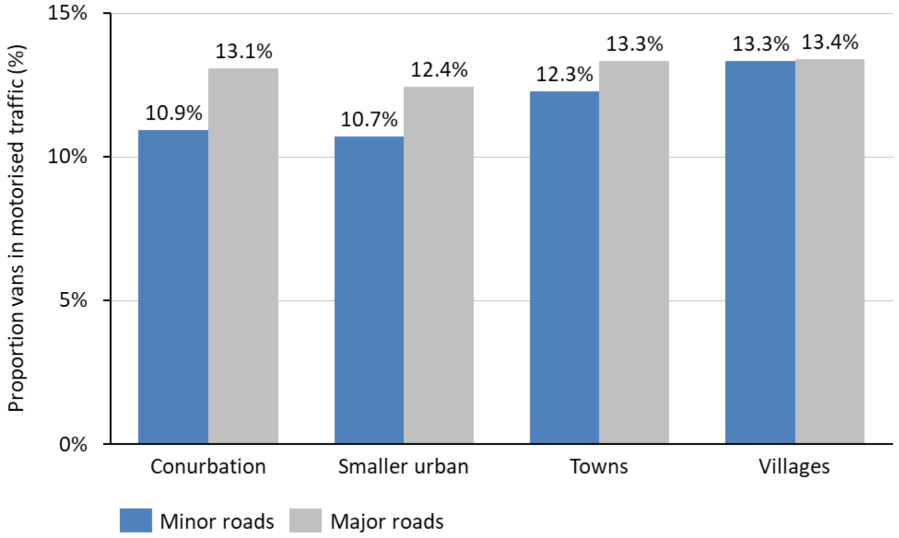

Figure 41: Proportion vans in motorised traffic on major and minor roads, travelling across different population densities

Additionally, analysis of the existing rapid charging market in the UK indicates that prices remain consistent across major charge point networks – in general, major CPOs set a fixed price per kWh at all of their rapid charge points, regardless of utilisation level[22]. For example, all 50 kW charge points on bp pulse's network currently cost 50 p/kWh[23]. If this remains the case, it may be that the additional price CPOs see of infrastructure with low utilisation is socialised across all charge points in their network, and therefore driver groups on rural or minor road networks will not be disadvantaged. However, as the UK's rapid charging network is still at a relatively early stage of development, the observed fixed pricing across networks (independent of utilisation) could be a result of no infrastructure yet installed at truly rural sites with low utilisation. As networks grow rapidly, CPOs will begin installing charge points in less well-utilised locations. As this takes place, networks may move towards the utilisation pricing model where the cost of charging to drivers is set by infrastructure utilisation, as described above. This would disadvantage EV drivers (both cars and vans) operating mostly in rural areas, with low-utilisation infrastructure and could delay transition to electric vehicles.

Costs across public charging networks could be regulated to prevent high disparity in the cost of charging across different areas as a result of factors such as utilisation. In reality, it is likely that CPOs will be unable to deploy infrastructure in locations that are unlikely to be profitable, such as due to low utilisation. This could lead to 'charging deserts', where there is a lack of available infrastructure in some areas of the country. Government could provide additional investment in the installation of infrastructure in areas likely to be under-utilised so that there is less pressure on network operators recouping investment costs through higher prices.

[22] Element Energy discussion with major charge point operators, and analysis of Zap-Map data
[23] Pay as you go (PAYG)/Contactless cost for bp pulse50, www.bppulse.co.uk/charging-on-the-go

5 Conclusions and recommendations

This section draws together the findings from the study to form conclusions on the optimal charging solutions for the UK van fleet, and recommendations to overcome the barriers to the uptake of electric vans.

Summary of key findings:

- Van drivers will make use of a range of charging infrastructure according to their operating profile, with additional charging infrastructure requirements on top of that installed for cars or other purposes expected to grow from 241k charge points in 2025 to 962k in 2035.
- Use of private charging infrastructure overnight, either at depots or using off-peak residential EV tariffs, is the most cost-effective method of charging.
- Drivers that are reliant on public infrastructure for both overnight and daytime charging, particularly in areas with low utilisation, may be left behind in the transition to EVs.
- Van drivers will see cost benefit from the development of business models and platforms for sharing of private infrastructure.
- Actors including government, DNOs, CPOs, and fleet operators have roles to play in alleviating barriers and facilitating the charging of electric vans.

5.1 Optimum van charging strategy

There will be a variety of optimum charging solutions for the UK's electric van fleet, depending on their operating profile. Overall, van drivers will not be significantly disadvantaged in the transition to electric vehicles, compared with car drivers.

Additional infrastructure required for vans on top of that installed for cars is expected to grow from 241k charge points in 2025 to 962k in 2035. This study found that ca. 160,000 public charge points (on-street residential, en-route and forecourt rapid charging) will be required for van fleets by 2030. The DfT's EV infrastructure strategy[11] projected that between 280,000 and 720,000 public charge points will be required by 2030 for electric cars and vans. The DfT projections assumes that 14% of van stock by 2030 is battery electric[12], while this analysis is based on the CCC's 6th Carbon Budget Balanced Pathway stock projections which predicts that 39% of the van stock will be battery electric by 2030[5]. The DfT electric stock projections are significantly lower than the CCC's projections, and therefore the total charge point need is likely to be lower than modelled in this analysis.

Overnight depot charging of van fleets is the cheapest option on a per kWh basis, unless van drivers are able to make use of off-peak EV tariffs at private residential charge points. Additionally, vans are in the unique position of typically visiting as part of their operating profile a wide range of sites likely to have charging infrastructure installed for other vehicles. Vans are likely to be able to 'graze' – make use of this charging infrastructure to top up charge whenever they stop. Sharing private infrastructure that has been installed for other vehicles lowers the average cost of daytime charging for vans and reduces the need for installation of additional infrastructure, instead improving the utilisation of other infrastructure. However, private infrastructure sharing business models and platforms must be further developed to facilitate adoption of this charging preference.

Van drivers that must charge residentially overnight and without access to off-street parking face the most significant disadvantage in terms of charging cost. The On-street charging study carried out by Ricardo for the CCC[8] found that it is unlikely that there will be a single charging solution to suit the needs and preferences of all EV drivers without access to off-street parking and therefore private residential charging. Van drivers without access to private residential or depot charging are therefore likely to use a mixture of on-street infrastructure overnight, and other charging locations during daytime operation, particularly rapid charge points. Significant investment in either on-street or rapid infrastructure might lead to a solution emerging as dominant, as explored in the Public Residential Charging Scenarios. Low preference for on-street charging infrastructure leads to a lower total cost of installing additional infrastructure but higher charging cost to drivers, particularly if utilisation-based pricing models are adopted in rural areas. Overall, it is likely that van drivers without access to private charging overnight will make use of a mixture of on-street and rapid charging. Across all scenarios, the average cost of charging is higher without access to depot or private residential charging overnight. Fleet operators should consider drivers' access to off-street parking for their vans, and compare commercial and domestic EV tariffs when determining the optimum solution for their fleet.

The cost impact of overnight residential charging, without access to off-street parking, is further exacerbated by high mileage, short stop operating profiles, where vans will have to top up charge during the day at costly rapid charge points. This group of van drivers, which makes up ca. 7% of the total van fleet in the UK and is largely made up of small fleets or self-employed drivers, face higher average charging costs. However, savings are still expected in comparison to the use of ICEVs. As a result, widespread availability of easy-to-use infrastructure may be more critical in the decision to switch to an electric van.

5.2 Key recommendations to policy makers

Actors including government, distribution network operators, charge point operators, and fleet operators have roles to play in alleviating barriers and facilitating the charging of electric vans.

Recommendations to central government

1. **Policy makers should encourage fleet operators to carry out overnight charging of their fleet at depots, where possible, instead of shifting the focus to charging at drivers' homes as this reduces charging costs and alleviates congestion at on-street charging points**.
    - It is significantly less expensive for vans to charge overnight at depots using commercial electricity rates than standard domestic tariffs. If drivers have access to off-street parking and off-peak EV electricity tariffs, this may lead to lower average costs of charging but burdens drivers with ensuring consistent access to off-street infrastructure and smart charging.
    - Policy could continue to support fleet operators in transitioning to depot charging by removing barriers to upgrade commercial fleet sites' grid connections, in line with recent regulations to lower connection charges[15]
    - Planning a depot conversion to BEV charging requires time and expertise. Public material on best practise and detailed case studies should be published by DfT/OZEV.
2. **Policy should encourage the development of business models for sharing of private charging infrastructure and support investment in platforms that provide a quick, seamless infrastructure sharing experience.**
    - As set out above, vans are often able to make use of existing private infrastructure to top up charge during the day without impacting their operating profiles, leading to lower average costs of charging and reducing the need to install additional infrastructure.
    - Current adoption of private infrastructure sharing is low as business models and sharing platforms are still emerging. To ensure van drivers make use of private

infrastructure sharing business models, the experience must be quick, seamless, and easy to use.

- Infrastructure sharing platforms have been seen to work well in European countries, such as France and Germany, but unable to gain significant market in the UK. A key example of this is car sharing – in Germany, as of 2019 3% of the population were car club members, compared to 0.5% in the UK[24]. This has been largely attributed to supportive local policy, in addition to early innovation in the space. A number of infrastructure sharing platforms have emerged from France, including peer-to-peer car rental platform Getaround (formerly Drivy) and carpooling marketplace BlaBlaCar.
- Support and investment will be required to develop existing and new innovative private infrastructure sharing platforms in the UK, to make sure EV drivers can make the most of installed charging infrastructure.

3. **Policy should support small businesses as they transition to electric vans, in particular those with high mileages using costly rapid charge points during the day and parking on-street overnight.**
    - As set out in section 5.1, van drivers that are part of small fleets or self-employed are generally likely to be more disadvantaged in the transition to electric vehicles than vans that are part of large fleets. This is a result of the lower likelihood of being able to make use of overnight depot charging and commercial electricity rates, and use of costly rapid charge points during the day. This leads to higher average costs of charging than other van driver groups, however, savings would still be expected compared to the use of ICE vans.
    - Policy should be developed to support these groups in the transition, for example education about cost-effective charging strategies, infrastructure purchase incentives, or encouraging widespread access to more cost effective on-street charging such as access to time of use tariffs.
4. **Policy should encourage smart charging of vans overnight to limit impact on the grid and reduce reinforcement costs.**
    - As discussed in section 3.3, unmanaged charging of vans overnight leads to a high peak in demand in the evening, aligning with other peak demand on the electricity network. Smart charging of vans could lead to high savings through reduced network impact and reinforcement requirements (indicative savings found to be ca. £400m, although higher savings possible due to complex interaction with other demand on the network).
    - Smart charging can also be used to make the most of off-peak electricity tariffs, leading to significant cost savings (30 – 50%) for van drivers.
    - UK government has introduced regulations to mandate that all domestic charge points sold from end of June 2022 must be capable of smart charging[25], but further incentives and education may be required to ensure drivers and fleets engage in smart charging.
    - In the case of depots with multiple chargers, there are economic incentives in place (through the connection charges, DNO changes and capacity charges) for fleets to manage their charging to achieve the lowest peak demand possible and minimise the use of power in peak times (DNO charges are time banded). However, such installations are not automatically able to respond to external signals (as is meant by 'smart' in the regulation of domestic charge points). The

[24] Barriers and opportunities for shared battery electric vehicles, Element Energy for Transport and Environment, January 2021
[25] Regulations: electric vehicle smart charge points, BEIS, May 2022

feasibility and need for intervention on this (e.g. through regulation, change to commercial tariffs and/or stronger guidance on depot charging design/installation) should be studied.

5. **Regulation should be put in place to prevent large regional disparity in the availability or cost of infrastructure.**
    - In the future, there may be disparity in the availability and cost of charging infrastructure across the UK.
    - As set out in section 4.3.2, currently major CPOs set a fixed price per kWh across their rapid charging network, regardless of utilisation level. In future, CPOs may adjust charging costs according to reflect willingness to pay, availability of local competition and/or utilisation level to maximise profits[8]. This would disadvantage EV drivers (both cars and vans) operating in specific places and along specific routes.
    - To avoid delaying the transition of these drivers' vehicles to battery electric, regulations could be put in place to set a maximum price per kWh on the rapid charging network.
    - However, commercial charge point operators may be unwilling to provide charging infrastructure in areas of low profitability. This could lead to 'charging deserts' – where there is a lack of available infrastructure. Government could provide additional investment in the installation of infrastructure in these areas to ensure everyone can transition to BEV without charging barriers.
6. **If current plans to regulate minimum reliability requirements of rapid infrastructure are put into place, policy should consider extending the regulation to ensure reliability of under-utilised/rural charge points.**
    - The UK government is currently planning to mandate minimum 99% reliability across rapid charging networks (50 kW and over)[10], which is expected to apply as an average across a CPO's entire fleet of charge points. As a result, there could be charge points in areas of the UK that are not well-maintained, particularly in rural or hard to reach areas, or where infrastructure is not well-utilised.
    - Further regulation may be required to ensure EV drivers (both cars and vans) in these areas are able to make full use of installed infrastructure.
7. **Regulation should be introduced to ensure vans and other larger commercial vehicles can access charge points.**
    - Public charging infrastructure, in particular rapid hubs, are often designed for passenger cars or small vans and may not be suitable for larger vans, for example due to the size of the parking space or a canopy over the charge point limiting vehicle height.
    - Regulations could be put in place to make sure these restrictions do not exclude larger vehicles and vans from using available infrastructure.
    - Similarly, van manufacturers often design EV models with charge point socket situated on the side of the vehicle where the petrol cap is in a traditional combustion engine vehicle. This may restrict larger vans from using charge points, as the connector cable may not be able to reach around the length of the vehicle. Van manufacturers should consider the typical design of charge points to ensure vehicles can make use of infrastructure.

Recommendations to local government

8. **Policy should facilitate vans' access to low cost on-street charging infrastructure as current first come first serve models are insufficient to support van users who are likely to want to charge every day.**

- As discussed above, van drivers that charge residentially overnight but do not have access to off-street parking are likely to make use of a mixture of lower cost on-street charging infrastructure overnight, and other charging locations during their daytime operation. Similar to other commercial vehicles with high mileages, such as taxis, vans that make use of on-street charging overnight are likely to need to plug in more frequently than typical car drivers.
- There are a number of barriers to the roll-out of and access to on-street charging infrastructure, explored in more detail in the On-street charging study carried out by Ricardo for the CCC[8], including the highly sensitive issues around the designation of EV-only bays.
- Local authorities should account for the requirements of high-mileage, commercial vehicles, such as vans and taxis, when assessing the case for installing on-street charging infrastructure or designating EV-only parking bays[26].

Recommendations to fleet and/or charge point operators

9. **Fleet and charge point operators should consider the needs of van fleets when designing the roll-out of charging infrastructure for other commercial vehicles, particularly HGVs.**
    - As set out in the above point, vans often visit a wide range of sites during their operating profile, that may have charging infrastructure installed for other vehicles. In particular, vans are likely to have significant overlap with other commercial vehicles, including HGVs, buses and taxis. For example, operators of HGV fleets often also operate van fleets. Additionally, as with buses and taxis, van often visit areas of high population density and would therefore benefit from networks installed in similar strategic locations.
    - An additional benefit is that truck overnight charging infrastructure is likely to be of sufficiently high power that vans can gain significant benefit from brief daytime charging sessions, similar to the use of a rapid charging hub.
    - Vans could significantly benefit from the roll-out of charging infrastructure for other commercial vehicles, including HGVs, buses, and taxis, if considered in advance to ensure suitability of sites, such as demand location, height restrictions, size of parking space, etc.
10. **Fleet and charge point operators should collaborate to develop a strategy for charging of vans during concentration of 'worst days' in winter months**
    - The modelling of charging infrastructure needs in this study has assumed a constant utilisation rate and demand throughout the year, spreading vans' 'worst day' demand. In reality, demand and infrastructure utilisation will be much higher in the winter months, and particularly around the Christmas period. This is as a result of higher consumer demand for home delivery of goods, home maintenance, and medical services.

[26] Not all parking bays associated with on-street EVCPs are turned into 'EV-only' bays in the UK. Obtaining such a designation requires the Local Authority to undergo a consultation process with local residents & local businesses, who might raise objections. As this comes at a cost (and has a significant time impact on the on-street EVCP rollout) and add to the parking pressure that can be acute in some places, some LAs prefer to avoid the 'EV-only' approach. In such cases, they would typically install several EVCPs in the same street, to increase the probability of EV drivers finding an available EVCP. High mileage/business vehicles might however require a more secure access to an EVCP to have the confidence of adoption an EV.

- The high concentration of charging demand over this period will likely lead to queuing at public charge points, and potentially disruption to business if there are long wait times to top up charge during the daytime.
- It is unlikely that CPOs will be willing to install more infrastructure to meet this demand, as utilisation and therefore profits will be low over the rest of the year.
- It is also unlikely that fleet operators will be willing to purchase vans with larger batteries to reduce the need for top up charging during the daytime, as again these would be under-utilised throughout the rest of the year.
- Charge point and fleet operators will need to work together to develop a strategy to cope with the concentration of vans' worst day demand in December. This could involve making use of mobile charging infrastructure, which could be moved temporarily into depots or other fleet sites to meet higher charging needs. Fleets could also share depot infrastructure with other fleets, if operational times sufficiently different. Alternatively, fleet operators could add old, low-value vehicles back into operation, which is currently a common strategy to meet the additional operational demand over this period. Over the transition to electric vehicles, this could involve making use of old, diesel vehicles. Although not zero-carbon, limited use of diesel vans in times of high demand could ensure that battery electric vehicles can be used for the majority of operations over the rest of the year.

6 Appendix

6.1 List of fleet operators and van drivers surveyed and interviewed

Table 6: Summary of fleet operators and van drivers surveyed and interviewed during WP1 stakeholder engagement

Name	Fleet size	Usage pattern	Operating type	Overnight base	Assumed daytime charging location	Contact type
Supermarket home delivery fleet	Large (101+)	**Town:** high mileage, with 2 waves of delivery per day (18 – 20 deliveries per wave), returning to depot in between for reloading **City:** lower mileage, with 4 waves of delivery per day (15 – 20 deliveries per wave), returning to depot in between for reloading	Local (urban areas) or regional	Depot	Private – in depot	Interviewed
Supermarket home delivery fleet	Large (101+)	3 waves of delivery per day for typical vans, returning to depot in between for reloading	Local (urban areas) or regional	Depot	Private – in depot	Interviewed
Parcel delivery fleet	Large (101+)	Delivery to homes. Driver and routes typically similar each day, higher mileages in towns than in cities.	Local (urban areas) or regional	Depot	Public en-route	Interviewed
Home delivery fleet	Large (101+)	Home delivery service, vans typically go out on 1 x 13 hour trip per day. Higher mileages in rural/towns than in cities.	Regional	Depot	Public en-route	Interviewed
Home delivery fleet	Large (101+)	8 – 10 house drops per day	Regional	Depot	Public en-route	Interviewed
Parcel delivery fleet	Large (101+)	Client site delivery, 2 – 3 drops per day. 30 mins to load and unload at customer sites.	Regional	Depot	Public en-route	Interviewed
Roadside assistance fleet	Large (101+)	Roadside assistance dispatched as needed, travelling from job to job. Typically 6 – 11 hour shift, no further than 60km from base	Regional	95 – 98% residential	Public en-route	Interviewed
Infrastructure service fleet	Large (101+)	Highly variable use case – some routine maintenance at Network Rail sites, some responding to an incident often track-side	Regional	90% depot, 10% residential	Private – customer or fleet sites	Interviewed
Infrastructure service fleet	Large (101+)	Highly variable use case, typically stopping at customer sites or Anglian Water sites.	Regional	Mostly residential	Private – customer or fleet sites	Surveyed
Parcel delivery outside service providers	Single van	Home delivery with 70 – 80 stops per day typically, with 2 – 3 miles between stops.	Local (urban areas) or regional	Residential	Public en-route	Interviewed

Delivery of medical goods	Single van	Home delivery service, long distances between drops mostly driven on motorways	National	Residential – off-street	Public en-route	Interviewed
Delivery of printed goods	Single van	Delivery to customer sites, 10 x 10-minute stops per delivery	Local (urban)	Workplace – on-street	Public en-route	Surveyed
Self-employed delivery driver	Single van	Specialised delivery service, stopping ca. 3 – 4 times per day, driving on motorways in between	National	Residential – off-street	Public en-route	Surveyed
Properties maintenance	Single van	4 x 1 – 2 hour stops per day	Local (urban)	Residential – on-street	Private – client sites	Surveyed
School maintenance services	Small fleet – 2 vans	4 x 1.5h stops per day at schools	Regional	Depot	Private – client sites	Surveyed
School maintenance inspection	Small fleet – 2 vans	3 x 2h stops per day at schools	Regional	Residential – on-street	Private – client sites	Surveyed
Construction	Single van	3 x 10 minute stops per day at customer sites	Regional	Residential – on-street	Public en-route	Surveyed

6.2 Survey questions

The following questions were asked van drivers and fleet operators during surveys and interviews.

1. What do you primarily use your van for?
    a. Private use
    b. Work
    c. Other, please specify
2. Which of the following best describes the use of your van for work?
    a. Construction, including electricity & plumbing installation, decorating, etc.
    b. Postal/courier delivery activities
    c. Other, please specify
3. Is your van used privately in addition to its primary work purpose? If so, please give us a brief description of how your van is privately used, including typical purpose of private use, length of private trips, frequency of private trips, and any other relevant information. E.g. van is used weekly for short shopping trips travelling ca. 5 miles, van is used for annual holidays travelling ca. 200 miles each way
4. If your van is registered to your business organisation, how many vans in total are registered to your organisation?
5. What is your van model and fuel type? E.g. diesel Ford Transit, electric Renault Kangoo.
6. Where is your van based overnight?
    a. Workplace depot
    b. At home, parked off-street in a private garage or driveway
    c. At home, parked off-street in a shared garage or driveway
    d. At home, parked on-street

   e. Other, please specify

7. How many days per week on average is your van used for work?
8. What is the average daily mileage (in miles) of your van, when used for work?
9. What is the highest daily mileage (in miles) your van drives semi-regularly for work (e.g. 3 – 5 times per year)?
10. On an average working day, how many stops are made by your van?
11. On a day where your van drives its highest mileage for work (as specified in Q8), how many stops are typically made by your van?
12. How long is an average workday stop?
13. Where are these workday stops typically made? [allow several choices]
    a. Workplace depot
    b. Customer site
    c. On the road in front of a customer's house
    d. Service station
    e. Other, please specify
14. Please comment on any reason that charging at daily stops described above would be impractical
15. Which of the following statements best describes your driving behaviour when working:
    a. I spend most of my time driving on motorways
    b. I spend a lot of my time driving on motorways, but regularly drive in my local area which is urban
    c. I spend a lot of my time driving on motorways, but regularly drive in my local area which is rural
    d. I spend some time driving on motorways and some time driving in my local area which is urban
    e. I spend some time driving on motorways and some time driving in my local area which is rural
    f. I spend a lot of time driving in my local area, which is urban, but regularly drive on motorways
    g. I spend a lot of time driving in my local area, which is rural, but regularly drive on motorways
    h. I spend most of my time driving in my local area, which is urban
    i. I spend most of my time driving in my local area, which is rural
16. Please comment on any charging-related barriers you see as preventing you from adopting an electric van

6.3 Defined archetypes

Proportion of total fleet made up of each archetype calculated from analysis of DfT van survey data[1].

Table 7: Van driver archetypes charging categories and proportion of total fleet

Archetype	Operating type	Overnight charging category	Daytime charging category	Proportion total fleet
1	Local	Residential	Public	12.31%
2	Local	Residential	Private	25.94%
3	Local	Depot	Public	7.80%
4	Local	Depot	Private	8.60%
5	Regional	Residential	Public	1.58%
6	Regional	Residential	Private	21.41%
7	Regional	Depot	Public	7.77%
8	Regional	Depot	Private	2.08%
9	National	Residential	Public	6.97%
10	National	Residential	Private	1.79%
11	National	Depot	Public	0.16%
12	National	Depot	Private	3.60%

6.4 Charging distribution model inputs

6.4.1 Mileage distribution

The model uses the distribution of average daily mileages, as identified from the DfT van survey data[1], to determine the split of daytime and overnight charging. The cumulative distribution of average daily mileages is shown in Figure 42 – note that the DfT van survey only provides average daily mileage, and this is used as the basis of the mileage distribution.

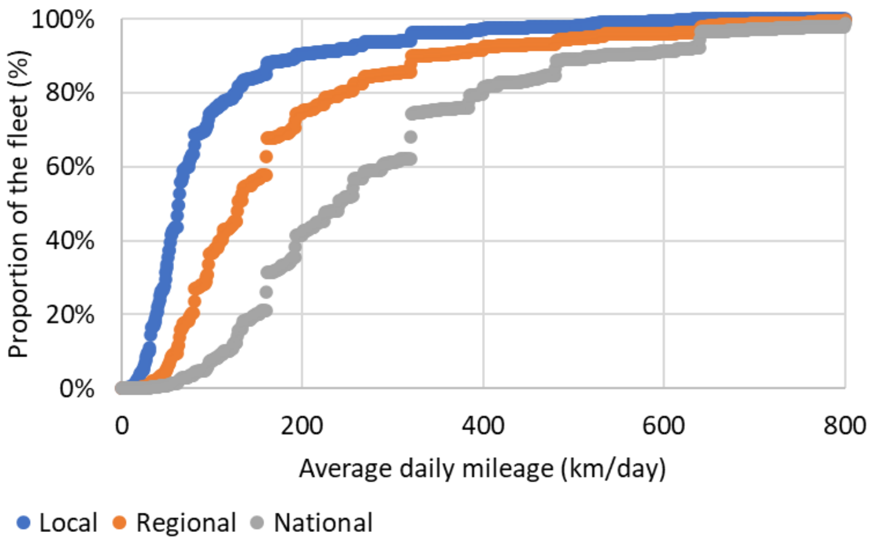

Figure 42: Cumulative distribution of average van daily mileage by operating type[1]

The distribution of average daily mileages is also used as the basis for the distribution of mileages on high mileage days. Previous analysis carried out by EE of telematics data for trucks (Figure 43) shows that a long day can be significantly longer than the average. It also indicates that it is a triangular function of the average daily mileage.

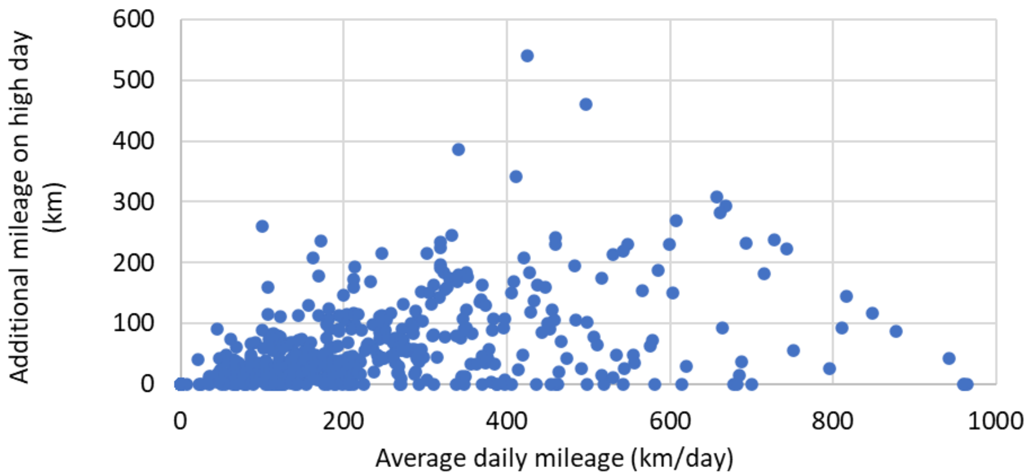

Figure 43: Additional range required on long days as a function of average daily mileage for trucks[27]

To determine the distribution of worst day mileages, the model applies this trend to the average daily mileage distribution of the different operating types. The trend is scaled to match the findings from the van interviews and surveys (max. ratio 2, as shown in section 2.1.2). The worst day mileage distribution is used to determine split of daytime vs. overnight charging demand on worst days.

6.4.2 Van specifications

The charging distribution modelling uses different battery sizes and fuel consumption estimates for the different operating types to best match reality.

In time, BEV van models are expected to be available with different battery sizes. Users are likely to select a battery size which meets most of their mileage requirements, to avoid the inconvenience of daytime top-up charging. As a result, the modelling fits an increasingly bigger battery for local, regional and national operating types. The battery size values are based on EE analysis of market data.

As shown in Figure 44, the battery sizes for each operating type are projected to increase over time to a maximum of 110 kWh in 2030. They are assumed to remain constant over 2030 – 2035. These projections are based on EE's Cost and Performance model and account for the shift from electric vans designed on legacy diesel platforms towards EVs designed around custom platforms which will allow more battery space and therefore a higher capacity battery.

[27] EE analysis of truck telematics data

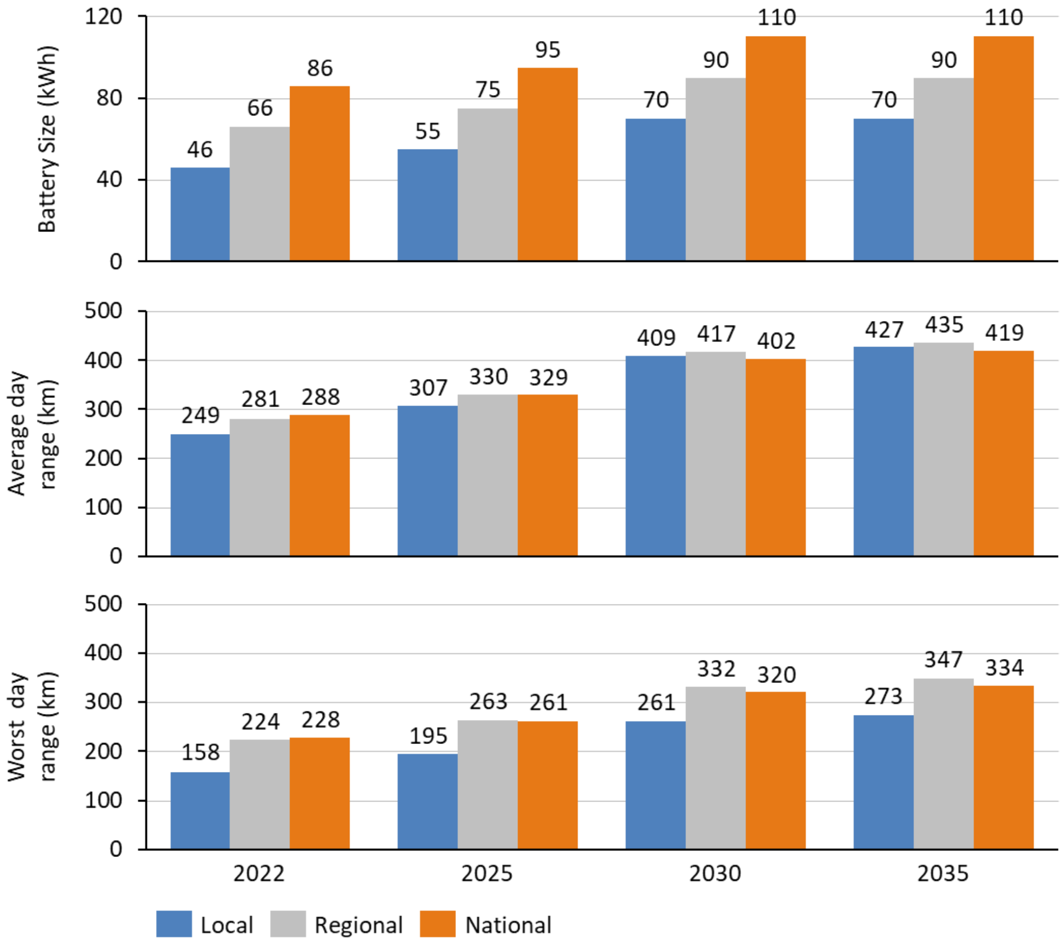

Figure 44: Graphs showing projected van specifications, including battery size and resulting maximum range, over operating type, and the two maximum range assumptions.

Maximum van range is determined by the size of the battery and the vehicle's fuel consumption. EE's Cost and Performance model projects van fuel consumption to vary over 2025 – 2035, with improvements in efficiency and vehicle design. Additionally, fuel consumption is dependent on weather and driving behaviour[28].

Two maximum range scenarios were calculated, one for determining charging mix on average days and one for worst days. On an average day, the weather is assumed to be mild. Local drivers are assumed to be doing urban driving, regional drivers mixed driving and national drivers motorway driving. This leads to the average day range projections, as shown in Figure 44.

On a worst day the weather is assumed to be cold, leading to higher fuel consumption. Local and regional drivers are assumed to be doing mixed driving. National drivers are assumed to be doing motorway driving. These assumptions lead to the worst day mileage projections, as shown in Figure 44.

[28] Adjustment to fuel consumption due to weather and driving behaviour based on values collected by EV-Database.uk

6.4.3 Powertrain projections

The projected electric van stock and split of BEV/PHEV powertrains used in the modelling is based on the CCC's 6th Carbon budget, Balanced Pathway scenario.

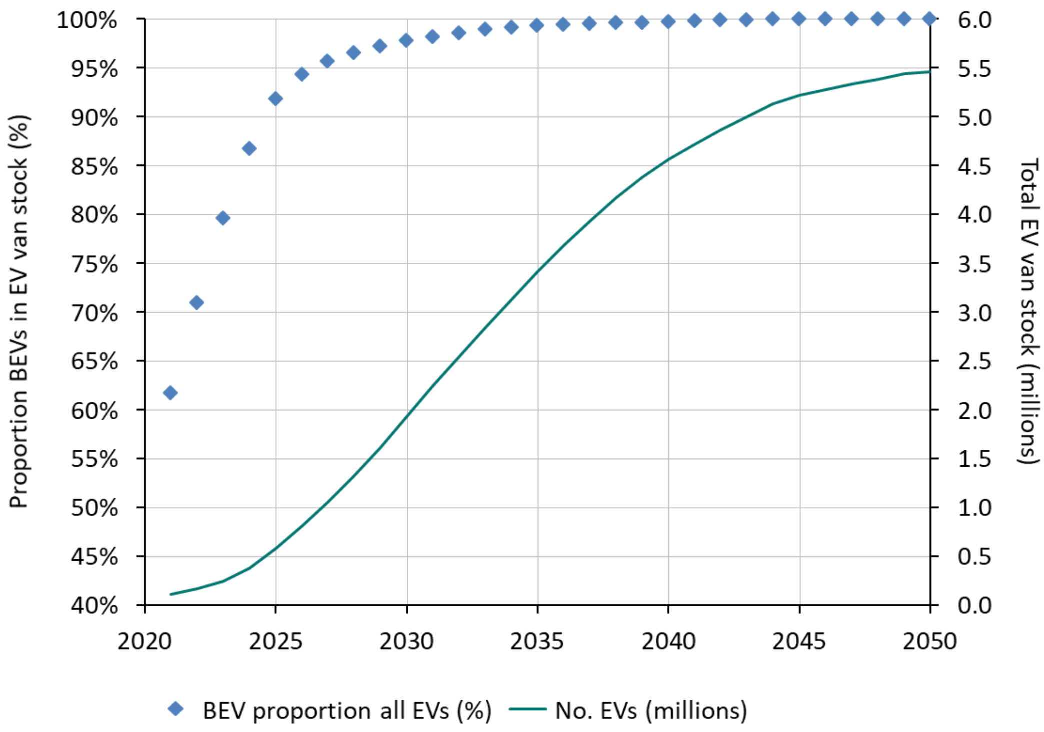

Figure 45: Projected BEV proportion of total electric van stock in the UK (%) and total electric van stock in the UK (millions)[5]

6.5 Car charging assumptions

ICCT car charging mix[2] for cars is used as a comparison with van charging assumptions. Full charging mix is shown in table below.

Table 8: Charging mix for cars, based on ICCT values[2]

Powertrain	Commuting Status	Residential Charging Availability	Residential	On-street residential	Destination	Work	En-route
BEV	Commuter	Yes	70%	0%	5%	20%	5%
		No	0%	35%	10%	45%	10%
	Non-Commuter	Yes	85%	0%	5%	0%	10%
		No	0%	75%	15%	0%	10%

6.6 Charging infrastructure assumptions

6.6.1 Charger specifications

Table with charging infrastructure specification assumptions, based on Element Energy's database of charging infrastructure.

Table 9: Assumed maximum power (kW) of charging infrastructure by charging location and over 2025, 2030 and 2035

Charging time	Charging location	2025	2030	2035
Overnight	Depot	8.5	10.0	11.0
Overnight	Private residential	7.0	7.0	7.0
Overnight	On-street residential	11.0	15.0	20.0
Daytime	En-route rapid charging	125.0	170.0	200.0
Daytime	Forecourt rapid charging	125.0	170.0	200.0
Daytime	Private residential	7.0	7.0	7.0
Daytime	On-street residential	11.0	15.0	20.0
Daytime	Client site	8.5	10.0	11.0
Daytime	Commercial zone	125.0	170.0	200.0

Table 10: Assumed utilisation (hours/day) of charging infrastructure by charging location and over 2025, 2030 and 2035

Charging time	Charging location	2025	2030	2035
Overnight	Depot	6.00	6.00	6.00
Overnight	Private residential	6.00	6.00	6.00
Overnight	On-street residential	1.75	3.00	4.00
Daytime	En-route rapid charging	2.25	4.00	6.00
Daytime	Forecourt rapid charging	2.25	4.00	6.00
Daytime	Private residential	2.00	2.00	2.00
Daytime	On-street residential	1.75	3.00	4.00
Daytime	Client site	6.00	6.00	6.00
Daytime	Commercial zone	2.25	4.00	6.00

6.6.2 Charger load profiles

Unmanaged charging profiles for each charging location are shown in Figure 46, normalised to represent 1 kWh/day demand. Some locations are assumed to have the same normalised demand profile, including forecourt rapid and en-route rapid charge points, private and on-street residential charge points, client site and commercial zone chargers.

These profiles are multiplied by the actual charging demand each day per charging location to give the overall demand profile from van charging.

Smart charging load profile is for depot charge points and residential chargers (both private and on-street) used overnight. This smart profile is shown in Figure 47.

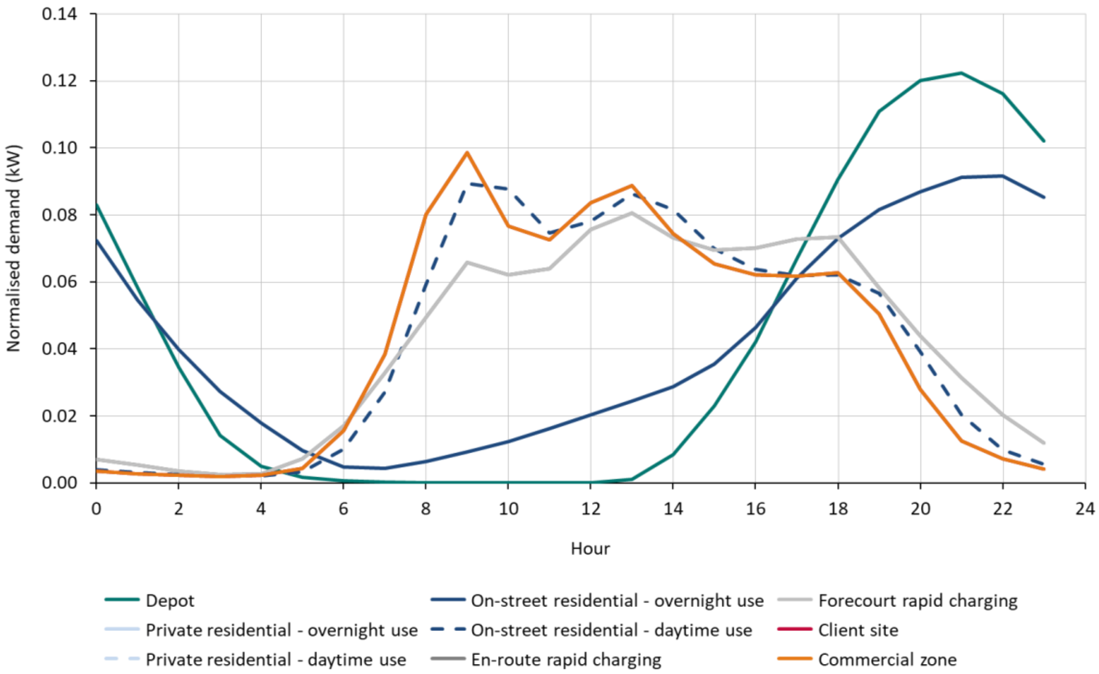

Figure 46: Unmanaged charging load profile by charging location, normalised to 1 kWh/day

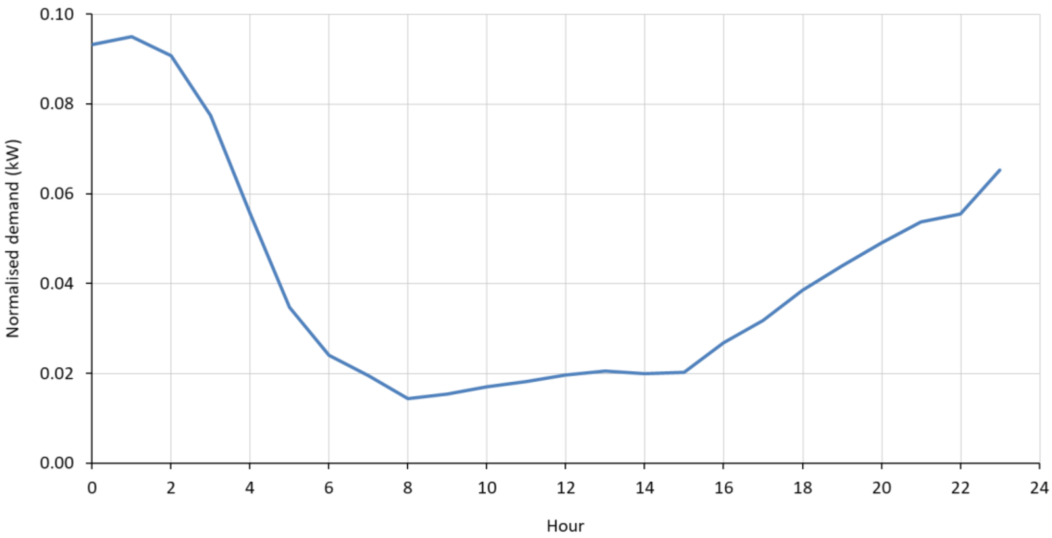

Figure 47: Smart demand profile for depot, private residential and on-street residential chargers, normalised to 1 kWh/day

6.6.3 Infrastructure cost assumptions

For each charging location, hardware, installations and maintenance costs were assumed as shown below. Baseline, low, and high infrastructure cost scenarios were defined for hardware and installation, as shown in Table 11 and Table 13. Annual maintenance cost was assumed constant over these scenarios and over the installation years, as shown in Table 12, and total maintenance cost calculated assuming 15-year lifetime.

Table 11: Assumed charge point hardware cost across low, baseline and high infrastructure cost scenarios, over 2025 – 2035

		Hardware cost (£/charge point)			
Charging location	**Year**	**Baseline**	**Low**	**High**	**Source:**
On-street residential	2025	1288	574	2000	Ricardo, 2022[8] (7 kW on-street residential charger)
On-street residential	2030	3358	2820	4500	Ricardo, 2022[8] (22 kW on-street residential charger)
On-street residential	2035	3358	2820	4500	Ricardo, 2022[8] (22 kW on-street residential charger)
En-route rapid charging	2025	74,875	63,750	86,000	Ricardo, 2022[8] (150 kW en-route rapid charger)
En-route rapid charging	2030	74,875	63,750	86,000	Ricardo, 2022[8] (150 kW en-route rapid charger)
En-route rapid charging	2035	74,875	63,750	86,000	Ricardo, 2022[8] (150 kW en-route rapid charger)
Forecourt rapid charging	2025	74,875	63,750	86,000	Ricardo, 2022[8] (150 kW forecourt rapid charger)
Forecourt rapid charging	2030	74,875	63,750	86,000	Ricardo, 2022[8] (150 kW forecourt rapid charger)
Forecourt rapid charging	2035	74,875	63,750	86,000	Ricardo, 2022[8] (150 kW forecourt rapid charger)
Client site	2025	1750	500	3000	Element Energy, 2022[29]
Client site	2030	1750	500	3000	Element Energy, 2022[29]
Client site	2035	1750	500	3000	Element Energy, 2022[29]
Depot	2025	1750	500	3000	Element Energy, 2022[29]
Depot	2030	1750	500	3000	Element Energy, 2022[29]
Depot	2035	1750	500	3000	Element Energy, 2022[29]
Commercial zone	2025	74,875	63,750	86,000	Ricardo, 2022[8] (150 kW en-route rapid charger)
Commercial zone	2030	74,875	63,750	86,000	Ricardo, 2022[8] (150 kW en-route rapid charger)
Commercial zone	2035	74,875	63,750	86,000	Ricardo, 2022[8] (150 kW en-route rapid charger)
Private residential	2025	839	839	839	Element Energy, 2022[29]
Private residential	2030	839	839	839	Element Energy, 2022[29]
Private residential	2035	839	839	839	Element Energy, 2022[29]

[29] Element Energy charge point cost database, 2022

Table 12: Assumed annual maintenance cost by charger location

Charging location	Annual maintenance cost (£/year)	Source
On-street residential	500	Ricardo, 2022[8] (7 – 22 kW on-street residential charger)
En-route rapid charging	3000	Ricardo, 2022[8] (150 kW en-route rapid charger)
Forecourt rapid charging	3000	Ricardo, 2022[8] (150 kW en-route rapid charger)
Client site	200	Element Energy, 2022[29]
Depot	200	Element Energy, 2022[29]
Commercial zone	3000	Ricardo, 2022[8] (150 kW en-route rapid charger)
Private residential	100	Ricardo, 2022[8] (off-street residential charger)

Table 13: Assumed charge point installation cost across low, baseline and high infrastructure cost scenarios, over 2025 – 2035

		Installation cost (£/EVCP)			
Charging location	**Year**	**Baseline**	**Low**	**High**	**Source:**
On-street residential	2025	3660	716	6000	Ricardo, 2022[30] (7 kW on-street residential charger)
On-street residential	2030	4680	2580	6000	Ricardo, 2022[30] (22 kW on-street residential charger)
On-street residential	2035	4680	2580	6000	Ricardo, 2022[30] (22 kW on-street residential charger)
En-route rapid charging	2025	16,125	16,000	40,000	Ricardo, 2022[30] (150 kW en-route rapid charger)
En-route rapid charging	2030	16,125	16,000	40,000	Ricardo, 2022[30] (150 kW en-route rapid charger)
En-route rapid charging	2035	16,125	16,000	40,000	Ricardo, 2022[30] (150 kW en-route rapid charger)
Forecourt rapid charging	2025	16,125	16,000	40,000	Ricardo, 2022[30] (150 kW forecourt rapid charger)
Forecourt rapid charging	2030	16,125	16,000	40,000	Ricardo, 2022[30] (150 kW forecourt rapid charger)
Forecourt rapid charging	2035	16,125	16,000	40,000	Ricardo, 2022[30] (150 kW forecourt rapid charger)
Client site	2025	2000	1000	3000	Element Energy, 2022[29]
Client site	2030	2000	1000	3000	Element Energy, 2022[29]
Client site	2035	2000	1000	3000	Element Energy, 2022[29]
Depot	2025	2000	1000	3000	Element Energy, 2022[29]
Depot	2030	2000	1000	3000	Element Energy, 2022[29]
Depot	2035	2000	1000	3000	Element Energy, 2022[29]
Commercial zone	2025	40,000	16,000	40,000	Ricardo, 2022[8] (150 kW en-route rapid charger)
Commercial zone	2030	40,000	16,000	40,000	Ricardo, 2022[8] (150 kW en-route rapid charger)
Commercial zone	2035	40,000	16,000	40,000	Ricardo, 2022[8] (150 kW en-route rapid charger)
Private residential	2025	375	375	375	Element Energy, 2022[29]
Private residential	2030	375	375	375	Element Energy, 2022[29]
Private residential	2035	375	375	375	Element Energy, 2022[29]

[30] Ricardo's On-street Charging Study, 2022. Note: it is assumed that charger cost presented is equivalent to cost per charge point, i.e. one charge point per charger.

For total infrastructure cost, the cost of required network reinforcement was defined based on predicted peak load increase, as shown in Table 14.

Table 14: Assumed network reinforcement cost

Type	Cost (£/MW)	Source
Primary substation	400,000	Element Energy, 2022[31]
Secondary substation	50,000	Element Energy, 2022[29]

6.7 Cost of charging to consumers

The cost of charging at each charging location was based on either the findings of the On-street Charging Study[8], market review values, or a calculation of electricity mark-up value. The type of cost to consumer is summarised in Table 15.

Table 15: Cost to consumer calculation type by charging location

Charging location	Cost to consumer source
On-street residential	Ricardo, 2022[8]
En-route rapid charging	Ricardo, 2022[8]
Forecourt rapid charging	Ricardo, 2022[8]
Depot	Electricity mark-up
Private residential	Electricity mark-up
Private residential – shared use during daytime	Market review, or electricity mark-up
Client site	Market review, or electricity mark-up
Commercial zone	Market review, or electricity mark-up

6.7.1 Cost to consumer for public chargers

The cost to consumer for on-street residential, en-route rapid, and forecourt rapid charging was based on the values from the On-street Charging Study[8]. Sensitivities are available for low, baseline, and high utilisation scenarios.

Table 16: Cost to consumer for public chargers

		Cost to consumer (£/kWh)		
Charging location	**Year**	**Baseline**	**High**	**Low**
On-street residential	2025	0.31	0.28	0.38
On-street residential	2030	0.26	0.25	0.29
On-street residential	2035	0.26	0.25	0.29
En-route rapid charging	2025	0.40	0.34	0.56
En-route rapid charging	2030	0.40	0.34	0.56
En-route rapid charging	2035	0.40	0.34	0.56
Forecourt rapid charging	2025	0.34	0.31	0.45
Forecourt rapid charging	2030	0.34	0.31	0.45
Forecourt rapid charging	2035	0.34	0.31	0.45

[31] Reinforcement costs are based on publicly available data from Distribution Network Operators' Statement of methodology and connection charges, as well as other sources including their draft business plans. The cost of a connection can vary significantly depending on the specific circumstances - the data taken gives an indication of typical expected costs.

6.7.2 Electricity mark-up calculations

To calculate the cost to consumers for charging at private residential and depot chargers, a calculation was carried out to determine the mark-up cost on price of electricity. This was calculated using the power and utilisation assumptions set out in Appendix 6.6.1 and assuming a 15-year lifetime. The calculation assumes an IRR of 0%, an annual maintenance cost of 8 £/kW/year, and the infrastructure cost set out in Appendix 6.6.3. Additionally, an average grid connection cost of 200 £/kW was assumed.

The electricity mark-up cost was calculated as follows:

$$Electricity\ mark\ up\ (£/kWh) = \frac{Total\ CAPEX\ (£) + Annual\ OPEX\ (£/year) \times Lifetime\ (years)}{Annual\ utilisation\ (kWh/year) \times Lifetime\ (years)}$$

The resulting electricity mark-up values are show in Table 17.

Table 17: Electricity mark-up cost by charging location

		Electricity mark-up value (£/kWh) by infrastructure cost scenario		
Charging location	**Year**	**Baseline**	**High**	**Low**
Depot	2025	0.04	0.05	0.03
Private residential	2025	0.02	0.02	0.02
Depot	2030	0.04	0.05	0.03
Private residential	2030	0.02	0.02	0.02
Depot	2035	0.03	0.04	0.03
Private residential	2035	0.02	0.02	0.02

The electricity mark-up is added to the cost of electricity to give total cost to consumers of charging. Four electricity cost scenarios were defined, for both domestic and commercial customers. Low, baseline, and high electricity cost scenarios were defined based on BEIS 2020 electricity price scenarios[16]. Commercial electricity purchase price additionally does not include VAT. Electricity prices are shown in Figure 48 across the three scenarios and over 2025, 2030 and 2035.

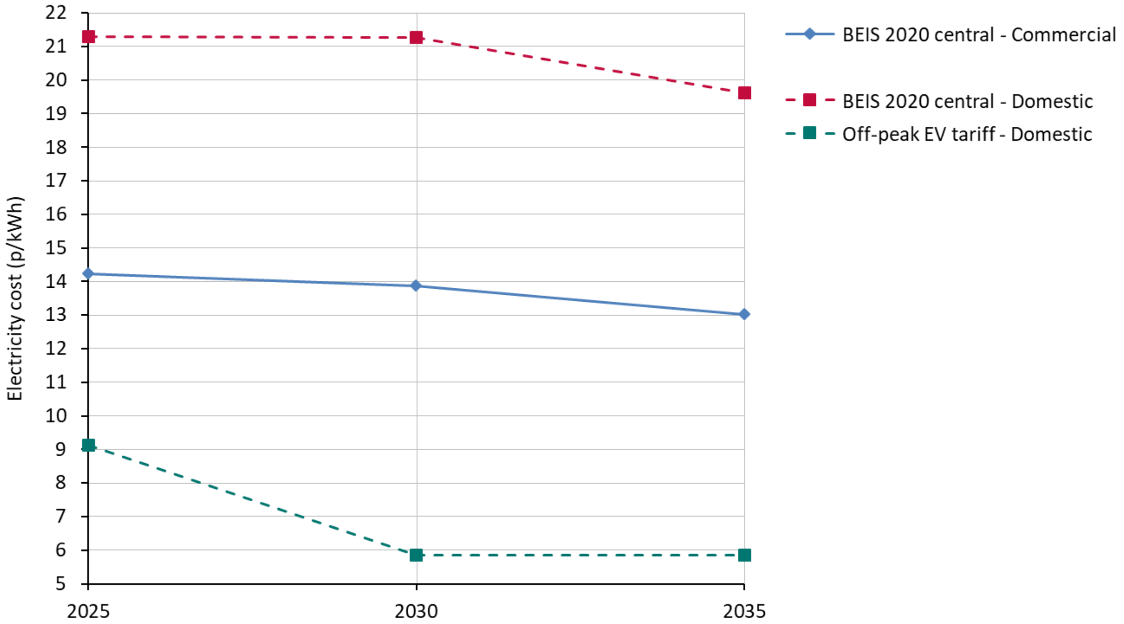

Figure 48: Electricity cost projections over 2025, 2030, and 2035, for commercial and domestic customers from BEIS 2020 projections and calculated off-peak EV tariff

To understand the impact of off-peak EV tariffs available to drivers charging overnight at private residential chargers on overall cost of charging, an off-peak EV tariff was calculated. This was based on the Octopus Go tariff offered by Octopus Energy, which provides an off-peak electricity rate between 00:30 – 04:30 overnight. As a result of the recent energy crisis, the off-peak value of the Octopus Go tariff was raised from 5p/kWh to 7.5p/kWh in addition to a high daily standing charge of 44.48p/day[32]. Modelling assumed that the off-peak rate falls back to 5p/kWh by 2030. The total cost of electricity per kWh using off-peak tariffs was calculated by spreading the daily standing charge over total household electricity consumption (3772 kWh[33]) in addition to electric vehicle consumption (based on Archetype 1's annual private residential overnight charging demand). Modelling used the current Octopus Go daily standing charge of 44.48p/day for 2025, and the UK-wide average standing charge in 2019 of 23p/day[34] for 2030 and 2035. Off-peak EV tariff electricity costs are shown in Figure 48.

6.7.3 Market review values

In addition to the uncertainty around the adoption of business models for sharing of private infrastructure, it is also unclear what will emerge as the dominant business model for sharing of infrastructure. Several platforms currently exist for sharing of private infrastructure, including Zap-Home[17], Zap-Work[18], and Bookmycharge[19]. A review of these platforms, suggests that 3 key business models are emerging:

1. **Electricity-based:** Owners of charge points set a price in p/kWh, so that EV drivers pay for the electricity charged at the shared infrastructure
2. **Session-based:** Owners of charge points set a flat rate for use, so that EV drivers pay a fixed amount for using shared infrastructure regardless of electricity charged

[32] https://octopus.energy/go/rates/
[33] Average annual domestic electricity consumption across UK in 2019, BEIS
[34] Calculated from the average annual fixed cost of £84.39 in 2019 across the United Kingdom, Source: BEIS, Average variable unit costs and fixed costs for electricity for regions in the United Kingdom, Table 2.2.4

3. **Cost recovery:** Owners do not plan to make a profit from offering shared use of charging infrastructure, but suggest a contribution towards the cost of electricity and infrastructure

Table 18: Summary of findings from review of existing platforms for sharing of private infrastructure

Business model	Platform	Charging type	Observed price range
Electricity-based	Zap-Home[17]	Private residential	20 – 60 p/kWh, average 35 p/kWh
Electricity-based	Zap-Work[18]	Workplace, commercial	20 – 150 p/kWh, average 35 p/kWh
Session-based	Zap-Home[17]	Private residential	£2 - £8/session, average £4/session
Session-based	Zap-Work[18]	Workplace, commercial	£1 - £15/session, average £5/session
Session-based	Bookmycharge[19]	Private residential	Recommend £5 - £10/session, most common £5/session
Cost recovery	Zap-Home[17], Zap-Work[18]	Private residential, workplace, commercial	Contribution suggested

The following cost for sharing of private infrastructure is used in modelling, with session-based cost converted from £/session to £/kWh, and cost-recovery cost values based on calculation of electricity mark-up and electricity costs.

Table 19: Cost of charging at shared private infrastructure

Location	Business model	Year	Cost (£/kWh)
Client site	Electricity-based	2025	0.35
Commercial zone	Electricity-based	2025	0.35
Private residential, shared use during daytime	Electricity-based	2025	0.35
Client site	Electricity-based	2030	0.35
Commercial zone	Electricity-based	2030	0.35
Private residential, shared use during daytime	Electricity-based	2030	0.35
Client site	Electricity-based	2035	0.35
Commercial zone	Electricity-based	2035	0.35
Private residential, shared use during daytime	Electricity-based	2035	0.35
Client site	Session-based	2025	0.29
Commercial zone	Session-based	2025	0.02
Private residential, shared use during daytime	Session-based	2025	0.54
Client site	Session-based	2030	0.25
Commercial zone	Session-based	2030	0.01
Private residential, shared use during daytime	Session-based	2030	0.54
Client site	Session-based	2035	0.23
Commercial zone	Session-based	2035	0.01
Private residential, shared use during daytime	Session-based	2035	0.54
Client site	Cost-recovery	2025	0.18
Commercial zone	Cost-recovery	2025	0.31
Private residential, shared use during daytime	Cost-recovery	2025	0.26
Client site	Cost-recovery	2030	0.18
Commercial zone	Cost-recovery	2030	0.21
Private residential, shared use during daytime	Cost-recovery	2030	0.26
Client site	Cost-recovery	2035	0.16
Commercial zone	Cost-recovery	2035	0.17
Private residential, shared use during daytime	Cost-recovery	2035	0.25

6.7.4 Car charging location costs

The cost of charging at each charging location was based on either the findings of the On-street Charging Study[8], market review values, or a calculation of electricity mark-up value. The type of cost to consumer is summarised in Table 15.

Table 20: Cost to car driver by charging location

Charging location	Cost (£/kWh)	Cost to consumer source
On-street residential	0.26	Ricardo, 2022[8]
En-route rapid charging	0.40	Ricardo, 2022[8]
Destination	0.29	Ricardo, 2022[8]
Private residential	0.23	Electricity mark-up
Workplace	0.18	Electricity mark-up