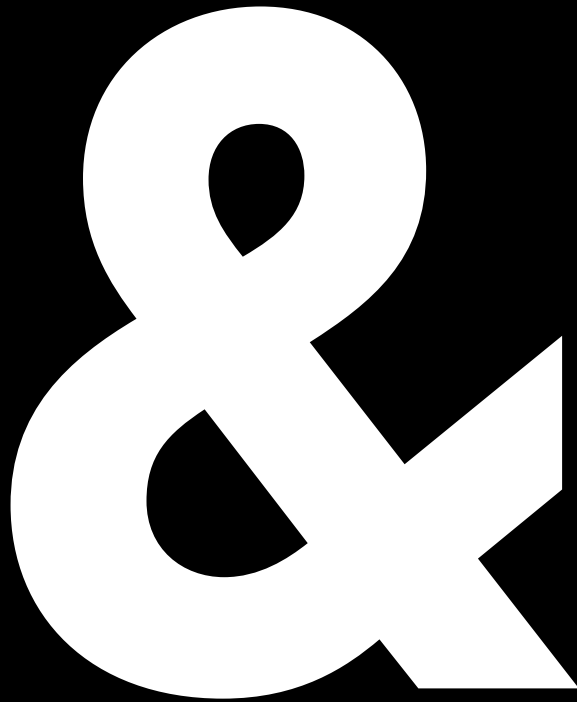


strategy&

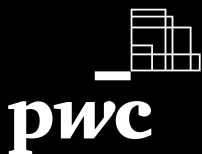


Consumer Research into Rapid Charging

**Conducted by PwC Strategy&, in association with
Complete Strategy Ltd**

Commissioned by National Grid

May 2019



Important Notice

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Executive Summary

Consumers would feel more comfortable purchasing an EV knowing they had access to a rapid charging network

We defined “range anxiety” as the perception of relative inconvenience of driving an EV that impacts buying decisions

We sought to distinguish between the experience of the car and the charging experience

- **EV car experience** – The extent to which buying decisions are influenced by drivers’ access to journey management software, by battery capacity and by the range of the EV.
- **Charging experience** – The extent to which (potential) buyers are influenced by:
 - The presence of a widespread interoperable charging infrastructure
 - Charging speeds.

We reviewed available research to test our hypotheses on rapid charging and range anxiety

We formulated two hypotheses and found a number of studies to be particularly relevant

- We formulated two hypotheses:
 - **Hypothesis 1** – The perceived inability to complete any journey in the UK as conveniently as in an internal combustion engine is a major barrier to EV uptake
 - **Hypothesis 2** – Rapid chargers are an effective method of improving perceptions that EVs can complete any journey in the UK as conveniently as an ICE.
- We reviewed 45 sources of research. These sources included surveys, articles, commercial, industry and government reports. We assessed the extent to which each study was relevant, applicable and reliable to testing these hypotheses.
- A number of studies were particularly relevant: Baringa, confused.com and the AA Populus Driving Survey.

We found that range anxiety is a key barrier to EV uptake and that a rapid charging network could help alleviate consumer range anxiety

Rapid charging has an important role to play ... although there are gaps in the research

- We found the research supported Hypothesis 1, with **nearly all surveys identifying range anxiety as a key barrier** to EV uptake.
- We also found that **a motorway rapid charging network could help range anxiety** for non-EV drivers with some of the sources reviewed confirming this.
- Research suggested **that reduced charging times** are the one charging infrastructure **improvement that EV users most desire**.
- **There is a significant gap in research into the attitudes of business drivers and fleet operators**. Little research has been directed at the business community and the research that is available does not score well on relevance or applicability.

Contents

1. Introduction
2. What we did and our scoring criteria
3. Findings from our research
4. Gap analysis
5. Next steps
6. Appendix

1. Introduction

Our objective and key hypotheses

Purpose of project

Objective

1

Objective

Clarify whether **existing research** into **customer EV buying behaviour** provides **robust evidence** that the lack of a network of **motorway rapid chargers** is a **barrier to uptake of EVs**

Hypotheses

1

Hypothesis 1

The **perceived inability to complete any journey in the UK as conveniently as in an ICE** is a **major barrier to EV uptake**

2

Hypothesis 2

Rapid chargers are an **effective method of improving perceptions that EVs can complete any journey in the UK as conveniently as an ICE**

Research

1

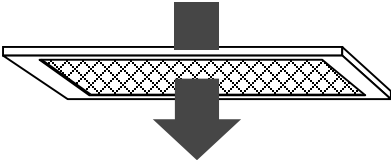
Hypothesis 1

Does existing research support Hypothesis 1?

2

Hypothesis 2

Does existing research support Hypothesis 2?



Gap

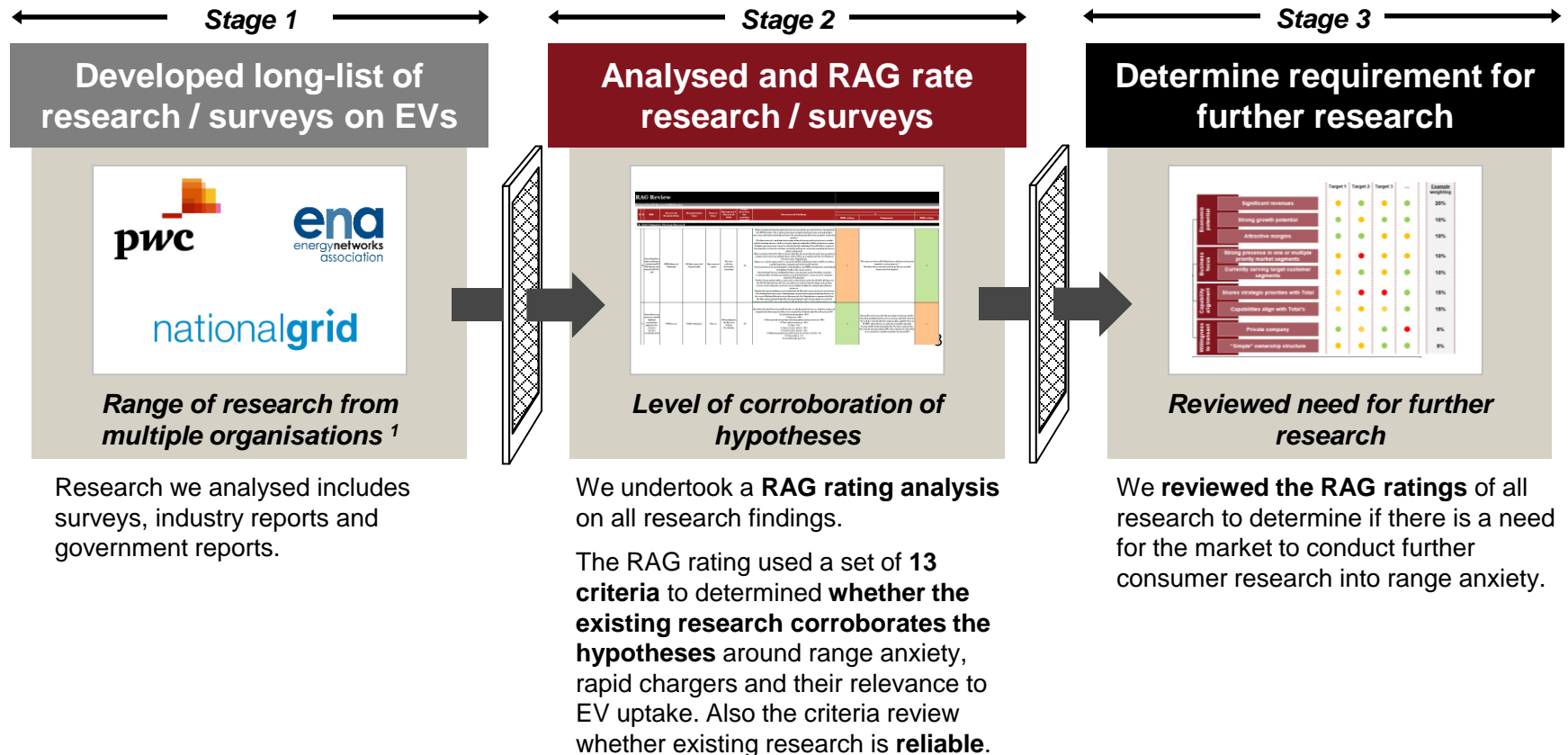
Is there a gap in the existing research of EV buying decisions?

We reviewed a range of existing research to determine if there is a gap in the research on EV consumer behaviour.

2. What we did

We worked across three stages to analyse existing research and determine if any gaps exist

Framework process



We assessed the extent to which each research project was applicable to our two hypotheses

RAG Framework

Scoring Factors		Red	Amber	Green	N/A
RAG scoring (points assigned in framework)		1 point	3 points	5 points	0
1)	Does the research have an appropriate definition for range anxiety?	No explicit reference of range anxiety	Range anxiety referenced in context of range limitations	Range anxiety referred to as a misperception	N/A
2)	Does the survey include rapid chargers?	No	N/A	Yes	N/A
3)	Does the research identify range anxiety as a major barrier to EV uptake?	No mention	Can be inferred but not explicitly stated	Explicitly stated	N/A
4)	Does the research identify any other key barriers to EV uptake?	Yes - multiple other reasons	Yes - one other reason	No other reasons	N/A
5)	To what extent is the research solely focused on range anxiety?	Low level	Medium level	High level	N/A
6)	Does the research identify rapid chargers as an effective method to reduce range anxiety?	No mention	Can be inferred but not explicitly stated	Explicitly stated	N/A
7)	Is this research UK specific?	No mention of UK	UK part of sample	Contains UK deep dive	N/A
8)	How recent is the research?	3+ years	3 > x >= 1 years	< 1 years	N/A
9)	How robust is the sample size?	0-99	100-299	300+	N/A
10)	How reliable is the publisher/survey source?	Online, untraceable source	EV player but possible conflict of interest or bias	Govt. organisation, major EV player or major market research firm	N/A
11)	Is the research segment specific (only B2C / only B2B focus)?	No focus	Only one of B2B/C	Both B2B/C	N/A
12)	Does the research provide varied data on different driver types?	No focus on different driver types	Some data on different driver types	Looks at all types of drives e.g. school runs, fleet (van, lorry) drivers, taxis	N/A
13)	If this is a survey, how many of the "right type" of questions we would ask (see Appendix) have been answered (/9)?	Not RAG, mark /9	Not RAG, grade /9	Not RAG, grade /9	N/A

Our research covered sources produced by a range of organisation types

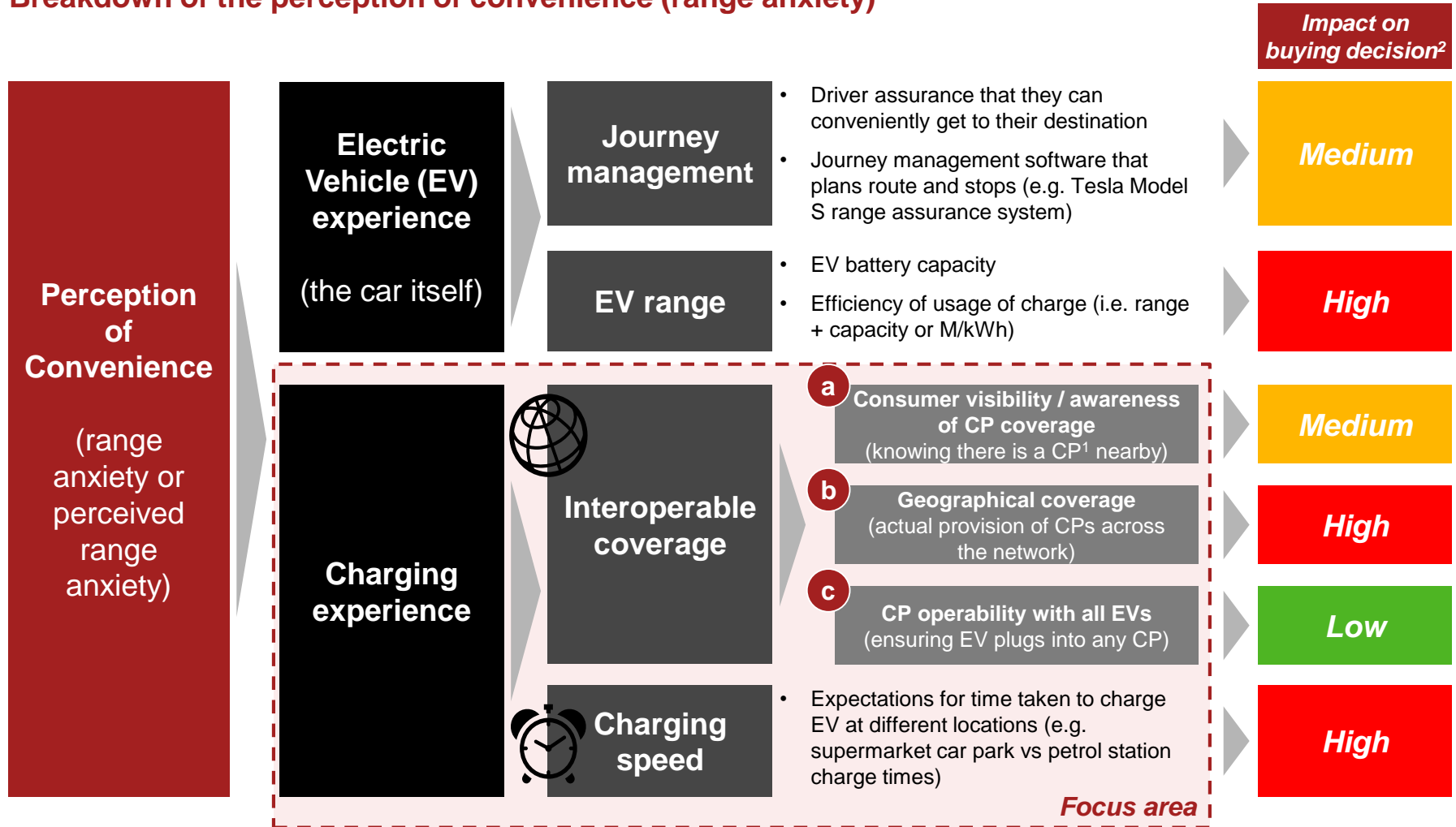
Research organisations covered as part of research

	Academic Institution	✓		Media Organisation	✓
	Charge Point Operator	✓		OEM / Car Manufacturer	✓
	Consumer Rights Group	✓		Other Automotive Company	✓
	Energy Network Specialist	✓		Road Association	✓
	EV Specialist	✓		Trade Association	✓
	Independent International Organisation	✓		UK Government Organisation	✓
	Market Research Firm	✓		Utility Company	✓

3.1 Summary of key range anxiety research findings

We defined range anxiety as a perception of EV driving convenience that impacts buying decisions

Breakdown of the perception of convenience (range anxiety)



And our findings showed that range anxiety is a barrier but rapid charging is one of several solutions

High level results of our analysis from the 45 sources we reviewed

Hypotheses

Results of our research

What consumers say

1

Hypothesis 1

The perceived inability to complete any journey in the UK as conveniently as in an ICE is a major barrier to EV uptake

Proven

Hypothesis 1 was proven, with perceived range anxiety, whether a consumer myth or a real issue, a universally acknowledged barrier to EV uptake for non-EV drivers

EV owners¹...

- do not consider range anxiety an issue for themselves²
- cite environmental motivations** as the main driver behind their adoption of BEVs²



Non-EV owners...

- cite a lack of geographical coverage of charging infrastructure (in relation to perceived range anxiety)** as a major barrier³
- have a **number of other concerns in purchasing an EV** of equal, if not greater importance, including **high EV sticker price, a lack of model choice and availability of vehicles**⁴



2

Hypothesis 2

Rapid chargers are an effective method of improving perceptions that EVs can complete any journey in the UK as conveniently as an ICE

Proven

The research indicates that the presence of rapid chargers would go some way to addressing the concerns of existing and potential EV owners.

EV owners¹...

- say that **improved charging times would improve their EV charging experience the most**²





Non-EV owners...

- identified **improved geographical coverage of charge points as the most effective solution to perceived range anxiety with 15 of 45 sources** reviewed confirming this⁴
- suggest that **rapid charging could also alleviate range anxiety**, however fewer sources reviewed (7 of 45) identified this as the most or one of the most effective methods⁵



With our three top scoring sources showing rapid chargers could alleviate elements of range anxiety

Key: Out of scope

Barriers	AA Survey	Confused.com Survey	ZapMap 2018 ¹ Survey
<p>1 EV Cost and Availability</p> <ul style="list-style-type: none"> i. High sticker price (upfront cost) ii. High running costs (e.g. high cost to charge, high cost of specialised parts, expensive battery repair) iii. Lack of availability of vehicles 	<p>83% of respondents claim price is one of their top 3 concerns</p>	<p>59% of respondents claim high stick price is a factor discouraging them from EV purchase</p>	<p>55% say the cost of buying and electric car is too high</p>
<p>2 EV Battery Range and Battery Life</p> <ul style="list-style-type: none"> i. Current average battery range is c.250 miles (vs. 400-mile ICEs) ii. Short battery life is a barrier to development of second-hand market, which will delay uptake 	<p>43% of respondents demand a “real world driving range” of at least 250 miles</p>	<p>“Concerns around the availability of charging points [are] tied to... the range of an electric car”</p>	<p>48% say inability to travel sufficient distance on one charge is a main barrier</p>
<p>3 Charging Infrastructure</p> <ul style="list-style-type: none"> i. Interoperable coverage  <ul style="list-style-type: none"> a Lack of consumer visibility / awareness of CP coverage (knowing there is a CP nearby) b Lack of geographical coverage (6999 locations in the UK today⁷) c Lack of CP operability with all EVs ii. Charging speed  <p>Too much time taken to charge EV (particularly in locations where consumers typically do not want to spend a lot of time e.g. petrol stations – refuelling ICE vehicles takes c. 7mins)</p> 	<p>80% of respondents claim a lack of CPI coverage is one of their top 3 concerns</p> <p>79% of respondents claim a lack of rapid chargers at motorways for long distance driving is one of their top 3 concerns</p>	<p>72% of respondents would not consider an EV on the basis of inadequate UK charging infrastructure</p> <p>61% said that long charging times would discourage them from purchasing an EV</p>	<p>46% of respondents said the lack of a public charging point near their home was a main barrier</p> <p>36% said that it takes too long to recharge an EV battery</p>

Range Anxiety

But other sources reflect that there are a variety of other solutions for range anxiety

← Hypothesis 1 →		← Hypothesis 2 →		Key: Out of scope
Barriers	Solutions	Urgency	Addressed?	
1 EV Cost and Availability				
<ul style="list-style-type: none"> i. High sticker price (upfront cost) ii. High running costs (e.g. high cost to charge, high cost of specialised parts, expensive battery repair) iii. Lack of availability of vehicles 	<ul style="list-style-type: none"> • State / Government intervention: Fiscal incentives (e.g. subsidies for upfront EV costs, import/road/VAT tax exemptions)⁶ • Market: Economies of scale and tech advancements, lower battery costs 	<p style="text-align: center;">High: Short-term need to address</p>	<p style="text-align: center; color: #e61e20;">Partially</p> <ul style="list-style-type: none"> • Need continued and new Govt. grant / exemption schemes (e.g. £3500 Plug-in Grant to 2020, £20m taxi grant funding, 2% Bik + 100% FYA⁵) 	
2 EV Battery Range and Battery Life				
<ul style="list-style-type: none"> i. Current average battery range is c.250 miles (vs. 400-mile ICEs) ii. Short battery life is a barrier to development of second-hand market, which will delay uptake 	<p>Market development / Private sector:</p> <ul style="list-style-type: none"> • Focus on car manufacturers to tackle • Achieved through economies of scale in EV production, improving battery technologies and capacities, improved EV efficiency 	<p style="text-align: center;">Medium: Short to mid-term need to address</p>	<p style="text-align: center; color: #e61e20;">Partially</p> <ul style="list-style-type: none"> • Most manufacturers have developed battery tech for 200 to 300-mile ranges • When this becomes cost competitiveness is now key 	
3 En-route Charging Infrastructure				
<p>i. Interoperable coverage </p> <ul style="list-style-type: none"> a Lack of consumer visibility / awareness of CP coverage (knowing there is a CP nearby) b Lack of geographical coverage (6999 locations in the UK today⁷) c Lack of CP operability with all EVs 	<ul style="list-style-type: none"> a Publicise to educate the public on benefits and availability of CPs b Install rapid CPs focusing on network gaps (e.g. motorways/ rural areas) – AEVB² mandatory for CPs in petrol stations / motorway service stations c Government : AEVB² standardising requirements for CP interoperability 	<p style="text-align: center;">Medium: High need to educate public now. Need for chargers to plug network gaps in the mid-term</p>	<p style="text-align: center; color: #e61e20;">Partially</p> <ul style="list-style-type: none"> • Building regulation changes increasing coverage and visibility³ • Gov. funding growing on-street resi CPs • NCR⁴ database to learn user habits • £40m gov. grant: wireless charging • 'Go Ultra Low', 'RTZ'⁸ comms campaign • AEVB²: interoperability and multiple CPs at petrol stations / motorway services 	
<p>ii. Charging speed </p> <p>Too much time taken to charge EV (particularly in locations where consumers typically do not want to spend a lot of time e.g. petrol stations – refuelling ICE vehicles takes c. 7mins)</p>	<ul style="list-style-type: none"> • Private funding or Govt. provision to install more rapid DC CPs with significant coverage and publicity. Will also reduce wait times. • Strategic investment in connection infrastructure for CPs to enable > 300kW power capacity to meet speed of charge needs for all EVs (e.g. E-HGV charging) 	<p style="text-align: center;">Medium: No urgency for >200kW CPs, but RCs will improve EV driver experience and drive EV adoption</p>	<p style="text-align: center; color: #e61e20;">No</p> <ul style="list-style-type: none"> • There are not enough rapid CPs to meet current demand for faster charge times (4366 RCs in 1393 UK locations⁷) • Charging Infrastructure Investment Fund; £400m to spend on CPI but not clear what this will target 	

Range Anxiety 1

3.2 Key range anxiety research case studies

Our ten highest scoring sources all identified range anxiety as a key barrier to EV adoption

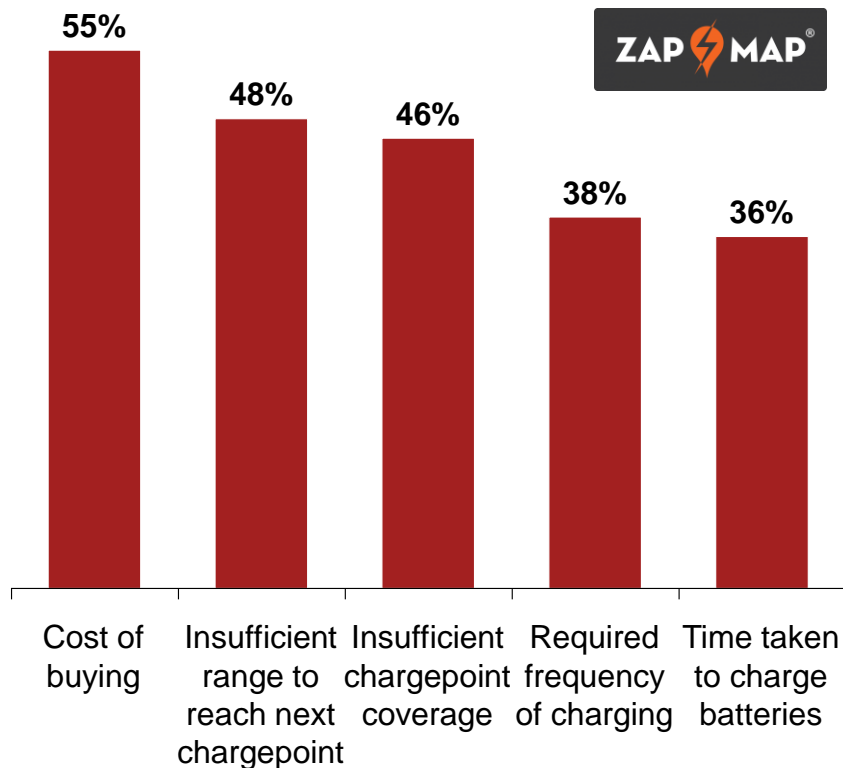
High level findings of our analysis from the top 10 out of 45 sources we reviewed

Source	Source Type	Score (/69)	Summary of key findings
Baringa	Survey	58	<ul style="list-style-type: none"> States that range anxiety is the second biggest barrier for EV (cost was identified as the greatest barrier)
Confused.com	Industry Report	50	<ul style="list-style-type: none"> Cites range anxiety as the number one barrier to EV adoption Suggests that improved coverage of CPI¹ as most effective solution
AA Populus Driving Survey	Survey	50	<ul style="list-style-type: none"> Finds that the number one factor that would convince AA non-EV drivers to purchase an EV is a 'real world' driving range of >250 miles
AutoTrader	Market Report	49	<ul style="list-style-type: none"> Quotes Steve Hood, Director of EVs at Ford Europe who suggests that increased rapid charging coverage will help dispel the range anxiety myth
European Federation for Transport and Environment	Commercial Report	46	<ul style="list-style-type: none"> States that being able to recharge cars within the recommended driving break time is expected to be a game changer for market uptake
OVO Energy	Survey	45	<ul style="list-style-type: none"> Reports that lack of charging points was identified as the largest barrier to EV uptake by the 2000 respondents to its 2017 survey
AA public attitudes article	Article	44	<ul style="list-style-type: none"> Highlights that range anxiety is a myth but concedes that 85% of its survey respondents said there wasn't enough CPI coverage
Department for Transport (ONS)	Government Report	44	<ul style="list-style-type: none"> Identifies range anxiety along with high sticker prices as the primary barrier to EV adoption in the UK
Automotive World	Industry Report	43	<ul style="list-style-type: none"> Mentions that Ford believe that a rapid charging infrastructure (e.g. Ionity) is a specific antidote to the perceived relative inconvenience of driving EVs
Department for Business, Environment and Industrial Strategy	Government Report	41	<ul style="list-style-type: none"> Suggests that rapid charging points on motorways will be instrumental in reducing range anxiety, particularly in rural areas

Subject of following 3 slides

With our highest scoring source, Baringa, identifying rapid charging as a key alleviator of RA

Main barriers to EV ownership (% of respondents who consider a barrier)



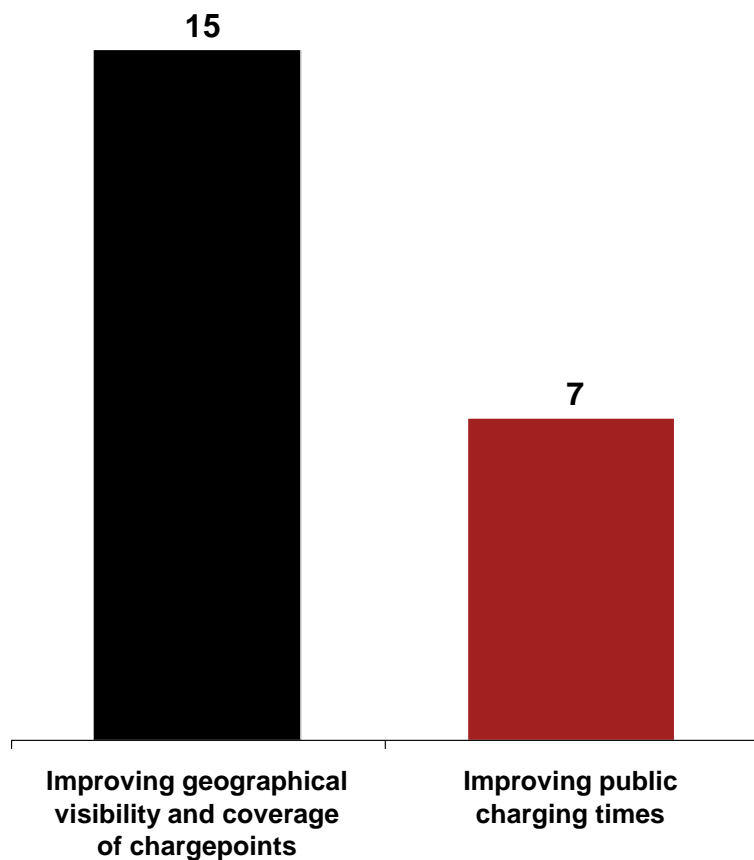
Case study: Baringa

- Baringa highlight the **important role rapid charging infrastructure will have in EV uptake**, citing results from a 2018 ZapMap survey (*see right*)
- They suggest that the **average maximum amount of time** consumer drivers would be **willing to wait in order to charge** in-transit is **just 13 minutes**
- They also mention that **the technology to facilitate this already exists**, with ABB's 350kW chargers already able to add 200km of range to a car in 8 minutes
- Identify that **proper selection and evaluation of appropriate locations for ultra-fast DC charging should be a consideration for Charge Point Operators**, citing moves by the Ionity¹ collaboration and Pivot Power



While Confused.com identified geographical visibility as most effective at reducing perceived RA

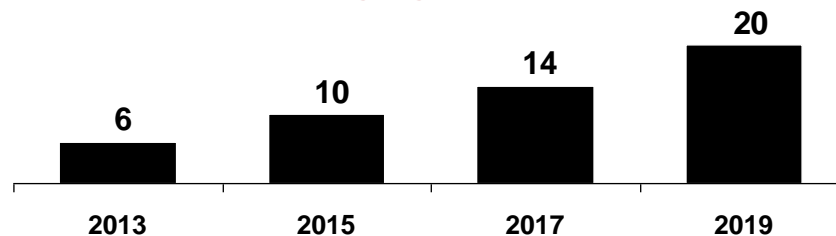
Most effective methods for reducing range anxiety (number of sources reviewed)



Case study: **Confused.com**

- 72% of respondents to the survey would not consider purchasing an EV on the basis of **inadequate UK charging infrastructure**
- Confused suggest that while range anxiety is a myth, improved charging point visibility and coverage are still needed to help drive EV adoption
- However, Confused go on to suggest that **charging point coverage is likely to improve with time regardless**, citing Zap Map data (*see below*)

Number of UK Charging Points¹ ('000s)





The AA monthly survey was the next highest scoring source, citing a need for motorway rapid chargers

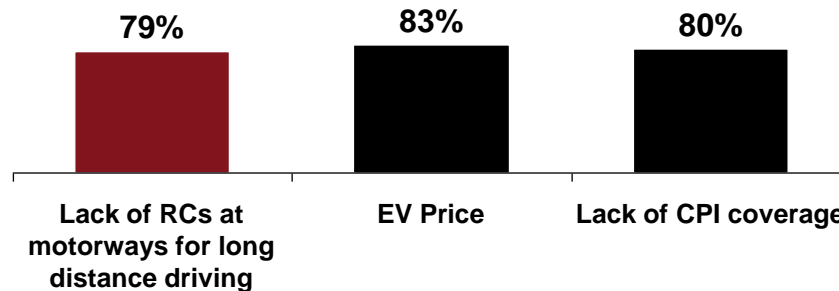
Case study background:

- Highlights from the AA's **2018 and 2019** monthly Driver Poll surveys
- EVs were largely discussed through **May - Sept 2018**
- The AA partners with market research experts **Populus**
- The poll is the **largest** dedicated **motoring opinion panel in Europe**.
- There were on average **c.10,000 respondents** for each monthly survey
- As this report was finalised a newer AA poll shows that en route Rapid Charging is **one of the top three factors** policy makers can influence to increase uptake of EVs¹

Case study findings:

- **43%** of respondents demand a “real world driving range” of at least **250 miles²**
- **31%** cited rapid charging at petrol stations (30 minutes to reach 80%) as one of **top 3 preferences**
- But only a very **small proportion** intend to use a plug in **hybrid (5%)** or go **pure electric (3%)** in their next car

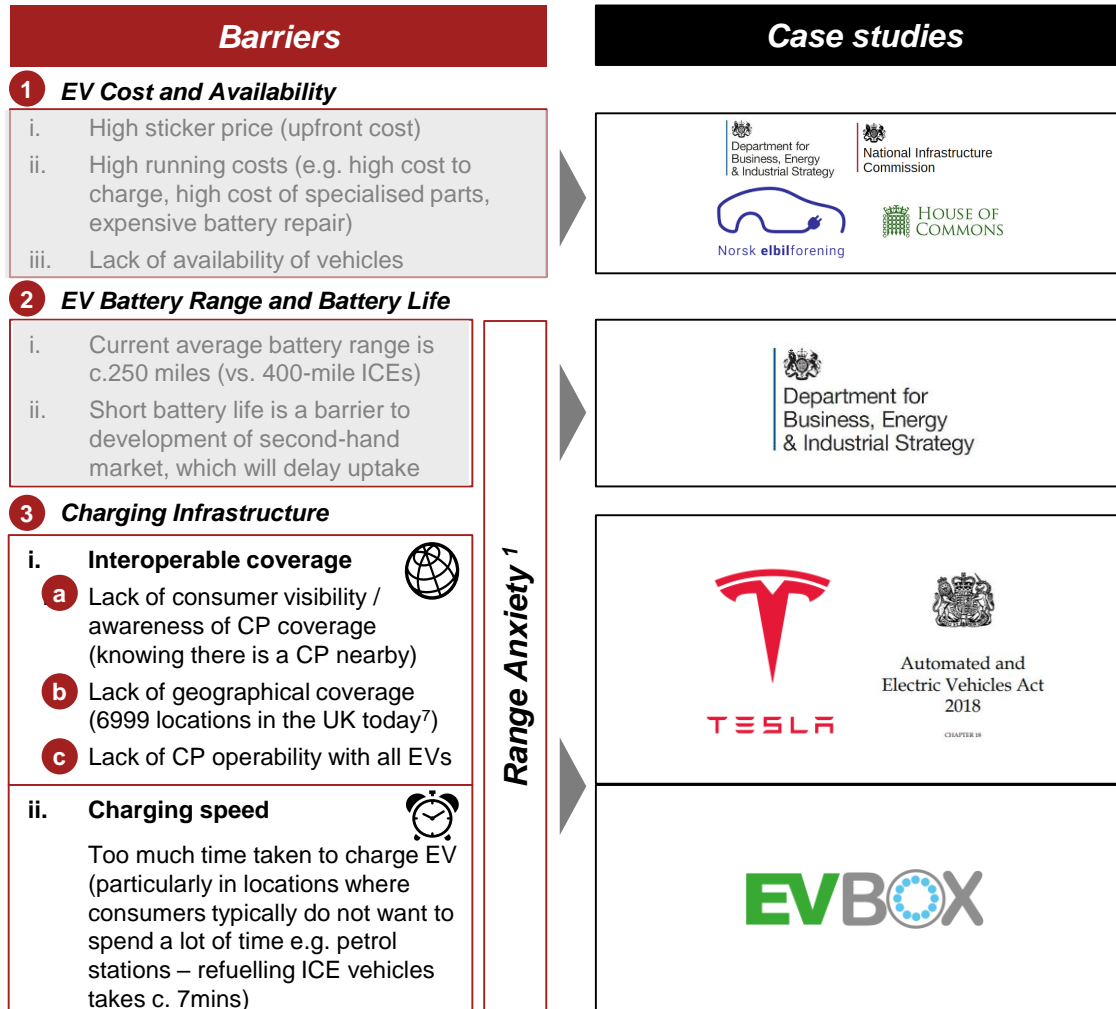
Main Non-EV owner EV purchasing concerns (%)



3.3 Other relevant case studies

We also found other interesting case studies relevant to range anxiety and other EV barriers

Key: Out of scope



Range Anxiety ¹



For example, Tesla drivers cite national coverage and reliability as reasons for high satisfaction rates

Tesla destination chargers, UK

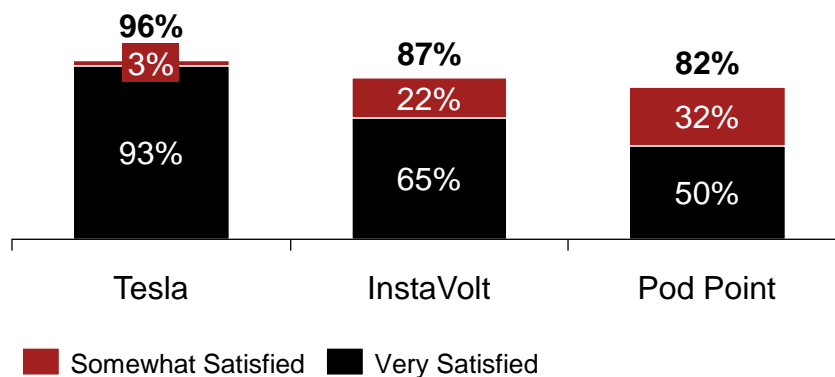


Case study:



- Survey suggests that **reliability and national coverage** are reasons that **93%** of respondents were **'very satisfied'** with the Tesla Supercharger network
- Ensuring reliability of performance and speedy repairs are key to maintaining visibility of CPs with customer base

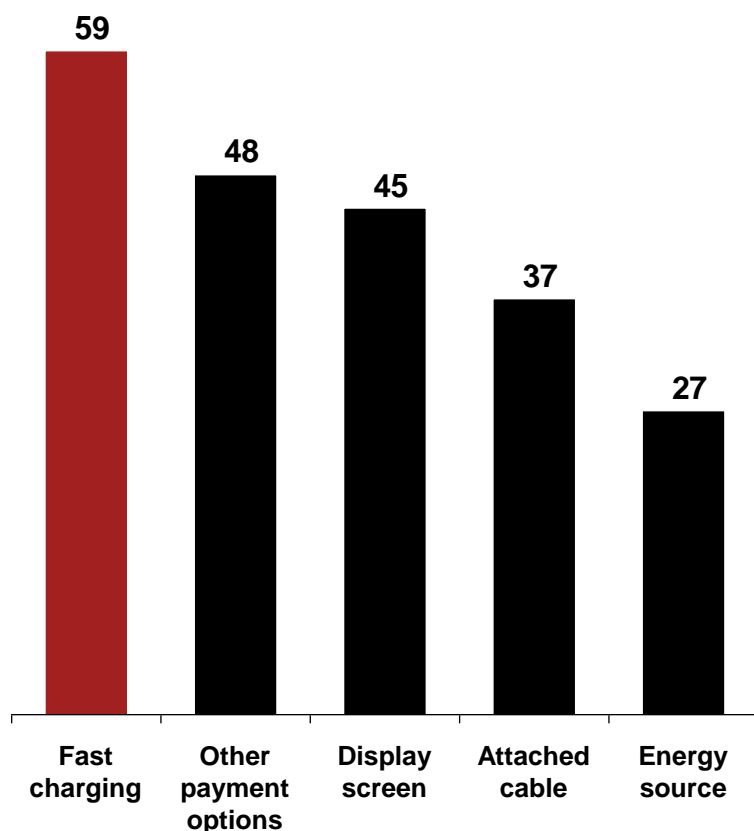
'Satisfied' customers of UK CP networks 2018¹ (%)





We also found that charging time is the public charge point improvement EV users most desire

EV users' most requested features for a public charging station (% of respondents)



Case study: **EVBOX**

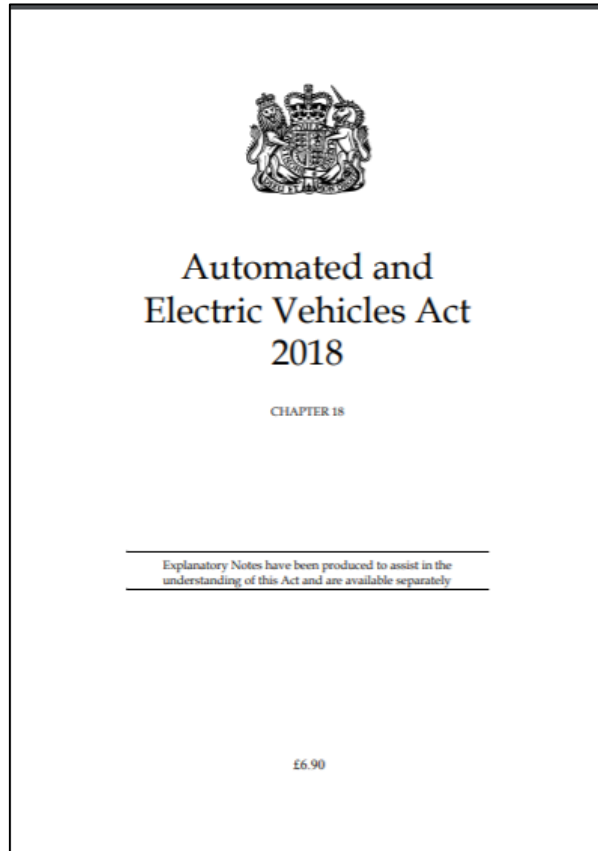
EVBox surveyed 850 EV (*BEVs with >100km range*) users and found that:

- **55%** of respondents have **never used a fast charging station**
- **42%** respondents say that **the largest incentive to buying a personal charger is faster charging**, 4x higher than next largest incentive (safer charging)
- **47%** said they were **dissatisfied with current EV infrastructure**
- **51%** said they had purchased an EV in order to contribute to a sustainable future

“Do electric drivers expect charging to be something like refuelling? They do favour speed over everything else, so it does seem like this is the case.” - EVBox



Charge point interoperability is another issue for EV drivers but is being addressed in the UK



The Automated and Electric Vehicles Act 2018

Aim

UK to become a world leader in the rollout of low-emission transport:

- Improvement of electric charging infrastructure across the country
- Motorway services upgrades
- Insurance rule modernisation to cover self-driving vehicles

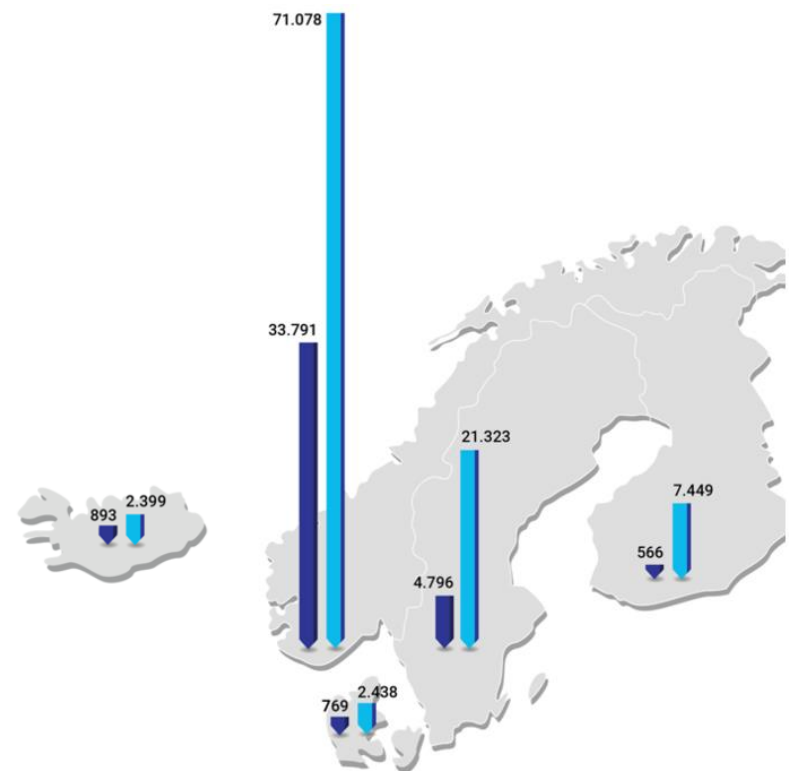
How?

Increase consumer confidence in EV charging by:

- ensuring public charge points are compatible with all vehicles
- standardising payment at charge points
- setting standards for reliability

In terms of the cost barrier, Norway has shown that fiscal incentives are effective in driving EV uptake

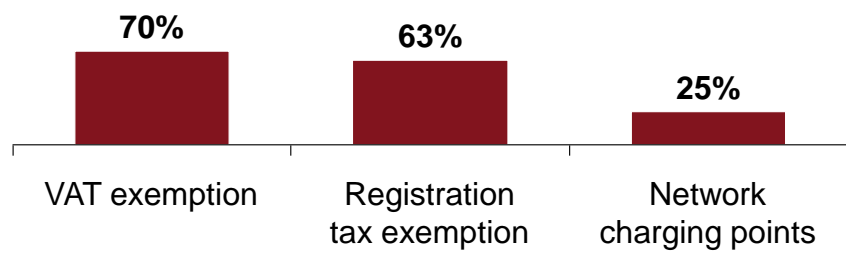
Nordic EV barometer: estimated electric car sales 2017 - 2018



Case study: Norsk elbilforening

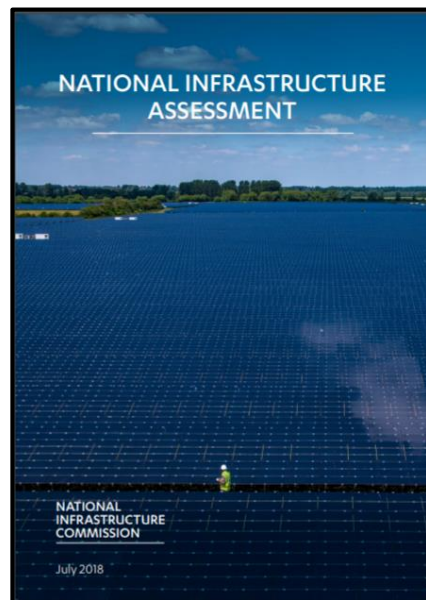
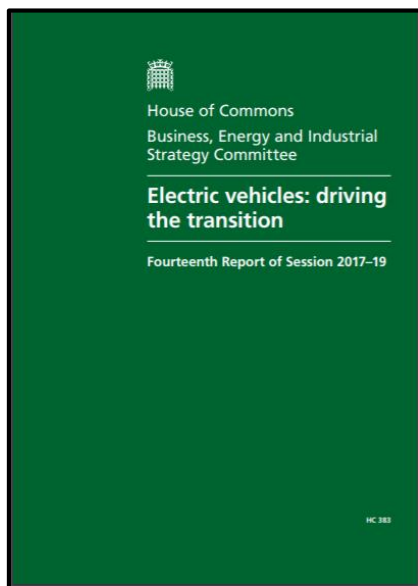
- In Nordic countries (particularly Norway which boasts high EV penetration), reduction in the purchase price has been the main driver influencing the decision to buy an electric car
- VAT and registration tax exemption are cited as the most important factors among a wide set of incentives
- However, Norwegian EV drivers also cite range anxiety as being the largest barrier to EV adoption (21% vs 6% for sticker prices)

Perceived importance of policy measures that would entice respondents to purchase an EV (%)¹



Notes – 1) Respondents were asked to pick the three most important policy measures related to their choice to purchase an electric car. The % reflects the proportion of which each policy measure was selected by the respondents
Source: Norsk Elbilforening

While BEIS¹ also highlighted fiscal policy and as well as battery prices as key to increasing EV uptake



Case study:  HOUSE OF COMMONS  Department for Business, Energy & Industrial Strategy  National Infrastructure Commission

 HOUSE OF COMMONS **BEIS committee witnesses said that...**

- further fiscal incentives are needed, as they are the primary driver for EV adoption
- charging infrastructure investment is not a current issue, there just needs to be the EV drivers there to use the infrastructure

 Department for Business, Energy & Industrial Strategy **The BEIS report says that...**

- Government's ambition to develop a national charging infrastructure is at odds with its decision to leave delivery to local authorities and private actors
- Highlights that when battery performance improves and cost reduces, EV uptake is likely to also increase

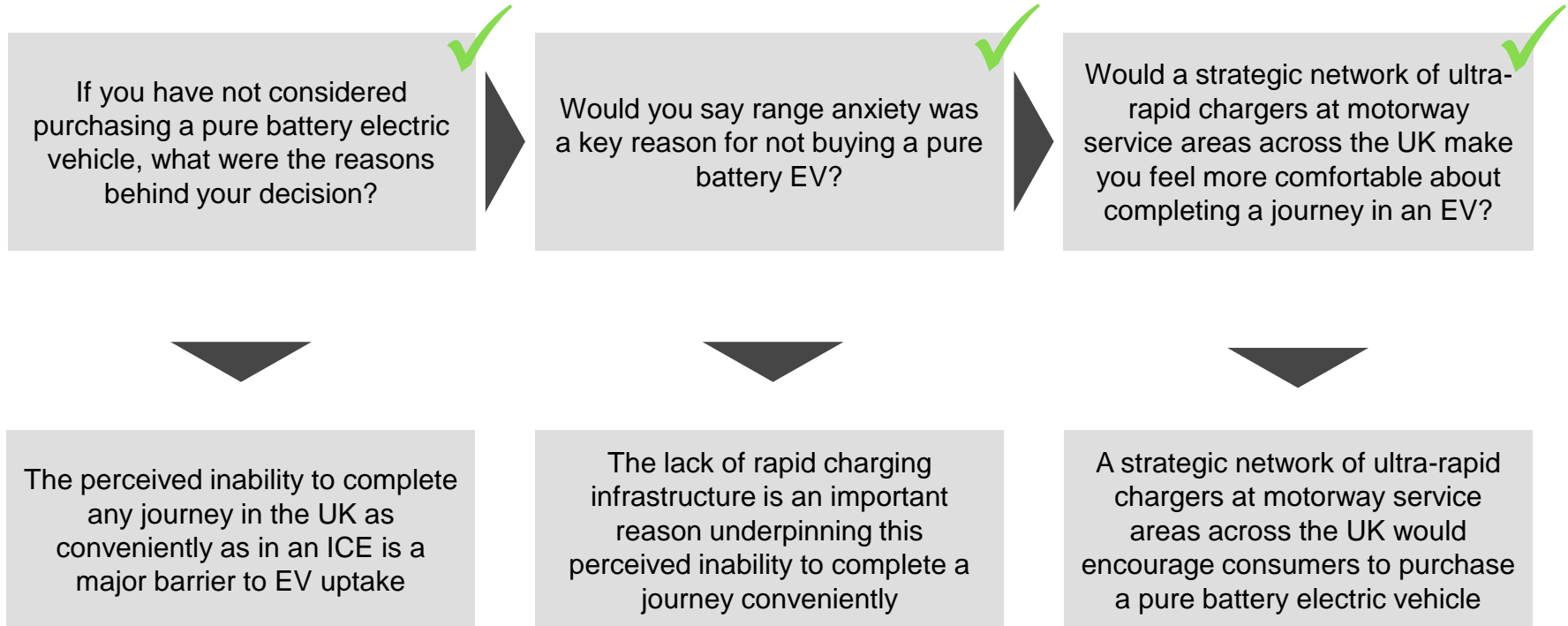
 National Infrastructure Commission **The NIC³ recommends...**

- Government subsidise the provision of rapid charge points in remote areas by 2022
- The NIC also recommends that future road investment reflect the potential impact of connected and autonomous vehicles

4. Gap Analysis

For B2C customers, there is solid evidence of the importance of a rapid charging network

Existing surveys provide robust answers to the key questions

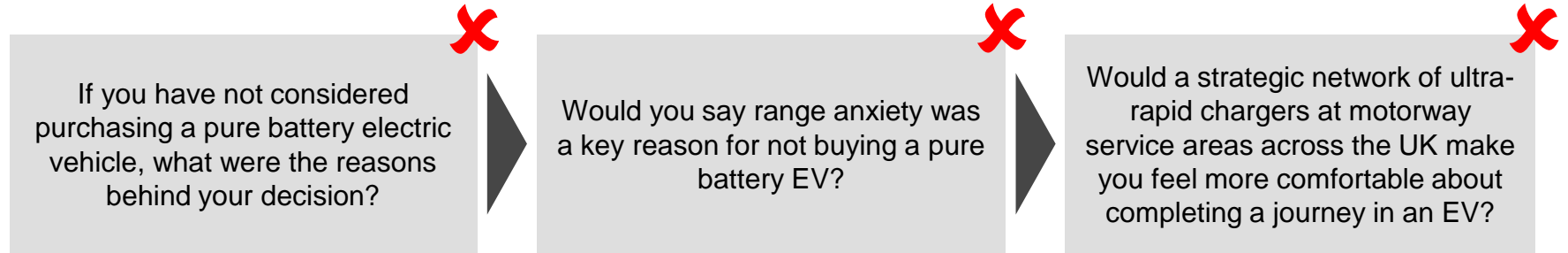


Legend: ✓ At least one survey reviewed answered question

✗ No surveys reviewed answered question

There a gap in research of B2B EV adoption barriers and further analysis should be considered

We did not find any survey that answered our 'right type of questions'¹, directly linking a strategic of ultra-rapid chargers to range anxiety...



... and there was a lack of B2B research in general:

B2C EV uptake barriers & solutions

Hypothesis 1	Hypothesis 2	Key	Out of scope
Barriers	Solutions	Legacy	Addressed?
<p>EV Cost and Availability</p> <p>High upfront costs, low resale value, high maintenance costs, limited availability of charging points, limited availability of ultra-rapid charging points.</p>	<p>State-backed infrastructure, public-private partnerships, incentives, subsidies, tax breaks, etc.</p>	<p>Highly dependent on local government, industry, and consumer behavior.</p>	<p>Partially addressed by government and industry, but not fully.</p>
<p>EV Range Charge and Battery Life</p> <p>Charging infrastructure, range anxiety, battery life, etc.</p>	<p>Market development, infrastructure, incentives, etc.</p>	<p>Medium, highly dependent on local government, industry, and consumer behavior.</p>	<p>Partially addressed by government and industry, but not fully.</p>
<p>Charging Infrastructure</p> <p>High upfront costs, low resale value, high maintenance costs, limited availability of charging points, limited availability of ultra-rapid charging points.</p>	<p>State-backed infrastructure, public-private partnerships, incentives, subsidies, tax breaks, etc.</p>	<p>Highly dependent on local government, industry, and consumer behavior.</p>	<p>Partially addressed by government and industry, but not fully.</p>
<p>Charging Speed</p> <p>High upfront costs, low resale value, high maintenance costs, limited availability of charging points, limited availability of ultra-rapid charging points.</p>	<p>State-backed infrastructure, public-private partnerships, incentives, subsidies, tax breaks, etc.</p>	<p>Highly dependent on local government, industry, and consumer behavior.</p>	<p>Partially addressed by government and industry, but not fully.</p>

Sources directly linked to B2B analysis from research scan:

- #24 – GemServ workshop: mentions range anxiety but does not discuss rapid charging
- #33 – ENA report: charge point infrastructure is a barrier – no mention rapid chargers as solution
- #36 – BEIS Parliamentary committee: charge point infrastructure is not a barrier
- #38 – PwC IoT survey: no mention of range anxiety or rapid chargers – focuses on EV benefits for SMEs

Interview findings on B2B:

- **Fleet Operator** – range anxiety one of multiple problems with fleet electrification. Rapid chargers needed but only in 10-15 years. Charge point infrastructure in rural areas is key but does not need to be rapid
- **Charge Point Operator** – Rapid chargers needed for >4 hour journeys but most fleets operate <4 hour journeys

Legend: ✓ At least one survey reviewed answered question ✗ No surveys reviewed answered question

5. Next steps

Potential next steps

There is a risk that the market may not invest in a rapid charging network, given the scale of the investment and the uncertainty of future revenue streams. We recommend that the industry assess whether there are likely to be barriers to the development of this critical infrastructure

1

Identify whether there is a case of market failure in EV rapid charging and in what context

- Discuss with investors, motorway service associations, OEMs, energy networks and Charge Point Operators:
 - **where they see investment in EV charging and over what timelines** and;
 - **whether there is a case of market failure**
- If there is a case of market failure identify:
 - **where the market may fail to deliver (in specific charging locations, higher power charging for battery electric trucks etc.)**

2

Identify what role Government should play in facilitating motorway rapid charging, if any

- If justified by the evidence, enter into a dialogue with BEIS and OLEV around EV transit rapid charging. Highlight if there is a **gap between what the market can provide and what drivers require** to facilitate and be prepared for large scale EV adoption
- Identify **what a Government led EV rapid charging framework needs to look like** if the market is to invest in motorway rapid charging and Government is to reach its 2040 Road to Zero targets

We also observe that, given the lack of research into the views of B2B EV users, there would be merit in conducting further research in this area.

6.1 Appendix: Summaries of research reviewed

Summaries of sources 1-10

High level findings of our analysis from the top 10 out of 45 sources

Source	Source Type	Score (/69)	Summary of key findings
Baringa	Survey	58	<ul style="list-style-type: none"> States that range anxiety is the second biggest barrier for EV (cost was identified as the greatest barrier)
Confused.com	Industry Report	50	<ul style="list-style-type: none"> Cites range anxiety as the number one barrier to EV adoption Suggests that improved coverage of CPI¹ as most effective solution
AA Populus Driving Survey	Survey	50	<ul style="list-style-type: none"> Finds that the number one factor that would convince AA non-EV drivers to purchase an EV is a 'real world' driving range of >250 miles
AutoTrader	Market Report	49	<ul style="list-style-type: none"> Quotes Steve Hood, Director of EVs at Ford Europe who suggests that increased rapid charging coverage will help dispel the range anxiety myth
European Federation for Transport and Environment	Commercial Report	46	<ul style="list-style-type: none"> States that being able to recharge cars within the recommended driving break time is expected to be a game changer for market uptake
OVO Energy	Survey	45	<ul style="list-style-type: none"> Reports that lack of charging points was identified as the largest barrier to EV uptake by the 2000 respondents to its 2017 survey
AA public attitudes article	Article	44	<ul style="list-style-type: none"> Highlights that range anxiety is a myth but concedes that 85% of its survey respondents said there wasn't enough CPI coverage
Department for Transport (ONS)	Government Report	44	<ul style="list-style-type: none"> Identifies range anxiety along with high sticker prices as the primary barrier to EV adoption in the UK
Automotive World	Industry Report	43	<ul style="list-style-type: none"> Mentions that Ford believe that a rapid charging infrastructure (e.g. Ionity) is a specific antidote to the perceived relative inconvenience of driving EVs
Department for Business, Environment and Industrial Strategy	Government Report	41	<ul style="list-style-type: none"> Suggests that rapid charging points on motorways will be instrumental in reducing range anxiety, particularly in rural areas

Summaries of sources 11-20

High level findings of our analysis from sources 11 – 20 out of 45 sources

Source	Source Type	Score (/69)	Summary of key findings
RAC	Market Report	41	<ul style="list-style-type: none"> Finds that 73% of non-EV drivers would require pure battery EVs to be the same price or lower than an ICE before they would consider one
RAC Foundation	Industry Report	41	<ul style="list-style-type: none"> Suggests that the EV charge point experience should be similar to that of refueling an ICE vehicle if EV adoption is to take flight
Consumer Reports	Article	40	<ul style="list-style-type: none"> Identifies in-car experience as key to range anxiety for actual EV users, with Tesla upgrading its Model S cars with a range assurance system
National Infrastructure Commission	Industry Report	40	<ul style="list-style-type: none"> Recommends that the UK government invest in UK CPI to achieve higher EV adoption, with importance stresses on investment on rural chargers
Fully Charged	Survey	40	<ul style="list-style-type: none"> Survey with 7.700 respondents who cited concern about range and a lack of charging point infrastructure, alongside cost, as the primary barrier
Norsk Elbilforening	Survey	39	<ul style="list-style-type: none"> Explains how Norway has achieved highest worldwide EV adoption through fiscal incentives/policy (e.g. VAT and registration tax exemptions)
Mintel	Industry Report	39	<ul style="list-style-type: none"> Identifies the top 5 barriers that respondents answered as being barriers to EVs, with charging time and accessibility being 1st and 3rd respectively
Financial Times	Article	39	<ul style="list-style-type: none"> Identifies range anxiety as the largest barrier to EV uptake, citing continental. The report explicitly mentions rapid charging as a solution
Continental	Press Release	39	<ul style="list-style-type: none"> Highlights range anxiety as a direct barrier to EV, and suggests that rapid charging is as important as battery capacity to solve range anxiety
Forbes	Article	39	<ul style="list-style-type: none"> Identifies range anxiety as the largest barrier to EV uptake, and mentions ChargePoint's Ultrafast DC rapid chargers as a direct solution

Summaries of sources 21-30

High level findings of our analysis from sources 21 – 30 out of 45 sources

Source	Source Type	Score (/69)	Summary of key findings
Changsha University of Scientific Technology	Academic Paper	37	<ul style="list-style-type: none"> "Range anxiety for a sample of EV users measured a buffer zone, the time between range anxiety onset and negative effects on driving occurs"
Energy UK	Workshop	37	<ul style="list-style-type: none"> Article provides recommendations to the UK Government to increase the uptake of EVs, with rapid CI direct solution to range anxiety
Pod Point	Workshop	37	<ul style="list-style-type: none"> Interview identifies small number of EVs as the largest barrier a large CI, and blames delivery times as a barrier with Nissan Leaf as an example
GemServ	Commercial Report	36	<ul style="list-style-type: none"> YouGov survey, with 35% stating that they would buy an EV if charging was more readily available, with 50% demanding a better CI
ZapMap	Survey	36	<ul style="list-style-type: none"> Article highlights that 88% of rapid charging network users are satisfied with the experience, but stated poor reliability as a key issue
Driving Electric	Article	36	<ul style="list-style-type: none"> Article suggests range anxiety is as EVs are available with a 300 mile range, at which point 37% of consumers would purchase one
RAC Foundation	Industry report	35	<ul style="list-style-type: none"> Explains how range is not an issue, but cites EV prices and battery life expectancy as the major barriers to EV uptake
Leading EV Manufacturer	Interview	35	<ul style="list-style-type: none"> Interview stating that CI is a loss leader for OEMs, and that lack of CI is the greatest barrier, with improvement in regulations and grid needed
Clean Technica	Industry Report	34	<ul style="list-style-type: none"> Focuses on the demands from EV users which include further range and better charging infrastructure, as well as software updates
Big 6 Supplier	Interview	33	<ul style="list-style-type: none"> Focuses on the importance of infrastructure. Interview focuses on the need for policy implementations to enable street level parking

Summaries of sources 31-40

High level findings of our analysis from sources 31 – 40 out of 45 sources

Source	Source Type	Score (/69)	Summary of key findings
Zap Map	Article	32	<ul style="list-style-type: none"> States that placing charging points in public spaces can attract EV with 90% of EV drivers using public charging places
EV Box	Commercial Report	32	<ul style="list-style-type: none"> Article has a strong focus on rapid charging, with 55% of EV driving respondents having never used a rapid charging station
ENA	EV Forum Presentation	31	<ul style="list-style-type: none"> Fleet operator case study with Royal Mail, who suggest: the following issues in the switch to EVs: cost, charging infrastructure, model choice
Corporate Vehicle Observatory	Industry Report	31	<ul style="list-style-type: none"> Focuses on different fleet vehicles, including financing, fleet composition, fleet growth, and different energy mixes including hybrid and EVs
Innovate UK	Survey	31	<ul style="list-style-type: none"> Survey which concludes that one of the remaining barriers inhibiting rapid uptake of EVs is lack of public recharging infrastructure
Business, Energy and Industrial Strategy Committee	Interview	27	<ul style="list-style-type: none"> Interview identifies no direct barriers to EV uptake. Suggests taxes and fiscal benefits as drivers of EV uptake, citing Norway as an example
Chargemaster	Workshop	27	<ul style="list-style-type: none"> Guide by Chargemaster, suggesting that the growing market needs to be serviced by workplace charging, with Government incentives taking place
PwC	Survey	27	<ul style="list-style-type: none"> Identifies reduced operational costs and CO2 emissions as the main driver of workplace EV charging infrastructure, particularly for SMEs
GoUltra	Article	26	<ul style="list-style-type: none"> Article highlights the need to dispel EV myths to improve EV uptake, with range and CI stated as false barriers
International Energy Agency	Industry Report	25	<ul style="list-style-type: none"> Consumer practices in the Nordic countries suggest that EVSE policies are secondary to economic incentives for the purchase of electric cars

Summaries of sources 41-45

High level findings of our analysis from sources 41 – 45 out of 45 sources

Source	Source Type	Score (/69)	Summary of key findings
Pod Point	Press Release	25	<ul style="list-style-type: none"> Non scientific article with no survey. Article provides comments on the EV driver experience
Daimler	Press Release	25	<ul style="list-style-type: none"> Car manufacturers suggesting that geographical distribution, ultra-rapid charging and choice of EV models are largest drivers of EV uptake
Green Energy Supplier	Interview	25	<ul style="list-style-type: none"> Interview with Head of smart charging, which states rapid charging is obsolete with current range, and charging habits are the major barrier
International Energy Agency	Article	22	<ul style="list-style-type: none"> Analyses the success of EVs in Norway, with significant legislation in favour of EVs including no import tax, VAT or road tax being drivers
Nordic EV Charging Specialist	Interview	17	<ul style="list-style-type: none"> Norway has high EV penetration given government fiscal incentives. Rapid charging is used at weekends for road trips and in winter for skiing

Sources 1-10

Source names

Source	Source Type	Source Title	URL
Baringa	Survey	Is the UK ready for electric cars?	https://www.baringa.com/getmedia/81a8c49b-cb7a-4e23-9f94-0f475f3222ee/Is-the-UK-ready-for-Electric-Cars-FINAL-WEB/
Confused.com	Industry Report	The Rise of Electric Cars: An in-depth look at a motoring revolution	https://www.confused.com/car-insurance/electric-cars-report
AA Populus Driving Survey	Survey	Driver Poll Surveys	https://www.theaa.com/about-us/public-affairs/aa-populus-driver-poll-summaries-2018#july2018
AutoTrader	Market Report	The evolution of the car	https://cdn-autotraderplc.azureedge.net/media/1590/auto-trader-market-report-march-2019.pdf
European Federation for Transport and Environment	Commercial Report	Charging infrastructure report 2018	https://www.euractiv.com/wp-content/uploads/sites/2/2018/09/Charging-Infrastructure-Report_September-2018_FINAL.pdf
OVO Energy	Survey	Whats stopping the Electric Vehicle Revolution	https://www.ovoenery.com/blog/ovo-news/whats-stopping-the-electric-vehicle-revolution.html
AA public attitudes article	Article	Drivers still need to be convinced about electric vehicles	https://www.theaa.com/about-us/newsroom/what-drivers-think-about-electric-vehicles
Department for Transport (ONS)	Government Report	Public attitudes towards electric vehicles: 2016 (Revised)	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/551446/electric-vehicles-survey-2016.pdf
Automotive World	Industry Report	Charging the Electric Vehicle	https://www.automotiveworld.com/research/special-report-charging-the-electric-vehicle/
Department for Business, Environment and Industrial Strategy	Government Report	Electric vehicles: driving the transition	https://publications.parliament.uk/pa/cm201719/cmselect/cmbeis/383/383.pdf

Sources 11-20

Source names

Source	Source Type	Source Title	URL
RAC	Market Report	RAC Report on Motoring 2018	https://www.rac.co.uk/pdfs/report-on-motoring/rac10483_rom-2018_content_web
RAC Foundation	Industry Report	Development of the UK CPN	https://www.racfoundation.org/wp-content/uploads/Development_of_the_UK_CPN_Harold_Dermott_December_2018.pdf
Consumer Reports	Article	Tesla aims to end range anxiety	https://www.consumerreports.org/cro/news/2015/03/tesla-aims-to-end-range-anxiety/index.htm
National Infrastructure Commission	Industry Report	National Infrastructure Assessment Chapter 3: Revolutionising Road Transport	https://www.nic.org.uk/wp-content/uploads/CCS001_CCS0618917350-001_NIC-NIA_Accessible.pdf#page=53
Fully Charged	Survey	Fully Charged Audience Survey	NO URL
Norsk Elbilforening	Survey	Nordic EV Barometer 2016, 2017, 2018	https://elbil.no/elbilstatistikk/nordic-ev-barometer/
Mintel	Industry Report	Hybrid and Electric Cars - UK - December 2016	http://reports.mintel.com/display/748922/#
Financial Times	Article	Range anxiety holds back electric cars	https://www.ft.com/content/8984ebaa-f7f9-11e5-96db-fc683b5e52db
Continental	Press Release	Electric mobility: charging is just as important as driving	https://www.continental-corporation.com/en/press/press-releases/2018-01-31-laden-e-mob-121374
Forbes	Article	ChargePoint's New Stations Promise Fast Charge In Minutes For Your Electric Car	https://www.forbes.com/sites/joannmuller/2017/01/05/chargepoints-new-stations-promise-fast-charge-in-minutes-for-your-electric-car/#731fd9f0492d

Sources 21-30

Source names

Source	Source Type	Source Title	URL
Changsha University of Scientific Technology	Academic Paper	Range Anxiety Empirical	https://www.hindawi.com/journals/jat/2018/8301209/
Energy UK	Workshop	The Future of Energy	NO URL
Pod Point	Workshop	<i>No Title</i>	NO URL
GemServ	Commercial Report	Electric vehicle workshop, summary & next steps	https://www.gemserv.com/wp-content/uploads/2018/08/EV-Workshop-Summary-Report-Gemserv-002.pdf
ZapMap	Survey	Zap-Map survey reveals top EV charging networks	https://www.zap-map.com/zap-map-survey-reveals-top-ev-charging-networks/
Driving Electric	Article	'Range anxiety' fades as electric cars' range increases	https://www.drivingelectric.com/news/794/range-anxiety-fades-electric-cars-range-increases
RAC Foundation	Industry report	Ultra-Low-Emission Vehicle Infrastructure – What Can Be Done	https://www.racfoundation.org/wp-content/uploads/2017/11/Ultra_Low_Emission_Vehicle_Infrastructure_Harold_Dermott_September_2017.pdf
Leading EV Manufacturer	Interview	<i>No Title</i>	NO URL
Clean Technica	Industry Report	Electric Car Drivers: Desires, Demands, & Who are they	NO URL
Big 6 Supplier	Interview	<i>No Title</i>	NO URL

Sources 31-40

Source names

Source	Source Type	Source Title	URL
Zap Map	Article	Survey supports the need for a public EV charging network	https://www.zap-map.com/survey-supports-the-need-for-a-public-ev-charging-network/
EV Box	Commercial Report	Manifesto of Electric Mobility	https://info.evbox.com/manifesto-electric-mobility
ENA	EV Forum Presentation	Electric Vehicle Forum #1	NO URL
Corporate Vehicle Observatory	Industry Report	2018 Fleet Barometer	NO URL
Innovate UK	Survey	Electric Vehicle Charging for Public Spaces: Feasibility Studies	NO URL
Business, Energy and Industrial Strategy Committee	Interview	BEIS Committee: Development of charging infrastructure for electric vehicles examined	https://parliamentlive.tv/event/index/539de0d3-cdac-4ec4-a2e1-912721ae5121?in=10:03:09
Chargemaster	Workshop	Quick Guide To: Workplace Electric Vehicle Charging	https://bpchargemaster.com/wp-content/uploads/2017/12/Quick-Guide-To-Workplace-Electric-Vehicle-Charging.pdf
PwC	Survey	IoT Survey	NO URL
GoUltra	Article	That's Shocking! Brits underestimate benefits of switching to a pure electric car, and 42% don't think you can put one through a car wash	NO URL
International Energy Agency	Industry Report	Nordic EV Outlook 2018 - Insights from leaders in electric mobility	https://webstore.iea.org/global-ev-outlook-2018 https://www.iea.org/gevo2018/

Sources 41-45

Source names

Source	Source Type	Source Title	URL
Pod Point	Press Release	Top 8 things only EV drivers know	https://pod-point.com/electric-car-news/the-top-8-things-only-ev-drivers-know
Daimler	Press Release	A Joint Venture for Ultra-Fast, High-Power Charging Along Major Highways in Europe	https://media.daimler.com/marsMediaSite/en/instance/ko/BMW-Group-Daimler-AG-Ford-Motor-Company-and-Volkswagen-Group-with-Audi--Porsche-Plan-a-Joint-Venture-for-Ultra-Fast-High-Power-Charging-Along-Major-Highways-in-Europe.xhtml?oid=14866747
Green Energy Supplier	Interview	<i>No Title</i>	NO URL
International Energy Agency	Article	Nordic region offers valuable lessons for rapid EV deployment worldwide	https://www.iea.org/newsroom/news/2018/march/nordic-region-offers-valuable-lessons-for-rapid-ev-deployment-worldwide.html
Nordic EV Charging Specialist	Interview	<i>No Title</i>	NO URL

6.2 Appendix: 'Right types of questions'

As part of the scoring criteria, we asked if the surveys we reviewed answered any of the below questions

'Right types of questions'

1) What are your typical driving habits?:

- What are the longest trips you make each year?
- How often do you make these trips?
- How far are they?

2) Have you considered purchasing a pure battery electric vehicle?

3) If yes, would this be your main car, or a second car?

4) If yes, what were the reasons for purchasing a pure battery electric vehicle?:

- Environmental
- Financial (cheaper to run a BEV)
- Other (please state)

5) If you have not considered purchasing a pure battery electric vehicle what were the reasons behind your decision?:

- Too expensive to buy
- Concerned by range anxiety

- Limited choice of models
- Other (please state)

6) Would you say range anxiety was the number one reason for not buying a pure battery electric vehicle?

7) If yes, would a strategic network of ultra-fast chargers at motorway service areas across the UK allay your concern about range anxiety?

8) If yes, would a strategic network of ultra-fast chargers at motorway service areas across the UK allay your concern about range anxiety and encourage you to purchase a pure battery electric vehicle?

9) If you purchased a pure electric battery vehicle which is the most likely way you would charge your vehicle?:

- Charge at home
- Charge at work
- Charge at destinations
- Rapid charging en-route such as at MSAs?

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Thank you

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