

Going electric?

Research report into the accessibility of plug-in electric vehicles

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Executive summary

This research investigates the needs and experiences of disabled motorists using plug-in electric vehicles.

The research consisted of three main elements: desk research, survey and consumer workshops which were designed to investigate the accessibility, suitability and impact of electric vehicles and the supporting infrastructure for disabled motorists.

The main findings from this research are:

- There is a lack of consideration of disabled motorists as users or potential users of electric vehicles
- The existing charging points infrastructure is not accessible for a large proportion of disabled people with mobility or dexterity impairments
- An increase in anxiety can lead to changes in motoring behaviour culminating for some people in a loss of independence
- Many assistive aids such as hoists, ramps and heaters will have a negative impact on electric vehicle's range.

The main recommendations are:

- There should be a concerted effort to influence policy at a local and national level to be more proactive in accommodating the needs of disabled motorists.
- In-situ usability testing of the main types of charging stations should be undertaken with disabled motorists as users.
- Manufacturers should undertake usability testing of in-car charging equipment with disabled and older motorists as users.
- More detailed information is required by disabled motorists to help inform them of the implications before purchasing an electric vehicle.
- More research is needed into the user experience (UX) of disabled motorists using electric vehicles.

The desk research and fieldwork were undertaken during the summer and autumn of 2019.

Introduction

This document reports on the work undertaken by the Research Institute for Disabled Consumers (RiDC) into electric vehicles of differing configurations and their charging requirements, processes and infrastructure, viewed from the perspective of disabled and older consumers.

Need & scope

Previous research into this area indicated that very little information was available to inform disabled and older motorists about going electric or choosing between vehicle models. Further to this, we found little evidence of research into the usability or accessibility of in-car charging equipment and charging points for disabled and older drivers or meaningful accessibility information about them.

We identified six key research questions which guided the direction of this work. They are as follows:

1. How easy is it to use in-car charging equipment?
2. Does the usability of charging cables and connectors vary by manufacture and model?
3. How accessible and varied are the locations and charging equipment at public charging points?
4. How usable are home charging points and do they vary by brand and model?
5. Is going electric more suited to motorist with particular disabilities?
6. How does the length of journey impact disabled motorists?

Other areas of interest were around specialist adaptations and Wheelchair Accessible Vehicles (WAVs), i.e.

- What adaptations are available on electric cars?
- What is the impact on car battery life of powered adaptations, such as boot hoist and electric hoists?
- Is boot storage space reduced on electric vehicles?
- Who are providing electric WAVs?

Method

This research comprised of three main elements:

1. **Background desk research** including telephone interviews with key industry and consumer motoring contacts
2. An online **survey of disabled consumers** investigating attitudes towards, and knowledge of, electric vehicles
3. **Consumer workshops** exploring the usability and accessibility of electric charging points

These three research elements are reported on separately as well as being viewed together to triangulate findings across the research.

Further to this, a review of products and information of both public and private charging points was carried out and used to inform the consumer information output.

Wherever possible, we worked alongside disabled and older motorists to inform the research. Respondents to the survey and participants who attended the workshops primarily came through the RiDC consumer panel which currently consists of over 1600 disabled and older consumers.

Background research

The desk research and telephone interviews were carried out to establish an understanding of what knowledge existed, both published and/or in-house, about the usability and accessibility of charging electric vehicles. When considering the charging of electric vehicles, a holistic journey approach was taken which embraced the whole process, from planning a journey, through to the journey itself and ending with its completion.

A variety of organisations and individuals were identified and approached as being stakeholders in the fields of disabled motoring and electric vehicles. Feedback was given over the phone and by email following a short semi-structured interview script. This script provided a framework to explore the organisation's knowledge and experience of existing research into disabled people and electric vehicles as well as the technologies and information provided by manufacturers. It was modified as necessary to align to the organisation's area of involvement. These can be seen in Appendix A.

In addition to this, reports and articles were reviewed further to inform our understanding of the electric vehicle market and its changing dynamic. Attendance at Transport for London's 'London's Electric Vehicle Charge Point installation guidance' consultations were used to both inform our understanding of the issues associated with distrustful charging point infrastructure and to extend our contacts network in this area.

Overview

At the time of undertaking this background research, Summer 2019, there was little evidence of disabled people being considered in the usability testing of charging cables, charging points or the supporting information infrastructure.

The 2018 House of Commons report '*Electric vehicles: driving the transition*', which seeks to identify the barriers and challenges behind transitioning to electric vehicles, fails to mention disabled people at all [1]. Accessibility is mentioned but only in a general sense and not in relationship to disability. This is also the case in the Automated and Electric Vehicles Act 2018 where the phrase "accessible to the widest section of the population" is used [2].

Similarly, in many other electric vehicle stakeholder consultations and reviews, there has been little or no consideration of the needs of disabled people in relation to the accessibility of equipment and infrastructure [3, 4, 5, 6, 7, 8].

Infrastructure

The development and deployment of public charging infrastructure throughout the UK has been gathering momentum with the number of installed devices almost doubling every two years [9]. This requires the close liaison between the product suppliers (energy companies), the real estate owners (petrol stations, car park operators, retail outlets, local government) and the policy makers (local and national government).

There is design guidance available on the provision of accessible parking spaces [10], which has been used to inform the accessible electric vehicle charging bay design [11]. These guidelines treat the space about the parking bay in isolation of the interaction with the charging point which can be problematic. This is discussed in more detail in Section 5, Consumer workshops.

Charging (cables, connectors and points)

The rapid development of electric vehicles has resulted in a variety of charging rates and connector types, leaving the consumer confused about compatibility and availability. There are three main charging rates (slow, fast and rapid) and a fourth (super) used on some Tesla vehicles. These charging rates will need different connectors to support the different charging rates. To compound this, different car manufacturers have been offering different connectors to their vehicles.

Recently, there has been some convergence between the Asian and European designs settling on three main connector types for the car side (CHAdeMO, Type 2 and CCS). On the supply side, where it is untethered (not permanently fixed on either end), there can be up to five different connector types. Zap Map¹ provide a clear description of the various combinations.

The desk research found no evidence of user testing of electric vehicle connectors with disabled people. We found only one mention of user testing involving the general population, which was undertaken in Canada to explore the effect of extreme cold on recharging.

Survey

A survey of consumers' knowledge of, and attitudes towards electric vehicles was distributed to the RiDC consumer panel and promoted through social media including Disabled Motoring UK' and local disability networks.

The survey ran for four weeks in July 2019 and received 201 completed responses. Respondents entered a prize draw of, one £100 and three £50 shopping vouchers. The survey could be completed over the internet, through the post in different formats or over the phone.

In order to uncover the respondents' knowledge of electric vehicles baseline questions were asked, such as questions on vehicle range, charging time, meanings of acronyms and charging cable connector designs. This was followed by a short explanation of the answers to these questions.

¹ <https://www.zap-map.com/charge-points/connectors-speeds/#more-32212>

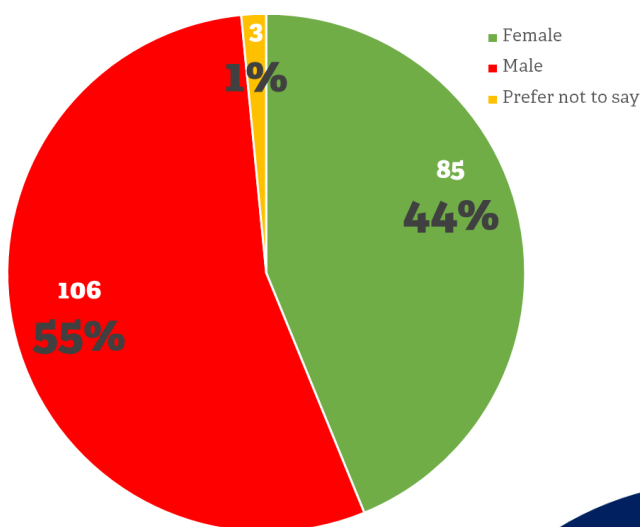
Following this the respondents were asked more detailed questions to uncover their attitudes towards electric vehicles, see Appendix C

The findings are presented by topic and combine both quantitative and qualitative data to support emerging themes.

Overview

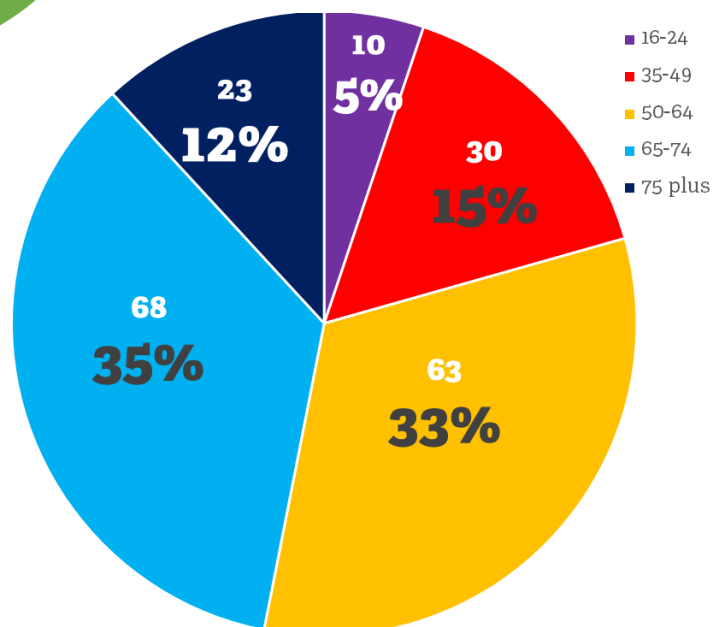
The demographic profile of the respondents was gender biased towards male respondents (55% to 45%) between the ages of 50 to 74 years old (68%).

Figure 1: Gender



It is worth noting the disability gender ratio between male and female in the general population (44% to 56%) is almost exactly reversed in our survey responses. This is consistent with the commonly held belief that the car sector is more aligned to men rather than women.

Figure 2: Age



The respondents were heavily skewed towards people with a mobility impairment (75%) and/or dexterity/limited strength impairments (27%). These representations are consistent with many disabled people having multiple impairments and align themselves with the general population of disabled drivers [12].

82% of the respondents owned, or had use of, a vehicle. 21 of these respondents had vehicles powered by alternative, or combination, fuels, i.e. electricity, electricity hybrid and biofuels.

Existing knowledge

The purpose of asking our respondents some basic questions about electric vehicles was to capture any gross misunderstandings about the technology. As such, the questions were designed to encourage the respondents to make approximate judgments and not be too concerned with providing definitive answers.

When the respondents were asked about their knowledge of abbreviations commonly used in the electric vehicle market, EV (Electric Vehicle) was the only term which most people understood, with 69% of respondents saying they understood its meaning. When asked the same question of the four other abbreviated terms (BEV, HEV, PHEV, E-REV) they all scored poorly.

However, the respondents' knowledge of the typical range of electric vehicles was largely correct with 59% estimating a range between 76 and 175 miles. This was also the case with estimating the charge times for the three main charging rates of slow, fast and rapid.

There was some confusion as to the number of different charging connectors used, with 42% of people believing there were only up to two connectors used. The actual number is between three or four connectors with half the estimating correctly.

Attitudes towards electric charging points and electric vehicles

Of the 76% of respondents who had seen public charging stations for electric vehicles, nearly three quarters of them (73%) perceived them as neither accessible nor easy to use.

Reasons for this related to the lack of local charging points available; the insufficient width of parking bays; the height and positioning of charging points and the excessive time needed to charge an electric vehicle, see Appendix C

“There aren’t many locally and they are in odd areas of car parks”

“The ones I have seen don’t have the same width as a blue badge parking space making it impossible to get out of the car or back in”

“All the charging stations are designed to use whilst stood up, which is a major problem if you use crutches, walking stick and/or a wheelchair”

“What am I supposed to do? Sit in a car for 8 hours while it charges in a car park...it is badly thought out. I would be totally dependent on public charging points”

When the respondents were asked if they would consider buying any type of electric vehicle, two thirds (66%) indicated they would. Of those who said they would, the majority (59%) cited hybrid options.

Figure 3: Would you consider buying an electric vehicle?

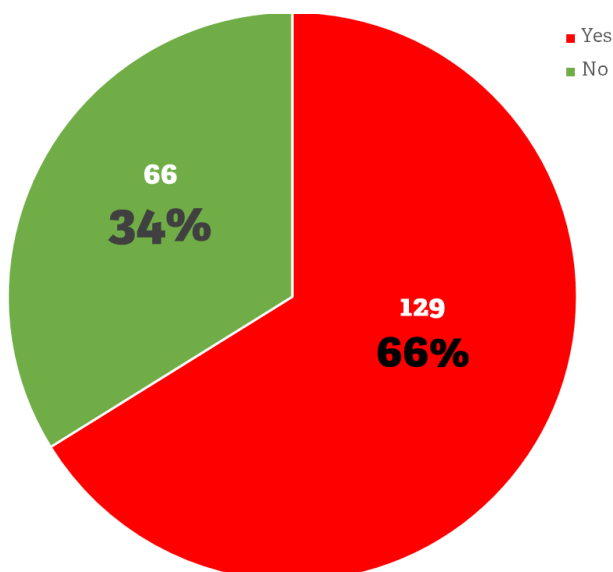
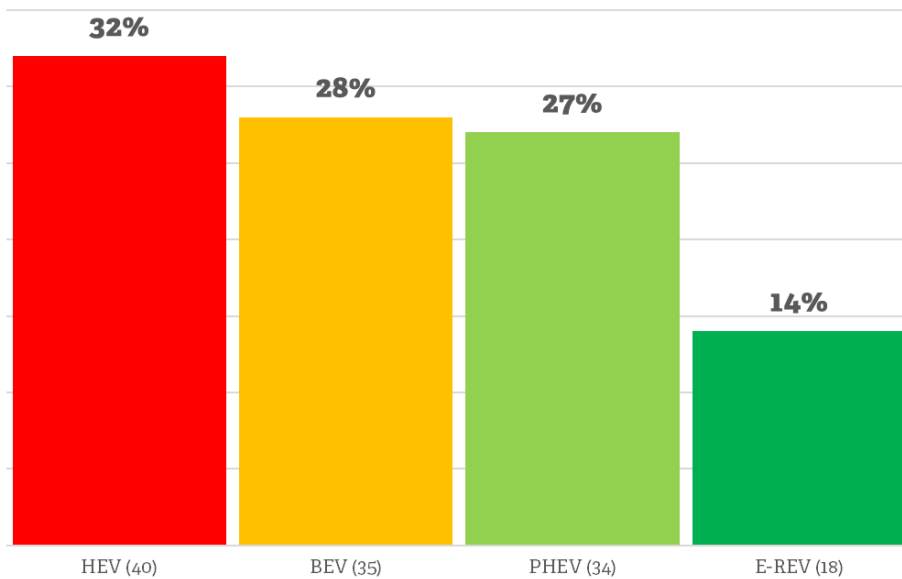


Figure 4: If yes, what type of electric vehicle would be your first choice to consider?



When asked what one thing would make them buy an electric vehicle, respondents mentioned affordability, the availability of more charging points and an ability to travel longer distances.

“The cost of having a home charging station installed”

“The price is far too high for people on disabled benefits”

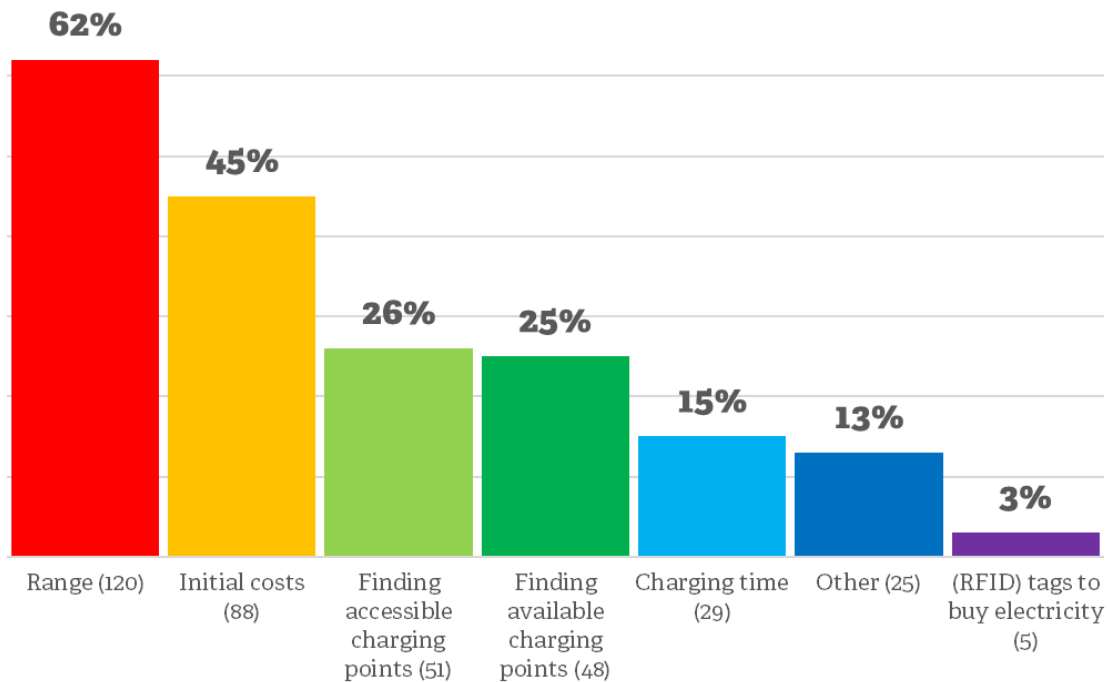
“I live in the countryside...as more people get electric cars charging points will be a huge problem”

“The distance restriction per charge is inadequate”

“Bigger mileage between charges”

To further explore any concerns our respondents might have about electric vehicles, we asked them to tick no more than two options from a list of possible reasons for concern.

Figure 5: What concerns you the most about owning an electric vehicle?



A repeated concern that the respondents raised throughout the survey revolved around running out of energy and not being able to charge the vehicle. This effect is known as range anxiety² and is a well-documented concern for all drivers of electric vehicles.

However, 'range anxiety' can be further increased in disabled people when considering the many practicalities behind peoples lived experience. This is evident in some of the free-text responses.

“If using air conditioning essentially means I cannot get anywhere as I would be stranded, I cannot travel independently”

“[My husband] has general anxiety disorder and says he would be in a constant state of panic about running out of charge before reaching his destination”

Additional concerns that were raised by respondents related to the cost of charging and maintenance and the lack of noise emitted by electric vehicles.

² Range Anxiety is the fear that a vehicle has insufficient range to reach its destination and would thus strand the vehicle's occupants. https://en.wikipedia.org/wiki/Range_anxiety

“If an electric vehicle uses a 60K Watt motor, then to charge it (because of losses in AC to DC conversion) is the equivalent of 80 Kwatt. At 15p/Kwatt this translates into £12 for each hour of operation. This is double the cost of a Diesel car. To us older people with fixed income, that is a major deterrent”

“The cost of replacing parts, including batteries”

“EV’s are largely silent, even those with an audible vehicle alert system installed often have them turned off. Driving an EV in silent mode is life threatening to those who rely on hearing to assess traffic risks... as a driver you don’t want to hit someone”

We completed the survey by asking people if they had any direct experiences, or had heard of any experiences, where disability was not compatible with driving an electric vehicle, and if so to explain their answers.

The two main issues that emerged from these questions concerned access requirements not being met, i.e. difficulty getting in and out of the vehicle with the battery position causing difficulties for WAV (Wheelchair Accessible Vehicles) conversions, and adaptive controls for steering and power being difficult to use.

Consumer workshops

Two workshops were carried out: one in Hammersmith London on the 27th November 2019 and the other in Nottingham on the 5th December 2019. Both workshops involved people with mobility impairments who owned a vehicle and showed an interest in electric vehicles.

The participants were a mixture of wheelchair users and people who used other walking aids (i.e. walking sticks or crutches). Most of the participants used the Motability vehicle hire scheme. In total, there were 11 participants across the two workshops, two participants were carers.

The aim of the workshops was:

- To test the usability of a selection of charging cables with disabled people in real life situations, i.e. a car park, roadside charging point and a garage charging hub
- To use this real-life test to put the participants, practically and emotionally, in the mind of potential electric vehicle owners and in doing so, uncover points of pain and pleasure.

These helped inform the research questions 2, 3, 5 and 6:

2. How easy is in-car charging equipment to use?
3. How accessible and varied are the locations and charging equipment at public charging points?
5. Is going electric more suited to motorist with particular disabilities?
6. How does the length of journey impact disabled motorists?

The workshops were divided into a practical session and a reflective session with both being audio recorded and lasting approximately 2½ hours. Where necessary to help illustrate points, images were taken. Participants signed consent forms and were given a small fee of £40 as a thank you for their attendance. Travel expenses were reimbursed.

Fully accessible community centres were used as bases for the workshops and chosen for their proximity to electric vehicle charge points and their ease to find and to get to.

Practical session

These sessions were exploratory and open-ended in their nature and not timed tasks measuring efficiency and effectiveness.

After short introductions, a review of the workshop and housekeeping information was given. Following this, the participants and researchers gathered at a local charge point where a BMW i3³ was parked alongside. A researcher demonstrated the process of using the particular charge point to charge the BMW after which the participants were invited to attempt to do it for themselves.

Four charging points were tested:

³ A BMW i3 120AH was sourced for these workshops through Motability Operations in cooperation with BMW corporate support, BMW UK.

1. Roadside pillar box design, Type 2. London. W6 9DX supplied by source
2. Charge master (BP) petrol station, charging hub, CCS. Hammersmith
3. Charge master (BP) petrol station, charging hub, Type 2. Hammersmith
4. Car park (Intu Victoria South), Type 2. Nottingham

All four of these charging points had different physical characteristics which allowed the participants to test various reach and access solutions, see Figure 6.

Figure 6: Charging points tested

1



2



3



4



Reflective session

After testing the charging points for ease of use and accessibility, the participants and researchers returned to the community centre to further discuss their experiences. The same questions which featured at the end of the survey, i.e. 'would you consider buying an electric vehicle?' and, 'what would make you want to buy an electric car?' were asked.

The most commonly used App (Zap Map)⁴ for locating charging points was shown on a computer and a discussion exploring its suitability for the needs of disabled people followed.

Overview

The two workshops produced similar outputs, complementing each other with many of the same issues being recorded across both workshops. The accessibility of charging points was of major concern with many features of and interactions with the process not suiting people with mobility or dexterity difficulties.

The time taken to recharge was also a significant concern as was the sense of increased anxiety associated with owning an electric vehicle.

Accessibility of charging points

All four charging points reviewed contained access problems for our participants who used wheelchairs and or walking sticks/crutches. In many cases there was not enough space around the parked vehicle and charging points for the wheelchair to be manoeuvred. To compound this, two of the charging points (#2 & 3) had obstacles placed in the way blocking access to charging cables. Where curbs existed (#1, 2 & 3), none had drop curbs to help wheelchairs gain access to the charging point.

There were many factors that our participants needed to consider when parking an electric vehicle at a charging station, most importantly of which was the location of the charging flap on the vehicle. Cable lengths and access for the driver will determine if the vehicle should be positioned into the parking space frontwards or backwards or on which side to face the curb for on street charging.

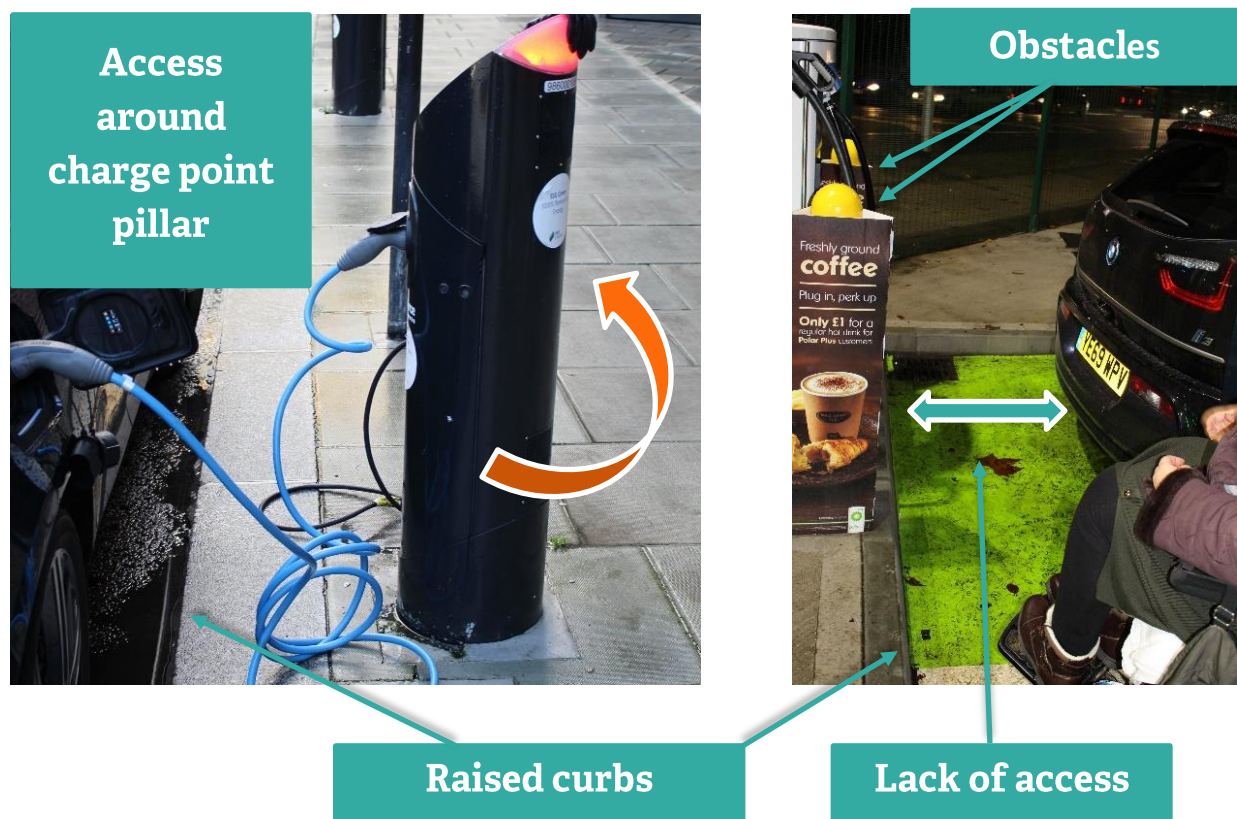
⁴ <https://www.zap-map.com>
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This was only part of the equation for our participants. As pointed out, many people with mobility impairments need access to the boot of the vehicle, either for equipment such as wheelchairs, scooters, sticks or crutches, or to gain access into the vehicle, such as a WAV. If the charging flap is near the rear of the vehicle it can make boot access almost impossible. This is an issue for people with hoists or ramps for their wheelchairs.

"It's completely inaccessible for a wheelchair user"
Brian

"Got to take the wheelchair out first, so the cable might be in front of the wheelchair"
John

Figure 7: Access difficulties



Once the vehicle is positioned at the charging point, and assuming that mobility aids have been accessed, the driver needs to be able to physically get to the standing charging point. There should be enough space around the vehicle for a person to manoeuvre with any mobility aids they might need, such as sticks, crutches or wheelchairs. This led to discussions about the availability of accessible charging point stations.

“Transfer on to the driver’s seat from a wheelchair is a problem. They need disabled bays for charging” Brian

Accessibility of charging cables

The handling of the cables and connectors, either those cables fixed at the charging station (#2 & 3), or those provided with the vehicle (#1 & 4), were a concern.

Where the vehicle’s own cables were used (#1 & 4) our participants felt that they were difficult to carry and plug in between the charging point outlet and the vehicle’s charging socket. This related to the cable being heavy and stiff which, when using with walking sticks or crutches was difficult to manhandle and when using a wheelchair, our participants placed the cable on their laps with one end plugged in. Further to this it was thought the cable would become dirty and oily over time making handling unpleasant, see Figure 8.

The action of plugging in the connector (Type 2 and CSS) was also problematic for some participants as it requires strength and dexterity to ensure that the plug is correctly placed into the socket. This action is made more difficult when the having to stretch from a wheelchair in order to reach the connector nozzle, see Figure 9.

Figure 8: Cables on lap



Figure 9: Reaching for nozzle



This process was remarked on as being time consuming, difficult and full of potential pitfalls.

“Having to take 20 minutes to get my wheelchair out and then having to fight with that, cables too heavy, it takes me too much strength to put them in, there wouldn't be enough room, especially in that car park. Somebody would come and park next to it and then what would you do?” Allison

Environment

The visit to the petrol station charge points (#2 & 3) was in late November in the early evening, around 4pm. The tarmac surrounding the charging points' parking bays was slippery from oil and general traffic grime. This did not provide very sure footing for our participants who were using crutches and walking sticks.

“Yeah, it's [the parking bay tarmac] awful. It's nasty, slippery” Andrew

“I can slip or fall ... I have to take off the cable, concentrate on that!” Richard

A further concern was the openness of the outside charging stations to extremes of weather conditions. Providing cover for these forecourt charging points (#2 & 3) was suggested as a way of mitigating environmental effects.

“Imagine if it was chucking it down or snowing with no cover, trying to hold an umbrella whilst trying to plug this in?” _ Allison

Attitudes towards electric charging points and vehicles

The accuracy of the quoted range of electric vehicles published in marketing materials was questioned with most people believing the actual achievable working range to be a

lot smaller. In addition to uncertainty about the quoted 'ideal' range by the car manufacturers, the participants cited the possible negative effects of in-car charging of electric wheelchairs, car and personal heating systems and boot hoists.

It was highlighted that many disabled people's lives were very busy and ran to strict timetables for carer swap-overs and medical appointments. The perceived uncertainty about being able to recharge an electric vehicle at will and without considerable inconvenience made our participants nervous about considering an electric vehicle for their next purchase.

Amongst the participants there was a general wish to make environmentally friendly purchase choices with one participant having already researched electric vehicle options. However, by the end of the workshop they were adamant that this was no longer a realistic option for them to pursue.

“I really wanted an electric car but that was no good for me, it was just impossible, I couldn't do it” Claire

When asked what would make our participants consider an electric vehicle for their next purchase, confidence in a fully accessible charging infrastructure and an extended and reliable vehicle range were most mentioned.

There was however a willingness to consider PHEV (petrol hybrid electric vehicles) especially where the participant's lifestyle supported short journeys.

“I would choose an Outlander (PHEV) and do short trips all on electric i.e. 20 miles and have the engine assist on longer journeys” Carl

Another participant said it was the lack of space for a charging point in their home that discouraged them along with the bother or hassle associated with owning an electric vehicle (e.g. running out of charge, difficulty finding an available charging point).

“I spent five years gaining my independence, and this is a step backwards. This is not for me, this is taking away my independence” Ron

What should car distributors and lease companies be telling their disabled customers about electric vehicles?

At the end of workshop, participants were asked what they thought leasing companies ought to be informing disabled people about when enquiring about purchasing an electric vehicle. It was noted that dealerships do not always discuss or lack the expertise to discuss, all the potential difficulties that might impact when choosing an electric vehicle.

The overwhelming response by the participants was to highlight the potential difficulties a disabled person might experience: ‘sense checking’ whether it is a suitable product for them to buy. Participants suggested that the following factors needed to be considered:

- **Customer’s lifestyle**
 - Use of the car (i.e. short or long journeys)
 - Home situation (i.e. parking arrangements and availability of space for home charging)
 - A home visit to assess the suitability was also discussed
- **Customer’s disability**
 - Dexterity / mobility demands on the user
 - Potential for increased anxiety
 - Impact on car driving controls or support equipment
- **Practicalities**
 - Charging cable weights, lengths and charging flow rate capacity
 - Types of connector
 - Availability of charging points in the area
 - Potential of reduction in battery performance in the winter
- **Finance**
 - Additional costs (cables, home charging)

Analysis

Overview of process

In order to explore a typical electric car journey by a disabled person, a process diagram was developed to highlight potential failures (i.e. setbacks) at various touch points along the journey. These failure points were used to show what their possible impact might be on the driver and what mitigations could follow (see Appendix D).

A holistic view was taken when developing this model, by following a typical journey from planning through to completion of the journey. Such a model would need to be adapted for the broad range of different journey scenarios such as: long journeys (including holidays), very short trips, shared driving, time of day/night, commuting, city/rural and so on.

Planning a journey



Overview

Disabled people often plan their journeys in detail, paying particular attention to potential failure points and thinking through contingencies to get around potential problems. This is no different when planning a journey with an electric car.

The first thing to be considered will be the route that the driver wishes to take. This will be informed by the driver's working knowledge of the actual range of their electric vehicle in relation to traffic conditions and the current charge status. Other factors also need to be considered such as: the presence of charging points, the time available, time of day, congestion and any extra use of the battery charge due to hoists, wheelchair battery charging, heat pads and so on. A balance is struck between these factors and a journey planned.

Accurate information is required to help inform this plan. However, information that is reliable and easy to understand is not always easy to come by, leaving the motorist to place greater value on their own knowledge and experience.

Charging point maps

This need for up-to-date and relevant information is exemplified when finding information about charging points. Whether they are broken or in-use and for how long as well as their type (i.e. fast, rapid or ultra-fast); plug configuration and who their electricity supplier is.

The most common method of finding this information is by scrutinizing online maps showing all the charging points available in the vicinity of their desired journey route. These online maps can be particular to the electricity supplier or more comprehensive Apps which cover all suppliers as seen in 'Zap Map', see Figure 10. Zap Map indicates the position and status of all the charging points in the UK and is the current most popular App of choice on the market.

Although there is a significant amount of information about each of the charging points, at the time of writing this report there is no information contained on Zap Map about the accessibility of charge stations. This information would be extremely helpful when planning a journey, as disabled motorists have to rely on their knowledge of where the accessible charging points appropriate for their electric vehicle and needs are.

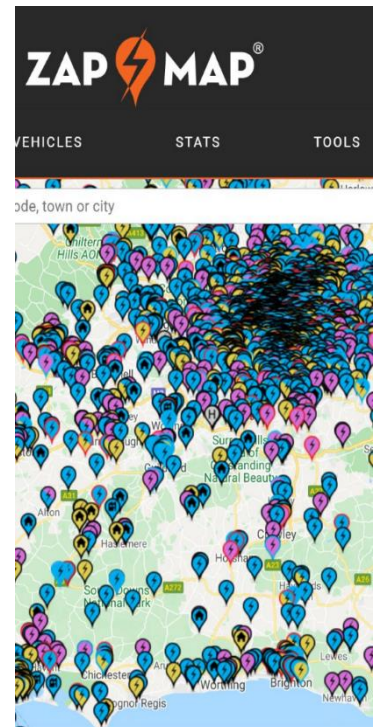
Additionally, the accessibility of the App itself needs to be confirmed through user testing by people across a range of different disabilities and assistive technologies.

Impact and mitigation

Not having easy to find information about the accessibility of charge points can result in being overly cautious when journey planning. One journey might be divided into two or three separate journeys over a number of days to ensure that a comfortable level of reserved 'emergency' battery power is maintained. This could result in returning home at regular intervals to keep topping up the vehicle's battery.

A lack of information about where the accessible charging stations are, is further compounded by the lack of numbers of accessible charging stations. This situation can lead to the few accessible charging stations that do exist (either by design or

Figure 10 Zap Map App



chance) being coveted by disabled people who have a disproportionately under-represented number of accessible charging stations to choose from. This will contribute to the uncertainty of finding an available accessible charging station.

The main impact of shorter journeys will be a loss or reduction in people's sense of independence.

Starting a journey



It is at this point of the journey that 'sense checking' will happen. This will be informed by any previous planning, driving experience, the actual available charge and any intention to recharge.

This level of preparation is not usual practice when motoring for any group of people but when placed alongside the typical preparation required by many disabled people when leaving their home, it can become prohibitive to making the journey.

When starting a journey, disabled and older drivers may experience an increase in range anxiety. Anxiety may be heightened because of the perceived potential failures within a journey and this could, in turn, impact driver performance. Motorists may be affected in different ways and effects may be expressed on a cognitive, emotional and/or behavioural level [13]. On a cognitive level, motorists may experience recurring negative thoughts such as running out of charge and not reaching their destination. There may also be negative effects in terms of increased cognitive load, with too many concerns imposing themselves at the same time and affecting the cognitive functions required for driving. On an emotional level, motorists may feel nervousness or fear and on a behavioural level, they may adjust their driving style to save energy or frequently monitor their range display [14].

The experience of range anxiety, however, will depend on a number of factors such as individual differences (e.g. access needs, trust in an electric vehicle, personality traits); system features that are in place (e.g. support through charging point maps, availability of charging points on route) and the driving environment (e.g. time of day, region: urban vs. rural) [15].

Providing disabled and older motorists with user-appropriate information about range (e.g. factors that influence range, strategies to save energy whilst driving) may help alleviate anxieties associated with starting a journey and reaching a

destination.

Getting to destination & the return journey



Although these two activities are similar in that they involve driving from one place to another, they do have their differences. It is quite likely that the return journey will be more predictable than the outward one. This could be for reasons such as not needing to find parking or charging spaces or being more confident about the remaining battery charge and range capacity. This predictability should contribute towards a lowering of anxiety.

However, there are still quite a number of potential events that might happen whilst driving to, and from, the destination. The most common of which is being caught up in traffic because of congestion or roadworks. This stop starting is inherently inefficient and will lead to a reduction in the range available.

Parking / Recharging



Finding an available accessible parking space can be problematic at the best of times. Finding one with a recharging power point will be even more difficult. Challenges about the accessibility of charging points have been highlighted in the consumer workshops section of this report. There has been a growing awareness of the need for fully accessible charging bays although this has not resulted in a policy driven rollout, they are still few and far between.

It is likely that a driver's local knowledge of 'accessible' charging points will provide the location of where to recharge. There is guidance provided^{11,12} for the design of footprint of accessible charging points, however when this applied, it is often not communicated at the station or through Zap Map and consequently can be used by anyone.

Figure 11: Accessible parking footprint (1), used for charging point not labelled (2) & occupied (3)



In addition to this, there is a need to make the whole task of recharging, not just the parking footprint, accessible. Attention should be placed on better understanding of the interaction between the user and the cables and connectors. Such usability testing should be in-situ involving disabled and older people as users.

Outreach

Some of the main outputs from this research project were presented at a breakfast round table event to a mixture of stakeholders at Toynbee Hall on Wednesday 26th February 2020. A copy of the presentation can be found [here](#).

Further outreach activity will be carried out by RiDC in June to promote both this research report and the online consumer guidance that has been informed by it to a wide range of audiences. This aims to help ensure that consumers are better able to make informed choices about plug-in electric cars, and that policy makers, whether local or central government and industry are better informed about the needs of disabled and older motorists.

Conclusions and recommendations

This research has uncovered several key challenges for the electric vehicle market when considering the needs of disabled people.

- We have found little evidence of the provision of accessible charging points in the UK. Little effort has been made to make existing charging points as accessible as possible by including, for example, dropped curbs or removing obstacles.
- We have also identified potential difficulties that disabled motorists might experience with owning an electric car, such as: increased anxiety, reduced car range and a loss of independence.
- Finally, we have identified a need for more appropriate information to be given to disabled motorists when considering buying an electric vehicle.

These challenges have been grouped by category, each directly responding to the research questions identified at the start of this report.

- Accessibility
- User experience
- Suitability

Accessibility

There is a need to improve the accessibility of many of the elements within a typical electric vehicle journey that a disabled motorist might encounter.

Improvements to the design of charging points (on street, car park, petrol station hub) to ensure they are accessible are urgently needed if the recharging of electric vehicles is to become a realistic option for many disabled people. Most importantly, these improvements should be made through undertaking in-situ usability testing with disabled motorists testing the whole charging process as one task and not as a series of individual elements. This will ensure that the ergonomic relationship between users, environment and devices (cable, connectors, car and charging point) is better understood and points of pain identified.

This holistic usability testing should not only include a variety of disabled motorists, but also different stakeholders such as: equipment designers, energy suppliers, landlords, local and central government policy makers and car manufacturers.

User Experience

Further to user testing equipment and physical infrastructure, there is also a need to better understand what the disabled motorists' current experience is. Our research showed the importance disabled motorists place on time and effort required. For example, time to start a journey, time to stow wheelchairs and other equipment, and time to be at particular place for medical reasons; effort to transfer in and out of vehicles, effort to pack and unpack assistive equipment, and effort in driving adapted vehicles.

When the time and effort required for finding and charging an electric vehicle is added to this already fully occupied lifestyle, the driving user experience is considerably diminished. The potential impact of this on disabled motorists' behaviour could be seen as a step backwards for people resulting in a sense of loss of independence.

Suitability

Owning an electric vehicle can suit some people above others. Having a house driveway or private parking can both make installing a home charging point easier to achieve. Other factors that can influence choice negatively are the use of ramps and/or hoists, both of which can have an impact on accessibility when recharging as well as on battery use. This could also be true for other assistive driving controls which use battery power.

The type and range of journey could also influence choice, shorter trips would mean less dependence on the difficult to manage public recharging infrastructure.

Although electric vehicles can be used, or adapted to be used, by a broad range of people with disabilities. There are certain qualities about the user experience and the inaccessibility of charging infrastructure that would not favour people with high anxiety, poor reach or limited strength or dexterity.

The future

The findings in this report highlight the lack of consideration given to disabled motorists where provisions for accessibility are reactive and not proactive. It is important for this message to reach as comprehensive an audience as possible to help influence change.

RiDC will be publicising this report and consumer guidance drawn from its findings as widely as possible through mainstream and specialist disability media, social media and professional networks.

Achieving change

A key strategic priority for RiDC's work is to understand and work to ensure that future transport and mobility initiatives are inclusive, ensuring that the needs of disabled and older consumers are not ignored in the rush to develop new technologies and services.

Our latest research into plug in electric cars indicates that unfortunately key failings exist around the accessibility of this new technology – in terms of the in-car charging equipment, the public charging points and the charge point information infrastructure. The desire for inclusion is often there – a number of documents say for example that the charging points should 'be accessible', but there is a lack of detail of what this actually means in terms of the design processes, specification, existing legislation or standards. This has led to accessibility failings. Some disabled participants went as far as to say that after the trials that owning an electric plug-in car would be a backwards step in terms of their ability to be independent drivers.

To achieve change in this situation we will be sharing our research findings widely in the Spring/Summer of 2020 with key stakeholders. We will also be promoting online consumer information, published at www.ridc.org.uk and based on our research findings. This aims to ensure that disabled motorists can make informed choices about plug-in electric cars.

Key stakeholder groups

It is important to note that there is a huge number and range of private, public and consumer stakeholders involved in the delivery of electric plug-in cars within the UK. These include:

- Motor vehicle manufacturers and designers
- Public charge point manufacturers and installers
- Private owners of sites buying or leasing public charge points e.g. petrol stations, motorway service stations, as well as owners of residential and non-residential buildings, retail and leisure sites
- Local authorities and Highways England as public owners of sites installing public charge points e.g. in public roads and car parks
- Charge point information and charging website providers
- Government legislators & policy makers (central and local)
- UK and International Standards bodies
- EU legislators
- Consumer groups representing the interests of and/or advising motorists.

Future actions

As noted, RiDC's will be extensively promoting the research to specific organisations within these stakeholder groups. Representatives from some were invited to a breakfast round table event to discuss initial findings from the project at Toynbee Hall in February 2020. A copy of the presentation can be found clicking [here](#).

Our next stage of promotion will be to share this research report and seek discussions around future action to mitigate the problems it highlights. Below we list these organisations and the identified levers for action.

1. Motor Vehicle manufacturers and designers

Individual Motor Manufacturers, Society of Motor Manufacturers and Traders (SMMT), European Car Testing /rating bodies Euro NCAP (European New Car Assessment Programme) & ICRT (International Consumer Research & Testing). Plus industry influencers: RAC Foundation, ADAC (German Automobile Association), Which?, What Car and major lease companies e.g. Motability, LexAutolease.

Objective: To encourage manufacturers and designers to carry out UX research focused on accessibility of charging equipment/processes. To ensure greater awareness of disabled and older motorists needs, UK Equality legislation, the forthcoming European Accessibility Act and existing BSI inclusive design Standards.

2. Public charge point manufacturers and online service providers

Charge point/ map businesses e.g. BP Charge Point; PodPOint; EV; ZapMap.
Private charge point sites: Petrol Retailers Association; Petrol Industry Association; Motorway Service Operators (Welcome Break, Moto, Road Chef, Extra; Euro Garages).

Objective: To encourage charge point manufacturers and online service providers to carry out UX research focused on the accessibility of charging equipment/processes and the online information and pay websites. To ensure greater awareness of disabled and older motorists needs, UK Equality legislation, the forthcoming European Accessibility Act and existing BSI inclusive design Standards.

3. Government legislators & policy makers (central and local)

- Department for Transport (Accessibility, Strategy and Equalities team);
- Office for Low Emission Vehicles (OLEV) – Cross government department supporting the early market for ultra-low emission vehicles. Provide grants to install home and work electric charge points, and to local authorities for on street residential charge points. They manage the charge point model approval process, listing authorized installers and approved charge points models; and publish guidance.
- Highways England – Government body responsible for England’s roads
- Local Government Association (work on behalf of local authorities)
- Metropolitan transport authorities – e.g. Transport for London and Transport for Greater Manchester (developed extensive electric vehicle infrastructure policy and delivery plans)
- Standards bodies BSI and ISO / Euro (develop new product and service standards)
- Equality and Human Rights Commission (EHRC) (review and monitor equality legislation)
- Law Commission (reviewing legislation around electric and autonomous vehicles)

Objective: OLEV as the main government co-ordinator of the electric cars initiative is our key target policy maker and information provider, but all the others have a potential role in delivering change. Our objective is to ensure greater awareness of disabled and older motorists accessibility needs when developing new infrastructure for electric plug-in vehicles. Importantly, the inclusion of detailed accessibility specifications for charging infrastructure within policies and guidance, as well as a recommendation for consumer involvement and consultation and enforcement of existing equality legislation.

4. Disabled and older consumers & consumer groups:

- *Representing disabled & older consumers* - Motability, Disabled motoring UK, Age UK, member organisations of the Joint Committee on the Mobility for Disabled (JCMD).
- *Representing all consumers* - Which?, Transport Focus, Consumers Advice, What Car, RAC, AA)

Objective: Disseminate the consumer information output to help ensure that consumers are better able to make informed choices about plug-in electric cars. Disseminate the research report and encourage lobbying of government and industry on behalf of disabled and older motoring consumers.

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Appendix A

List of organisations contacted, and interview script used to explore knowledge and experience of user testing.

Organisation / contact	Description	Link
Motability operations Hayley Ingram	UK vehicle lease scheme for disabled people and their families	https://www.motability.co.uk/
ICRT	International Consumer Research & Testing (ICRT). Global consortium carrying out joint research and testing in the consumer interest	https://www.international-testing.org/
Protégez-vous	Canadian consumer testing group	https://www.protegez-vous.ca/
Test Achats	Belgian consumer testing organisation	https://www.test-achats.be/
RAC foundation	Motoring organisation	https://www.racfoundation.org
TfL	Transport for London	
TRL	Transport Research Laboratory	https://trl.co.uk/
Steering development Ltd	Well-established vehicle conversion/adaptation specialist for disabled drivers/passengers.	https://www.steeringdevelopments.co.uk/
Ann Frye Ltd	Transport access consultant	https://www.transport-associates.net/tan-people/ann-frye/
SMMT	The Society of Motor Manufacturers and Traders Ltd	https://www.smmt.co.uk/
Consumentenbond	Dutch non-profit organization which promotes consumer protection	https://www.consumentenbond.nl/
Euro NCAP	European vehicle safety rating	https://www.euroncap.com/en
Energy Saving Trust	Aims to promote the sustainable use of energy and to cut carbon dioxide emissions.	https://energysavingtrust.org.uk/
Older drivers forum	not-for-profit organisation - road safety experts aiming to keep older people on the road.	https://olderdriversforum.com/

Driving Mobility	Driving Mobility accredits a network of 20 UK driving assessment centres	https://www.drivingmobility.org.uk/
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Background research – script used in interviews

Building on existing knowledge

Research Questions:

Existing Research

1. What research are you aware of concerning disabled people and EVs and PHEVs?
 - a. Is there any accessibility research?
 - b. Who is doing this research?
 - c. Who should be doing this research?

Technology

2. What recharging information do car manufacturers provide: w.r.t. to cables / plugs lengths, weights, types?
 - a. Are there standards emerging?
 - b. What are they?
3. Is there an optimum dimension for length?
4. Are there adaptors available on the market between plug types?
5. How are the cables stored? Wound on a reel or ...?

In the field

6. Are you aware of any difficulties being experienced by disabled people in the field?
7. What do you think the main issues are for disabled people and EVs or PHEVs?
8. Are charging bays accessible?

Appendix B

Stakeholder outreach – Toynbee Hall Weds 26th February 2020 attendees

Zahrah Ali	Transport for London
Enda McLaughlin	Individual
Tom Jamison	Impact publishing – Able Magazine
Catharine Brown	Designability
Jennifer Synnott	Motability Operations
Chunqiu Li	University of London
Doreen Lam	RAC Foundation
Catherine Folca	Transport Focus
Catriona Barker	Transport for London
Rachael Badger	Motability
Joscelyn Terrell	The Office for Low Emission Vehicles
Martin Pett	Connected Places Catapult
David Partington	Individual
Jose Paris	Individual
Jianxun lai	Individual
Rajni Nair	Citizens Advice

Appendix C

Thematic analysis from survey

Q11. Reasons why public charging stations are perceived as neither accessible nor easy to use

Lack of local charging points

“None in the vicinity of my home”

“There aren’t many locally and they’re in odd areas of car parks”

“There are not enough of them. I have only seen some by chance so I wouldn’t know where they are.”

Insufficient width of parking bays beside the charging points

“The ones I have seen don’t have the same width as a blue badge parking space making it impossible to get out of the car or back in.”

“If I had an electric WAV there would be insufficient room to get my vehicle into the space”

“No space for a wheelchair user to plug in”

“There are no charging bays wide enough to be able to get my wheelchair out of the car. They’re all standard bays.”

Awkward height and positioning of charging points

“All the charging stations are designed to use whilst STOOD UP which is a major problem if you use crutches, walking sticks and/or a wheelchair.”

“Difficult to access the cable and plugs to inlet charge”

“Not enough space to get into my wheelchair and could not reach charger.”

“Too high for a wheelchair. I would need help.”

“As I struggle to use a petrol pump, I’m assuming that a charging station would be equally difficult to use from a wheelchair”

Confusing range of charging points

“Too many different types. Even different powers of chargers could use the same sockets, with controllers recognising which pins to use”

Lack of 'available' charging points

"Too much in demand especially in motorway service areas where "charging rage" is already happening!"

"Often occupied."

The excessive time needed to charge an EV

"What am I supposed to do? Sit in a car for 8 hours while it charges in the car park... It is badly thought out. I would be totally dependent on public charging points."

"Not clear... how long it would take."

Q14. Reasons why charging cables are perceived as being neither accessible nor easy to use

Perceived strength required to use charging cable

"I use an electric wheelchair and have weak muscles. I expect I would struggle to get my wheelchair into a safe position to plug in and I expect I would be too weak to do it safely by myself"

"I have arthritis in both hands, Spondylitis which makes pulling cables painful, but mostly I have poor grip control."

"Possibly too heavy and difficult to plug in"

"They look heavy and clumsy."

Cumbersome nature of the charging cable

"You need 3 hands to use, one to keep the flap up and 2 hands to plug it in."

"Long twisty cable is cumbersome."

"I do not think I could connect the plugs at each end."

Q22 What one thing would make you buy an electric vehicle?

Affordability of both the car and a home charging point

"Cost is a big factor."

"The cost of having a home charging station installed"

"The price is far too high for people on disabled benefits."

"Availability of grants to install private charging point"

Availability of more charging points

"A greater range of charging points"

"I live in the countryside...as more people get electric cars charging points will be a huge problem."

"More charging facilities."

Quicker charging time

"Fast charging without detriment to battery life."

"Shorter charging time"

An ability to travel longer distances

"Make them cover longer distances"

"The distance restriction per charge is inadequate."

"Bigger mileage between charges."

Q23 What concerns you most about owning an electric vehicle? Other:

Running out of charge

"If using air conditioning essentially means I cannot get anywhere as I would be stranded, I cannot travel independently."

"(My husband) has general anxiety disorder and says he would be in a constant state of panic about running out of charge before reaching his destination."

The cost of charging and maintenance

"If an electric vehicle uses a 60K watt motor, then to charge it (because of losses in Ac to Dc conversion) is the equivalent of 80Kwatt. At 15p/Kwatt this translates into £12 for each hour of operation. This is double the cost of a Diesel car. To us older people, with fixed income, that is a major deterrent."

"The cost of replacing parts, including batteries."

"The cost of running. Cost of replacement batteries...Insurance is also more expensive."

Lack of sound which may put pedestrians at risk

"EV's are largely silent, even those with an audible vehicle alert system installed can often have them turned off. Driving an EV in silent mode is life threatening to those who rely on hearing to assess traffic risks. This includes blind people, but also children, cyclists... as a driver you don't want to hit someone"

Perceived environmental impact

"The environmental impact of replacement of parts such as batteries. Production of electricity is heavily dependent on fossil fuels, especially most of the so called "green"

sources.”

“Pollution figures suggest an annual total of 2.4 million tons for an electric charge and the same for my Euro6 diesel car...there is no gain for twice the price.”

Capacity for mobility aids (i.e. wheelchair)

“Would it be big enough to take a wheelchair? e.g. an estate car.”

Appendix D

Driver touch points during typical journey, including an example of potential failure

