TRANSPORT STUDIES UNIT

Second Interim Report, July 2019

Go Ultra Low Oxford

Monitoring and Evaluation

Second Interim Report

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Executive Summary

On-street charging technologies can significantly improve access to charging infrastructure for prospective and existing ultra-low electric vehicle (ULEV)[1] owners without private off-street parking space. Go Ultra Low Oxford (GULO), led by Oxford City Council in partnership with Oxfordshire County Council, is trialling five different on-street charging technologies across 30 locations in Oxford with approximately 20 private households and a car club. The technologies include one home charger with a cable channel, a lamppost charger and three freestanding bollard chargers.

The trial is monitored and evaluated by the Transport Studies Unit (TSU) at the University Of Oxford, which acts as an independent evaluator. This Second Interim Report draws on two rounds of interviews with 18 participating households to provide preliminary insights into the four objectives associated with these activities.

1. Performance of the various on-street charging installations

Nine criteria for assessing the performance of the five on-street charging technologies from a user perspective have been identified in an open and bottom-up manner: 1) utilisation; 2) reliability; 3) ease of access; 4) ease of use; 5) adoption capacity; 6) risk of damage to vehicle; 7) risk to other street users; 8) maintenance and repair; and 9) charging installation footprint (see Table 5, page 29 for details). Both the identified criteria and the assigned scores should be considered preliminary. They may change over the course of the trial.

After approximately six months of use, the lamppost chargers on average performed marginally better than the home chargers with cable channel. Bollard-style chargers seem to perform adequately on most criteria, except footprint and the risk of damage to the vehicle. Differences have emerged, however, in relation to the reliability and maintenance of repair of individual installations, particularly the bollard-style chargers.

All chargers have experienced some malfunctions or breakdowns. Differences in the durability of installations, problem identification processes and procedures and response capacities of organisations have been pronounced. In particular, the Zeta Smartscape bollard charger has appeared vulnerable to impact collisions and has required long repair times due to its design and lack of replacement parts and units. It should be borne in mind, however, that an early model of this charger was used in the trial and that only one private household was offered this charger in the trial.

2. Adaptations to car-use routines and the formation of charging habits

The clearest changes in trial participants' routines and habits have occurred in how they negotiate parking and in when, for how long, where and how often they charge their vehicle. Habits and routines develop over time as people become familiar with their car's range and how long it takes to charge using a particular installation. The timing and duration of charging episodes depends on multiple factors, including the proximity and accessibility of a charging space, personal and/or household routines, the nature of car journals that have been or will be undertaken, and the capacity of their battery.

Five car club members have agreed to participate in the monitoring and evaluation of the trial. Their behaviours, views and experiences differ in some ways from those of the private participants. Some of the differences can be attributed to car club participants driving BEVs with limited range, using these vehicles less regularly, having extremely limited ability to monitor and control the battery state of charge and uncertainties about how to charge away from the trial installation. Accordingly, the car club participants agreed that BEVs are best suited to short and local journeys. Having overcome initial difficulties, four out of five found the charging process fairly straightforward. Much like private participants, they expressed concerns about storing and using cables, but

[1] Cars or vans that emit at most 75 g/km Co2 (according to the New European Driving Cycle (NEDC) test), including 'pure' or battery electric vehicles (BEVs), extended-range electric vehicles (EREVs), and plug-in hybrid electric vehicles (PHEVs).

also the additional burden charging places on users. Car club users appear to be less concerned than private participants, however, about ensuring that the car had started charging properly.

3. Scaling up of the pilot within Oxford and transfer to other local authorities

There were three main lessons in the First Interim Report for local authorities elsewhere in the UK that seek to increase EV adoption through the creation of charging infrastructures on public streets in residential areas. Those concerned the factors shaping the usability or appropriateness of parking spaces for on-street charging, the need for a new parking etiquette around parking, and the specificity of Oxford as a site for social learning about on-street charging technologies.

This Report identifies four additional lessons for local authorities. First, the monitoring, maintenance and repair of installations are important issues for consideration. It is inevitable that there will be issues with installations malfunctioning and breaking down. Informal or formal processes, procedures or systems that allow users to determine the status of charging installations and report any issues need to be either developed or co-opted (e.g., Zap-Map). From an operational perspective, durable and modular designs, the availability of replacement parts and units and staff availability are critical in assessing potential damage and the amount of time required for diagnosis, maintenance and repair.

Second, taking the adoption capacity of a charging installation into account will help to reduce the likelihood of publicly available chargers being underutilised or not used at all. Adoption capacity is the potential for new or extra users to start using a charger. It depends on: a) whether the installation available for public or private use; b) the number of ports; c) the types of connectors available; d) the number of associated parking spaces; e) the need for additional equipment (e.g. special cables), and/or f) membership rights required for connecting.

Third, local authorities should consider on-street charging installations in residential areas in the context of a wider local ecosystem for ULEV use. The two Interim Reports demonstrate that multiple factors affect ULEV users' ability to access and use chargers. Publicly available local chargers in nearby streets or car parks may act as important back-ups for users when their regular charger is intermittently available, for instance, due to maintenance and repair. The ability of chargers to perform this function, however, is often limited by ongoing membership requirements or the positioning of chargers in private car parks requiring users to pay for parking. Both of these configurations discourage particularly PHEV users from charging on a more informal and discretionary basis.

Finally, there is scope for integration of more battery electric vehicles (BEVs) into existing car club operations. Car club participants agreed that BEVs are best suited to shorter and local journeys. This aligns with both the business model of many car clubs and the aspiration of most local authorities for local journeys that cannot be completed on foot or bicycle to be made in BEVs. At the same time, given the range of current BEVs, operators should also have other ULEV vehicles (plug-in and non-plug-in hybrids) on their fleets in order to cater to demand for longer trips without charging.

1. Introduction

On-street charging technologies can significantly improve access to charging infrastructure for owners of ultra-low emission vehicles (ULEVs)[2] who live in terraced or communal housing without private off-street parking space. This can reduce one of the key barriers to ULEV uptake within this group. A consortium of parties led by Oxford City Council in partnership with Oxfordshire County Council is undertaking Go Ultra Low Oxford (GULO), a pilot project in Oxford that is funded by the Office of Low Emission Vehicles (OLEV). GULO is trialling five different on-street EV charging technologies across 30 locations on public streets in Oxford over a 12-month period. Both private individuals and car club users are using the installations.

The Transport Studies Unit (TSU) at the University of Oxford has been commissioned by Oxford City Council to monitor and evaluate the trial. An important aspect of this collaboration is the TSU's role as an independent evaluator. The insights, views and conclusions summarised in this report correspondingly are those of the TSU and may not necessarily reflect those of Oxford City Council. They may be used by Oxford City Council in their decision making about the further roll out of charging installations in public streets across Oxford.

The evaluation by the TSU seeks to address four main objectives:

1. Evaluating the performance of the various on-street charging installations;
2. Examining the adaptations to car-use routines and the formation of charging habits among pilot participants;
3. Identifying local community responses to the charging installations;
4. Developing insights about how the pilot may be scaled up within Oxford and transferred to local authorities elsewhere in the UK.

To understand these issues, we have adopted a longitudinal approach combining quantitative charging data and qualitative interviews with trial participants and other key stakeholders. The current document is the Second Interim Report, which draws on up to three rounds of interviews with private participants in the trial and one round of interviews with car club participants. Due to the various delays in the trial and the unavailability of quantitative charging data, this report discusses neither insights from the interviews with trial stakeholders such as local authorities or technology providers nor the analysis of the quantitative charging data.

The remainder of this document is divided into three main sections. Section 2 provides a brief overview of the research approach and methods that have been adopted to monitor and evaluate the trial. The GULO trial, the technologies considered and the characteristics and motivations of the participants involved in the trial are then summarised in Section 3. Section 4 presents preliminary findings based on the pre-trial, ±1-2 and ±5 month interviews with private users and field-based observations. The three subsections here address Objectives 1 and 2. Section 4.1 focuses on the charging patterns and habits and routines of private participants. Following this, Section 4.2 examines non-access related factors affecting the utilisation of chargers including breakdown, organisational response capacities and participant dropouts. Section 4.3 explores car club users' experiences and views of shared EVs and the installations. Section 5 concludes by providing a summary of the main findings from the initial stages of the research and reflecting on how these insights might be scaled up in Oxford and transferred to local authorities elsewhere in the UK (Objective 4).

[2] Cars or vans that emit at most 75 g/km Co2 (according to the New European Driving Cycle (NEDC) test), including 'pure' or battery electric vehicles (BEVs), extended-range electric vehicles (EREVs), and plug-in hybrid electric vehicles (PHEVs).

2. Monitoring and evaluation research approach and methods

A longitudinal and mixed method approach has been adopted to meet the study objectives. The mainstay of the approach consists of repeated interviews with private ULEV owners and car club members in the trial. It also makes use of quantitative information on charging point usage; observations of the installations and their use over the trial period; responses to consultations organised by the City and County Councils; and interviews with stakeholders such as the technology providers and local authorities.

Interviews with private participants are conducted at four different times, one before and three during the trial at ±1-2 months, ±5 months and ±11 months after a the charging installation in their vicinity became available for use. Each interview involves a short questionnaire and open-ended and follow-up questions on a variety of topics. The second (±1-2 months) and third (±5 months) interviews also involve participants giving a video recorded demonstration of how they use the charger.

Recurring topics in the interviews include the performance of participants' charging installation and changes to participants' household and car-related routines. Other topics include:

Interview 1: Personal and household travel, why participants own or use an electric vehicle, their experiences of electric vehicles, the location of their installation, and their expectations of the trial;

Interview 2: Street parking, and community responses to the charging installation;

Interview 3: the costs associated with the charging installation, and the nature and availability of information about participants' charging behaviours;

Interview 4: Participants' reflections and evaluation of the trial.

Interviews with car club participants differed in various ways form those with private ULEV owners. There were only two interviews and these focused a narrower set of issues, including why they had decided to join a car club, how they used the car club vehicle, and their experiences with using the charging installations.

There were two motivations for using a mixed method approach. One is practical: The scale of the pilot is too limited for meaningful quantitative measurement and analysis of technology performance, changes to participants' routines and habits, and community responses. The other is theoretical: The adoption of a new technology cannot be reduced to a rational decision about whether to use it or not. Instead, it needs to be understood as a complex process of 'domestication' or embedding of a new technology in everyday life whereby perceptions, meanings, identities, routines and habits change over time as people repeatedly interact with, and learn about, the charging installation. Qualitative methods such as in-depth interviews and participant observation are best suited to understanding the complexities of the embedding of new technologies and dynamics in perceptions and meanings.

Approval for the study and the methods used has been obtained from the University of Oxford's Research Ethics Committee. Throughout the report, synonyms will be used in order to preserve the anonymity of participants.

This Second Interim Report makes use of up to three rounds of interviews with private participants and one round of interviews with car club participants, as well as field-based observations of the charging installations and their use. Quantitative data from the charging installations could not be used as these were not available for all installations. These, together with interviews with stakeholders other than users, will be used for the Final Report.

3. The Go Ultra Low Oxford (GULO) trial, charging technologies and participants

3.1 Charging technologies

The five different charging technologies operating in the trial can be grouped into three main types: 1) lamppost chargers; 2) bollard chargers; and 3) home chargers.

1) Lamppost Chargers

a. Ubitricity Lamppost Charger

Features:

- Manufactured by Ubriticity
- Mounted to lamp post
- Slow charger, ±6 hours to full charge
- Power output: 5 kW
- Not compliant with OPCC 1.5
- 1 socket, Type 2 Mennekes
- Accessible with smart cable only
- Billing via Ubriticity

2) Bollard Chargers

b. Smartscape Charging Bollard

Features:

- Manufactured by Zeta Specialist Lighting
- Freestanding pillar
- Fast charger, ±3-4 hours to full charge
- Power output: 7.4 kW
- Compliant with OPCC 1.5
- 1 socket, Type 2 Mennekes
- Accessible with RFID card and app
- Billing via NewMotion

2) Bollard Chargers (Continued)

c. e-Post Charging Bollard

Features:

- Manufactured by ePost
- Freestanding pillar
- Fast charger, ±3-4 hours to full charge
- Power output: 7.4 kW
- Compliant with OPCC 1.5
- 2 sockets, Type 2 Mennekes
- Accessible with RFID card and app
- Billing via NewMotion

d. Chago Pro Charging Station Bollard

Features:

- Manufactured by Ensto
- Freestanding pillar
- Fast charger, ±3-4 hours to full charge
- Power output: 7.4 kW
- Compliant with OPCC 1.5
- 2 sockets, Type 2 Mennekes
- Accessible with RFID card and app
- Billing via NewMotion

3) Home Chargers

e. APT Home Charger and Cable Channel

Features:

- Manufactured by eVolt
- Home charger paired with pavement channel
- Slow charger, ±6-8 hours to full charge
- Power output: 3.7 kW
- Not compliant with OPCC 1.5
- 1 socket, Type 2 Mennekes
- Only accessible from residence where charger is placed
- Billing via home energy provider

3.2 GULO TRIAL PARTICIPANTS: HOUSEHOLD CHARACTERISTICS, ELECTRIC VEHICLE TYPE AND MOTIVATIONS

The original plan was to have 30 on-street charging installations across Oxford, ten of which would be allocated to a car club operator and twenty would be located close to the dwelling of 20 private households who had signed up to the trial. Co-wheels were selected as the collaborating car club operator during the procurement process. Out of the ten installations, four of these have been in use since August 2018.

The twenty private households were recruited through a comprehensive media campaign. They have agreed in writing to participate in the GULO monitoring and evaluation. Locations for the installations close to their home have been selected by Oxford City and County Council staff based on consultations with participants and surrounding residents and the characteristics of the electricity supply in those locations. Of the original 20 households, four have dropped out for various reasons and two have been replaced by other households. As a result, there were 18 households participating in January 2019. At that time, all households had been through the first round of interviews but at different stages in the overall monitoring and evaluation process due to delays in the coming online of many charging installations (see **Table 1**). Eight participants had completed all four rounds of interviews, two had finished three rounds, five had completed the first two interviews, and three had not yet been through the second round interview (see Section 4.2). This report draws on the first, second and third-round interviews that were available at the time of writing.

Table 1. The number of households at different stages of the monitoring and evaluation, January 2019.

Status	Interview			
	Round 1	Round 2	Round 3	Round 4
Completed	18	15	10	8
Not Completed	0	3	8	10
% Completed	100.0	83.3	55.6	44.4

The trial charging installations used by the 18 private households are fairly well distributed across Oxford (see Figure 1). While the home chargers are reasonably dispersed across Oxford, the lamppost chargers are primarily situated in the north and the bollard chargers in the east. Despite this, the various installations are located in a range of different neighbourhood and street settings. Some are found in lower socio-economic areas in the east (Cowley, Littlemore, Headington) and others in higher socio-economic areas in the north (Jericho, Summertown). Installations are also present in more central and older neighbourhoods with very narrow streets, conservation areas and newer neighbourhoods with typically wider streets.

The characteristics of the main participants in the trial are presented in **Table 2**. The vast majority of participants are male (77.7%). There is only one female involved as a main participant (5.6%). In contrast to this gender imbalance, the main participants are fairly well distributed across different age categories. Most participants were living as a couple either with (44.4%) or without children (44.4%).

The type of ULEV and number of cars used by a household is shown in **Table 3**. Over half of the households (55.5%) own or lease plug-in hybrid electric vehicles (PHEVs). The remaining households have either full battery (BEVs; 27.8%) or extended range electric (EREVs; 16.7%) vehicles. This corresponds with broader trends in the UK where, after non-plug in hybrid electric vehicles (HEVs; 60.6%), PHEVs and BEVs make-up 28.1% and 11.4% of new registrations of alternative fuel vehicles (SMMT, 2018). For just over half of the households (55.6%), their ULEV is the only car that they own. The rest of the households had an additional petrol or diesel car. One household had more than two cars.

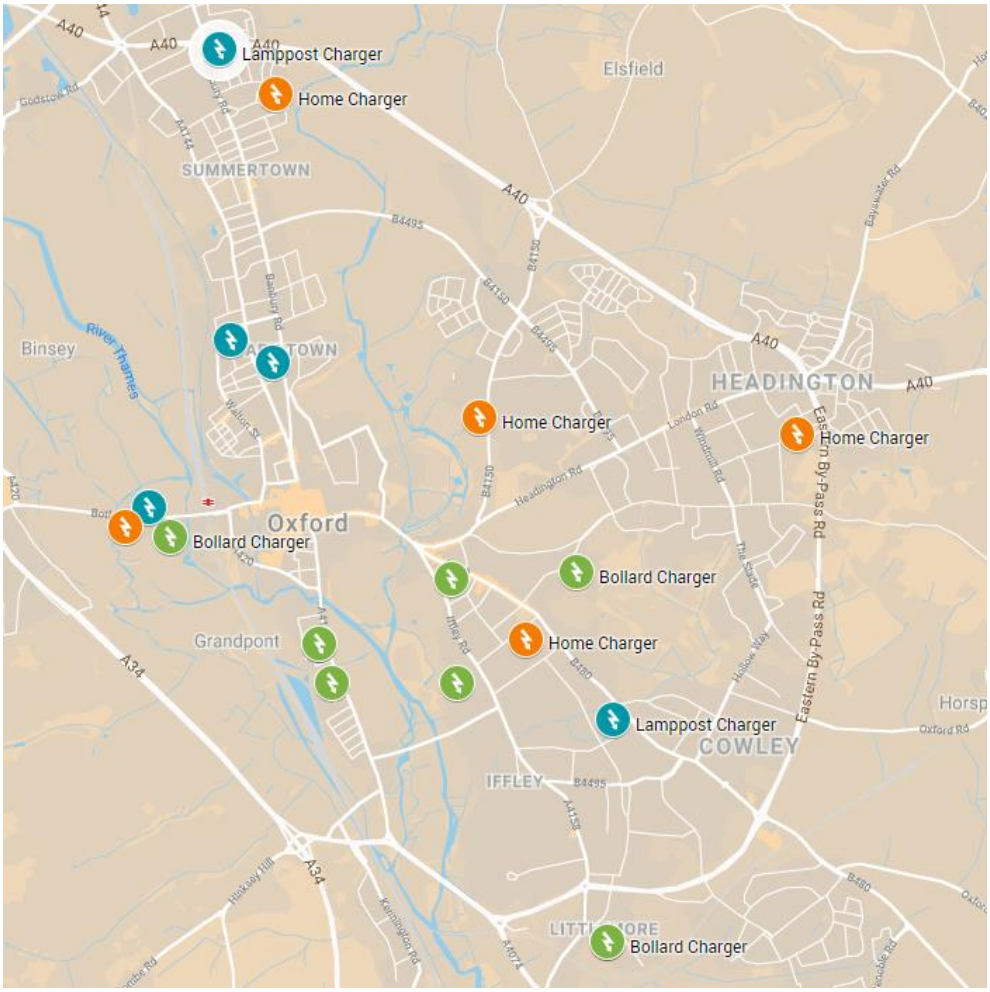

Figure 1. A map of the three different types of charging installations used by private participants. At least three lamppost chargers are located in one or neighbouring streets. Charging installations used only by car club members have been omitted. Source: Map created in Google Maps.

A primary motivation to partake in the trial for all participants was to have the opportunity to charge their car in a location close to their house. Prior to starting, many ULEV users had struggled to find opportunities to charge regularly. A few were using temporary, informal and improvised measures such as drains and road cones to reduce the chances of someone tripping on the cable while charging (see **Figure 2**). A number of participants did not use an ULEV prior to the charge and the opportunity to participate and charge legally in Oxford made them adopt an ULEV. Alongside access, convenience and legality, other reasons that motivated participants included a desire to reduce the environmental impacts (i.e., air pollution and climate change) of their car use, to support the development of charging infrastructure and to encourage friends, family and neighbours to get ULEVs.

The facts that most private participants are male and use a PHEV rather than a BEVs has three implications for the evaluation of the trial. First, the perspectives of women on the ease of use, suitability and aesthetics of the charging installations will be significantly underrepresented. Second, the consequence of not being able to charge will, on balance, be less severe for many participants compared to BEV users, the number of whom may increase strongly in the (near) future. Third, PHEVs take considerably less time to charge (~3 hours) compared to BEVs (~8 hours). The trial may therefore not generate much insight into how participants fit these charging periods into and around their existing household routines and, where relevant, parking restrictions.

Table 2. Characteristics of the main research participant.

Characteristic of main participant	Participants (n=18)	
	Number	Percentage
Gender		
Male	14	77.7
Female	1	5.6
Couple	3	16.7
Age		
20-29	1	5.6
30-39	4	22.2
40-49	4	22.2
50-59	3	16.7
60-69	5	27.8
70-79	1	5.6
Household structure		
Couple household	8	44.4
Couple with children	8	44.4
Living alone	2	11.2

Table 3. The type of ULEV and number of cars in the household.

Cars in the household	Participants (n=18)	
	Number	Percentage
ULEV type		
Battery Electric Vehicle (BEV)	5	27.8
Plug-in Hybrid Electric Vehicle (PHEV)	10	55.5
Extended Range Electric Vehicle (EREV)	3	16.7
Number of cars		
One car	10	55.6
Two or more cars	8	44.4

Figure 2. Two examples of how trial participants used temporary and informal measures such as road cones and rain drains to reduce the chances of someone tripping on the cable while charging their electric vehicle. Picture taken by: B. J. Doody.

3.3 GULO Car Club participants: Household characteristics and electric vehicle type

Co-wheels were selected as the collaborating car club operator during the procurement process. They are one of a number of car club or car sharing organisations operating in the UK who provide individuals and businesses with access to a personal vehicle on a pay-per-trip basis without the obligation of ownership and maintenance (see CoMoUK, 2018 for further details). The costs of each trip are calculated on the type of vehicle used and duration of and/or distance covered during a hire. Five Co-wheels users from three different households were interviewed. The characteristics of these users are presented in **Table 4**.

Table 4. Characteristics of the car club research participants. The figures in bracket for gender represent the total number participants interviewed.

Characteristic of main participant	Participants (n=5)	
	Number	Percentage
Gender		
Male	1 (3)	33.3 (60.0)
Female	0 (2)	0.0 (40.0)
Couple	2	66.6
Age		
30-39	1	20.0
40-49	2	40.0
60-69	1	20.0
70-79	1	20.0
Household structure		
Couple household	1	33.3
Couple with children	1	33.3
Couple in shared household	1	33.3

Co-wheels operate low emission, hybrid and electric cars in over 60 locations across the UK and have over 30 vehicles in Oxford (Co-wheels Car Club, 2019a). Out of the ten installations allocated to them as part of the trial, four have been in use since August 2018 (see **Figure 3**). The vehicles associated with these installations are all BEVs: three are a Renault Zoe (Range: ~75-130 miles depending on the model) and one is a Citroen C-Zero (Range: ~90 miles).

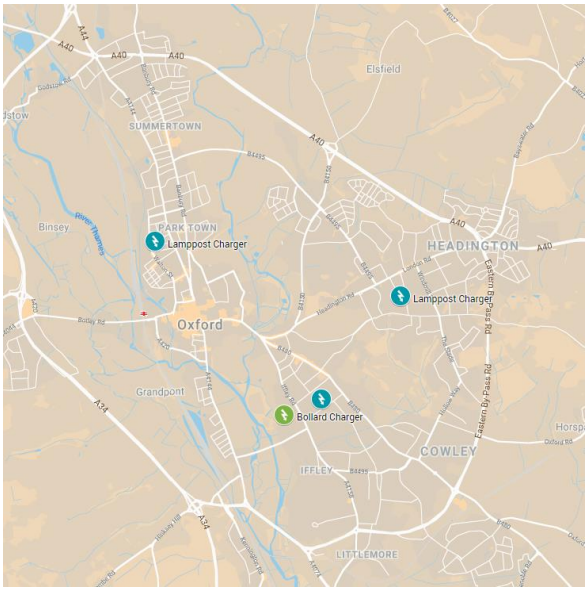

Figure 3. The two different types of charging installations being used at present by car club users in the GULO trial. Charging installations used by private participants have been omitted (see Figure 1). Source: Map created in Google Maps.

4. Usage habits and routines, charger utilisation and car club users experiences of the installations

This section discusses themes that relate to Objectives 1 and 2 and to lesser extent Objective 3 of the monitoring and evaluation of the GULO trial (page 3). Section 4.1 focuses on the charging patterns and the habits and routines of private participants and therefore addresses Objective 2. Section 4.2 discusses several aspects of charging installation performance (Objective 1), including breakdown and repair. Section 4.3 explores car club users' experiences and views of shared EVs and the installations (Objectives 1-3).

4.1 Usage habits and Routines

4.1.1 Daily and weekly charging Patterns

Participants' charging patterns, as noted in the First Interim Report, have developed over time as users have become familiar with their car and how long it takes to charge using the installation assigned to them. The frequency, timing and length of these charging events were influenced by multiple factors. These include participant's proximity to and ability to access a charging space, their personal and/or household routines, how far they have recently driven, the likelihood and nature of upcoming trips, and the capacity of their vehicle's battery.

Several conclusions can be drawn about the time of the day at which private participants charge. In general, charging over night was most common but this was not undertaken by everybody. Several participants chose not to charge their ULEVs overnight because of concerns over vandalism and the possible damage to their car, to free up the parking space for others to use, or to eliminate the need to unplug the car for the household member who was responsible for chauffeuring children in the morning (see also Section 4 of the First Interim Report). These participants were mostly PHEV drivers whose cars only required only a few hours to charge. Those who did charge overnight included more BEV drivers whose cars took longer to charge. Those charging during day time consisted of two groups: those charging before and after 4 pm. The former were more likely to be retired or working from home and drivers of PHEVs, the latter tended to use their vehicle for commuting to work and charge after returning home on weekdays. On weekend days these commuters tended to vary the times at which they charged.

Three further trends are related to how regularly participants charge. First, it is extremely rare for participants to charge, use and then reconnect their car to the charging installation more than once in a day. Second, there are some participants who charge every day or most days during the week. These participants tend to regularly drive a PHEV with a limited range, to work. Third, participants who are retired or work from home and/or drive a BEV or EREV, tend to charge once or twice a week or fortnight. This trend corresponds with the more infrequent car usage of these participants and the larger battery capacity of BEVs.

4.1.2 Changes in habits and routines

The analysis of second and third round interviews confirmed the conclusions in the First Interim Report about changes to habits and routines. First, there have been no significant changes in how often, where or when they drive their cars for most private participants. Second, the most notable changes have occurred in how participants negotiate parking and when, for how long, where and how they charge. Third, a number of participants have to varying degrees altered their driving style and one participating. household has purchased a new petrol car to use on longer journeys.

The remainder of this subsection focuses on changes in how the charging installations have been used, changes in using other chargers, alterations in driving styles and the purchasing of the new petrol car.

a. Plugging into chargers

The plugging in process involves a range of physical movements including the handling of cables, pushing and/or pulling of charging flaps and covers, and inserting cable ends into the car and installation. Through repetition of these actions and the efficiencies afforded by habit, the movements of all users have become 'increasingly precise, graceful and effortless' over the trial (Bissell, 2014, p. 485).

The most noticeable changes in charging habits and routines, however, have been observed in and reported by the users of the home chargers. This is perhaps of little surprise given that the use of the home charger is the most involved and lengthiest when compared to the lamppost and bollard chargers. Four out of the five users of these installations have changed the order in which they complete the plugging in process between the first (Interview 2) and second (Interview 3) demonstration of using the charger. In contrast, there have been no changes to the order of the plugging in process observed in or reported by users of other charger types.

The three main tasks involved in the home charger plugging in process, which can be completed in different sequences, are: 1) plugging the cable into the home charger; 2) placing the cable into the cable channel; and 3) plugging the cable into the car. The most significant change between the demonstrations in interviews 2 and 3 has been that users now place the cable into the cable channel after plugging it into the home charger or car. Steve, while looking back over the first video of himself charging in Interview 3, explained how he no longer attempts to measure up how much cable he might require before placing the cable into the channel (see **Figure 4**). He now instead plugs the cable into the car and then places it into the channel.

Oliver has also stopped trying to estimate how much cable he may require and now just plugs it straight into his car. He then places the excess cable around the tyres and under his car and into the channel. This is one of three main changes he made between demonstrations. He has also stopped regularly putting the cable away inside under the stairs:

> [I]t happened sometime during the winter because it came in wet and muddy quite often [as] it's lying on the ground. [I]t is [also] sixteen metres long, [so] it's actually really quite heavy and just cumbersome to take in and out. So what I do now is roll it up and tuck it under here [where] it stays dry and then I just turn off the electricity.

Aware that the cable is 'quite expensive', Oliver continues to store it inside when they go away for a 'longer period of time' and is considering buying a lockable storage for the cable around as a more permanent solution. The third change he has made is that, whenever possible, he now parks his car so that the rear of his vehicle is positioned over the top of the cable channel. In his view this helps to further reduce risk to other street users as 'no one would ever walk there [and] actually trip on it' (see **Figure 5**).

b. Changes in charging, driving and car ownership

Differences in the charging practices between PHEV and BEV drivers were particularly pronounced in terms of charging away from the trial installation. All BEV drivers in the trial suggested they charge at non-trial public chargers, especially on longer journeys. Meanwhile, only half of PHEV drivers reported that they had attempted to charge away from their trial installation. Most felt due to the restricted range of their vehicle, it was not worth the time, money and effort to charge elsewhere. Rob, for instance, noted how before joining the trial he had looked into and then ruled out using publicly available charging points in a local carpark:

> [I]t would [have] cost me [for] parking and then to top it up [with electricity] for the equivalent of about twenty miles charge. Twenty miles is next to nothing on petrol, probably two to three pounds, I'd probably end up paying more than that in parking. [Then you] have to leave it there for two hours [and] then wander back. It just seems like a waste of time.

Figure 4. Three video stills demonstrating Steve measuring up how much cable he would need before plugging the cable into his car during the first demonstration in Interview 2. Looking back at the video of himself charging in Interview 3, he explained he has subsequently stopped doing this and now plugs the cable straight into the car before placing it into the channel. Video recorded by: B. J. Doody.

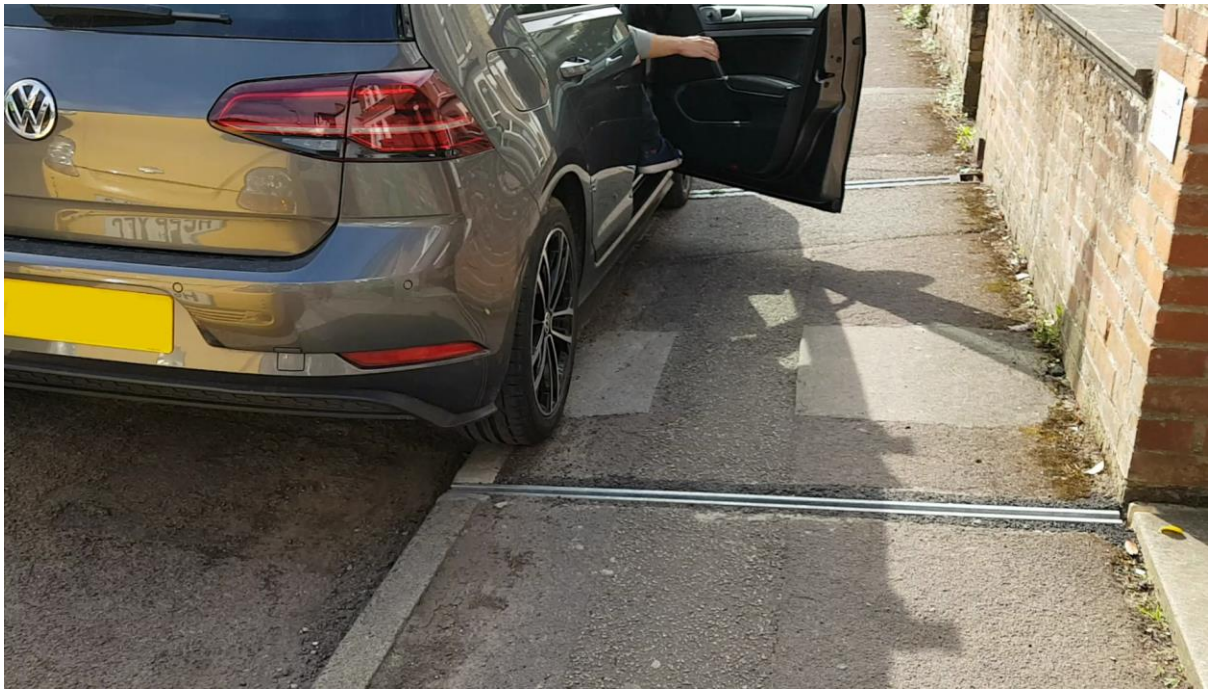

Figure 5. A video still highlighting how, whenever possible, Oliver parks his car so that the rear of the vehicle is positioned over the top of the cable channel. He suggests that this helps to further reduce the trip hazard associated with the cable. Video recorded by: B. J. Doody.

Two of the PHEV drivers who had charged elsewhere had used other trial chargers. These were bollard-style chargers with dedicated ULEV parking bays and signage. Evan has used alternative nearby installations when his assigned bollard-style charger was not functioning. This was made possible by the fact that they were all operated by NewMotion and he and other bollard-style charger users had a membership with them owing to the trial. This was not the case for users of lamppost and home chargers. Home charger user Oliver was able to use the bollard-style charger closest to his son's school. This was because he had taken out a NewMotion membership in order to charge during a recent family holiday in the Netherlands. Both of these cases highlight how other publicly available local chargers can act as back-ups for users when their regular home or public charger is unavailable. At the same time, the ability of chargers to perform this function may be limited by ongoing membership requirements or the positioning of chargers in private carparks which require users to pay for parking.

A number of participants discussed how they had altered their driving style, and to a lesser extent the use of the car stereo and air-conditioning, to increase the range of their ULEV. George, for example, observed how in his case this entails 'not putting your foot to the floor so often' or 'doing 80mph constantly along a motorway'. Instead, he 'lock[s] it in cruise [control] on about 65mph/70mph, which is a good speed [as] you're not as slow as some of the lorries'. Meanwhile, Charlie has learnt during winter that when his range is low that the 'heated seats' use 'significantly less power' than the 'cabin heater':

> The heated seats reduce your range by three or four miles whereas heating the whole cabin reduces [it] by twenty to thirty miles. [S]o it's like going along and 'oh my bum's quite warm but my hands are about to drop off, this is crazy'. So there have been a few times like that but not many.

Unlike these participants, most PHEV or Tesla Model 3 drivers had made very few changes to their driving style. For PHEV drivers this was because of their small battery capacity and ability to drive on petrol. With a battery capacity of at least 220 miles, Tesla Model 3 drivers were much less concerned about range, especially compared to other BEV drivers. Correspondingly, it was due to their frustration with the 80 mile range of their Nissan Leaf and experiences of the uneven distribution and unreliability of public chargers, that William and his wife have purchased another petrol car. They are 'increasingly' now only using their Leaf 'for city use' and their new car for 'longer journeys'. Other participants have expressed very few concerns about range anxiety but once again this in part reflects the fact many are driving BEVs with extensive rangers or PHEVs.

4.2 Factors affecting charger use: Installation breakdown, street dynamics and participant dropouts

This subsection examines two sets of factors affecting the utilisation of chargers that were not covered in detail in the First Interim Report: installation breakdown, organisational response, street life, and participants dropping out of the trial. The subsection concludes by summarising these factors and introducing the notion of adoption capacity as another possible criterion for assessing the performance of chargers.

4.2.1 Installation breakdown and organisational response

All chargers have experienced some malfunctions or breakdowns. Causes include faulty hardware, miscommunication between hardware, back office and technology providers, user-related factors, inadvertent damage caused by parking vehicles and vandalism. In some instances, the exact causes of problems are still to be clarified or determined. Yet to be completed interviews with key stakeholders including the charging technology providers Ubitricity, APT and Zeta, and the back office operator NewMotion, will assist in identifying and clarifying possible causes. This section is at present only informed by information gathered through interviews with private participants, informal discussions and correspondence with staff at the Oxford City Council and field-based observations.

A number of factors have influenced the nature and extent of problems experienced by users of different chargers. The design and durability of an installation and the capacities of technology providers and NewMotion

to identify and respond to issues have all influenced how long chargers have been offline and unavailable for use. In the trial, technology providers and NewMotion have slightly different responsibilities for maintaining and repairing installations. All technology providers are responsible for maintaining and repairing any physical faults or damage to their chargers. NewMotion oversees the metering and billing of users of and monitor connection faults for the three bollard chargers. Ubitricity performs both of these roles for the lamppost chargers. APT oversees the operation of the home chargers but users are billed separately by their household electricity supplier. This complexity, sometimes coupled with unclear reporting processes and procedures, has resulted in confusion among some participants over who to contact when they have experienced an issue or fault with their charging installation.

a. Reported issues with lamppost chargers

Overall the lamppost chargers have been functioning well, although a few intermittent issued have occurred. Users of the Ubitricity lamppost chargers have experienced a few issues with installations either not working or failing to charge their vehicle. Those who have encountered problems observed that it was straightforward to contact Ubitricity through their app and that they were responsive and generally able to resolve issues in a timely manner. The main causes of issues appear to have been associated with the plugging-in procedure, the metered cable and the functioning of the installation. Charlotte, for example, noted that there had been a few occasions when she had plugged in and it 'doesn't light up' to indicate it is charging. She elaborated that it might 'have been a user error the first time it happened' because 'when I spoke to somebody [at Ubitricity] he said wait longer [for it] … to register [whereas I] expected it to happen immediately'. Due to these earlier issues, Charlotte now routinely double-checks that it has started charging on the smartphone app for her car. Edward had experienced issues with the installation beginning to charge his car and then after a period of time stopping. This occurred during his demonstration of using the charger during the second interview (see **Figure 6**):

> Ah, so that's interesting, it's now flashing red. Now I think that is because it's not charging and that was the problem I had before. I need to tell them about that because I think we'll find it's stopped [as even though I didn't need a lot of charge]. According to that [*he checks the app on his smartphone*] its fifteen miles and it should be twenty-eight when it's fully charged. But it says it's plugged in but I

Figure 6. Three video stills capturing how Daniel's car after successfully plugging into an Ubitricity lamppost installation (left video still) stopped working even though his battery was not at full capacity (centre video still) and then resumed after being unplugged and re-plugged in (right video still). Video recorded by: B. J. Doody.

> think that red flashing means it has stopped charging. So I do need to tell them there is a fault with this. Yeah you see on the app it now says that there is no power supply so it has stopped. So what I did before was I disconnected [and reconnected] it but that's not ideal because I think also there's a connection [fee] charged [when] you plug in. […] You see it's reverted to blue which is what it should be. So that's doing what it should. Connect your vehicle. Plug that in. Yeah it works, it says it's charging. […] There's a thing on the app where you can report faults.

In the third interview, Edward recounted how he had been in touch with Ubitricity about this issue and they sent him 'a USB stick and got [him] to download the data from the unit'. He sent this back and then 'they thought it was a fault on the [metered cable] so they sent [him] a new one'.

All users also noted that there were occasions when one or more of the charging installations were unavailable. Daniel, like Edward, explained how he had learnt to recognise whether a charger was operational both by the colour of the light on the installation and its status in the Ubitricity app:

> I plugged in one day and it became quite obvious that it wasn't charging. It was straight after [1] January [and we] just sort of ignored it for a day or two and then suddenly it started working again. The car wasn't going anywhere so it didn't really matter too much. [But] at night you can see the colour [of the light and] I think they were all not working because they're normally bright blue and they were showing maybe orange. […] In fact, the app also tells you which ones are live.

This was one of two instances where Daniel and other lamppost users were not able to charge because of what appeared to be a fault with all of the nearby installations.

b. Reported issues with home chargers

Users of the APT home charger and cable channel system have drawn attention to issues with cables becoming deformed and twisted, the cable no longer working and the cable channel filling up with leaves and dirt. There have been no reported issues with the wall box charge point and RCD (Residual Current Device) box. Participants who have experienced difficulties have been unsure about who to contact to resolve issues with their cables because of unclear reporting processes and procedures. Most have ended up contacting the Oxford City Council's GULO project officer as a result. Some users were aware that the Oxford City Council had agreed to clear the cable channels as part of regular street maintenance but were unsure if this had occurred.

All of the users' cables, irrespective of how they have been handled and stored, have become somewhat twisted and deformed over the course of the trial (see **Figure 7**). These cables were a general source of frustration for all users. Only William, who was still able to charge, suggested that this deformation had made it more 'difficult to manage'. He had reported this to the Council and was subsequently been informed that 'unless it's faulty or becomes hazardous' that he would not receive another cable. It was 'suggested' that 'the cable could be straightened by twisting'. While attempting to do so later in the interview, William observed that they 'shouldn't be expecting [you] to do this kind of thing really'.

Lucas was one of two users who were not able to charge because of a fault. His experience highlighted once again uncertainties around reporting processes and procedures but also liability for ongoing repair and maintenance for the cable and installation and the importance of providing loan equipment or alternative charging solutions while issues are resolved. He suspects 'it's the cable' that is not working as his car started to charge 'for a few minutes and then stopped again'. The cable has been removed by APT which has meant much to his frustration that Lucas has had to rely fully on his PHEV's petrol engine for 'about four weeks'. He suggested that 'if something breaks' they could provide 'a temporary replacement cable' while they are 'evaluating' the problem. For Lucas, the breakdown had also made him realise that he was unsure about 'what kind of support there is in future if anything goes wrong, who the charging unit belongs to, who the cable belongs to' and who was liable for the ongoing costs of maintenance and repair.

Figure 7. A few of the participants using the home charger reported that the allocated cable began to show signs of deformation reasonably early into the trial. The extent to which different users cables have become twisted and deformed has varied as the trial has proceeded. William has suggested that it has become harder to feed his cable pictured above into the channel as it has become more twisted. Picture taken by: Trial participant William.

c. Reported issues with bollard-style chargers

Users of all three bollard chargers have experienced some connection and metering problems. These appear to have primarily been the result of problems in the back-office operations overseen by NewMotion. Nevertheless, Oxford City Council's continuity of provision agreement with NewMotion meant that users were still able to charge despite these issues, with some being undercharged or not billed at all for electricity use during the first few months of the trial.

Figure 8. A side and front view of a Chago Station charging bollard of the damaged caused by a vehicle driving or reversing into the front of the charger. The image on the left illustrates that this accident has removed the door on the left side of the charger. According to Thomas this has rendered this port unusable. The right side port continues to function. Pictures taken by: B. J. Doody.

Bollard-style user Evan has been less fortunate in that he has encountered ongoing problems with his Smartscape charger. His experience shows, as before, that the processes and procedures for users or members of the public wishing to report an issue or fault with an installation are currently unclear. None of the chargers currently overseen by NewMotion have contact details or serial number on the actual charger. Evan noted that when he first contacted NewMotion they had no record of the charger on their system. This has subsequently been rectified. After initially failed attempts to reset his assigned charger by NewMotion, Zeta has sought to repair the charger. It was subsequently suggested that there might be a problem with his key fob registering on the charger. The inability of NewMotion and Zeta to identify and resolve Evan's charging problem has meant he has not been able to use his assigned charger for a period of approximately 6 months.

Some of the Chago Pro Station and Zeta Smartscape charging bollards have been rendered partially or fully unusable due to inadvertent or deliberate physical damage. The main source of damage has been vehicles either driving or reversing into chargers. This can partly be attributed to the fact that the bollard-style chargers have been positioned particularly close to the kerb to reduce the likelihood of people walking between a charging car and the bollard. Charlie reported signs that someone has crashed into the eVolve e-Post Charging Bollard he has been assigned. He attributed the fact that this has not affected the functionality of the installation to its size and 'robust' and 'solid' design. Similarly, Chago Station user Thomas pointed out that there are visible 'gash' signs in the front of his assigned charger where it appears it has been hit by what 'looks like the side of a van' (see Figure 8). This collision has 'ripped the end cover off'. He explained that you now 'can't charge from that side because it can't tell whether the flap's open or closed'. Thomas continues to be able to use the other charging port. He had not reported the damage at the time of the second interview. When visited two months later for the third interview, the door had not been replaced.

Of all the five chargers in the trial, the Zeta Smartscape chargers have been damaged the most and non-operational the longest. At four different sites, chargers have been partially or fully displaced by vehicles inadvertently driving or reversing into them. Additionally, the top of one of the chargers has been removed by what appears to be an intentional act of vandalism (see Figure 9). The likelihood of these chargers being damaged and the time required to repair them appears to be due to their durability and design. Unlike other trial technologies, the version of the Zeta Smartscape charger that is used for the trial is not modular in design. This has meant that damaged chargers have had to be fully removed and taken away from the site for repair. Moreover, as Zeta have only recently ventured into manufacturing chargers, they did not have a wide range of replacement parts or charging units readily available to swap out during the first months of the trial.

Figure 9. Two separate views of the side of a Zeta Smartscape Charging Bollard which has had the top of the unit removed by what appears to be an intentional act of vandalism. Pictures taken by: Oxford City Council Staff.

4.2.2 STREET LIFE

The First Interim Report noted how the availability of and demand for parking, vehicle use in streets are the enforcement of parking restrictions are enforced affect private participants' ability to access and use the trial chargers. In subsequent interviews, participants have highlighted two other examples of how dynamics in the use and regulation of streets affect access to a space to charge.

Sam, an Ubitricity lamppost user, observed that since the second interview, a resident had been granted planning permission to drop the kerb and install a private off-street driveway (see **Figure 10**). As a result, there is 'now only one' rather than the original 'two spaces' available. This has made it increasingly more difficult for him to access the lamppost installation closest to his property.

Several participants have pointed out how skips used for garden or home renovations can temporally disrupt pre-existing parking dynamics by taking up one or more on-street spaces (see **Figure 11**). Steve, for example, noted how the recent introduction of a skip had meant that people had been 'nudging up in[to] different places' at his end of the road. Despite this, his neighbours have been 'brilliant' at continuing to leave the only space where he is able to charge vacant.

Figure 10. Loss of an on-street parking space due to a resident being allowed to install a private off-street drive way. Picture taken by: B. J. Doody.

Figure 11. Skips for garden or home renovation projects can disrupt pre-existing parking dynamics and reduce access to charging spaces directly or indirectly. Picture taken by: B. J. Doody.

4.2.3 Participant dropouts: Changing decisions and life circumstances

Four of the twenty (20%) households who initially signed up for the GULO trial dropped out. These dropouts were the result of changing circumstances associated with home and work and assessments of the (ongoing) suitability of a ULEV for undertaking various everyday activities including commuting, shopping, chauffeuring children and driving-based holidays. Alex's household, who have not ended up participating because they did not switch to a ULEV, is a good example of how dropouts were often the result of a culmination of personal and household factors that unfold over shorter and longer timescales.

In the pre-trial interview, Alex recounted how he was working full-time and his wife was on maternity leave when they signed up to the trial. At the time, he was eligible for an employee car allowance if his car was less than five years old. As his was not, he was being 'encouraged to buy an EV … or at least a plug-in hybrid … by work'. Alex 'had considered' whether a ULEV would be a 'more cost efficient way of having a car' and 'how to switch to an EV'. A particularly important criterion was 'how it would fit in with [his family's] life':

> If it was our only car, it would have to be a plug-in hybrid [as] I've got two kids. They limit your flexibility considerably. If you're a couple, it's an adventure. 'Are we going to make it all the whole way to Devon on two charges or where are we going to stop?' With two kids, who are on different schedules and want to sleep and are cranky and all sorts of other stuff, you think how do I get there with the least effort required? [I]t would [need to] have that fall back engine. [It would also need] to be big enough to us all in.

At the time, he was driving their only car to work which meant his wife 'had to take the bus everywhere with the kids'. So they started to think about how they could use the car 'differently' or whether they should buy a second car with his allowance. 'Then [he] started driving off and leaving [the car] in a car park all day somewhere' which made him 'think two cars is a bit of an extravagance'. Despite this, had he continued working there 'I would [now] be looking at the EV as a replacement as it was an arbitrary thing we had to do … after five years'. As he is not, he suggested it was highly unlikely he would be purchasing a ULEV any time soon:

> As I'm freelance, I can't justify a car if I'm not forced to and I'm not using it as much [as I work from home]. My wife [works] in telecoms too so we are used to being made redundant every few years [due to mergers and take-overs]. So no-one is really sure what's happening and the car has [just] passed an MOT again. [When it does not] I'm going to have to probably offload this thing and then that's the next decision point where I might do it [i.e., switch to a ULEV].

Alex's household, and the other dropouts, highlight the importance of recognising that the adoption of ULEVs is not simply the outcome of 'rational' decisions about the cost of purchasing and running vehicles alone. Instead, decisions are shaped by the way the household or 'home economy' is managed (Bulkeley et al., 2014). In managing the home economy, people make various forms of calculation about resources (financial, maintenance and repair, running costs), the distribution of these resources (over time, between members of a household), and investments (of finance, time, emotion) in their homes and possessions. Accordingly, financial and tax-based incentives for ULEVs are often considered in terms of how they align with shorter and longer-term household priorities and considerations.

Decisions to no longer adopt or continue using a ULEV have implications for the ongoing use of charging infrastructure. The trial highlights both that such decisions are relatively common and the importance of considering if other users will be able to start or continue using the infrastructure when they inevitably occur. The ability of new or extra users to start using the charger can be understood as its *adoption capacity*. There are multiple factors affecting this capacity:

a) if a charging installation is available for public use or is restricted to a private business or individual household;
b) the number of ports available on the installation;

c) the types of connectors available (i.e., CHAdeMO, CCS (Combined Charging Standard, Type 1, Type 2, Commando and 3-pin outlets);
d) the number of associated parking spaces;
e) additional objects or equipment required for connecting (e.g., a metered cable; RFID tag or card); and
f) if the installation can be used on an informal and discretionary basis or requires an ongoing membership.

All private participants who dropped out had been assigned lamppost or bollard-style chargers located on public streets. These could then to be reassigned to new recruits. This would have been extremely difficult to do with a home charger as these are installed on private property and use residents own home power supply. The adoption capacity of the home charger compared to the lamppost and bollard-style chargers is therefore much lower. The risk of the charger becoming redundant if the existing residents stop using their ULEV or move house is also much higher than the alternative installations.

4.2.4 Summary

Private participants' use of the assigned charging installations has been affected by breakdown and degradation, repair processes and timeframes, and street life. All chargers have experienced some malfunctions or breakdowns. Identified causes include faulty hardware, miscommunication between hardware, back office and technology providers, user-related factors, and inadvertent damage caused by parking vehicles and vandalism. The length of time chargers have been unavailable has been dependent on how easily it has been to report the malfunction or breakdown, identify and rectify the cause, the design of the charger and the response capacities of different organisations. There have been relatively few issues with the Ubitricity lamppost chargers and Chago Pro and the eVolve e-Post bollard-style chargers. The cables of APT home chargers have suffered deformation and in some cases developed faults which have rendered them non-working. Non-working cables have been removed but users have not been provided with a temporary replacement cable or an expected repair timeframe. Zeta Smartscape chargers appear to be prone to impact collisions and their non-modular design and lack of replacement parts and units have resulted in long repair times. Only Ubitricity lamppost users were clear on who to contact and through what channel they were able to report an issue or fault.

Utilisation has also been affected by two new factors that have or had the potential to impact access to spaces for charging. The development of a private driveway and the introduction of a temporary skip for garden or home renovations have altered pre-existing parking dynamics by reducing the availability of spaces.

One-fifth of the original participants have dropped out of the trial as a result of personal and household factors including financial priorities, changing jobs and assessments of the (ongoing) suitability of a ULEV for undertaking various everyday activities. These examples highlight that such decisions are relatively common and the importance of taking into account the adoption capacity of chargers. Adoption capacity is the potential for new or extra users to start using the charger and is influenced by whether it is: a) available for public or private use; b) the number of ports; c) the types of connectors available; d) the number of associated parking spaces; e) additional objects and equipment and/or f) membership rights required for connecting.

4.3 Car club users' use and experiences of the installations

This subsection examines car club users' experiences and views of the charging installations. It draws on interviews with five Co-wheels car club users from three different households. Unlike other Co-wheels[3] or private trial participants' vehicles, all of the vehicles used by these participants are 'pure' or full battery EVs (BEVs) with a relatively limited range[4]. Correspondingly, this section uses BEV instead of ULEV throughout. Users' initial encounters with car club BEVs are considered in Section 4.3.1. Their subsequent experiences of

[3] Co-Wheels also have non-plug-in hybrid vehicles in their Oxford fleet.

[4] The Renault Zoe and the Citroen C-Zero are the two models currently on the Co-Wheels fleet in Oxford. These have ranges of ~130 miles and ~90 miles respectively. As noted in Section 3.2, there are only five participants in the trial with BEVs. Two of these participants have a Tesla Model 3 (range: ~220-325 miles), two a Nissan Leaf (range: 80-120 miles depending on the model), and one a Renault Twizzy (range of ~60 miles).

driving and using (Section 4.3.2) and charging car club BEVs (Section 4.3.3) are then reported. The information users have received and would like to have about driving and charging is elaborated upon in Section 4.3.4. These preliminary findings are summarised and their implications for car club operators are outlined in Section 4.3.5.

4.3.1 Initial encounters with car club BEVs

Prior to using the car club BEVs involved in the trial, two of the interviewed users had for a brief period driven and charged another EV trialled by Co-wheels in East Oxford and one couple had been passengers in a family member's vehicle. At first, four out of five users experienced some difficulties trying to work out how to unplug the cable from the car and charging installation. This was mainly because they were unable to locate the release button that unlocks the cable from the vehicle's charging socket and allows it to be removed from the installation. Some also struggled to start the vehicle and the battery ran out of charge for one participant during his first use.

Most managed to overcome these initial difficulties through trial and error and, if present, reading the laminated step-by-step instructions provided. Many accepted, although sometimes reluctantly, that becoming acquainted with the charging process and the vehicle itself would require some time and effort. Ursula, for example, was unaware she had booked a BEV until arriving at the vehicle and was unable to unplug the cable and phoned her husband Michael who came to the vehicle to help. When Michael was also not able to resolve the situation, they decided to end the booking and to rebook it when they had more time to 'figure out how to … get it going'. This subsequent booking involved having a 'fiddle around', reading the 'instructions' provided and ringing up Co-wheels. Debra, who was 'quite taken by the whole EV thing', initially found the process of trying to unplug and start the car 'new and exciting rather than new and frustrating' as she 'wasn't in a terrible rush'. The 'instruction sheet wasn't there' and so she had a 'fumble about, going oh what if I press that or what if I [*laughs*], maybe I need to have my foot on the brake at the same time. It wasn't self-evident'.

Clement meanwhile had 'seen the Renault being charged' at the front of the vehicle and so tried at first to push and pull it open there. After his initial attempts failed, he decided to search inside the car and found the button where 'normally [you open] the [petrol] flap'. The battery ran out of charge, however, during his first journey of just over a mile with his girlfriend. He was informed by Co-wheels that it was the user's responsibility to check if the BEV's state of charge before beginning their hire, something he now routinely does.

4.3.2 Driving and using car club BEVs

These initial and previous experiences have influenced participant's views and uses of car club BEVs. There was a general consensus that the car club BEVs are best suited to shorter and local journeys for a number of reasons. As noted above, all of these vehicles are BEVs with a relatively limited range. Most users were unsure about how and where to charge away from the trial installation and expressed concerns about their inability to monitor and control the battery state of charge outside of their hire period. Moreover, because they drive BEVs less frequently than private participants, they are less likely to learn about or be interested in understanding their range capabilities. At the same time, all five participants enjoyed the quietness, acceleration and size of the Renault Zoe.

Various factors determined how frequently participants used the car club BEVs. The most common were proximity of the vehicle to their home, the availability of an alternative and cheaper petrol or hybrid equivalent, the nature of the planned journey and how comfortable they were with the charging process. It is relatively rare for Debra and Frank, for example, not to use a BEV as both of their two closest vehicles are in the trial and usually they only make short journeys to, for instance, the shops and their children's leisure activities. Debra also discussed how her ongoing use of the BEVs has been reinforced by how good she 'feels' knowing that there are 'no nasty fumes […] coming out of [the] tailpipe […] into the local environment'.

In contrast, there are two petrol vehicles closer to Michael and Ursula and both feel somewhat reluctant about using their local BEV. Michael observed that the 'plugging and unplugging eat[s] into [your time]' and adds additional steps to the process compared to a petrol or hybrid car. Alongside this, Ursula discussed how she tends to stick with cars she has 'got to know' because of the time it takes to 'learn' how 'different cars' operate

and function. Here, she suggested although it will 'take a while', she will 'eventually be fine with the electric car' too. In light of these factors, Michael and Ursula have only used it about three times in six months, once as part of an exploratory trip and twice to go to the swimming pool. In comparison, they use other car club vehicles once or twice a week for mainly short journeys. Clement has also used the BEV less frequently because of its range, cost and proximity. To date, he has used it for local journeys to the shops, the garden centre and the badminton courts. In this context, Clement noted that the benefit of the BEV is that it is nearly 'always available' as 'people don't really take it for long trips' because 'you cannot really go very far' given its range. This is particularly important on weekends when demand for petrol vehicles is usually high.

4.3.3 Charging car club BEVs

Having overcome their early difficulties, four of the five participants were relatively indifferent about charging the car club BEVs. As with private participants, cables were a recurring topic of conversation. Conversations focused on the time required unplugging and plugging into vehicles and the inconveniences associated with storing and using cables because of their weight and length and especially during wet weather and winter. Despite these frustrations, users have generally found the charging process fairly straightforward. They were often less concerned than private participants, however, about ensuring that the car had started charging properly.

All participants suggested that the vehicle has almost always been plugged in when they have gone to use it and that they always plug it in again at the end of their booking. Michael and Debra both noted that these processes place an additional demand on users, especially given it is possible to go a long time without having to fill-up a petrol car club vehicle at the station. Some of the participants also felt that the Ubitricity cable was unnecessarily long. Its length, coupled with the integrated metering box, made it somewhat 'cumbersome', 'bulky' and unpleasant to use and store. Frank noted that often 'your hands get dirty fold[ing] [cables] up' particularly when it is 'wet' as they 'trial around [in] the gutter' with dead animals, 'dog pooh or whatever' (see Figure 12). He also suggested that the trialling cable creates 'a trip hazard' as someone could 'get caught up in [it]' as often it 'just strays over the pavement' (see Figure 13). Some users felt having the cable plugged in while charging might make the cars slightly more vulnerable to vandalism. Debra and Michael meanwhile both observed that the Ubitricity and the standard cables take up valuable space in what is already a very small boot.

One participant, Ursula, did not overcome initial difficulties with the charging process. At the time of the interview, she expected to remain reluctant to use the BEV on her own until she will become more comfortable with the process. Thus, along with their perceptions of a BEV's utility, a user's knowhow and confidence around new technologies may also influence whether or not they use these vehicles. Clement's experience has been notably different. An engineer by training, he describes himself as technologically 'literate'. He and his girlfriend have developed a specific routine for plugging in and unplugging the car:

> I open the car with my card [and then] the flap. My girlfriend opens the boot at the same time [and] takes the cable [and] plugs it in one side. Sometimes I have the time to get out and plug it in the other side. And we stand, wait to see if it is charging or [alternatively I] push a button to [release it from] charging [so she can] unplug it [and] then put it in the boot. I'm already in the driver's seat [then] and we are ready to leave. So we don't lose too much time.

Despite this, Clement suggested that it still ends up taking 'two or three minutes to set it up'. Unlike Clement, most other users have paid relatively little attention to whether or not the vehicle is charging properly. Debra, for example, suggested that she has 'always trusted that it's idiot proof as long as you put each end in when it's done'. As a result, she has 'never paid any attention to flashing or clicking'.

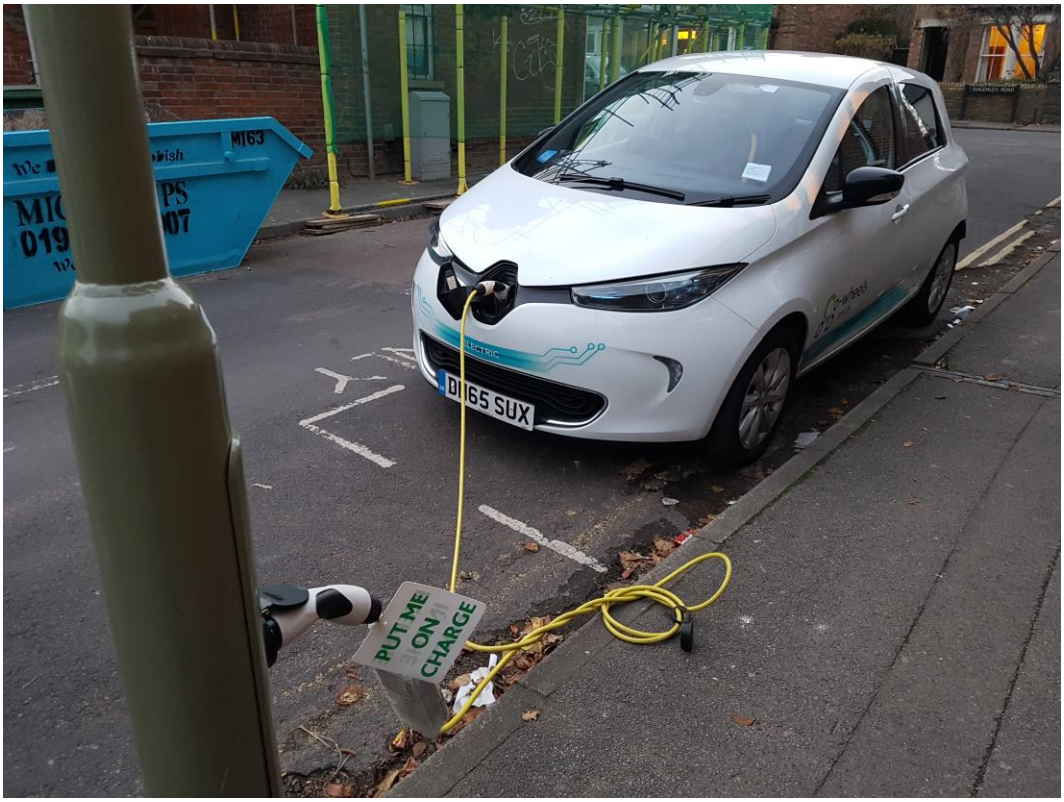

Figure 12. A Co-wheel's Car Club Renault Zoe charging using an Ubitricity lamppost charger. Users noted that although it is a relatively simple process, the cable can is somewhat cumbersome, bulky and unpleasant to use and store.

Figure 13. A Co-wheels' Renault Zoe charging using an Ubitricity lamppost charger. Users noted that the cables might make the cars more vulnerable to vandalism and create a potential trip hazard.

4.3.4 Information received and wanted about car club BEVs

Based on users' accounts, it appears that Co-wheels members were not informed that BEVs had been added to the Oxford fleet. [5] Ursula was 'furious' about this as she had not realised the new car 'was electric' and felt at a minimum Co-wheels should make people aware of this. Others who had noticed the addition of BEVs to the fleet also reported that they had not received any introductory information from Co-wheels via email. Several participants suggested that even if they had, they would probably not have read such information. Participants often found the step-by-step instruction sheet in the car helpful and Frank mentioned he had subsequently realised that further information was available on the Co-wheels website about ULEVs on their fleet (see Co-wheels Car Club, 2019b).

Participants were interested in receiving a range of both specific and more general information about the car club BEVs. Clement, who experienced the cars running out of battery on his first journey, wanted to be able to see a vehicle's state of charge before arriving to pick it up. He and Michael also pointed out that at present the car club BEVs unlike other models on the market such as the Nissan Leaf do not provide users with any information about whether they will have sufficient charge for their planned journey or where they might be able to charge en route. Clement suggested that this feature was available in the Renault Zoe but not been purchased by Co-wheels. Debra wanted to be provided with additional information about how and where she could charge away from the trial installation. At a more general level, Michael wanted to know more about their usage and outlay and maintenance costs compared to other petrol and hybrid vehicles on the fleet. Meanwhile, Debra was interested in receiving information on the actual energy consumption of and pollution impact an BEV has compared to a petrol or diesel car.

4.3.5 Summary and implications for car club operators

In summary, the view users' experiences of driving and charging the car club BEVs have been somewhat varied. They tended to agree that the vehicles are best suited to short and local journeys because of users' perceptions of their range and uncertainties about how to charge them away from the trial installation. Four out of five users found the charging process fairly straightforward after overcoming some initial difficulties. Much like private participants, they expressed some concerns about storing and using cables, especially during wet weather and winter. They also drew attention to the additional burden that the time and effort involved in charging places on users. Nevertheless, car club users appeared to be less concerned than private participants about ensuring that the car had started charging properly.

There appear to be five main implications emerging from these preliminary findings for car club operators. The first of these also applies to local authorities attempting to encourage car club operators to electrify their fleet. It needs to be recognised that like private owners, car club users may wish to use vehicles for a variety of journey types, covering both shorter and longer distances. Reflecting the current range of BEVs, it will potentially be important for operators to continue to have other ULEV vehicles (plug-in and non-plug-in hybrids) on their fleets for longer journeys without the need for charging. This is especially important if users are expected to cover the cost of charging away from the car club installations[6].

Second, operators need to consider that users will often not read information provided in their newsletter, website or even booking emails about the addition of BEVs to their local fleet. As a result, operators may need to make users aware of these changes and how they will impact their use of the car club vehicle through a range of different channels and at a variety of stages in the booking process. Possible examples might include:

a) a notification during the initial reservation asking the user to confirm they are aware booking a BEV;
b) a link to further information about charging and driving the BEV in the booking confirmation email;

[5] A news story did appear on the Co-wheels website reporting the addition of new electric vehicles to the Oxford fleet on 30 August 2017 (see Co-wheels Car Club, 2017).

[6] Co-wheels users, for example, are currently able to recharge the car free of charge when parked in its dedicated bay. Away from the dedicated bay, users are required to cover any costs associated with charging (Co-wheels Car Club, 2019b).

c) provision of easy to follow reference guides (preferably written and pictorial) and audio-visual materials available online (i.e., demonstration video);
d) provision of easy to follow reference guides in the vehicle; and
e) potentially identifying unusual but important features of the BEV such as the cable release button.

Third, operators need to recognise the additional burden that BEVs put on users. These include the initial period of learning about the charging process, the amount of time it requires to unplug and plug-in the BEV and the uncertainties related to the battery's state of charge.

Fourth, and related to the first three points, it is important that users have the ability to gain two types of information which may impact on their use of the vehicle before and during their booking:

a) real-time information about the BEV's state of charge; and
b) geo-located information about where it might be possible for them to charge and how long it make take during the course of their journey.

Fifth, as users are less concerned than private participants about whether a BEV has started charging properly it may be important for operators to have systems in place to both monitor charging and allow sufficient time for charging between uses.

5. Conclusion

This Second Interim Report for the GULO trial of five different on-street charging technologies for ULEVs across 30 sites in Oxford has made use of three rounds of interviews with 18 participating households and one round of interviews with five car club users. In this final section, we reflect on the preliminary insights that have been gained in relation to three of the four objectives of the monitoring and evaluation activities of the GULO project:

1. Evaluating the performance of the various on-street charging installations;
2. Examining the adaptations to car-use routines and the formation of charging habits among pilot participants; and
3. Developing insights about how the pilot may be scaled up within Oxford and transferred to local authorities elsewhere in the UK.

5.1 Performance of the installations

Instead of specifying in advance which criteria would be used to evaluate the performance of the installations from a user perspective, we have opted for a more open and bottom-up approach. Many of the criteria were derived from participants' narrative accounts of their views, concerns and experiences during the interviews. This approach has allowed us to learn extensively from participants, which is beneficial because consensus about what 'good' performance means does not (yet) exist for on-street charging of ULEVs. Table 5 lists the criteria that have been identified so far. This list of criteria may change over the remaining period of the trial.[7] It should be emphasised that the assessment of the charging technologies is qualitative and preliminary. It is based on: a) the researchers' interpretation of the narrative accounts and demonstrations by the private and car club participants in the trial, and b) their own in-field observations.

Nevertheless, Table 5 suggests that the different charger types perform better in some of the suggested criteria than others. Installations are assessed on two scales: 1) Very Poor; Poor; Neutral; Good; Very Good; and 2) Very Small; Small; Medium; Large; Very Large. The nine criteria reported in Table 3 are defined as:

1. *Utilisation*: The level of use the charger receives and by how many unique vehicles;
2. *Ease of access*: Proximity of the charger to residents, whether it has a dedicated bay and the ease of parking;
3. *Ease of use*: User friendliness of the charging cable and interface;
4. *Adoption capacity*: Potential for adoption by new/extra user/s. This is based on the number of ports available and whether it is available to the public or restricted to a business;
5. *Risk of damage to vehicle*: Likelihood of vehicles being damaged parking and/or charging;
6. *Risk to other street users*: Likelihood of harm/injury to street users (e.g., tripping over the charging installation or cable);
7. *Reliability*: Likelihood that the charging installation is working, how long it is down and the main causes of breakdown;
8. *Maintenance and repair*: Ease and speed at which chargers are repaired and the ability of users to report breakdowns or to view which chargers are operational; and
9. *Installation footprint*: Area covered by installation (charger, transformer, etc.).

The performance of different chargers on some criteria such as access and risk to other street users depends partly on contextual factors such as characteristics of the vehicles (size of the vehicle, position of the flap), characteristics of the street (width) and the parking bay (length of the bay) and other's parking practices. On average, however, it would appear that, over the first half of the trial, lamppost chargers just outperform the

[7] For instance, over the first few months of the trial, there were few instances of installation breakdown and vandalism. This may of course change.

home chargers across these criteria. Collectively, bollard-style chargers seem to perform adequately on most criteria, except footprint and risk of damage to the vehicle.

Differences have emerged between individual bollard-style chargers, especially in relation to reliability and maintenance and repair. The small and compact nature of the Zeta Smartscape installations used for the trial makes it more prone to impact collisions when cars move in and out of parking spaces. Zeta installations have been rendered non-functional after being knocked over on four separate occasions by vehicles. As this installation is not modular in design, repair involves removing the entire charger and taking it off-site. This design, coupled with a lack of replacement Smartscape parts and units, has resulted in long repair times for these installations. In contrast, signs of vehicle impact on the Chago Pro and eVolve e-Post chargers seem to indicate that both may remain partially or fully functional after collisions.

5.2 Adaptations to routines and new habits

So far the research indicates that changes have occurred not so much in how often, where or when private participants drive cars but rather in how they negotiate parking and in when, for how long, where and how often they charge. Some participants have developed a more moderate driving style, decreasing how fast they accelerate and their average speeds, and when required reduce their use of stereos and air-conditioning, in order to increase the range of their ULEV.

With regard to charging, the results indicate that habits and routines develop over time as private participants become familiar with their car's range and how long it takes to charge using a particular charging installation. The timing and duration of a charging event are shaped by multiple factors. These include the proximity and accessibility of a charging space, personal and/or household routines, the nature of recent or upcoming journeys, and the capacity of their vehicle's battery. In terms of the practice of charging itself, the most noticeable changes have occurred among home charger users. Most of them have begun to place the cable into the channel after plugging into the car or charging installation, which eliminates the need to estimate the amount of cable required.

The formation of routines and habits differs to some extent between private and car club participants. This reflects that car club participants drive BEVs with limited range, use these vehicles not very often, cannot monitor and control the battery state of charge, and are often uncertain about how to charge away from the trial installation. Accordingly, the car club users in the trial agreed that the Co-wheels BEVs are best suited to short and local journeys. Having overcome initial difficulties, four out of five car club participants found the charging process fairly straightforward. Much like private participants, they expressed concerns about storing and using cables, but also emphasized the additional burden charging places on users. They were, however, less concerned than private participants about ensuring that the car had started charging properly.

5.3 Lessons for other local authorities

The First Interim Report identified three lessons for local authorities elsewhere in the UK that seek to increase EV adoption through the creation of charging infrastructures on public streets in residential areas. Those concerned the factors shaping the usability or appropriateness of parking spaces for on-street charging, the need for a new parking etiquette around parking, and the specificity of Oxford as a site for social learning about on-street charging technologies.

Four additional lessons have emerged in the preparation of this Second Interim Report. First, the monitoring, maintenance and repair of installations are important issues for consideration. It is inevitable that there will be issues with installations malfunctioning and breaking down. Informal or formal processes, procedures or systems that allow users to determine the status of charging installations and report any issues need to be either developed or co-opted (e.g., Zap-Map). From an operational perspective, durable and modular designs, the availability of replacement parts and units and staff availability are critical in assessing potential damage and the amount of time required for diagnosis, maintenance and repair.

Table 5. Potential criteria for assessing the performance of on-street charging technologies from a user perspective. Installations are assessed on two scales: 1) Very Poor; Poor; Neutral; Good; and Very Good; and 2) Very Small; Small; Medium; Large; and Very Large.

Performance criteria[8]	Lamppost charger	Bollard-style charger			Home charger
	Ubitricity	Chago Pro Station	eVolve e-Post	Zeta Smartscape	APT
Utilisation	Good • Regularly used when available	Good • Regularly used when available	Good • Regularly used when available	Good • Regularly used when available	Good • Regularly used when available
Ease of access	Good • Not dependent on a limited number of spaces (three or more spaces available[9]) • Proximity to user's property varies	Good • Associated with dedicated EV parking bay • Dependent on the availability of a limited number of spaces (one or two spaces available) • Proximity to user's property varies	Good • Associated with dedicated EV parking bay • Dependent on the availability of a limited number of spaces (one or two spaces available) • Proximity to user's property varies	Good • Associated with dedicated EV parking bay • Dependent on the availability of a limited number of spaces (one or two spaces available) • Proximity to user's property varies	Neutral • Dependent on the availability of a limited number of spaces (between one to three spaces available) • Close proximity to user's property
Ease of use	Very good • Very simple and easy to use • Requires an additional metered cable	Neutral • The design and lack of instructions make it initially difficult to use	Very Good • Simple and easy to use	Very Good • Simple and easy to use	Neutral • Involves a lot of bending and manipulation of the cable especially into the channel • Typically requires a long cable (>10m) which can be difficult to handle
Adoption capacity	Neutral • Accessible to anyone who meets local parking requirements • Not installed on private property • Requires a metered cable	Good • Accessible to anyone who meets local parking requirements • Not installed on private property • Each charging installation has two ports available	Good • Accessible to anyone who meets local parking requirements • Not installed on private property • Each charging installation has two ports available	Neutral • Accessible to anyone who meets local parking requirements • Not installed on private land • Each charging installation currently only has one port available	Very Poor • Installed on private property • The installation is dependent on gaining access to home electricity supply • Not available to other users without special permission

[8] Charging installations are assessed on two scales: 1) Very Poor; Poor; Neutral; Good; Very Good; and 2) Very Small; Small; Medium; Large; Very Large.

[9] There are three lamppost chargers installed for each trial participant. Depending on the street, participants sometimes have the ability to park and charge in at least three or more spaces.

Risk of damage to vehicle	Small • User concerns over the possibility of the charging port being damaged by an attempt to pulled the cable out of the car	Medium • Possibility of hitting the charging bollard when moving in or out of the parking space • User concerns over the possibility of the charging port being damaged by an attempt to pulled the cable out of the car	Medium • Possibility of hitting the charging bollard when moving in or out of the parking space • User concerns over the possibility of the charging port being damaged by an attempt to pulled the cable out of the car	Large • Small size increases likelihood of charging bollard being hit when moving in or out of parking space • User concerns over the possibility of the charging port being damaged by an attempt to pulled the cable out of the car	Small • User concerns over the possibility of the charging port being damaged by an attempt to pulled the cable out of the car
Risk to other street users	Medium • Cable is not stored securely • Variability in distance between lampposts and kerb, meaning that sometimes people can walking between the charger and the car and thus greater hazard of tripping over the cable • Sometimes too much cable to be moved out of harm's way • Bright coloured cable is visible in most light conditions • Users generally give little consideration to the risks posed by the cable	Medium • Cable is not stored securely • Located on the pavement, bollards and transformer box can create additional trip hazards • Bollards are located close to the kerb minimising the likelihood of people walking between the car and charger and cable on the pavement • Cables that come with cars tend to be shorter so not necessarily sufficient excess cable to move out of harm's way • Cables are generally black so less visible especially in bad light conditions and night; • Users generally give little consideration to the risks posed by the cable	Medium • Cable is not stored securely • Located on the pavement, bollards and transformer box can create additional trip hazards • Bollards are located close to the kerb minimising the likelihood of people walking between the car and charger and cable on the pavement • Cables that come with cars tend to be shorter so not necessarily sufficient excess cable to move out of harm's way • Cables are generally black so less visible especially in bad light conditions and night; • Users generally give little consideration to the risks posed by the cable	Medium • Cable is not stored securely • Located on the pavement, bollards and transformer box can create additional trip hazards • Bollards are located close to the kerb minimising the likelihood of people walking between the car and charger and cable on the pavement • Cables that come with cars tend to be shorter so not necessarily sufficient excess cable to move out of harm's way • Cables are generally black so less visible especially in bad light conditions and night; • Users generally give little consideration to the risks posed by the cable	Very Small • Charging box installed on the house and channel is incorporated into the pavement; • Cable is stored securely in the cable channel; • Generally sufficient excess cable to move out of harm's way • Using the cable channel appears to increase users awareness of the potential risks posed by the cable; • Black cable is less visible especially in bad light conditions and night
Reliability	Good • Some temporary problems with chargers not working	Neutral • User has reported that one of two charging points does not work because of damaged cover	Good • No information available on where to report problems on chargers	Poor • Ongoing problems with one charger not working (~3 months)	Neutral • Unknown fault, possibly with the cable, has made the Installation unavailable for some users

Maintenance and repair	Very Good • Information available about operational chargers in the Ubitricity app • Problems resolved quickly	Neutral • No information available on where to report problems on chargers • Capable of withstanding impact collisions • Continues to function after impact • Modular in design • Problems appear not to have been identified and resolved	Very good • No information available on where to report problems on chargers • Capable of withstanding impact collisions • No reported problems to date	Very poor • No information available on where to report problems on chargers • Appear to be vulnerable to impact collisions • Not modular in design • Lack of replacement parts and units • Long repair times	Neutral • No information available on where to report problems on chargers • Cables appear to be vulnerable to deformation • Lack of temporary replacement parts
Installation footprint	Very small • Charger incorporated into existing street furniture (lamppost)	Medium • Both charger and transformer need to be accommodated on the footpath	Medium • Both charger and transformer need to be accommodated on the footpath	Medium • Charger is small and compact • Both charger and transformer need to be accommodated on the footpath	Small • Cable channel is incorporated into the pavement

Second, taking into account the adoption capacity of an installation will help to reduce the likelihood of publicly available and government funded chargers being underutilised or not used at all. Adoption capacity is the potential for new or extra users to start using a charger. It depends on: a) whether the installation available for public or private use; b) the number of ports; c) the types of connectors available; d) the number of associated parking spaces; e) the need for additional equipment (e.g. special cables), and/or f) membership rights required for connecting.

Third, and related to point two, local authorities should consider on-street charging installations in residential areas in the context of a wider local ecosystem for ULEV use. The two Interim Reports demonstrate that multiple factors affect ULEV users' ability to access and use chargers. Publicly available local chargers in nearby streets or car parks may act as important back-ups for users when their regular charger is intermittently available, for instance, due to maintenance and repair. The ability of chargers to perform this function, however, is often limited by ongoing membership requirements or the positioning of chargers in private car parks requiring users to pay for parking. Both of these configurations discourage particularly PHEV users from charging on a more informal and discretionary basis.

Finally, there is scope for integration of more battery electric vehicles (BEVs) into existing car club operations. Car club participants agreed that BEVs are best suited to shorter and local journeys. This aligns with both the business model of many car clubs and the aspiration of most local authorities for local journeys that cannot be completed on foot or bicycle to be made in BEVs. At the same time, given the range of current BEVs, operators should also have other ULEV vehicles (plug-in and non-plug-in hybrids) on their fleets in order to cater to demand for longer trips without charging.

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Appendices

Appendix 1: Interview 1 Schedule: Pre-trial

Introduction

Hi my name is Brendan Doody I'm a researcher from the Transport Studies Unit at the University of Oxford. Part of my job is to monitor and evaluate how the Go Ultra Low Oxford trial influences trial participants' usage and attitudes towards on-street charging technologies.

More specifically, the four areas we will try to understand are how:

1. Different charging installations perform;
2. You adapt to driving and charging electric vehicles over time;
3. Your neighbours and others respond to the installations; and
4. The pilot might be scaled up within Oxford and elsewhere in the UK

In this context, it is important to stress that we are independent from the Council and so you should feel free to openly share any thoughts, feelings or issues that arise during the trial. The information and views will be shared with the Council and other partners only in an anonymised form.

As a trial participant your participation in the project will involve four interviews, this one before, and three at different intervals after, the start of the trial. Alongside this interview the interviews will take place at 1-2 months, 5 months and 11 months after the start of the trial. In doing so, the intention is to identify and explore how participants' views on the charging technology and their associated routines and habits change over time.

As a participant your rights are to:

- decline to answer any particular question;
- ask any questions about the study at any time during participation;
- provide information on the understanding that your name will not be used unless you give permission to the researcher;
- ask for the audio recording to be turned off at any time during the interview;
- be given access to a summary of the project findings when it is concluded.

1. Personal and household mobility

- Describe a normal week in your life. What do you do and where do you go? Is it a fixed or flexible routine? How does it vary on different days/weekends?

2. Exploring electric vehicle use

- How did you come to be involved with or driving an electric vehicle?

- Recent research into everyday travel has found that the way we travel today is often a result of longer term events and processes which sometimes stretch back to our childhoods.

    - To begin on the x or time –axis can you identify the city/town/villages in which you have lived over your life;

    - Can you now note whether or not you had access to a car as either a passenger or a driver;

    - For each of these periods I would like you to now draw a line of your estimated car use during this period;

    - Could you now note down the reasons why you did or did not drive during that period (e.g., for practical reasons; chauffeuring others (children; friends; family) or being chauffeured; getting to work; getting to different activities; going on holiday; visiting friends; you enjoyed driving; infrastructure);

- How did you feel about driving at the time?
- When did you first become aware of or experience an EV (e.g., 1) as a concept; 2) in person; and 3) as a potential car)?

3. Administer the questionnaire

- The pre-trial questionnaire for both first-time and experienced users of electric vehicles.

4. Experiences driving electric vehicles

- Can you please tell about your experiences driving electric vehicles?

5. Experiences charging electric vehicles

- Can you please tell about your experiences charging electric vehicles?

6. Involvement in and expectations of the trial

- How did you come to be involved in the trial? What motivated you to be involved?
- What are you personally hoping to get out of the trial?
- What do you think the City of Oxford will get out of the trial?
- When will the trial be a success for you?
- At this stage, do you anticipate any issues or problems in the trial?
- What are your thoughts about where your charging installation will be installed?
    - What are your views on the physical attributes (i.e., width of the footpath or street; the size of the guttering; proximity to parking bay) of the site itself?

Conclusion of the interview

- Thank the participant for their time
- Make them aware of the content and timing of the next interview

Appendix 2: Questionnaire information sheet and Survey: for new EV drivers

Introduction

The main task of the Transport Studies Unit is to monitor and evaluate the Go Ultra Low Trial. The four areas we will try to understand are how:

1. Different charging installations perform;
2. You adapt to driving and charging electric vehicles over time;
3. Your neighbours and others respond to the installations; and
4. The pilot might be scaled up within Oxford and elsewhere in the UK

Purpose of the questionnaire

The intention of this brief questionnaire survey is to provide us with a more quantitative measure of your views, routines and expectations associated with both the trial and driving electric vehicles. The questionnaire has been developed on the basis of the available literature on EV use.

The questionnaire will be repeated at subsequent interviews which will allow us to track how your attitudes change over the course of the trial.

Definition of an electric vehicle (EV)

For the purposes of the questionnaire we do not make a distinction between different types of electric vehicles (EVs) such as Battery Electric Vehicles (BEVs), Extended-Range Electric Vehicles (E-REVs) and Plug-In Hybrid Electric Vehicles (PHEVs).

1. **Using the following scale please indicate whether you agree or disagree with the following statements? (Tick one box on the scale for each statement)**

	Statement	Strongly disagree ⟷ Strongly agree				
	Expectations/experiences of driving an EV					
1.	Learning to drive my EV will be easy	☐1	☐2	☐3	☐4	☐5
2.	My EV will be fun to drive	☐1	☐2	☐3	☐4	☐5
3.	My EV will not be as flexible as my normal car	☐1	☐2	☐3	☐4	☐5
4.	I am very interested in the latest developments in EVs	☐1	☐2	☐3	☐4	☐5
	Range of an EV					
5.	The range of the EV will be sufficient for my daily needs	☐1	☐2	☐3	☐4	☐5
6.	I will have to plan (i.e., routes and charging duration) my journeys more carefully compared to my previous car	☐1	☐2	☐3	☐4	☐5
7.	The range of my EV will be mostly affected by factors over which I will have no control	☐1	☐2	☐3	☐4	☐5
8.	While driving, I will be often worried about the range	☐1	☐2	☐3	☐4	☐5
	Charging EVs					
9.	It will be difficult to connect my EV to the trial charging point	☐1	☐2	☐3	☐4	☐5
10.	I will have no problem gaining access to my allocated trial charging point	☐1	☐2	☐3	☐4	☐5
11.	I will prefer charging to going to petrol stations	☐1	☐2	☐3	☐4	☐5
12.	The electricity costs associated with charging my EV represent value for money	☐1	☐2	☐3	☐4	☐5
	Frequency and timing of charging					
13.	I will have to change my everyday routines to accommodate the charging of my EV	☐1	☐2	☐3	☐4	☐5
14.	I will charge my EV whenever I get the chance	☐1	☐2	☐3	☐4	☐5
15.	I will not have to charge at other charging points because of the trial installation	☐1	☐2	☐3	☐4	☐5
	Social norms of EVs and charging					
16.	People who are important to me will find it strange that I am driving an EV	☐1	☐2	☐3	☐4	☐5
17.	The reactions of my neighbours and other street residents make me feel uncomfortable using the charging point	☐1	☐2	☐3	☐4	☐5
18.	When it is finished charging, a user should free up the point by moving their EV	☐1	☐2	☐3	☐4	☐5

Appendix 3: Questionnaire information sheet and Survey: for current EV drivers

Introduction

The main task of the Transport Studies Unit is to monitor and evaluate the Go Ultra Low Trial. The four areas we will try to understand are how:

1. Different charging installations perform;
2. You adapt to driving and charging electric vehicles over time;
3. Your neighbours and others respond to the installations; and
4. The pilot might be scaled up within Oxford and elsewhere in the UK

Purpose of the questionnaire

The intention of this brief questionnaire survey is to provide us with a more quantitative measure of your views, routines and expectations associated with both the trial and driving electric vehicles. The questionnaire has been developed on the basis of the available literature on EV use.

The questionnaire will be repeated at subsequent interviews which will allow us to track how your attitudes change over the course of the trial.

Definition of an electric vehicle (EV)

For the purposes of the questionnaire we do not make a distinction between different types of electric vehicles (EVs) such as Battery Electric Vehicles (BEVs), Extended-Range Electric Vehicles (E-REVs) and Plug-In Hybrid Electric Vehicles (PHEVs).

1. **Using the following scale please indicate whether you agree or disagree with the following statements? (Tick one box on the scale for each statement)**

	Statement	Strongly disagree ← → Strongly agree				
	Expectations/experiences of driving an EV					
1.	Learning to drive my EV has been easy	☐1	☐2	☐3	☐4	☐5
2.	My EV is fun to drive	☐1	☐2	☐3	☐4	☐5
3.	My EV is not as flexible as my normal car	☐1	☐2	☐3	☐4	☐5
4.	I am very interested in the latest developments in EVs	☐1	☐2	☐3	☐4	☐5
	Range of an EV					
5.	The range of the EV is sufficient for my daily needs	☐1	☐2	☐3	☐4	☐5
6.	I have to plan (i.e., routes and charging duration) my journeys more carefully compared to my previous car in my EV	☐1	☐2	☐3	☐4	☐5
7.	The range of my EV is mostly affected by factors over which I have no control	☐1	☐2	☐3	☐4	☐5
8.	While driving, I am often worried about the range	☐1	☐2	☐3	☐4	☐5
	Charging EVs					
9.	It will be difficult to connect my EV to the trial charging point	☐1	☐2	☐3	☐4	☐5
10.	I will have no problem gaining access to my allocated trial charging point	☐1	☐2	☐3	☐4	☐5
11.	I prefer charging to going to petrol stations	☐1	☐2	☐3	☐4	☐5
12.	The electricity costs associated with charging my EV represent value for money	☐1	☐2	☐3	☐4	☐5
	Frequency and timing of charging					
13.	I have had to change my everyday routines to accommodate the charging of my EV	☐1	☐2	☐3	☐4	☐5
14.	I charge my EV whenever I get the chance	☐1	☐2	☐3	☐4	☐5
15.	I will not have to charge at other charging points because of the trial installation	☐1	☐2	☐3	☐4	☐5
	Social norms of EVs and charging					
16.	People who are important to me find it strange that I am driving an EV	☐1	☐2	☐3	☐4	☐5
17.	The reactions of my neighbours and other street residents make me feel uncomfortable using the charging point	☐1	☐2	☐3	☐4	☐5
18.	When it is finished charging, a user should free up the point by moving their EV	☐1	☐2	☐3	☐4	☐5

Appendix 4: Interview 2 Schedule: 1-2 Months into the Trial

Introduction

Hi this is the first of the three interviews which will take place during the trial the remaining two will be at 5 months and 11 months into the trial.

Today we will talk about the we will talk about the performance of your charging installation and your views on it, your charging behaviour and impact it has had on your car use and everyday activities. Alongside this we will cover issues surrounding street parking and community responses to the charging installation. If we have time we may also revisit some of the topics from the first interview around how you have ended up driving an electric vehicle.

As a participant you have the right to:

- decline to answer any particular question;
- ask any questions about the study at any time during participation;
- provide information on the understanding that your name will not be used unless you give permission to the researcher;
- ask for the audio recording to be turned off at any time during the interview;
- be given access to a summary of the project findings when it is concluded.

1. Administer trial questionnaire

- The questionnaire for experienced users of electric vehicles (Appendix 4)

2. Experiences of charging using the trial technologies

- Can you please tell about your experiences charging your electric vehicle using the trial installation?
    a. What do you like about using the installation?
    b. What frustrates you about using the installation?
    c. Would you recommend this installation to Oxford City and County Councils?

3. Personal and household mobility

- Can you please tell me about how you go about planning your travel?
    a. Has anything in the household changed that has affected this?
    b. How do you manage conflicts in your time schedule and availability?
- Is the charger available when you want to charge?
    a. How do you feel when you are not able to charge?
    b. How do you deal with the uncertainty around charging?

4. Community interactions and responses to the installations

- Does anyone talk to you about being involved in the trial? What sorts of things have they discussed?
    a. How do you think your neighbours or social networks feel about electric vehicles because of your involvement in the trial so far?
- What sorts of interactions have you had with people around the trial installation?

5. Trial technology demonstration [At the charging installation]

- Can you please provide me with a demonstration of how you would go about charging your electric vehicle using the trial installation?
    a. How user-friendly is the installation to use?
    b. What do you have to consider or think about when charging an electric vehicle?
    c. What do you not have to think about? (i.e., what is now second nature or almost automatic for you?)
    d. Is that different from when you started?

Conclusion of the interview

Thank them for their time and if possible, try to reconfirm the best times to meet them. Update them on any outputs that have come out of the research.

Appendix 5: Interview 3 Schedule: 5 Months into the Trial

Introduction

Hi this is the second of the three interviews which will take place during the trial the remaining two will be at 5 months and 11 months into the trial.

Today we will talk about the we will again talk about the performance of your charging installation and your views on it, your charging behaviour and impact it has had on your car use and everyday activities. Alongside this we will also cover the cost of using the chargers.

As a participant you have the right to:

* decline to answer any particular question;
* ask any questions about the study at any time during participation;
* provide information on the understanding that your name will not be used unless you give permission to the researcher;
* ask for the audio recording to be turned off at any time during the interview;
* be given access to a summary of the project findings when it is concluded.

1. Administer trial questionnaire

- [Administer the trial version of the questionnaire].

2. Trial technology demonstration [At the charging installation]

- Can you please provide me with a demonstration of how you would go about charging your electric vehicle using the trial installation?
    a. How user-friendly is the installation to use?
    b. What do you have to consider or think about when charging an electric vehicle?
    c. What do you not have to think about? (i.e., what is now second nature or almost automatic for you?)
    d. Is that different from when you started?

3. Experiences of charging using the trial technologies

- Can you please tell about your experiences charging your electric vehicle using the trial installation?
    a. What do you like about using the installation?
    b. What frustrates you about using the installation?
    c. Would you recommend this installation to a friend or family member?
    d. Would you recommend this installation to Oxford City and County Councils?
- I am interested in getting your thoughts on the first video that I recorded of you using the charger? [Show them the video of them using the charger after 1-2 months].
    a. What are your initial impressions?
    b. Do you notice anything different?

4. Personal and household mobility

- Is the charger available when you want to charge?
    a. How do you feel when you are not able to charge?
    b. How do you deal with the uncertainty around charging?
- Can you please tell me about how you go about planning your travel?
    a. Has anything in the household changed that has affected this?
    b. How do you manage conflicts in your time schedule and availability?

5. Information about the cost of using the GULO trial technologies

- How does the payment process for charging your electric vehicle in the GULO trial work?
- What sort of information do you want about your charging?
    a. Total price per month/per charge/per day?
    b. Do you have any thoughts on how you would like this presented (in what format; how frequently)?
- What sort of information do they provide you with in the app or bill?
    a. Most electricity companies charge you per kilowatt hour and this is something you mentioned just then. Does this mean anything to you?

6. Costs of charging as part of the trial and potentially in the future

- How do you feel about the amount you pay?
- When you receive the bill, do you compare the price it costs you to charge using the trial installation with something else?
    a. What do you compare it with?
    b. Do you know how much it costs you to run or charge other appliances (e.g., water, heating, televisions, charging phones, tablets and computers)?
- Do you know how much it costs you to charge elsewhere outside of the trial (i.e., work, other on-street charging, and motorways)?
- When do you charge most in a 24 hour period?
- Hypothetically, what would you do if the electricity cost started to vary at different times of the day alongside existing peaks in energy demand? 10%, 30%, 50%? (show them the scenario cards)

Conclusion of the interview

Thank them for their time and update them on any outputs that have come out of the research.

Appendix 6: Car club Interview 1 Schedule

Introduction

Hi this is the first of two interviews which will take place during the trial the remaining one will be at 11 months into the trial.

Today we will talk about the we will talk about the performance of your charging installation and your views on it, your charging behaviour and impact it has had on your car use and everyday activities. Alongside this we will cover issues surrounding street parking and community responses to the charging installation. If we have time we may also revisit some of the topics from the first interview around how you have ended up driving an electric vehicle.

As a participant you have the right to:

* decline to answer any particular question;
* ask any questions about the study at any time during participation;
* provide information on the understanding that your name will not be used unless you give permission to the researcher;
* ask for the audio recording to be turned off at any time during the interview;
* be given access to a summary of the project findings when it is concluded.

1. Administer trial questionnaire

- [Administer the trial version of the questionnaire].

2. Experiences driving and charging electric vehicles

- Had you used an electric vehicle before using the Co-Wheels electric vehicles?
    - Did you have any previous experience of charging an electric vehicle?

3. Experiences of using Co-Wheels electric vehicles

- Why did you start using the Co-Wheels electric vehicle?
- Has that this is an electric vehicle had any impact on you plan and use Co-Wheels cars?
    a. How frequently have you been using it?
    b. For what sorts of journeys have you been using the Co-Wheels electric vehicle?
- Can you please tell about your experiences using the Co-Wheels electric vehicle?
    a. What do you like about using the electric vehicle?
    b. What frustrates you about using the vehicle?
    c. Would you recommend that Co-Wheels acquires more of these vehicles?
- What preparation, if any, did you do before using the electric vehicle for the first time?
    a. Did you read the instructions on the Co-Wheels website?
    b. Did you do any research on the internet or watch any Youtube videos?

4. Experiences of charging using the trial technologies

- Can you please tell about your experiences charging the Co-Wheels electric vehicle using the trial installation?
    a. What do you like about using the installation?
    b. What frustrates you about using the installation?
- What kind of information would like about using or charging the Co-Wheels electric vehicle?

5. Community interactions and responses to the installations

- What sorts of interactions have you had with people around the trial installation?

6. Trial technology video demonstration and reflections

- I have a video of someone demonstrating how to use the installation you have been using.
    a. How does this compare to your own experience?
    b. How user-friendly is the installation to use?
    c. What do you have to consider or think about when charging an electric vehicle?
    d. Would you recommend this installation to friends, family and neighbours?
    e. Would you recommend this installation to Co-Wheels and the Oxford City and County Councils?
    f. How do you see the use of electric vehicles for car clubs such as Co-Wheels in the future?

7. Conclusion of the interview

Thank them for their time and if possible, try to reconfirm the best times to meet them. Update them on any outputs that have come out of the research.