energy saving trust

Powerloop Vehicle-to-Grid trial

Customer insights and best practice guide

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Introduction to Powerloop and this best practice guide

Powerloop was one of the UK's key demonstrator projects for Vehicle-to-Grid (V2G) electric vehicle (EV) charging. The project was delivered by six organisations, led by Octopus Energy and Octopus Electric Vehicles.

The project aimed to demonstrate the technical, commercial, and practical viability of V2G technology at a domestic level, through a trial of V2G-enabled vehicles and chargers. 135 customers signed up to the trial, which was completed in 2022.

This guide has been developed to give future V2G industry stakeholders insights and best practice advice, based on the customers' driving and charging behaviours as well as their perceptions of V2G services.

Key customer insights

Over 85% of customers in the trial were likely to use a V2G service in the future and 87% would recommend it

These promising statistics show that the technology trialled was, generally, fit-for-purpose and met customer needs. It is important to note that this was the perception of 97 of the 135 trialists who responded to the final trial survey. In total, only 16% of respondents said they were dissatisfied with the service overall

58% of customers found it easy or very easy to integrate using the V2G service into their daily routine

In addition to this, a further 31% found it neither easy nor difficult. In the first survey, after the contract was signed, customers expected this to be one of the trial's most difficult aspects.

On average, over 70% of customers said they were plugged in between 6pm-8am

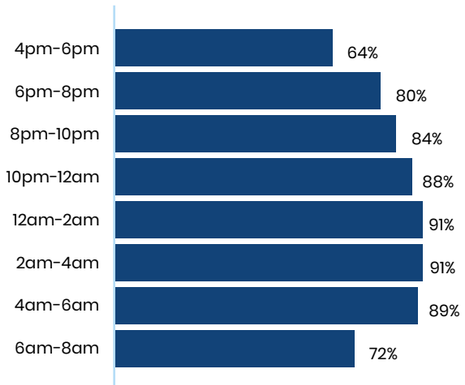
This shows that there is large potential for flexibility services during times of peak energy demand. Between 8am – 10am, the average dropped to 32%.

Figure 1: **Customers who would recommend the V2G service after the trial**

Other key insights included:

- Customers' key incentive for joining the trial was an environmental one, although financial incentives were also important.
- Only 33% of customers were commuting more than two or three times a week, 30% were retired.
- 90% of customers had a typical daily mileage of 50 miles or less.
- 90% of customers said they typically charged their vehicle multiple times a week, 80% used V2G multiple times a week.
- 62% of customers plugged in their vehicle more than usual as a result of having a V2G charger.

Figure 2: **Average percentage of customers plugged into their V2G charger at different times**



Recommendations of best practice

After analysing the customer data, we developed several best practice tips for future V2G product and service providers.

Many customers wanted more control through the app along with more flexibility in charging and discharging, but preferences varied

The survey data showed customers wanted to be able to monitor and control the system in a number of ways, and future services should accommodate for those varying preferences.

Environmental benefits of V2G and the financial incentives could be useful marketing tools

Service providers should use these incentives to help engage with different customer markets.

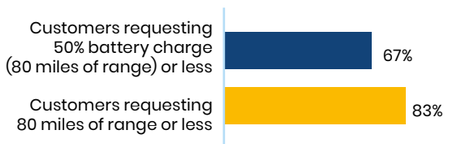
Services should use mileage or range as a metric for post-charge thresholds, not battery percentage

In V2G services, most providers will likely offer customers a minimum threshold of charge they desire after a V2G session. We found that customers are more likely to ask for more energy when battery percentage was used as a metric, compared to range. This could mean services potentially utilise more flexibility and capacity in the overall system, although the conversion between range and battery capacity must be carefully considered.

Other advice includes:

- Customers need informative resources and customer support to help them understand the app, the system, and their tariff.
- Reliable internet connectivity is essential for a V2G system, with Ethernet being the best choice.
- Both the customers in the trial and Octopus Electric Vehicles called for a one-app solution.
- Some of the concerns of using V2G are linked to using an EV, so services should look to support customers with their adoption of EVs where possible.
- Customers were initially highly concerned about changing their routine, so services should highlight this point during customer engagement to reduce those anxieties.

Figure 3: **Minimum post-V2G-charge threshold metric comparison**



02

Introduction

Powerloop is one of the UK's key demonstrator projects for Vehicle-to-Grid (V2G) electric vehicle (EV) charging. The project was funded by the Department for Business, Energy and Industrial Strategy (BEIS), the Office for Zero Emissions Vehicles (OZEV), Innovate UK, and was delivered by a consortium of partners. Octopus Energy and Octopus Electric Vehicles managed the project centrally, while other organisations supported on specific areas.

The project aimed to demonstrate the technical, commercial, and practical viability of V2G technology at a domestic level, through a trial of V2G-enabled vehicles and chargers. 135 customers signed up to the trial, which was completed in March 2022.

This section introduces the purpose of this document and gives more detail about the trial that was undertaken.

Table 1: **Consortium partners**

Partner	Role
Octopus	Octopus Energy is one of the UK's leading energy suppliers, providing their customers with 100% renewable energy. They are the project lead, supported by Octopus Electric Vehicles, a sister company that leases EVs.
Energy Saving Trust	Energy Saving Trust are an organisation committed to the promotion of sustainable energy use and analysed the customer experience during the project.
Guidehouse	Guidehouse is a global consulting firm that provided project advice and data analysis for Powerloop. They engaged with the UK distribution network operators to gain their insight and leveraged Powerloop learnings to develop a roadmap for the large-scale roll-out of V2G.
Open Energi	Open Energi are providers of an AI-enabled platform to manage V2G and other low carbon technologies and connect them to energy markets. They provided Powerloop with chargepoint monitoring services and provision of the scheduling mechanisms.
UKPN	UKPN is the distribution network operator that supported the project, developing a streamlined connection process for customer participating in V2G.

Role of the consortium partners

Table 1 shows all the consortium partners involved in Powerloop, along with their roles.

Energy Saving Trust's role in Powerloop

Our key function in the project was to gain insight into customers driving and charging habits, how they interact with V2G technology, and their perceptions of the technology.

To do this, we developed three customer surveys which were sent to the 135 trialists before, during, and after the trial, forming the basis for our evaluation. Table 2 shows the timeline of the trial and when the surveys were sent. There was also a survey sent to a different cohort of potential trialists prior to the trial which provided further insights.

Table 2: **Timeline**

Milestones	
December 2019	Pre-start, post-contract, survey
2021	Vehicles and chargers delivered
December 2021	Mid-trial survey
February 2022	End of trial survey
March 2022	End of trial

Purpose of this best practice guide

One of the final outputs for the project was to develop a 'best practice guide' that could give an insight into customer perceptions and behaviours in relation to their experience in the V2G trial.

The findings from the trial should enhance industry's ability to develop V2G products or services that are fit-for-purpose and help increase the widespread roll-out of V2G charging. Those industry stakeholders could include:

- Energy suppliers.
- Energy service providers, such as aggregators.
- Automotive manufacturers.
- Chargepoint operators.
- Distribution Network/System Operators (DNO/DSO).
- Chargepoint installers.

In this guide, we build a basic profile of the customers in the trial cohort, followed by an overview of the key customer insights. The final section presents our best practice advice for future stakeholders in V2G.

Recruiting for the trial

Octopus began engaging with their customer-base in 2018 through paid online advertisements, live events, newspaper and magazine postings, podcasts, and social media.

Initially over 2,500 customers registered interest in Powerloop, with 135 participating in the trial. All customers were situated within UK Power Network's coverage area, as they were the selected DNO consortium partner. This includes most of the Southeast of England and Greater London.

Trial details

The 135 customers that signed up to the trial all leased a Nissan Leaf, with 95% of customers receiving the 40kWh Leaf, and 5% having the 62kWh Leaf. Nissan extended the warranty for their vehicles to accommodate V2G charging and discharging. In addition, trialists had a Wallbox Quasar bi-directional V2G charger installed at their homes free of charge.

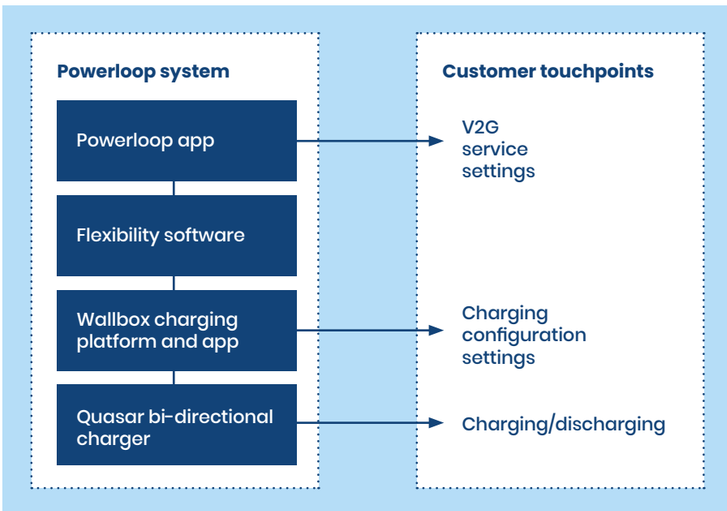
Trialists could control their V2G charger configuration settings through the Wallbox Charger App. The main interface used for scheduling customers' charges and discharges was the Powerloop dashboard, which could be found online or on the Powerloop app. The structure of the technology and how customers interacted with it is shown in Figure 4.

Customers were also offered a financial incentive for participating in the trial. If customers had their vehicle plugged into their charger, and were available for the V2G service between 4-7pm at least 12 times a month, they were offered a £30 monthly reward. Partway through the trial, two thirds of customers were moved to an import and export time-of-use tariff, which incentivised them to charge and discharge at certain times.

Further detail about the new tariff that was introduced to Powerloop customers is shown below:

- **Import Tariff**: the Powerloop import tariff matched the pricing of Octopus's newest next generation EV tariff, 'Intelligent Octopus'. The cheap overnight window of the 'Go' tariff was extended by an additional two hours, giving customers six hours of green energy at a low rate of 5p/kWh from 11:30pm-5:30am. Depending on location, the day rate varied between 15.90-16.26p/kWh. The standing charge was 25p/day for all areas.
- **Export Tariff**: the Powerloop export tariff introduced dual-band pricing of 5p/kWh throughout the day and 15p/kWh between 4-7pm.

Figure 4: **Overview of the Powerloop system**



Trial cohort's characteristics

Although the trial was marketed to a broad range of customers, the participants who expressed interest could be considered 'early adopters' of technology. The insights from this cohort will be useful for developing products and services fit for the early adopting market. It is important to consider that the mass market may have differing opinions on certain aspects of the technology, although many of the insights will still be relevant.

Impact of COVID-19

COVID-19 had a large impact on Powerloop. Many vehicles and chargers could not be delivered or installed in the planned timeframes, and working and travelling behaviours of customers changed dramatically.

96% of respondents of the pre-start survey responded after the national lockdowns of 2020. The last two surveys were delayed so that customers could experience more time with their vehicle and V2G chargers. This compressed the time between the two final surveys, meaning there were relatively small deviations in some responses. These surveys also coincided with stricter restrictions being imposed due to the Omicron variant in January 2022, likely further impacting results.

Readers should consider how customer behaviour will change as we adjust to routines without COVID-19 restrictions.

Charger hardware and software issues

During the trial, most customers experienced some technical issues with their V2G system.

As V2G is a new technology, the final hardware had to be comprised of existing charging technology, integrated with newly designed hardware and software. Consequently, the likelihood of technology-related issues increased as a result of the untested and newly developed technology.

The main issues encountered were:

- Chargers struggled to maintain a Wi-Fi connection between the charger and the customer's router, often even with a range-extender in place.
- The alternative connection option, Ethernet, meant some customers needed unsightly cables installed during a secondary engineer visit.
- Some Android users had a specific Wallbox app issue which led to an inability to control their charger through Bluetooth if they had Wi-Fi issues.
- The Powerloop app generally had reliability issues, meaning chargers would often not follow schedules set by customers, ignoring the minimum required charge threshold set by the customer.
- The Powerloop app was also reported to display incorrect information to customers in relation to the amount of transferred energy.

Many of these errors and malfunctions were difficult to diagnose remotely for the Octopus Electric Vehicles customer service team, meaning that some customers had prolonged periods where they could not use the service as expected. Approximately 15% of people did not use the Powerloop app to manage their charges at all, and nearly 25% of customers required some form of hardware replacement through the trial.

These issues resulted in a partial lack of trust in the service, apps and interfaces, resulting in some negative comments from customers.

Readers should consider that these issues impacted the majority of customers, which could negatively influence their perception of V2G technology and its readiness for market.

03

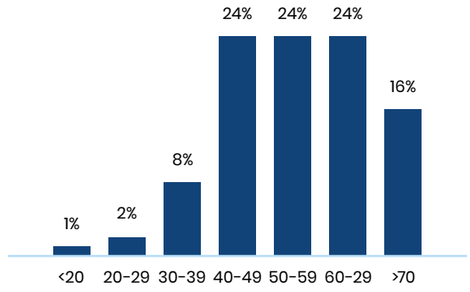
Customer demographics

This section gives an insight into what types of customers participated in the trial. It is important to remember that the opinions and perceptions of the V2G service are only based on the customers who have opted into the Powerloop trial. These opinions may not be shared by all future V2G users.

Around 90% of customers were aged 40 or more and shared the same gender

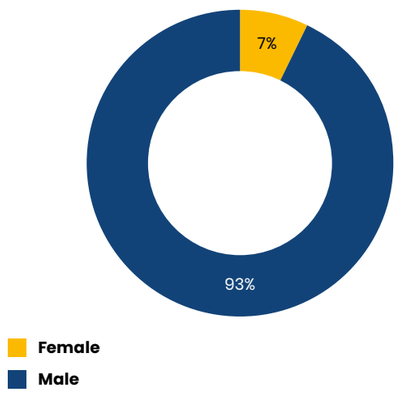
The customers in the trial were mostly evenly spread across ages above 40 years old, as shown in Figure 5. This is likely due to factors such as property ownership, disposable income, or energy-usage consciousness. Of these customers, over 30% were retired. This demographic of customers is likely to be an important target group for promoting the adoption of these technologies.

Figure 5: **Ages of customers on the trial**



Over 90% of customers were male, as shown in Figure 6.

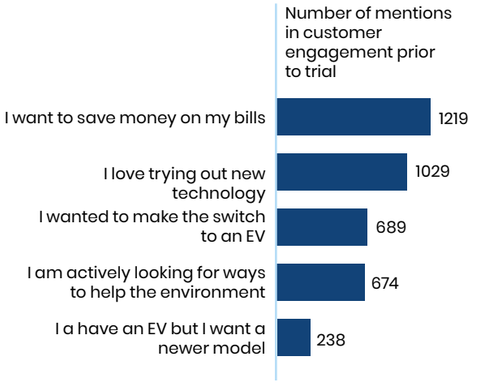
Figure 6: **Gender identity of the customers in the trial**



The top incentive for interested customers was initially the financial savings, but the final trialists were most incentivised by environmental reasons

Customers who engaged with the marketing campaign were asked what their main incentives were for wanting to find out more about Powerloop. The main reason was to help save money on their energy bills, as shown in Figure 7.

Figure 7: **Most common reasons for the initial 2,500 customers showing interest in the trial**



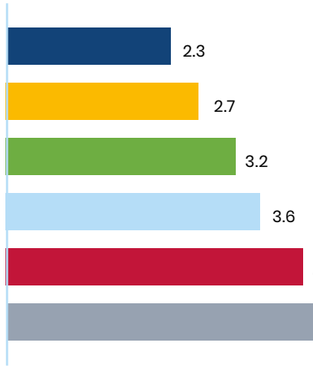
The 135 trialists were asked what incentivised them to sign up for the trial. Out of their free text answers, six common themes emerged, which customers were then asked to rank in order of importance. As shown in Figure 8, the most important incentive for customers on the trial was the environmental benefit V2G could offer in helping to utilise energy more efficiently.

"Most people I speak to think it's a brilliant idea to solve our future renewable energy challenges."
Powerloop customer

The other important incentives were supporting a new technology's development and having access to a complete bundle of vehicle, charger, and tariff. Lowering bills was not considered the most important, although readers should be aware that this may not be the case for other customers.

It is important to note that the initial targeted marketing for the trial and the on-boarding decisions that took place by Octopus Electric Vehicles will have influenced the user group.

Figure 8: **Average rank of most important incentives for joining the trial**

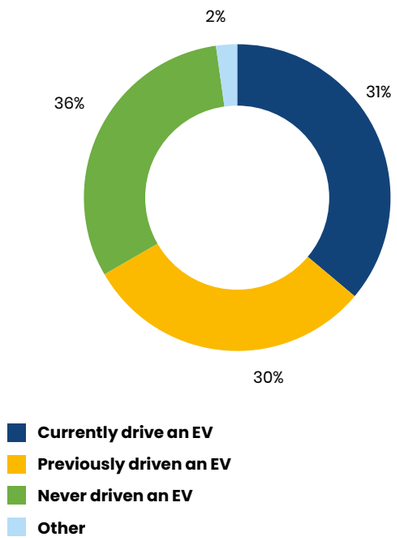


Most customers did have some experience with EVs before the trial, and 72% of customers had little or no knowledge of V2G technology before starting the trial

The pre-start survey showed that two thirds of the customers had used an EV before, with nearly a third already driving one, as shown in Figure 9. This means that most customers already had some experience in charging an EV and integrating EV use into their routines. However, nearly a third of customers had no experience with EVs at all.

While the majority of customers did have experience with EVs, they had very little, or no pre-existing knowledge around V2G technology and charging.

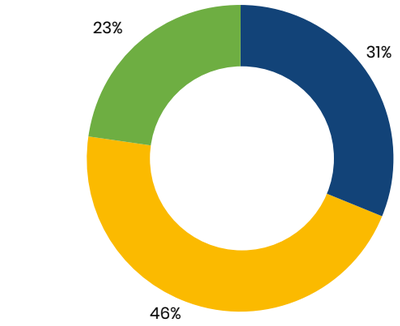
Figure 9: **Customer experience with EVs**



Although most customers had another vehicle in the household, most used the trial vehicle as their main vehicle

Over two thirds of customers had at least one other vehicle in the household, as shown in Figure 10. However, 91% of customers who answered the end-of-trial survey said they used their Powerloop Nissan Leaf as the main vehicle in their household. This is promising as it can give us confidence that perceptions of the experience are based on regular usage of the trial vehicle.

Figure 10: **Number of vehicles in the household**



Most customers shared their vehicle with another driver

82% of customers said that they shared their vehicle with at least one other person, with 18% being the only user of the trial vehicle. Car insurance data showed that all trialists were either in a couple or had a family.

This shows us that although just one customer signed up for the trial, their trial vehicle was often used by multiple people. This means that a V2G service also needs to work for someone with potentially less interest or knowledge of the service or product.

04

Vehicle usage and driving habits

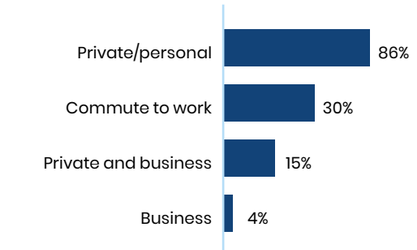
We developed the customer profile further by assessing how customers intended to use their vehicles, how far and frequently they typically drove, and how long they parked at home for.

Most customers intended to use their vehicle for private and personal use

Customers were asked about their intended use for the trial vehicle after signing the contract. 86% of customers intended to use the trial vehicle for personal and private usage, as shown in Figure 11.

The post-contract survey was answered in the latter stages of 2020, after the COVID-19 pandemic changed many people's working and travelling routines.

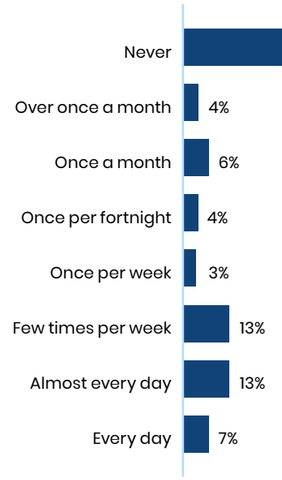
Figure 11: **How customers intended on using the trial vehicle**



During the final survey, most customers were still not commuting regularly

49% of customers did not use their trial vehicle for commuting at all, as shown in Figure 12. However, this was expected as 30% of customers were retired. 33% of customers were commuting at least two or three days a week. This final survey also happened to capture data when the Omicron COVID-19 variant was causing disruptions to many workplaces in early 2022.

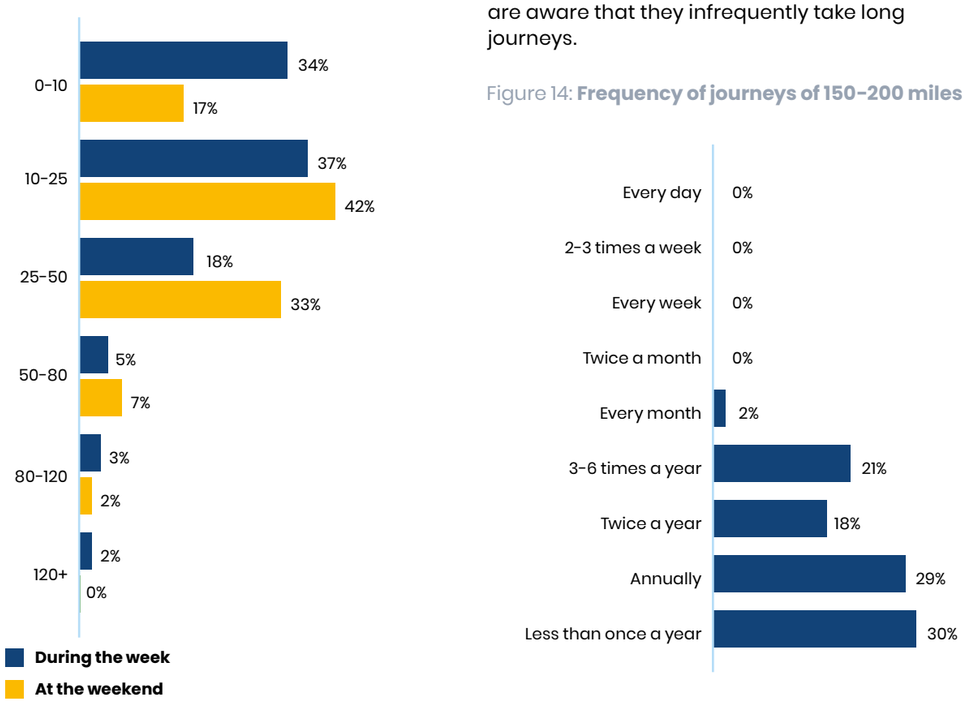
Figure 12: **How many days a week customers used their vehicle for commuting**



Daily mileage was relatively low for the customers

Customers were asked what their typical daily mileage was before they started the trial. As illustrated in Figure 13, 90% customers did not typically drive over 50 miles in a day. This is well below the average range of today's EVs which can have a range of around 200 miles[1], depending on a variety of factors.

Figure 13: **Typical daily mileage for customers**



98% of customers undertook journeys of 150-200 miles less frequently than once a month prior to the trial

Many EVs can be driven 150 miles without the need for a charge, though the 40kWh Nissan Leaf has a range of approximately 140 miles. The frequency of longer journeys customers undertook pre-trial is illustrated in Figure 14. Despite the range constraints of the trial vehicle, these customers could still feel confident in using an EV because they are aware that they infrequently take long journeys.

Figure 14: **Frequency of journeys of 150-200 miles**

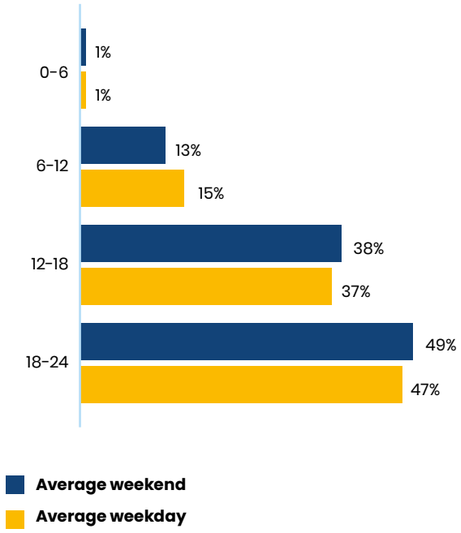
1 https://www.nimblefins.co.uk/average-electric-car-range

Nearly 90% of customers parked their vehicle at home for at least 12 hours a day

Customers were asked how long they parked their vehicle at home before and at the end of the trial, with little change in their responses. There was also little variation between weekdays and weekends for these customers, with Figure 15 showing the average number of hours parked at home across both surveys.

Nearly 50% of customers parked their vehicle at home for over 18 hours a day, giving opportunity to utilise V2G charging. Although this trend could be due to COVID-19 restrictions or usage patterns of the core demographic, it is a very positive finding for the potential utilisation of V2G services in the future.

Figure 15: **Number of hours parked at home**



05

Charging habits and vehicle-to-grid system usage

Customers were asked several questions about how they used the V2G charger so that we could understand how they interacted with the technology.

We extracted information about general charging behaviour as well as V2G-specific functionality. This will help future V2G stakeholders understand when and where customers were charging their trial vehicles.

All customers used the V2G charger at home and there was little use of other chargepoints

When customers were asked how frequently they charged at a chargepoint other than their trial V2G Wallbox charger, on average, they said they used one less than once a month.

The locations where customers charged their trial vehicle away from home are shown in Figure 16.

Figure 16: **Where customers charged their trial vehicle**

90% of customers said they typically charged their vehicle multiple times a week, 80% used V2G multiple times a week

Customers did habitually plug in their vehicles as illustrated in Figure 17, although they did not necessarily use their V2G functionality for every charge, as Figure 17 demonstrates. 58% of customers used their V2G functionality at least 4 times a week. This indicates that the trialists were engaged with their V2G service and chose to adopt the service into their routines.

Figure 17: **Typical time customers spent between charge**

Over 80% of customers were plugged in and available for V2G services between 6pm-6am on weekdays

The average percentages of mid and end-of-trial survey results, shown in Figure 18, illustrate when customers were typically plugged in and available for V2G services. The difference between the weekend and weekday seems minimal, although time plugged in extends in the morning by a difference of 27% between 8am-10am at weekends.

The surveys also evaluated customers' experiences during a period where there were COVID-19 restrictions in place between Christmas 2021 and February 2022. This could indicate that customers were more frequently at home. This is validated further by Figure 12, which illustrates that customers were not commuting regularly. This behaviour might change if commuting patterns return towards pre-pandemic standards.

Additionally, customers were also asked prior to the trial when they thought their vehicle would be available for the V2G service. The anticipated pattern, illustrated in Figure 19, was similar compared to the reality of customers' experience. This could be because the pre-trial survey was also taking place during COVID-19 restrictions.

Figure 18: **Average percentage of customers who are plugged in and available for V2G across the week**

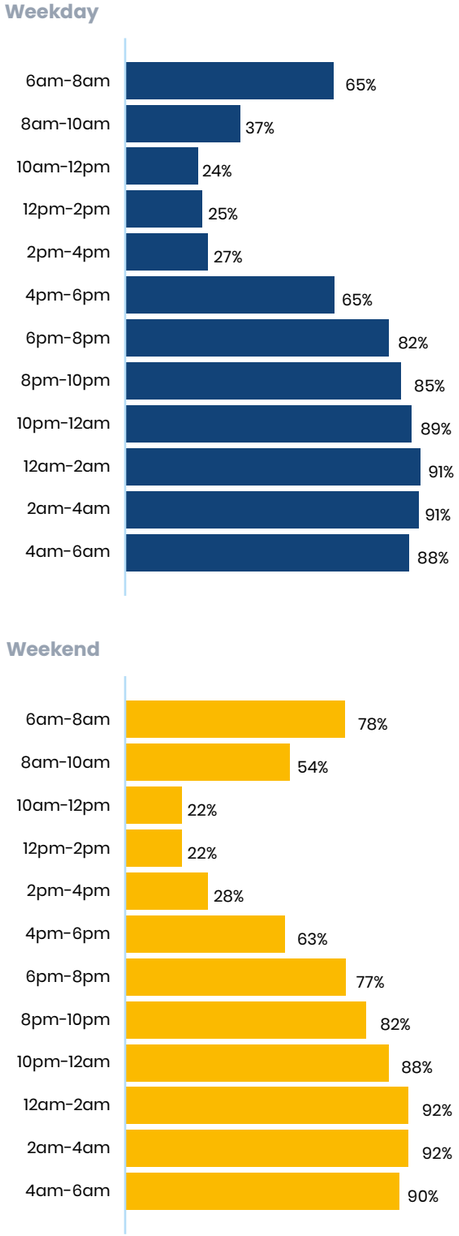
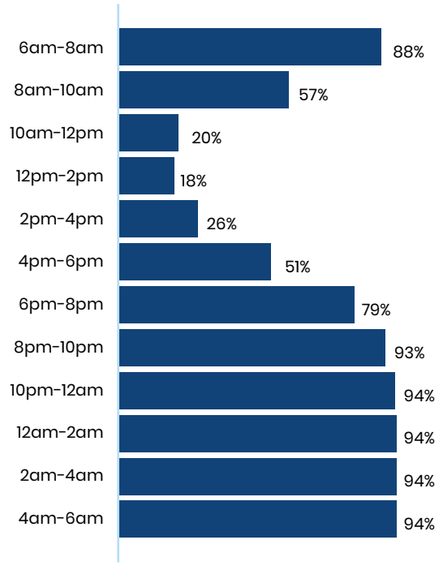


Figure 19: **Average anticipated times prior to trial start for customers being plugged in and available for V2G**



By the end of the trial 83% of customers requested a range of 80 miles or less after a V2G charging session

80 miles of range in a 40kWh Nissan Leaf, as shown in Table 3, can be the equivalent of a little more than 50% charge, in optimal conditions. We know around 95% of customers had a 40kWh version.

It is important, however, to consider that range is impacted by several factors including temperature, weather, driving style, and battery health, so the values in Table 3 are approximate.[2]

Table 3: **Battery statistics for 40kWh Leaf**

Battery charge	Miles added	Hours to charge with 7kW charger
20%	25	1.0
30%	50	2.0
40%	60	2.5
50%	75	3.0
100%	150	7.0

2 Own calculation based on range of consumption data and vehicle specifications as detailed at https://ev-database.uk/car/1656/Nissan-Leaf

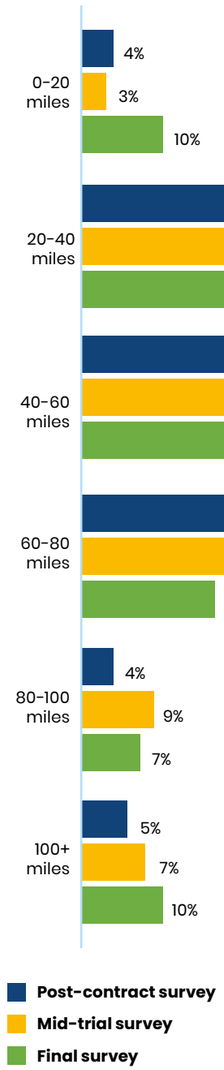
Customers were asked the same question prior to, during, and at the end of the trial. The shift in desired range after a charge is shown in Figure 20. As travel and working patterns shift, and mileage potentially increases, these figures could change again.

Customers are also likely to want to complete a journey with some range remaining, which should be accounted for in the state of charge provided.

After starting the trial, customers wanted more range after their charging sessions compared to the previous survey. This could be due to several reasons including:

- Customers increased their mileage.
- Customers anticipated needing more mileage.
- Customers ran out of charge quicker than expected, possibly due to driving style or weather conditions.

Figure 20: **Minimum driving range requested by customers post V2G session in miles**



Customers were requesting additional mileage after a V2G session compared to their typical daily mileage

The customers generally had low daily mileage, with 91% of customers estimating they drove 50 miles or less. In 2020, the UK average for daily miles was around 12 miles per day[3], showing that these customers either drove more miles than average, or customers tend to overestimate the number of miles they drive.

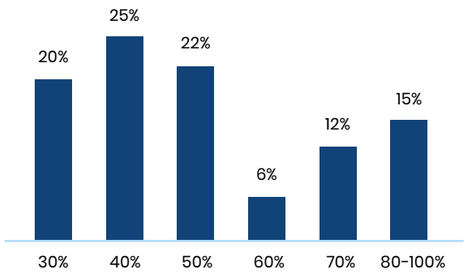
The previous sections show us that most drivers requested around 80 miles or less of range after a V2G session, suggesting that most customers are integrating some additional range into their minimum range calculations. This figure will vary between customers and could change again as travel patterns potentially shift.

Customers have different perceptions when thinking about range and battery percentage for minimum energy thresholds after V2G sessions

Customers were asked in the mid-trial survey about the minimum range and battery percentage they required after a V2G session. A certain percentage of charge will translate to a certain range on the Nissan Leaf, as shown in Table 3. Although there is a theoretical conversion between miles added and battery percentage, there are numerous factors that will impact the conversion such as weather conditions and driving style.

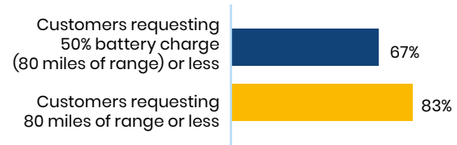
When asked how much battery percentage they wanted, Figure 21 shows customers requested a battery percentage that equated to a higher number of miles. The equivalent mileage based on the charge is shown in Table 3.

Figure 21: **Percentage of customers choosing the minimum battery percentage after V2G**



Converting these battery percentages to miles of range, we can see that 67% of customers desired 80 miles or less after a V2G session. This compares to 83% of customers illustrated in Figure 20, who said they would need 80 miles of range or less. The impact of using different metrics for the minimum threshold after a V2G session on customers perceptions is shown in Figure 22.

Figure 22: **Customer perceptions of minimum charge thresholds after a V2G session**



This customer mentality could have a significant impact on V2G, therefore products and services should consider using mileage as opposed to battery percentage when setting minimum charge thresholds. This will allow more power to be transferred per vehicle and increase the storage and flexibility of the portfolio of V2G assets. It is important to ensure that the conversion between range and battery percentage is carefully considered to incorporate weather conditions and driving style.

3 https://www.gov.uk/government/statistics/national-travel-survey-2020

06

Customer perceptions of vehicle-to-grid technology

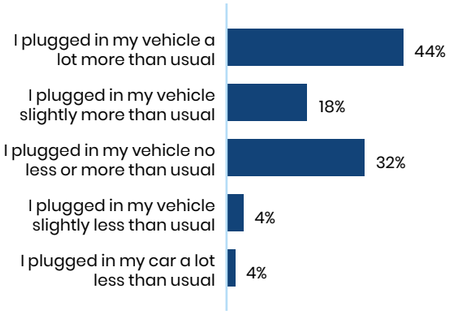
Customers were asked for their opinions on the service they used during the trial and about V2G in general. This section highlights which components of the technology worked well, and which need to be developed further.

Most customers felt that using the V2G service did not impact their use of the vehicle, but did increase the number of times they plugged their vehicle in

84% of people drove their vehicle more or the same as usual during the trial, with only 16% using the vehicle less than usual. Considering there were several technological issues for many customers, this is an incredibly positive outcome.

Over 60% of customers plugged their vehicle in more due to using the V2G service, as shown in Figure 23. This demonstrates that customers were positively engaged with the service and were adopting behavioural change to meet the needs of the tariff and service.

Figure 23: **Customers' opinion on how much the V2G service affected how much they plugged in their vehicle**



Around 85% of customers are likely to use a V2G service in the future and would recommend it

Although some customers were not satisfied, they still believe the service was good enough to recommend it to others, as shown in Figure 25 and Figure 26. Furthermore, they are likely to engage with a V2G service again in the future once further developments have been made as illustrated in Figure 24.

It is important to consider that these opinions are from the 97 customers who responded to the final survey, there were 38 who did not respond.

"It was a Beta test and for a Beta test it was brilliant." **Powerloop customer**

Figure 24: **How likely customers were to use this type of service in the future**

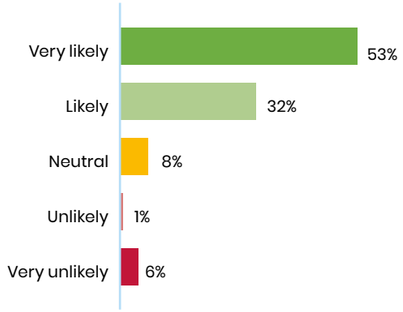
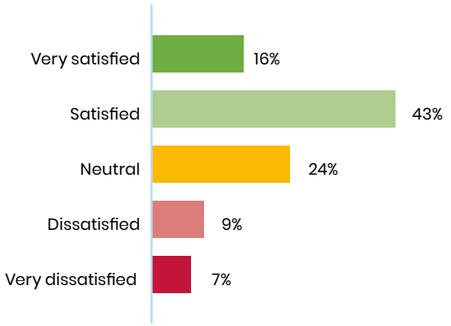


Figure 25: **Customers who would recommend the V2G service after the trial**

Most customers were satisfied with the overall V2G service, including the customer service and financial incentive

Only 16% of customers in the final survey were dissatisfied with the service overall, as shown in Figure 26. Nearly a quarter of customers had a neutral opinion.

Figure 26: **How customers rated the V2G service overall**



80% of customers said that they were specifically satisfied with Octopus Electric Vehicles customer service, with 47% of those being very satisfied. This is an excellent reflection on the support system that was created for customers. This included both email and phone support for customers. A forum for customers to communicate with others was originally planned and proposed to customers, however, this was not implemented in the trial due to operational capacity constraints. Customers used the free text sections of the surveys to emphasise that this would have been beneficial to them.

Customers were also initially offered a £30 reward for using their V2G service between 4-7pm, 12 times a month. 74% of customers were satisfied with this form of financial incentive offered. Some customers, who had technical issues, were also offered compensation.

Many customers found charging and fitting V2G into their routine easy, although this was not the case initially

This was the largest perceived challenge for the technology prior to the start of the trial, based on free text comments, as shown in Figure 27. Over the course of the trial, however, timing the charges became less of a challenge to users. 58% of customers found integrating the V2G service into their daily routine easy, and only 11% found it difficult, as shown in Figure 28. This could partly be related to some customers switching to the new import and export tariff that did not necessarily require them to plug in at certain times. This indicates that it was easier than expected to adopt this type of V2G charging.

Figure 27: **Two largest perceived challenges for customers pre-trial**

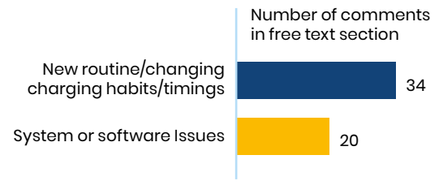
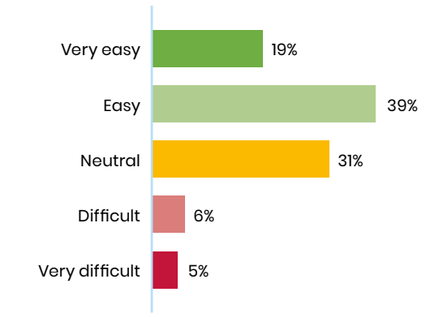


Figure 28: **Customers' opinions on how easy it was to integrate the V2G service into their travel routine**



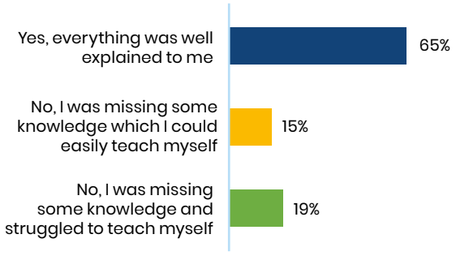
Around two thirds of customers felt the trial and technology were well explained, but some struggled

65% of customers were happy about how the trial and the app were explained to them, as shown in Figure 29. However, almost one third were struggling to learn how the V2G technology worked. Although 15% of customers believed they could easily teach themselves the missing knowledge, these findings indicate that more needs to be done to support customers understanding of this technology when considering future services, especially for mass markets.

"As an early adopter, I could never recommend this to my less technical friends." **Powerloop customer**

These customers suggested that a YouTube account with regular updated training videos would have been extremely useful. Additionally, they would have liked a user forum for an exchange of advice and experience.

Figure 29: **Customers' perceptions of whether they had the V2G service explained sufficiently**



Customers were pleased with the trial vehicle's performance, but many were unhappy with the range

Customers were pleased with the Nissan Leaf and its performance, as shown in Figure 30. This was shown in the free text components of the surveys.

"The Leaf is a cracking car." **Powerloop customer**

However, many customers felt that the vehicle did not have sufficient range for them. Although the driving data suggests that the vehicle range was sufficient for most customers' journeys, some comments highlight that people felt limited in their ability to undertake irregular longer journeys.

"In the future having slightly bigger range will be key." **Powerloop customer**

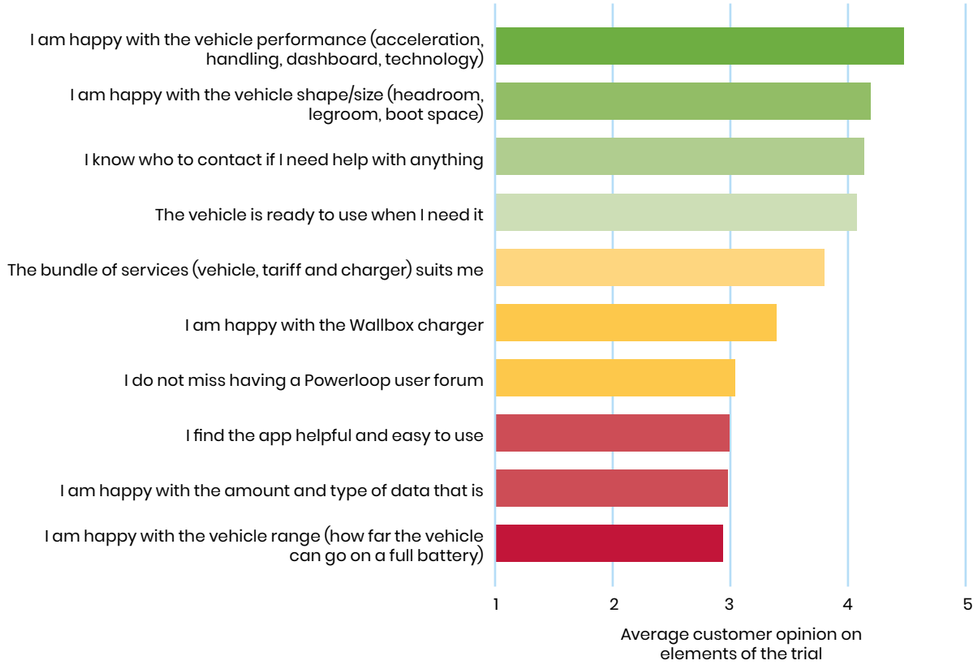
On average customers agreed that the vehicle was ready when they needed it. This is a fundamental success for a V2G trial and was something that customers were previously apprehensive about in the initial survey.

Due to various technical issues, some consumers complained about not having enough battery left after a session in the free text section, resulting in range anxiety and concerns about unplanned journeys and flexibility. This highlights the sensitivity that customers have about having the right amount of range and charge available after a V2G session.

Table 4: **Likert scale used for perceptions**

Completely agree	5
Agree	4
Neutral	3
Disagree	2
Completely disagree	1

Figure 30: **Customers perceptions on different elements of Powerloop**



"There have been some occasions where a cycle hasn't worked correctly and we have been left with 10-30% left in the battery (when the Powerloop app hadn't worked and therefore the discharge reverted to the Wallbox standard of stopping at 10% rather than the Powerloop lowest point of 30%). This occasionally caused concern about having enough battery level to carry out the school run etc. " **Powerloop customer**

Customers were not satisfied with the Powerloop app

On average, customers didn't find the app useful or easy to use and felt that it lacked information and data. For these customers, the interface didn't necessarily meet their needs in supplying adequate, or the correct, information. This indicates a clear need for significant user research and testing when developing future V2G service interfaces.

"Yet another complicated interface that is unreliable." **Powerloop customer**

Software and system issues were by far the largest challenge customers encountered

In the free text sections, there were 66 comments about technical and system-related issues. This was the most common theme for complaints in the survey data. These included issues with the charger and its connectivity, general app functionality, and unreliable charging and discharging.

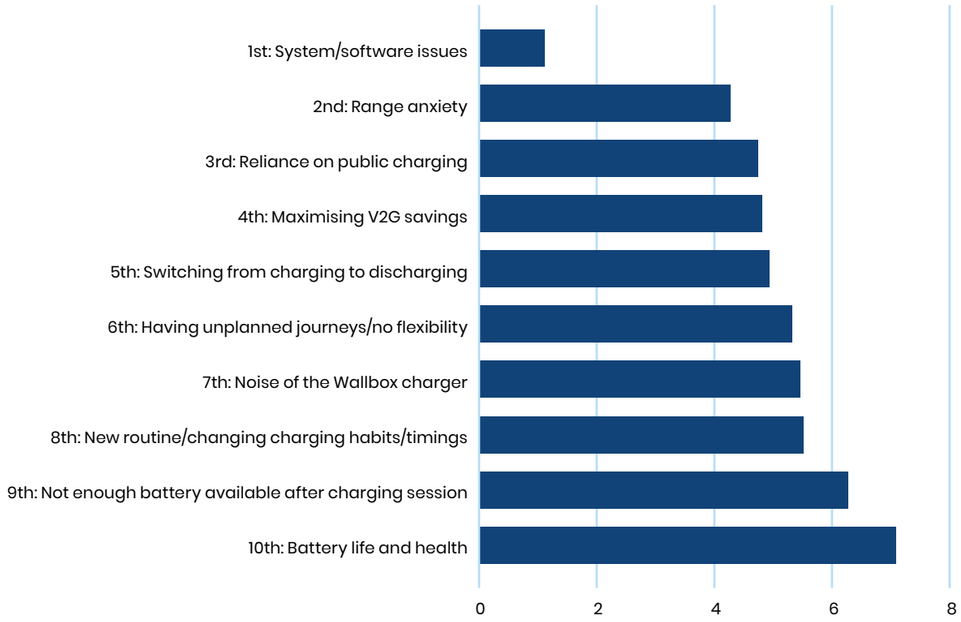
"The unreliability of the Wallbox charger (I am on my third one!), the difficulty of using the app, the lack of compatibility between Powerloop operating modes and Wallbox operating modes and consequent problems, and hence a lack of confidence in the functioning of the system." **Powerloop customer**

Software and system issues were the largest challenges faced by customers, as shown in Figure 31. Customers did generally feel that their trial vehicle was ready to use when they needed it, although it is not certain whether this was in reference to a V2G, or regular, charging session.

Although battery life and health were considered the smallest challenge, 25% of customers did have some concern about the impact of V2G on their battery

The effects of V2G on a vehicle's battery life and health are not fully discovered yet, although it is expected to be less impactful than regular use of rapid chargepoints. A quarter of the customers were at least 'somewhat concerned' about V2G having a negative impact on their car. More research is required to explore the impacts of V2G on battery health and the findings should be shown to customers to alleviate concerns around battery health.

Figure 31: **Average ranking of biggest challenges for customers**



Range anxiety and reliance on public charging were large barriers for customers

We know that customers were generally unsatisfied with the Nissan Leaf's range and stated that it is not suitable for longer journeys unless the route has adequate charging infrastructure. We expect this insight is mostly related to the 40kWh model, not the 62kWh.

However, Figure 31 shows that most customers did not rank 'not enough battery available after a charging session' high in the list of largest challenges. This leads to the conclusion that customers' range anxiety could be due to the Nissan Leaf's range, as opposed to the V2G service.

It is well-known that in many areas of the UK, public charging infrastructure is perceived to be inadequate by some consumers. Regardless of whether customers use a V2G charger at home or not, it is clearly still a barrier for the general uptake of EVs. In 2022, however, the UK Government has pledged significant capital investment into slow, fast, and rapid chargepoint infrastructure[4].

Maximising V2G savings became more of a challenge during the trial

Although environmental benefits were the key incentive for the final set of trialists, customers did also express their interest in the financial benefits V2G offers.

Overall, we know that 74% of customers were satisfied with the financial incentives of the Powerloop trial. However, Figure 31 shows that in the final survey, customers ranked 'maximising V2G savings' as a large challenge. This opinion differed from the first survey when customers expected financial challenges to be comparatively minor in relation to others.

The technical difficulties experienced by customers did impact their ability to use the service, and therefore maximise the savings promised in the original incentive.

Some customers may have also become more conscious of maximising savings due to the initial costs of having the technology integrated into their homes.

Customers found it difficult to manage the discharging function

Over 50% customers found it difficult to manage the discharging function of their V2G system, as shown in Figure 32. This could be due to the combination of technical issues faced by many customers along with the difficulties some had using the Powerloop app. As a result of the technical issues, Octopus Electric Vehicles prioritised the charging function over the discharging function.

Figure 32: **Customers' opinions on how easy it was to manage the charge and discharge function of their V2G system**

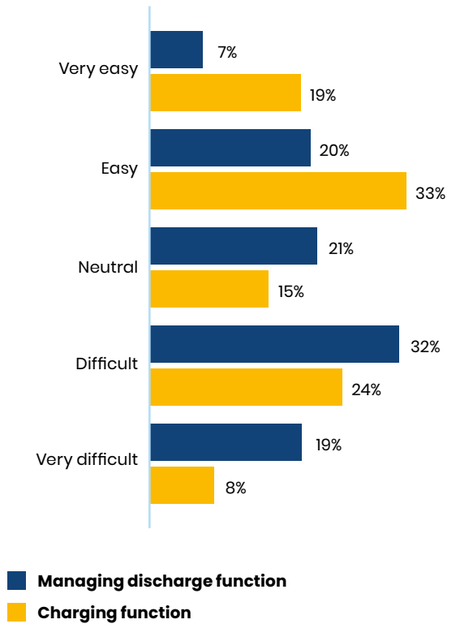
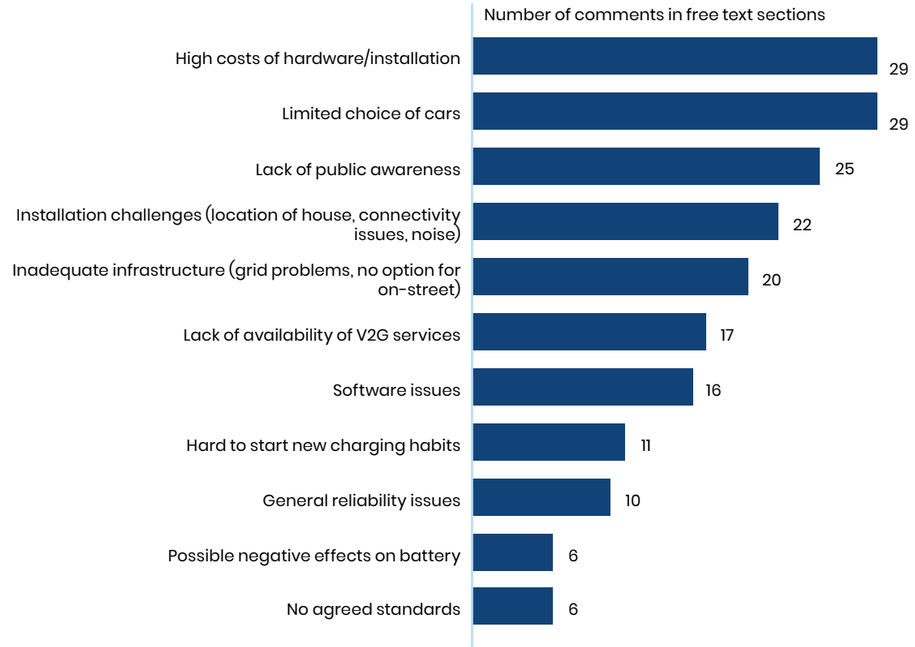


Figure 33: **Barriers to the uptake of V2G in the UK referred to most in the free text sections**



4 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1009448/decarbonising-transport-a-better-greener-britain.pdf

"I installed a new driveway to enable use of the charger, entered into an onerous car leasing agreement, spent extra on my house insurance to cover the charger, purchased an additional wifi extender to try to get the Wallbox to work, all in good faith. I do not feel that the good faith has been repaid."
Powerloop customer

Customers believed that high costs would be the main barrier for V2G charging uptake in the UK

Customers believe that high costs associated with V2G will be the biggest barrier for uptake in the UK, as shown in Figure 33. Some customers, as shown below, were concerned the financial reward wouldn't be sufficient once the trial offering was finished.

These concerns were raised by customers despite the trial being heavily subsidised, indicating that significant incentives and subsidies will be needed during early adoption while costs of implementing V2G are high.

"While helping the grid is a priority I need to be able to make the most financial benefit from the program, especially in the future if the other incentives were gone."
Powerloop Customer

Comparably, customers seemed to believe that technical issues would be less of a problem for the uptake of V2G in the future, indicating that they know the current technology is in a state of development and believe in its further advancement.

Customers felt that lack of vehicle choice will restrict V2G

We had mixed feedback regarding the experience customers had with their Nissan Leaf. This was partly due to the vehicle battery size and range, but also due to the limitations of a CHAdeMO charger. Overall, consumers believed that it is crucial to diversify the availability of V2G-compatible cars to make the technology future-proof. This is an understandable perception since the UK has not widely adopted CHAdeMO charging technology, however, at the time it was the only available option for the trial.

Lack of public awareness is seen as a major barrier for the uptake of V2G in the UK

Due to the early stage of development for domestic and commercial V2G, many consumers know little about it. In our first survey of customers interested in taking part in the trial, 72% had either no previous knowledge, or very little, of V2G. Establishing public awareness about the existence and functionality of V2G is crucial to a successful implementation. This will come through the development of new vehicle models with V2G capability, as well as through other V2G market stakeholders like energy providers.

"No one even knows about it (V2G)!"
Powerloop Customer

07

Conclusion and best practice recommendations

We developed several recommendations for V2G product and service developers after assessing the qualitative data on customers' driving and charging behaviours, and perceptions of the V2G service.

These recommendations are intended to guide industry to develop services that meet the needs of future users of V2G.

The environmental benefit of V2G is an attractive offer for many early adopters of the technology, alongside the financial benefit

For this cohort of trialists, it was the concept of supporting the development of a green technology that benefited the environment, that incentivised them the most. However, it is safe to say that financial savings will also act as a key incentive for many customers.

The financial savings element was not only a close second for customers on the trial, but also the biggest incentive for the wider 2,500 customers that engaged with the initial Powerloop marketing.

Awareness of these incentives could help service developers target future customers and rapid chargepoint infrastructure.

The largest consideration for developers is to ensure that their technology is reliable before hitting the market

The largest challenge customers faced was around the performance and reliability of their V2G system. This point was the most frequent issue raised in the free text section as well as being ranked the largest challenge in other survey questions. Comments suggested customers lost trust in the app due to unreliable information being presented.

"At times it [the Powerloop app] fails to detect the vehicle, I spend a lot of time resetting the Quasar, the apps etc. with no real idea how it eventually decides to start working again. I don't trust it to charge the car overnight."
Powerloop customer

"The system needs to be more reliable so users can trust their vehicle will be available when needed."
Powerloop customer

Sufficient internet connectivity is essential for a V2G system

Many of the software and hardware issues arose from poor internet connection between the V2G system and the customers' homes. Technology developers should look to use a reliable and fast internet connection, such as Ethernet, as opposed to WiFi. Although there are some additional considerations during installation such as cable routing, the benefits of a stable connection would outweigh the issues that impacted many of the trialists.

Control and flexibility in charging and discharging was key for customers, but preferences varied, and future services should accommodate that

We had numerous comments regarding a lack of flexibility around V2G functionality and customers struggling to effectively discharge their vehicle via the dashboard and app. Customers seemed to want more control to discharge their vehicle to off-set their home energy demand, but also needed confidence the vehicle will be sufficiently charged. This will require a fit-for-purpose scheduling engine that allows customers to have this flexibility and control.

"I want to be able to set charge and discharge times throughout the day and make the most use of the battery."
Powerloop customer

While some customers did want more control, others noted that the technology was too complex to effectively manage, and wished the service was presented with a simpler interface. This is likely due to customers needing two apps to control the trial system. This shows developers that customers want to be able to optimise the level of control and information they have with their system, to meet their own specific needs.

"Simplification and less intervention from the customer. Way too much for the average consumer to think about. Different tariff vs. the incentive scheme. Different apps to use. How to optimise for the time of day and when to plug in and when not to."
Powerloop customer

Customers need informative resources to help them understand both the app, the system, and their tariff.

The surveys showed that some customers were unhappy with the amount of data that was provided via the Powerloop app as well as with the type of data that was available. Some customers requested more general information and updates about the trial. Future developers should consider that not all customers will want or need this additional information, so it should be presented with optional detail. Suggestions from customers for information resources included:

- YouTube video tutorials.
- V2G customer forum to link experienced and new users.
- More detail within the app explaining terminology and data sets.
- More notifications from the app, including status and failure updates.
- More details about charging/discharging sessions, including kWh sent to the grid, historical data, and financial savings.

Both the customers in the trial and Octopus Electric Vehicles called for a one-app solution

The design of the V2G system meant that it was necessary to have two separate apps for the technology. One app was to configure the Wallbox charger, and the other to operate the V2G functionality.

Having the system spread across multiple apps made the system more susceptible to software issues that were difficult to diagnose. Although this can also happen with one app, having multiple interfaces increase the chance of failure, while reducing the chance of diagnosis.

Having two apps also led to confusion with numerous customers calling for a single app in the free text sections.

"I would like to see less apps much as I love my tech I have now got 10 + apps for the car alone not all for the V2G but we need less not more apps. Older generations will not use this if it is too difficult ideally it needs a smart hub so in the future all this is easily controllable." **Powerloop customer**

"I'd rather not have two apps competing with each other."
Powerloop customer

After discussions with the Powerloop team at Octopus, it became clear that by having just one app several issues encountered by customers would be alleviated.

Customers wanted more choice of vehicle and charger

There were several comments suggesting that some customers would have been happier with a vehicle with more range and space. Customers also requested that their charger was more universal, such as using Combined Charging System (CCS) and Type-2 technologies. Currently, in the UK market, CHAdeMO charging is limited to a few Japanese manufacturers. It is important to note that it is highly likely that future technologies will include, or be replaced by, CCS and Type-2, and that CHAdeMO was the only option for the trial at the time.

Effective customer support is essential for the adoption of V2G technology

Many customers had system issues and required technical customer support. Even though these issues caused some customers to be unable to use their system for prolonged periods of time, 87% of those who answered the final survey, would still recommend the technology to others. This will partly be due to the expertise of the Powerloop support team, who had the ability to diagnose issues around the charger hardware, smart meters or tariffs, and the vehicle itself. Having a team that understands each element of the system can lead to easier diagnosis, rather than separate support teams.

Services should use range as a metric for minimum post-V2G-charge thresholds, not battery percentage

When customers are choosing their minimum charge thresholds after a V2G session, service providers should consider using minimum range as the metric, not battery percentage.

The surveys suggested that when customers use battery percentage as the metric, they claim they require more energy compared to when using mileage as the metric. Multiplying this difference in energy across many vehicles could mean a significant difference in potential capacity and flexibility storage. When services are estimating conversion between battery percentage and mileage it is crucial that driving style and weather conditions are considered to avoid unreliable estimations.

Some of the concerns for V2G are linked to using an EV, so services should look to support customers with their adoption of EVs where possible

When customers identified the challenges of using the service, many were commenting on the typical use of EVs, such as range anxiety and reliance on public chargepoints.

Future V2G service providers should therefore also consider offering broader support for the adoption of EVs, such as public chargepoint mapping, route planning, and driving style advice to increase range.

Customers were initially concerned about changing their routine, but this was not the reality, so services should highlight this point during customer engagement to reduce their concerns

One of the key trends identified in all the surveys was the change in perception around customers adopting the V2G service into their travel and charging routine.

In the first survey, this was seen as the largest potential challenge for customers. However, when the customers were asked again at the end of the service, they ranked it the third lowest challenge and mostly felt that the vehicle was ready when they needed it. This indicates that besides their concerns, they quickly got used to the new V2G technology and charging routine.

Service providers can use that knowledge to address future customers' concerns right from the beginning and reassure them about the fact that using a V2G service is not as intrusive as expected.

It is also important to express the possibility that COVID-19 restrictions and changes in working patterns meant that V2G services were easier to use during the trial period, as more people were home-based.

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