Influence of trial experience with V2G on consumer acceptance of EV drivers in the Netherlands

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Influence of trial experience with V2G on consumer acceptance of EV drivers in the Netherlands

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by

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Acknowledgements

Hereby, I confidently present the reader my Master thesis report titled *"Influence of Trial Experience with V2G on consumer acceptance of EV drivers in the Netherlands"*. This thesis project, as part of the MSc programme *Management of Technology* at TU Delft, finalises my degree and my time (for now) as a student. Throughout the programme, I have gained valuable knowledge and useful skills that I could apply to my thesis project and will use in my future endeavours. While I flew through courses as part of the master's programme, the thesis challenged me in different ways than I had experienced before. Learning to both conduct research independently and perform qualitative research was challenging given the unfortunate circumstances of 2021, for it is challenging for students to perform a large project in physical separation from peers. Yet, building on existing knowledge of quantitative research and (multidisciplinary) project work, enhancing my skillset this way while refreshing my English writing and project management skills was incredibly valuable.

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Koen Nijssen

Amsterdam, 30 December 2021

Summary

Background

This thesis aims to understand how trial experience with V2G influences consumer acceptance of EV drivers in the Netherlands. In the Netherlands, a big move towards electrification has been underway for decades, including moving from fossil-fuelled vehicles to electric vehicles (EVs). Meanwhile, the share and quantity of renewable energy in the Dutch energy mix is increasing. Renewables are often intermittent, and together with the large demand from a growing EV-fleet, grid capacity issues arise. The introduction of V2G may alleviate this problem. V2G allows for bi-directional flows of energy when connected to a DC charger. With V2G, EVs are not only vehicles but also large mobile battery packs that can support the grid through peak shaving and grid balancing, as well as store excess energy from renewables as a buffer for times of lower production. There are many business models and use cases imaginable for V2G but focussing on consumer acceptance is vital for widespread adoption of V2G. One of those use cases is using V2G for your daily commute and routine, which encompasses a majority of the trips made by personal cars in the Netherlands.

Research gap, objective, and question

The exploratory literature review revealed that preceding research on V2G has mainly focussed on the technical and socio-economic properties of V2G. Most of these studies used surveys, choice experiments or expert interviews, which often fail to provide the underlying or deeper opinions and understandings of the consumer. Literature meanwhile revealed the importance of considering consumer acceptance, both in relation to V2G or technology acceptance in general. While there are some studies considering social acceptance or consumer preferences regarding V2G, focussing on contract types or factors influencing their acceptance, such as barriers and opportunities, no scientific literature has been found which considers trial experience of V2G in relation to consumer acceptance. Previous research stresses the importance of considering experience in regard to acceptance or changes in behaviour.

The objective of this research, then, is to fill this knowledge gap and determine how trial experience of V2G influences consumer acceptance of EV drivers in the Netherlands. By first reviewing literature on factors influencing consumer acceptance of V2G and developing a conceptual model based on the technology acceptance model "Unified Theory of Acceptance and Use of Technology" (UTAUT), the goal of this thesis is answering the main research question of:

"How is consumer acceptance of vehicle-to-grid by EV drivers in the Netherlands influenced by trial experience of the technology?"

Methodology, literature, and theory

Due to the explorative nature of this research, a qualitative research approach was selected which consisted of using two different methods at subsequent times. The first method of data collection comes from conducting semi-structured interviews and subsequent data reduction and analysis using coding. Semi-structured interviews were chosen as the primary qualitative research method as previous literature on consumer acceptance was heavily reliant on surveys, choice experiments and expert interviews, which may not reveal hidden or deeper insights of the research subjects. 17 semi-structured interviews were conducted in which all participants were employee or students at TU Delft, live within a 70km radius and have experience with EVs. Participants were

asked to drive a Nissan Leaf with bidirectional DC charging capabilities required for V2G for a week as part of their normal routines. As the participants had to park and charge the car at the V2G trial setup in the GreenVillage near TU Delft, they would connect the Leaf to the V2G station for charging for at least three working days. Apart from this and other small requirements described in the trial setup in chapter 2, participants were allowed to use the Leaf for personal use.

The second method of data collection comes from the literature review. A literature review is performed to determine the state-of-the-art in V2G research, focussing on the factors influencing consumer acceptance found in other literature and listing the benefits and challenges of V2G such as considering consumer acceptance. Here, the research gap is also specified in further detail, and the reader is referred to chapter 3 for further insights.

Different technology acceptance models are considered and the Universal Theory of Acceptance and Use of Technology (UTAUT) from Venkatesh et al. (2003) was chosen and served as the guiding structure for the creation of a conceptual model. Given the objective of the research is to assess the influence of trial experience with V2G on consumer acceptance of EV drivers in the Netherlands, the UTAUT model was adopted by adding the determinant of *Trial Experience*. The UTAUT is a suitable model overall as it combines the determinants of many acceptance models but may lack the capacity to explicitly assess the influence of (trial) experience, unlike for example the Theory of Planned Behaviour.

The literature review generated an initial list of factors influencing consumer acceptance of V2G technology. Together, these initial factors formed the initial codebook. Codes were categorized per determinant from the conceptual model in table 3, where determinants *Performance Expectancy, Effort Expectancy, Social Influence* and *Facilitating Conditions* functioned as code categories, in addition to the added *Trial Experience* determinant.

Interview questions are generated based on the factors in this conceptual model and aimed to determine what the effect of trial experience with V2G is through the lens of these factors. As a result, it is also assessed whether these factors from previous research are valid and comprehensive in this trial set up, and whether the UTAUT is a suitable model to assess trial experience in relation to acceptance.

Results and discussion

After all interviews were conducted and analysed, the investigation revealed 74 codes across eight code categories. In addition to the four original UTAUT determinants and the added determinant of *Trial Experience*, code categories of *Driver Profile Characteristics, Mediating Variables* (Consisting of Gender, Age, Experience (familiarity) and Voluntariness of Use, as per the original UTAUT model) and *Other* were added to categorise specific types of additional data from the interview analysis. For example, mentions of participant's (lack of) interest into V2G help with assessing the conditions for which trial experience influences consumer acceptance.

A list of top-20 codes was composed to share the most mentioned statements and topics of discussion. Part of the codes contains conceptualized factors based on statements from participants mentioned in relation to their consumer acceptance, such as barriers, risks and benefits. The other part of the codes contains statements not directly related to consumer acceptance. Top codes are described impressionistically to provide a clear understanding of the statements included in the short code name and what subtle distinctions are important to discuss. Special focus was put on the

analysis of trial experience of V2G influencing the acceptance of the participants. Analysing the codes allowed for the creation of a list of factors on consumer acceptance of V2G. The resulting theoretical model, with the factors and the influence of trial experience on these factors, is shown in figure 1.

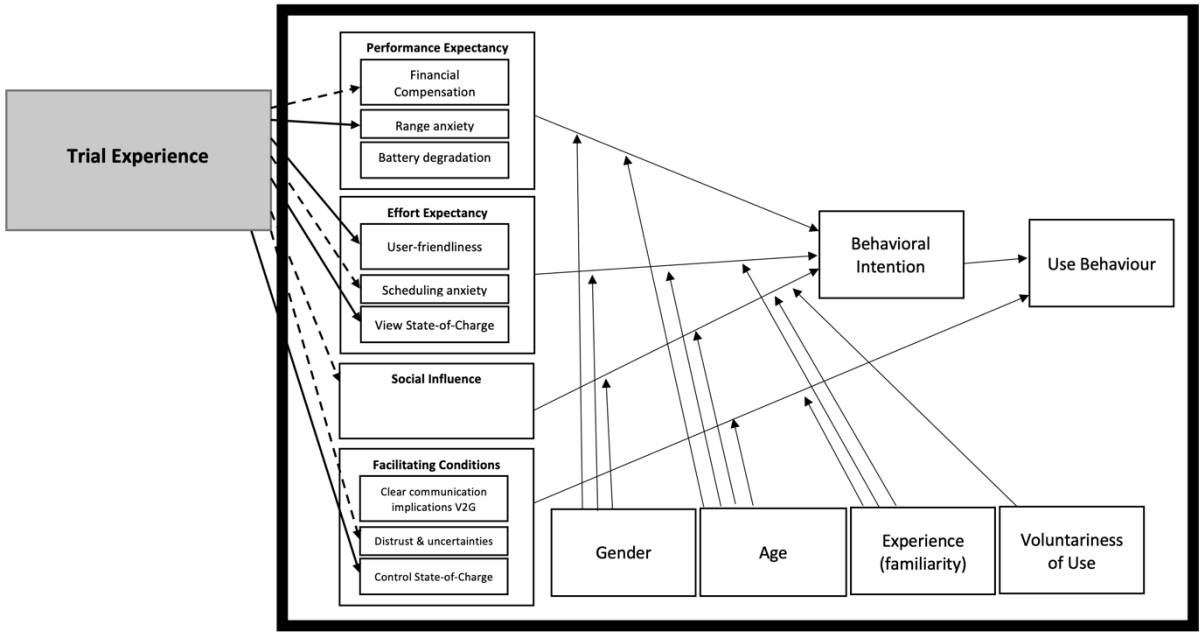

Figure 1: Resulting conceptual model of trial relationship in relation to V2G acceptance

Factors related to *Performance Expectancy* in the conceptual model were *Financial Compensation*, *Range Anxiety,* and *Battery degradation.* Factors related to *Effort Expectancy* were *User-friendliness, Scheduling Anxiety,* and *View State-of-Charge.* The determinant of *Social Influence* was determined to not have any significant factors related to consumer acceptance, but there is still some influence of trial experience present. *Facilitating conditions* factors were *Clear communication implications V2G, Distrust and uncertainties,* and *control state-of-charge.*

Investigation of the interviews revealed that the participants were split in their opinion towards V2G technology before partaking in the trial. Though nobody was initially pessimistic, some participants were sceptical of the technical feasibility of V2G or the benefit V2G would provide to them as a potential consumer. In other words, they had initial beliefs. After participating and gaining trial experience of V2G, most sceptics became optimists too, though often with reservations.

It was discovered that trial experience does not influence each factor regarding consumer acceptance, and that the factors that are influenced differ in the level of change. In the resulting model in figure 1, arrows are drawn to the factors that are influenced by trial experience, with the dotted line representing a slight or inconsistent influence. Trial experience directly influences how participants experience range anxiety, as they will match their attitude towards the technology's behaviour after trial experience. Trial experience therefore decreased range anxiety in the sample, however, those with much experience or knowledge (*Familiarity)* of EVs or V2G would experience less strong of a decrease in range anxiety.

A critical condition for acceptance is financial compensation, though participants differ as to whether this compensation should cover the costs for battery degradation only or also for the

inconvenience of having a flexible SOC. Results show that trial experience generally does not change the participants' attitude towards financial compensation. Similarly, trial experience does not change the attitude towards battery degradation itself, which is part of the necessity for financial compensation. Not until the interview is conducted is when the participants knew about such issues, which is a recommendation for future research. Participants frequently state that education will assist with adoption, for the simple reason that most people are unaware of V2G and its implications such as battery degradation.

Under *Effort Expectancy*, trial experience influences the attitude of the sample with regards to user-friendliness to a certain extend. Most participants found the V2G station easier to use than expected, while participants generally state that due to their experience, they have thought of ways to improve user-friendliness, for example through an app. This allows them to view the current state-of-charge, which after trial experience is found to be a minimal necessity for the sample's acceptance. Though many in the sample were aware of potential range anxiety related to EVs and V2G in particular, trial experience made participants aware of scheduling anxiety due to V2G discharging.

No specific factors on *Social Influence* were determined, yet trial experience did affect the *social influence* determinant slightly. For example, half of the participants mentioned that due to their experience, they became aware of their electricity use or became interested in other use cases of V2G or similar solutions. Under *Facilitating Conditions,* clear communication of the implications of V2G was considered by the participants for their, but more notably, other's adoption of V2G. Similar to education, clear communication of the implications of using V2G may push people towards adoption, but trial experience only makes them aware of this need. Experiencing V2G influences the attitude of participants regarding distrust and uncertainties, where participants provided more statements of distrust and uncertainties when the car or V2G system did not behave as expected.

Overall, interviewees stressed that having the possibility to control the state-of-charge in of your EV is a critical condition for their acceptance of V2G. Participants state that thanks to trial experience, they became aware that having control over the SOC decreases or eliminates both range and scheduling anxiety. Some participants listed these two conditions before their trial experience, while after trial experience all participants who noticed a discharging event and most others who did not also set these conditions as critical for acceptance.

The mediating determinant of *familiarity* decreases the influence of trial experience, as for participants who mentioned knowledge and/or interest into V2G technology showed little change in attitude towards aspects of V2G technology before and after trial experience. Drawing conclusions regarding *voluntariness in use* if difficult, as each participant contributed voluntarily. However, participants who were sceptical of the potential and necessity of V2G (or EVs in general) generally did not show changes in attitude. No conclusions can be drawn regarding *gender* differences, and regarding *age* data shows that the only participants for which trial experience did not improve their attitude towards V2G were above 35, but this may also be a result of greater experience with cars.

In addition to the factors found and categorized in the conceptual model, participants mentioned many ideas, views and other opinions related to V2G. They suggested other use cases for V2G, potential improvements, and acknowledged the system benefits of V2G, such as grid stabilization and energy storage capacity.

The analysis of the qualitative data first focussed on the representativeness of the sample in relation to the population of EV drivers in the Netherlands. The sample consisted of 17 people of which a majority was young to middle aged, highly educated and male. The majority of participants had experience driving EVs in some form, while two participants owned their EV. This is different from samples in similar research, where the participants leased or owned their EVs more often or where the sample had a more universal population with respect to age and gender. Yet, as the population of EV drivers in the Netherlands is on average male, middle aged and highly educated according to statistics on Dutch EV drivers, the sample can be considered quite representative.

Conclusion and recommendations

In short, it was found that trial experience with V2G influences consumer acceptance only in certain ways and is often mediated by different variables. Using factors determined from literature and the UTAUT acceptance model to conceptualize a model on the relations between these factors on consumer acceptance, results from the interview data reduction and analysis allowed for conclusions and comparisons to be drawn. Trial experience influences consumer acceptance most significantly by changing participant's attitudes towards the factors of range anxiety and (desired) user-friendliness. Participants also became aware they find viewing or controlling the state-of-charge to be a vital barrier for adoption, which could take away scheduling anxiety and other uncertainties as a result. High *Experience (familiarity)* generally decreases the influence of trial experience, while conclusions for *Gender*, *Age* and *Voluntariness* of Use are hard to draw.

In comparison to other research, many of the factors explaining consumer acceptance found in literature overlapped with the ones found in the analysis of the interview data reduction. This confirms their relevance in consumer acceptance research, though not all factors found in literature were retrieved in the analysis. Previous research stated the importance of considering consumer aspects for V2G adoption and trial experience in relation to attitude changes, and this research re-affirmed these conclusions. Future research should focus on similar trial experiences in different case settings, such for work environments or in other countries, and policy makers and researchers alike would benefit from comparing the influence of trial experience with education.

Keywords

Vehicle-to-grid, V2G, trial experience, consumer acceptance, Dutch EV drivers, Unified Theory of Acceptance and Use of Technology.

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Acronyms

A	Age
AC	Alternating Current
AM	Acceptance Metrics
BEV	Battery Electric Vehicle
BI	Behavioural Intention
DC	Direct Current
DPC	Driver Profile Characteristics
E	Experience
EE	Effort Expectancy
EV	Electric Vehicle
FC	Facilitating Conditions
G	Gender
ICE	Internal Combustion Engine
IDT	Innovation Diffusion Theory
PE	Performance Expectancy
PHEV	Plug-in Hybrid Electric Vehicle
RES	Renewable Energy Sources
SCT	Social Cognitive Theory
SI	Social Influence
SOC	State-of-Charge
TAM	Technology Acceptance Model
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
UB	Use Behaviour
UTAUT	Unified Theory of Acceptance and Use of Technology
V	Voluntariness of Use
V2G	Vehicle-to-Grid

1. Introduction

1.1. Background

1.1.1. Urgent electrical grid issues in the Netherlands

In the Netherlands, a big move towards electrification has been underway for the last decades. Laws have been established requiring new homes to be powered by electricity with no gas connection allowed, but the personal vehicle too is more frequently powered by electricity than fossil fuels. Conventional internal combustion engine (ICE) powered cars have dominated the automobile industry for decades, but due to rapid technological advancements in battery and electric drivetrain technologies, many of the drawbacks of electric vehicles (EVs) as compared to ICE vehicles, such as limited range and high purchase costs, are now being alleviated. EVs make up 3.73% of all personal vehicles in August 2021, compared to 1.33% five years earlier (Nederland Elektrisch, 2021). In fact, from 2035 only zero- and low-emission vehicles can be sold in the EU, which should result in a further increase to the share and number of EVs. (European Commission, 2021)

Meanwhile, the generation of renewable energy sources (RES) have been growing steadily in the Netherlands. In 2020, 11.1 percent of all energy use in the Netherlands came from renewables, largely thanks due to the generation capacity of wind and solar energy (CBS, 2021a). In 2019, this was only 8.8 percent. Meanwhile, total electricity production has risen by 6 percent in the first quarter of 2021 as compared to 2020 (CBS, 2021b), which is in line with the electrification of the country. RES are, despite its environmental benefits, often intermittent in nature and a stable renewable-intensive grid would require storing excess energy in times of abundant supply and the opposite on a cloudy windless day.

Despite the many benefits of EVs, such as the absence of tank-to-wheel emissions and related local health benefits, EVs have numerous drawbacks too such as the large energy demand. One EV can use up to three times as much energy as one house, and with energy companies already having to cancel new connections in 2021 due to grid capacity limits such as in Amsterdam(van de Weijer, 2021), the potential to grow the EV-fleet seems limited. EVs are usually unnecessarily charged as fast as possible, after which the vehicle and the energy inside its large battery pack sit idle. Vehicle-to-grid, or V2G, could be a promising answer to the issues presented by greater electrical power demand, a limited power grid and the intermittent supply of RES.

1.1.2. Potential solution: Vehicle-to-grid

With vehicle-to-grid, EVs are not simply considered to be a vehicle with an electric drivetrain but also as a large mobile battery pack to supply or withdraw electrical energy when deemed necessary by the grid operators. Vehicle-to-grid can be considered a local solution, having the potential to tackle grid and power issues locally and therefore potentially decreasing the amount of regional or national infrastructure investments, by using solar or wind energy generated in the close vicinity. However, widespread adoption of V2G may also alleviate power issues on a regional or national scale.

The solution of automated demand response for EVs has been studied extensively under the terms of grid-to-vehicle (G2V), V2X, V2H, vehicle-grid integration, etcetera, but V2G can be considered as

an umbrella term for the bi-directional flow of energy between an EV and an electrical system. In this study, V2G is therefore defined as “A system whereby plug-in electric vehicles, when connected to electric vehicle supply equipment (EVSE) can provide bi-directional flows of energy.” (MacLeod & Cox, 2018). Figure 2 shows a visual schematic a V2G setup, in which a V2G enabled EV, a V2G charge and discharge station, and the grid are shown in connection to each other. Research, as is summarized in the literature review, has established that V2G has many potential use cases: grid power balancing, back-up power, energy trading, etc. Such use cases have the potential to generate new business opportunities or benefits for a variety of stakeholders, including EV owners or drivers and corporations boasting EV fleets. “EVs can provide ancillary services to the grid such as voltage and frequency regulation, peak power leveraging and reactive power support to enhance the operational efficiency, secure the electric grid and reduce power system operating cost.” (Mwasilu, 2014)

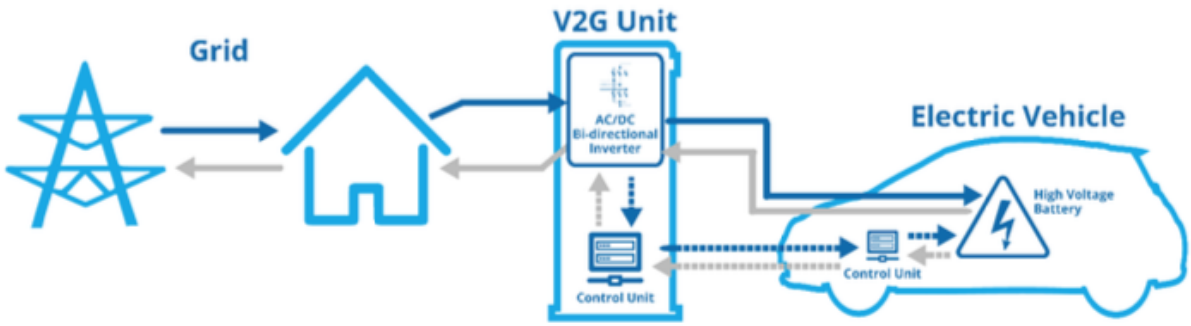


Figure 2: Visual representation of V2G System (MacLeod & Cox, 2018)

1.1.3. Vehicle-to-grid for everyday use

As mentioned, the vehicle-to-X connection can take many forms. Even simply V2G, the connection between the vehicle and electricity grid, has many potential use cases. Suitability and feasibility of V2G is dependent on many technical, social, and economical developments. Evidently, long-term parking, such as at airports, are valuable use cases for V2G due to the high plug-in durations, large volume of parked EVs and the relatively predictable parking patterns (Payne, 2019). Previous research found that people using V2G for long-term parking have high acceptance albeit the conditions of compensation for battery degradation and no additional discomfort are met. (van Heuveln et al., 2021)

A little researched, yet potentially highly valuable use case is V2G for everyday use. Everyday use consists of mainly short-term parking of under 48 hours. These short-term parking situations are so potentially valuable as they are very common amongst potential consumers, parking their owned or leased EV at office buildings, shopping centres, sports clubs or around their home. While V2G at large scale long-term parking use the idle battery capacity of an EV most efficiently, a vast majority of parking sessions is short term and therefore carries a lot of potential for both system benefits and potential consumer benefits. The single trial experiment found which involves experience suggested that users find sufficient driving energy a key factor in influencing V2G value. (Cenex UK, 2021)

1.1.4. The significance of consumer acceptance for vehicle-to-grid diffusion

The concept of vehicle-to-grid, or sometimes called vehicle grid integration, is not new. Already in 1997, Kempton and Letendre opted the idea of using electric vehicle batteries for storage

of excess energy and to deliver energy back when necessary. (Kempton & Letendre, 1997). From here on, preceding research on V2G has mainly focussed on the technical and socio-economic properties of V2G. Lund and Kempton's for example "designed a suitable modelling of electric vehicles with three types of controls, in order to conduct detailed hour by hour overall system analyses of the impact of V2G on national energy systems". (Lund & Kempton, 2008). As the technology moved from a theoretical concept to an experimental concept, more specific studies using specific target groups or using particular methodologies emerged.

While technical opportunities and limitations, as well as advantages and disadvantages towards both consumer and supporting technologies such as the grid and EVs themselves have been discussed in previous research, the perception of customers towards vehicle-to-grid requires further insights (Sovacool, Noel, et al., 2018). In this research, the definition of consumer acceptance was adapted from Huijts et al. (2012): "the public's behavioural responses to the availability of technological innovations, that is, the purchase and use of such products" to be "the behavioural responses of EV drivers in the Netherlands to the availability of V2G, that is, the purchase and use of V2G as part of their daily routines."

1.2. Research gap

As part of this research, an extensive literature was conducted to establish the current knowledge of V2G research with respect to consumer acceptance. This literature review, found in section 3.1, also helped determine the underexamined parts in the current knowledge which led to the research gap. The research gap was found that there are no studies considering the influence of trial experience with V2G on relation to consumer acceptance. Comparable studies on the influence of trial experience on similar technologies has been conducted, and the connection between attitude changes and behaviour or (trial) experience has been established. (Huijts et al., 2012; Hülsmann & Fornahl, 2014; van Wee et al., 2019). Additionally, many research articles suggest social dimensions on V2G acceptance are under researched.

1.3. Research objective and approach

The objective of this research is to fill the knowledge gap of assessing the influence of trial experience with V2G on consumer acceptance of specifically EV drivers in the Netherlands. In other words, it is determined how EV drivers in the Netherlands react differently to automated demand response of V2G after trial experience than before.

Where previous research on consumer acceptance of V2G largely focused on the perception of car drivers in general, discussed expert opinions or looked for the responses in (stated) choice experiments, little has been discovered on the deeper insights of EV drivers as a comparison between before and after experiencing V2G. Therefore, this research will follow a qualitative format, using semi-structured interviews to assess the influence on certain factors that EV drivers find important to adoption. These factors are to be discovered in the literature review. The Universal Theory of Acceptance and Use of Technology (UTAUT) is used as a theoretical lens to create a conceptual model of trial experience in relation to consumer acceptance.

1.4. Research questions

The main research question is then derived from the research gap mentioned in section 1.2 and the resulting research objective in section 1.3. Since answering the main research question requires several aspects to be discovered beforehand, several sub-research questions are developed. Each sub-questioned is answered using different methods, as is described in section 2. The conclusions to these sub-research questions build towards answering the main research question and in turn satisfy the research objective. The research questions are shown in table 1.

Table 1: (Sub-)Research Questions

Research Question:	
"How is consumer acceptance of vehicle-to-grid by EV drivers in the Netherlands influenced by trial experience of the technology?"	
Sub-question #	**Sub-research question:**
1	"What are the factors influencing consumer acceptance of vehicle-to-grid by EV drivers in the Netherlands?"
2	"Which theoretical model (and what aspects of it) can be used to determine consumer acceptance of automated demand response?"
3	"How does trial experience of using vehicle-to-grid change consumer acceptance of the technology with respect to determined factors?"

1.5. Scope of the study

This thesis focussed on determining influence of weekly trial experience with V2G technology on the consumer acceptance of EV drivers in the Netherlands specifically. The individual participant of the research was decided to be the point of view to assess the acceptance. The setting was as such that the participants were asked to drive and charge the V2G-enabled Nissan Leaf for at least three days of a given workweek, with the additional characteristics explained in the methodology of chapter 3. This *short-term* type of parking was chosen as it is common travel behaviour of commuters, which account for a big share of trips made on Dutch roads every day. The participant's consistent and predictable travel behaviour, and related connection times to the charger, allow for interesting conclusions both in this research and as a stepping stone for further research. To the best knowledge of the writer, assessing the influence of multiple short-term charging (and related driving and parking) experiences in a weekly period in a qualitative manner, was not a focal point of research before. As a geographical scope, the Netherlands was used due to its relatively high EV and charger maturity and density in Europe, imminent issues arising from challenges related directly and indirectly related to increased EV uptake, and the necessity and interest to research and invest in technologies such as V2G.

2. Methods

This chapter presents the selected methods to perform meet the research objective, which is explorative in nature. Therefore, a combination of a thorough literature review and semi-structured interviews were chosen. The research is structured in a stepwise manner using the sub research questions, as is described and visualized in section 2.1 on the research flow diagram. Subsequent sections 2.2 through 2.4 focus on the choice and implication of the methods chosen. Section 2.2 emphasises the semi-structured interviews, section 2.3 the analysis thereof, while 2.4 highlights the methodology of the literature review, leading up to chapter 3 on literature and theory.

2.1. Research Flow Diagram

To conduct this research in a structured manner, a research flow diagram was created. The research flow diagram, as shown in figure 3, is structured by phases. In each phase, the data and theoretical input required are listed along with the outcomes of each phase. From phase 1, each stage of the research builds towards the next and builds towards answering the main research question. The diagram offers a quick overview for the reader to understand the flow of the research and the integration of the different methods to answer the research question.

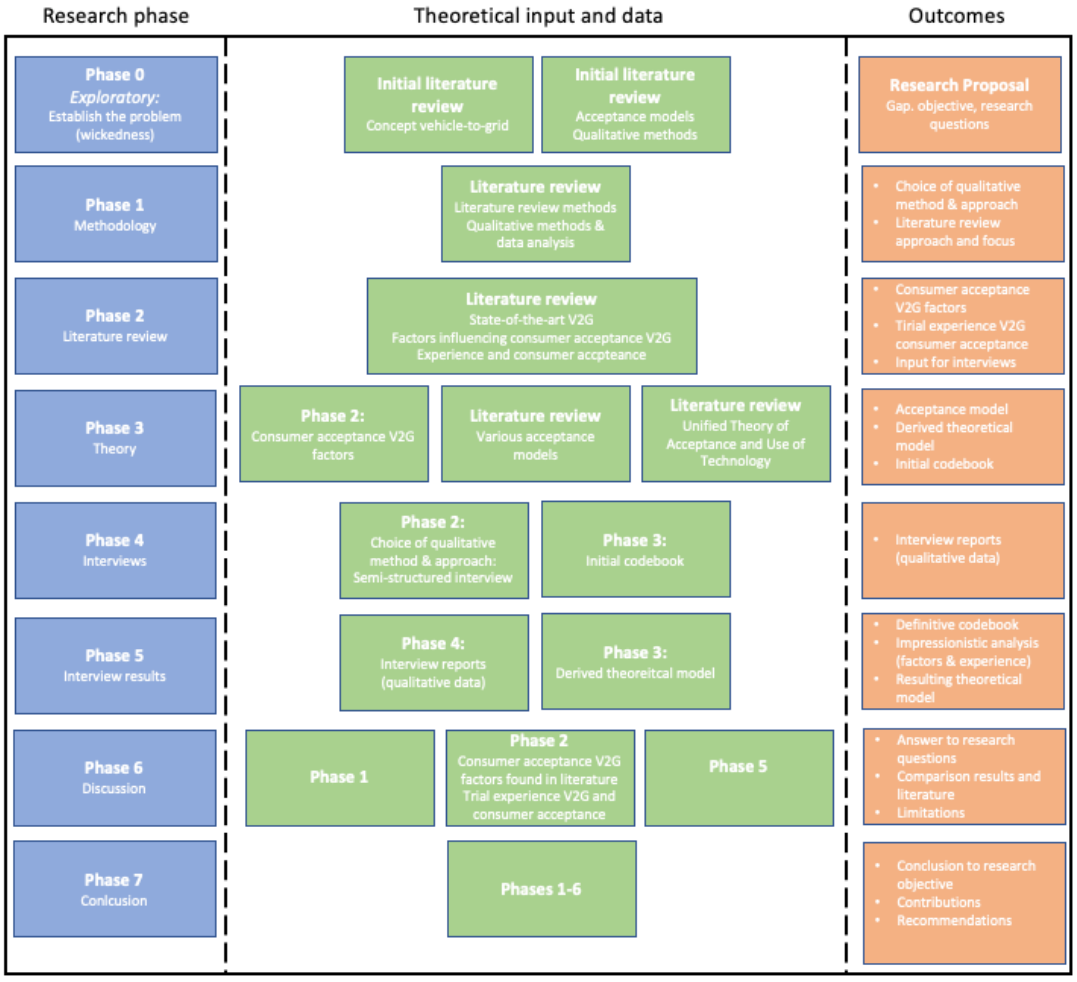


Figure 3: Research Flow Diagram

2.2. Qualitative Research: Semi-structured interviews

In this section, the semi-structured interview methods are explained. Previous studies on consumer acceptance of V2G heavily relied on surveys, choice experiments, and expert interviews. Many review studies on different facets of V2G were also available, though consumer acceptance of V2G or, in more general terms, social aspects related to V2G adoption, were mentioned more often in the suggested future research than in reviewed findings. Surveys and choice experiments, though requiring little time and financial means, do not deliver a full understanding of the attitudes, views, and opinions of the research participant. Expert interviews meanwhile offered very detailed insights thanks to the experts' knowledge of the subject but may be prone to bias as their views may not reflect those of potential consumers.

The lack of research relating trial experience of V2G to consumer acceptance allows for an exploratory type of research. Interviews are an excellent way to rather data in exploratory research. In general, there are three types of interviews, structured, unstructured, and semi-structured. The goal of unstructured interviews is to explore several elements that may not have come to light through the literature research and TAM analysis but might be key to the broad problem area. Unstructured interviews are named as such because the interviewer does not enter the interview with a planned set of questions. During structured interviews, the interviewer does know on the outset what information is need, and therefore the goal is finding qualitative data that can be analysed and used to compare or describe certain phenomena. (Serakan & Bougie, 2016) The goal of semi-structured interviews is to gather both generalizable and detailed insights into how V2G is perceived after experience. Semi-structured interviews combine the benefits of both structured and unstructured interviews. Semi-structured in-depth interviews are the most widely used interviewing format for qualitative research, take between 30 minutes and several hours to complete and often are the sole data source for a qualitative research project. This type of interview allows the interviewer to delve deeply into social and personal matters (DiCicco-Bloom & Crabtree, 2006).

The interview process is structured as follows. First, based on the findings in literature and the incorporation of these findings into the conceptual model, the interview is structured, and interview questions are formulated. Secondly, trial participants were searched, and a selection of participants was made to partake in the research and corresponding interview. This process is called sampling. All participants had to be an employee or MSc/PhD at TU Delft, live within a 70km radius, and have experience with EVs. Finally, the interviews are conducted, after which data processing and analysis is conducted as explained in section 2.3. For more details on the protocols followed during the preparation, conduction and analysis of the interviews, the reader is referred to Appendix A.

Sampling

Before selecting the actual sample and sampling size, it is important to first define the target population. For matters related to sampling design, population selection etc., Serakan & Bougie is used as it provides a thorough explanation on the requirements and conditions of the entire sampling process. The book notes that the target population needs to be "defined in terms of elements, geographical boundaries, and time." (Serakan & Bougie, 2016) The sample of interviewees should be fairly homogenous and share critical similarities related to the research question (McCracken, 1988).

Sampling is be based on several demographics, namely age and gender, to represent the population of EV drivers in the Netherlands. The sampling unit, as described by Serakan & Bougie, is the element that is up for selection, which in this case will be the individual participant of the trial experiment with the V2G-enalbed Nissan Leaf.

Interview structure and questions

Each interview consisted of four distinct parts: *interview opening*, *core interview questions*, *closing questions and remarks*, and the *representation questionnaire*. The *interview opening* consisted of welcoming the interviewee and thanking them for their participation and time. They are reminded of the contents of the informed consent form such as ethical consideration of their data, anonymity and rights for access, rectification, and deletion of personal data. Interviewees are also asked for permission of an audio recording and clarification questions.

The *core interview questions* consisted of *introduction questions* and *questions on V2G trial. In* the *introduction questions*, the aim was to develop an understanding of the interviewee, their background, motives, and opinions towards EVs and V2G before participating in the trial, and their level of knowledge of V2G before participation. Coded statements related to the participants characteristics and views towards topics related to V2G are categorized under *Driver Profile Characteristics* and *Acceptance* Metrics respectively. The introduction questions also allowed the participants to become acquainted with the online interview setting and to encourage sharing their full answers. Example questions in the introduction questions were question 3 “For what reasons did you decide to participate in the V2G trial?” and question 5 “How knowledgeable and interested are you in EV charging technology?” A full list of interview questions is attached in Appendix A as part of the interview protocol.

The questions on V2G trail are generated based on the factors identified to influence consumer acceptance of V2G in relation to the conceptual model in chapter 3. The conceptual model is shown in figure 7 in subsection 3.3. To estimate the influence of trial experience, often questions asked for their difference in opinion or belief before and after participation. Additional questions to gauge how trial was experienced were created as well as questions related to considerations in assessing their experience. The first questions on the V2G trial, questions 9 and 10, are examples of questions assessing considerations.

> *Q9: Have you noticed the discharging of the EV? What did you notice?*
> *Q10: Were you at any point unable to reach your end destination?*

To assess the hypotheses in the conceptual model, such as *financial compensation / gains*, categorized under the determinant *Performance Expectancy,* several questions were created. An example:

> *Q12: Can you name any additional … costs or rewards before participating, and can you reflect on the changed in your views before and after participating?*

This question simultaneously allows for assessing the influence of trial experience. Later in the interview, after the interviewees were asked about *battery degradation*, questions were posed such as:

> *Q26: Would you use V2G for your own EV if you know it would degrade your battery? How is compensation related?*

Here too, two concepts or factors are investigated in one question.

Each interview ended with closing questions and remarks, where interviewees were again thanked for their effort and asked about any final remarks or additions to their answers. They are reminded of their rights and informed consent.

Trial setup

In figure 4, the trial setup of the PowerParking project in the Green Village at TU Delft is shown. The solar carport in question, which is the PowerParking prototype setup at the Green Village near the TU Delft, boasts a bidirectional DC (V2G) charger and a 'normal' AC charger. Participants are asked to park here and charge the Nissan Leaf using the bidirectional DC charger. In addition to both chargers, the setup includes solar modules and a solar inverter. Also, while the bidirectional AC charger is to be exclusively used by the Nissan Leaf of the trial, the AC charger is often in use by an employee of the Green Village. This should represent a more realistic scenario in which the energy stored in the Leaf could indeed be discharged for useful purposes.

Participants of this research trial are asked to use the Nissan Leaf as part of their daily routines while parking at the PowerParking trial setup at least 3 working days in a given week, arriving in the morning and leaving in the late afternoon. Connecting the Leaf to the bidirectional charger is simple and only requires the user to plug in the charging cable attached to the charger into the Leaf, and check for any error messages in the first ten seconds for normal operations to start. This is similar to conventional one-directional chargers, where the user must wait for the system to initialize and (frequently) provide a blue light. Disconnecting may be perceived slightly more cumbersome, as the user first must disable the charger before the cable can be disconnected on the vehicle side. Users are provided with conventional charging cables and free charging passes and are allowed to use any public chargers, including fast chargers, to accommodate their trips. They are reminded, however, that the goal of the research is to use the V2G charger as much as possible.

Each participant receives a thorough thirty-minute introduction many aspects related to the research and the trial setup. This introduction is performed by either the researcher or the external supervisor. First, the concept and implications of V2G are explained again, making sure to answer any questions or doubts the participant perceives early. Then, the trial setup is explained, including the function of individual components.

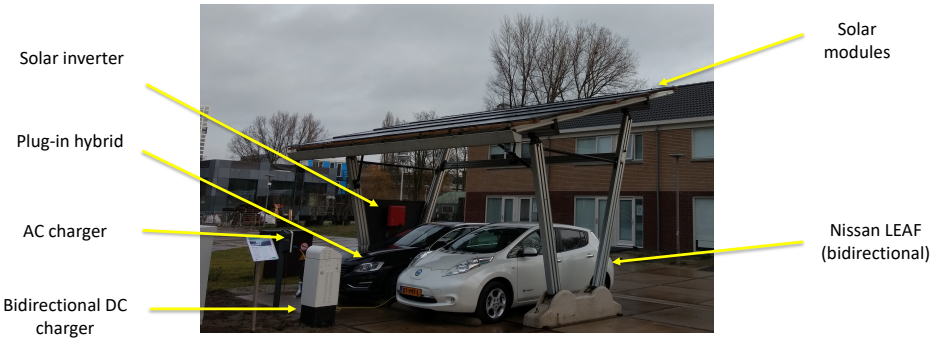


Figure 4: Prototype V2G system at the Green Village (Ghotge, n.d.-b)

In figure 5, several power streams related to the V2G station are graphically shown as a function of time. Before the first car arrives, the PV system starts generating power as suggested by the green line moving down from zero power. This energy is delivered to the grid directly, as the red

and green lines overlap. In other words, the grid connection 'draws negative power'. As soon as the non-V2G EV arrives and connects using the AC charger represented by the blue line, the grid connection reverses the flow of power and extracts power from the grid, which charges the conventional EV in addition to PV. When the V2G EV arrives around 09:00, signified by the orange line, power extraction from the grid is halted and the conventional EV is charged using both solar PV and power from the battery in the V2G-enabled EV, visualized by the yellow line sitting below the Power-intercept. At a little before 12:00, when the conventional EV is finished charging, the V2G battery is recharged using solar energy, until being fully charged just before 18:00. The fact that power line for the V2G DC charger is on both sides of the ancillary load line shows how the V2G charger can both charge and discharge the connected battery.

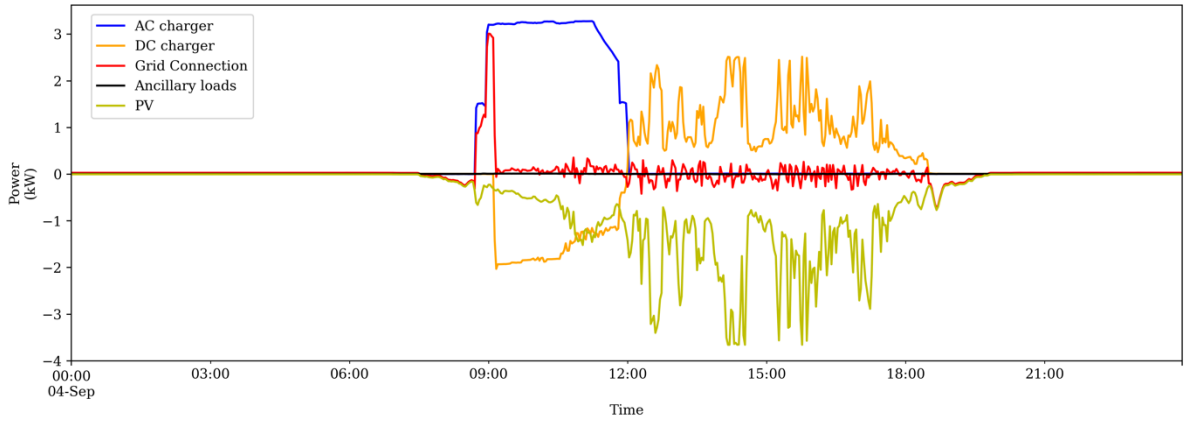


Figure 5: Power consumption pattern of trial V2G system (Ghotge, n.d.-a)

2.3. Processing & analysis of interview data

As soon as possible after conducting the interview, the audio recording is transcribed and combined with notes taking during the interview. After approval or 2 weeks of non-response from the interviewees, the analysis starts. Qualitative data, such as interview transcriptions, are data in the form of words. Interview data meanwhile contains a big number of words, making it tedious to analyse. In contrast to quantitative data analysis, there are few established and commonly accepted rules and guidelines for analysing qualitative data. A common approach introduced by Miles & Huberman (1994) in processing and analysing the interview data is based on three distinct steps: *data reduction, data display* and *drawing conclusions*.

Data reduction is the process of selecting, coding, and categorizing the data. Coding, as defined by Sekaran & Bougie as "the analytic process through which large amounts of qualitative data are reduced, rearranged and integrated with the objective of forming theory" (Serakan & Bougie, 2016, p. 334). The three stages are iterative and continuous in nature and therefore not a linear stepwise procedure. For example, early findings may result in the creation of new codes. Similarly, coding is an iterative process, requiring the researcher to combine codes, rearrange code categories or recognise patterns. (Serakan & Bougie, 2016) The analysis of qualitative data preferably occurs at the same time as data collection to allow researchers to develop a developing understanding of the research questions (DiCicco-Bloom & Crabtree, 2006). In cases where a preliminary theory is used to categorize the codes, such as in this research, allows the researcher to build on prevailing knowledge. If necessary, the codes and categories from the theoretical model can

be changed or refined as new codes and code categories appear inductively (Miles & Huberman, 1994; Serakan & Bougie, 2016) The iterative process of data collection (or data reduction) and analysis eventually leads to a point in the data collection where no new codes or code categories develop. This is referred to as saturation, signalling that data collection is complete. (Crabtree, 1999; DiCicco-Bloom & Crabtree, 2006).

Again, data reduction starts with selecting the data. The chosen data came from interviews whose methodology was described in section 2.2. Each interview was audio-recorded and subsequently transcribed along with notes written during the interview into individual reports. Each report first lists a table with interviewee information, some of which is used for the representation questionnaire. Subsequently, interviewee statements were written down in chronological order. As questions were not asked in a set order and often follow-up questions or conversations emerged, the transcription may feel unstructured. Coding allows for the structuring of this scattered data. To represent the frequency of codes properly, no statements were omitted for redundancy or repetitiveness. Yet, for clarification purposes, certain arguments from the interviewees were summarized. In some occasions, direct quotations were written down if this clarified the interviewee's point. As most interviews were conducted in Dutch, and a few in English, the researcher translated the transcription to British English. The individual interview reports are included in Appendix B.

Data reduction continues with coding and categorizing the interview data. A hybrid coding strategy was used by first generating an initial codebook and code categories based on literature on factors influencing consumer acceptance using a conceptual model based on the UTAUT acceptance model. The initial codebook can be found in section 3.3 in table 3. During the coding of the interview transcriptions, new codes emerged, more detailed codes were created by splitting existing codes, or codes were merged to encompass a small number of related statements. This iterative process eventually led to the final codebook, which can be found per code category in Appendix D and the top-20 codes in table 6 in section 4.1.

A sample statement from the transcription of interviewee ID8 is given, which was first assigned the code of *User-inflexibility* in the code category of *Performance Expectancy*. As many transcriptions were analysed, the need for a distinction between range and scheduling anxiety appeared, resulting in splitting the code of *user-inflexibility* into *range anxiety* and *scheduling anxiety* among others. Similarly, other codes were combined, such as *setting SOC* and *Opt-in/out* were combined into *control SOC.*

Finally, data is to be displayed and conclusion drawn. A large number of codes, namely 74, emerged of which 20 were considered significant. These were displayed in a table format showing their respective code categories, groundedness and frequency. Groundedness refer to the number times a code is used across all interviews, while frequency refers to the number of interviews a code was found. These codes were described impressionistically with special focus on the statements related to trial experience. Codes from the top 20 are then divided into factors influencing consumer acceptance of V2G by EV drivers in the Netherlands and other statements related to V2G. The conceptual model is altered to reflect the results from the data, after which conclusions can be drawn. The combination between using tables and the visual representation of the resulting model allows for the reader to interpret the results in two different ways.

2.4. Literature review approach

The literature review serves as the starting point of the research. Before any word is written, searching for literature allows the researcher to establish what the state-of-the-art in knowledge and information is available on vehicle-to-grid technology and the consumer or social acceptance of the technology. Literature is first collected using the methods described in the next paragraph, after which all collected literature is analysed, reviewed and subsequently this review is composed in this document. The literature review is the core of this research as it serves as the foundation upon which additional scientific research is added. The literature review therefore serves the following purposes. First, as mentioned, the initial literary search allows for the developing of a deep understanding of consumer acceptance of V2G. Secondly, from this preliminary search, the research gap such as presented in the introduction is established.

The search engine of Google Scholar was used to start finding important literature related to the research topic. Google Scholar allowed for searching multiple databases simultaneously, though mainly ScienceDirect by Elsevier and IEEExplore were used to find additional literature. To find relevant literature, the following keywords or a combination thereof were used on both Google Scholar and the scientific databases: “Vehicle-to-Grid”, “V2G”, “consumer acceptance”, “social acceptance”, “acceptance”, “attitude”, “factors”, “vehicle grid integration”, “VGI”, “Grid-to-vehicle”, “G2V”, “technology acceptance model”, “acceptance model vehicle-to-grid”, “perception”, “sociotechnical”, “Socio-demographic”, “trust”, “anxiety”, “UTAUT”, “Unified theory acceptance use”, “TAM”, “TPB”, “TRA”, “SCT”, “IDT”, “qualitative data analysis”, “semi-structured interview”. Articles were initially selected based on their title for usefulness and applicability, and subsequently the abstract, introduction, conclusion and sometimes methodology of the selected studies were scanned to establish their validity in the literature review. From here, the snowballing technique was used to find additional literature and to determine which literature was referred too often, which would suggest a high-quality article. In addition to scientific literature, the researcher attended webinars to gain different insights into the latest developments of vehicle to grid and use the related industry reports, such as from Cenex UK. Also, some government reports and policy documents were used.

3. Literature Review and Theory

In this chapter, a distinction is made between the literature review and the theoretical perspective. First, the literature review summarises the present state-of-the art in V2G research and provides the research gap. The section compares different technology acceptance models, provides reasons and implications of using the UTAUT model, and ends with providing a conceptual model and an initial codebook.

3.1. Literature Review

The literature review is the first method used in this research. In the introduction, the concept of V2G is already shortly presented as a potential solution to the societal problem of grid capacity issues. The importance of considering consumer acceptance is stressed upon, and the related gaps in the available research are made visible. In this literature review, the current state-of-the-art in V2G research is presented further while the gaps are explained in greater detail. The section first presents the state of the art descriptively in subsection 3.1.1, which is summarized in table 2. Then, subsection 3.1.2 provides the research gap.

3.1.1. State-of-the-art

Broad outline of V2G concept

The concept of vehicle-to-grid, or sometimes called vehicle grid integration, is not new. Already in 1997, Kempton and Letendre opted the idea of using electric vehicle batteries for storage of excess energy and to deliver energy back when necessary. (Kempton & Letendre, 1997). Though originally just a theoretical concept, some studies focussed on researching the conceptual framework while others developed specific use-case models. Where Guille and Gross committed to "a proposed framework to effectively integrate the aggregated battery vehicles into the grid as distributed energy resources to act as controllable loads to levelise the demand on the system during off-peak conditions and as a generation/storage device during the day to provide capacity and energy services to the grid" (Guille & Gross, 2009), Lund and Kempton's paper "designed a suitable modelling of electric vehicles with three types of controls, in order to conduct detailed hour by hour overall system analyses of the impact of V2G on national energy systems". (Lund & Kempton, 2008). Vehicle-to-grid or V2G is part of the umbrella term V2X, which means vehicle integration with anything from a house to a microgrid. It has also been studied extensively under the terms of grid-to-vehicle (G2V), V2X, V2H, vehicle-grid integration, etcetera. In this study, V2G is therefore defined as "A system whereby plug-in electric vehicles, when connected to electric vehicle supply equipment (EVSE) can provide bi-directional flows of energy." (MacLeod & Cox, 2018) The EV must possess three elements to operate in V2G configuration, namely a power connection to the grid, a control or communication device, and precision metering on board the vehicle. (Sovacool & Hirsh, 2009)

Overview of research focusses involving the user.

V2G Contracts

Most research in which the user or consumer is considered involves V2G contracts, contract types and attributes. Huang et al. (2021) considered contract parameters for participating in V2G contracts, and found that discharge cycles, a guaranteed minimum battery level, monthly

remuneration and plug-in time were important parameters(Huang et al., 2021). Other research compared multiple types of charging schemes or contract-types. Delmonte et al. (2020) presented the charging schemes of user-managed charging and supply-managed charging and found that the willingness to engage in both schemes is conditional on large reductions in charging costs, and that user-managed charging is preferred because of greater perceived personal control and lower perceived risk of not being fully charged (Delmonte et al., 2020). Similarly, Park Lee et al. (2018) conceptualized three V2G contract types, of which two new, and found that different contract types serve different goals. Two articles focussed on the preferences of Dutch EV users or drivers regarding contracts and found that the most significant elements were remuneration, guaranteed energy or range, and contract duration (Meijssen, 2019; Zonneveld, 2019). Finally, research on the willingness of consumers to pay for V2G revealed that consumers are generally willing to adopt V2G, although they believe having flexibility and high driving range is a condition (Noel, Papu Carrone, et al., 2019; Parsons et al., 2014).

Other

Other research reviewed visions, expectations, policy mechanisms or business models. Based on expert interviews, the key components for sustainable business models in the Netherlands were assessed (Başer, 2020). Sovacool et al. (2019) aimed to list eight different visions and socio-technical expectations of electric mobility and V2G, while Kester et al. (2018) analysed expert advice on policy mechanisms for accelerated consumer diffusion. He found that there are 5 categories of policy mechanisms, namely restructuring the energy market, innovation and R&D, information and awareness, other policy advice and determinism. Van Noort researched the influence of nudging on smart charging solutions and found that while consumers find the environmental benefits and integration of renewable energy sources attractive for personal motives, nudging has little effect on the adoption (van Noort, 2019).

Factors influencing consumer acceptance V2G

A decent chunk of literature focusses on social aspects related to adoption of V2G. Some even specifically centre their research on factors influencing consumer acceptance. Others simply state preferences or barriers of potential consumers or EV drivers.

Van Heuveln et al. (2021) focused specifically on factors influencing consumer acceptance of V2G. Using semi-structured interviews and a modified Theory of Planned Behaviour, it was found that financial compensation, transparent communication, and reliable control had a positive effect on consumer acceptance. Range anxiety, discomfort during participation and battery degradation have a negative effect on acceptance (van Heuveln et al., 2021). Chen et al. (2020) compared factors for EV adoption and V2G adoption, and found that V2G capability can foster EV adoption due to added revenue streams, but that charging time is a negative factor for adoption (Chen et al., 2020). Interestingly, some studies contradict findings from other research. Gardien et al. (2020) found the possibility of an override button important, but found that financial incentives have no influence on attitude towards V2G (Gardien et al., 2020).

Research focussing on the barriers of V2G adoption find many factors against consumer acceptance. Barriers found include a preference for other technologies, consumer resistance or a lack of consumer awareness, a poor business case, complexity of the technology, general uncertainties when using the technology such as range anxiety, cost, battery degradation and the

structure of the EV market. Consumers desire a minimum range and remuneration for the uncertainties. (Geske & Schumann, 2018; Gschwendtner et al., 2021; Noel, Zarazua de Rubens, et al., 2019a, 2019b; Schmalfuß et al., 2015). Gschwendtner et al. (2021) adds that incentives and V2X operations should be tailored to the individual vehicle user, while Schmalfuß et al. (2015) lists supporting grid stability and contributing to the green energy supply as motivations for personal acceptance of V2G.

Several review studies consider social or socio-technical aspects in relation to V2G adoption or consumer acceptance of V2G. Sovacool, Noel et al. (2018) considers environmental benefits, inconvenience of deferred EV charging, perception of battery degradation, the required change in lifestyle or travel pattens and range anxiety to be factors related to consumer acceptance (Sovacool, Noel, et al., 2018). The socio-technical review from Sovacool et al. (2017) summarizes the behavioural components for V2G integration to be cost savings and environmental benefits in positive regard, and inconvenience, distrust, confusion and range anxiety in negative regard (Sovacool et al., 2017).

Public awareness and acceptance is also researched, and results showed the public in the Nordic focus group found V2G a clever technology with questionable benefit to the consumer. There should be compensation for battery degradation and a system in place to not disturb routines. Information on V2G should be provided and the organization should somehow be involved (Kester et al., 2019).

The factors influencing consumer acceptance of V2G found in the literature review are assigned codes and summarized in table 3 in section 3.3. As the same (or very related) concepts were presented in a different name along the interviews, the most general term was selected. All codes are categorized in the code categories based on the determinants in the adapted conceptual model figure 6 in section 3.3

Literature Review Conclusion Table

Table 2: Overview of reviewed V2G studies covering consumer acceptance or experience.

#	Research Authors	Geography	Approach	Topic	Relevant findings
1	(Gschwendtner et al., 2021)	-	Literature review / Expert interviews	Overview of predominate trial configurations and technical, social and regulatory challenges for V2X implementation	Most common trial configurations: Vehicle-to-customer & transmission-level services provided by commercial fleets. Social challenges: incentives and V2X operations need to be tailored to the individual vehicle user. Barriers to V2X uptake: cost, inconvenience, distrust, range anxiety.
2	(Huang et al., 2021)	Netherlands	Choice Experiment	EV Driver's Preference for participating in V2G contracts	Contract parameters: Discharge cycles, guaranteed minimum battery level, monthly remuneration and plug-in time.
3	(van Heuveln et al., 2021)	Netherlands	Semi-structured interviews	Factors influencing consumer acceptance of V2G	Positive effect: Financial compensation, transparent communication, reliable control. Negative effect: range anxiety, discomfort during participation, battery degredation.
4	(Başer, 2020)	Netherlands	Expert Interviews	Key components for potential sustainable V2G business models in the Netherlands	Business environment is vital, and the Dutch market has potential but is not commercially ready. Business model created could form the basis of other sustainable V2G business models.
5	(Chen et al., 2020)	Nordic Region	Hierarchical regression analysis	Assessment of different factors for EV adoption, and the influence of V2G preferences on adoption.	V2G capability can foster EV adoption due to added revenue streams, only for EV owners. Charging time and V2G attributes both significant for EV adoption, both negative.
6	(Delmonte et al., 2020)	United Kingdom	Semi-structured interviews	Present charging behavior and responses to two types of managed charging schemes	Willingness to engage with both schemes conditional on large reductions in charging costs. UMC preferred because of perceived personal control and lower perceived risk of not being fully charged. Preference supplier managed charging mainly based on perceived advantages to society
7	(Gardien et al., 2020)	Netherlands	Mixed-method Case Study	EV owner's preferences and experiences with controlled (smart) charging of EVs via home chargers.	No difference in attitude static vs dynamic charging profile groups. Possibility override button is important. Controlled charging minimal effect on attitude towards charge management. Financial incentive no influence on attitude.
8	(Ghotge et al., 2019)	Netherlands	Desk research	Challenges faced during implementation of a V2G set-up in a living lab	Major barriers: Legislative and institutional. Minor barriers: Technical. Underexplored barriers: Societal. Other barriers: Economic
9	(Kester et al., 2019)	Nordic Region	Focus group study	Public awareness and acceptance of EVs and V2G using a focus group study.	Findings V2G: Clever technology, Questionable benefit consumer, Compensation for battery degredation, planning system to not disturb routines, information. Organization: Should they be involved, grid integration

10	(Meijssen, 2019)	Netherlands	Stated choice experiment	Preferences of Dutch EV drivers regarding V2G contracts.	Preferences found: Remuneration, plug-in time, guaranteed range, recharging speed, contract duration, discharging cycles.
11	(Noel, Zarazua de Rubens, et al., 2019b)	Nordic Region	Expert Interviews	Barriers of V2G adoption derived expert skepticism and consumer distrust	Extensive range of barriers facing V2G. Expert interviews revealed skepticism, though previous literature contradicts this. Barriers: Preference for other technologies, consumer resistance, poor business case, complexity, uncertainty, cost, battery degradation, EV market structure.
12	(Noel, Zarazua de Rubens, et al., 2019a)	-	Survey	Discussion on current consumer views of V2G and its barriers. Conceptualization of the consumer	Consumer awareness of V2G is a barrier for adoption. Consumers should be given active role in development V2G, like trial participation. Consumers should be considered a key actor, level of engagement will determine pace of future adoption.
13	(Noel, Papu Carrone, et al., 2019)	Nordic Region	Choice experiment	Willingness to pay for EV and V2G applications in 5 Nordic countries	Driving range and recharging time high importance, and higher than expected. Some attributes vary across countries. Willingness to adopt V2G is high in some countries, while in other countries education and awareness implied to accelerate adoption.
14	(Sovacool et al., 2019)	Nordic Region	Expert interviews	Different visions and sociotechnical expectations of electric mobility and V2G innovation	Analysis of eight visions. I don't think this study distinguishes much between EVs and V2G.
15	(van Noort, 2019)	Netherlands	Survey	The influence on adoption of smart charging solutions through nudging	Environmental benefits, integration of renewable energy sources as personal motives. Nudging has little effect and may be negative.
16	(van Wee et al., 2019)	-	Research agenda / literature review	Impacts of the built environment and travel behaviour on attitudes.	Two conclusions dominate in literature. First, attitudes may change due to new experiences. Second, attitudes may change due to mismatches between attitudes and behaviour, and individuals may similarly change attitudes after undergoing specific behaviour.
17	(Zonneveld, 2019)	Netherlands	Stated choice experiment	Examination of Dutch EV users' preferences regarding V2G contract elements	Minimal difference in expected demand between price- and volume-based contracts. Most significant contract elements are remuneration, guaranteed energy and contract duration.
18	(Geske & Schumann, 2018)	Germany	Survey / Choice Experiment	Willingness (barriers) of vehicle users, both EV and fossil-fuelled, to participate in V2G.	Range anxiety, minimum range, remuneration, EV/V2G awareness
19	(Kester et al., 2018)	Nordic Region	Expert Interviews	Expert advice on policy mechanisms for accelerated diffusion of V2G	5 categories of policy mechanisms: Restructuring the electricity market (Payment for storage service), Innovation and R&D, Information and awareness, other policy advice (planning, EV, RES), and determinism

20	(Park Lee et al., 2018)	-	Agent based modelling	Conceptualization of three (of which two new) V2G contract types.	Depending on the purpose of providing V2G and the goal of the system, different contract types are needed. Price- and volume-based contracts were added, control-based existed in literature. Simulation shows how price- and volume-based contracts can be used for different purposes.
21	(Sovacool, Noel, et al., 2018)	-	Literature review	Summary of insights V2G literature, focus on neglected social dimensions such as consumer acceptance	Underexamined dimensions: Environmental performance, financing and business models, user behavior (consumer acceptance), etc. Consumer acceptance: environmental benefits, inconvenience deferred EV charging, perception of battery degradation, lifestyle or travel patterns, range anxiety.
22	(Sovacool, Noel, et al., 2018)	Nordic Region	Literature review	The influence of gender, education, occupation, age and household size on electric mobility preferences	Predominantly men, with higher levels of education in full time employment, and below middle age (30-45) are most likely to buy electric mobility or V2G. Higher income females and retirees are also likely to buy V2G.
23	(Sovacool et al., 2017)	-	Literature review	Socio-technical review and research agenda on V2G integration	Split into technical, financial, socio-environmental and behavioral components. Behavioral: Cost Savings and Environmental Benefits, but also Inconvenience, Distrust, Confusion and Range Anxiety. Complexity of Users.
24	(Schmalfuß et al., 2015)	Germany	Field trial / Interviews	Motivations, attitude, and willingness to use controlled smart charging system	Suitable for daily life, reliable and trustworthy. Motives: ecological, societal. Benefits: support grid stability, financial benefits, ecological effect, contribution to grid stability, contribution to green energy supply, lower financial costs
25	(Hülsmann & Fornahl, 2014)	Germany	Survey	Influence of use of EVs on consumer acceptance	Diffusion of innovation model was used. Gaining experience with EVs has positive influence on certain predictors of acceptance. Visibility and observability is also relevant.
26	(Mwasilu, 2014)	-	Literature review	Review on V2G and RES integration	"EVs can provide ancillary services to the grid such as voltage and frequency regulation, peak power leveraging and reactive power support to enhance the operational efficiency, secure the electric grid and reduce power system operating cost."
27	(Parsons et al., 2014)	United States	(Stated preference) Choice Experiment	Willingness of potential consumers to pay for V2G EVs using different contract terms in comparison to an ICE vehicle.	V2G likely to help EV adoption if aggregators operate on pay-as-you-go basis or with advanced cash payment. Imposing fixed requirements are unlikely to help. Inconvenience with signing V2G-EV contracts, desire for flexibility and uncertainty of earning money selling power to power companies.

3.1.2. Research gap

There is a lack of research involving trial experience of V2G in relation to consumer acceptance. While it is uncertain why this is the case, some research provide insight into the possible reasons. For example, research on the challenges faced during implementation of a V2G set-up in a living lab found that there are major legislative and institutional barriers. There are some technical barriers and the societal barriers remain unexplored underexplored. Less than 2.1% of V2G related academic studies between 2015 and 2017 consider consumer routines and norms. (Ghotge et al., 2019). By performing qualitative research on trial participants in routine situations, this thesis fills a research gap in V2G academic literature. The researchers add that in research on the social challenges of V2G, the focus needs to be on education of EV users unaware of V2G and on different contract types.

Noel, Zarazua de Rubens, et al. (2019a) discussed the current consumer views of V2G an conceptualized the consumer in this research. They found that consumers should be given an active role in the development of V2G, such as trial participation. In a different paper, they concluded that consumers should be considered as a key actors as the level of engagement will determine the pace of future adoption (Noel, Zarazua de Rubens, et al., 2019b). Many similar research articles state that there is a need for focus on the neglected social dimensions of consumer acceptance (Sovacool et al., 2017; Sovacool, Noel, et al., 2018). Other recent research has included an overview of predominate trial configurations. It was found that the most common trial configurations were vehicle-to-customer and transmission-level services provided by commercial fleets, so no regular consumers are considered (Gschwendtner et al., 2021). By analysing the opinions of potential consumers while focussing on many social dimensions of consumer acceptance in relation to trial experience, the research gap suggested by the above literature can be filled.

van Wee et al. (2019) aimed to discover what triggers attitude change, and found amongst other things that people change their attitude (towards anything from performing an activity to embracing a new technology) after being exposed to new experiences. Van Wee calls this “attitude change due to behavioural process” (van Wee et al., 2019). He adds that the impact of the behavioural processes is linked to ‘doing’, and that experiences are therefore needed. Similarly, Huijts et al. (2012) suggests that attitude is directly related to the intention of a person to accept a technology. Therefore, researching the changes in attitude or opinion towards a technology before and after trial participation provides useful insights in regards to consumer acceptance of V2G.

Comparable research has meanwhile been done similar innovations. The influence of use on consumer acceptance has been researched for EVs, for example. Using the diffusion of innovation model, it was found that gaining experience, and more significantly test drive opportunities, with EVs has a positive influence on certain predictors of acceptance (Hülsmann & Fornahl, 2014). Due to these conclusions and the assumptions that consumers play an active role in the development of V2G, it is expected that trial experience of V2G also has a positive influence on predictors of acceptance.

3.2. Theory of Acceptance Models

From the literature review and research gap sections, it was concluded that there is little research considering consumer acceptance of V2G technology, or social aspects related to V2G adoption general. Moreover, to the best knowledge of the writer, no research has considered trial experience of V2G in relation to consumer acceptance. Therefore, several technology acceptance models are reviewed and compared in subsection 3.1.1. In 3.1.2, the acceptance model UTAUT is described. Subsection 3.1.3 contains the conceptual model based on the UTAUT model and altered based on literature, as well as the initial codebook.

First, consumer acceptance needs to be defined. The definition is borrowed from psychology. Consumer acceptance was previously defined as "the public's behavioural responses to the availability of technological innovations, that is, the purchase and use of such products" (Huijts et al., 2012, p. 526) This definition is operationalised to fit the research objective, resulting in the definition for consumer acceptance of "The behavioural responses of EV drivers in the Netherlands to the availability of V2G, that is, the purchase and use of V2G as part of their daily routines." This definition fits the research well, as the trial setting involved researching EV drivers who participated during their daily routines.

3.2.1. Various Competing Models

Using technology acceptance models is a proper method when trying to assess the influence on trial experience on consumer acceptance, as most models consider some relationship between intention of using and actual use.

Theory of Reasoned Action (TRA)

Drawn from social psychology, TRA is one of the most fundamental and influential theories of human behaviour. It has been used to predict a wide range of behaviours, and suggests that behavioural intentions are immediate antecedents to behaviour and a function or beliefs about the likelihood that a particular behaviour leads to a certain otucome (Venkatesh & Davis, 2000). The core constructs of the TRA are *Attitude Toward Behaviour* and *Subjective Norm*, which Fishbein and Ajzen defined respectively as "an individual's positive or negative feeling (evaluative affect) about performing the target behaviour" and "the person's perception that most people who are important to him think he should or should not perform the behaviour in question" (Fishbein and Ajzen 1975, p. 302, SQ).

Technology Acceptance Model & Technology Acceptance Model 2 (TAM/TAM2)

Originally developed in 1989, the Technology Acceptance Model (TAM) was developed to understand the conditions in which information systems are to be embraced by the human. It has since accumulated substantial theoretical and empirical support and is typically able to explain 40% of the variance in usage intentions and usage behaviour. The core constructs of the TAM model are *Perceived Usefulness*, which is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance", P*erceived Ease of Use*, defined as "the degree to which a person believes that using a particular system would be free of effort" (Davis et al., 1989) and in TAM2 additionally *Subjective Norm* (Venkatesh & Davis, 2000). The addition of Subjective Norm for TAM2 shows that subjective norm has a significant relation with usage intention. TAM2 is able to explain 60% of variance in Perceived Usefulness, one of the important

drivers of usage intention. It was found Perceived Usefulness is influenced by the Subjective Norm significantly though internalization and identification.

Theory of Planned Behaviour (TPB)

The Theory of Planned behaviour can be considered as an extension to the Theory of Reasoned Action. It added *Perceived Behavioural Control* and in comparison with the TRA, the TPB was able to explain more variation. The core constructs of the Theory of Planned Behaviour are *Attitude Toward Behaviour*, *Subjective Norm*, both adapted from the TRA, and *Perceived Behavioural Control,* which is defined as "the perceived ease or difficulty of performing the behaviours (Ajzen 1991, p. 188).

3.2.2. Unified Theory of Acceptance and Use of Technology (UTAUT)

The Unified Theory of Acceptance and Use of Technology, or in short UTAUT, was developed by Venkatesh as a synthesis of eight acceptance models. These models are the ones mentioned in 3.2.1, namely TRA, TAM(2), TPB, SCT and IDT, in addition to the Combined TAM and TPB (C-TAM-TPB) Motivational Model (MM) and the Model of PC Utilization (MPCU). Each of these models contain two to seven determinants of technology acceptance, for a total of 32 combined. In his review, Venkatesh determined that seven constructs appeared as significant, of which four are theorised to play a role as direct determinants of user-acceptance. These determinants are *Performance Expectancy, Effort Expectancy, Social Influence*, and *Facilitating Conditions*. (Venkatesh et al., 2003). By assessing user-acceptance and usage behaviour through the lenses of these determinants, Venkatesh states that "the UTAUT provides a useful tool for managers needing to assess the likelihood of success for new technology introductions and helps them understand the drivers of acceptance in order to proactively design interventions targeted at populations of users that may be less inclined to adopt and use new systems".

Interestingly enough, one of the constructs that was not considered as a direct determinant was *attitude towards using technology*. In the literature review and research gap, it was determined that researchers find that new experiences may trigger attitude change. Assessing the influence of trial experience and therefore changes in attitude towards using V2G requires a slight addition to the original UTAUT model presented by Venkatesh. In the theoretical model in figure 6, the determinant of *Trial Experience* is therefore added. The implications of this are discussed in section 4.7. In addition, the UTAUT model was originally developed as a tool for managers to assess the likelihood of success for new technologies specifically in the information systems realm, while the case of this thesis focusses on a different type of new technology. The original definitions, tabulated in table 3, are operationalized to fit the case of consumer acceptance of V2G.

Venkatesh additionally determined four mediating variables, namely *Gender, Age, Experience,* and *Voluntariness of Use.* The original UTAUT model is presented in figure 6 and clearly shows how determinants are mediated by the four variables, and that not all determinants are mediated. To avoid confusion, the mediating variable of *Experience* is named *Experience (Familiarity)* in future text and final theoretical models, such as in figure 7.

Performance Expectancy is considered the strongest predictor of intention to use in all of the underlying models that were also explained in 3.1.1. It was conceptualized from, among others, the construct of Perceived Usefulness from the TAM model and Extrinsic Motivation from the

Motivational Model, and Venkatesh states the relationship between *performance expectancy* and *Behavioural Intention* is moderated by *gender* and *age*. This is an interesting topic of discussion. It is expected that *Trial Experience* has a significant influence on certain constructs, or factors, embedded in the *performance expectancy* determinant. The initial codebook in table 4 lists these factors retrieved from literature. Interestingly enough and a topic worthy of discussion, *performance expectancy* is not mediated by *Experience (familiarity)*.

Similarly, *Effort Expectancy* captures the constructs of (perceived) ease-of-use and complexity from several of the previously described models. It is also considered a strong predictor in each acceptance model, especially in early stages. *Effort expectancy* is mediated by *gender, age,* and *Experience (familiarity)*. The analysis of interview transcriptions should reveal whether this is the case for this research too. *Social Influence*, present in other acceptance models as *subjective norm* or *image,* was found to be non-significant in a voluntary context. Therefore, it is expected that in this research, *social influence* will not be affected significantly by trial experience. *Social Influence* may be significant when behaviour is rewarded or punished, and hence in addition to *Voluntariness of Use, Social influence* is mediated by *Gender, Age,* and *Experience (familiarity).*

Finally, *Facilitating conditions* encompasses the contracts of *Perceived Behavioural Control* (present in the Theory of Planned Behaviour and the Combined TAM-TPB, for example), *Facilitating Conditions*, and *Compatibility*. Venkatesh concludes that *Facilitating Conditions* is significant In both mandatory and voluntary settings in all models. There is, however, some overall with *Effort Expectancy* as for example 'support infrastructure' also eases the level of effort required. It is considered that *Facilitating conditions* is mediated by *Age* and *Experience (familiarity)* but that *Facilitating conditions* does not have a direct influence on behavioural intention, but directly influences the use behaviour. (Venkatesh et al., 2003)

Table 3: Operationalized definitions UTAUT

Determinant	**Original Definitions (Venkatesh et al., 2003)**	**Operationalized definition**
Performance expectancy	The degree to which an individual believes that using the system will help him or her to attain gains in job performance.	The degree to which an individual believes that using V2G will help him or her attain mobility needs.
Effort expectancy	The degree of ease associated with the use of the system.	The degree of ease associated with using V2G.
Social influence	The degree to which an individual perceives that important others believe he or she should use the new system.	The degree to which an individual perceives social pressure or norms and values to use V2G.
Facilitating conditions	The degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system.	The degree to which an individual believes that a proper organizational and technical infrastructure exists to support using V2G.
Trial Experience	-	*The degree to which an individual changes perception regarding constructs embedded in one of the original determinants.*

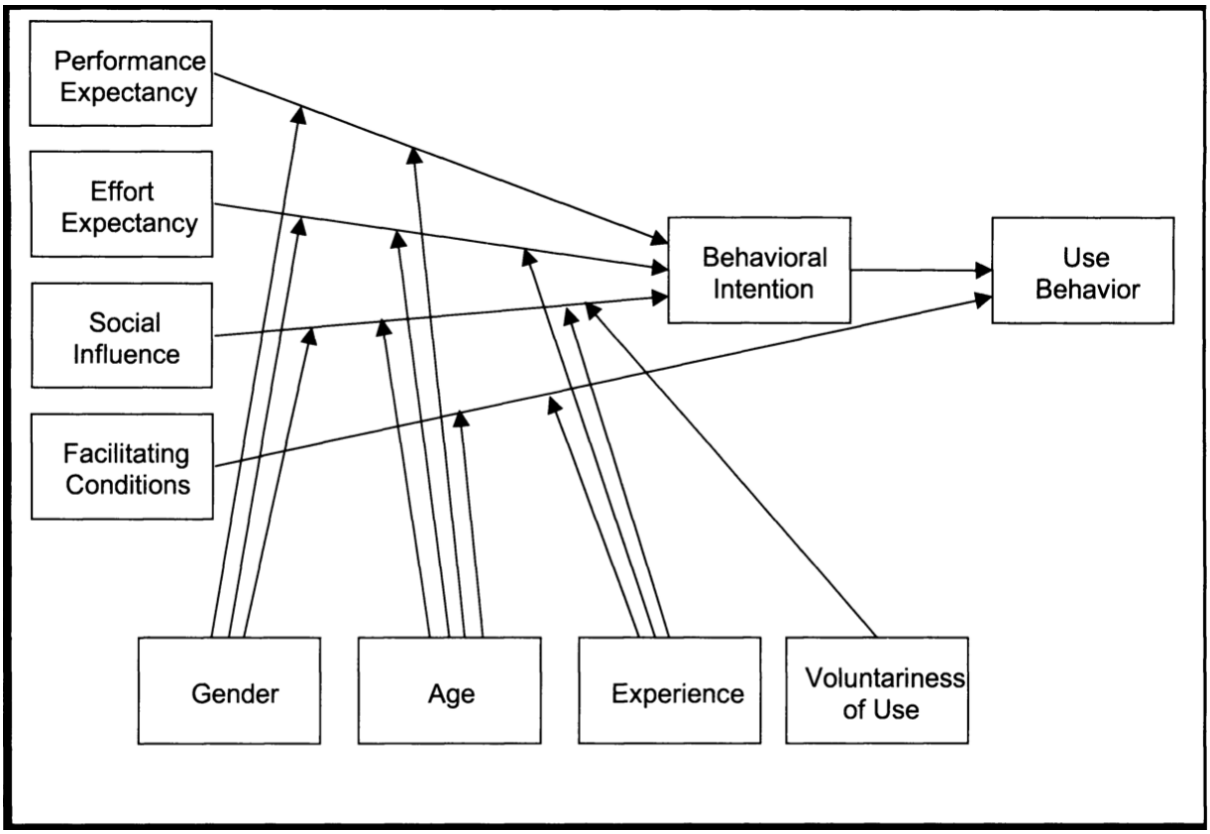


Figure 6: Original UTAUT visualisation (Venkatesh et al., 2003)

3.3. Initial codebook and theoretical model

Table 4: Initial codebook based on literature review acceptance factors in relation to UTAUT

Code category	Code	Source
Performance Expectancy		
1	Financial compensation / gains	(Chen et al., 2020; van Heuveln et al., 2021)
2	Remuneration	(Geske & Schumann, 2018)
3	Range anxiety	(Geske & Schumann, 2018; Gschwendtner et al., 2021; Sovacool et al., 2017; Sovacool, Noel, et al., 2018; van Heuveln et al., 2021)
4	Battery degradation	(Kester et al., 2019; Noel, Zarazua de Rubens, et al., 2019b; Sovacool, Noel, et al., 2018; van Heuveln et al., 2021)
5	Charging time	(Chen et al., 2020)
Effort Expectancy		
6	Complexity and confusion	(Noel, Zarazua de Rubens, et al., 2019b)
7	Required lifestyle or travel pattern change	(Sovacool, Noel, et al., 2018)
Social Influence		
8	Preference other technologies	(Noel, Zarazua de Rubens, et al., 2019b)
9	Consumer resistance / lack of awareness	(Geske & Schumann, 2018; Noel, Zarazua de Rubens, et al., 2019b)
10	Environmental benefits	(Sovacool et al., 2017; Sovacool, Noel, et al., 2018)
Facilitating Conditions		
11	Control	(Gardien et al., 2020; van Heuveln et al., 2021)
12	Transparent communication	(van Heuveln et al., 2021)
13	Discomfort, uncertainties	(Noel, Zarazua de Rubens, et al., 2019b; van Heuveln et al., 2021)
14	Poor business case	(Noel, Zarazua de Rubens, et al., 2019b)
Trial Experience		
15	Trial Experience	-

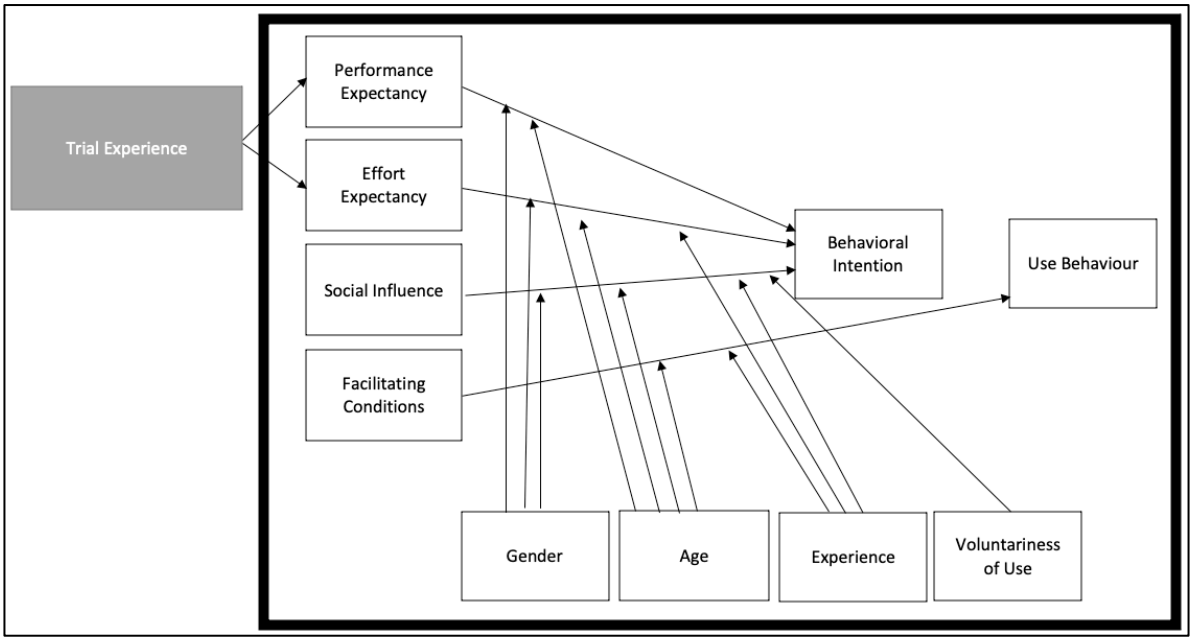


Figure 7: Theoretical model based on previous V2G studies and UTAUT model

4. Results

The results chapter will put forward the findings of the analysis of 17 interviews conducted according to the methodology described in chapter 2. The 17 interviews were carried out from May to July 2021. Each interviewee participated in a V2G pilot trial for at least one workweek and participation trials occurred from June 2020 to July 2021. Section 4.1 first provides an overview of the codes identified during the data reduction from the interview transcriptions. Describing the interview findings per code in an impressionistic manner, as is done in section 4.2, provides some deeper insights into the statements related to the code. In section 4.3, the analysis of the codes results in the generation of a list of factors related to consumer acceptance that are present in the trial. Section 4.4 then forms the core of the results, where the influence of trial experience is explained in relation to factors concerning consumer acceptance found in 4.3 as well as possible demographic or characteristics deducted from non-determinant code categories. Here, the final theoretical model is also introduced. Section 4.5 shortly recaps on findings from the interview data reduction that were not based factors, while section 4.6 states data on the representativeness of the sample. Though discussion of the results is present throughout the sections, section 4.7 provides additional topics of discussion, such as a reflection on the chosen methods.

4.1. Codes identified in interview analysis

This section of the results chapter provides important data with respect to answering sub-research question 1: “What are the factors influencing consumer acceptance of vehicle-to-grid by EV drivers in the Netherlands?”. These factors are encompassed in the many codes found, as is listed in section 4.3, yet other codes simply captures views, opinions and beliefs of interviewees, such as the need for scalability. These additional views towards V2G are shortly explained in section 4.5. The code of ‘scale issues’, then, does not represent a factor influencing consumer acceptance, but a shared opinion of multiple participants. Adding upon the factors determined in the literature review and summarized in table 4, subsection 4.1.2 provides the final codebook. First, subsection 4.1.1. covers the code saturation.

4.1.1. Saturation graph

Throughout the iterative coding process, new codes were added, existing codes merged and certain codes were redefined. The final codebook consists of 74 codes, of which 71 were present in the interview analyses. The three codes in the final codebook that did not appear in interviews were related to *acceptance metrics (AM)* or the mediating variables, in this case *Age (A)* and *Gender (G*). In the first interview, already 28 codes or 39% of all mentioned codes were determined. After the third interview, this was already 51 codes or 72% of all mentioned codes, while in the latter half of the interviews only 5 new codes were identified. More details can be found in the Code Saturation Graph in figure 8. While one might argue that the first six interviews would have provided enough data on the factors influencing consumer acceptance of V2G, the latter eleven allow for a further validation of the findings in the earlier interviews, a deeper understanding of the words behind the codes, and provide additional insights that cannot be described in a code format.

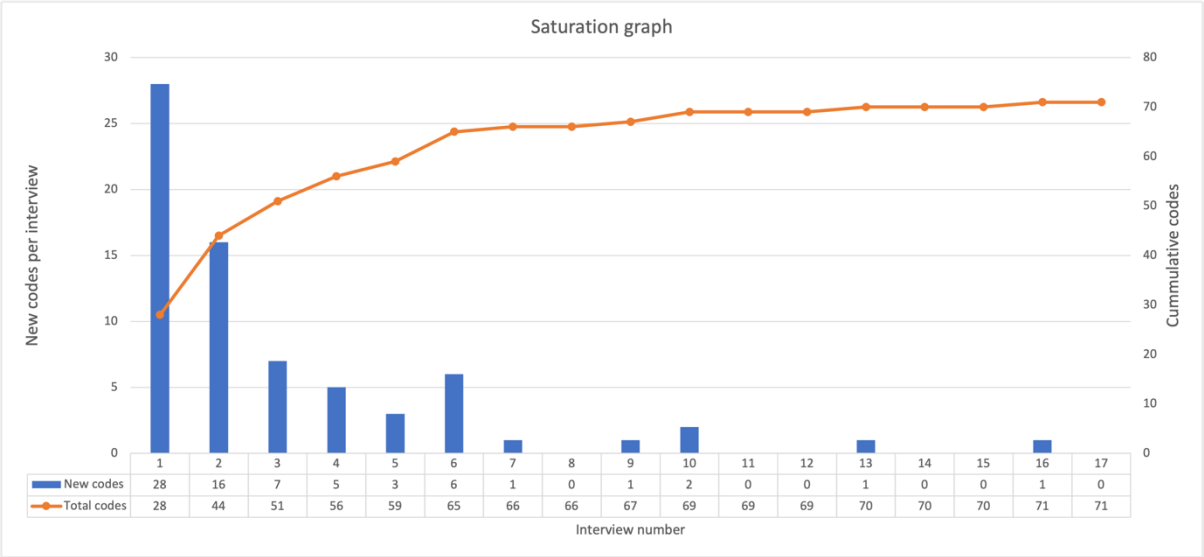


Figure 8: Code Saturation Graph

4.1.2. Final codebook

Number of codes per code category

In table 5 below, the number of codes per code category are provided. From the table, it can be concluded that 74 codes in total were generated, while the quantity of codes per code category varies. The categories embedded in the original UTAUT model, namely *Performance Expectancy*, *Effort Expectancy*, *Social Influence* and *Facilitating Conditions* accounted for the majority of codes, namely 50. Mediating variables *Age, Gender, Experience (Familiarity)* and *Voluntariness of Use* were combined into one code category, while the code category *Trial Experience* was added as described in the theoretical model. Finally, *Driver Profile Characteristics* and *Acceptance Metrics / Other* were included to assist in the interpretation of the final codes.

Table 5: Code categories and quantity of embedded codes

Code category	Number of codes
Trial Experience (TE)	1
Performance Expectancy (PE)	20
Effort Expectancy (EE)	7
Social Influence (SI)	6
Facilitating Conditions (FC)	17
Driver Profile Characteristics (DPC)	7
Mediating Variables (A, G, E, V)	8
Acceptance Metrics / Other	8
Total	**74**

Table 5 provides the reader insight into the relative number of codes per code category, with a higher number of codes suggesting a larger variety of answers. This does not entail that the category with the highest number of codes, in this case *Performance Expectancy*, contains the most frequently mentioned codes related to consumer acceptance of V2G, as is seen in the top 20 codes in general. Again, codes are not directly interpreted into factors, can also not relate to factors influencing consumer acceptance, for example the code “other use cases” presents the statements

from interviewees regarding other business models or applications for V2G, not that they saw other use cases as a requisite for acceptance.

Top-20 codes based on groundedness

From the 74 codes in total, the top 20 were selected based on groundedness. Groundedness is the number of statements from the interviews that are assigned to a certain code. This means if an interviewee mentions range anxiety twice, the groundedness of that code in the respective interview is 2, while the frequency is only 1 as the number of statements related to the code does not influence the frequency. Table 6 provides the top 20 codes based on groundedness, where every individual codes encompasses statements related to the opinions, thoughts and observations of the interviewees. Clearly, the codes with highest groundedness have been discussed, though often there are large differences in underlying motivation for certain statements. Section 4.3, hence, provides an impressionistic description of each code, allowing for a more in-depth understanding behind the meaning of each code. In Appendix D all codes, including their groundedness, per code category are given an individual table. It is important to note that the code categories of *DPC, AM, Mediating Variables* and *Other* are not included in the top-20 codes.

Table 6: Overview of the top-20 codes from the definitive codebooks

#	Code	Code category	Groundedness	Frequency
1	Trial Experience	TE	48	17
2	Social Influence (Code Category)	SI	35	13
3	Control/set SOC (maybe split into general control, set SOC or minimum SOC)	FC	28	13
4	User-friendliness V2G (maybe split subparts of V2G, user-interface for example)	EE	27	16
5	Financial compensation / gains	PE	24	15
6	Range Anxiety	PE	24	14
7	Distrust, uncertainties	FC	19	14
8	Other system benefits	PE	19	10
9	Other use cases	PE	19	13
10	Scheduling anxiety	EE	17	12
11	Battery degradation	PE	16	12
12	Peak shaving / Grid stabilization	PE	16	12
13	Clear communication benefits/costs/risks/etc.	FC	15	11
14	View State-of-Charge	FC	15	8
15	System comparison / compatibility	PE	15	12
16	Requires more V2G cars / scale issues	FC	14	9
17	Societal benefits	PE	14	10
18	Works with other systems	PE	14	13
19	Disbalance societal/personal benefits. Conflicting goals	PE	12	10
20	Energy storage / Power bank	PE	11	8

Given that one of the main goals of this research is to determine how Trial Experience alters consumer acceptance of V2G by EV drivers in the Netherlands, the code *Trial Experience* was given its own code category and was mentioned the most frequently and notably in all interviews. This is not surprising as the interview questions were heavily focused on gauging the participants' opinions, thoughts and observations regarding V2G before and after using the technology. Because Trial Experience is such an important determinant in the theoretical model and the construct around

which the research question revolves, section 4.4 covers the statements on trial experience in more detail in an impressionistic way.

The second code in the top-20 consists of all codes related to *Social Influence* combined, as interviewees presented a very wide variety of views regarding *Social Influence* that were hard to capture in individual codes. The impressionistic description of the codes within the *Social Influence* code category will shed additional light on the underlying views of the interviewees. All other 18 codes in the top-20 are embedded in the code categories of *Performance Expectancy, Effort Expectancy* and *Facilitating Conditions*.

4.2. Impressionistic description of interview codes

Section 4.2. offers a deeper insight into the attitudes, opinions, beliefs, etc. regarding V2G embedded in the interviewee's statements in each code. The top-20 codes were already provided in table 6, and all the codes included in this graph are explained using statements and quotations from participants, and categorized by code category. All interview transcriptions can be found in Appendix B. It is important to note that while *Social Influence* was included in the top-20 table as a code category, in this section the codes within the category are described individually. Also, while many codes were not mentioned frequently enough to be included in the top-20 table, sometimes codes are closely related to one of the codes in the table that a short description is given as well. An example of this is the code *Opt-in/out*, which is related to *Control/Set SOC* but is different from setting a minimal level of charge. In this section, the focus of analysis is still the codes. In section 4.5, the codes encompassing factors related to consumer acceptance of V2G are summarized.

Performance Expectancy

Financial Compensation / Gains

The first code of the initial codebook in table 4 was the code of financial compensation / gains. To assess the sample's views regarding financial compensation in relation to using V2G, questions such as question 12 were prompted:

> *Q12: Can you name any additional … costs or rewards before participating, and can you reflect on the changed in your views before and after participating?*

In the analysis, plenty of statements indeed related to financial compensation or gains. It was found that financial compensation for potential battery degradation, inconveniences, uncertainty of SOC and other uncertainties is important to those who participated in the trial. Interviewees differed in their opinion as to the extent that financial compensation would be considered adequate. Interviewees differ in their opinion on how this compensation, or even benefit, should be enacted.

Some participants would only want the costs of decreased battery life to be covered, either at purchase or while using V2G.

> *P1: The participant would choose for V2G if it was available for purchase, but states that the costs of decreased battery life should be covered, preferably at purchase. [ID5]*
> *P2: When presented with the fact that batteries degrade quicker when charged and discharged frequently, he says he would like to be financially compensated for this. [ID7]*

Financial compensation or gains should be clearly communicated to potential consumers of V2G to increase their likelihood of accepting the technology, some trial participants believe. Some participants additionally believe that compensation should not only cover (future) costs, but also cover the uncertainty and inconvenience using V2G might present to the consumer.

> *P3: Compensation should be clearly defined, and should not only cover the financial costs of battery degradation but also the uncertainty of not knowing your state of charge. [ID12]*
> *P4: She mainly thinks a clear visualization of the costs and benefits (and respective savings that consumers can expect) … are likely to improve social acceptance. [ID16]*

Some trial participants see a business case where financial gains can be achieved by exchanging energy at times of different energy prices. Some argue that the financial gains of this business case could cover the costs of an 'expensive' V2G charging station.

> *P5: This can be compensated financially and mentions the different energy tariffs throughout different times of the day that the Netherlands used to have. This way, the car can be charged using grid energy when it is cheap and sell energy when it is expensive. [ID11]*
> *P6: The idea of charging using cheap energy and discharging at times when energy is expensive is a business case he likes and which could cover the costs of the expensive charging station. [ID5]*

Additionally, interviewees communicate that leasing the V2G-enabled EV would cause less worries related to financial compensation. On the other hand, it would take away the possibility to make financial gains through using V2G.

> *P7: Her motives to adopt V2G differ whether she would own the EV or lease it. When leasing, the potential to generate profits from selling energy to the grid would be taken away, but on the other hand, one would not have to worry about battery degradation. [ID2]*

Especially people using their V2G-enabled EV infrequently would likely gain the most financially, according to some trial participants.

> *P8: He mentions that he sees a lot of people that only use their car once a week, and especially for those people the 'energy trading' could be financially beneficial. [ID5]*

Finally, certain interviewees mention that they believe for other Dutch EV drivers to accept vehicle-to-grid technology, cost reductions or financial gains are paramount. Some even argue that Dutch consumers are primarily driven by savings or financial gains.

> *P9: Other people owning the car would likely want to have net financial gains, or at least no losses from opting for V2G. [ID9]*
> *P10: He believes Dutch consumers are primarily driven by financial savings or potential financial gains. [ID8]*
> *P11: ID3: "For others, experience would do little to enhance consumer acceptance, as financial incentives are a lot stronger factor for most Dutch consumers." [ID3]*

Range anxiety

Range anxiety was another factor present in the initial codebook that had siginifcant groundedness. Questions 1 and 22 serve as examples of questions aiming to discuss range anxiety. Yet, as with other topic areas, respondents often mentioned range anxiety when discussing other factors influencing acceptance, such as battery degradation.

> *Q10: Were you at any point unable to reach your end destination?*
> *Q22: Do you think V2G is compatible with your lifestyle? Did you think differently before using the car?*

As the V2G trial setup in the Green Village did not offer any settings, either on the system of through a smartphone application, many participants suffered from range anxiety. This is different

from scheduling anxiety as range anxiety is related to the (lack of) distance one is able to drive once the EV has been disconnected from the V2G charger, while scheduling anxiety is related to having to schedule one's trips or opting in/out of V2G. There is often a thin line between scheduling and range anxiety, and some statements encapsulate both factors, as in the quote used by interviewee ID8:

P12: ID8: "If I suddenly have to leave at 1 in the afternoon, the car needs to have enough charge" [ID8]

Interviewee ID8 adds that "the final goal of the technology is to indeed not notice any discharging, but that there is difficulty in assessing when the car needs a sufficient charge", suggesting his comment is related more to scheduling anxiety, but also adds that "EVs already have a low range, and V2G may decrease this range even further.", implying range V2G-induced range anxiety as well.

A big number of participants mentioned range anxiety in some form. Many, when experiencing range anxiety, mentioned they did not appreciate it. One person, who was aware of potential range anxiety of V2G, experienced it more heavily than expected. Another participant even decided to switch to the non-V2G charger to be certain of having enough range that day. One specific participant mentioned that range anxiety related to using V2G would push wealthy customers away from adoption, as the small financial gains would not compensate for the uncertain battery level.

P13: He mentions the drawback of uncertainty on state-of-charge when using V2G, which he experienced more heavily than expected [ID17]
P14: The participant experienced a discharging event multiple times and decided to switch to a conventional charger mid-day to be certain of enough range at the end of the day. [ID3]
P15: Mainly wealthier customers, would never purchase V2G as the small financial gains do not compensate for the uncertainty in state of charge. [ID7]

While many did not enjoy the range anxiety, like participant ID17, he mentioned that he would rather call it 'range curiosity' as he would have to look up charging stations before his trip.

P16: He was always able to reach his final destination but suffered some range anxiety on one of his longer trips, meaning that he had to consider his charging locations constantly. He mentions he would not call it 'range anxiety' but 'range curiosity' as he looked up his charging locations beforehand. [ID17]

Some even argued that range anxiety is not a problem unique to EVs, as cars with an ICE may have to diverge from their usual route too.

P17: She states that range anxiety is not a problem unique to EVs, as ICE car can also have this problem when a car station is not on your route. [ID9]

In addition to financial gains or a reduction in costs, participants also mention that decreasing range anxiety increases the likelihood of consumers adopting V2G.

P18: for other (consumers) to adopt V2G he believes they also would like more certainty in battery range. [ID7]

It is important to mention that while many participants suffered from range anxiety or at least mentioned it, some argue that this may partly also be related to the range of the Nissan Leaf. While interviewees were frequently reminded to mention their perceptions regarding V2G technology, they sometimes found it hard to distinguish between the two. This is a topic worthy of discussion. One example except where the participant likely speaks about the Leaf's range, instead of the range resulting from V2G, is given below:

P19: The car was always fully charged, and he was always able to reach his end destination. The participant did mention that he was always cautious about the range of the Leaf. [ID15]

System benefits

System benefits is the first code generated by the interview analysis that did not reflect a code based on a factor of consumer acceptance in the initial model. However, one of the codes in the initial codebook was 'poor business case'. To assess whether the participants saw other business or use cases, question 16 was presented, for example:

Q16: Do you think V2G technology could be useful for other purposes? Has your idea about this changed after using the Nissan Leaf?

Many participants were aware that there are many system benefits inherent to V2G technology. Most frequently, interviewees mentioned the importance of peak shaving and grid stabilization. Many also mentioned the battery of a V2G-enabled EV could be used for energy storage, which is beneficial in several situations. Whether interviewees found these system benefits interesting, they did not specifically mention it would influence their or overall consumer acceptance. Many of these participants did mention that societal, environmental, or personal gains resulting from these system benefits are important to their acceptance.

P20: He believes V2G is a great concept for the future, as the electricity grid cannot cope with the large power demanded by EVs with limited local PV energy generation. [ID17]
P21: ID7: "Solving the problem of intermittent energy generation from solar and wind sources, and temporarily storing this energy in a large battery in the shape of a idle EV, is a great benefit of V2G" [ID7]
P22: V2G could in the future function as a large power bank, being able to power large-scale events or for personal use away from home. [ID12]

Finally, trial participants mentioned some other system benefits. For example, the local energy production through solar panels requires less infrastructural investments. Also, an occupied V2G station serves a useful purpose, while charged EVs connected to a conventional charger only seize useful space.

P23: He appreciates the fact that V2G is local solution and mentions the fact that the solar panels on-site are used primarily to charge the EV. [ID11]
P24: The participant considers V2G to be a better way of charging. The main reason for this is that the charging station is then always used, either to charge the car slowly or to deliver energy to the neighbourhood. [ID5]
P25: Especially in countries with large potential for solar energy, such as Dubai, V2G could be beneficial to stabilize the electricity grid. In the long run, V2G may even decrease the number of power plants required, he thinks. [ID6]

System judgments

While asking about several aspects related to V2G specifically, some participants drew comparisons with other technologies or mentioned other use cases. These comparisons often contrasted the benefits and drawbacks of V2G with the pros and cons of other technologies. Also, some participants mentioned the compatibility with other technologies, such as Smart Grids. Here too, responses were sceptical, positive, or in between.

Participant ID9 considers V2G to be part of Smart Grids but does not specifically mention whether the gains of V2G would influence her adoption.

P26: She considers V2G to be part of Smart Grids, and states that there are many technologies and actors in the electricity system where gains may be achieved. [ID9]

ID6, meanwhile, states that there is more potential for V2G if it is scaled in a central location. Here too, the interviewee does not mention whether this would influence her acceptance, as it suggests societal benefits more so.

> *P27: There is huge potential (for V2G) as an EV can use more energy than multiple houses. He believes the systems should be scaled for the biggest potential to store energy in a central location. [ID6]*

Participant ID8, while not explicitly mentioning other technologies, argues that V2G is the easiest and least invasive way to charge as many cars as possible without overloading the grid.

> *P28: He believes V2G is the easiest and least invasive way to get as many electric cars charged without overloading the grid. [ID8]*

Participant ID3 mentions

Battery degradation

Many participants expressed their worry that due to the increased charge and discharge frequencies with V2G, the battery of their owned or leased EV would degrade faster and lead to decreases battery life and range. Owning and leasing would have different implications.

> *P29: He acknowledges a downside of V2G, namely that due to the charging and discharging cycles, the battery life is decreased. [ID12]*
> *P30: She believes consumers will experience V2G differently due whether they own or lease the car as they won't have to bother with the battery degradation. [ID16]*
> *P31: Her motives to adopt V2G differ whether she would own the EV or lease it. When leasing … one would not have to worry about battery degradation. [ID15]*

To overcome the worry of battery degradation in owned V2G-enabled EVs, two participants suggest leasing the battery pack.

> *P32: The problem of battery degradation could be solved by leasing the battery pack alone, like Renault offers currently. [ID9]*
> *P33: The {problem of} battery degradation could be solved through leasing the battery, like Renault does with Zoë. [ID4]*

Conflicting societal/communal and personal goals

> *P32: To fit his personal and working life, he states that V2G should not be too much of a 'communal' technology, as he still values his personal freedom a personal vehicle should provide. [ID10]*
> *P33: He believes more if something is 'just' or 'unjust', people using V2G should have benefits over those not using V2G, as they contribute something to society. This benefit should not be monetary, but for example, faster charging. [ID4]*

Effort Expectancy

User-Friendliness V2G

The majority of participants believed the V2G system was user-friendly and easy to use, and many believed this would be the case for others or the general public as well. Some even found it superior due to the increased functionalities V2G may offer.

> *E1: He does believe anybody should be able to use a V2G station. [ID7]*
> *E2: He considers the V2G charging station as easy to use as conventional charging stations, and thanks to the additional functionality, he may consider it superior. [ID12]*

Some people disliked having to wait for initialization, while others suggested improving the user interface would have a positive effect on consumer acceptance.

E3: The participant thinks everybody would be able to use the V2G station as it is,yet waiting for the system to start up might scare some people away. [ID5]
E4: A proper interface of what is going on would also attract people to adopt V2G, as this would increase their feeling of control. [ID4]

Trial participants also suggested the biggest step for consumers is actually from cars with an ICE to EVs as this is where the biggest change in behaviour is required.

E5: ID9: "Switching from an ICE car to an EV is already a big step, so including V2G in this is a small price for people." She did not find the V2G station harder to use than conventional stations. [ID9]

Scheduling anxiety

As the V2G trial setup in the Green Village did not offer any indicators (either on the system or through a smartphone application), many participants suffered from scheduling anxiety. This is different from range anxiety as scheduling anxiety is related to having to schedule one's trips or selecting a charging method, while range anxiety is related to the distance one is able to drive once the EV has been disconnected from the V2G charger.

Scheduling anxiety also arose from participants checking the current SOC in the middle of a period of discharge, enhancing their worry that they will not be able to make their next trip. Car owners should also be able to make unexpected trips, some participants say.

E6: She did not enjoy having to go to the car to check the current state-of-charge on days where she really required some range. … A V2G-enbaled EV should still primarily be a car, meaning it should be able to get you from A to B on your own schedule. [ID9]
E7: ID8: "If I suddenly have to leave at 1 in the afternoon, the car needs to have enough charge" [ID8]
E8: The necessity for freedom, that car owners should be able to make unexpected trips, or trips with a longer distance than expected, too without much hassle. [ID16]

Social Influence

The codes within the Social Influence category were not mentioned with enough groundedness individually to be considered as part of the top codes. As a large majority of interviewees remarked some kind of Social Influence, the codes were merged to be part of the top codebook. Social Influence in the UTAUT is quantified by the three determinants of *Subjective Norm*, *Social Factors* and *Image*, and this distinction is used to declare the differences between the Social Influence codes.

Subjective Norm

Subjective norm is related to the social pressure a potential consumer experiences. Many participants, for example, experience we live in a time of changing norms. For example, V2G would fit together with automation and car sharing platforms, as owning cars will not be the norm in the future. The feeling of working together to solve a problem is also beneficial towards consumer acceptance. Others think V2G will make people perceive energy differently, either as always being part of the grid or the V2G battery functioning as an energy buffer.

S1: He also believes V2G will help in the change in perception that everybody should own a car as it is very suitable for car sharing platforms. [ID13]
S2: Other stimulants to adopt V2G may be promotion the social aspect of the technology by "solving a problem together" [ID15]
S3: Participant ID4 believes in the future, there is no ownership of electricity, it is always part of 'the grid'. Smart contracts could help in this switch [ID4]

S4: He believes you should see your state-of-charge as a buffer of energy. [ID4]

Social Factors

Social Factors are related to the norms, values, and roles inherent to a potential consumer. For example, some participants believed the energy passing through V2G systems should only be used for certain participants. Participants like to be aware of their energy use, and some are surprised at how much electricity EVs actually consume.

S5: He additionally mentions that he would like to be able to choose where the discharged energy is going. He mentions that this technology should have societal benefits, and if your neighbor decides to use his sunbed, this is not energy well-used. [ID13]
S6: She enjoyed the feeling of knowing that charging the leaf was done mostly locally through the PV panels, and mentions she would have liked to see more specifically where the electricity had come from or where it contributed to when not properly charged. [ID9]
S7: He became aware of increased benefits such as knowing the amounts of energy used in daily life [ID11]

Image

A group of seven participants mentioned something related to the image of owning or driving a V2G enabled car. The ambiguity, which is also often stated as a reason for doubting the potential of V2G, could be seen as attractive to certain potential consumers.

S8: She also thinks people will fall for the 'newness' of the technology calling it a 'gadget' for some tech-savvy people to show their current charging or earning patterns. [ID14]

Facilitating Conditions

Control/Set State-of-Charge

A large majority (13 out of 17) of participants mentioned that having some way to control the EV battery's state-of-charge is important to their acceptance of V2G as a potential consumer.

The different methods of controlling the SOC suggested by interviewees can be categorized as follows. First, some participants would only require some basic level of control, such as opting in or out at the charging station or through a smartphone application.

F1: ID4: "In certain cases, for example for large trips, there should be a way to ask for an exception to control your state of charge manually." [ID4]
F2: For future adoption, he believes you should be able to set certain parameters. The most important of these parameters is to set the 'full or V2G' option, while he believes that for most days setting to V2G will suffice, as even a small percentage of charge will function for commuting. [ID4]

Others demand a more interactive approach where the user can set a desired or minimum SOC at a certain point in time, preferably from a smartphone application or in the car.

F3: Having additional control options would have greatly improved her experience, being able to set certain parameters such as minimum range at a specific point in time. [ID2]
F4: She suggests using a smartphone app, where you can set a minimal range at a certain point in time for additional control. [ID9]

Several participants mentioned a smart or automated way of controlling the state-of-charge, namely by integrating it with their personal agendas.

F5: ID4: "Using intelligent systems, it can be determined for you how much charge you need to get from A to B and anticipate accordingly." [ID4]

Ex6: A way to utilize V2G even better would be to connect it to your personal agenda, which is a smart way to control the minimum state of charge. [ID5]

Controlling the SOC is not only considered to be beneficial to the primary user of V2G, being able to communicate that your car will not be in use and therefore require little drivable charge, would also increase some system benefits.

F7: In some way, she would like to communicate with the V2G station to set a minimum charge at a certain time or not require any power in the next days. [ID14]

Participants also expressed that being able to control the SOC would help decrease or eliminate their scheduling anxiety (and range anxiety?)

F8: To alleviate this problem {of having to schedule his trips}, he would like to have control the minimum state of charge at a specific point in time. [ID15]

Distrust and uncertainties

Participants mentioned cases of distrust and uncertainties in different shapes. Some people did not believe V2G would achieve a societal goal or would decrease their feeling of freedom or control, while others were simply uncertain whether they connected properly or if the system worked.

F9: One requirement he would like to see for adoption is a way to set a minimum distance, as you don't want the feeling of not being in control, which he considers is characteristic to cars. [ID10]
F10:He liked the fact to see the V2G station on-site, but is worried he may have done something wrong when connecting the car. [ID13]
F11: ID5: "The main goal of experience is to take away the doubt of uncertain levels of charge in the car." [ID5]

View State-of-Charge

Some participants suggested being able to view the current SOC on demand would be enough for their or other consumer's acceptance of V2G. Like with controlling the State-of-Charge, some say they would only opt for V2G if they had a way to control or at least view the current SOC.

F12: She would like to see the current state of charge, preferably from a smartphone application, and compares it to smart energy meters in homes. [ID14]
F13: When buying an EV, she would opt to include V2G only if there was a way to control the level of charge and have a way to view the current state-of-charge. [ID16]

Clear communication of benefits, costs, risks, and opportunities

As we have seen, experience is considered by many participants to alleviate certain doubts and uncertainties. Yet, some participants find that clearly communicating the (balance of) benefits, costs, risks, and opportunities would additionally help with consumer acceptance of V2G technology. Some participants believe this would steer them towards adoption, others think the general consumer would profit from this specifically.

F14: If there is a proper business case, meaning the savings and/or profits from energy storage outweighing the costs of an earlier battery replacement, this should be communicated to the consumer. [ID1]
F15: ID5: "For large-scale adoption, consumers should get clear answers to those potential benefits or barriers, or it may scare them away instead." [ID5]
F16: He is curious to know about the exact battery degradation, and having a clear answer to this (presented at time of purchase) would help him with choosing V2G. [ID13]

4.3 Established factors and implications

Based on the resulting codes presented in section 4.2 and the analysis of the impressionistic descriptions thereof, a list of factors influencing consumer acceptance can be made, as attached in table 7. As certain codes are closely related, the resulting factors are occasionally a combination of several codes. It is important to restate that not all codes analysed in sections 4.2 and 4.3 were related to factors on consumer acceptance, some codes included more general views, opinions and beliefs regarding V2G. Based on the factors in table 7, the resulting conceptual model is created. This is clearly described after the visual representation in 9. The resulting conceptual model provides a visual representation of the factors influencing consumer acceptance of V2G by EV drivers in the Netherlands. The goal of the conceptual model is to get a clear overview of the aspects related to the adopted UTAUT model in relation to Use Behaviour.

Driver profile characteristics (DPC) codes were not included in table 6 on top-20 codes, or in the impressionistic analysis, as they are not related to factors influencing consumer acceptance. The codebook for the *DPC* is, like all code categories, included in Appendix D. Codes included in the *DPC* code category include mentions of whether participants would or would not buy an V2G-enabled EV, whether participants spoke to friends about V2G, or whether they would or would not recommend buying an EV with V2G technology. Also, remarks on EV vs ICE favourability, and the need of EVs or V2G, are included in driver profile characteristics metrics as well.

Though the *DPC* were not collected to give a quantitative representation of the participant's opinion regarding the codes described above, they still give some interesting insights into how favourable they really are of V2G. In essence, stating that a participant would buy a V2G-enabled EV suggests that they, as potential consumers and EV drivers in the Netherlands, accept V2G, albeit under certain conditions only. A great number of participants state, for example, that they would opt for V2G when buying their first EV. For some of them, they would only include V2G if there was a way to turn it on or off, or if there is some way to control the SOC, and a single respondent would only go for V2G if he or she could view the current level of charge. Some would only opt for V2G for their second car, while others simply would not. They argue that the uncertainty in range is too much of a limiting factor, even when money is earned, or that the technology is not developed to a stable level right now. Participant ID9 leaves in the middle if she would chose a V2G-enabled EV, and mentions that "It really depends what is in it for me" [ID9]. All participants who were very fond of personal V2G adoption, would also recommend it to friends.

Almost all participants spoke to friends, family or peers in some form, most of which was positive. Various interviewees mentioned that those acquaintances showed interest in V2G and the implications of the technology, and nobody was completely sceptical. Similarly, about half of the respondents mentioned their favourability of EVs over fossil-based vehicles, particularly with regards to the environment, while about a quarter believe EVs are not as environmentally friendly as many believe. Two participants are sceptical of the need for V2G, one of them mentioning that the energy transition is not required while the other states that there are simply no purposes for using V2G in the consumer market.

The resulting factors influencing consumer acceptance of V2G of EV drivers in the Netherlands can be enumerated as:

Table 7: Factors determined influencing consumer acceptance

Factor	Explanation
Control over State-of-Charge	Controlling the state of charge is different from being able to view the state-of-charge, which is another factor influencing acceptance and described below. Control over SOC does include being able to opt-in or -out of V2G. Controlling the SOC can be done in many ways, and the reader is referred back to section 4.2 for more details. Many participants found being able to control the SOC to be a requirement for personal adoption of V2G.
User-friendliness V2G	User-friendliness includes the code of operational reliability. Participants found that the V2G trial system was easy to use, though some experienced error messages. It is argued that the system should remain easy to use and should be operationally reliable for potential consumers to not be scared away
Financial compensation	Financial compensation includes cost reduction and financial gains. Participants stated that they would like to be compensated, especially financially, for the additional battery degradation and uncertainty of range and scheduling. Some hope to save money in addition to this compensation, while others see business models and consider potential savings to be potential financial gains.
Range anxiety	Many trial participants experienced range anxiety in some form and to a certain extent. Often they did not appreciate facing range anxiety and believe V2G might decrease the level of charge upon departure as compared to conventional charging. Being able to control or view the SOC would decrease their range anxiety.
Distrust & uncertainties	Distrust and uncertainties come in many forms. Some participants simply were not sure they connected and initialized the charger correctly or whether there are any benefits, while others are wary it would take away their personal freedom.
Scheduling anxiety	Apart from range anxiety, participants also frequently experienced scheduling anxiety. Having to schedule one's trips around the uncertain V2G charging pattern caused anxiety for the participants. Interviewees stated that having some way to view or set the battery level or state-of-charge would decrease their scheduling anxiety.
Battery degradation	Many participants were aware that increased frequencies of charging and discharging would degrade their battery quicker. As the battery pack is an expensive part of the EV, they were wary of the replacement cost or the decreased range. Interviewees believe financial compensation for this battery degradation should come in some form. Some participants state that they would experience battery degradation differently if the car was leased, while others suggest leasing the battery pack while owning the EV with V2G themselves.
Clear communication of implications V2G	Implications of V2G are the benefits, costs, risks, opportunities, etc. related to using V2G. Along with education, participants believe that being well-informed increases the likelihood to choose V2G.
Viewing State-of-charge	Being able to view the current state-of-charge, preferably on-demand through a smartphone application, is named by many to be an important barrier for personal adoption of V2G. Many prefer being able to control the SOC, but state that viewing the SOC is a minimal requirement. Being able to view the SOC would also decrease range and/or scheduling anxiety, the interview analysis implies.

4.4 Trial Experience

Trial experience

Throughout the interviews, participants were continuously asked whether they thought differently of certain aspects of V2G before and after participating, or whether experience using (systems related to) V2G made them look at the technology differently. Examples of such questions are plentiful, and were sometimes related to testing another concept / factor.

> *Q12: What do you think of the V2G concept after participating? Can you name any additional benefits, barriers, risks, opportunities, costs or rewards after participating? Can you reflect changes in your views before and after trial experience?*
> *Q14: Will experience using V2G change how you influence others?*
> *Q19: Do you think everybody could use V2G in its current form to charge their EV? How did you think before using the Nissan Leaf?*

Before participating in the trial, the opinion of the participants regarding V2G technology was split. Though nobody was initially pessimistic, three participants were sceptical of the technical feasibility of V2G or the benefit V2G would provide to them as a potential consumer. A third believed there may mainly be external benefits, such as societal and environmental benefits. Still, a majority of participants found the technology fascinating or innovative. Eight participants were proponents of V2G and ten stated the need for V2G, with two people arguing before being in the trial that V2G will become embedded into the general EV charging infrastructure naturally. After participating and gaining trial experience of V2G, all-but-one of the sceptics became optimists too, though with reservations. Interestingly, almost all of the participants who initially considered the technology to be innovative or "the next big thing in EV charging", still believed so though with new reservations. Only in two cases, trial experience has made participants who were initially positive of V2G very sceptical of the technology.

It was discovered that trial experience does not influence each factor regarding consumer acceptance, and that the factors that are influenced differ in the level of change. In the resulting model in figure 1, arrows are drawn to the factors that are influenced by trial experience, with the dotted line representing a slight or inconsistent influence. Trial experience directly influences how participants experience range anxiety, as they will match their attitude towards the technology's behaviour after trial experience. Trial experience therefore decreased range anxiety in the sample, however, those with much experience or knowledge (*Familiarity)* of EVs or V2G would experience less strong of a decrease in range anxiety.

A critical condition for acceptance is financial compensation, though participants differ as to whether this compensation should cover the costs for battery degradation only or also for the inconvenience of having a flexible SOC. Results show that trial experience generally does not change the participants' attitude towards financial compensation. Similarly, trial experience does not change the attitude towards battery degradation itself, which is part of the necessity for financial compensation. Not until the interview is conducted is when the participants knew about such issues, which is a recommendation for future research. Participants frequently state that education will assist with adoption, for the simple reason that most people are unaware of V2G and its implications such as battery degradation.

Under *Effort Expectancy*, trial experience influences the attitude of the sample with regards to user-friendliness to a certain extend. Most participants found the V2G station easier to use than

expected, while participants generally state that due to their experience, they have thought of ways to improve user-friendliness, for example through an app. This allows them to view the current state-of-charge, which after trial experience they aware of is a minimal necessity for the sample's acceptance. Though many in the sample were aware of potential range anxiety related to EVs and V2G in particular, trial experience made participants aware of scheduling anxiety due to V2G discharging.

> *T1: The V2G station is easy to use, and everybody should be able to use a final version of a V2G station, while he expected it to be harder before participating. [ID15]*

No specific factors on *Social Influence* were determined, yet trial experience did affect the *social influence* determinant slightly. For example, half of the participants mentioned that due to their experience, they became aware of their electricity use or became interested in other use cases of V2G or similar solutions. Under *Facilitating Conditions,* clear communication of the implications of V2G was considered by the participants for their, but more notably, other's adoption of V2G. Similar to education, clear communication of the implications of using V2G may push people towards adoption, but trial experience only makes them aware of this need. Experiencing V2G influences the attitude of participants regarding distrust and uncertainties, where participants provided more statements of distrust and uncertainties when the car or V2G system did not behave as expected.

Overall, interviewees stressed that having the possibility to control the state-of-charge in of your EV is a critical condition for their acceptance of V2G. Participants state that thanks to trial experience, they became aware that having control over the SOC decreases or eliminates both range and scheduling anxiety. Some participants listed these two conditions before their trial experience, while after trial experience all participants who noticed a discharging event and most others who did not also set these conditions as critical for acceptance. During analysis, it was found that for many, experiencing V2G has made them aware of this barrier's existence as well as confirm that this barrier should be overcome for personal adoption or overall consumer acceptance.

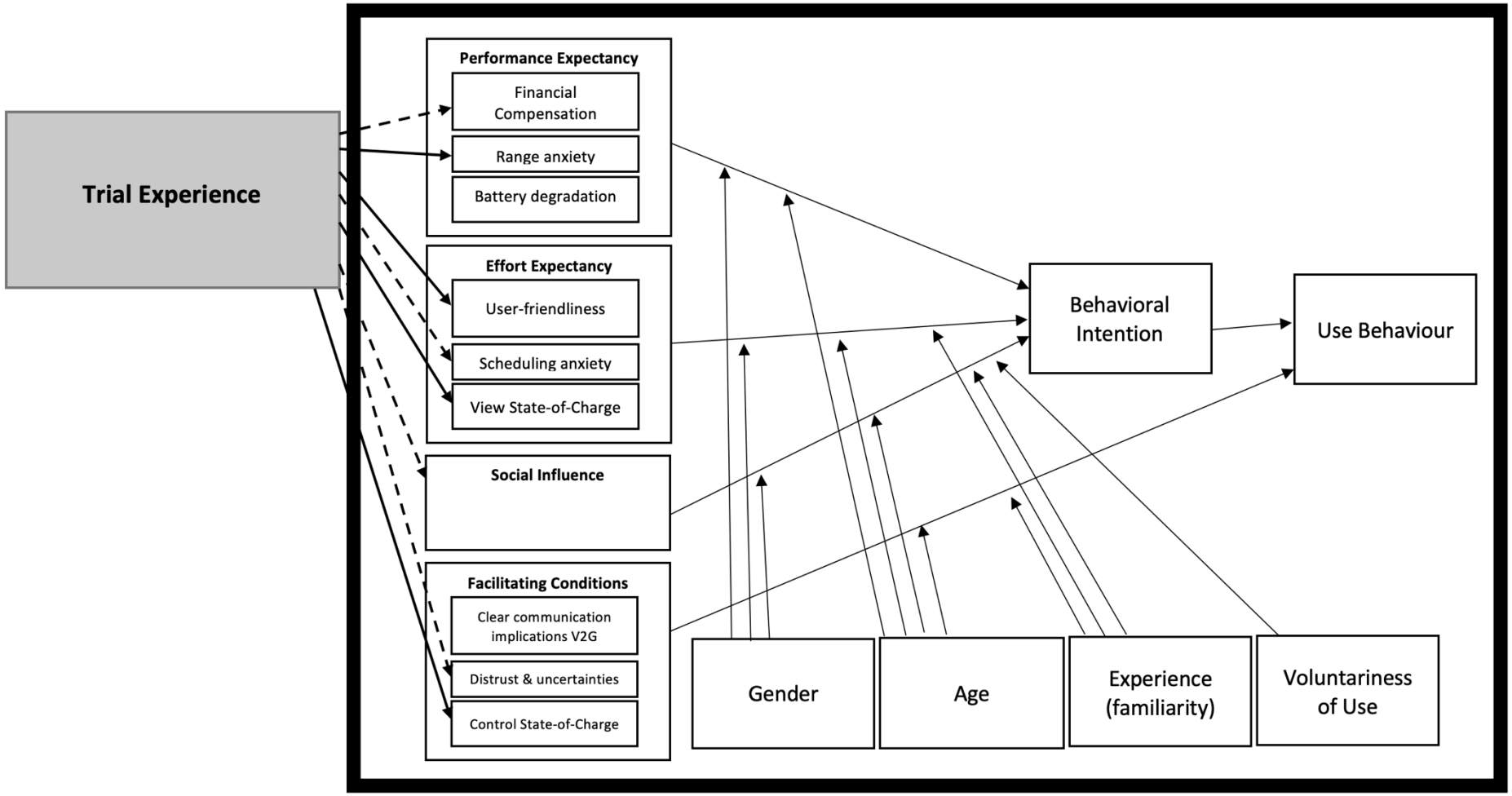
> *T2: Experiencing V2G has made the interviewee aware of that she finds the barrier of controlling the minimum charge to be very important for adoption. [ID2]*

For others, experience has made little to no difference to their belief into the benefits or practicality of V2G. Some say that experience confirmed their doubts, other participants mentioned they saw more drawbacks than before.

> *T3: After participating, she still does not believe V2G to be practical for personal use as you are limited by the unknown schedules of those around you [ID14]*

The mediating determinant of *familiarity* decreases the influence of trial experience, as for participants who mentioned knowledge and/or interest into V2G technology showed little change in attitude towards aspects of V2G technology before and after trial experience. Drawing conclusions regarding *voluntariness is use* if difficult, as each participant contributed voluntarily. However, participants who were sceptical of the potential and necessity of V2G (or EVs in general) generally did not show changes in attitude. No conclusions can be drawn regarding *gender* differences, and regarding *age* data shows that the only participants for which trial experience did not improve their attitude towards V2G were above 35, but this may also be a result of greater experience with cars.

Figure 9: Resulting model



4.5 Other relevant findings

System benefits (Performance Expectancy)

System benefits encompasses all codes for system benefits, Peak shaving / Grid stabilization, energy storage / power bank, as well as any other system benefits mentioned by the interviewees, such as local energy generation and a decreased need for large infrastructural investments. Participants frequently state that they see many potential system benefits with the introduction of V2G. They also believe that for system benefits to occur in the greatest capacity, scale issues should be overcome. Generally, system benefits alone are not attractive in pushing consumers towards adoption. All participants who are considered sceptical of the technology, believed that there were still many benefits for the greater society, such as peak shaving.

Conflicting societal and personal goals (Performance Expectancy)

Especially before partaking in the trial, participants were excited about the societal, environmental, or communal benefits of V2G. Mainly system benefits were named. However, particularly after trial experience, participants were sceptical of the personal benefits. While some were excited about potential financial gains and others willing to give up on some freedom, many argue that V2G should not be too intrusive. Not being able to set any control parameters contributed to this feeing.

System Judgments (Performance Expectancy)

System judgments are a combination of several codes, namely: Other use cases, Superior to other systems and Works with other systems. Participants frequently mention V2G in relation to other novel technologies, or other use cases for V2G. Many believe V2G can be used to its best potential at high volume locations, while others see possibilities for integration into the smart grid. Two participants mentioned they would like a Vehicle-to-home solution.

4.6 Representation

Section 4.6 contains information regarding the sample and its relationship to the population of EV drivers in the Netherlands. The goal is to know who participated and interviewed, how the participants were contacted, and whether the sample is representative of the population. The representation of the sample was considered in the initial stages of the research and is considered important to the validity of the results. Yet, as the focus of this research was on assessing the influence of trial experience on consumer acceptance, representation follows the core findings described from 4.1 to 4.4.

As described in the interview methodology in section 2.1, candidates got in touch with the research through the researcher's own network, the supervisor's own network, a social media advertisement, posters and digital screens on campus, and through word of mouth. All channels ended up being used, with the majority of participants getting in touch through personal networks and the posters on campus. Participants were selected to provide a sample as representative as possible of the population based on age, gender and level of education completed. Each participant was then contacted personally to set their (at minimal) week of trial and subsequently to plan the semi-structured interview of about an hour.

As part of the interview, each interviewee was asked several questions related to a representation questionnaire. These questions ask for certain demographical background information. Having this data present serves two goals, first to help assess whether the trial and interview sample were representative of the set population of 'Dutch EV drivers', and secondly to give the reader a better feeling of the sample and interviewees.

In figure 10, an overview of the distribution in gender, age and highest level of education completed. From this figure, it is determined that the sample comprises mainly a young, highly educated, and male group. Upon further inspection, 76% is male and 65% is under 35. Also, 77% can be considered highly educated (HBO or higher), with 71% even having completed a university degree. Over two thirds have completed a university degree, while over one third had completed a master's degree. The data per participant can be found in Appendix C, while the relative percentages of the representation questionnaire are further discussed in section 5 as part of a comparison with percentages of the set population.

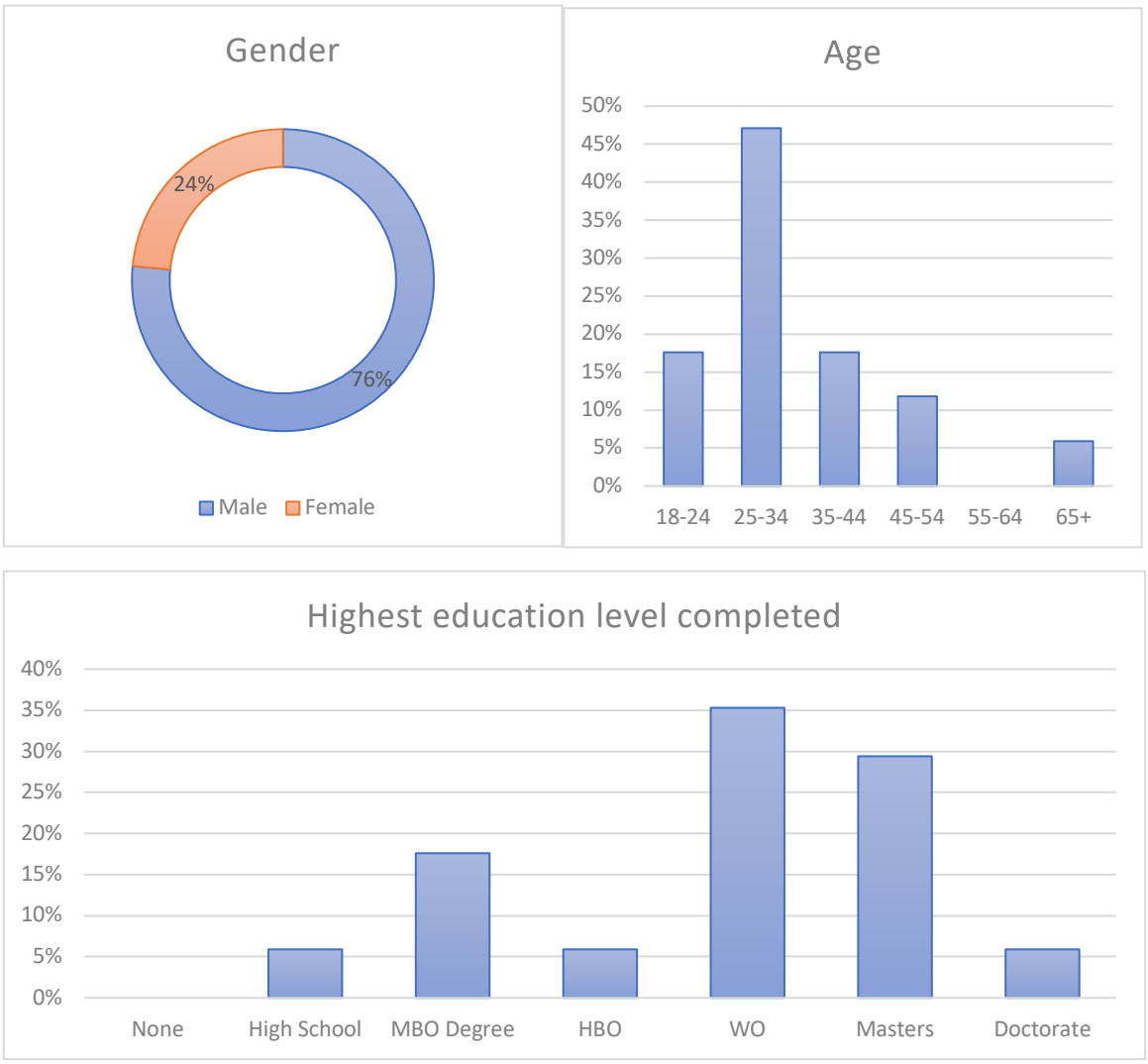


Figure 10: Demographical background interviewees (n=17)

Certain additional characteristics regarding level and type of experience were measured, and the source/type of experience is shown in figure 11. Interviewees were asked about what kind of

experience they have previously had with an EV, what type of EV this was, and if this experience was through lease or ownership, how many years the vehicle had been with them. From analysing the data, one finds that nobody leased their EV, two people owned their EV, fourteen people had other experience of some form and one person had no previous experience with EVs. Hence, 94% of the sample had some experience with EVs. All these participants had at least two experiences of driving EVs. All-but-one (thirteen) participants with experience of some form had experience with BEVs, while three also had experience with PHEV. From the two cases of ownership, one owned a PHEV for 1-3 years while the other owned a BEV for over 3 years already. 15 out 17, or 88% of participants, had never owned or leased an EV. It can be concluded that the vast majority had experience using BEVs, like the Nissan Leaf in the trial, before.

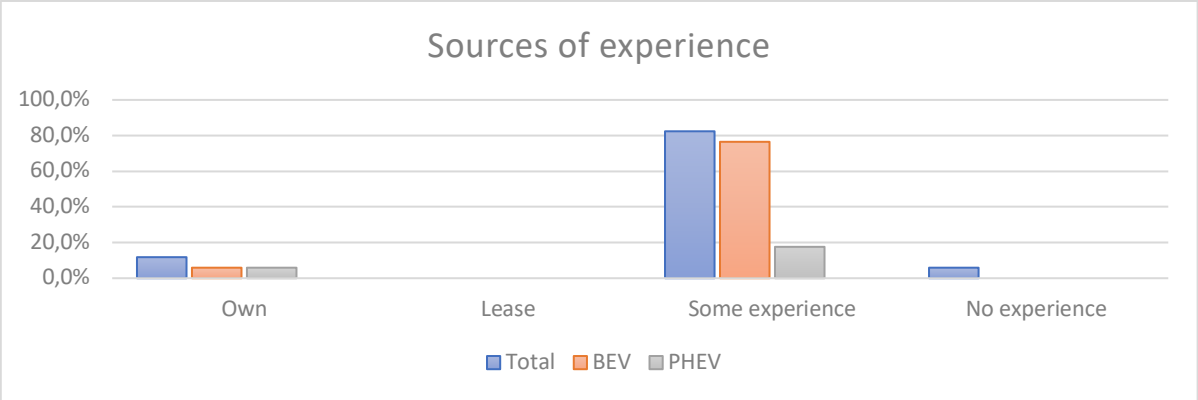


Figure 11: Sources of experience

Representativeness comparison

The ultimate aim of the representation questionnaire is to determine the representativeness of the sample. In this study's sample, participants were predominantly male, highly educated and young (65% under 35). Almost all participants had experience with a BEV, and only some with PHEV. Also, nobody leased their EV, two owned their EV and a vast majority had experience through car sharing platforms, their family, other a general interest in EV technology.

Unfortunately, in the Netherlands no database on the socio-demographic characteristics of EV drivers is available. The Dutch government agency of RVO, however, publishes statistics regarding EV type registration. Published through an external website, the Netherlands counts 208,564 BEVs and 128,816 PHEVs on September 30, 2021. This is a relative percentage of 61.8% BEV and 38.2% PHEV, up from 105,011 or 53.3% BEV and 91,847 or 46.7% PHEV at the end of 2019 (Nederland Elektrisch, 2021). Additionally, many studies reviewed in the literature review, boasted a similar sample with regards to age, gender and education, yet ownership numbers are very different among other studies. In table 8, both socio-demographic characteristics and characteristics of EVs on the Dutch roads from other studies and sources are compared with the available data from this study.

		This study	(Zonneveld, 2019)	(Parsons et al., 2014)	(Sovacool, Kester, et al., 2018)	RVO, 2020 [5]
Socio Demographic Characteristics		Percentage (n=17)	Percentage (n=96)	Percentage (n=3029)	Percentage (n=367)	Percentage
Gender	**Male**	76%	91% (+15%)	43% (-33%)	67% (-9%)	-
	Female	24%	9% (-15%)	57% (+33%)	33% (+9%)	-
Age	**18-24**	18%	2% (-16%)	30% (-34%)	20% (+2%)	-
	25-34	46%	9% (-36%)		25% (-21%)	-
	35-44	18%	22% (+4%)	43% (+13%)	24% (+6%)	-
	45-54	12%	38% (+26%)		18% (+6%)	-
	55-64	0%	18% (+18%)	27% (+21%)	8% (+8%)	-
	65+	6%	11% (+5%)		5% (-1%)	-
Highest education level	**None**	0%	0% (=)	-	0% (=)	-
	High School	6%	8% (+2%)	-	11% (+5%)	-
	MBO	18%	14% (-4%)	-	6% (-12%)	-
	HBO	6%	29% (+23%)	-	31% (+25%)	-
	WO	35%	40% (-30%)	37% (-33%)	52% (-18%)	-
	Master's	29%	-	-	-	-
	PhD	6%	-	-	-	-
EV Type	**BEV**	76%	-	-	-	62% (-14%)
	PHEV	24%	-	-	-	38% (+14%)
EV Ownership	**Lease**	0%	42% (+42%)	-	-	-
	Own	12%	46% (+34%)	-	-	-
	None (experience)	82%	12% (-70%)	-	-	-

Table 8: Overview of sample's demographic characteristics in comparison

The data in this table requires some sidenotes. First, definitions vary across articles and sources. "EV type" for this study considers the type of EV that participants have had experience with. As some had experiences with both, the cumulative percentage surpasses 100%. For the RVO, EV type is defined by the relative percentage of EV registrations in the Netherlands. As car sharing platforms in the Netherlands are generally BEV, this could explain the difference in this number. Also, comparing highest education level completed required some internalization. Zonneveld and Sovacool et al., for example, considered different levels of high school (VMBO and HBO/VWO) and no distinction in university degrees (Sovacool, Kester, et al., 2018; Zonneveld, 2019). Hence, in the comparison, some options are combined, for example, to compare university education level with Zonneveld (2019) and Sovacool et al. (2018), WO, Master's and PhD are combined. Parsons et al. meanwhile only states that 37% has completed a BA or higher, and grouped age in larger categories.

After comparing the distribution of certain socio-demographical and EV ownership characteristics, it cannot be determined whether this study is statistically representative. However, as the participants of EV drivers share similar demographics as statistics from the ANWB and …, the sample can be considered representative for measuring opinions and arguments. In general, the age in this study was on average lower than other studies, and the highest education level higher than the other studies. The gender distribution fell in the middle of other studies. This does not make the sample unrepresentative, as the Dutch EV driver has the characteristics of being male, middle aged and highly educated as well. Considering that the Nordic Countries are different than the Netherlands in terms of socio-demographic characteristics, conclusions of this study should be thoroughly and critically discussed.

4.7 Discussion

Though many results and implications were already discussed, a final discussion will conclude the results section of this research. This discussion will compare the results with the existing scientific literature, discuss the differences between participants, and reflect on the chosen methods.

Comparison results and literature

The literature review revealed that there are several factors related to consumer acceptance of V2G. These were *financial compensation / gains, remuneration, range anxiety, battery degradation, charging time, complexity and confusion, required lifestyle or travel pattern change, preference other technologies, consumer resistance or lack of consumer awareness, environmental benefits, control, transparent communication, discomfort and uncertainties, and a poor business case.* Arguing on the push towards or pull from acceptance related to each factor is beyond the scope of this study, but suffering from range anxiety likely decreases consumer acceptance. Each factor was categorized according to the determinants of the conceptual model.

Many of the factors in literature are included in the final codebooks and resulting model. These were based on the analysis of the interview transcription's data reduction using coding, which revealed both factors influencing consumer acceptance of V2G and factors related to other technical, economical and more views and opinions related to V2G. For example, *financial compensation / gains* was found in both the initial factor codebook and the resulting list of factors in table 7. *Remuneration*, meanwhile, was not found to be a factor influencing consumer acceptance of itself, although many interviewees mentioned remuneration as part of financial compensation. *Range anxiety* and *battery degradation* were found both in literature and in the final codebook, while *charging* time was not mentioned by the participants directly. Likely, long charging times would give the participants *scheduling anxiety*, which was one of the codes found in the analysis which was designated as a factor influencing consumer acceptance.

Control, a factor found in literature, was found to be very significant to the interviewees, but in the analysis a division between *Control State-of-Charge* and *Set State-of-Charge* were made in coding, and the codes were designated as factors influencing consumer acceptance. The factors in the initial codebook of *Complexity and confusion* together with *Discomfort, uncertainties* were split in the final codebook in *Distrust & Uncertainties* and *User-friendliness V2G*, as not many participants showed confusion regarding use of V2G because they found it easy to use, while they explicitly state uncertainties towards V2G benefits and distrust of their data. Finally, *Transparant communication* was perceived among the participants to be important to their and other's likelihood to buy V2G, but they believed the communication should focus on conveying the risks, benefits, barriers and opportunities of V2G. Therefore, in the final codebook and list of factors, the term *clear communication of implications V2G* was used. This entails that the poor business case, lack of consumer awareness, preference of other technologies and environmental benefits were not considered as factors influencing consumer acceptance of V2G, and *User-friendliness, Viewing State-of-Charge* and *scheduling anxiety* were added.

Participant characteristics and differences

The characteristics of the participants and the sample at large is also an important topic of discussion with respect to the implication and interpretation of the results. The sample consisted of

a predominantly young, highly educated, and male group, which is in line with the characteristics of EV drivers in the Netherlands. In this regard, the sample is representative of the population of EV drivers. The fact that the majority of the sample did not own or lease an EV, but only had experience through sources like car sharing and their parents or friends, requires a longer discussion on the validity of the results. First of all, people driving an EV regularly are well-aware of the characteristics of the vehicle and, more importantly, the charging thereof. A large portion of the V2G technology revolves around the charging station, and some of the participants mentioned they had not used a conventional charger before.

Secondly, considering people with just several experiences driving EVs to be EV drivers, may be a simplification. They have not experienced differences in battery performance due to weather conditions, wear and tear, etc. and may not be aware of the issues that come with driving electrically, even without V2G. Yet, for safety reasons, only people related to the TU Delft through work or study were allowed to apply. Bachelor students were excluded, as their experience relating to EVs may be even lower. Also, the covid-19 pandemic made it difficult to find more participants who leased or owner their EV, as most of the people that would use those vehicles worked from home at the time of research.

Reflecting on chosen qualitative methods

Finally, the method of semi-structured interviews has certain implications. For example, even though the semi-structured format allows for follow-up questions and conversations, it is hard to quantify the data because it is so vast. Each participant's answer is slightly different, meaning that it is up to the interpretation of the interviewer to assess codes to the statements made. Gauging acceptance from, for example, asking a question related to their likelihood of buying V2G in the future does not bring conclusive answers. While for some it is a definitive yes or no, others set requirements of barriers, such as is actively discussed in the results. Investigating each participant's requirements for adoption and comparing this with their background and other views is tedious, and often no significant rationalisation can be found regardless. Still, as compared with closed interviews or surveys, the level of detail of the information derived from the data is very insightful and provides unique views.

Also, again due to the open format, it may be that the interviewer put too much or too little emphasis on certain topics, which affects the results by the groundedness of certain codes. To compensate for this, the statements and quotes inside each of the top-20 codes are analysed and compared with codes outside of the top-20. In the impressionistic description and the resulting factors, therefore, in certain occasions codes outside the top-20 but related to one of the codes in the top-20 are also described and, in case of a factor influencing consumer acceptance, considered in the final list of factors.

5. Conclusions, Contributions and Recommendations

This chapter provides the conclusions and contributions, both practical and theoretical, of this research. Additionally, recommendations for future research, policy makers and designers of V2G and electricity grid systems are listed.

5.1. Conclusions

The goal of this dissertation, as described in the research objective, was to fill the knowledge gap of assessing the influence of trial experience with V2G on consumer acceptance of specifically EV drivers in the Netherlands. A research question was constructed:

> "How is consumer acceptance of vehicle-to-grid by EV drivers in the Netherlands influenced by trial experience of the technology?"

In short, it was found that trial experience with V2G influences consumer acceptance only in certain ways and is often mediated by different variables. Using factors determined from literature and the UTAUT acceptance model to conceptualize a model on the relations between these factors on consumer acceptance, results from the interview data reduction and analysis allowed for conclusions and comparisons to be drawn. Trial experience influences consumer acceptance most significantly by changing participant's attitudes towards the factors of range anxiety and (desired) user-friendliness. Participants also became aware they find viewing or controlling the state-of-charge to be a vital barrier for adoption, which could take away scheduling anxiety and other uncertainties as a result. High *Experience (familiarity)* generally decreases the influence of trial experience, while conclusions for *Gender*, *Age* and *Voluntariness* of Use are hard to draw.

Investigation of the interviews revealed that the participants were split in their opinion towards V2G technology before partaking in the trial. Though nobody was initially pessimistic, some participants were sceptical of the technical feasibility of V2G or the benefit V2G would provide to them as a potential consumer. In other words, they had initial beliefs. After participating and gaining trial experience of V2G, most sceptics became optimists too, though often with reservations.

It was discovered that trial experience does not influence each factor regarding consumer acceptance, and that the factors that are influenced differ in the level of change. In the resulting model in figure 1, arrows are drawn to the factors that are influenced by trial experience, with the dotted line representing a slight or inconsistent influence. Trial experience directly influences how participants experience range anxiety, as they will match their attitude towards the technology's behaviour after trial experience. Trial experience therefore decreased range anxiety in the sample, however, those with much experience or knowledge (*Familiarity)* of EVs or V2G would experience less strong of a decrease in range anxiety.

A critical condition for acceptance is financial compensation, though participants differ as to whether this compensation should cover the costs for battery degradation only or also for the inconvenience of having a flexible SOC. Results show that trial experience generally does not change the participants' attitude towards financial compensation. Similarly, trial experience does not change the attitude towards battery degradation itself, which is part of the necessity for financial compensation. Not until the interview is conducted is when the participants knew about such issues,

which is a recommendation for future research. Participants frequently state that education will assist with adoption, for the simple reason that most people are unaware of V2G and its implications such as battery degradation.

Under *Effort Expectancy*, trial experience influences the attitude of the sample with regards to user-friendliness to a certain extend. Most participants found the V2G station easier to use than expected, while participants generally state that due to their experience, they have thought of ways to improve user-friendliness, for example through an app. This allows them to view the current state-of-charge, which after trial experience they aware of is a minimal necessity for the sample's acceptance. Though many in the sample were aware of potential range anxiety related to EVs and V2G in particular, trial experience made participants aware of scheduling anxiety due to V2G discharging.

No specific factors on *Social Influence* were determined, yet trial experience did affect the *social influence* determinant slightly. For example, half of the participants mentioned that due to their experience, they became aware of their electricity use or became interested in other use cases of V2G or similar solutions. Under *Facilitating Conditions,* clear communication of the implications of V2G was considered by the participants for their, but more notably, other's adoption of V2G. Similar to education, clear communication of the implications of using V2G may push people towards adoption, but trial experience only makes them aware of this need. Experiencing V2G influences the attitude of participants regarding distrust and uncertainties, where participants provided more statements of distrust and uncertainties when the car or V2G system did not behave as expected.

Overall, interviewees stressed that having the possibility to control the state-of-charge in of your EV is a critical condition for their acceptance of V2G. Participants state that thanks to trial experience, they became aware that having control over the SOC decreases or eliminates both range and scheduling anxiety. Some participants listed these two conditions before their trial experience, while after trial experience all participants who noticed a discharging event and most others who did not also set these conditions as critical for acceptance.

The mediating determinant of *familiarity* decreases the influence of trial experience, as for participants who mentioned knowledge and/or interest into V2G technology showed little change in attitude towards aspects of V2G technology before and after trial experience. Drawing conclusions regarding *voluntariness is use* if difficult, as each participant contributed voluntarily. However, participants who were sceptical of the potential and necessity of V2G (or EVs in general) generally did not show changes in attitude. No conclusions can be drawn regarding *gender* differences, and regarding *age* data shows that the only participants for which trial experience did not improve their attitude towards V2G were above 35, but this may also be a result of greater experience with cars.

5.2. Contributions

5.2.1. Scientific contributions

The scientific contributions are contained in the research objective. The research objective was to fill the knowledge gap in consumer acceptance of V2G, namely of trial experience of V2G influences this consumer acceptance for specifically EV drivers in the Netherlands.

Additionally, by answering the sub-research questions, some additional scientific contributions are made. Firstly, while there is extensive literature on factors related to consumer acceptance, likelihood of adoption or similar social aspects of V2G. Much of this research was conducted in Nordic countries, though the Netherlands, Germany and other countries were also focus areas in research. Also, research involves mainly surveys, choice experiments or expert interviews. Nevertheless, little studies used semi-structured interviews, and none combined this with a trial experiment in a regular-day setting, which provides different insights into these factors than previous research.

In comparison to other research, many of the factors explaining consumer acceptance found in literature overlapped with the ones found in the analysis of the interview data reduction. This confirms their relevance in consumer acceptance research, though not all factors found in literature were retrieved in the analysis. Previous research stated the importance of considering consumer aspects for V2G adoption and trial experience in relation to attitude changes, and this research re-affirmed these conclusions.

No previous research on the influence of trial experience with V2G on the consumer acceptance thereof was conducted previously. This foundation can function as the starting ground for many similar types of research, in which for example the researcher changes certain parameters, such as different charging contract types. The conclusions drawn from this research can be used in similar research on V2G acceptance, which generally do assess the participant perceptions in such a detailed qualitative manner.

5.2.2. Link to MSc Management of Technology

The goal of the MSc Management of Technology is to learn how technology can function as a corporate resource and how the technology can be implemented best. With regards to V2G, companies may benefit from offering V2G enabled cars to their workforce by using both the stored energy and storage capacity of large fleets of leaded cars. Adopting V2G could, for example, allow a company to become energy neutral without the need for local energy storage infrastructure.

The thesis has significant overlap with core courses of the Management of Technology program. In Technology Dynamics, students were taught on the adoptions and diffusion patterns and reasons, where the importance of considering your customer's wishes were stressed upon. Results from this thesis confirmed this notion. Similarly, in the Emerging and Breakthrough Technologies course, the importance of using Innovation Projects was presented, which explains how trial experiments help move a technology from a concept to a marketable product by discovering underlying motivations of the consumer.

5.3 Recommendations

5.3.1. Recommendations for future research

Future research could focus on a similar trial experiment with different parameters, such as a group with system control options and one without. Similarly, quantitative research could assess the relative strength of influence of consumer acceptance factors in relation to trial experience. Other research could use a representative trial setup but in other regions or other settings, such as at work, or for companies. The demographics of the Netherlands do not make the results as relevant

and directly interpretable in locations with, for example, lower population density or EV adoption percentages.

Policy makers should, as suggested by previous research and affirmed in this thesis, consider the needs and desires of the consumer or their citizens. V2G offers many system benefits that may help assist in meeting certain targets or goals, such as with the energy transition and the embedded intermittency of the sustainable energy sources. However, the greatest system benefits occur at the least control of the user, which is undesirable. Working together with grid system designers, policy makers should aim to determine a good balance between control characteristics and system benefits on one hand, and battery degradation and financial compensation on the other.

Policy makers can, in addition to additional possibilities for trial experience to increase consumer awareness, educate the public on the need for V2G-like solutions and the implications to their future transport possibilities and characteristics. Policy makes should encourage automobile makers to educate their users on the implications of V2G, which should influence their acceptance positively.

Finally, V2G and grid system designers should be aware of the general attitudes of the future consumer. Consumers vary to the extent that they are willing to give up freedoms for uncertainties, and participants require compensation for their uncertainties and battery degradation. Allowing users to view the current and projected levels of charge in the battery may satisfy some, but others would demand full control over their battery level. Additional control for the consumer results in decreased potential for system benefits such as grid balancing. V2G and grid system designers should consider that educating and communicating the benefits and implications of using V2G generally increases the acceptance of consumers in a similar manner trial experience does.

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Appendices

Appendix A: Interview protocol

Interview Protocol

Related to the MSc Thesis:
Influence of Trial Experience with V2G on consumer acceptance of EV drivers in the Netherlands

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As part of
MSc Management of Technology

Graduation committee

Chair:	Prof. Dr. ir. Zofia Lukszo, section Energy & Industry (TPM)
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Introduction

Research background

As nations strive towards sustainable practices in both energy supply and (personal) transportation, large barriers have to be overcome. One such barrier is the intermittency of renewable energy supply, the inflexible energy demand patterns and the disbalance thereof, requiring temporary but costly electric energy storage. Electric vehicles, boasting large idle battery capacities, sit idle for a majority of the time and using vehicle-to-grid technology may assist in overcoming this energy supply-demand disbalance while providing benefits to the owners of EVs. Conventional chargers are usually one-directional, meaning that they can only provide energy to the vehicle. For this reason, vehicle-to-grid (V2G) technology has been developed as an idea to support the energy grid during these fluctuations of supply and demand. Using V2G technology, (renewable) energy is drawn from the grid and stored in EV batteries during times of excess supply when the energy is cheap, and energy is drawn from the batteries to the grid during times of excess demand when energy is more expensive

The goal of the research, and subsequently of these interviews, is to determine whether the experience of using vehicle-to-grid technology changes the consumer acceptance of participants on a commuter basis. This has led to the following research question: *"What factors explain consumer acceptance of vehicle-to-grid by car drivers in the Netherlands and how is this perception changed by experience?"*. Where previous research has focused the technical and environmental aspects of V2G, literature shows that more research is required to fill the knowledge gap on the social dimensions of the technology. In this realm, research has focused on the perception of car drivers in general, discussed expert opinions or looked for the impact of specific use cases, little has been discovered on the deeper insights of EV drivers as a comparison between before and after experiencing V2G. In order to answer the research question, semi-structured interviews are held based on the insights discovered using the Unified Theory of Acceptance and Use of Technology (UTAUT) and literature research. The semi-structured interviews will be held with weekly trial participants of V2G technology, where each participant is asked to use an electric car for a week and charge it using V2G technology in the Green Village at the TU Delft.

Reasoning behind semi-structured interviews

From literature review, it was found that previous research on consumer acceptance of vehicle-to-grid technology or smart charging applications has relied heavily on survey or structured interviews within a specific use case. More in-depth insights into people's incentives and perceptions is needed, as many studies have established that considering social dimension plays an important role in the successful adoption of a technology. The goal of the interview is to investigate how **experience** using V2G technology changes **acceptance** of V2G technology, by analysing how participants perceive certain predetermined variables or factors after a one-week trial. Using a semi-structured interview, one can pre-determine the direction of the interview through selection of certain interview topics, yet allow for additional insights through conversation. Questions may be added or altered depending on previous interview results.

Goal of interview protocol

This interview protocol serves as a guide to provide an overview of the procedures required before, during and after the interview, to present the topics to be researched as are determined in a theoretical framework, and to lay out the questions to be asked. The interview protocol should give an overview of how topic areas and questions are related through theory, and to describe what data is to be researched and analysed.

Structure of interview protocol

Succeeding the introduction, this interview protocol consists of the subsequent sections:

- **Interview methodology:** Overview of steps required for taking a successful interview.
- **Theoretical framework:** Based on the literature review, a summary of the main findings is presented. Through these findings, topics areas for the interviews are determined.
- **Interview script:** Linking the interview methodology and theoretical framework allows for the creation of the interview script. The goal of the interview script is to formulate questions covering the topic areas determined in the theoretical framework.
- **Trial advertisement:** Copy of the physical/digital advertisement used to reach trial participants.
- **Research ethics & data management:**
- **Informed consent form:** Form (in English only) asking participants for permission to use interview data and information for the analysis of this Master thesis research and other academic research purposes.

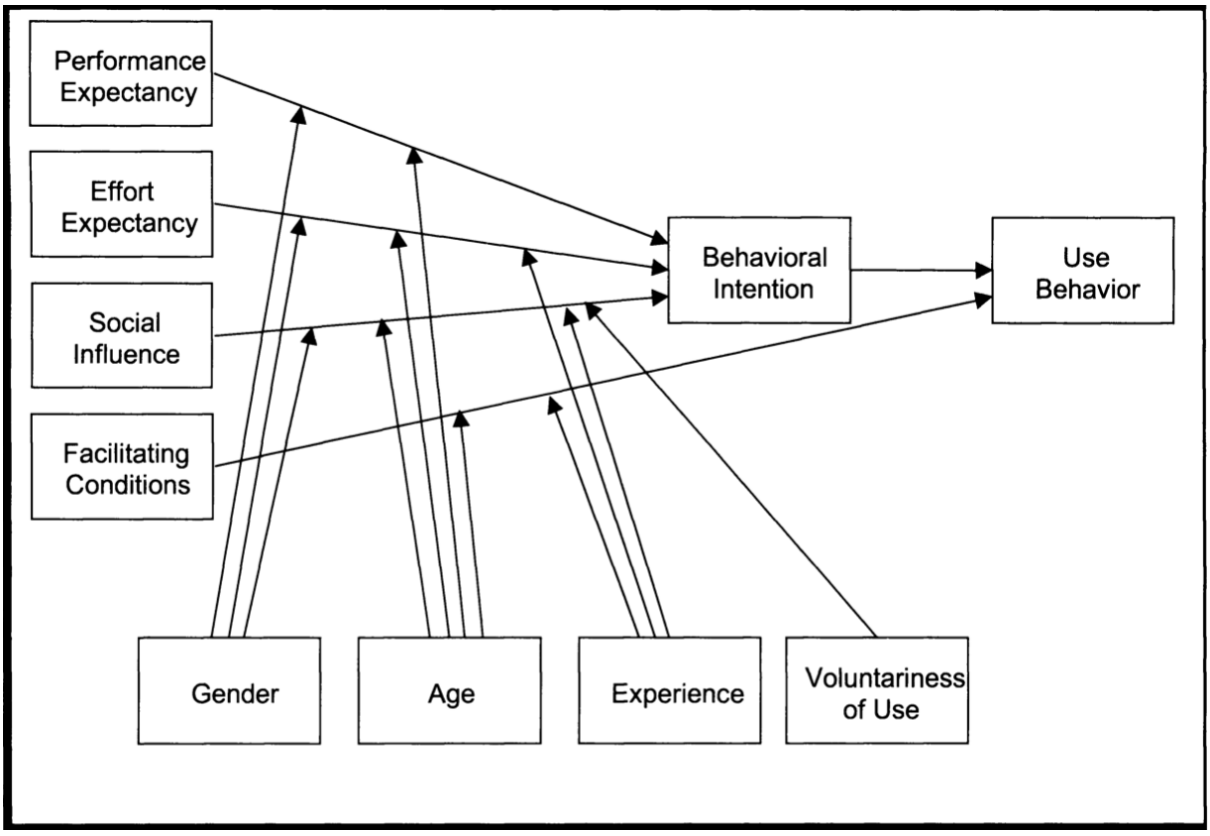
Interview methodology

The following steps are taken from early preparation of the interview to integration of the interview data into the thesis research.

1. Determine the required information for the interview. What topics, factors or variables do we want to know more about?
2. Prepare the initial interview questions. Covering the topics, factors and variables to be researched as presented in the theoretical framework. As the interview is semi-structured, additional questions may be added or existing questions may be altered, as new insights are revealed.
3. Finding participants for trial and evaluation interview. Candidates must adhere to several set criteria, such as having experience with an EV and working or studying at the TU Delft. Participants are found using the researcher's own network, the supervisor's own network, social media advertisement, posters on campus and using the digital screens on campus.
4. Participant selection. In the aim of reaching a sample as representative of the population as possible, participants are selected based on age, gender and education level.
5. After participants are selected on a running basis, trials and subsequent interviews are planned separately. After trial, the participant is given a couple of options for the evaluation interview that should occur within a few weeks. The interviews will be executed in an online environment using Teams, as the Covid situation in the spring of 2021 does not allow for interviews in a face-to-face manner.
6. After each interview, the researcher will transcribe the spoken text and combine them with notes taken during the interview into an interview report. This report is shared with the participant within 7 days after the interview. After 2 weeks of non-response, permission to use the data Is assumed. Until that point, the interviewee can rectify or omit any personal data from the interview.
7. Using code saturation, the interview transcript is then analysed and graphed.
8. After data analysis and graphing, the new knowledge is integrated in the thesis. Using the new insights, further conclusions on the research topic can be drawn, and discussions and suggestions for further research can be made.

Theoretical framework:

In order to maintain a theoretical backbone into technology acceptance models, the Unified Theory of Acceptance and Use of Technology (UTAUT) was reviewed, and aspects of the model used in the creation of interview questions. Where many models on technology acceptance are available in literature, the UTAUT combines several of such models which allows for a unified view of user acceptance of technology. (Venkatesh, 2003).



The UTAUT conceptual model depicted in the graph acknowledges 4 constructs that appear to have a significant role as direct determinants of user acceptance and usage behaviour. These are depicted on the left as 'performance expectancy', 'effort expectancy', 'social influence' and 'facilitating conditions'. Venkatesh also established that in other models, the constructs of 'attitude toward using technology', 'self-efficacy' and 'anxiety' appeared to be of significant influence yet were not included in UTAUT. Still, as previous research has shown that at least to a certain extend these factors are mentioned during interviews, questions on these topics are prompted as well. Finally, in the conceptual model below, 'Gender', 'Age', 'Experience' and 'Voluntariness of Use' are considered as key moderators, with the latter two being allowing for questions.

'Performance expectancy' is defined as the degree to which an individual believes that using the system will help him or her attain gains in job performance. As technology acceptance models interpret this factor differently, five constructs used in different models are given in the UTAUT: Perceived usefulness, extrinsic motivation, job-fit, relative advantage and outcome expectations. While the definition and scales/explanation are included in my thesis, sample questions and

statements will need to be altered to fit the specific use case of the V2G technology. Hence, a sample statement of 'Using the system would improve my job performance' would become 'Using V2G technology would improve my commute', leading to the question 'Do you think using V2G technology would improve your commute?'.

Similarly, effort expectancy is defined in the UTAUT model as the degree of ease associated with the use of the system. This variable is defined differently in technology acceptance models too, leading to the three constructs of 'perceived ease of use', 'complexity' and 'ease of use'. Sample statements such as 'Using the system takes too much time from my normal duties' can be fit into the question 'Do you think using the system takes too much time from my normal duties, as compared to normal EV charging?', with the possible follow-up questions of 'Why?' and 'How?'.

Social influence is defined as the degree to which an individual perceives that important others believe he or she should use the new system, with the constructs of 'subjective norm', 'social factors' and 'image. Finally, facilitating conditions are defined as the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system, with the constructs of 'perceived behavioural control', 'facilitating conditions' and 'compatibility'.

What is interesting about the model is that the variables of performance expectancy, effort expectancy and social influence, along with the moderating variables of gender, age, experience and voluntariness, all point towards 'Behavioural intention' before leading to 'Use behaviour'. Meanwhile, facilitating conditions have a direct correlation with 'Use behaviour'. I will explain this in further detail in my thesis.

In addition, previous research has pointed towards some factors influencing consumer acceptance of smart charging or more specifically V2G technology. While the definition of the constructs described in the UTAUT model are quite generalizable and should be modified in order to fit the V2G technology use case, the factors from previous research are specific and will allow for direct question generation. Usually, they fit into the constructs defined in the UTAUT model. For example, 'battery degradation' or 'lack of control' are considered barriers for adoption, these can be categorized under 'performance expectancy'. Additional factors 'Range anxiety', 'system inflexibility', 'privacy and security', 'environmental benefits', 'monetary compensation', 'availability of facilities' and 'location' will form the basis for additional questions as well. Finally, questions more directly related to the trial setup, participation and handling are posed.

Interview script

In the theoretical framework, a conceptual model was created. Using this model, the topic areas to be asked questions on .. . The interview script consists of the interview opening, the core interview questions (which are based on the topic areas presented), closing questions and a final representation questionnaire. Questions and prompts of each category are presented in tabular format in both English and Dutch, as the interview is conducted in either of the two languages. Transcription is always presented in English.

Interview opening

The following prompts are used to start the interview formally.

Table 1: Interview opening prompts

English	**Dutch**
1. Thank you for your participation in the V2G trial and your time in conducting this evaluation interview. 2. This interview will be used as data for my Master thesis and for other academic purposes related to the PowerParking research. 3. You will be participating anonymously. 4. During the interview, notes will be taken. 5. Do you give permission for an audio recording of the interview? 6. Do you give permission for possible clarification questions? 7. The interview recording and notes will be transcribed. Within seven (7) days, you will receive this transcript for approval. 8. You have the right to request access to, rectification of or deletion of personal data. 9. In case of non-response on the transcript, permission to use the data is assumed after two (2) weeks.	1. Bedankt voor het meewerken aan het onderzoek naar V2G en uw tijd tijdens dit interview. 2. Dit interview wordt gebruikt om data te verzamelen voor mijn Master scriptie en voor andere academische doeleinden omtrent PowerParking onderzoek. 3. Deelname is volledig anoniem. 4. Tijdens het interview zullen aantekeningen worden genomen. 5. Geeft u toestemming voor audio opname van dit interview? 6. Geeft u toestemming voor mogelijke toelichtingen naderhand? 6. De audio opname en notities worden digital uitgeschreven. U ontvangt deze binnen 7 dagen ter goedkeuring. 7. U heeft recht te vragen om toegang tot, correcties van en verwijdering van persoonlijke data. 8. Indien binnen 2 weken geen reactie is ontvangen, wordt aangenomen dat er toestemming is gegeven de data te gebruiken.

Core interview questions

The core interview questions are categorized according to the several factors that are to be investigated. Questions are numbered for consistency and clarity purposes.

Table 2: Core interview questions

English	Dutch
Introduction questions	**Introductie vragen**
1. Can you tell me more about the trial you participated in?	1. Kun je me meer vertellen over het onderzoek waarin je hebt meegedaan?
2. How did you get in touch with the research trial?	2. Hoe kwam je in contact met het onderzoek met de Nissan Leaf?
3. For what reasons did you decide to participate in the V2G trial?	3. Voor welke redenen besloot je mee te doen aan het onderzoek?
4. Did you have previous experience driving EVs, and how much? What is your opinion on electric driving?	4. Heb je eerdere ervaring met het rijden van elektrische auto's, en hoe veel? Wat is je mening over elektrisch rijden?
5. How knowledgeable and interested are you with electric driving technology? How does that differ from conventional fossil-fueled cars?	5. Hoeveel kennis en interesse heb je ten aanzien tot elektrische auto technologie? Verschilt dit van traditionele auto's met verbrandingsmotor?
6. How knowledgeable and interested are you in EV charging technology? Had you heard of V2G or smart charging technology before?	6. Hoeveel kennis en interesse heb je ten aanzien van oplaadtechnologie van elektrische auto's? Had je ooit van V2G of smart charging gehoord?
7. What did you think about the trial? What did you like, what could be improved?	7. Wat vond je leuk aan de proef, wat kon er beter?
8. Do you have any experience with other V2G systems?	8. Heb je ervaring met andere V2G systemen?
8.1. Would you buy an EV equipped with V2G technology? Did experiencing V2G change your views?	8.1. Zou je een EV met V2G technologie kopen? Heeft de ervaring je mening hierover veranderd?
8.2. Did you talk to friends or family about V2G? Did experiencing V2G change your views?	8.2. Heb je V2G besproken met vrienden of familie? Heeft de ervaring je mening hierover veranderd?
8.3. Would you recommend adopting V2G technology to people around you? Did experiencing V2G change your views?	8.3. Zou je mensen in je omgeving aanraden om V2G te omarmen? Heeft de ervaring je mening hierover veranderd?
Questions on V2G trial	**Vragen over de V2G proef**
9. Have you noticed the discharging of the EV? What have you noticed?	9. Heb je het ontladen van de elektrische auto opgemerkt? Wat merkte je op?
10. Were you at any point unable to reach your end destination?	10. Kon je op enig moment je eindbestemming niet bereiken?
11. Before participating, what did you think of the V2G concept?	11. Voor deelname aan het onderzoek, wat vond je van het V2G concept?
11.1. Can you think of any benefits, barriers, risks, opportunities, costs or rewards that came to mind before participating?	11.1 Kun je van de periode voor deelname aan het onderzoek benoemen of je enige voordelen, barrières, risico's, perspectieven, kosten of beloningen in gedachten had?
12. What do you think of the V2G concept after participating?	12. Wat vond je van het V2G concept, na deelname aan het onderzoek?

12.1 Can you name any additional benefits, barriers, risks, opportunities, costs or rewards after participating? 12.2 Can you reflect changes in your views before and after trial experience? 13. Were you influenced by your environment to participate, if so, how? 14. Will experience using V2G change how you influence others? 15. Do you think trial experience has a big influence on people's acceptance to adopt V2G technology? What else could improve this acceptance potential? 16. Do you think V2G technology could be useful for other purposes? Has your idea about this changed after using the Nissan Leaf? 17. Do you have any new motivation to adopt V2G? Why? 18. Would you perceive V2G as a superior way of charging electric vehicles? Has this changed by using the technology? 19. Do you think everybody could use V2G in its current form to charge their EV? How did you think before using the Nissan Leaf? 20. Did you find the interaction with the V2G tedious? Was it different from what you expected? (after/before introduction) 21. After using the V2G charger, do you think it is easy to learn how to use V2G? 22. Do you think V2G is compatible with your lifestyle? Did you think differently before using the car? 23. Do you think V2G fits within your work life? Has this changed after experiencing the technology? 24. Would any (monetary) incentive push you towards adoption of V2G technology? 25. Has your perception on this changed since using the car? 26. Would you use V2G for your own EV if you knew it would degrade your battery? And how is compensation related to this? 27. Were you worried about range issues while using the V2G car? How would you alleviate those worries?	12.1 Kun je van de periode na deelname benoemen of je nog andere voordelen, barrières, risico's perspectieven, kosten of beloningen had bedacht? 12.2 Kun je reflecteren op het verschil in je antwoorden voor en na de onderzoekservaring? 13. Ben je beïnvloed door je omgeving om mee te doen? Indien ja, hoe? 14. Verandert ervaring met het gebruik van V2G hoe je anderen erover benaderd? 15. Denk je dat ervaring met V2G technologie de acceptatie/bereidheid tot gebruiken van V2G beïnvloedt? Wat zou hier nog meer invloed op kunnen hebben? 16. Denk je dat V2G voor andere doeleinden nuttig zou kunnen zijn? Heb je hier een andere mening over gekregen sinds het gebruik van de Nissan Leaf? 17. Heb je sinds gebruik van de Nissan Leaf/meedoen aan het onderzoek, andere motivatie/redenen gekregen om de technologie te omarmen? Waarom? 18. Zie je V2G als een betere manier van opladen t.o.v. de huidige manier? Is je mening hierover veranderd door het gebruik van de oplader? 19. Denk je dat iedereen de V2G oplader in zijn huidige vorm kan gebruiken om hun elektrische auto op te laden? Hoe dacht je hierover voor het gebruik van de Nissan Leaf? 20. Vond je de interactie met het V2G laadstation tijdrovend/langdradig? Is dit veranderd in de loop van het onderzoek? 21. Denk je dat het makkelijk is om de V2G oplader te gebruiken? 22. Denk je dat V2G technologie (onzekerheid, slecht voor de accu, maar wel stimulans zoals extra geld) past bij je levensstijl? Hoe dacht je hierover voordat je de auto had gebruikt? 23. Denk je dat V2G technologie binnen je werkschema past? Was je idee hierover anders voor gebruik van de auto? 24. Zou een externe stimulans je bereidheid tot het gebruik van de technologie veranderen? Zoals geld, of extra plaatsen? 25. Is je mening hierover veranderd door het gebruik van de auto? 26. Zou je V2G voor je eigen elektrische auto gebruiken als je wist dat het de leeftijd van je accu zou verminderen? Hoe is compensatie hiertoe gerelateerd?

	27. Had je last van afstandsangst tijdens het onderzoek? Hoe zou je deze kunnen verminderen?

Closing questions and prompts

Table 3: Interview closing questions and prompts

English	**Dutch**
1. This is the end of the formal interview. I'd like to thank you again for your time in both the trial and interview. 2. Would you like to add to your answers? 3. Do you have any comments or questions regarding this interview? 4. Do you have any comments or questions about my research? 5. Are you interested in receiving the final research report? 6. I would like to again mention the following: My notes and transcript will be sent for approval within 7 days. 7. You have the right to request access to, rectification of or deletion of personal data. 8. In case of non-response on the transcript, permission to use the data is assumed after 2 weeks. 9. Would you know any other people interested in participating in the V2G trial?	1. Hiermee eindigt het formele deel van het interview. Nogmaals bedankt voor uw tijd tijdens dit interview en het onderzoek. 2. Wilt u iets toevoegen aan uw antwoorden? 3. Heeft u nog vragen of opmerkingen over dit interview? 4. Heeft u nog vragen of opmerkingen over mijn onderzoek? 5. Wilt u de eindversie van mijn onderzoek ontvangen? 6. Ik wil graag nogmaals het volgende mededelen: Mijn aantekeningen en transcriptie zullen binnen 7 dagen worden opgestuurd voor goedkeuring. 7. U heeft het recht te vragen om toegang tot, correcties van en verwijdering van persoonlijke data. 8. Indien binnen 2 weken geen reactie is ontvangen, wordt aangenomen dat er toestemming is gegeven de data te gebruiken. 9. Kent u andere mensen zie mee zouden willen doen aan mijn onderzoek?

Representation questionnaire

The following questions will only be used to validate a representative sample of interviewees and is treated anonymously throughout the rest of the research.

Interviewee code: ____.

Interview date: __-__-2021

What is your gender?
☐ Male
☐ Female

What is your age?
☐ 18-24 years
☐ 25-34 years
☐ 35-44 years
☐ 45-54 years
☐ 55-64 years
☐ 65+ years

What is your highest level of education completed?
☐ None
☐ Middelbare school (High School)
☐ MAVO (Secondary vocational education)
☐ HBO Bachelor's degree (Applied Sciences)
☐ WO Bachelor's degree (University)
☐ Master's degree
☐ Doctorate (PhD)
☐ Other, please specify _____

Please select what is applicable
☐ I own an electric vehicle, namely a ____ (PHEV, BEV, HEV)
☐ I lease an electric vehicle, namely a _____ (PHEV, BEV, HEV)
☐ I have driven an electric vehicle before. If so, about _____ times
☐ Other, please specify: _____

If owning or leasing an EV, for how long?
☐ <1 year
☐ 1-3 years
☐ >3 years

Advertisement to find trial participants

The advertisement below is used to approach as many students and TU Delft employees as possible while practicing social distancing during Covid times. Hence, no flyers were handed out and this advertisement was distributed in physical form by posters visible at most faculties, as well as in digital form through social media groups and the video screens on campus faculties and libraries.

The advertisement deliberately displays only the four main requirements to participate in the research. After the QR-code is scanned or the URL is filled in using an internet browser, prospective participants are asked to provide their contact information and availability, while at the same time given additional information as follows:

At the Green Village, a unique vehicle-to-grid (V2G) charger is installed.
V2G technology allows excess energy supply from the grid and local renewable sources, such as solar panels on parking lot roofs, to be temporarily stored in EV batteries.
Similarly, when excess energy is demanded, EV batteries can be discharged.
Research on EV drivers acceptance of V2G requires your help
For one week of choice, comfortably drive a Nissan Leaf for free!

Requirements to participate:
An employee or MSc student of TU Delft working physically on campus
Drive the car 3 days of any given week, while parking and charging at the Green Village during the day
Available between April and July for trial and one-hour evaluation
Live within a 70km radius and have experience driving an EV

For more information or other questions, please email to: powerparking-3me@tudelft.nl

Informed consent form

You are being invited to participate in a research study titled **PowerParking project**. This study is done by **Rishabh Ghotge** (PhD candidate) and assisting MSc graduates under supervision from Ad van Wijk from the TU Delft.

The purpose of this research study is two-sided:

1. investigating technical feasibility of vehicle-to-grid (V2G) in a microgrid at GreenVillage;
2. Identifying social factors contributing to EV drivers' (end-users) acceptance of V2G.

The data will be used for academic research purposes (PhD, Master theses and scientific publications). Participation includes: information session, 4-5 days driving an electric vehicle, daily charging at the V2G station at GreenVillage, (audio-recorded) interview afterwards.

There are no other known risks associated with this research beyond risks of driving and charging. Interview answers in this study will be included anonymised in publications. Any data collected by TU Delft is according the GDPR legislation. Data is stored on the secured data storage of TU Delft. For this research, approval was received by the TU Delft human research committee.

Please tick the appropriate boxes	**Yes**	**No**
Taking part in the study		
I have read and understood the study information dated […./…./…..], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	○	○
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	○	○
I understand that I am in temporary possession of expensive equipment, will take care of the same within reasonable limits and will return them in similar condition to that in which I received them.	○	○
Use of the information in the study		
I understand that information I provide will be used for academic research (PhD & Master theses & scientific papers). Anonymised research data will be stored for 15 years for academic purposes.	○	○
I understand that personal information collected about me that can identify me, such as my name or where I live, will not be shared beyond the study team.	○	○
I understand that all information will be anonymised before publications.	○	○
I agree that my information can be quoted in research outputs (e.g. interview citations)	○	○
Future use and reuse of the information by others		
I give permission for the audio-interview and location-based data to be collected and that I provide to be archived in TU Delft so it can be used for future research and learning.	○	○

Signatures:

_____	_____	_____
Name of participant	Signature	Date
_____	_____	_____
Name of researcher	Signature	Date

Contact details: Rishabh Ghotge, R.Ghotge@tudelft.nl

Information sheet

A) Summary Research

The research involves the building and testing of a solar carport for charging electric vehicles, including a bidirectional charger that allows energy from the vehicles to be discharged at a later point. The technical research question involves both the measurement of the reduction in grid energy used as well as the reduction of peak energy consumption by the set-up. However, there will also be research conducted on the operation of the system here, collection of commuter parking patterns, using the measurements collected here for modelling of larger scale systems as well as social research on the acceptability of bidirectional charging for Dutch electric vehicle drivers.
As part of the project, TU Delft employees who regularly drive electric vehicles to work will be given the opportunity to charge their vehicles at the (unidirectional) charger. Similarly, the project vehicle will be used for bidirectional charging. Data related to their electric vehicle battery charging will be measured by means of energy meters. Times of arrivals and departure from work and GPS locations will also be measured. The data will be used in a variety of research applications.

B) Risk assessment

The participants in the project will be handling electric cables and vehicle charging infrastructure at the test site. However, there are expected to be no special risks involved. The parking space will also include the bidirectional charger with higher voltage and the solar equipment, but these will have a high voltage sign and be locked in a cabinet respectively. Careful driving of the vehicle is expected at all times and a speed limit sign will be placed at the site location (the Green Village) to ensure low driving speeds are maintained.
The personal data (arrival and departure times, GPS locations, etc.) collected will be confidential and may only be accessible for researchers in the project and will be anonymised before publication in any form. Participants will be asked before participation for consent to the fact that their data will be collected for research and publication purposes. Anonymised research data will be stored for 15 years for academic purposes.

C) Contact details

Rishabh Ghotge	PhD candidate, project lead researcher r.ghotge@tudelft.nl
Koen Nijssen	MSc. Candidate K.P.Nijssen@student.tudelft.nl

Appendix B: Interview reports

Report: Interview 1

Interviewee information

Interviewee code	ID1
Interview date	17-05-2021
Gender	Male
Age bracket	25-34
Highest education level	Master's Degree
EV ownership & type	None, multiple experiences with BEV
Length of lease/ownership	-
Would like copy research?	Yes

Interview transcription

Opening information and background

Participant ID1 used the V2G station with the Nissan Leaf over a year ago, for a period of a whole month. He got in contact with the research through his work at the Green Village. The participant lives in a major city in the Randstad and usually travels by public transport to Delft, he was eager to discover the difference in experience by travelling by car. Reason to participate were his interest in sustainability, the convenience of a car and to try out an EV. He has previously driven a BEV through car sharing platforms and believes EVs are the future. The participant does not have a technical background, but he follows the news on new technologies, and he was able to name a few examples of smart charging, but he seemed.

He liked to proper explanation and believes everything was handled well and easy to use. He was surprised by the range of the Nissan Leaf, having experienced an event where his battery almost died on a long trip, result in having to charge at somebody's private home charger after public stations were unavailable for various reasons. He did find this a funny experience.

Experiences using V2G technology

When asked about the interaction with V2G technology, ID1 mentions that he did notice slight differences in range when leaving from the V2G station, but never to an extent that he was close to not reaching his house or back. This discharging, therefore, never bothered him. He loves the concept of V2G, he believes there is a big need for a electric energy storage capacity as the amount of green energy increases. He likes the fact that the PV panels above the V2G station deliver energy to a local source. He cannot name any more pros and cons.

He mentions he is hesitant to buy an EV at this point as there are little fast chargers or V2G stations but would consider buying an EV when there are more available. The car would have to have a larger range than the Nissan Leaf used in this research. He was not influenced by his environment to participate but did talk to his friends and family about it. His friends were also sceptical of V2G technology, mainly because it is not widely adopted yet, but the concept itself seemed promising to them.

He believes that experience using V2G would positively influence his and other's willingness to adopt the technology. He additionally believes the benefits should be properly stated at purchase. From participating, he now believes V2G is a better way of charging, and he would purchase a V2G station himself if it were possible. Before participating, he did not think of the difference between charging

stations. He also likes the idea of a 'decentralized grid' using the two-way flow of energy, in addition to the capabilities of V2G.

Later he points out an additional downside he thought of after participating, which is that he believes V2G makes the charging potentially very slow. That would decrease the willingness to adopt V2G for the public. When asked how he would alleviate this problem, he suggests some way to set a specific level of power at a certain time. He believes the V2G charging station was easy to use and should be for others as well. He believes V2G fits his work schedule, and could potentially work for his private life when the above mentions conditions are met.

When asked about the degradation of the battery, he would like to see what the real costs of the technology is. If there is a proper business case, meaning the savings and/or profits from energy storage outweighing the costs of an earlier battery replacement, this should be communicated to the consumer. He believes leasing a V2G car would cause less monetary worries as compared to owning a car equipped with V2G.

Report: Interview 2

Interviewee information

Interviewee code	ID2
Interview date	17-05-2021
Gender	Female
Age bracket	25-34
Highest education level	Master's Degree
EV ownership & type	None, multiple experiences with BEV
Length of lease/ownership	-
Would like copy research?	Yes

Interview transcription

Opening information and background

Interviewee ID2 participated in 2020 for about 2 weeks. She got in contact through a common acquaintance at work. Her main reason to participate was the fact that she did not have a car yet while the public transit route was very inconvenient, but also enjoyed contributing to research. She had a couple short experiences driving BEVs (battery electric vehicles). Her perception towards EVs is generally positive, although she does not like the high purchase costs. She also does not like that EVs generally overestimate the range, meaning that she would have to leave with double the range to get home safely.

The participant considers herself to have minimal knowledge of EVs and EV charging, and does not think this has increased a lot by experiencing V2G and the Nissan Leaf. She did become aware of the vast number of EVs and charging stations around already, something she normally would not have noticed. She has become more 'aware of the benefits and drawbacks of EVs'. She has no other experience of V2G systems. With regards to the research, she liked everything except for the Leaf's range.

Experiences using V2G technology

With regards to experiencing discharge events, participant ID2 experienced this multiple times. To be certain of a satisfactory charge, she checked the state of charge in the early afternoon multiple times, often to see a range shorter than upon arrival in the morning. In about half the times, the V2G

Nissan Leaf actually had a lower charge on departure in the late afternoon compared to arrival in the morning, resulting in a couple occurrences of range anxiety. She states early in the interview that a way to check the state of charge away from the car would alleviate her worries, preferably through an app. She thinks the other PHEV charging at the Green Village may have contributed to a lower battery charge.

Before participating, she did not know about V2G and therefore did not have an option or thoughts about it. After participating, the believes the potential of the technology is fantastic, but in her case, it did not work out practically, which she found quite frustrating. She believes V2G in its current form is not ready for adoption. While she sees potential for V2G to help with peak electricity shaving, she believes other innovations to store energy are required as well. Having additional control options would have greatly improved her experience, being able to set certain parameters such as minimum range at a specific point in time.

The participant replies that she was not influenced in any way by her environment to participate, as her main reason was to have a car for a couple weeks. Experiencing V2G did make her talk to friends about it, who responded in a positive way. She also thinks experiencing V2G increases the likelihood for her and other people to opt for V2G, mainly because she was not aware of the technology's existence. It could also help in easing doubts regarding range. Other factors may influence their likelihood to adoption too, but experience is the most important factor.

Experiencing V2G has made her more aware of the amount of electricity that goes into EVs. She thinks everybody should be able to use a V2G station, as she had no previous experience charging them but learned effortlessly. As she did not have to use any charging pass, she found the V2G station even more convenient than conventional street-side charging stations. As charging is not instantaneous, she would at this point still opt for a (Plug-in) Hybrid Electric Vehicle (PHEV or HEV) compared to a BEV, either with or without V2G.

She mentions the idea of charging your personal V2G enabled car at work fully, while then using the energy at home to power your house. With V2G, she says, options are endless, from charging personal devices to other vehicles. Her motives to adopt V2G differ whether she would own the EV or lease it. When leasing, the potential to generate profits from selling energy to the grid would be taken away, but on the other hand, one would not have to worry about battery degradation. Still, V2G is more environmentally friendly in her opinion.

Experiencing V2G has made the interviewee aware of that she finds the barrier of controlling the minimum charge to be very important for adoption. Only then would V2G be able to suit her lifestyle. Overall, the V2G infrastructure needs to be widely spread throughout the country, to make it as easy as possible for users.

Report: Interview 3

Interviewee information

Interviewee code	ID3
Interview date	27-05-2021
Gender	Male
Age bracket	25-34
Highest education level	Master's Degree
EV ownership & type	Ownership, PHEV
Length of lease/ownership	1-3 years
Would like copy research?	Yes

Interview transcription

Opening information and background

When asked about his first thoughts about the V2G research the interviewee participated in, he replies that he used the Nissan Leaf for two weeks quite a while ago. He got in contact through a common employee at the Green Village and was told participants were needed to assess how the Nissan Leaf behaves in relation to the V2G station. He decided to participate because he finds it important to contribute to research, but also liked to learn about this new technology. He considers himself tech savvy but does not have a particular interest in EVs. He has previous experience with his leased PHEV and considers electric vehicles to be better than gas-powered cars in certain ways but lacking in other ways (such as range and capacity to pull loads). In essence, it simply takes some practice to appreciate EVs.

He did not have a particular interest in charging technology either (he is always interested in technology). He liked the research and could not name anything negative regarding V2G. To him it felt like using his own PHEV.

Experiences using V2G technology

The participant experienced a discharging event multiple times and decided to switch to a conventional charger mid-day to be certain of enough range at the end of the day. He was therefore always able to reach his end destination, but at one point suffered some range anxiety when the V2G charger did not provide him with much charge. He mentioned using the 'SpyApp' on the phone in the car, which can give a much more accurate range approximation compared to the Leaf (which tends to overestimate).

Before participating, the participant had heard of V2G before, as he works on the Green Village. He believed V2G is promising to tackle potential grid issues that will arise when a lot of cars become propelled by electricity. After participating, he became aware of the difference between theoretical possibilities and practical realities. He names the example of the V2G station having a very strict limit on power extraction from the grid, which was initially set as not enough to charge the Leaf if another car was also charging.

Interviewee ID3 acknowledges that people can only be flexible to a certain extent, they will not opt for V2G if it would determine for them when the car can be used. Balancing between automated demand response from V2G and the personal freedom cars or EVs should offer is difficult, while for example a smart washing machine could do the laundry during the day when overall energy demand is at a low. Another example is heating and cooling, which is often already integrated to a certain extent by smart meters. Regardless, such smart devices could, when connected to a V2X system (Vehicle to home in this case), really balance the local energy system.

From experience, he spoke to other family members and colleagues about the V2G technology, thought mainly because they were intrigued by the car being different from his own PHEV. Experience using V2G makes him more aware of the potential of V2G while on the other hand knowing the technology is not ready for adoption. For others, experience would do little to enhance consumer acceptance, he thinks, as financial incentives are a lot stronger factor for most Dutch consumers. Aesthetics and performance area also considered as important factors for adoption of V2G.

Report: Interview 4

Interviewee information

Interviewee code	ID4
Interview date	27-05-2021
Gender	Male
Age bracket	45-54
Highest education level	Doctorate (PhD)
EV ownership & type	Ownership, BEV
Length of lease/ownership	>3 yesrs
Would like copy research?	Yes

Interview transcription

Opening information and background

When asked about what interviewee ID4 remembers most from his participation, he mentions several things. He remembers having to charge at his own house multiple times, even though he planned to only use V2G in the Green Village. He also remembers specific times with specific percentages of getting home, where he notes that the level of charge was not always the same upon departing the Green Village in Delft. He was aware that the charging potential of the V2G station is dependent on the weather for PV electricity generation and the other car's charge. At one point, the V2G station did not work at all and he had to use a FastNed charger. He does not consider this to be range anxiety, he believes people should not schedule so much and actually suffer from time anxiety. In the Netherlands, there are basically charging stations everywhere. If this time is used purposefully, there is no need for anxiety. He liked how there is no need for a charging pass.

The participant got in contact through a physical advertisement on campus. The participant can be considered really tech-savvy, he speaks very fondly of his EVs and knows about the larger Powerparking station in Dronten as well as the technology behind and the barriers of the system. The participant knows that large charging powers require thick cables, reiterating the need for a solution like V2G to optimize resource infrastructural investments. He decided to participate because his parents own a Nissan Leaf, like the technology of electric driving, and has a problem with the current charging system at the TU Delft, which only offers 9 charging stations on campus with no way to see which one is available ahead of time. He enjoyed having a dedicated parking space for a week, and was really interested into the V2G technology. He acknowledges that during a long workday, you don't have to be fully charged or charged fast, and V2G uses the grid to its maximum potential.

While the interviewee is very fond of EVs, he still owns a traditional ICE car but considers it part of the past and does not enjoy it. He really dislikes fuelling up and perceives it as dirty. EVs are also more innovative, he considers part of EVs are also automation, and therefore EVs more future-proof. He likes driving slow with an EV, and likes the instantaneous torque. He has no other V2G experience, but is very fond of making his own house as self-sustaining as possible. While he does not believe this is better than using power from the grid, it does make him more aware of his electricity use, and he considers V2G to do something similar.

Experiences using V2G technology

With regards to charging, interviewee ID4 did not experience any other issues than normal charging stations. He did not notice any discharging events actively, and mentions the battery level upon

departure from the Green Village was either fully charged or about the same as when he arrived in the morning. Sometimes, a conventional charger does the same.

He believes there is more potential for V2G when there are multiple V2G-enabled cars at a larger station. At the Green Village, the PHEV also parked at the station, which can only charge and not discharge, now cannibalizes the potential of the V2G station. Participant ID4 has an interesting home setup, and mentions that if he could include bi-directional technology for a vehicle-to-home setup, he could become his own island of power, though he acknowledges becoming fully off-grid is almost impossible.

The participant mentions an occurrence when he was at a Nissan event, where somebody used the Leaf to power anything you would usually use a generator for, like inflatable castles. He sees this, in addition to camping, as potential use cases for V2G beyond the benefits from the grid connection. He questions the ownership of the electricity used in V2G systems, being able to fully charge at work and then use this energy to warm your own house is not ethical. Participant ID4 believes in the future, there is no ownership of electricity, it is always part of 'the grid'. Smart contracts could help in this switch.

For adoption, he believes more types of cars should offer V2G. Not many people will buy the Nissan Leaf, you need to achieve a critical mass for V2G to become a commonly accepted technology. For more people to adopt the technology, financial incentives are the most likely to make an impact on most consumers. For participant ID4, this is not the case. He believes more if something is 'just' or 'unjust', people using V2G should have benefits over those not using V2G, as they contribute something to society. This benefit should not be monetary, but for example, faster charging. Car sharing platforms could, for example, charge rapidly the first hour (to cover most trips) and then charge slow afterwards. Similarly, doctors could get faster charging at certain times of the day.

The battery degradation could be solved through leasing the battery, like Renault does with Zoe. The end solution is not owning the car, or the battery or energy at all, but simply paying per-use. The participant believes automation and sharing is part of the transition to electric driving.

Through using V2G, the participant sees V2G as a better way of charging compared to conventional (smart) chargers. He believes you should see your state-of-charge as a buffer of energy. Using intelligent systems, it can be determined for you how much charge you need to get from A to B and anticipate accordingly. The other energy can then be used for other purposes, while this is not the case for conventional chargers or ICE cars. In certain cases, for example for large trips, there should be a way to ask for an exception to control your state of charge manually.

V2G would fit the participant's lifestyle and work schedule. He usually works from 9 to 5, giving the V2G car plenty of time to slowly charge and assist the grid in the meantime. He believes battery degradation is not such a big problem, and could be compensated by additional parking spots. Financial incentives could work for other people too. He hopes that a future visualization of the energy streams will not show batteries like a bottle of liquid (like a hydrogen tank). Also, data on the availability of charging stations would help people drive EVs, or V2G enabled EVs. A proper interface of what is going on would also attract people to adopt V2G, as this would increase their feeling of control.

Report: Interview 5

Interviewee information

Interviewee code	ID5
Interview date	27-05-2021
Gender	Male
Age bracket	25-34
Highest education level	WO Bachelor's Degree (University)
EV ownership & type	None, multiple experiences with BEV
Length of lease/ownership	-
Would like copy research?	Yes

Interview transcription

Opening information and background

When asked about his initial thoughts of his participation in V2G technology research, the interviewee replies with the fact that EV batteries are used to compensate for the peak loads in the electricity grid, also using the solar panels as the primary and local source of energy. The participant considers himself an early innovator, usually being up to date with new technologies. He got in contact through a physical advertisement on campus, and decided to participate because he had heard of V2G and was curious what it entailed. It was also convenient for him to use a car for a week. He had several experiences with a BEV.

The participant considers electric vehicles to be better than gas-powered cars as they are quiet and accelerate rapidly and in a constant pattern, however the Leaf's battery capacity is not big enough for himself. While he was interested in V2G, he did not have a particular interest in EVs or cars in general. He was, however, conscious of the changes in infrastructure required when large percentages of cars become electric. He liked being able to use a car for a week and the freedom that comes with it, while he disliked the fact that only the charger in the Green Village was V2G enabled. He had not experience with other V2G systems before.

Experiences using V2G technology

The participant did not actively experience a discharge event, as the car was always full on his return at the end of the day. The participant always connected the car in the morning and left in the late afternoon. He was surprised to hear that discharging occurred. Because the car was always full, he was always able to reach his end destination and suffered no range anxiety.

Before participating, he considered V2G technology quite innovative, and his perception did not change during or after the trial. He hopes V2G is adopted in society quickly, as currently many people have solar panels on their roofs which generate energy to be send to the grid without a way to store the energy locally, requiring electricity to be extracted from the grid later. With V2G, you could store this energy locally and not require as many investments in grid infrastructure. After participating, he is worried about the costs of the V2G charging stations.

The idea of charging using cheap energy and discharging at times when energy is expensive is a business case he likes and which could cover the costs of the expensive charging station.
The participant was not directly or indirectly influenced by others to participate, he was really interested himself to participate. Through participation and experience, he now speaks with others enthusiastically about the potential of V2G. Experience using V2G positively influences his likelihood to adopt V2G, and he thinks this is also true for others. The main goal of experience is to take away

the doubt of uncertain levels of charge in the car. Other factors that may contribute to adoption are whether consumers have solar panels themselves, although then it becomes more of a Vehicle-to-home solution rather than V2G.

He mentions other use cases of V2G to function as a large power bank, even being able to function as a large source of energy in emergency situations. In all, the participant considers V2G to be a better way of charging. The main reason for this is that the charging station is then always used, either to charge the car slowly or to deliver energy to the neighbourhood. A way to utilize V2G even better would be to connect it to your personal agenda, which is a smart way to control the minimum state of charge.

The participant thinks everybody would be able to use the V2G station as it is, yet waiting for the system to start up might scare some people away. Using the V2G charger was not tedious either. The participant thinks V2G would fit his lifestyle, and believes being able to 'trade energy' would even generate money. He did not consider this 'energy trading' aspect before participating, but already thought of having to set a minimum level of charge for longer trips. He mentions that he sees a lot of people that only use their car once a week, and especially for those people the 'energy trading' could be financially beneficial.

Other incentives to adopt V2G would be additional charging spots for V2G enabled cars, as users of V2G contribute to a societal goal and should therefore be compensated. He thinks others would feel the same, again mentioning the potential financial incentive, and adds that without such incentives, you really have to be a 'fan of V2G technology' or have strong societal or environmental motives. He did not think of such incentives before participating, and suggests that experiencing V2G allows for people to see additional benefits or barriers. For large-scale adoption, consumers should get clear answers to those potential benefits or barriers, or it may scare them away instead.

The participant would choose for V2G if it was available for purchase, but states that the costs of decreased battery life should be covered, preferably at purchase. As a final note, the participant states that because of experience he learned that the technology was easier to use than expected, and learned that the technology is already developed beyond the prototype stage.

Report: Interview 6

Interviewee information

Interviewee code	ID6
Interview date	07-06-2021
Gender	Male
Age bracket	25-34
Highest education level	WO Bachelor's Degree
EV ownership & type	None, multiple experiences with BEV
Length of lease/ownership	-
Would like copy research?	Yes

Interview transcription

Opening information and background

When asked about his first thoughts about his participation in the V2G research, he was excited to hear about the technology because he was not aware something like this existed. He mentions he found cars being able to charge other cars to be very cool, all while not using more energy from the grid than necessary. He got in contact with the research through a friend who participated and

decided to participate because he liked to drive a car for a week and found the technology novel and interesting.

The participant had several previous experiences with EVs with a BEV. When first trying EVs he was a bit reserved, as the energy and water required to make the batteries is vast, but he now finds it interesting as the EV market is growing rapidly. He is slightly more interested in EVs compared to conventional cars, but overall, he is interested in other technologies, such as electric helicopters. He did not know anything about charging technologies other than Tesla's superchargers. Overall, the participant liked the trial a lot, but he would have liked a more extensive introduction to the car. Also, the range of the Nissan Leaf was not so great, but the trial itself went great.

Experiences using V2G technology

When asked whether the participant experienced a discharging event, he answered affirmatively. "I put it there in the morning and in the afternoon, it was at 70 percent or something, while one time I left it there with a 100 percent. When I left the car charging in the Green Village for a night and arrived in the morning, it was always fully charged". He remembers the day the battery went from 100 to 70 percent to be a cloudy day.

Before participating, the participant did not think much of the potential benefits or drawbacks of V2G. He considers himself a typical German, being fonder of gas-powered cars. He did mention experience using V2G has really opened his mind to how smart the technology is.

After participating, the participant considered V2G technology to be 'revolutionary'.
First applications he thought of were during power outages that happen in developing countries. A V2G car can then, especially when combined with solar panels, really function as a backup system of energy. He also acknowledges, through a conversation with a friend who participated in the same research, that money can be made by intelligent energy charging and discharging times. There is huge potential as an EV can use more energy than multiple houses. He believes the systems should be scaled for the biggest potential to store energy in a central location. Especially in countries with large potential for solar energy, such as Dubai, V2G could be beneficial to stabilize the electricity grid. In the long run, V2G may even decrease the number of power plants required, he thinks.

After participating, the interviewee also sees risks and costs. A primary risk he names is the danger of having many EVs together in case of fire, as battery fires are hard to extinguish. He also wonders how different charging and safety standards among countries will halt adoption and mentions that much more infrastructure will be required even when opting for V2G throughout society. He again mentions the potential for countries with an unstable electricity grid. Another risk with V2G is that if you plan a trip and the battery at departure is less than required to make the trip at once, this will not be pleasant for the customer. He therefore names 'setting a threshold' to be an important barrier to be overcome for widespread adoption.

For the wide public to adopt the technology, it should be slowly integrated into a normal part of society, the participant believes. Experiencing V2G changes how he approaches others about it, as he now sees the potential that he would not have seen without the experience. Experience has pushed him to believe V2G should become the norm, as only having EVs will not solve the energy problem and might increase wasted energy. For other consumers, the participant believes experience may change their idea of the technology and therefore likelihood to adopt it, but the consumer should not have too many negative experiences with low battery levels. He therefore restates there should be the option to set thresholds. He also believes potential consumers may be attracted by the potential to make money with a V2G car that sits idle often.

The interviewee states again that for the potential of V2G to be truly captured on a societal level, there needs to be a wide adoption. And for customers to adopt the technology, the personal and societal benefits should be clearly communicated to them. Financial incentives may help people overcome the initial barrier to adopt V2G. Comfort is also important, so there should not be too big of a drop in comfort compared to conventional EVs.

The participant tasked about the technology with friends, but only after talking about the car (there was no specific interest towards the technology when talking with friends). The participant currently would not buy an EV unless the range is significantly extended, also not if V2G was included. He would also not recommend a V2G car to others, unless they lived in a country like the Netherlands where everything is close by. He was not influenced by his environment to participate, his main reason to participate was to be able to use a car for a week. The participant does not consider EVs to be environmentally friendly at this point.

The participant, to always have enough range, always planned his trips. After participating, he now sees V2G as a much more intelligent way of charging than conventional charging. He thinks everybody could use V2G in the current form, but control settings (to set thresholds) should be convenient to use 'consumer friendly'. He did not think the V2G system was tedious to use and expected it to be more difficult before participating. Still, for the wider public the interface should be made easier.

He believes V2G would fit most people's lifestyles and working life, especially when control mechanisms can be set for longer trips. He believes the additional battery degradation due to additional charging and discharging should be compensated in some way, preferably at purchase. Before participating, he did not think of this issue, but experiencing V2G made him aware of this risk. Seeing the bigger picture, and having plenty of money, could be motivators to still adopt V2G despite its drawbacks.

Report: Interview 7

Interviewee information

Interviewee code	ID7
Interview date	08-06-2021
Gender	Male
Age bracket	18-24
Highest education level	WO Bachelor's Degree (University)
EV ownership & type	None, multiple experiences with BEV
Length of lease/ownership	-
Would like copy research?	Yes

Interview transcription

Opening information and background

When asked about his first thoughts of the research interviewee ID7 participated in, he mentions a new power-grid system to charge your EV. The fact that V2G charging is so new initially gave him a slight unsafe feeling, but after using V2G and the Nissan Leaf he never felt unsafe. The range of the Leaf was considered very low, but he does not think this is related to V2G. He got in contact through an on-campus advertisement, and decided to participate because he was curious to see whether having a car would be beneficial compared to using public transport. He did not participate for other reasons, such as new technologies or environmental motives.

He considers EVs to drive better and more comfortable than gas powered vehicles, although as a cyclist he is a little afraid of them due to a lack of engine sound. He is also sceptical to the range EVs offer, requiring planning your trips even though fast chargers are available. In the Netherlands, this should not be a problem, but abroad it could be. He does not have particular interest or knowledge of EVs or cars in general. He says he did not know many specifics regarding charging technology, but was able to mention that there are different charging powers and that certain companies use other types of plugs, and knew the difference between charging using direct and alternating current (so he is actually quite knowledgeable). He did not have any other experience with V2G systems.

Experiences using V2G technology

The participant believes the V2G charger was easy to use. He did not like having to walk between the Green Village charging station and his study location across campus, and mentions that for the technology to be adopted, there should be plenty of chargers close to destinations or on-site, but also mentions a larger V2G (Powerparking) station from which bikes can be used for the final minutes of travel.

The participant almost always left with a fully charged car, except for one time when another EV was parked at the V2G Powerparking station. This day, the car only had a slightly bigger range at departure compared with arrival. The participant therefore experienced a discharging event actively. Regardless, he was always able to reach his end destination, did not have to charge outside the Green Village, and did not suffer from range anxiety.

Before participating, he had never heard of V2G but perceived it to have a lot of benefits. Solving the problem of intermittent energy generation from solar and wind sources, and temporarily storing this energy in a large battery in the shape of a idle EV, is a great benefit of V2G. He acknowledges that even before participating, he thinks about where the energy should go and who should get priority in charging to be important questions to be answered. He also sees benefits in Vehicle-to-home applications. After participating, he now worries about the state of charge when departing, and that there should be some way to eliminate this worry. When asked about how he would do this, he replied with setting a minimum battery percentage.

Interviewee ID7 spoke to others about V2G, but not very extensively, and mostly discussed the other capabilities V2G could offer. For example, being able to charge many appliances on-the-go. He hopes to buy a car in the future but mentions that he would never select a car based on a certain type of charging technology (such as V2G). If the car had V2G, it should at least be able to opt out of it. Control is very important to him to adopt this technology

Other motivators to adopt V2G would be the financial aspect. When presented with the fact that batteries degrade quicker when charged and discharged frequently, he says he would like to be financially compensated for this. When presented with the case where users could earn money by charging cheap energy and discharging when it is expensive, he likes this idea but argues that this will bring more uncertainty too. Hence, the compensation should come without the user actively steering the system what to do.

For others to adopt V2G, he thinks the financial aspect may attract some people, while other, mainly wealthier customers, would never purchase V2G as the small financial gains do not compensate for the uncertainty in state of charge. The potential of V2G also changes with the number of times a car is used, it may be more difficult to use a V2G car daily while only using such as car once a week may

result in more of the societal gains. He also mentions there could be an alternative when your car is fully discharged and you unable to leave; the main goal of the car is to take you from A to B.

Experiencing V2G changes how he approaches others about it, mainly because he is now able to qualify the benefits and uncertainties. For others to adopt V2G, he thinks it is definitely beneficial for people to use a V2G enabled car, but mentions that it is important users have a positive experience, as only one day in a week without enough charge would push them away from adoption instead. Other reasons for others to purchase a V2G enabled car are comfort and finances, so it should not cost users money, ideally save them money, and boast other beneficial technologies.

Other potential use cases of V2G are connecting one V2G car to another V2G car, without having to connect to a V2G station. Without the barrier of controlling the minimum state of charge, he does not consider it to be better than conventional chargers. He does believe anybody should be able to use a V2G station. Experiencing V2G has made him aware of the risks in uncertainty, and for other's to adopt V2G he believes they also would like more certainty in battery range. He always thought the station was easy to use, before and after participating.

V2G would not directly suit his lifestyle, he would like more comfort and certainty, but would recommend V2G to others who have societal and environmental motives to adopt it. Even when financial benefits outweigh the costs of battery degradation, he would not opt for V2G as the uncertainty in range is a very big drawback to him.

Report: Interview 8

Interviewee information

Interviewee code	ID8
Interview date	08-06-2021
Gender	Male
Age bracket	65+
Highest education level	MBO
EV ownership & type	None, multiple experiences with PHEV/BEV
Length of lease/ownership	-
Would like copy research?	Yes

Interview transcription

Opening information and background

When asked about his first experiences with the V2G research, he replies that it was important to drive the V2G car as much as possible to gather enough data. He states that the Leaf with V2G is more innovative than most EVs on the market, and therefore enjoyed driving while contributing to research. The interviewee participated for over a week. He got in contact through a common acquaintance at work. He decided to participate because he likes to contribute to research and was interested in driving electric. He mentions that he is currently looking to buy an EV as part of being more self-sufficient. At this point, he believes PHEV are the best option to combine benefits from gas-powered cars and EVs.

The participant is very knowledgeable about cars, EVs and battery technology. He knows how to properly use batteries and mentions that V2G should try to discharge and charge as much as possible (no half charges). Keeping the car connected with small loads after charging, like V2G does, should help to maintain battery performance. He is sceptical on the environmental friendliness of

EVs, as they require more energy to be produced, and after their lifespan may leave more precious materials behind.

Early in the interview, the participant already mentions he sees more potential in V2G when a lot of charging stations are located in a central location. For example, the top floor of a parking garage could, with solar panels, function as a large battery while using most charging power from solar energy.

Experiences using V2G technology
While the participant mentioned he did not actively notice a discharging event, he did state that the car was not always fully charged on departure, meaning a discharge event must have occurred. He mentions the final goal of the technology is to indeed not notice any discharging, but that there is difficulty in assessing when the car needs a sufficient charge. "If I suddenly have to leave at 1 in the afternoon, the car needs to have enough charge". EVs already have a low range, and V2G may decrease this range even further.

Before participating, the participant was already aware that while EVs use less energy on a driving basis, they do ask for large loads on the electricity grid. He sees many benefits of V2G before participating, and his experience using the technology has not generated many new insights. He now knows that V2G can offer a similar benefit as hydrogen cars do, being able to discharge electric energy.

After participating, he now believes that V2G should not decrease the level of comfort in driving, and especially should not feel like a 'penalty'. He believes V2G is the easiest and least invasive way to get as many electric cars charged without overloading the grid. He spoke to others about V2G in a positive and enthusiastic manner. He did not think V2G is more difficult to use compared to conventional charging stations, and that this will be the case for other potential consumers too. He believes Dutch consumers are primarily driven by financial savings or potential financial gains.

Additional battery degradation due to frequent charging and discharging should be financially compensated in some way, either at purchase or during use.

Report: Interview 9

Interviewee information

Interviewee code	ID9
Interview date	14-06-2021
Gender	Female
Age bracket	25-34
Highest education level	Master's Degree
EV ownership & type	None, several experiences with BEV
Length of lease/ownership	-
Would like copy research?	Yes

Interview transcription

Opening information and background

When asked about what the participant remembers most from participating in the V2G trial, the interviewee responds that it has been a while, but that she can remember it was important to get usage data for the researchers. She says that driving a V2G enabled car adds a new function to the personal car, namely that you are driving around in a large battery. The role of the personal car is

now different and she was curious to see how her behaviour is influenced by participating. She got in contact with the research through a common acquaintance, and decided to participate because she was curious about driving an EV again (she had previously driven a BEV before). Interviewee ID9 participated for two weeks.

When asked about her opinion on cars and EVs, the interviewee responds that she hates filling up her tank (as it always comes at an inconvenient moment) and that being connected to a charging station can take this inconvenience away by always being filled up. She also puts trust into fast chargers to get her to destinations further from home. She believes EVs are more comfortable and even long-distance travel could be less stressful. She is more interested in EVs than conventional ICE cars additionally because they are the future, and hopes to buy an EV when her current car gets too old and the prices have dropped. Throwing her ICE car away early would not be 'sustainable'. She enjoyed the feeling of knowing that charging the leaf was done mostly locally through the PV panels, and mentions she would have liked to see more specifically where the electricity had come from or where it contributed to when not properly charged. She is sceptical of the electricity that comes from the grid, which may not be 'green', while with V2G you have the potential of using local sustainable electricity. Interviewee ID9 can be considered quite knowledgeable of EVs and electricity streams, as this was a large part of her Master thesis.

Experiences using V2G technology

The participant did notice a discharging event several times. She noticed this by having more power left upon arrival in the morning compared to leaving in the afternoon. The V2G system did not always charge the Leaf properly. While in most cases, the car was charged enough and the participant was able to reach her end destination, at one point she could not make her end destination. She did not enjoy having to go to the car to check the current state-of-charge on days where she really required some range.

Before participating, she found the idea of using the idle battery capacity charming. By using these idle batteries, you do not have to produce other batteries to store electricity, and are using resources more efficiently. She believes V2G can work better on a large-scale setting. Experiencing V2G has made her view of the technology less theoretical and more realistic, as she became familiar with the costs that using idle battery capacity brings. She suggests using a smartphone app, where you can set a minimal range at a certain point in time for additional control. Other ways to become more certain to reach your end destination are possible too, an app is not necessary. A V2G-enbaled EV should still primarily be a car, meaning it should be able to get you from A to B on your own schedule.

Before participating, she was technically aware that the Leaf can discharge energy, but only through participation she became aware what this entails for her feeling of freedom a car should provide. Through driving an EV, she also became aware of the vast number of public charging points available already and how easy it is to connect to such a station. She also felt a connection to other EVs and notices how many are on the road already. She spoke to friends and family about V2G in an enthusiastic manner, while she believes explaining it to friends did not make them more aware of the potential of V2G.

Participant ID9 stated she would buy an EV for her next car, and when asked if this would be a V2G-enabled car, she states that it really depends on what is in it for her. She is okay with decreasing some of her flexibility to have some external/societal benefits, though she would like to see where this benefit is going. She names the example of supporting her employer to gain a more sustainable car fleet. Another reason to opt for V2G is a financial incentive of paying less per kWh.

When asked about the additional battery degradation due to frequent charging and discharging of the V2G battery, she responds that this should really be covered financially. She states that she is personally okay with taking this risk as she is interested in the technology and has financial means to cover this loss, but for others this is probably not the case. Also, for people leasing their car, she thinks they would not experience this as a problem. Other people owning the car would likely want to have net financial gains, or at least no losses from opting for V2G. The problem of battery degradation could be solved by leasing the battery pack alone, like Renault offers currently.

She was not involved by her environment to participate but experiencing V2G made her approach others about it differently as she is now able to share the practical side in addition the theoretical potential. She considers V2G to be part of Smart Grids, and states that there are many technologies and actors in the electricity system where gains may be achieved. It may be easier to just have a neighbourhood battery instead of many people experiencing range or scheduling anxiety. She states that range anxiety is not a problem unique to EVs, as ICE car can also have this problem when a car station is not on your route.

The interviewee names other motives for people to adopt V2G as follows. Switching from an ICE car to an EV is already a big step, so including V2G in this is a small price for people. Also, the urgency should be stressed, as right now V2G feels like a distant technology. To her it feels like the 'chicken and egg story', there should be plenty of V2G enabled stations already out there for people to start adopting it. Companies like Qpark should start offering this in bulk, to make a noticeable impact. Her biggest barrier to adoption not having some way to control the battery charge. If the control barrier is taken away, V2G would fit the participant's work and personal lifestyle schedules. She did not find the V2G station harder to use than conventional stations, and sees potential in having an overview of the energy streams as there is a data connection already. She suggests the V2G car should be nice looking for people to adopt it quicker.

Report: Interview 10

Interviewee information

Interviewee code	ID10
Interview date	14-06-2021
Gender	Male
Age bracket	18-24
Highest education level	WO Bachelor's Degree (University)
EV ownership & type	None, multiple experiences with BEV
Length of lease/ownership	-
Would like copy research?	Yes

Interview transcription

Opening information and background

When asked about what participant ID10 remembers most about his participation in the research, he mentions that he was able to drive an electric car and consequentially experience the vehicle-to-grid charger as a potential user. He was interested to see how this technology could, in practice, alleviate peak loads on the electricity grid due to extra electric cars.

He got in touch with the research through a physical poster on-campus. He considered himself amongst the target population, as he has frequently driven EVs before as his parents own an EV and he has additionally tried the Volkswagen ID3 and Jaguar I-pace. He would likely buy an EV for his first

car as he does not support the pollution emitted from cars with an internal combustion engine. For now, public transport suffices his travel needs. He considers EVs to be more comfortable.

Participant ID10 is slightly knowledgeable on EVs and the supporting infrastructure, such as charging. When asked about EV charging and smart charging, he mentioned different charging powers but did not know about plugs.

Experiences using V2G technology

Participant ID10 liked participating in research and the instructions were clear However, he experienced many error messages throughout the three days he aimed to charge the car using V2G. He therefore had to charge the Leaf at his internship's office using a conventional charger as well. He did not appreciate the lack of communication during these issues, yet the technical aspects of the car and recording device functioned properly.

The participant never noticed a power discharge, partly because the car did not charge at the V2G station for the majority of times. He could not always reach his destination always, due to the issues mentioned above, but solved the problems by himself. Before participating, he did not know about V2G technology although he was aware of grid capacity issues due to peak loads. After signing up, he did some research on the technology and considered it an intelligent technology. He thought the technology might not necessarily benefit the individual but may be beneficial for society as a whole.

After participating, he mentioned the technology is still early in development and may therefore not be suited for everybody, yet his perception on the potential societal benefits did not change. By head, he did not think of any new costs of benefits associated with V2G. When asked specifically, thanks to his participation, he would like to have V2G functionality when purchasing an EV, with the main benefit of cost reduction for either him or his employer. One requirement he would like to see for adoption is a way to set a minimum distance, as you don't want the feeling of not being in control, which he considers is characteristic to cars.

The participant spoke to others about the research, but unfortunately as the V2G station did not work for him properly, they only spoke about the theoretical situation where they all found it promising but not surprising that there are still barriers to adoption. He was not influenced by his environment to participate but notes that his stepdad works with charging stations and acknowledges that this might influence his opinion and perception. He does not think his experience using V2G changes how he approaches other people and also does not think experience influences other people's purchasing behaviour. He has a strong view on the fact that people who want EVs for whatever reason will purchase it regardless of V2G capacity, while V2G should just become part of the infrastructure, suggesting that for most people it does not matter how they charge their car.

When asked about other incentives that may push people towards an EV with V2G technology, he first states that monetary benefits or savings should be communicated to potential customers clearly. A barrier that really should be overcome is the lack of control that the current V2G system has. The participant states that V2G is especially useful to shave off electricity peaks in production, but that the customer should still come first. He did not think differently of this after participating.

He does not have any new motivation to adopt the technology, again stating that it barely worked for him, but notes that the time in between a prototype and a market product stems more than a year. When the V2G station becomes as easy to use as a 'normal' station, everybody should be able to use it. A V2G system would fit his lifestyle, given the above mentioned barriers are taken away, and he did not think of this differently before participating. With regards to the decreased battery

capacity and/or lifetime, the interviewee clearly wants to know how much the battery degrades. Compensation is important, and in case of a negative business case for the consumer, he believes the likelihood of adoption of the technology is severely decreased.

He mentions a concept similar to Vehicle to Home, for those people that do not live in a dense neighbourhood. To fit his personal and working life, he states that V2G should not be too much of a 'communal' technology, as he still values his personal freedom a personal vehicle should provide. He is interested in the final business case, including anything from personal costs and benefits to cost and benefits to society, companies investing in the grid, etc..

Report: Interview 11

Interviewee information

Interviewee code	ID11
Interview date	28-06-2021
Gender	Male
Age bracket	35-44
Highest education level	MAVO
EV ownership & type	None, multiple experiences with BEV
Length of lease/ownership	-
Would like copy research?	Yes

Interview transcription

Opening information and background

When asked about his first thoughts related to the research, is the potential of V2G technology to not only charge the car but also to discharge the car, using a pilot on the Green Village. The potential of V2G, he says, is to shave of peak loads. He got in contact with the research through a previous participant, and decided to participate because he is interested in electric cars and, as an employee at TU Delft, to contribute to research on campus. He had previously driven in a variety of BEVs. Driving in an EV makes him aware of the amount of energy used by cars, and as a result, how much energy is used by houses.

He still likes traditional cars due to their feeling (sound and being able to manually shift gears) but also appreciates the quietness and societal and environmental benefits of EVs. An EV with a simulated gearbox would be a nice idea. He had little knowledge of EV charging stations, but was aware that certain chargers charge more quickly than others. He did not know about other V2G systems, but named his Samsung smartphone that is able to charge another Samsung phone.

Experiences using V2G technology

He liked participating in the V2G research. The only downside he mentioned was when connecting the charger, you have to wait for the initialization of V2G. He disliked the waiting, but believes it is interesting to see what is going on. He mentions that the car was always fully charged and disconnecting the charger was easy. He therefore never experienced a discharging event, but experienced slight differences in range when leaving. He mentions this may also be due to his driving style. He always reached his end destination, did not suffer from range anxiety, and never charged outside the Green Village. The participant replies that he would definitely buy a V2G enabled EV when the option arrives, and at this point mentions the other benefits a V2G car can boast, for example when camping. He spoke with friends about V2G which according to him seemed interested

in the technology but received little feedback. He sees EVs with V2G as the future, and again mentions his enthusiasm.

He appreciates the fact that V2G is local solution and mentions the fact that the solar panels on-site are used primarily to charge the EV. Before participating, the considered V2G to be a great solution on paper, but had some reservations such as the uncertain range. After participating, he was even more enthusiastic than during participation. After participating, his doubts on the uncertain range faded, and he became aware of increased benefits such as knowing the amounts of energy used in daily life. Using energy that is normally wasted is the biggest benefit he sees of V2G.

When asked about risks of V2G, he mentions he did not think of this during participation. After some thinking, he mentions the 'competition' between a V2G car and a EV with conventional charging, where the latter may use all energy available in the station while the V2G car is not charged. Especially when big trips are planned, this could become a problem. When asked how he would like to decrease such a risk, he first mentions that there are plenty of fast chargers available nowadays. Another method is to visualize the state of charge using an app on a smartphone or smartwatch.

When asked about battery degradation, and the costs related to replacing a battery, he hopes V2G enabled cars have batteries that can combat this loss in battery life or range. If not, the consumer should be notified on purchase that the batteries in the car may not last as long. This can be compensated financially and mentions the different energy tariffs throughout different times of the day that the Netherlands used to have. This way, the car can be charged using grid energy when it is cheap and sell energy when it is expensive. When told about a trial occurring in England, where participants earned a noteworthy sum of money, he said he would not see this necessarily as profits, but as a fee related to the uncertain state-of-charge that comes with such practices.

Experience using V2G technology will push many people towards adopting the technology, but the participant also acknowledges that the potential financial gains would attract other customers. A barrier to be overcome for adoption is to have a visual picture of the state of charge, controlling a minimum state of charge is not so important. He was not influenced by his environment to participate, but now that he participated he perceives EV more positively as well as V2G, but another reason for this is that he was not very aware of V2G. He did not see other use cases for V2G before participating, and as mentioned now sees other but limited use cases outside of the EV-grid connection with peak shaving and intelligent charging and discharging times with the potential of saving or earning money. Saving energy that is usually lost is a big motivator for him to adopt the technology, and considers V2G to be superior to conventional chargers. He thinks many systems could work together in a similar manner as V2G with the grid, such as inside a private home.

He believes V2G is easy enough to use for everybody to use, but expected it to be more difficult before participating. He does not think V2G fits his lifestyle, but he was so fond of V2G that he would like to change his lifestyle to fit the technology. He names awareness of energy use as the primary reason to do so. V2G would, in contrast, already fit his working life.

Report: Interview 12

Interviewee information

Interviewee code	ID12
Interview date	28-06-2021
Gender	Male
Age bracket	25-34

Highest education level	WO Bachelor's Degree (University)
EV ownership & type	None, multiple experiences with PHEV
Length of lease/ownership	-
Would like copy research?	Yes

Interview transcription

Opening information and background

What participant ID12 remembers most from his week-long experience was that he enjoyed the freedom of the car a lot and that he was interested how V2G technology is experienced by a potential customer. He was also curious whether using his car for his daily commute was faster than public transit, while supporting the research. In the beginning he stated right away that had a positive experience using V2G and that he believes that because it was a sunny week, the battery was always charged fully upon return.

He got in contact with the research through one of the physical advertisements on-campus. He considers himself quite knowledgeable and interested in research and innovation. He has previously experienced a PHEV for about ten times and considers electric driving to be not much different from a gas-powered car with an automatic gearbox. He names the higher torque at low speeds, the low ranges that EVs are prone to have, and compares the types of EVs. He knows the different types of chargers available better through this experiment. He had previously heard of V2G through his degree.

Experiences using V2G technology

When asked about his perception of V2G technology, he calls it the 'logical next step' in charging. He names something related to vehicle to home, and how V2G could provide a bigger share of cars as only so many houses have a private parking space. He mentions V2G as it was included in his degree when he learned about MAAS (Mobility as a service).

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Before participating, having the benefit of knowing V2G from his studies, he considers it a logical step. He mentions the "ideal situation" of a detached house being connected to a Tesla, which then functions as the battery for that house, along with solar panels. Although this Vehicle-to-Home system (he does not name it like this) sounds ideal, he mentions the majority of people don't have access to this kind of set-up, which is where V2G comes into play. He was generally positive towards V2G or V2X in general, and names the biggest downside to be the required change in consumer behaviour.

After participating, his thoughts haven't changed much. He still considers V2G to have largely positive contributions to society, yet does not name them yet, and mentions the slight stress caused by continuously having to plan your next trip while not knowing the exact state of charge. This stress could be taken away in several ways, firstly through additional range, secondly through some way to

visualize the actual range on-demand, for example through a phone app, and finally by having a set or projected range presented either at the charging point, in the car, or on-demand.

The participant never experienced a discharging event of the Nissan Leaf, which sounds surprising to him. But he also mentions that at one point he was not able to reach his end destination, requiring him to charge using a normal charger. Therefore, he suffered a little bit of range anxiety. At this point he acknowledges a downside of V2G, namely that due to the charging and discharging cycles, the battery life is decreased.

When asked about buying a V2G enabled car, he mentions it is not for him at this point. He mentions he believes more in the V2H solution and would buy a car with bi-directional capabilities when he owns a detached house. He would also only recommend bi-directional charging to others with a home connection, as there is some kind of 'prisoners dilemma'; you can help your neighbourhood to shave of peak loads, but in return you may end up with an empty car while electric cars charging the conventional way do not add anything to the neighbourhood while always departing with a fully charged car. Worse still, the battery is degraded more quickly! He mentions compensation is important, he would only consider buying a V2G car if the financial benefits outweigh the financial costs of battery degradation. Other methods of compensation, such as additional parking spots, are nice but will not influence his adoption. He talked to friends about his experiences with V2G in an enthusiastic manner.

The participant was not influenced by his family or friends, but considers himself tech-savvy and pursues a degree in a related field. He believes experiencing V2G technology changes his perspective regarding the technology only to clarify his doubts and beliefs of the technology. He considers the V2G charging station as easy to use as conventional charging stations, and thanks to the additional functionality, he may consider it superior. Experience using V2G may not impact others so greatly as he believes most consumer value the security of a fully charged car more than the societal benefits V2G provides. He believes other factors that may influence their adoption are firstly education related to the limitations of charging multiple cars and secondly through compensation. Compensation should be clearly defined, and should not only cover the financial costs of battery degradation but also the uncertainty of not knowing your state of charge.

The candidate sees little other purposes for V2G, he really believes in the peak-shaving of the electricity grid and having a connection with a private home. V2G could in the future function as a large power bank, being able to power large-scale events or for personal use away from home. He considered the V2G station easier to use than expected. V2G does not suit his lifestyle as he lives in the city and has no room for a car. Other stimulants to adopt V2G would be subsidies, as he believes doing something for society should be stimulated. Another idea is forcing people to adopt V2G by making all charging stations V2G-enabled.

Report: Interview 13

Interviewee information

Interviewee code	ID13
Interview date	06-07-2021
Gender	Male
Age bracket	45-54
Highest education level	Master's Degree
EV ownership & type	None, multiple experiences with BEV
Length of lease/ownership	-
Would like copy research?	Yes

Interview transcription

Opening information and background

When asked what participant ID13 remembers most of the research, he mentions the fact that cars can be used to store energy and deliver it back to the grid in times of need. The thinks the research revolves around how he, as a potential customer, experiences with energy exchange. He also mentioned the local energy generation through solar panels above the parking spaces. He got in contact with the research through an earlier candidate, as he had to travel to TU Delft and does not own a car himself and mentions a slight interest in this new technology.

The participant had previously driven several EVs through car sharing platforms, all of which are BEVs. He considers EVs to be better than gas powered cars with respect to the environment, but more so believes in car sharing to limit the number of cars parked on the road. He was not particularly interested in or knowledgably of EVs or cars in general, and thinks he has a general level of knowledge regarding new technologies. He knew there are differences in charging powers, but the theory behind charging he did not know about. He liked the fact to see the V2G station on-site, but is worried he may have done something wrong when connecting the car. Before asking about improvements, he mentions the fact that he would have liked to see the current battery charging patterns on his phone. He had no other experience using V2G systems.

Experiences using V2G technology

When asked whether the participant experienced a discharging event, he said he did not and was pleasantly surprised that V2G actually occurred. He always arrived with a relatively empty battery and upon departure almost always retrieved a full car, causing him to think this way. He was at one point not able to reach his end destination, when the car was retrieved with a low battery charge after which he used a FastNed station (which he enjoyed trying as it was his first time using this system).

Before participating, he was sceptical of EVs. He mentions the fact that EVs are not as clean as many think, as much energy goes into producing the car and batteries, and argues the same for PV energy. He does believe an energy transition is required, and V2G might help to reach this goal but the participant has more faith into hydrogen fuel cell cars. He was already knowledgeable of V2G as there is a pilot close to his house, and he believes V2G can allow ‘large driving batteries’ to be more efficiently used and meanwhile shave off peak loads in the grid.

After participating, he names certain barriers that need to be overcome for consumers to accept the technology. He expects the possibility for users to set certain parameters, such as a minimum range at a certain point in time, or a way to see what the current state of charge is. He additionally mentions that he would like to be able to choose where the discharged energy is going. He mentions that this technology should have societal benefits, and if your neighbour decides to use his sunbed, this is not energy well-used. He summarizes this as: control, insight and control over the destination of discharged energy.

He additionally remarks the fact that most EV charging stations are often taken, and that helping the grid using V2G should be compensated by enough charging stations so it does not become a burden on the user. Still, he considers V2G as a superior way of charging. Yet, V2G does not take away range anxiety and may actually increase it.

He was not influenced by his environment much, but was motivated by a colleague to participate. The participant also considers himself environmentally conscious, hence the reason he does not own a car and always uses trains or car sharing platforms. Experiencing V2G does not change how he approaches others about it, but this is mainly because he was very busy with work. He would talk to others about V2G when he has time, would buy a V2G enabled car if he would ever buy a car (or a hydrogen-based alternative), and would recommend a V2G car to others if they would need or want to own a car themselves.

He sees other purposes of V2G, mainly to have the car serve as a large battery pack / source of energy when you are away from a grid connection, such as when camping. Especially with portable solar panels, this would allow a user to be truly 'off-grid'. He also believes V2G will help in the change in perception that everybody should own a car as it is very suitable for car sharing platforms.

While experiencing V2G itself does not change his or (in his mind) others' perception regarding the technology, adding additional interfaces may promote this. Being able to see what happens with the car may interest people, especially those with societal or environmental motives. "You helped 2 people charge their car without causing peak loads" is a quote he uses. He did not think of other purposes of V2G or ways to increase adoption before participating,

Finally, the participant mentions the fact that the discussion of 'who should be able to use my energy' is a really interesting one, and may have to be solved politically. He is curious to know about the exact battery degradation, and having a clear answer to this (presented at time of purchase) would help him with choosing V2G. He also believes more (V2G) charging stations should be added, as currently there seem to be more EVs than charging stations, which would limit the potential of V2G.

Report: Interview 13

Interviewee information

Interviewee code	ID13
Interview date	06-07-2021
Gender	Male
Age bracket	45-54
Highest education level	Master's Degree
EV ownership & type	None, multiple experiences with BEV
Length of lease/ownership	-
Would like copy research?	Yes

Interview transcription

Opening information and background

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Experiences using V2G technology

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Report: Interview 14

Interviewee information

Interviewee code	ID14
Interview date	06-07-2021
Gender	Female
Age bracket	35-44
Highest education level	High School
EV ownership & type	None, also no experience with HEV, BEV or PHEV
Length of lease/ownership	-
Would like copy research?	Yes

Interview transcription

Opening information and background

When asked about what participant ID14 remembers most from the research, she mentions the solar charging station (PowerParking station) at the Green Village which functions along with a V2G system able to exchange electricity with the other parked car. The participant got in contact with the research through her work at one of TU Delft’s faculties where she shared the physical poster with her colleagues. She spoke with others about the car and research in a positive way, and would buy a V2G enabled car as a second car but would not recommend anyone else purchasing an EV with V2G until certain barriers are overcome.

She decided to participate because of her passion for cars and was interested to drive an electric vehicle for once. She is very fond of gas powered (classic) cars and initially not a fan of EVs, and therefore did not know much about electric vehicles and charging technologies. During the research, she started to like the gearless acceleration and instant torque. During the research, she suddenly noticed how many public chargers are available. She did not have any other V2G experiences, but did mention her phone being able to charge a different phone to be a similar idea in her opinion.

Experiences using V2G technology

When asked about whether the interviewee experienced a discharging event, she said she unfortunately did not, she would have liked to see what was happening. When asked what the interviewee thought of V2G before participating, she did not find it practical for personal use. She gives the example of both her and her neighbour both arriving home with a low battery charge and having to go on holiday the next day. After participating, she still does not believe V2G to be practical for personal use as you are limited by the unknown schedules of those around you. She believes V2G might work better if you could share a system with people you interact with, or if you are wealthy enough to connect one or more V2G-enabed cars with your home.

She says V2G is only a desirable option if there is a guarantee you have enough charge the next day, by having some variables to control. In some way, she would like to communicate with the V2G station to set a minimum charge at a certain time or not require any power in the next days. She then repeats that she would like to see the current state of charge, preferably from a smartphone application, and compares it to smart energy meters in homes. She likes the societal aspect of V2G and believes this is a positive influence in consumer acceptance.
Experiencing V2G changes the way she approaches others about it as it is a novel technology that she did not know about but was keen to share with friends. Her friends shared her initial doubts about the goal of the technology about leaving with an empty battery. She believes people want to be in control of their range while V2G may restrict their feeling of freedom. Experiencing V2G makes her more likely to adopt the technology and believes this would be the case for other consumers as well, as they are able to take their doubts away.

When asked about other uses for V2G, she mentions companies with large car fleets such as rental companies. She already thought of this example before participating when she was still skeptical of V2G. After participating, she believes V2G has potential in the consumer market when control settings are present. When asked about other factors positively influencing consumer acceptance, she again mentions the societal and sustainability benefits in a community. She also thinks people will fall for the 'newness' of the technology calling it a 'gadget' for some tech-savvy people to show their current charging or earning patterns.

She considers the combination of V2G and solar panels to be superior to traditional charging stations, and her belief regarding this has changed due to experience. The V2G station is easy enough for everybody to use, she thought so already before participating, but notes that it is still a prototype and error messages should be avoided. She participant believes V2G could in theory work for her daily life, but practically (she thinks the same before and after participation) it will not because of the lack of freedom. For her working life, it could function as this consists of a standard two-daily trip. Vehicle to home, with controls, would be something to take away her worries, but even for V2G control is very important for others to increase adoptions, preferably through a smartphone app also showing current charging status. She did not think of these barriers beforehand.

With regards to the battery degradation with respect to the societal gains, she believes there should be come kind of financial compensation. On top of earning money directly from the favorable charging and discharging patterns, she suggests funds going towards a new battery pack out of reach of the customer, to always ensure a functional battery. She did not have to charge the Leaf anywhere other than on the Green Village and was always able to reach her end destination without range anxiety.

Report: Interview 15

Interviewee information

Interviewee code	ID15
Interview date	26-07-2021
Gender	Male
Age bracket	25-34
Highest education level	HBO Bachelor's Degree (Applied Sciences)
EV ownership & type	None, multiple experiences with BEV
Length of lease/ownership	-
Would like copy research?	Yes

Interview transcription

Opening information and background

When questioned about his experience in the research, participant ID15 mentions that it involved an innovative new method of charging EVs and that he was able to use the Nissan Leaf for a week. He was able to explain the difference between V2G charging and conventional charging, mentioning that the V2G method of charging has more societal benefits and has the potential to save money by charging the batteries when energy is abundant and sell energy when energy is in short supply. He was interested in the possibilities in the 'local grid', but when asked about charging technology he only mentioned fast charging. He was not influenced by his environment to participate.

He got in touch through an advertisement through WhatsApp. He decided to participate as he needed a car for that week (for work and leisure purposes, which he usually travels to by bike) and has an interest in electric cars. He has driven a Volvo XC40 (BEV) before a few times. He was also curious to drive the Nissan Leaf, as it is the most sold EV in the Netherlands. In the future, when sufficient income is generated, he will buy an electric car, and when asked about the adoption of V2G technology, he mentioned he would like this functionality in addition to traditional charging capabilities due to the uncertainty he considers is inherent to V2G. His interest in EVs developed from an overall interest in cars, yet he considers EVs to be superior now. He spoke about V2G with friends and would recommend acquaintances to adopt V2G when buying an EV, specifically when having a personal charge point at home.

Experiences using V2G technology

Participant ID15 did not actively experience a discharge event, although it is very likely this has happened because another car was parked at the Powerparking station. The car was always fully charged, and he was always able to reach his end destination. The participant did mention that he was always cautious about the range of the Leaf.

Before participating, he did not understand the technology very well except that he considered it innovative. After the introduction on site, one of his first thoughts was that he should not arrive with a relatively empty battery due to the uncertain charging pattern of the V2G station and the relative distance of his travels. To alleviate this problem, he would like to have control the minimum state of charge at a specific point in time. After participating, the participant considered the system easier to use than expected, but he still missed the control over the state-of-charge in case there was a long trip upcoming. He liked that a big portion of the energy came from local solar cells and the sharing of electric energy, making the Powerparking station both sustainable and social in nature.
He sees additional benefits for companies with a large fleet of electric vehicles, such as delivery companies, where vehicles with low levels of charge can be charged by a desirable level by full vehicles without impacting the electrical grid much.

He does not think that experience of V2G changes the way he communicates with others about the technology, yet he does think that experience using V2G influences his acceptance of the technology and expects the same for other people. The reason for this, he states, is that there is a lack of control with current V2G technology and experience will allow users to gauge better what the benefits and limitations are. He does think older generations might be less likely to adopt V2G technology, even after experience, as they are used to being in control of their range due to experience with combustion engine cars. When asked about other factors that may influence his own or other people's acceptance of the technology, he remarks additional insight into the current state-of-charge and to set a minimum state-of-charge for specific moments.

He again mentions the possibilities of V2G systems at companies, where a company may control the individual ranges of their cars more precisely given the trip at hand. He mentions again that he sees most benefits of V2G at larger locations, such as company parking lots, and he did not think of any purposes before participating. Before participating, participant ID15 considered V2G to have mainly environmental purposes, but after participating he sees the technology as not necessarily have environmental benefits but more practical purposes, again mentioning the companies with large EV fleets to benefit from decreased peak power consumption.

He thinks the common individual / customer does not see many purposes to V2G technology, both before and after participating, but the technology should eventually be easy enough to use for every customer. After participating, he does consider is to be a better way of charging as compared to conventional charging, specifically when EVs become more commonplace. Before participating, he looked at this differently, namely that it would be more environmentally friendly, but now he disagrees with his earlier thoughts. The V2G station is easy to use, and everybody should be able to use a final version of a V2G station, while he expected it to be harder before participating.

The uncertainty and potential battery harm of V2G technology would fit his lifestyle when there are clear numbers as to what the real financial costs of benefits are. For most people, however, he thinks the yearly cost reduction due to charge and discharge of energy would be enough to persuade them to adopt the technology. Other stimulants to adopt V2G may be promotion the social aspect of the technology by "solving a problem together", but mentions again that most people probably consider financial motives most.

Report: Interview 16

Interviewee information

Interviewee code	ID16
Interview date	27-07-2021
Gender	Female
Age bracket	18-24
Highest education level	WO Bachelor's Degree (University)
EV ownership & type	None, one experience with BEV
Length of lease/ownership	-
Would like copy research?	Yes

Interview transcription

Opening information and background

When asked about her first thoughts of the experiment, participant ID16 first mentions several key words, namely: Electric vehicle, solar panels, and future. She then further elaborates that V2G technology would benefit society in the future, especially when EVs become the norm in mobility, but also states that there should be an app for consumers to adopt V2G in order to check the status of charging or to control a minimum level of charging.

She got in contact with this research through an old roommate and decided to participate primarily because she could use a car for a week but has always been interested in EVs given her study background. She had once driven an EV before, a BEV from a car sharing company, but was unaware about the specific type. She does not have any particular interest in cars, or EVs in general, and only considers EVs to be better due to their reduced environmental impact. Participant ID16 did not know

anything about charging technology. When purchasing a car in the future, she will opt for an electric variant, as long as the range is comparable to a conventional combustion engine car.

She liked the research, especially appreciated the great explanation and feeling of support. When buying an EV, she would opt to include V2G only if there was a way to control the level of charge and have a way to view the current state-of-charge. She finds it very important to always have sufficient range available. She talked to peers about V2G in an enthusiastic manner but would only advise them to purchase V2G if, again, they have control and insight over the range.

Experiences using V2G

Participant ID16 did not notice a discharge event, and mentions this could be due to the fact that she always charged it for long periods of time. For this same reason, she was always able to reach her end destination without any fear of having to charge midway.

When asked about her perception of V2G before participating, after the concept was explained to her at the introduction, she was quite sceptical. She states that you don't always plan your trips ahead of time, and V2G might take away the freedom that a personal car should offer. Additionally, she mentioned that after the introduction V2G may be a necessity to charge the vast amount of EVs expected within the coming years. After driving this EV for a week, she already noticed the great number of charging points already available.

She says that her experience using V2G did not change her perception of the technology much. When diving deeper, she did mention again the necessity for freedom, that car owners should be able to make unexpected trips, or trips with a longer distance than expected, too without much hassle. Having less power available after charging than before is a real dealbreaker for her, and she found herself lucky to not having had to experience this. On the other hand, she mentions that she would have liked to experience this discomfort, though she is pretty certain she would not have liked it.

Participant ID16 mentioned that a way to increase the feeling of freedom is to be in control of the desired state of charge at a certain point in time, or to at least have insight of what the battery level will be at a given time. She states specifically that control is not always necessary or possible for all charging points, so insight will do. When asked about how experience using V2G affects how she communicates with others, she says that it is different mainly because she had no knowledge of V2G's existence so never spoke to others about it, and now speaks in a neutral manner about it providing the pros and cons. However, when asked whether experience of V2G changes her likelihood to adopt V2G for personal use, she responds affirmatively by stating that she then already knows to look for which barriers have been taken out or are still imbedded in the technology. For other consumers, she believes they are all initially sceptical and experience can only change their perception to a certain degree, she mainly thinks a clear visualization of the costs and benefits (and respective savings that consumers can expect) as well as increased control over the battery percentage are likely to improve social acceptance.

The participant cannot think of other applications of V2G, but mentions the idea of V2V, being able to charge another vehicle or e-bike. She thought of this during the interview, and had not thought of any applications beforehand. Her only motivation to embrace this technology is that she feels it may be necessary when the EV fleet continues to grow, and remarks that investments are required to optimize the electricity grid. She thinks V2G is a better way to charge when control options are embedded as the main goal when connecting to a charging station is to charge your car. When such controls are integrated in some way, she believes anyone should be able to use a V2G station.

With regards to the degradation of the battery due to the additional charge and discharge frequencies, the interviewee was asked how she would like to be compensated for this by either a discount on the car purchase or on energy tariffs. When asked about how the potential profits from selling energy with respect to the costs of battery degradation, she mentions that she would like to have a clear visualization of the relative costs and believes this is important in other people's purchase behaviour. She believes consumers will experience V2G differently due whether they own or lease the car as they won't have to bother with the battery degradation. She thinks a social stimulant of solving a problem together might push people to adopt V2G.

Report: Interview 17

Interviewee information

Interviewee code	ID17
Interview date	29-07-2021
Gender	Male
Age bracket	25-34
Highest education level	MBO Degree
EV ownership & type	None, multiple experiences with BEV and PHEV
Length of lease/ownership	-
Would like copy research?	Yes

Interview transcription

Opening information and background

When asked what participant ID17 remembers most from the research, he mentions the constant consideration about the next charging cycle, especially on longer trips. The participant says he is used to the convenience of his own gas-powered car. He did not like the speed destination chargers offer but liked the powerful stations on the highway. When asked about his thoughts of V2G, he answers with quite some detail. He believes V2G is a great concept for the future, as the electricity grid cannot cope with the large power demanded by EVs with limited local PV energy generation. He is also aware of the potential downsides of V2G, naming a situation in which a car with a full battery arrives and leaves hours later with much less power. He does not appreciate this uncertainty, as he believes this limits the freedom of the personal car. Experiencing V2G did not change his beliefs on the technology.

Interviewee ID17 got in touch with the research through a colleague who also participated in this research. He decided to participate as he wants to support his employer (TU Delft) as well as to gain additional insights into the technology, and finally to assess his experience as a consumer. He has previous experience with several types of BEVs and PHEVs, which he never owned or leased. He thinks electric vehicles are the future as fossil fuels are a limited resource and meanwhile finds EVs drive more comfortably and quieter. He considers himself a car enthusiast, but after years of 'missing the feeling' he now believes EVs are better from now onwards. When he buys his first EV, he would like it to offer V2G capability, but notes that he should have the option to choose whether to enable V2G for each session. This should not be a different charger as this would be cumbersome. He spoke to others about V2G in an enthusiastic manner and would recommend they adopt V2G as well. Before participating, he already knew about different types of charging infrastructure.

Experiences using V2G

After participating, he now believes there should be some way to set a minimum state-of-charge or dis-/enable V2G for the next charge. The method does not matter, whether through a smartphone application or on the charging station. This is more important to him than having an insight into the current battery level. Regardless of what charging settings you select; it does require the consumer to think of his schedule constantly.

He did notice some discharging events, as several times upon leaving the V2G station the car was not fully charged. This never bothered him much. Once, this even let him to use a conventional charger around his house. Sometimes error messages occurred. He was always able to reach his final destination but suffered some range anxiety on one of his longer trips, meaning that he had to consider his charging locations constantly. He mentions he would not call it 'range anxiety' but 'range curiosity' as he looked up his charging locations beforehand.

The participant again states that experience using V2G does not change his perception on the technology at all, as he was knowledgeable and opinionated on the technology before participation. The experience only reaffirms his beliefs. He then mentions the drawback of uncertainty on state-of-charge when using V2G, which he experienced more heavily than expected, and notes that most EVs now have some way to view the state-of-charge in real-time.

The idea of earning money through V2G had never occurred to him, and he is curious to see what the 'real costs' are of V2G due to additional discharging cycles. He speaks very cautiously as to how compensation should be provided with respect to the decrease in battery capacity and battery life, which he states are two different concepts. He had not thought of this before participating in this research. He believes experience using V2G does not change how he approaches others about the technology, except for the fact that he did not know of the technology's existence before being introduced. Experience using V2G does not affect his purchasing behavior, as he believes V2G will become part of the charging standard in the future. For future adoption, he believes you should be able to set certain parameters. The most important of these parameters is to set the 'full or V2G' option, while he believes that for most days setting to V2G will suffice, as even a small percentage of charge will function for commuting.

When asked which factors would influence consumer acceptance, the participant mentions the ambiguity a new technology brings along with the uncertainty of range, while conventional (gas powered) technology has been around for a long time with certain range on departure. Modern EVs have proven to charge rapidly and boast long ranges, offering more certainty, while V2G may add some additional uncertainty. Ideally then, this ambiguity and uncertainty should be eliminated. It should be clearly communicated to the customer what the pros and cons of using V2G are. The participant thinks there may be conflicting goals with various stakeholders using or offering V2G, as shaving off peak loads (a societal goal) may conflict with earning money by charging with cheap energy and delivering expensive energy (personal financial goal). He cannot think of other business opportunities for V2G. As a final remark, he thinks that V2G may not be the final solution to an all-electric car fleet, but will assist in delivering power to as many cars as possible while infrastructure investments catch up.

Appendix C: Representation Questionnaire

Questionnaire overview

Table 9: Absolute overview representation questionnaire

Interviewee code	Gender	Age bracket	Highest education level	EV ownership or experience + type	Own/lease length
ID1	Male	25-34	Master's Degree	None, one experience (BEV)	-
ID2	Female	25-34	Master's Degree	None, multiple experiences (BEV)	-
ID3	Male	25-34	Master's Degree	Own (PHEV)	1-3 years
ID4	Male	45-54	Doctorate (PhD)	Own (BEV)	>3 years
ID5	Male	25-34	WO Bachelor's Degree	None, multiple experiences (BEV)	-
ID6	Male	25-34	WO Bachelor's Degree	None, multiple experiences with (BEV)	-
ID7	Male	18-24	WO Bachelor's degree	None, multiple experiences (BEV)	-
ID8	Male	65+	MBO Degree	None, multiple experiences (BEV)	-
ID9	Female	35-44	Master's Degree	None, multiple experiences (BEV)	-
ID10	Male	18-24	WO Bachelor's Degree	None, multiple experiences (BEV)	-
ID11	Male	35-44	MBO Degree	None, multiple experiences (BEV)	-
ID12	Male	25-34	WO Bachelor's Degree	None, multiple experiences (PHEV)	-
ID13	Male	45-54	Master's Degree	None, multiple experiences (BEV)	-
ID14	Female	35-44	High School	None, no experience	-
ID15	Male	25-34	HBO Bachelor's Degree	None, multiple experiences (BEV)	-
ID16	Female	18-24	WO Bachelor's Degree	None, one experience (BEV)	-
ID17	Male	25-34	MBO Degree	None, multiple experiences (PHEV & BEV)	-

Representation overview

Table 10: Relative overview representation questionnaire

Gender	Percentage	Count
Female	23.5%	4
Male	76.5%	13

Age	Percentage	Count
18-24	17.6%	3
25-34	47.1%	8
35-44	17.6%	3
45-54	11.8%	2
55-64	0%	0
65+	5.9%	1

Highest education level	Percentage	Count
None	0%	0
High School (Secondary vocational education)	5.9%	1
MBO Degree (Post-secondary vocational education)	17.6%	3
HBO Bachelor's Degree (Applied Sciences)	5.9%	1
WO Bachelor's Degree (University)	35.3%	6
Master's Degree (University)	29.4%	5
Doctorate Degree (PhD)	5.9%	1

EV Ownership or experience.	Type of EV (HEV, PHEV, BEV)	Percentage	Count
Own	*Total*	11.8%	2
	HEV	0%	0
	PHEV	5.9%	1
	BEV	5.9%	1
Lease	*Total*	0%	0
	HEV	0%	0
	PHEV	0%	0
	BEV	0%	0
Experience of some form	*Total*	82.4%	14
	HEV	0%	0
	PHEV	17.6%	3
	BEV	76.5%	13
No experience	*Total*	5.9%	1

If owning or leasing EV, for how long?	Percentage	Count
Never owned or leased EV	15=88.2%	15
<1 year	0%	0
1-3 years	5.9%	1
>3 years	5.9%	1

Appendix D: Codebooks

Performance Expectancy

Table 11: Performance Expectancy (PE) definitive codebook

Code	Grounded	Frequency
PE: Financial compensation / gains	24	15
PE: Range Anxiety	24	14
PE: Other system benefits	19	10
PE: Other use cases	19	13
PE: Battery degradation	16	12
PE: Peak shaving / Grid stabilization	16	12
PE: Superior to other systems	15	12
PE: Societal benefits	14	10
PE: Works with other systems	14	13
PE: Disbalance societal/personal benefits. Conflicting goals	12	10
PE: Energy storage / Power bank	11	8
PE: Other compensation	10	8
PE: Skeptical of benefits	10	9
PE: Community benefits	7	6
PE: Environmental benefits	7	5
PE: Inferior to other technologies	7	7
PE: V2G becomes (part of) the standard	7	5
PE: Cost / Complexity increase	4	4
PE: Cost reduction	4	3
PE: No (personal) energy waste	3	2

Effort Expectancy

Table 12: Effort Expectancy (EE) definitive codebook

Code	Grounded	Frequency
EE: User-friendliness V2G (maybe split subparts of V2G, user-interface for example)	27	16
EE: Scheduling anxiety	17	12
EE: Operational reliability	7	7
EE: Required behavioral change	7	5
EE: Worry of non-V2G using all energy	3	3
EE: Complexity V2G charger	2	2
EE: Inconvenient location	2	2

Social Influence

Table 13: Social Influence (SI) definitive codebook

Code	Grounded	Frequency
SI: Image of Comfort and Luxury	8	7
SI: Changing norms	8	6
SI: Fair destination electricity	7	4
SI: Aware of energy use	6	3
SI: Personal norms or values	6	5
SI: Range anxiety is time anxiety	1	1
Social Influence (any)	35	13

Facilitating Conditions

Table 14: Facilitating Conditions (SI) definitive codebook

Code	Grounded	Frequency
FC: Control/set SOC (maybe split into general control, set SOC or mimimum SOC)	28	13
FC: Distrust, uncertainties	19	14
FC: Clear communication benefits/costs/risks/etc.	15	11
FC: View SOC (maybe split on different ways of 'user interface')	15	8
FC: Requires more V2G cars / scale issues	14	9
FC: Limits freedom personal car	7	5
FC: Fits lifestyle	6	6
FC: Fits work schedule	6	6
FC: Insight technology / energy	6	5
FC: Plenty of chargers available	6	5
FC: Does not fit lifestyle	5	5
FC: Opt in-out	5	4
FC: Data/privacy doubts	3	2
FC: Education	3	3
FC: Subsidies	3	3
FC: Lack of standards	2	2
FC: Does not fit work schedule	0	0

Driver Profile Characteristics

Table 15: Driver Profile Characteristics (DPC) definitive codebook

Code	Grounded	Frequency
DPC: Knowledge need for V2G	12	9
DPC: Knowledge general innovations	8	7
DPC: Knowledge V2G	8	7
DPC: Knowledge EV batteries / infrastructure	7	7
DPC: Not influenced by environment	7	7
DPC: Interest in details V2G technology	4	4
DPC: (Slightly) influenced by environment	2	2

Mediating variables

Table 16: Mediating variables (A,G,E,V,O) definitive codebook

Code	Grounded	Frequency
E-Having experience with EV or other smart technologies	13	13
V: Having a car / freedom of car	11	11
V: Interest in V2G technology	10	10
V: Interest in customer experience	8	8
V-Support university innovations	7	6
V-Interest in general innovations	2	2