DUTCH ELECTRIC VEHICLE DRIVERS' ACCEPTANCE OF VEHICLE-TO-GRID AT LONG-TERM PARKING

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Dutch electric vehicle drivers' acceptance of vehicle-to-grid at long-term parking

Exploring factors that contribute to the acceptance of vehicle-to-grid by conducting semi-structured interviews with Dutch EV drivers and V2G pilot participants

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Summary

Background

This thesis research examined Dutch electric vehicle (EV) drivers' acceptance of vehicle-to-grid (V2G) applied at long-term parking. Within the Netherlands, the number of EVs on the roads is rapidly growing. Charging of EVs batteries and the use of renewable energy sources are expected to evoke grid balancing issues. V2G is a form of bi-directional charging which makes it possible to charge and discharge the battery of an EV and to serve as (temporary) energy storage for the grid. With V2G systems, batteries of EVs can support the electricity grid through several grid services such as grid balancing, peak shaving, frequency regulation. V2G will help to make better use of renewables by storing energy during off-peak demand periods and delivering it back during peak power demand periods. There are various potential V2G application locations such as V2G at home or office buildings. V2G at long-term parking (e.g. at airports) is also a potential application because of the high number of plug-in sessions, large volume of parked cars and predictable parking patterns of EV users.

Problem definition

Previously, V2G research has mainly been technical or has investigated the economic aspects. These studies neglected mostly the perspective of the EV users, as little research has been conducted on the consumer side of V2G. Still, a few studies have focused on EV drivers' preferences regarding V2G contract attributes utilizing stated preference experiments and surveys. However, none of the previous researches has aimed at investigating Dutch EV drivers acceptance of V2G or taken into account the long-term parking use case. In this study, EV drivers' acceptance was defined as "EV drivers' behavioural responses to the availability of technological innovations (V2G services), that is, the purchase and use of such products as part of their daily lives". To the researcher's best knowledge, Dutch EV drivers' attitudes and opinions towards V2G at long-term parking and EV users' acceptance levels was never researched before. Therefore, this MSc thesis research aimed at answering the following research question:

"To what extent do Dutch EV drivers accept V2G at long-term parking?"

This research question was answered by using identified factors that contribute to Dutch EV drivers' acceptance of V2G at long-term parking.

Methodology

To answer the main research question, a qualitative research approach was chosen including two data collection phases. Firstly, a preparatory phase in which literature has been reviewed to create a conceptual model or theoretical perspective – collecting V2G acceptance factors – developed based on a literature review of previous V2G studies that have included consumer-aspects and Theory of Planned Behavior. Secondly, a main research phase in which 20 semi-structured interviews have been conducted with Dutch EV drivers. The literature review indicated that interviews with EV drivers was a suitable methodology since most previous V2G studies relied on surveys and stated choice experiments. In this main phase, a total of 20 semi-structured interviews have been conducted to gain insights into EV users' attitudes and opinions regarding V2G at long-term parking. The sample consisted of 17 current Dutch EV drivers and 3 V2G pilot project participants. Subsequently, the research lens created through the literature review was used to formulate different topic areas for interviews, i.e. perceived benefits and ease-of-use. Finally, the qualitative data has been analysed through the coding of the interview reports.

Results

Based on the literature review, a research lens or theoretical perspective has been established by adopting the Theory of Planned Behavior by Ajzen (1991) as the main framework. A conceptual model has been created including TPB's 5 categories: attitude towards V2G, perceived behavioural control, subjective norms, intention towards V2G acceptance and V2G acceptance. Based on the literature, the model has been extended by including perceived benefits, perceived barriers, EV driver's profile characteristics and trust. The theoretical perspective served as the guiding philosophy for this research.

Based on the interviews, 85 factors contributing to V2G acceptance have been identified. A list of top-factors has been created based on the highest frequency mentioned by the 20 interviewees. The most common factors have been grouped into the 9 categories within a *resulting model*. This is visually shown in Figure 1. The figure includes the number of relative importance within each category. Representativeness of the sample could not be justified, but the results showed that the interview sample mainly consisted of young adult males with higher income and education levels. This was similar to other Dutch studies focusing on EV drivers.

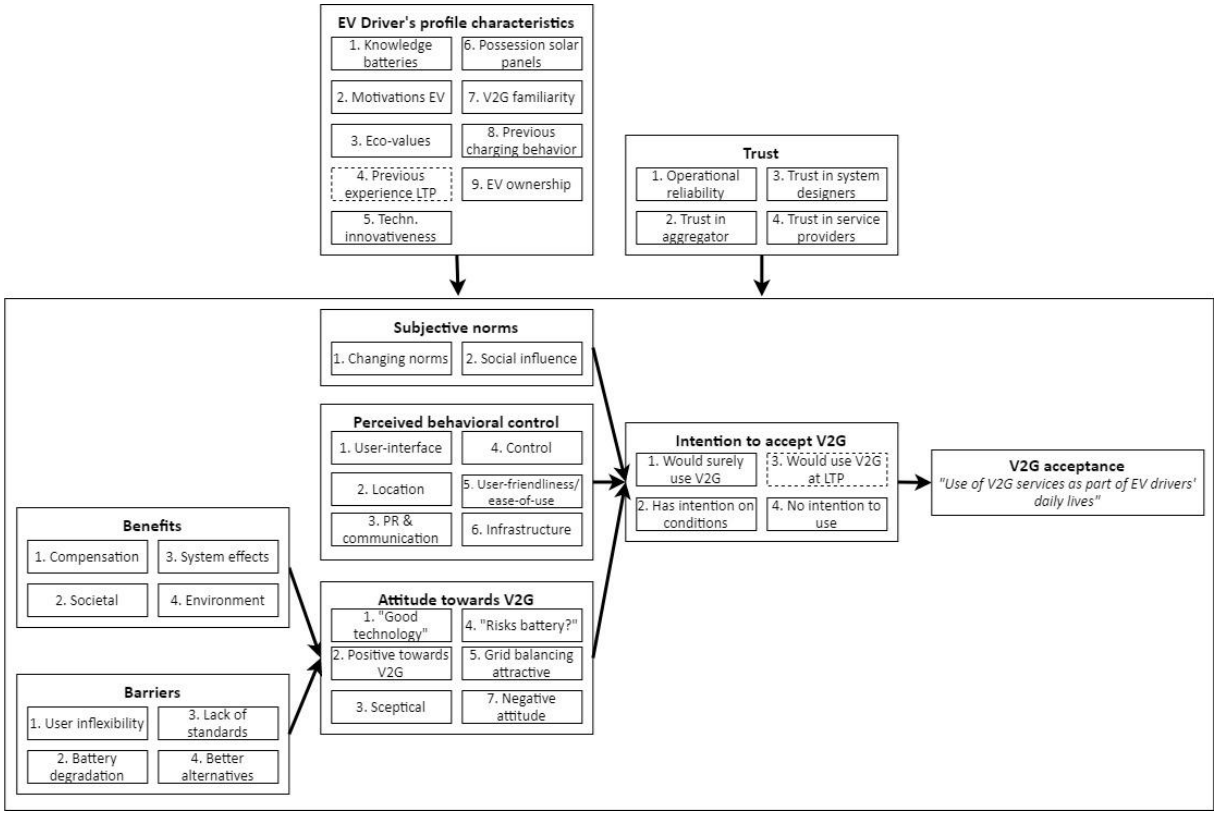

Figure 1: Resulting model V2G acceptance based on interviews

The results showed that interviewees were mainly positive towards V2G at long-term parking. The sample admired the *system effect's* (e.g. grid balancing, RES-integration) and perceived V2G as a "smart solution". The majority of the interviewees expressed that they would have the intention to use V2G at long-term parking provided the following two conditions: provision of compensation and clear-cut information about the risks of battery degradation. Furthermore, participants requested simple, clear and transparent information provision about the system such as how it works, the benefits, risks. The sample indicated that V2G's *societal contribution* triggers a large part of the EV driver, i.e., help to balance the grid and *environmental benefits*. EV users also perceived *practical*

advantages, e.g. solving the *charging station sticking issue*. Lastly, the results indicated that the *operational reliability* of V2G systems is an essential precondition of acceptance.

Nevertheless, interviewees expressed also concerns and uncertainties. The interview results showed that *user-inflexibility*, the collective term for 'range anxiety' and experienced discomfort of additional trips planning, is one of the largest perceived barriers of V2G acceptance. However, the interviewees expressed that this less an issue for the long-term parking use case because they expected that their parking duration could be predicted with high certainty (e.g. based on flight information). Moreover, EV users expressed concerns regarding battery degradation caused by V2G. The results showed that battery degradation is a larger barrier for the long-term parking use case compared to other V2G applications since a higher number of (dis)charging cycles are expected to be made. Furthermore, a lack of V2G standards and protocols seems to block acceptance since interviewees were predominantly sceptical about whether their current EV does support V2G and/or future EVs will support it. Also, low maturity of the infrastructure can obstruct acceptance, as the sample indicated that they will not participate in V2G services when bi-directional chargers are occupied on a frequent basis or not available at all. Parts of the sample believed in possible better alternatives meaning that there might be better technological solutions to solve grid balancing problems (e.g. static batteries or hydrogen storage).

Conclusion

The results generally showed a high degree of acceptance of V2G at long-term parking, with a few sceptical participants included and divided opinions. Based on the sample, acceptance is high on condition that end-users are compensated for possible battery degradation and do not experience additional discomfort compared to the current charging situation. Interviewees found it appealing that they could contribute to the service provider's energy system and they also perceived practical benefits of V2G at long-term parking. The sample had divided attitudes regarding possible battery degradation caused by V2G and the results showed that this was influenced by the EV ownership type (leased/purchased) and battery knowledge. Based on the sample, EV users indicated that battery degradation is acceptable as long as the technical risks are communicated in a transparent and clear manner and users can have a certain level of control through a user interface. The interviewed V2G pilot driver participants had actual experience with mobility planning for V2G and all had a positive attitude towards V2G, while current Dutch EV drivers had more divided attitudes towards V2G. The results indicated that V2G location did not influence acceptance. An open-view was adopted with regards to other applications and revealed that drivers prefer certain V2G locations based on their previous charging behaviour and for practical reasons. EV drivers' attitudes towards V2G at long-term parking and short-term parking did not differ. Except that for long-term parking, user-inflexibility is not an issue and slightly more concerns are raised about battery degradation.

Discussion

The results of this research added several scientific and practical contributions. The approach of semi-structured interviews with EV users made it novel within the field of V2G research. Furthermore, it has accommodated requests of Nordic researchers to conduct research in V2G consumer acceptance. Another unique feature of the work is its focus on V2G at long-term parking and the examination of differences with short-term parking. It challenged existing theory, mainly the Theory of Planned Behavior by Ajzen (1991), by identifying missing factors and expanding it further to contextualize the model for V2G acceptance. Nevertheless, this research was prone to several limitations regarding the choice of theory, research methodology and generalizability. Not all known

limitations of TPB could be circumvented and still affected this study: individuals are assumed as rational actors and TPB lacks predictive power. The chosen research methodology caused possible interviewer bias, response bias and framing of the sample. The field of e-mobility is rapidly evolving and new groups of EV drivers may emerge soon, which may cause attitude changes. It was not feasible to hold interviews with EV users that experienced discharging of the battery due to specific circumstances in the V2G pilot projects (e.g. software failures). Lastly, since the representativeness of the sample could not be justified, the results are most probably not generalisable. However, both the comparison with other Dutch studies and interview code saturation implied that the results provided quite a representative overview of the prevailing views of current Dutch EV drivers.

Recommendations

Several directions for future research follow from this research and recommendations to practical stakeholders of V2G systems that have a direct link to consumers. Firstly, future research should point out whether actual usage of V2G influences EV drivers' attitudes and opinions. Norms, values and mobility demands of EV drivers should be incorporated (e.g. 'car as status symbol'). Moreover, scientists should clarify the feasible amounts of compensation for EV users and the actual influence of bi-directional charging on the EVs battery. It requires research in technical, operational, consumer and business models domains. Secondly, V2G system designers should adopt a consumer-centric approach, focus on a steady business case, take into account deviating demands and needs of EV drivers and provide clear-cut information about V2G systems to EV users. Thirdly, mobility service providers should be prepared to work together with aggregators to further integrate V2G user interfaces with existing applications and ensure that payments handling includes V2G compensation. Finally, policy-makers should stimulate information provision, develop laws and regulation to avoid double taxes, stimulate the creation of V2G standards and continue with short-term provision subsidies for V2G demonstration projects in case consumer awareness is low.

Keywords: vehicle-to-grid, Dutch EV drivers, V2G acceptance, long-term parking, bi-directional charging, Theory of Planned Behavior

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List of abbreviations

V2G	Vehicle-to-grid
EV	Electric vehicle
PHEV	Plug-in hybrid electric vehicle
RES	Renewable energy sources
MW	Megawatts
VDP	V2G driver participant
CED	Current EV driver
SOC	State-of-charge
MSP	Mobility service provider
EVSE	Electric vehicle supply equipment
TPB	Theory of Planned Behavior
LTP	Long-term parking
A	Acceptance
ATV	Attitudes towards V2G
I	Intentions
SN	Subjective norms
PBC	Perceived behavioural control
PBN	Perceived benefits
PBR	Perceived barriers
TR	Trust
EPC	EV driver profile characteristics

1 Introduction

1.1 Problem background

1.1.1 Electrical power grid issues in the Netherlands

Over the past years, the capacities of renewable energy sources (RES) have been growing in the Netherlands. In 2018, the installed capacity of solar photovoltaics saw a record increase of over 1,500[1] megawatts (MW) to a total of 4,400 MW. Wind energy generation rose by 4% to 36 PJ in that year. Simultaneously, electric vehicles (EVs) are becoming more popular in the Netherlands. On 31 December 2019, a total number of 203,421 electric passenger automobiles were registered. This implies a growth of 43% compared to 31 December 2018[2]. Despite the numerous benefits of increased adoption of these technologies (e.g. reduction of greenhouse gas emission), increased EV charging and increased RES capacities may lead up to various electrical power grid issues: local/global adequacy issues (e.g. amplified electricity peaks) and local/global power quality issues (e.g. voltage dips or frequency variations) (Dubey & Santoso, 2015; IRENA, 2019). But, there is a promising solution: vehicle-to-grid (V2G).

1.1.2 Potential solution: vehicle-to-grid

With V2G, EVs are viewed as mobile self-contained power sources so that electrical power can be temporarily stored and delivered back to the grid when needed. Subsequently, variable RES such as wind and solar photovoltaics can be better integrated into the energy grid by storing energy during off-peak demand periods and delivering it back during peak power demand periods. Despite the fact that there are numerous terms (e.g. V2Home, V2X, vehicle-grid integration), V2G has been used as an umbrella term. In this study, V2G has been defined as *"a system whereby EVs, when connected to electric vehicle supply equipment (EVSE), can provide bi-directional flows of energy*" (Cenex UK, 2018). Figure 2 provides an overview of the V2G concept. The figure includes a schematic representation of an EV, V2G (dis)charger, grid, house with barn, solar and wind park. The two-sided black arrow represents the two-sided energy flows or bi-directional charging. Researchers have acknowledged that V2G provides various potential grid services: ancillary services, energy trading, back-up power and frequency regulation, etc. These services may lead up to new business cases and economics benefits for various stakeholders, including EV drivers (owners & lessees) and grid operators.

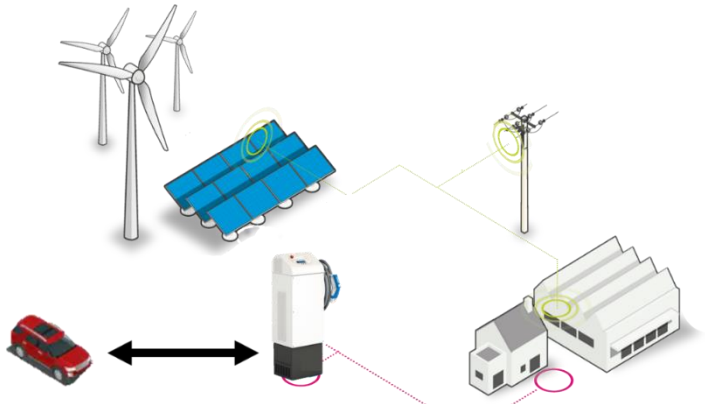

Figure 2: Schematic V2G concept overview

[1] https://www.cbs.nl/en-gb/news/2019/22/share-of-renewable-energy-up-to-7-4-percent
[2] https://nederlandelektrisch.nl/actueel/verkoopcijfers

1.1.3 V2G at long-term parking

There are multiple applications of V2G such as V2G at home or at office buildings. Suitability of V2G is dependent on a wide-range of factors and often case-specific (Cenex UK, 2018; Reynolds, 2018). For instance, *duration of service* (e.g. short-term) of EVs and the *location* (e.g. at office buildings) (Cenex UK, 2018, 2019; Reynolds, 2018; Smart, 2015). A high potential use case is *V2G at long-term parking lots*. Long-term parking lots are mostly at airports, but can also be at holiday destinations or public traffic hubs. Strong drivers of the applicability of V2G at long-term parking are high plug-in durations, large volume of parked cars and relatively predictable parking patterns to achieve an optimal aggregation of battery capacities (Cenex UK, 2019). Short-term parking lots, on the other hand, also provide high potential applications such as V2G at office buildings or shopping centres. In this research, short-term parking was defined as 0-48 hours parking and long-term parking as 48+ hours of parking, as used by most airports[3]. A few studies made a distinction between short-term (0-2 hours) and mid-term parking (3-48 hours). However, it was decided to merge these for simplicity and use short-term parking as an umbrella term.

1.1.4 The increasing importance of potential end-users of V2G systems

Kempton and Letendre (1997) invented the concept of V2G in 1997. From this point onwards, multiple researches mainly focused on technical and economic aspects. These studies have made outstanding contributions such as the feasible technical designs, the impact of V2G on EVs batteries, etc. V2G is slowly evolving from a theoretical concept to a tangible product still in the pre-commercialization phase. An increasing amount of pilot tests have been carried out over the last few years globally.

In the Netherlands, numerous pilot tests have been executed. All with its user profile, customer type and markets. For example, Smart Solar Charging in Utrecht region (e.g. vehicle-to-home at Lombok), NewMotion's vehicle-to-office project in Amsterdam, SEEV4-city with vehicle-to-home and vehicle-to-office in Amsterdam region (and 4 other EU cities)[4]. PowerParking is a recent V2G pilot of the Delft University of Technology which aims to design and implement a solar-powered long-term parking lot for the charging of EVs at Lelystad Airport and Businesspark and analyse its operation. Part of this project is the installation of V2G at Green Village at the Delft University of Technology for initial testing and demonstration, which is still ongoing. Pilot projects are essential to practically demonstrate the technology together with its benefits. Furthermore, these pilot projects provide the opportunity for different end-users to try the technology and develop user experiences. But why is that important?

In these pilots, EV drivers, who are the end-users of V2G systems, can experience how V2G systems work and whether it is appealing to them. But in many cases, pilot tests and corresponding researches are still very focused on the technical aspects, and the end-user is not (yet) at the centre of research. Industry experts and academia recently realised that investigating the consumer side or end-user side of V2G, in particular, acceptance, is of utmost importance. Namely, when V2G becomes available on a larger scale and will enter the commercialisation phase, actual use of EVs for energy storage is likely to depend on the acceptability of V2G to the EV drivers (owners & lessees). In recent years, some researchers even regard "consumer barriers" as the largest challenge to succeed in the large-scale implementation of V2G (Noel, de Rubens, Kester, & Sovacool, 2019d).

[3] https://www.schiphol.nl/en/parking/product/p1-short-term-parking/

[4] https://www.hva.nl/binaries/content/assets/subsites/urban-technology/vehicle2grid-repository.pdf?1518609633302

1.2 Research gap

Part of this research was an extensive literature review to provide the state-of-the-art of V2G researches that included consumer aspects. Based on Section 3.1, a research gap has been identified, which consists of three elements. Firstly, it remains unclear what factors contribute to V2G acceptance and what their possible respective relations are. Secondly, previous V2G studies provided only superficial insights regarding drivers' preferences of V2G contract attributes. Thirdly, previous researches focused solely on short-term parking applications of V2G (under 3 days parking). These elements will be further discussed.

1.2.1 Unclear which factors contribute to EV drivers' acceptance of V2G

EV drivers' acceptance is a key uncertainty for V2G diffusion, but an important requirement to maximise the availability of EVs for providing various grid services through V2G (Turton & Moura, 2008). The definition of Dutch EV drivers' acceptance of V2G is "*EV drivers' behavioural responses to the availability of technological innovations (e.g. V2G services), that is, the purchase and use of such products as part of their daily lives*". While the majority of studies focus on technical aspects of V2G (e.g. RES storage, batteries, load balancing), a low amount of studies focus on the role of consumer acceptance and knowledge of V2G systems (Sovacool, Axsen, & Kempton, 2017; Sovacool, Noel, Axsen, & Kempton, 2018). In their sample of 197 V2G related studies, Sovacool et al. (2018) identified that only less than 3% included aspects regarding social acceptance, consumer norms and informing consumers. EV driver (user) behaviour aspects were hardly present: consumer routines and norms discussed in less than 2.1%, range anxiety (<1.1%), information and educational material (<0.5%) (Sovacool et al., 2018). We found that a few studies have focussed on contract attributes and perceived utility. However, EV drivers' acceptance of V2G as a technology was hardly present in these studies. It is unclear to what extent EV drivers acceptance V2G. In other words, studies focusing on identifying factors that contribute to consumers' (especially EV drivers') acceptance of V2G is scant.

1.2.2 Hardly any insights about underlying motivations and perceptions of V2G

An extensive line of research focused on EV drivers' preferences regarding V2G contracts. However, there is also criticism regarding this type of studies. Major assumptions are underlying V2G contract preference researches (Zonneveld, 2019). A first significant assumption is that they assume the necessity of the presence of a contract between the aggregator and end-user. Almost every study focusses on fixed and variable compensation. These studies thereby automatically exclude other forms of business models or compensation forms (e.g. discount on purchase price EV). Secondly, choice experiments measure the consumer's reaction to V2G contracts and their attributes, as opposed to V2G participation generally or the technology itself. In other words, the focus is on the contracts and not on the technology as a whole. Nevertheless, these studies provide insights that certain V2G contract attributes (e.g. plug-in time), may prove burdensome to consumer acceptance (Noel, Zarazua de Rubens, Kester, & Sovacool, 2019). Based on Table 5, the majority of studies adopted a choice experiment or survey approach. The disadvantages of choice experiments and surveys are that they do not provide in-depth insights about underlying motivations for certain answers since it does not provide the possibility for the researchers to question further.

1.2.3 Studies aiming at long-term parking applications are lacking

Previous studies focused mainly on short-term parking applications of V2G (e.g office applications). However, a limited number of studies specifically aimed at long-term parking

applications. To the knowledge of the researcher, acceptance of V2G at long-term parking has not yet been investigated.

1.2.4 Resulting main research question

This research focused on EV drivers' acceptance of V2G through analysing current Dutch EV driver's attitudes, perceptions and beliefs towards the V2G concept at long-term parking lots. This identified research gap results in the following main research question:

> **"To what extent do Dutch Electric Vehicle drivers' accept vehicle-to-grid at long-term parking?"**

1.3 Research objectives

The main objective of this research was the *identification of factors contributing to Dutch EV drivers' acceptance of V2G at long-term parking.* Using the identified factors, an answer could have been provided to the main research question.

As discussed in the research gap, academics acknowledged the need for more research insights into consumer aspects of V2G. Moreover, V2G acceptance at long-term parking was investigated before. This research intended to also make also practical contributions, especially for the PowerParking project. Their aim is to develop V2G at Lelystad Airport and Lelystad Business Park. Nevertheless, similar V2G projects, including long-term parking (e.g. holiday destinations) can also reap the benefits from this study. The scientific and practical contributions are further discussed in Section 5.2.1.

1.4 Research approach

In this MSc thesis research, a qualitative and explorative research approach was chosen as a complementary to (a few) previous V2G consumer studies that mainly relied on survey or stated preference experiments. The research approach was divided into a preparatory literature review phase and the main interview phase. Firstly, a literature review was conducted in which a conceptual model or research lens – collecting V2G acceptance factors – has been developed by reviewing previous V2G studies that have included consumer-aspects and social psychology theories. Second, the main phase of this research was based on 20 semi-structured interviews with Dutch EV drivers. Sampling was done by means of purposive sample: individuals with low V2G familiarity (e.g. who never heard of it) and high V2G familiarity (who experienced actual V2G use). Participants were approached using the researchers' own professional network through advertisements and social media posts in EV driver groups. This resulted in a sample of 17 individuals who drive an EV on a daily basis. Between October '19 – December '19, they were interviewed to gain insights in their views and opinions regarding the V2G concept in general and their acceptance of V2G at long-term parking. The sample was supplemented with 3 additional interviews with EV driver participants of previous Dutch V2G pilot projects to gain additional insights on actual usage or acceptance. However, it was not anticipated that V2G pilot participants never experienced actual discharging of the EVs battery due to specific conditions and limitations of the V2G pilot projects. Subsequently, the qualitative interview data has been analysed through coding of the interview reports and reported in the results section. Based on these results, an answer could be provided to the main research question.

1.5 Scope of the study

This research analysed Dutch EV drivers' acceptance of V2G at long-term parking occasions. In the present thesis, the point of view of the EV driver was chosen as the main stakeholder perspective. As mentioned earlier, long-term parking was assumed to have the following characteristic: *3+ days parking of automobiles*. The scope of long-term parking lots was chosen because V2G charging points at long-stay parking areas is a high potential application due to high plug-in durations, high predictability of parking behaviour and large amount of EVs parked simultaneously. Moreover, to the researcher's best knowledge, long-term parking was not selected as a research focus before. The Netherlands was chosen as a geographical scope because of four reasons. Firstly, its high EV maturity (especially in the Randstad), compared to other EU countries (Nordic region excluded). Secondly, severe grid challenges are faced by Dutch grid operators due to a high number of charging points and EVs charged on a daily basis in this region. Thirdly, within the Netherlands, there is a high interest and willingness to invest in V2G from the perspective of governmental institutions, grid operators and NGOs. To illustrate, the Dutch government recently announced the provision of €5 million subsidies for approximately 450 V2G chargers which will be delivered in 2020[5]. To the best of the researcher's knowledge, at least five V2G pilot tests have been in the Netherlands. This is a high number compared to other EU regions and provided opportunities for data collection.

1.6 Reader's guide

Scientists that want more information about the adopted research methodology, more specific the interview questions, chosen data analysis approach or (initial) coding schemes are referred to Section 2. Scholars that may want to repeat (parts) of this research to validate the findings by holding semi-structured interviews with either current EV drivers or V2G pilot driver participants, can use the interview protocol as an inspiration for their own design of interview questions (Appendix I). Readers with a special interest in the study's theoretical foundations or the state-of-the-art of V2G consumer research, for instance, other thesis students or academics, are redirected to the literature review in Section 3. This section provides the results of a literature study that provides the current state of V2G consumer research, chosen guiding philosophy (also called a *conceptual model* or *theoretical perspective*) and argumentation for the identified research gap in 1.2. Practitioners or academics that want more information about the interview sample, identified factors influencing V2G acceptance or an impressionistic view of the results (e.g. with interview quotes), are redirected to the results in Section 4. Section 5 includes the conclusion, discussion and recommendations. In more detail, readers that want a direct answer to the formulated main research question are recommended to go to the conclusion in Section 5.1. This section also includes a sub-section about the generalizability of the findings to other V2G applications, since not all practitioners or academics have a direct interest in V2G at long-term parking. Or they want to know what the findings mean for other V2G applications. All readers, especially if you may consider applying the findings (e.g. for marketing and communication plans), are recommended to take a closer look at Section 5.2. In this section, there is critically reflected upon the limitations of this study. Lastly, Section 5.3 provides concrete recommendations to scientists by means of areas for further research. Furthermore, recommendations are provided for 3 practical stakeholders of V2G systems development that (can) have a direct influence on consumer acceptance. These stakeholders are V2G system designers, Mobility Service Providers and policy-makers.

[5] https://www.rijksoverheid.nl/actueel/nieuws/2019/09/02/5-miljoen-voor-laadpalen-van-de-toekomst

2 Methodology

In the previous chapter, a research gap and corresponding main research question have been presented. This chapter presents the chosen research methodology to answer the formulated main research question. Given the 3 dimensions of the research gap, a suitable research methodology was chosen. As already mentioned, explorative research based on both literature review and semi-structured interviews with Dutch EV drivers was conducted. This chapter reports the research design choices and chosen research methodology to collect the data and describes the process of analysing the qualitative data generated during 20 interviews.

In Section 2.1 the motivation for the chosen research approach is provided. Both the literature review approach and purpose of the literature review is explained in Section 2.2. In Section 2.3 the interview methodology is explained. For instance, the process of formulating interview questions is explained and the data analysis approach is provided. For a detailed overview of the interview approach, we also refer to the Interview Protocol in Appendix I. In Section 2.4 an overview of data management and research ethics is provided including choices with regards to privacy and data security of the research participants (consumers). In Section 2.5 a research flow diagram is presented which allows the reader to understand the research process on a high level.

2.1 Choice of approach: qualitative research

As mentioned in the research gap, previous V2G contract preference studies solely relied on surveys and administering questionnaires electronically (e.g. in stated preferences research). Although these quantitative approaches are efficient in terms of researcher time, energy and costs, these approaches did not provide sufficient insights about underlying motivations, perceptions and attitudes of consumers. In general, survey methodologies are highly sensitive to bias, i.e. if some questions are interpreted differently by the respondent, wrong answers will be obtained. Moreover, it is not possible to clarify questions if a respondent does not understand a question. Respondents must be willing to complete the survey and it is unable to follow-up on answers and deviate from the prepared questions (Sekaran & Bougie, 2016).

The objective of this research was to discover Dutch EV driver's perceptions, attitudes and beliefs towards the concept of V2G applied at long-term parking locations and to identify factors contributing to EV drivers' acceptance. In general, the nature of the study and methodology depends on the stage to which knowledge about the topic has advanced (Sekaran & Bougie, 2016). In general, exploratory research is done when not much known about the situation at hand, or a low amount of information is available about how similar issues are solved. In the present study, the area of interest is exploring the situational factors to obtain a grip on the characteristics of the phenomena of V2G acceptance by Dutch EV drivers and to what extent EV drivers do accept V2G at long-term parking. As mentioned before, the literature on V2G consumer acceptance is scant and the vast majority of studies rely on quantitative research methodologies. Therefore, an exploratory and qualitative research approach was chosen in this research.

A feature of qualitative research is that data is being collected on the perceptions of local actors "from the inside", through a process of deep understanding (Verstehen) (Miles, Huberman, Huberman, & Huberman, 1994). This was considered an essential characteristic to give answers to the main research question. In this study, the attitudes, beliefs and perceptions of Dutch EV drivers towards the V2G concept were investigated. The researcher wanted to know what their underlying motivations of

using V2G or not using V2G are. For this purpose, data has been collected from both individual Dutch EV drivers and V2G driver participations. The *unit of analysis* was the individual Dutch EV driver. The research was done in the EV driver's natural environment where work proceeds normally. This is called research conducted in non-contrived settings (Sekaran & Bougie, 2016). Lab setting or contrived setting have been possible alternatives. However, this was not considered as suitable for the present study since we wanted to explore factors and not establish relationships or do cause-and-effect testing. In order to answer the main research question, qualitative data was gathered over a period of months from September 2019 until December 2019 which is called a cross-sectional or one-shot study (Sekaran & Bougie, 2016). It was not feasible to study the phenomena of V2G acceptance at more points in time due to the thesis time constraints of 25 weeks.

2.2 Literature review approach

A first phase of the research was the execution of the literature review. The overarching goal of the literature review was to lay the foundations for a scientifically substantiated research and selection of an appropriate research lens or theoretical perspective following from previous researches. In more detail, the literature review served four different purposes. Firstly, to develop an in-depth understanding of the core concepts related to the research problem and the main research question. The literature review provides an overview of the state-of-the-art regarding the V2G research field, specifically previous studies that have already included consumer or EV driver aspects. This made it possible to generate an initial idea of factors influencing EV drivers' V2G acceptance, i.e. facilitators and barriers. Secondly, the development of the research gap as presented in the introduction of this research (Section 1.2). Thirdly, the choice of a theoretical perspective to address the main research question including the development of a conceptual model. Fourthly, as already mentioned before, the main methodology of this research was conducting interviews with Dutch EV drivers. The literature review had also an important role for the development of the interview protocol (e.g. identification of topic areas and development of research questions) and for the qualitative data analysis phases (e.g. for the development of the initial codebook).

The 3 scientific literature databases (Elsevier, IEEExplore, Science Direct) and search engine Google Scholar have been used in order to find relevant literature. The following keywords are interchangeably used in the search queries: "vehicle-to-grid", "V2G" or "vehicle-grid integration", "consumer acceptance", "consumer feedback", "acceptance", "attitudes", "usefulness", "ease of use", "technology acceptance", "adoption factors", "public perception", "barriers", "benefits", "location", "trust", "privacy", "diffusion", "social aspects" and "intention to use". Title scanning was done which resulted in a list of 57 potentially relevant papers. Subsequently, the snowballing method was used to extend the literature review. After that, selecting the final set of literature was done by scanning the abstracts, introductions and conclusions. Several industry reports have been used (e.g. by Cenex and PowerParking project) which are also included in the literature review. Ultimately, this resulted in an overview of 27 articles that cover consumer aspects of V2G (Table 5). Literature for the theoretical domain or theoretical perspective was found by using search queries for relevant studies (not necessarily in the V2G research domain) that had technology acceptance or consumer acceptance of technological artefacts as a focal point of research. Subsequently, snowballing and reviewing of the theory sections resulted in finding a suitable theoretical perspective (Theory of Planned Behavior). Chapter 3 explains the results of the literature review. After finishing the literature phase, the interview phase started.

2.3 Interview methodology

As mentioned above, the main methodology used in this research was conducting semi-structured interviews. The motivations for choosing this methodology and the interview process itself is explained in this section.

Interviewing is a useful data collection method during the exploratory stages of researches (Sekaran & Bougie, 2016). In a situation where a large number of open questions are asked, interviews are more suitable compared to surveys. Especially face-to-face interviews provide rich data and help to explore and understand complex issues. To illustrate, if certain interview answers require further elaboration on those answers to generate a more in-depth understanding of the issue, interviews are more suitable compared to surveys (Emans, 2004). Furthermore, when there is any missing data, there is often an understanding of the reason for the missing data with interviews (Emans, 2004). In general, a distinction is made between unstructured, semi-structured and structured interviews (Sekaran & Bougie, 2016). Semi-structured interviews have the advantage of flexibility in terms of adapting and changing interview questions as the researcher proceeds with the interviews. The same questions will be asked of every interviewee in the same manner and are captured in the interview protocol. Sometimes, however, based on the exigencies of the situation, the interviewer might take a lead from a respondent's answer and ask other relevant questions not present in the interview protocol. It provides the ability to gain deep insights into certain factors, but also the opportunity to identify new elements. Semi-structured interviews are useful to collect information about attitudes, facts, opinions and beliefs (Wilson, 2013). Therefore, given the fact that in-depth information about underlying motivations is wanted, semi-structured interviews are deemed as most suitable for the present research. There are also advantages for respondents when conducting interviews. In situations where the interviewer asks various open questions, the respondent does not have to write down long answers to open questions and can just explain them. For the participants, interviews demand fewer language skills and discipline of the respondent since information is transferred verbally (Emans, 2004).

2.3.1 The interview process

Figure 3 provides an overview of the adopted interview process. First, the chosen theoretical perspective (conceptual model) was used as an input for the interview process. Secondly, based on the theoretical perspective and main research question, the required information or different 'topic areas' have been defined. The topic areas are linked to the factors identified in the conceptual model. For instance, perceived benefits was a topic area which was based on the conceptual model (see Figure 11 in Chapter 3). Thirdly, interview questions have been created after the identification of the required information and corresponding topic areas. Each interview question was linked to a predetermined topic area. In other words, the theoretical perspective helped the researcher to formulate the interview questions. Fourthly, the researcher's own network and different advertisements were used to find interview candidates. The sampling design was used to select interview candidates. In short, a criterion for the sample was that interview candidates had to be part of either the group of current Dutch EV driver or had to be a driver participant of a current or past V2G pilot project. The sampling design will be further explained in Section 2.3.2. Fifthly, after reaching out to interview candidates, the interviews have been conducted and each interview was audio recorded. The location of the interview was selected based on the personal wishes of the individual research participants. Most interviews were conducted in a meeting room at the Delft University of Technology. Sixthly, after each interview, an interview report was created as part of the qualitative data processing step. The interview report

includes the most important comments and answers of each interviewee. The reports have been subsequently translated from Dutch to English by the interviewer. The interview reports can be found in Appendix II. Each interview report was sent to the interviewee for approval. After confirmation of the interview report by the research participants, the interview reports could be deemed as empirical scientific data. During the data analysis phase, content analysis of the gathered information was done through coding of the qualitative interview data. A detailed explanation of the data analysis phase is included in Section 2.3.4. Lastly, the interview results have been inserted in the research report in Chapter 4. The acquired knowledge from the interviews or results of the interviews have been used to answer the main research question and for an extensive discussion of the results.

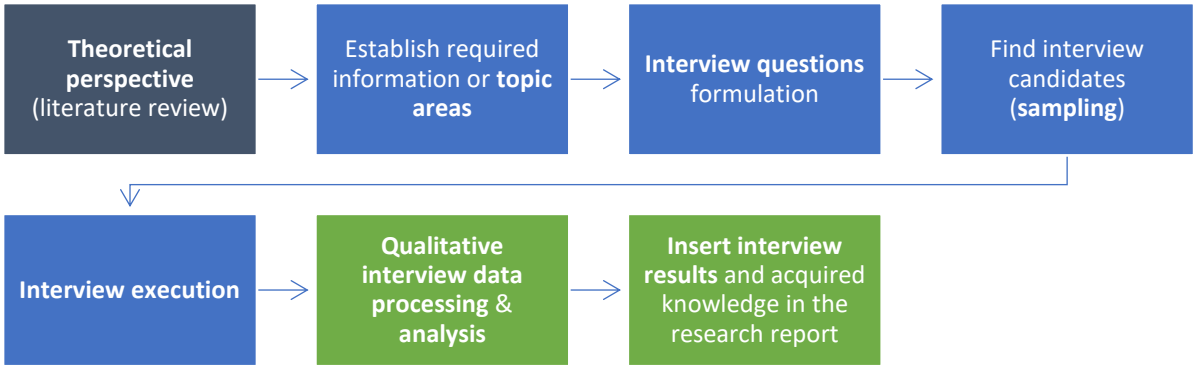

Figure 3: The overall interview process (adapted from Turner III (2010)).

2.3.2 Sampling

The population is defined as plug-in EV drivers in the Netherlands. On 31 December 2019, a total number of 203,421 electric passenger automobiles were registered which is an increase of 43% compared to 31 December 2018. It was assumed that this number is equal to the amount of current Dutch EV drivers within the Netherlands (CED). Besides the CEDs, it was decided to add another group as part of this research: V2G driver participants (VDP). Interviewing both CEDs and VDPs has been done because it was anticipated that CEDs are less familiar with V2G. In other words, only some of them had heard of the V2G concept before. Therefore, it was hypothesized that VDPs had more experience with the actual use of V2G and more knowledge about V2G systems. Before the research was conducted, it was expected that VDPs could provide additional insights regarding V2G acceptance. In the results Chapter 4 , there is reflected upon whether these hypotheses turned out to be correct or not.

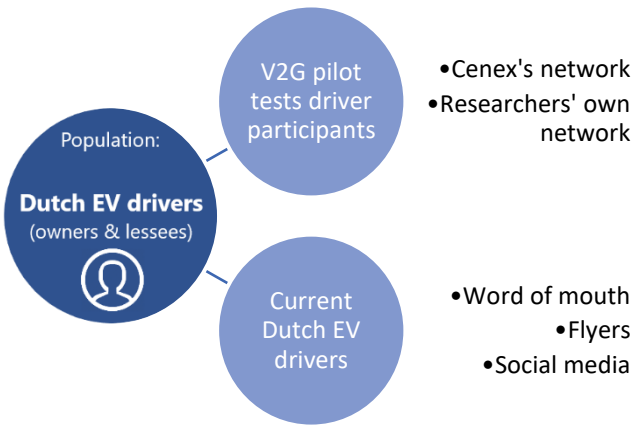

Figure 4: The two groups of interviewees

Not much is known about the population of V2G pilot driver participants. It is known that at least 6 V2G pilots have been executed in the Netherlands based on a repository of 18 European V2G pilots[6]. Based on that repository, an estimation was made that at least 84 EVs participated in these projects. But, exact numbers of Dutch V2G driver participants of current or past V2G projects remains unknown.

Nonprobability sampling was chosen as the sampling method since no databases are publicly available of the Dutch EV driver population and V2G test pilot driver participants in the Netherlands. Nonprobability sampling is a sampling type where individuals of the population or *elements* do not have a known or predetermined chance of being selected as interviewees. A sub-type of nonprobability sampling is purposive sampling. Purposive sampling has been done because data could be collected from specific target groups: CEDs and VDPs (Figure 4). Purposive sampling has been done through 1) the creation of a list of Dutch EV drivers using the researchers' own professional network and through advertising on social media and 2) reaching out to participants of a V2G pilot projects in the Netherlands by contact project managers of V2G test pilots. Cenex Nederland[7] is a Dutch not-for-profit organization focussing on research and consultancy and is active in the fields of e-mobility and sustainable energy. Cenex helped to assist the researcher in locating and approaching participants of Dutch V2G pilot tests and Dutch EV drivers. A flyer has been made in order to approach current Dutch EV drivers and V2G driver participants. All used advertisements are included in the interview protocol in Appendix I.

Despite the small battery capacities of PHEVs, it was decided to include PHEVs in this research because of three reasons. Firstly, a set of previous V2G researches investigated the potential of PHEVs in V2G systems and concluded that PHEVs certainly can deliver value for grid services (e.g. Sioshansi & Denholm). Secondly, (future) V2G pilot projects will often include PHEVs because, if the EV driver faces a low battery due to V2G operations, the EV driver can still drive using the internal combustion engine. Thirdly, it is known that a limited amount of EV models do support V2G operations. There do exist PHEV models that support V2G capabilities (e.g. Mitshubishi Outlander) and it is therefore expected that PHEV drivers will also use V2G bi-directional chargers in the future.

The final sample consisted of 17 CEDs and 3 VDPs. Their backgrounds and characteristics are further discussed in the chapter that covers the interview results (Chapter 4). Also, issues related to representativeness is further discussed in this chapter.

2.3.3 Interview questions

Semi-structured interviews have been chosen as the main research methodology. There are numerous advantages of semi-structured interviews that contributed to the choice of this methodology. For instance, having a predetermined interview structure based on theoretical foundations to make sure that similar questions are asked during each interview adds scientific rigour (Sekaran & Bougie, 2016). Furthermore, semi-structured interviews provided possibilities for the interviewer to be flexible and to explore new topics of interest during interviews.

Before the interviews started, an interview protocol was carefully designed. The interview protocol contains two parts. Firstly, important findings from the literature review related to the chosen theoretical perspective. Secondly, based on the literature review, the different topic areas for the interviews together with a list of concrete interview questions. Thus, each interview question was

[6] https://northsearegion.eu/media/4308/v2g-projects-in-europe.pdf
[7] https://cenexgroup.nl/

related to a specific topic area or component of the theoretical framework. This section explains the process of creating interview questions. Each interview had the following structure: *interview opening*, *main interview questions* and *interview closure*. The interview steps of the *interview opening* and *interview closure* are included in the interview protocol in Appendix I. In this section, a closer look is taken at the *main interview questions* because this was the core source of information extracted from each interview. In other words, the *main interview questions* provided information which allowed the researcher to answer the main research question.

The main interview questions have been separated into 3 parts: part A, part B and part C. Different questions have been designed for current Dutch EV drivers (CEDs) and V2G pilot driver participants (VDPs) because it was anticipated that they would have different V2G knowledge levels. In part A, each interview participant was asked questions to reveal information about their personal profile (EV driver's profile), experiences with EVs and charging. The goal of part A was to gain an in-depth understanding of who was interviewed. During this part, questions were asked such as "to what extent do you think you are up-to-date about the latest technological developments regarding e-mobility and why?" and "at which locations do you charge your EV mostly?". In other words, in part A, introductory questions have been asked so that interviewees got used to the interview setting, topic and to reveal information about their personal profile as an EV driver. Table 1 presents four example questions. On the left-hand side, interview questions for CEDs. On the right-hand side interview questions for VDPs. As can be seen in the table, each interview question was related to a defined topic area which is included after each question between square brackets (e.g. *EV driver profile*). The topic areas are formulated based on the conceptual model which was created in the literature review (next Chapter 3). The complete list of interview questions is included in the interview protocol in Appendix I.

Table 1: Part A main interview questions with example questions

Part A: Introductory questions V2G & revealing personal profile	
Main interview questions for **current EV drivers (CEDs)**	Main Interview questions for **V2G driver participants (VDPs)**
Example questions*: • Can you tell me about your experience with parking and charging? *[EV driver profile]* • How involved are you with the technological developments regarding electric driving? Are you always up-to-date? *[Technological innovativeness]* **The complete list of interview questions is included in the interview protocol in Appendix I*	Example questions*: • Could you tell me about the pilot you have participated in? [-] • For what reasons did you participate in the pilot project? How did that happen? [-]

At the moment of the interviews, current EV drivers did not have had the option to participate in V2G services in the real world. Therefore, part B started with an objective animation of the V2G concept with a general explanation. The animation which was used during the interviews is provided in Appendix I, Section I.9. In short, the animation provided a brief technical description of V2G. It also provided an overview of the situation of V2G application at office buildings. Showing this use case ensured that interviewees could get a feeling of how V2G systems work from an end-user perspective.

A definition of V2G and explanation of V2G systems (e.g. that it may solve grid balancing issues) was also provided. On the other hand, VDPs had more prior knowledge of V2G. Therefore, a shorter animation was shown to VDPs. See Section I.9.

During part B, questions have been asked about the EV drivers' attitudes towards the V2G concept and which benefits and barriers they did perceive regarding V2G participation. The interview questions have been constructed based on the findings of the literature review in Chapter 3 (see also the conceptual model in Figure 11). During part B, the aim of these questions was to discuss the V2G concept from a general perspective (not a specific use case) and reveal their general *attitudes* and opinions towards the V2G concept. During this part, also questions related to the topic areas *perceived behavioural control* and *subjective norms* have been asked. These topic areas are derived from the conceptual model. Table 2 contains examples of interview questions asked during part B and mainly focus on the V2G concept. The interview questions for CEDs (left-hand side in Table 2) have been designed differently compared to interview questions for VDPs (right-hand side in Table 2). Whereas the interviews with CEDs included questions regarding V2G on a conceptual level, interviews with VDPs included more practical questions regarding V2G usage to stimulate discussion about actual V2G usage and mobility planning required for V2G participation. The complete list of interview questions is included in the interview protocol in Appendix I.

Table 2: Part B main interview questions with example questions

Part B: Questions based on the V2G concept	
Main interview questions for **current EV drivers (CEDs)**	Main Interview questions for **V2G driver participants (VDPs)**
-show animation V2G concept-	***-show animation V2G concept-***
Example questions:* • Have you heard before of V2G? *[V2G familiarity]* • Based on what you have seen, what do you think about V2G? *[Attitude]* • What are the important benefits of this system for you? [*Perceived benefits]* **The complete list of interview questions is included in the interview protocol in Appendix I*	*Example questions*:* • What do you think of the V2G concept? *[Attitude]* • Can you tell me more about your experiences with V2G systems? • Could you tell me about the benefits of using V2G? *[Perceived benefits]*

In part C, a second animation (Appendix I) was shown to the interview participants. This animation involved an overview of the situation of V2G at long-term parking. V2G at long-term parking can be at hotels, camping sites, airports, etc. This animation included the example of V2G at long-term parking at an airport. This use case was separately discussed with each interviewee during part C. After the animation was shown to the interview participants, questions have been asked to explore their opinions regarding the concept and to reveal their attitudes towards V2G at long-term parking. Furthermore, questions have been asked about whether participants already experienced parking and/or charging at long-term parking. Table 3 contains examples of interview questions asked during part C (question for CEDs in the first column, questions for VDPs in the second column). The complete list of interview questions is included in Appendix I.

Table 3: Part C main interview questions with example questions

Part C: Questions based on V2G at long-term parking application	
Main interview questions for **current EV drivers (CEDs)**	Main Interview questions for **V2G driver participants (VDPs)**
-show animation V2G at long-term parking- *Example questions*:* • Have you ever parked 3 days or longer with your electric vehicle? *[EV driver's profile characteristics]* • What would you think of V2G at long-term parking? What is different to you? *[Attitude]* • When it comes to benefits, costs, risks; tell me about what would be different? *[Perceived benefits & barriers]* **The complete list of interview questions is included in the interview protocol in Appendix I*	***-show animation V2G at long-term parking-*** *Example questions*:* • Have you ever parked 3 days or longer with your electric vehicle? Where? *[EV driver's profile characteristics]* • What do you think of V2G at long-term parking? What is different from the system you have used? *[Attitude]* • When it comes to benefits, costs, risks; tell me about what would be different? *[Perceived benefits & barriers]*

To conclude, the interviews have been divided into *interview opening, main interview questions* and *interview closure.* In this section, a closer look has been taken on main interview questions, consisting of part A, part B and part C. Part A included introductory questions and questions about the EV driver's profile. Part B included questions revealing EV drivers' attitudes and opinions regarding the V2G concept on a more conceptual level. Part C focused on V2G at long-term parking. The interview questions slightly differed for CEDs and VDPs based on their initial knowledge of V2G. After conducting the interviews, the generated data has been processed and analyzed carefully.

2.3.4 Qualitative interview data processing & analysis

After the approval of the interviewee on the interview report, data processing and analysis has been done. In general, qualitative interview data contains a high number of words rather than data in the form of numbers. Therefore, three main steps have been done during qualitative data processing and analysis: data reduction, data display and drawing conclusions (Miles et al., 1994). During the interview reporting phase, a first data reduction step was done by leaving out redundant and repeating information. Then, data reduction was further done by selecting, coding and categorizing the collected data. *Coding* is "the analytic process through which large amounts of qualitative data are reduced, rearranged and integrated with the objective of forming theory" (Sekaran & Bougie, 2016, p. 334). It is done to draw meaningful conclusions about the data (Sekaran & Bougie, 2016). Subsequently, data display has been done which is the selection of quotes, tables, graphs, or a chart for illustrating data patterns. Data display provides a better understanding of the collected data and to draw conclusions based on them. In this research, a combination of tables, quotes and graph (code saturation) has been used. During the step of displaying the data and drawing conclusions, in-depth comparative analysis of the arguments has been done. These are included in the chapter interview results (Chapter 4).

Figure 5 is an abstraction of the data processing and analysis method which was used. It involved three main steps, as described above. It is acknowledged that data analysis was not a step-

by-step process, but rather an iterative process. During data reduction and coding, new insights and ideas have been developed which feedbacked into the way data was coded and displayed. Adjustments have been made along the way of data analysis. This declares the two-sided arrows in Figure 5. The three steps are further described in the next sections.

Figure 5: Data analysis approach adapted by Miles et al. (1994).

Data reduction

Interview Reporting

Each interview was audio-recorded. Furthermore, interviews have been documented in the so-called interview reports. The interview reports included the most important points and answers of the interviewees on the interview questions and their views on the topic areas, as described above. During reporting of the interviews, redundant and repeating information was excluded from the interview report. Sometimes, short transcriptions and quotations have been included in interview reports to clarify certain statements or to highlight nuances. All interviews have been conducted in Dutch, so the interviewer translated the interview to (British) English. The goal was to sketch a realistic view of the interview in each interview report. This means that the points discussed during interviews have been omitted as little as possible. Often, certain points of interviewees have been summarized instead of including quotes. This approach was chosen because the activity of transcribing the interviews was deemed as too time-consuming given the project time of 25 weeks of a thesis project. Furthermore, not much additional value was perceived of transcribing interviews because it was possible to clarify certain discussed points by concisely writing down it down as bullet points and by summarizing. Each interview report was sent to the interview for approval by e-mail. All 20 interview reports are included in Appendix II.

Coding: First coding iteration (selective coding)

After the approval of the interview reports, coding of the interview reports has been done. Two iterations of coding rounds have been done. Scientists often make distinction between deductive or selective coding, inductive or open coding and a hybrid version (Emans, 2004). The hybrid coding strategy has been adopted in this research by creating an initial codebook based on the literature review and adjusting it based on the 20 interviews (definitive codebook). This is further explained. First, a form of deductive coding was done. Based on the theoretical perspective, topic areas have been defined which have been formulated as code categories. Previous literature review also resulted in a list of initial codes. These initial codes have been used to execute a first coding iteration of the interview reports. After the first iteration, new codes had emerged. The initial codebook used for selective coding during the first iteration is included in Appendix III.

Coding: Second coding iteration (open coding) including an example

During the second iteration, inductive coding strategy was adopted by using the newly emerged codes and exploring them further. The second iteration of coding resulted in the definitive codebook which is included in 4.2.2 and Appendix V (detailed). For open coding, it was of importance that a balance between general codes and specific codes was found. In other words, there should be sought

for an appropriate level of abstraction of the codes. Therefore, a decision was made regarding the strategy of appointing codes. This strategy is visually explained in Figure 7. On the left-hand, an example quotation is provided from an actual interview report (CED3). On the right-hand, the code category is presented which was known from the theoretical perspective beforehand or from the initial codebook (see also Table 6 on page 33 or initial codebook in Appendix III). The 1st order codes represented detailed codes ('unexpected trips' and 'concerns empty battery'). Often, it was found that 1st order codes could be aggregated/merged into 2nd order codes (in this case user inflexibility). In such cases, then the 2nd order (abstract code) was chosen as the level of abstraction and relevance to keep the list of codes simple and well-ordered.

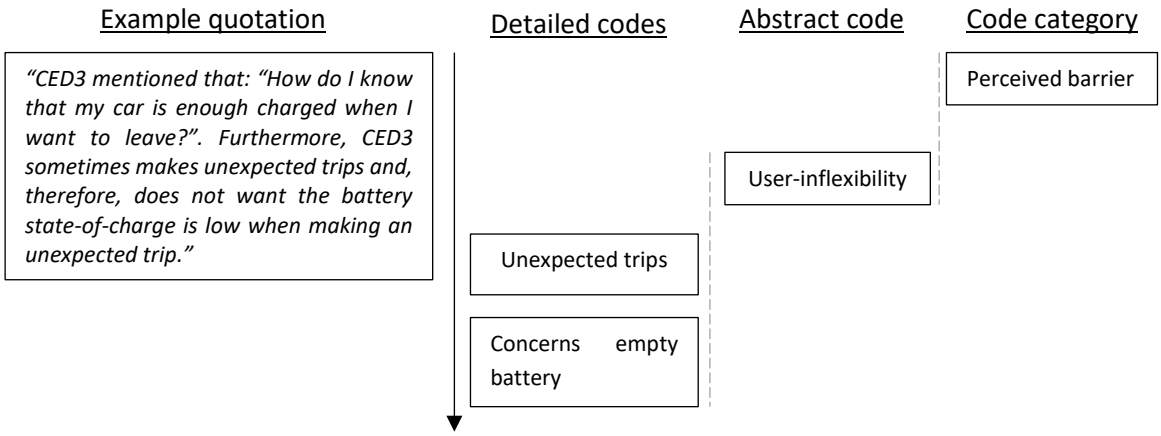

Figure 7: Strategy for coding the interview reports

Data display

The development of the interview reports and coding of the interviews reports resulted in a large volume of codes or factors (85 in total). Therefore, it was important to select appropriate data display methods. In general, data display is important to extract information out of the data and to generate an overview for the reader done in the results Chapter 4. It has been decided to use a combination of tables, including most frequently mentioned codes, and an impressionistic view of the results, where parts of interview reports have been cited and quotes of interviewees have been displayed. Tables provide a good overview of the data but do not provide insights regarding underlying motivations and reasons mentioned by interviewees. Therefore, it was decided to complement them with quotations and pieces of reports.

Drawing conclusions and inserting insights into research report

Based on a large volume of data, the conclusion has been been drawn. Drawing conclusions out of a large volume of qualitative data can be a challenging task. Most important is to provide an answer to the main research question. The objective was to provide a strong, brief and concise answer while being clear and precise. Coding helped to provide structure in the data and to generate a helicopter-view of the data. This perspective was used to provide an answer to the main research question and to critically discuss the findings in Chapter 5.

2.4 Data management & research ethics

Before starting field research and conducting interviews, an HREC application was done and approved by the Human Research Committee of the Delft University of Technology. As part of this, each interviewee filled in an informed consent form where approval is provided that the provided interview data was used for this research. An example of an informed consent form that every

interviewee signed can be found in Appendix I, Section I.8. Subsequently, a meeting with the data officer of faculty 3mE was organized on 24-9-2019. During this meeting, topics related to the chosen software programs have been discussed. Especially, data storage was perceived as an issue since personal data of consumers had to be stored. Ultimately, it was decided to use WebDrive as the data storage location. WebDrive's main functionality is that the researchers could access the TU Delft project drive at all places. In other words, all data has been stored on TU Delft servers and project storage. See Table 4 for an overview of the used software programs. The first column indicates in which phase the software was used. The second and third column include the name and a brief description of the product that also indicates for what purposes the software was used.

Table 4: Used software for data collection and analysis

Required in phase	Name software	Description
All	EndNote	Reference manager
Field research	Atlas.ti	Coding and the collected qualitative interview data
All	WebDrive	TU Delft cloud storage software, project storage.
All	Microsoft Office	The suite of products that includes Excel and Word

2.5 Research flow overview

An overview of the used research methodologies and general structure of the research is provided in Figure 8 using the form of a research flow diagram. On the left-hand side, the different phases of the research have been included. For example, the research design phase. In the middle column, the core activities are provided. For instance, formulating the research approach or research methods. On the right-hand side, the deliverables of the different phases are present. For instance, the interview protocol was mainly based on insights from the literature. Sometimes, however, different activities have been executed in parallel. This is not included in the graph. For further information about project planning, we refer to the research proposal, available on request.

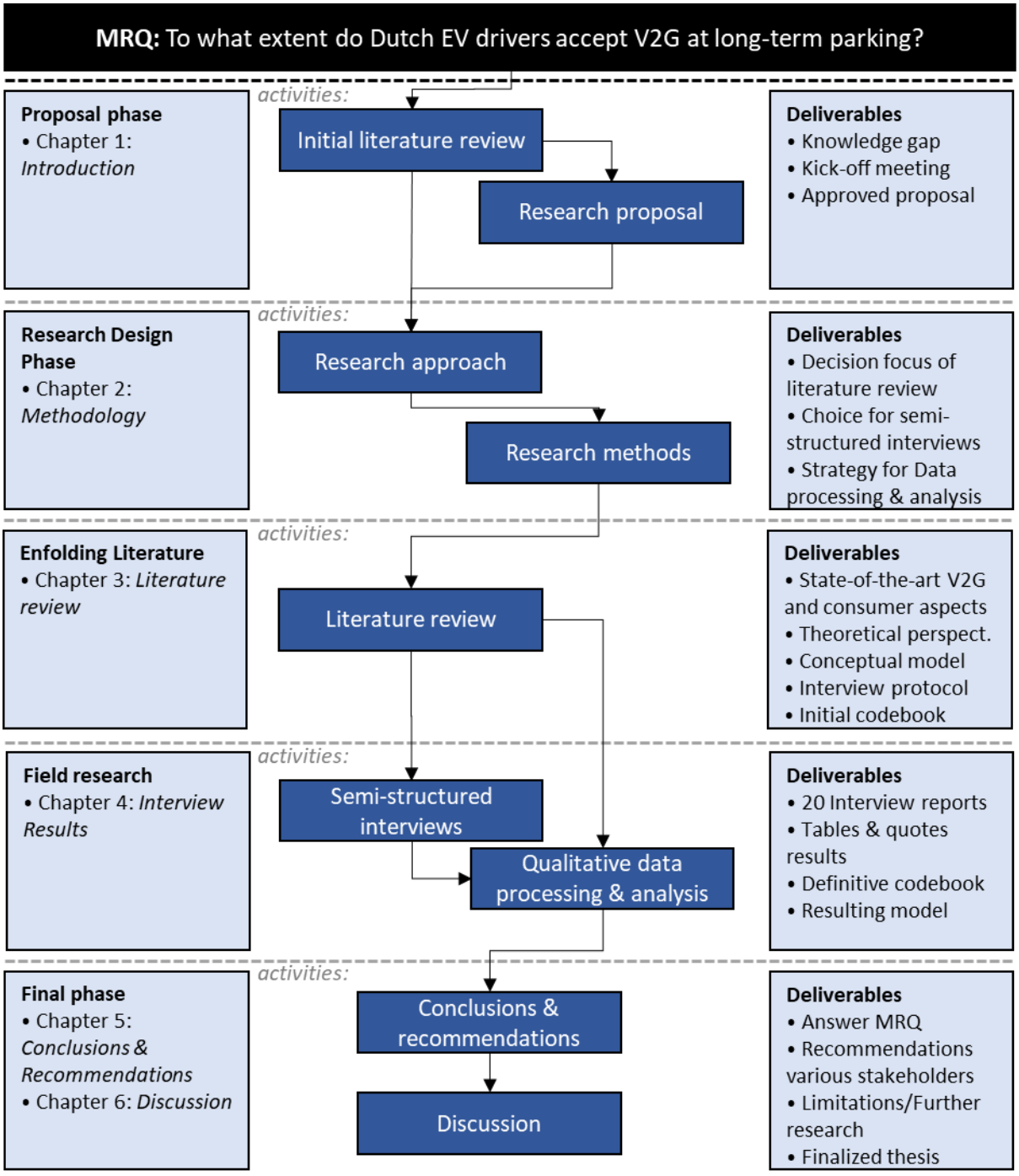

Figure 8: Research flow diagram

3 Literature review

As described in the previous chapter, two research methodologies have been used in this study. Firstly, a literature review as a preparatory phase. Secondly, semi-structured interviews with EV drivers as the main research phase. The overarching goal of the literature review was to lay the foundations for a scientifically substantiated research and selection of an appropriate research lens or theoretical perspective following from previous researches. This theoretical perspective was used as an input for the main interview phase, namely for the development of the interview protocol and for providing structure during qualitative interview data analysis. This chapter presents the results of the literature review which was the first used research methodology and is divided into three parts. Section 3.1 presents the state-of-the-art of V2G line of research that has covered consumer aspects (practical domain). Section 3.2 describes the theoretical perspective which was used as a guiding perspective throughout this research: Ajzen's (1991) Theory of Planned Behavior (theoretical domain). Section 3.3 concludes with the provision of the created conceptual model which integrates the findings of the two previous sections. It was used as an input for the interview protocol (e.g. for designing interview questions) and for qualitative data analysis (e.g. for the development of the initial codebook).

3.1 V2G studies that have included consumer aspects

This section describes the relevant concepts identified by previous V2G studies that already focused on the consumer side of V2G. However, the literature on this topic is scant. The results of this section are summarized in Table 5 and have been used for the development of the conceptual model in order to adjust and to extend the chosen model (which is the Theory of Planned Behavior adapted to technology acceptance). First, an overview of the process of finding literature is provided including the keywords used for searching in literature databases. Second, a general brief overview of the V2G field of research is provided and the socio-technical challenges that restrain V2G of a large-scale (global) roll-out are described. Third, the facilitators and barriers from the perspective of the EV driver are presented. Fourth, a closer look is taken at V2G contract attributes. Namely, there exists an extensive line of research on V2G contracts and contract attributes and might provide useful insights for the research lens. The results of this review have been also used to formulate the earlier presented research gap in the introduction (Section 1.2).

3.1.1 General overview V2G systems line of research

Before focusing on the V2G studies that have included consumer aspects, a general overview of the entire V2G line of research is provided. An extensive line of research on V2G emerged over the last 15 years. In their paper, Kempton and Letendre (1997) were the first that initiated the idea of vehicle-grid integration and using an EV as a power resource. Both an increase of renewable energy sources capacities and an increase of EV charging results in imbalances of the electrical energy grid (Noel, de Rubens, et al., 2019d). EVs themselves provide an opportunity to contribute to solving those issues. Namely, EVs have a great potential of making contributions to the electricity supply system in the form of storage or generation resources (or both). Nowadays, vehicle-to-grid (V2G) is the most commonly applied term for this concept (Sovacool et al., 2018). V2G is defined in the present research as "a system whereby EVs, when connected to electric vehicle supply equipment (EVSE) can provide bi-directional flows of energy" (Cenex UK, 2018, p. 10). When EVs are parked and plugged-in, ongoing intelligent two-way communication between the electricity grid and EVs allows controlled charging and, if necessary, back-feeding of electricity to the grid (Sovacool, Kester, Noel, & de Rubens, 2019b).

The other forms of charging, conventional "dumb" EV charging and smart charging stations (V1G) do not enable these functionalities of delivering energy back to the grid. From a technical perspective, in order to enable bidirectional charging, different and newly designed systems are necessary including software with complex algorithms, bidirectional off-board DC chargers and the required hardware within the vehicles. When these technical components are present, a new system emerges where cars interact with the energy grid as proposed by Kempton and Tomić (2005b).

V2G system effects

Emerging energy grid balancing issues require new forms of smart charging and grid support solutions. V2G can contribute to solving these balancing issues faced by grid operators. Researchers acknowledge that there are numerous grid services V2G can provide: frequency regulation, peak shaving, spinning reserves, energy arbitrage and backup power storages amongst others (Ghotge, 2019; Sovacool et al., 2018; Tomić & Kempton, 2007; Wang, Coignard, Zeng, Zhang, & Saxena, 2016). In the short-term, *frequency regulation* is deemed as one of the highest value services that V2G can participate in (Kempton & Tomić, 2005a; Noel, de Rubens, et al., 2019d). *Peak shaving* is when vehicles' batteries are used in order to absorb energy peaks in the grid. *Spinning reserves* is another service which is also known as synchronized reserves or inertial control. It is a market that helps an electricity grid to unexpected outrages or other emerging events (Noel, de Rubens, et al., 2019d). Lastly, electricity prices are variable and volatile in many countries. Aggregators are able to perform *energy arbitrage* and trading (charging when energy is cheap and discharging when expensive) (Han & Han, 2013). Lastly, the batteries of EVs can be used as *backup power* storages in cases when the other power sources are failing. In literature, more potential grid services can be found, but these are assumed the most important ones. A so-called *aggregator* would be a new actor in the system managing the different types of grid services by ensuring that the EVs can participate in different energy markets and that all stakeholders would receive their share of the benefits in the end (Cenex UK, 2018).

Socio-technical challenges regarding V2G systems

The idea of V2G emerged in 1997, but a valid question is: "why it not yet implemented on a large-scale?". Academics have identified numerous challenges regarding V2G, mainly from a technical and economic perspective. Over the last 3 years, numerous V2G studies emerged that emphasized the importance of adopting a sociotechnical perspective. However, a clear-cut answer to the above-mentioned question has not yet been provided and is rather a mix of certain factors that play a role. In literature, various challenges have been identified: technical, economic, institutional and social challenges. First, there are uncertainties regarding *battery warranties* handled by EV manufacturers (Ghotge, 2019). For instance, the Nissan Leaf[8] is one of the first commercially available V2G-enabled EVs. However, some car brands do not provide clear information about V2G participation and battery warranty. It is possible that V2G causes *battery degradation* effects (Proost, Greaker, & Hagem, 2019; Sovacool et al., 2017; Yilmaz & Krein, 2012). This is the accelerated reduction of battery condition caused by charging and discharging of the battery (Proost et al., 2019). Nevertheless, the influence of V2G participation on battery lifecycle is highly studied, but the actual effect remains unclear (Noel, de Rubens, et al., 2019d). Second, the cost of V2G systems is another challenge and the justification of a solid business case. It is argued that the initial costs of V2G-enabled chargers are relatively high compared to traditional charging and smart charging systems (Geske & Schumann, 2018; Ghotge, 2019; Sovacool et al., 2017). Since V2G enables new revenue streams for various stakeholders (e.g. fleet owners, parking facility owners and EV drivers), one can calculate a return on investment (ROI)

[8] https://www.nissan.nl/voertuigen/nieuw/leaf.html

for a business case. However, uncertainty about both estimating the amount of revenue and the different types of revenue models makes the formulation of a steady business case often challenging and case-specific (Lauinger, Vuille, & Kuhn, 2017; Noel, de Rubens, et al., 2019d). Fourthly, due to a large number of different involved actors and stakeholders in V2G systems, it is a complex topic to study and to implement. Uncertainties remain about how V2G systems and institutions should be designed and what, for instance, exact tasks or role of an *aggregator* will be (Cenex UK, 2018; Noel, de Rubens, Kester, & Sovacool, 2019a). Over the years, various researches emerged that aimed at technical aspects of V2G and its economic benefits (Lauinger et al., 2017; Sovacool et al., 2017; Sovacool et al., 2018). Up until now, researchers are investigating how V2G systems work from a technical perspective and analyse its operation. These studies result in the identification of technical challenges and economic challenges. However, the end-user (the EV drivers) is an important stakeholder since they will have to actually use the designed systems, but is often neglected.

3.1.2 Facilitators and barriers V2G participation from an EV driver perspective

The end-user of V2G bidirectional chargers, namely the EV driver, is a crucial actor in V2G systems. The EV driver determines whether the system will be used on a large scale over its alternatives: traditional charging and smart charging (V1G). In the present research, the concepts 'consumers', 'end-users', 'EV drivers' and 'EV users' are often used interchangeably. These terms are used to represent or refer to the EV drivers, who are the end-users of V2G applications. But, why would EV drivers use V2G systems? Few studies highlighted facilitators and barriers for an EV driver to participate in V2G services.

Compensation

EV owners can reduce the lifecycle costs of their EVs through *financial incentives* for providing power back to the grid (Kester, Noel, Lin, de Rubens, & Sovacool, 2018). In other words, EV drivers may receive *monetary compensation* for the provision of the battery for various grid services. This can be in many forms and is highly depended on the business case: discount on their lease contract, discount on the purchase price of an EV, free parking at public places, discount on charging, compensation for the actual amount of energy delivered back to the grid, compensation before or after the V2G transaction, fixed and flexible monetary compensations, etc. In scientific literature, there is an ongoing discussion about the amount of revenue that an EV drivers could potentially earn. Some researchers have found that consumers can earn around €10-€100 per year, while others argue that it is from a few to several thousand euros per year (Geske & Schumann, 2018).

Battery degradation

Battery wear already deserved major attention within V2G literature (Noel, de Rubens, Kester, & Sovacool, 2019b), mainly from a technical perspective. As discussed above, the actual effects of V2G on battery degradation are not known (yet) by scientists (Noel, de Rubens, et al., 2019d). However, an EV drivers' attitude towards V2G may still be influenced by possible battery wear caused by V2G. Various researchers discuss the possibility of end-users worrying about battery degradation which is caused by charging and discharging in V2G participation (Bailey & Axsen, 2015; Kester, de Rubens, Sovacool, & Noel, 2019). Of course, their EV is one of the most valuable items in a person's possession. Nevertheless, there are various types of ownership and might influence a person's attitude. These EV ownership types are: lease or are the owner.

Societal benefits

EV drivers may be motivated to use V2G since it may be in line with their personal eco-friendliness values and fit their lifestyle (Sovacool et al., 2018; Will & Schuller, 2016). V2G can help to

reduce GHG emissions further (Sioshansi & Denholm, 2009), however, the actual contribution still strongly depended on the energy mix which is used to charge and discharge batteries (Ma, Houghton, Cruden, & Infield, 2012). Due to V2G, energy from RES can be better utilized. This concept of *RES integration* is shown in Figure 9. The figure shows different photovoltaics (PVs) which are connected to a static battery and controlling system. All components are interconnected by a communication system. When there is a PV generation peak and low energy demand, the energy could be temporarily stored in the battery. This concept of RES integration could lead to environment benefits through a better use of PVs. EVs could contribute to this by making available their internal battery. However, based on literature, not much is known about the societal benefits (e.g. environmental benefits) of V2G from an EV driver perspective.

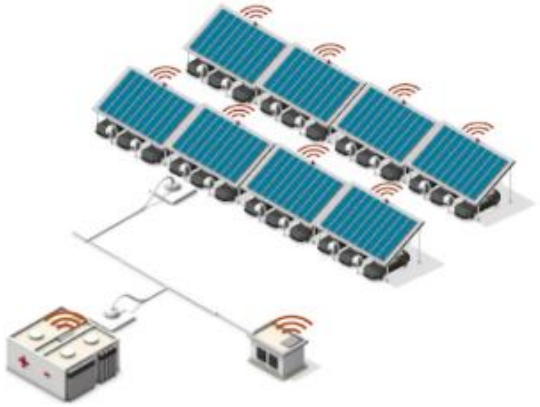

Figure 9: Schematic view of the integration of solar photovoltaics using battery packs

User-Inflexibility

EV drivers could perceive V2G as limiting their flexibility or disadvantageous due to increased battery wear (Broneske & Wozabal, 2017). In V2G operations, the aggregator should ideally have data or statistics about parking behaviour of an individual EV driver. A possible structure is that the EV driver provides data input about their expected next trip (e.g. through a smartphone app). Compared to other forms of charging (traditional and smart charging), this is an extra task that the end-user should perform. Academics hypothesize that the end-user may experience this as a burden since it less allows EV drivers to make unexpected trips. In other words, people may feel a loss of flexibility or experience *inflexibility* due to additional planning and scheduling of trips (Sovacool & Hirsh, 2009; Will & Schuller, 2016). Perceived reduction of flexibility is closely connected to possible *range anxiety* of the EV driver. Range anxiety is defined as the presence of anxiety caused by a probability that the battery is not enough charged or not charged at all at the start of their next trip. In a consumer focus group in the Nordic region, it was found that participants “felt that V2G would inhibit their freedom” and “worried about having an empty battery” (Noel, Zarazua de Rubens, et al., 2019, p. 144).

Data security & privacy

Bailey and Axsen (2015) investigated consumer perceptions of controlled charging in case of a nightly charging program in Canada. Consumers favoured the development of renewable energy, but one-fourth of the respondents were concerned about the perceived loss of control as well as privacy concerns (Bailey & Axsen, 2015). Noel, de Rubens, Kester, and Sovacool (2019c) argue that security and privacy related to data collection of end-users is a minor challenge in current V2G systems with private fleets of tens of EVs. But that this will be a major challenge when V2G becomes a dominant technology in the mobility sector (Noel, de Rubens, et al., 2019c).

V2G familiarity

The level of awareness regarding V2G may be a barrier for the end-users to participate. In previous consumer researches, it was highly frequent the case that only the minority of the participants had heard from V2G before. Meijssen (2019) found that in the sample of 148 Dutch EV drivers, 37% had never heard of V2G before and that 25% heard about it but is not familiar with V2G yet. EV drivers that were unfamiliar with V2G seemed to be less in favour of V2G than EV drivers that were familiar with the technology (Meijssen, 2019). Even in some studies, none of the participants had heard from V2G. Noel, Zarazua de Rubens, et al. (2019) organized consumer focus groups in the Nordic region and found that none of the participants had heard from V2G before. Since none of the participants was aware, it was not possible to draw conclusions about the possible link between awareness and willingness to participate. Consumers' awareness of the V2G concept may stimulate scepticism about the technology (Noel, Zarazua de Rubens, et al., 2019).

V2G location

Zonneveld (2019) included (dis)charging location as an attribute. V2G services are location specific and can be divided into private environment where the EV driver owns the V2G charger (i.e. at home), semi-public locations where a building tenant operates the charging station to be used for its employees or guests (i.e. in parking garages or at the office), public locations where a CPO operates a set of charging stations in the public environment (i.e. at supermarkets or Fastned at highways) (Zonneveld, 2019). It is argued that the (dis)charging location might have an effect on the willingness to participate in V2G programs. However, in their research sample, no relation was found between the charging location and the utilities and demand regarding V2G (Zonneveld, 2019).

3.1.3 V2G contracts and EV drivers' preferences regarding contract elements

Numerous researchers focused on consumers' preferences and desires regarding V2G contracts and contract attributes. V2G contracts between the aggregator and EV driver are necessary to define rules on availability and boundaries for V2G operations (Park Lee, 2019). The objective of these researches is to generate knowledge about which attributes should be included and the preferences of the EV drivers. Up until now, however, the results about consumer's preferences regarding V2G contract are diverging and is possibly due to the design of the experiments and research assumptions made (Zonneveld, 2019). Nevertheless, the explored factors are relevant for the present research since they provide an initial idea about the factors which consumers care about and take into account before actually accepting and using V2G. Therefore, the identified factors that influence a consumer's willingness to participate in V2G contracts are discussed further. They are considered in the theoretical framework which will be discussed at the end of this chapter.

Remuneration

EV drivers may experience discomfort (user-inflexibility) due to different obligations. Furthermore, V2G may cause battery degradation. Compensating the cost of discomfort experienced by the end-users with a V2G contract is also called remuneration (Meijssen, 2019). Remuneration can be in the form of fixed payments or as flexible payments based on plug-in time (pay-as-you-go contract) (Parsons, Hidrue, Kempton, & Gardner, 2014). According to Zonneveld (2019), Dutch EV drivers highly value remuneration in terms of relative importance compared to the other included contract attributes.

Plug-in time

Plug-in time means "the average plug-in duration over a specific period" (Meijssen, 2019, pp. 3-4) which can be specified in days. Parsons et al. (2014) used a variation of 5 to 20 hours a day, while

Geske and Schumann (2018) took a variation of 0 to 14 hours a day. Meijssen (2019) restricted the plug-in time to 5, 10 and 15 hours per day plug-in time. Plug-in time is an attribute of a V2G contract because the aggregator should be able to predict the storage capacities (Meijssen, 2019). Zonneveld (2019) found that plug-in duration is not an important preference for Dutch EV drivers.

Guaranteed driving range

A guaranteed driving range has to do with a level or minimum battery state of charge below which power aggregators will not draw power from the battery (Meijssen, 2019). The objective is that EV drivers can still make unexpected trips if necessary. This is a contract attribute because there should be clear agreements about the minimum battery state of charge level so that the chance of returning an uncharged vehicle is almost zero.

Discharging cycles and EV ownership

Battery degradation is a widely discussed topic. Despite that, the actual influence of V2G participation on battery degradation has not yet been determined (Wang et al., 2016), consumers may take it into account while considering to participate in V2G contracts or not (Meijssen, 2019). This is taken into account by including the number of discharge cycles per period as a contract attribute. Zonneveld (2019) argues that it has a considerable effect on willingness to participate. However, Meijssen (2019) found that Dutch EV drivers are less concerned about the number of discharge cycles. People might care less because a large part of the research sample (64.9%) leased an EV (Meijssen, 2019). So, the form of EV ownership (lessee/owner) may play a role in battery degradation concerns, thus, in V2G acceptance.

Contract duration

The period in which EV drivers participate in a V2G contract is defined as the contract duration (Meijssen, 2019). Kubli, Loock, and Wüstenhagen (2018) included contract duration as a contract attribute by making a distinction between: ‘cancel anytime’, ‘1 year’, ‘2 years’, ‘4 years’. Meijssen (2019) and Zonneveld (2019) respectively included 6 months or 1 month, 12 months and 24 months. It is found that the importance of contract duration is rather limited and that the preference of shorter contract duration is relatively weak compared to the other attributes (Kubli et al., 2018). Despite that one can expect that longer contracts would result in lower utility, Zonneveld (2019) found that longer contract durations result in higher perceived utility. One possible explanation could be that people want their V2G contract to be as long as the lifetime of their EV or the total duration of the lease contract.

Recharging speed

In general, recharging speed is an important attribute for EV adoption. Therefore, one study included this as a V2G contract attribute. It was found that recharging speed may have a positive effect on the willingness to participate in V2G contracts (Meijssen, 2019). In their sample, it was found that one-third did not prefer a V2G contract over conventional charging, while only less than a quarter would not prefer V2G over conventional charging if the charging speed was faster (Meijssen, 2019).

3.1.4 Factors based on V2G literature that included consumer aspects

In total, 27 scientific papers and industry reports have been reviewed. Table 5 provides a summarized overview of the literature review results per paper. The review resulted in 7 drivers and barriers for V2G acceptance from the perspective of the EV user, as discussed above. Furthermore, 5 V2G contract attributes have been found in the literature that may play a role in an individual's willingness to participate. In this research, V2G contract attributes are further left out of scope because this research did not intend to investigate EV drivers' acceptance of V2G contracts. The focus of this study was on V2G drivers' acceptance of V2G, as a technology. However, from the literature, it remains unclear which factors are perceived as more important than others by EV drivers and whether the overview is comprehensive. Furthermore, they do not provide sufficient insights to answer the main research question. These findings have been integrated in the formulation of the research, as already presented in the introduction chapter (Section 1.2, page 3). Table 5 (next page) includes the main findings of reviewing the 27 scientific papers contains five columns. Besides the three columns 'authors', 'main topic' and 'identified factors or relevant topics', the other two columns are 'geographical location of research' and 'research methodology' used. Firstly, it contains the geographical location because cultural aspects may have an influence on people's perceptions and attitudes towards V2G. Secondly, research methodology was included to provide an overview of the methodologies used by other researchers and is used as justification for the chosen methodology in the present research.

Table 5: Overview of state-of-the-art V2G studies that covered consumer aspects

#	Authors	Application type	Main topic	Methodology	Relevant explored subject areas and factors
1	(Tomić & Kempton, 2007)	USA	Economic potential V2G for various stakeholders	Pilot and modelling	Economic benefits vehicle owners, institutional barriers
2	(Turton & Moura, 2008)	Switzerland	Long-term energy analysis of V2G and its impact on the energy system	Energy systems modelling	Electricity market impact, EV uptake, energy scenarios, consumer acceptance uncertainties
3	(Sovacool & Hirsh, 2009)	Singapore	Benefits and barriers PHEVs and V2G transition: the importance of socio-technical obstacles	Literature review	Technical state-of-the-art, social barriers, cultural values, business practices, political interests and consumer benefits
4	(Allison Ojeda, 2013)	Netherlands	Car as power plant: Assessing vehicle technology acceptance and its implications for the business model design	Consumer interviews and survey	Car as power plant acceptance level, adoption factors, benefits and concerns, business model suitability, policy recommendations
5	(Brandt, Feuerriegel, & Neumann, 2013)	Germany	Benefits V2G on an individual household level	Modelling	Revenues from V2G for households, renewables generation, ICT aspects of V2G
6	(Parsons et al., 2014)	USA	Potential consumer demand for V2G electric vehicles and their contract terms	Stated preference survey	Willingness to pay, V2G contract strategies, guaranteed driving range, plug-in rate, cashback payment, (in)flexibility car usage
7	(Michaels & Parag, 2016)	Israel	Perceptions of energy storage technologies as prosumer activities in Israel	Survey	Willingness to participate V2G, V2G transaction time, guaranteed driving range, monetary compensation
8	(Will & Schuller, 2016)	Germany	User acceptance factors of EV smart charging (V1G)	Survey	Monetary incentives, system effects, user-friendliness, data security, the general attitude
9	(Broneske & Wozabal, 2017)	Germany	V2G contract parameters between aggregators and EV owners and profitability of vehicle pools	Modelling	Contract parameters: plug-in rate, guaranteed driving range, connection power. Profitability vehicle fleets.
10	(Sovacool et al., 2017)	Denmark	New V2G research agenda: V2G's benefits, opportunities and barriers from a socio-technical perspective	Literature review	Technical, financial, socio-environmental and behavioural components (e.g. lifestyle, range anxiety, inconvenience, confusion, distrust).

11	(Adnan, Nordin, & Althawadi, 2018)	Malaysia	Barriers to wide-scale adoption of V2G	Literature review	Consumer attitudes and motivation, cultural and social barriers, energy losses, consumer concerns, institutional barriers
12	(Geske & Schumann, 2018)	Germany	The willingness of vehicle users to participate in V2G	Choice experiment	Awareness EVs, range anxiety, minimum range, remuneration, information provision, V2G awareness,
13	(Kester, Noel, de Rubens, & Sovacool, 2018)	Nordic region	Expert advice on policy mechanisms for accelerated diffusion of V2G in Nordic countries	Expert interviews	Restructuring the electricity market, innovation and R&D, required policies, believe in V2G, information and (consumer) awareness
14	(Noel, de Rubens, Kester, & Sovacool, 2018)	Nordic region	Co-benefits of electric vehicles and vehicle-to-grid	Expert interviews	Benefits: RES-integration, controlled charging, vehicle-to-home, TSO and DSO services, economic savings, emergency backup, arbitrage
15	(Sovacool et al., 2018)	Denmark	Neglected social dimensions in vehicle-to-grid research: a critical an systematic review	Literature review	RES-integration, grid stability, battery degradation, DSO services, environmental performance, business models, user behaviour
16	(Kester, Noel, Lin, et al., 2018)	Global	Coproduction of V2G ISO standards across Asia, Europe, North America.	Case studies	Control and user engagement, interoperability and scalability
17	(Kubli et al., 2018)	Switzerland	Measuring the willingness to co-created distributed flexibility	Choice experiment	Willingness for distributed flexibility, EV owners, heat pump owners, PV and battery owners, costs, power mix, contract duration
18	(Zonneveld, 2019)	Netherlands	Increasing participation in V2G through contract elements: preferences of Dutch EV drivers	Choice experiment	V2G price, remuneration, battery degradation, contract duration, time interval, guaranteed driving range, charging location, income
19	(Proost et al., 2019)	Norway	Impact V2G on consumers' choice of battery capacities	(Stylized) Modelling	Cost EV ownership, choice of battery capacity EV, social welfare, backup power
20	(Noel, Zarazua de Rubens, et al., 2019)	Nordic	Consumer, society and V2G	Literature review	Consumer perspectives of V2G, awareness, consumer interaction, consumer acceptance, consumer knowledge
21	(Noel, Carrone, et al., 2019)	Denmark	Willingness to pay for EVs and V2G applications	Choice experiment	V2G's influence on EV adoption, benefits V2G, consumer knowledge, incentives

22	(Noel, de Rubens, et al., 2019b)	Nordic region	V2G barriers and exploring expert scepticism and consumer distrust	Expert interviews	Consumer resistance, complexity to understand, alternative technologies, business model, uncertainty, battery degradation, costs
23	(Ghotge, 2019)	Netherlands	Challenges faced during the creation of a V2G living lab	Desk research and pilot	Technical, economic, legislative, institutional challenges. Social challenges of consumer acceptance identified
24	(Sovacool, Kester, Noel, & de Rubens, 2019a)	Nordic region	Gender, identity, environmental values in personal transport and V2G preferences	Survey, expert interviews, focus group	Gender and car usage, environmental values, masculinity, V2G preferences and gender
25	(Sovacool et al., 2019b)	Nordic region	Visions and sociotechnical expectations regarding electric mobility and V2G	Expert interviews	Optimistic and pessimistic visions electric mobility and V2G, emotive forces (of consumers) regarding V2G
26	(Meijssen, 2019)	Netherlands	Dutch electric vehicle drivers' preferences regarding V2G contracts	Choice experiment	Remuneration, plug-in time, guaranteed driving range, contract duration, discharging cycles, recharging speed
27	(Kester et al., 2019)	Nordic region	Public awareness and acceptance of EVs and V2G	Focus groups	V2G: battery degradation, compensation, organization, information, the general perception

3.2 Theoretical perspective

From the analysis of previous V2G studies, it was concluded that the topic of consumer acceptance within the V2G research field is scant (see also the research gap in Section 1.2). Therefore, other research fields (e.g. social psychology, innovation management and information systems research) have been reviewed in order to gain insights about the phenomenon of end-users' technology acceptance. Specifically, behavioural psychology has provided suitable models and concepts for the present study and will be discussed in this section. Section 3.2.1 provides the definition of the core concept in this study, (consumer) acceptance. The Theory of Planned Behavior (Ajzen, 1991) adapted to Technology Acceptance by Huijts, Molin, and Steg (2012) will be presented in Section 3.2.2. Its suitability and adjustments will be further explained in Section 3.2.3. In Section 3.2.4, the limitations of the TPB adapted to technology acceptance will be discussed. The findings have been used to create the conceptual model in Section 3.3.

3.2.1 A definition of EV drivers' acceptance

In previous studies, consumer acceptance was mainly 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 contextualized for V2G technology. This resulted in the following definition of 'EV drivers' acceptance of V2G' used throughout this research: *"EV drivers' behavioural responses to the availability of technological innovations (e.g. V2G services), that is, the purchase and use of such products as part of their daily lives*". Previous studies have distinguished different types of acceptance: consumer, public (or citizen) and socio-political acceptance (Huijts et al., 2012). The aim is to reveal EV drivers' perceptions and attitudes towards new technology that can be used for charging and discharging their car's battery. Hence, the main focus will be consumer acceptance and not citizen acceptance.

3.2.2 Theory of Planned Behavior adapted to Technology Acceptance

In the present research, the objective is to answer the main research question by identifying factors that contribute to Dutch EV drivers' acceptance of V2G at long-term parking locations. To explain factors that influence acceptance and actual usage, a theory that is closely related to innovation management and social psychology was deemed as a suitable choice. It has been decided to choose the Theory of Planned Behavior (TPB) developed by Ajzen (1991) as the theoretical foundation in this study. Subsequently, to extend it step-by-step so that it is suitable to integrate the findings from the previous section about V2G studies. TPB is a theory that connects an individual's beliefs and behaviour. Its core factors are explained at the end of this section.

A first step was to take a closer look at the work of Huijts et al. (2012) who adjusted the Theory of Planned Behavior (TPB) so that it is suitable for technology acceptance by including outcomes that influence attitudes (costs, risks and benefits). Of course, only perceived and most noticeable costs, risks and benefits will influence attitude and indirectly acceptance at a specific moment (Ajzen, 1991). Huijts et al. (2012) developed a conceptual model for public acceptance of risky technologies (e.g. hydrogen fuel storage). As discussed in the previous paragraph, the focus of this thesis study was investigating EV drivers' (consumer) acceptance of V2G and not public acceptance. These two concepts significantly differ in terms of focus. For instance, public acceptance also involves individuals who live nearby the technology and do not necessarily reap the system's benefits (e.g. citizens that live nearby a nuclear reactor). Moreover, V2G technology is not necessarily as risky compared to the focal technologies used in the work of Huijts et al. V2G participation only involves the regular risks of EV

usage such as risks caused by charging with high voltage charging plugs (e.g. risks of electric shock and cable overheating). Risky technologies typically include larger risks (e.g. risk of explosion), which also pose a risk for the direct environment or citizens who live nearby (Huijts et al., 2012). For these reasons, it was decided to not use the entire model of Huijts, but only use usable parts of it. In this case, perceived benefits, perceived costs and perceived risks and trust are further explored as factors to extent TPB in the next sections.

Going back to the original model of TPB, the model has been applied to predict technology acceptance in previous studies. In general, TPB allows identifying new factors that are technology-specific. In other words, it is also an adjustable model and validated by numerous academics. TPB adjusted to technology acceptance includes the following elements (Ajzen, 1991; Huijts et al., 2012):

- *Subjective norm* refers to perceived social pressure to use a new technology or not;
- *Perceived behavioural control* is the perceived ease of use or difficulty of usage;
- *Attitude* towards the behaviour refers to the extent to which a person has a favourable or unfavourable evaluation of the behaviour and the evaluation of the importance of these outcomes;
- *Perceived costs* can include personal financial costs or non-monetary costs (e.g. effort to understand the technology);
- *Perceived risks* can include safety risks or uncertain costs (e.g. maintenance costs);
- *Perceived benefits* can include personal benefits or can include collective benefits (e.g. reduction environmental problems)
- *Intentions to accept* are based on outcome evaluations and perceived behavioural control;
- *Acceptance* is dependent on the intentions which are directly influenced by outcome evaluations and perceived behavioural control

The factors and respective relations based on TPB are visually represented in Figure 10. The grey coloured factors (perceived costs, risks and benefits) are factors that originate from the model of Huijts et al. (2012).

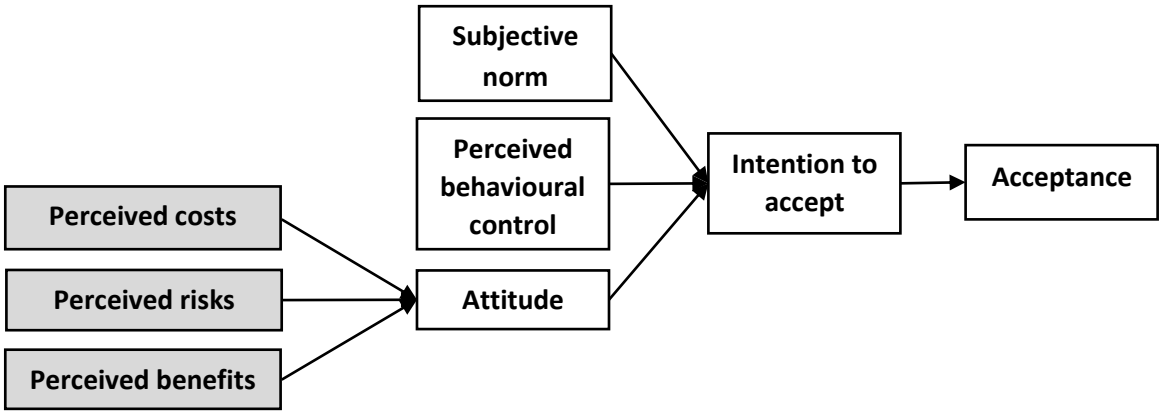

Figure 10: Theory of planned behaviour adapted to technology acceptance

3.2.3 Suitability of chosen theoretical perspective

Now that the relevant concepts are clear, the suitability of the research lens is discussed in this section. Before this study was conducted, TPB had been used before to investigate technology acceptance. Put differently, other researches have also used it for technology acceptance. For

example, a study on information technology (IT) acceptance tested the unified theory of acceptance and usage of technology (UTAUT) which was, in essence, an adjusted version of TPB (Venkatesh, Morris, Davis, & Davis, 2003). It has been found that *performance expectancy*, *social influence* and *effort expectancy* influenced intentions to accept and use the IT by employees in a company. Also, previous studies on the acceptance of smart grids technologies have used TPB. For instance, Allison Ojeda (2013) studied acceptance of the "car as a power plant" (CaPP) concept and proposed the CaPP technology acceptance model which was also based on TPB. Besides the regular TPB factors, the model included *anxiety*, *opinion leadership*, *environmental behaviour*, *environmental concerns* and *perceived safety*. Will and Schuller (2016) investigated smart charging acceptance and partly based their model on TPB. It was found that *monetary incentives, system effects, user-friendliness, data security* and *general attitudes* (e.g. towards EVs) influenced the acceptance of smart charging (V2G excluded). This study has been particularly interesting for this study since it focused on smart charging acceptance.

It was concluded that there was a match between the chosen main research methodology (semi-structured interviews) and chosen theoretical perspective. The model can be adjusted and further extended based on new empirical evidence and is, therefore, suitable for more explorative qualitative research approaches. Furthermore, the model provided tangible and noticeable elements for the interviews. For instance, p*erceived costs, perceived risks* and *perceived benefits* are most noticeable for the consumers during interviews and have been included in the model as well. Ajzen (1991); Huijts et al. (2012) argued that these outcomes influence individuals' attitudes and, therefore, have been included in the theoretical perspective.

A clear link between the TPB and previous V2G studies was observed. Identified factors based on existing literature on V2G have been interpreted in the TPB. For example, the factor '*subjective norms'* is generally used to investigate whether people are likely to be influenced by their environment. Individuals are likely to be influenced by their social environment when it comes to purchasing and using low-carbon energy transition products (Axsen & Kurani, 2012). Noel, Carrone, et al. (2019) supported this view by arguing that future studies should include the role of governmental leadership (e.g. through advertisements or pilots) and how it influences consumer preferences, particularly with V2G. However, clear evidence of subjective norms influencing V2G acceptance was not yet been provided by existing V2G studies and could be further explored. *Perceived behavioural control* is the perceived ease of use or difficulty and has been widely discussed in V2G research. With V2G, EV drivers should use software tools to provide input about when and what is needed in terms of driving range and at what point in time (dependent on the expected next trip). *Ease of use* of V2G was a widely discussed topic in V2G literature. For instance, Daim, Wang, Cowan, and Shott (2016) explained that these V2G software applications should be easy to use for EV drivers. Furthermore, a*ttitude* is most likely to be influenced by end-users' *perceived costs, risks and benefits* (Ajzen, 1991). These topics have been discussed in previous V2G studies as well. For instance, EV drivers' *perceived benefits* of V2G are reducing the cost of EV ownership, generating additional revenue streams and the presence of environmental benefits. Battery degradation, range anxiety (e.g. fear for empty battery) are *perceived risks*. Moreover, making significant initial investments for installing a bi-directional charger could be a *perceived monetary cost*. Huijts et al. (2012) included also consumer *trust* (in the responsible actors for the technology) within their model. Previous V2G studies emphasized the importance of consumer trust and distrust in during the investigation of behavioural components of V2G (Noel, de Rubens, et al., 2019b; Sovacool et al., 2017). However, far too little attention has been paid to this concept in these previous studies. Looking at the original TPB, trust cannot be included as one of the factors in

the model in Figure 10. It is therefore decided to take trust into account within this research to make the model more suitable. The V2G acceptance factors that have been identified are interpreted in the TPB. This will be further discussed in Section 3.3 where the final conceptual model is presented.

3.2.4 Circumventing TPB's known limitations

TPB has several known limitations. During the early stages of this research, it was decided to use TPB as the main foundation for the theoretical perspective or conceptual model. TPB is known for having a number of limitations. While creating the final conceptual model and before entering the interview phase, several attempts have been made to circumvent these limitations by adjusting and extending TPB. These are now discussed one-by-one. Firstly, the model is not complete since it excludes habits and emotions moderating variables (Jokonya, 2017). Other potential variables influencing a person's motivation and intention, such as fear or past experiences, are not present in the TPB. As discussed during the suitability assessment, the factor 'trust' has been added to partly include subjective elements in the model. Secondly, TPB assumes individuals as rational actors and their exclusive focus on rational reasoning (Sniehotta, Presseau, & Araújo-Soares, 2014). As mentioned, the factors 'trust' and 'perceived benefits' have been added. This allowed the researcher to ask more concrete questions about the subjective sides of V2G. For instance, whether V2G participation provides EV drivers with a "good feeling" because they are contributing to the greater good (e.g. environmental benefits). Thirdly, TPB has limited predictive validity (Sniehotta et al., 2014) and, therefore, lacks explanatory power for what happens when individuals form an intention towards behaviour and do not perform the actual behaviour. No concrete adjustments have been made to circumvent this limitation. It was not possible to formulate precise adjustments based on previous (V2G) literature. In the discussion section in Chapter 5, both this limitation and its impact on this study are further discussed. Lastly, a possible correlation between the factors *acceptance* and *attitude* has been further explored. In TPB, the effect of attitudes towards behaviour on actual behaviour is assumed to be constant. This assumption can be considered as a limitation of TPB because it is likely to be variable in reality. Therefore, academics have discussed whether there exists a correlation between the actual usage of technology and attitudes towards behaviour. In other words, whether daily experiences and actual behaviour also do affect an individual's attitudes and beliefs. For instance, Van Wee, De Vos, and Maat (2019) presented a conceptual model for attitude changes in the context of travel behaviour. They have argued that attitudes could change based on the built environment and travel behaviour. In this study, two groups of EV users are of interest; those with low V2G familiarity and high V2G familiarity. The latter group may have actually experienced V2G usage. It was considered interesting to observe whether this relation can be further validated in this research. The relation between attitudes and V2G acceptance is added in Figure 11 which represents the final conceptual model. In the interview results chapter, Section 4.7, it is further discussed whether the existence of this correleation could be validated.

A further reflection on the limitations of this research is provided in the discussion section in Chapter 5. This section also includes the impact of the choice of theory on this research and ideas about how future researches could further circumvent these limitations.

3.3 Conceptual model

The literature review findings of previous V2G studies including consumer aspects (3.1) and analysis of the theoretical domain or chosen theoretical perspective (3.2) have been used to create a conceptual model. The literature-based conceptual model is visually shown in Figure 11. As can be seen in the figure, the conceptual model is mainly based on TPB, including certain adjustments or extensions. Like TPB, 'intention to accept' influences 'actual acceptance of the V2G technology'. The factors 'subjective norms', 'perceived behavioural control' and 'attitudes towards V2G' influence 'intention to accept'. The factor 'attitudes towards V2G', in turn, is influenced by 'perceived benefits' and 'perceived barriers'. It has been decided to merge two factors identified by Huijts et al. (2012). The factors 'perceived costs' and 'perceived risks' have been merged into 'perceived barriers'. This has been done because it was beforehand expected that, during interviews, individuals could not recognise clear boundaries between perceived costs and risks.

In this chapter, TPB has been extended by using the literature review of V2G studies that included consumer aspects. As can be seen in figure Figure 11, EV driver's profile characteristics have been added to the conceptual model based on the finding of Will and Schuller (2016). A finding was that an individual's general attitude (e.g. EV-interest) and different personal characteristics (e.g. EV experience) influence acceptance of smart charging. Furthermore, as described in the limitations sections (3.2.4), a correlation between 'attitudes towards V2G' and 'V2G acceptance' has been inserted (see the two-sided arrow between *attitude* and *acceptance* in the figure). As described in the suitability assessment (3.2.3), 'trust' (in the responsible actors for the technology) has been added as

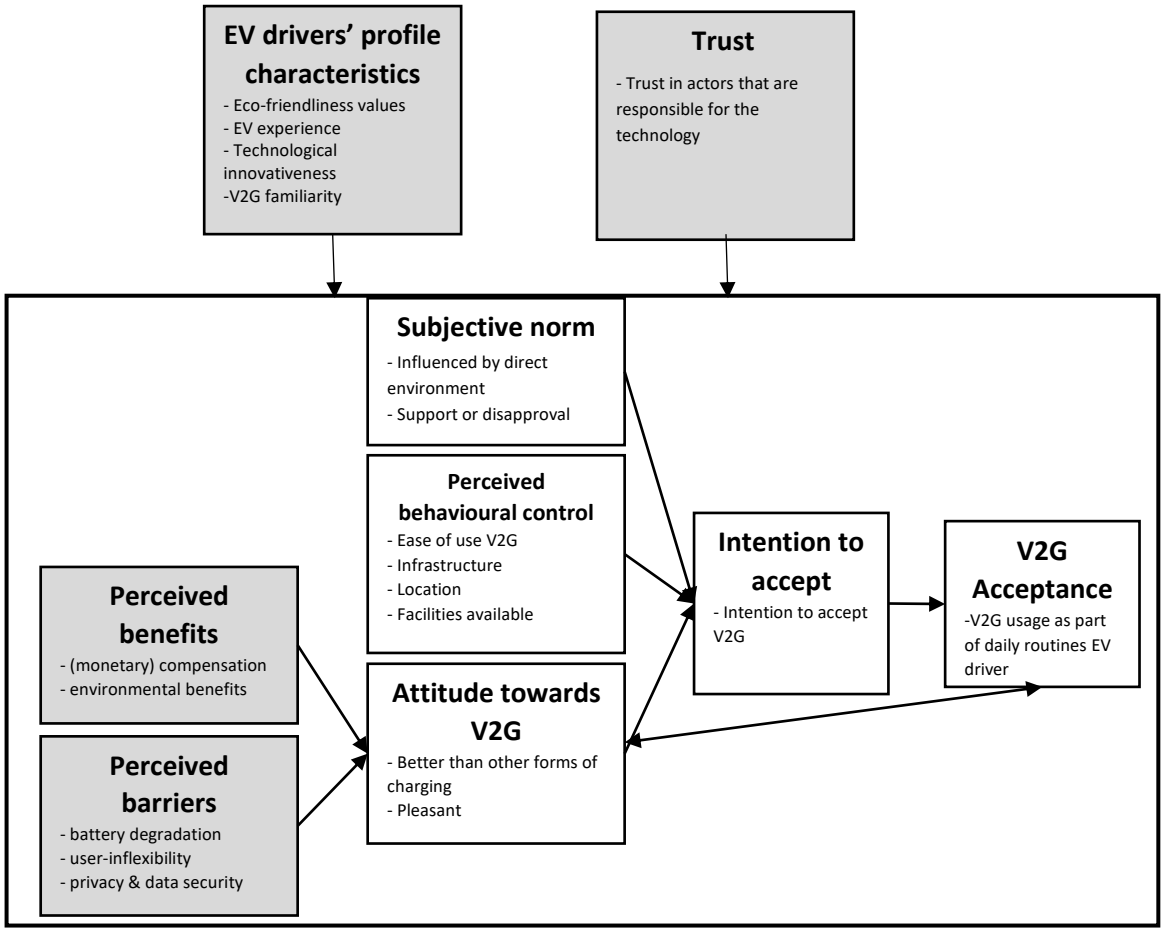

Figure 11: Theoretical model or conceptual model based on previous V2G studies and TPB

a separate factor. It could not be concluded from the literature review how 'EV drivers' profile characteristics' and 'trust' influenced the other identified factors. Therefore, as can be seen in the figure, both factors influence a square or box which surrounds the (core of) the model. The grey coloured boxes are extended or included factors based on studies other than TPB. The transparent or white coloured boxed are the primary factors from TPB.

During the interview phase, the conceptual model has been used to identify interview topic areas and, subsequently, design interview questions in the interview protocol. Furthermore, the conceptual model has been used to develop an initial codebook for the first iteration of coding the interview reports, as described in Chapter 2 (Methodology). The interview questions and codebook have one thing in common. They have both used the same (code) categories or topic areas. Topic areas are areas of interest about which the researcher wants to collect in-depth information based on interviews. Since these concepts or factors play a crucial role in both the interviews and codebooks, an overview of the core concepts with its definitions has been provided in Table 6. In the left column, the nine factors of the conceptual model Figure 11 are provided. In the second column of Table 6, the abbreviations of the factors used throughout the research are provided. The right column presents the

Table 6: Interview topic areas and code categories based on the conceptual model

Topic areas or (Code) categories	**Abbreviation**	**(Brief) definition**
Adapted from Theory of Planned Behavior (Ajzen, 1991)		
Attitude towards V2G systems	**ATV**	"Perceived benefits and barriers (costs and risks merged) determine someone's attitude towards V2G systems."
Subjective Norm	**SN**	"Perceived social pressure or influence to perform or not perform the behaviour and required changing norms."
Perceived Behavioral Control	**PBC**	"Individual's perceptions of their ability to perform given behaviour."
Intention towards behaviour	**I**	"Indication of an individual's readiness to perform a given behaviour."
Acceptance	**A**	"EV drivers' behavioural responses to the availability of technological innovations (e.g. V2G services), that is, the purchase and use of such products as part of their daily lives."
Adapted from theory Huijts (2012)		
Perceived Benefits	**PBN**	"The perception of the positive consequences that are caused by a specific action."
Perceived Barriers	**PBR**	"An individual's assessment of the obstacles to behaviour change."
Trust	**TR**	"Belief that an individual or organisation is good and honest, or that this entity is safe and reliable."
Added category based on previous V2G studies		
EV driver's profile characteristics	**EDP**	"Socio-demographic and personal characteristics related to EV driving."

used definitions. These definitions are partly used from the originating author or an adjusted version has been used. Adjusting definitions has been sometimes done in order to contextualise a definition for V2G acceptance. The table also includes rows mentioning the literature sources.

To conclude, in this chapter, the state-of-the-art of V2G studies that have included consumer aspects has been provided (3.1). Furthermore, analysis and reflection upon the theoretical domain or chosen theoretical perspective have been provided (3.2). Both these parts of the literature review resulted in the conceptual model as presented in this section (Figure 11). Given these findings, an interview protocol has been carefully designed. The interview protocol including both the topic areas and design of the interview questions can be found in Appendix I. Furthermore, the above categories have been used to design an initial codebook for the first round of interview report coding. This initial codebook can be found in Appendix III. Based on the interview protocol, 20 interviews with Dutch EV drivers have been executed. The interview phase is considered as the main phase of this research. The results of the interviews are presented in the next Chapter 5.

4 Interview results

This chapter presents the results of a total of 20 semi-structured interviews: 17 interviews with current Dutch EV drivers (CEDs) and 3 with V2G pilot participants (VDPs). These interviews have been held between October and December 2019. The objective of the present research is to answer the main research question by *identifying factors contributing to Dutch EV drivers' acceptance of V2G at long-term parking lots*. In Section 4.1, an overview is provided of the research participants and answering the question "who was interviewed?". In section 4.2, an overview of the coding schemes and top-codes will be be provided. In this section, the results are presented quantitatively (e.g. by showing the code frequencies). Section 4.3 presents the resulting model based on coding of the interview reports. In section 4.4, the results of the most important codes and categories are further discussed and the results are presented in an impressionistic manner (e.g. by including interview citations). Section 4.5 pays specific attention to the V2G at a long-term parking use case. Section 4.6 takes a closer look at a comparison of the two interview groups. This section provides case-specific results. The results are used to draw conclusions and provide recommendations in section 5.

4.1 Descriptive information of research participants and their profiles

After each interview, the participants filled in a short questionnaire focusing on demographic information and background information of the driver. This paragraph takes a closer look at the results of this questionnaire to generate a better feeling for the reader about who was interviewed. In Section 4.1.1, the results of the questionnaire are presented. Section 4.1.2 provides a general overview of the data distribution and sample statistics. Section 4.1.4 discusses the representativeness of the sample.

4.1.1 Interview participants: Current EV drivers & V2G driver participants

Table 7 contains an overview of the interviewee codes (CED or VDP) which have been used to anonymise the interviewees. The first column presents the names of the two interview participant groups. The second column demonstrates the used codes or abbreviations for the interviews and report. The third column presents the number of interviewees in each group. In total, 20 interviews have been conducted. In the next section, a closer look is taken at the personal profile characteristics and backgrounds of the interviewees.

Table 7: Overview of interview participant codes

Participant group	Interviewee code	Total number of interviewees per group
Current EV drivers	CEDs	17
V2G pilot driver participants	VDPs	3

4.1.3 Sample statistics

To provide the reader with a better understanding of the personal profiles, an overview of the distribution of socio-demographic characteristics is provided including gender, gross income, education levels and age categories. Furthermore, this section presents an overview of additional EV characteristics, i.e. EV ownership types (lease/purchased), are included.

Based on Figure 12, the research sample mainly consisted of high-income, young-adult male. Taking a closer look, 75% of the research sample is a male, and 80% is highly educated (HBO and WO combined). Furthermore, most participants are part of a higher income category (80% part of the categories '€35,000-€70,000' and '>€70,000'). Moreover, 55% belongs to the age category 18-45. Later in this chapter, these characteristics of the sample will be compared with other studies to examine the representativeness of the sample. Implications regarding representatives will be also critically discussed.

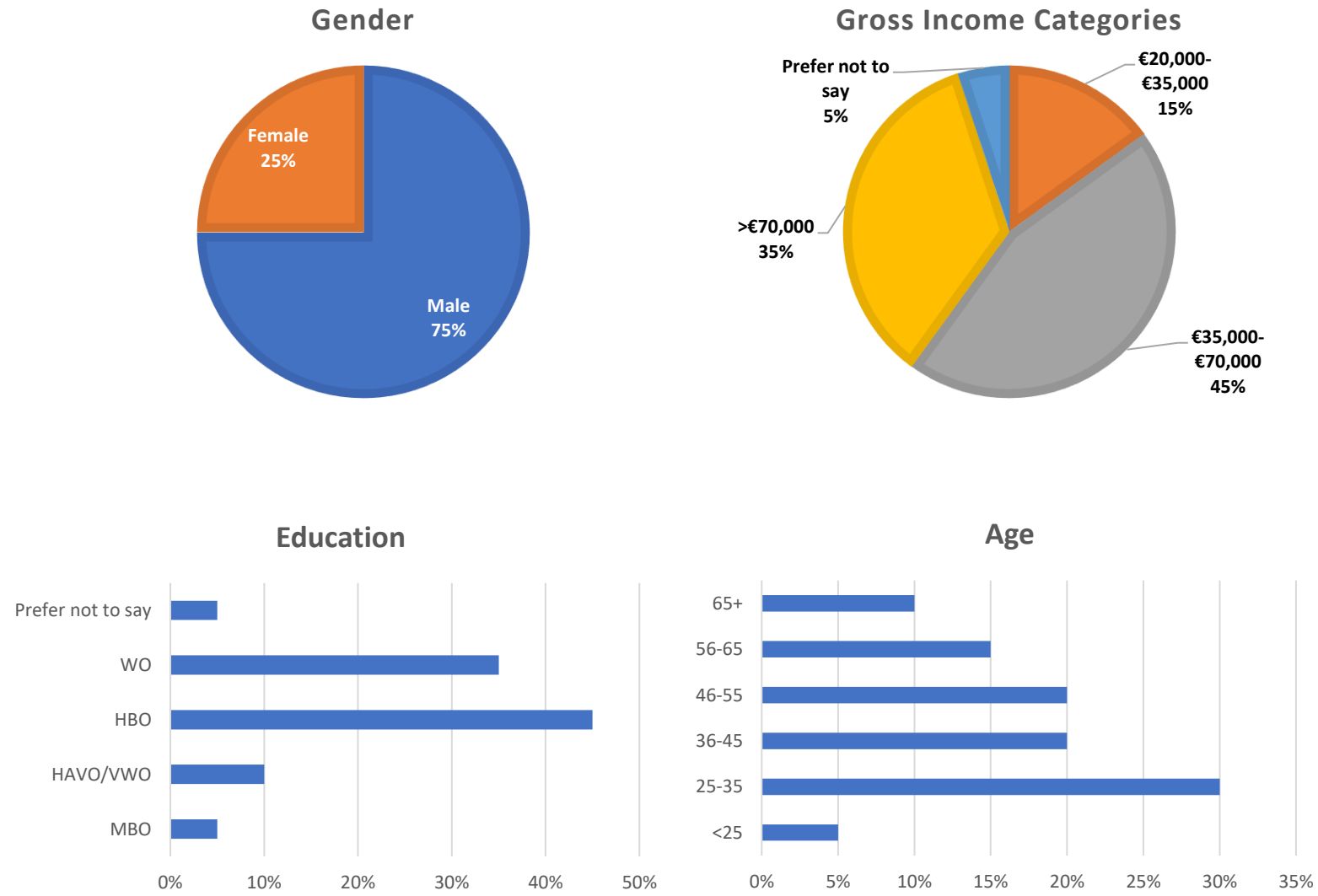

Figure 12: Socio-demographic characteristics of the interview participants (n=20)

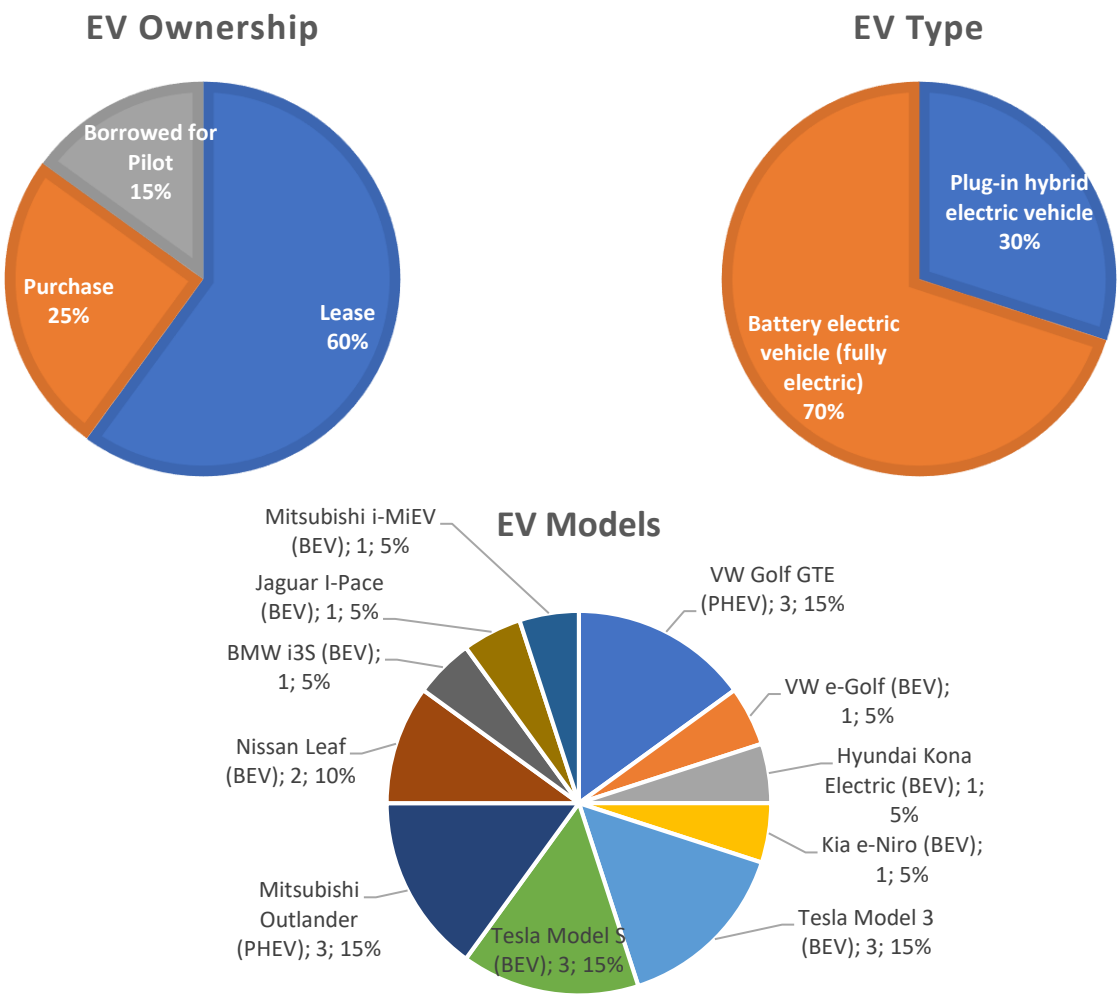

Figure 13: Additional EV driver profiles or characteristics

Interview participants mainly leased their fully electric vehicle and were part of the group of Tesla drivers. Carefully considering the additional EV driver characteristics in Figure 13, the majority of the interviewees is in possession of a BEV (70%) and 60% leased an EV. As can be deduced from Figure 13, 15% of the sample borrowed an EV for a V2G pilot (the VDPs). Furthermore, 30% of the research sample was part of the "Tesla group". It is questioned whether this sample is representative for the population (Dutch EV drivers).

4.1.4 Representativeness

The goal of the exit questionnaire is to develop a richer perspective of the interviewed EV users. Furthermore, the results can be used to make a statement about the representativeness of the sample. It is argued that it is tough to demonstrate representativeness of this study's sample, but that some aspects are quite similar to other studies. For instance, that EV drivers are mostly young-adult males with higher income and education levels. The issue of demonstrating representativeness stems from the practical problem that no database including socio-demographic statistics of EV drivers is available. This means that the collected data could not be compared with the actual socio-demographics of the population (current Dutch EV drivers). Therefore, the results of other researches were taken into account.

Based on three other studies in the Netherlands, it was found that most EV drivers are young-adult male, with higher education and income level. For instance, Meijssen (2019) conducted a survey among Dutch EV drivers and concluded that 86% was male, 93% is highly educated, 63% belong to middle-aged age categories and that 61% belong to higher income groups (€50.000+). The income group of this study and the study of Meijssen (2019) could not be further compared because different income categories have been used. Nevertheless, this view of highly-educated male with high income is supported by consumer research conducted by ANWB[9]. They concluded that consumers with high EV-interest possess more financial possibilities for driving an EV, 60% is male, relatively young (18-45) and is part of the above-average education groups. However, the study of ANWB was conducted among consumers in general and not solely Dutch EV drivers and is therefore not highly useful for comparing results. Income is close compared to the sample in Zonneveld (2019), who executed a stated choice experiment about V2G contract attributes among EV users in the Netherlands. However, the sample in this research is younger, and the sample of Zonneveld (2019) contains significantly more male. Table 8 shows the results of comparing this study with the two studies of Zonneveld (2019) and Meijssen (2019). The study of ANWB was not added because the data set was not further accessible.

Table 8: Overview of comparing the sample's socio-demographic characteristics

		This study	Zonneveld (2019)	Meijssen (2019)
Socio-demographic characteristics		**Percentage (n=20)**	**Percentage (±) (n=96)**	**Percentage (±) (n=148)**
Gender	**Male**	75%	91% (+16%)	86% (+11%)
	Female	25%	9% (-16%)	14% (-11%)
Age	**<25**	5%	2% (-3%)	7% (+2%)
	25-35	30%	9% (-21%)	19% (-11%)
	36-45	20%	22% (+2%)	26% (+6%)
	46-55	20%	38% (+18%)	18% (-2%)
	56-65	15%	18% (+3%)	26% (+11%)
	>65	2%	11% (+9%)	4% (+2%)
Education	**No education**	0%	0% (+0%)	-
	VMBO/MAVO	0%	2% (+2%)	-
	MBO	5%	14% (+9%)	5% (0%)
	HAVO/VWO	10%	6% (-4%)	2% (-8%)
	HBO	45%	39% (-6%)	32% (-13%)
	WO	35%	40% (+5%)	59% (+24%)
	Unknown	5%	-	-
Income	**<20.000**	0%	4% (+4%)	-
	20.000-35.000	15%	16% (+1%)	-
	35.000-70.000	45%	42% (-3%)	-
	>70.000	35%	39% (+4%)	-
	Unknown	5%	-	-

[9] https://www.anwb.nl/binaries/content/assets/anwb/pdf/belangenbehartiging/mobiliteit/rapport-erm-def.pdf

Taking a closer look at driver characteristics (EV type and EV ownership), statistics about EV type have been publicly made available by 'Rijksdienst voor Ondernemend Nederland' (RVO, 2020). On 31 December 2019, a total of 107.536 BEVs and 95.885 PHEVs were registered within the Netherlands[10]. On this date, this means that 53% of EVs was a BEV which is a difference of 17% in the sample of the present study. Furthermore, no database is available containing EV ownership statistics of the population. Therefore, the findings are compared with the study of Meijssen (2019). In Meijssen (2019), 65% of the EV drivers owned a leased EV. This is comparable with 60% in our study. Zonneveld (2019) did not include EV type or EV ownership within the sample. Table 9 compares the statistics related to the two EV driver characteristics 'EV type' and 'EV ownership' from this study with the study of Meijssen (2019) and RVO (2020).

Table 9: Comparing EV driver characteristics results exit questionnaire

		This Study	Meijssen (2019)	RVO (2020)
		Percentage	Percentage (±)	Percentage (±)
EV type	**BEV**	70%	-	53% (-17%)
	PHEV	30%	-	47% (+17%)
EV ownership	**Lease**	60%	65% (+5%)	-
	Private	25%	35% (+10%)	-
	Other	15%	-	-

In conclusion, it has been tough to conclude whether the sample is representative since no socio-demographic statistics or EV driver characteristics statistics of the population (EV drivers in the Netherlands) was available. But by comparing the results with other studies focusing on Dutch EV drivers, it seems that quite a natural spread of both demographic characteristics and EV driver characteristics was achieved despite the given number of 20 interviewed research participants (n=20). However, it could not be explicitly stated that the sample is representative. Therefore, the conclusions of the present study must be carefully considered with a critical view and can, most probably, not be generalized to the population. This will be further discussed in the research's limitations in section 6.

4.2 Identified factors contributing to EV drivers' acceptance of V2G

This ssection provides an overview of the main results with regards to the main research objective *identifying factors contributing to Dutch EV drivers' acceptance of V2G at long-term parking*. Section 4.2.1 takes a closer look at code saturation. Section 4.2.2 includes the top-codes and the definitive codebook. A detailed definitive codebook can be found in Appendix V.

4.2.1 Code saturation

During coding, new codes emerged and existing codes changed. Subsequently, a total of 88 codes have been generated: 26 codes related to EV drivers' profile, 58 codes related to the V2G concept (in general), 4 codes related to the specific case of acceptance of V2G at long-term parking. During the first four interviews, 61.8% of the total codes have been identified. See also Figure 14. The figure shows the code saturation of the codes present in the definitive codebook. Based on the figure, not many new codes have been found during the 16 other interviews. However, these interviews

[10] https://nederlandelektrisch.nl/actueel/verkoopcijfers

helped with developing a more in-depth understanding of the codes and these interviews helped to further validate earlier findings.

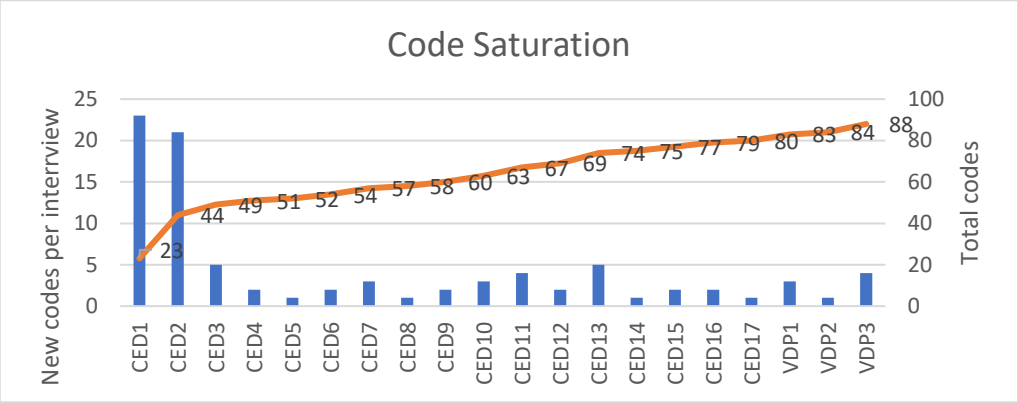

Figure 14: Interview code saturation

4.2.2 Definitive codebook

After two coding iterations, the definitive codebook was obtained. This section presents the definitive codebook.

Number of codes in each code category

Table 10 shows the number of codes each category contained. The table shows a total of 85 codes. It can be seen that some code categories only contain 1 or 2 codes. Namely, three code categories have become a code in itself. For example, when an interviewee's attitude became apparent during an interview, it was labelled using the code "attitude towards V2G" which is also a code category. In sum, the codes 'ATV', 'I', 'A', 'TR' have become therefore codes in themselves. The code categories 'ATV', 'TR' and 'I' have 2 codes included because a separate code was generated for long-term parking specific attitudes and intentions.

Table 10: Overview codes categories and number of codes

Code category	Number of codes
EV driver profile characteristics (EDP)	23
Perceived behavioural control (PBC)	20
Perceived barriers (PBR)	18
Perceived benefits (PBN)	10
Subjective norms (SN)	7
Attitude towards V2G (ATV)	2
Intention to accept (I)	2
Trust (TR)	2
Acceptance of V2G (A)	1
Total	**85**

Top-25 codes: Codes with the highest groundedness

A total of 85 codes have been developed. Each code refers to different attitudes, opinions and interviewees' views. Put differently, a high number of codes related to different attitudes and opinions which could be diverging. This made coding a complex task, because of the high number of different

views of interviewees. Below, an overview is provided of the top-25 codes based on *groundedness.* This is the number of interview report quotations assigned to a given code. The codes with *groundedness higher than 4* are presented below. See Table 11. For a detailed overview of all codes, we refer to Appendix V. This means that the codes on top are discussed most often. An important note is that this does not mean that 30 interviewees find compensation important or that it is mentioned that compensation is an important factor. Different attitudes and opinions have been observed regarding the code 'compensation'. For a detailed overview with an example of how coding was done there is referred to page 14 of the Methodology section.

Table 11: Overview of the top-codes from the definitive codebook

#	Code	Part of category	# Grounded	Frequency of interviewees mentioned
1	Compensation	PBN	33	17
2	User inflexibility	PBR	32	17
3	Battery degradation	PBR	25	18
4	User interface	PBC	23	12
5	Location	PBC	22	18
6	PR and communication	PBC	15	8
7	Societal contribution	PBN	13	9
8	Control important	PBC	13	12
9	Doubts & uncertainties V2G	PBR	11	5
10	Lack of standards/protocols	PBR	11	6
11	User-friendliness	PBC	10	10
12	Battery degradation not important (leased)	PBC	10	9
13	Customer segmenting	SN	10	6
14	Changing norms	SN	9	8
15	Minimum SOC	PBC	8	7
16	Environmental benefits	PBN	6	4
17	System effects	PBN	6	5
18	Energy trading	PBN	5	4
19	Operational reliability	TR	5	3
20	Better alternative technologies	PBR	5	5
21	Infrastructure	PBC	5	5
22	Trust	TR	5	5
23	Charging station stickers solved	PBN	5	5
24	Ease of use	PBC	5	4
25	Possibility opt-out	PBC	4	4

In general, EV drivers were very enthusiastic about the concept of V2G at long-term parking. It was perceived as a "cool" concept whereby the EV's battery serves a purpose while the car is stationary. Most EV drivers are triggered by the concept of V2G and its functionalities and system effects (e.g. grid balancing, storage capacity). It was observed that EV drivers carefully consider the perceived benefits and perceived disadvantages of V2G participation. EV drivers often had the following recurring question or remark: "what's in it for me?". This is reflected by the fact that 'compensation' is on top of the list. The results indicated that a broad range of factors influences

drivers' acceptance. A total of 85 interview codes have been identified. These factors have been classified into: subjective norms, perceived behavioural control, person EV driver's profile, perceived benefits, perceived barriers, attitudes, intention and acceptance. Perceived benefits and barriers determine attitudes. In turn, attitudes, perceived behavioural control, subjective norms, EV driver's profile determine the EV driver's intentions. The general view was that the importance of these factors varies on the individual level. So, certain factors may be more important for one individual driver while these are less important for another EV driver. During interviews, interviewees even came up with solutions to overcome barriers. Despite the high volume of insights and diverging attitudes and opinions, a general line within the findings could be identified and their relative importance.

Interpreting the table above, the following top-factors are found to be most important to foster EV drivers' acceptance of V2G:

1. **Compensation**: Financial advantages through compensations;
2. **PR & communication**: Clarification and transparency towards the end-user about actual effects of V2G on battery degradation;
3. **Control**: Presence of an operationally reliable user interface for planning mobility;
4. **Societal:** Contribution to grid balancing and helping V2G service providing organization (e.g. airports) with the achievement of environmental objectives (e.g. GHG emissions reduction goals);
5. **Practical**: Charging sticking issue solved, no need moving EV when the battery is fully charged;
6. **System effects:** A part of EV drivers perceive the concept of V2G as appealing and realize the importance of its system effects: battery capacity, grid balancing. Some even think that V2G will be part of future charging points. However, not all EV drivers are interested in this information.

The following factors are found to be most important to block EV drivers' acceptance of V2G:

1. **User inflexibility:** Collective name for range anxiety and experienced discomfort from V2G participation (e.g. trips planning). In the long-term parking, it is not an issue to interviewees which will be discussed in the next paragraph about LTP;
2. **Battery degradation:** Battery wear caused by V2G participation and additional charging cycles. Not every EV driver perceives this as a barrier;
3. **Lack of standard/protocols:** Uncertainty whether their current EV is V2G-capable;
4. **(Low) availability infrastructure:** Not enough V2G bi-directional charging devices available at the location;
5. **Possibility better alternatives:** EV drivers believing other better alternatives will become or are already available to solve grid balancing issues.

The most important codes are further elaborated in the next section of the results chapter where an impressionistic view of the codes is provided.

4.3 Resulting model based on interviews

This section provides the resulting model and an explanation of the framework (see Figure 15 on page 44). It is basically an overview of the most important identified factors and their respective relations.

Given the overview of the codes and code categories, the resulting model has been created which is based on the 20 semi-structured interviews with both CEDs and VDPs. Figure 15 on page 44 shows the resulting model. The model consists of various elements on the earlier determined theoretical perspective or conceptual model in Section 3.3. As can be seen in Figure 15, the resulting model states that 'subjective norms', 'perceived behavioural control' and 'attitude towards V2G' influences the 'intention to accept V2G'. 'Perceived benefits' and 'perceived barriers' influence 'attitudes towards V2G'. 'Intention', in turn, directly influences 'V2G acceptance'. In addition, the 'EV driver's profile' and 'trust' have been added, which have been identified in the earlier literature review. When comparing the conceptual model (Figure 11) with the resulting model (Figure 15), the main factors or categories (e.g. 'intention towards acceptance') have remained the same compared to the conceptual model (Figure 11). Furthermore, the relations have remained the same, except for the causal relation between 'attitude towards V2G' and 'V2G acceptance'. This causal relation is not present in the resulting model because no empirical evidence was found based on the interviews. The resulting model, however, includes a higher number of factors within each category, compared to the conceptual model. The interview-based factors (from Table 11) have been filled in the categories. In other words, the higher number of factors is explained by the 85 identified factors during interviews from which a top-25 was made in Table 11. The factors are included in the resulting model based on their relative importance within each category. Their relative importance has been determined based on the *frequency mentioned by interviewees* (see Table 11). For instance, compensation is found to be the most important perceived benefit and was also the most frequently mentioned. In other words, the top-factors for each category has been determined. The resulting model includes also long-term parking case-specific codes (see dotted rectangular in Figure 15). The different categories and including factors present in the resulting model are discussed in more detail in the next sections.

The top-codes and resulting model have been used as a guideline to present the results in an impressionistic manner. For instance, by providing corresponding quotes and explicating the different arguments of interviewees. This is done in the next Section 4.4.

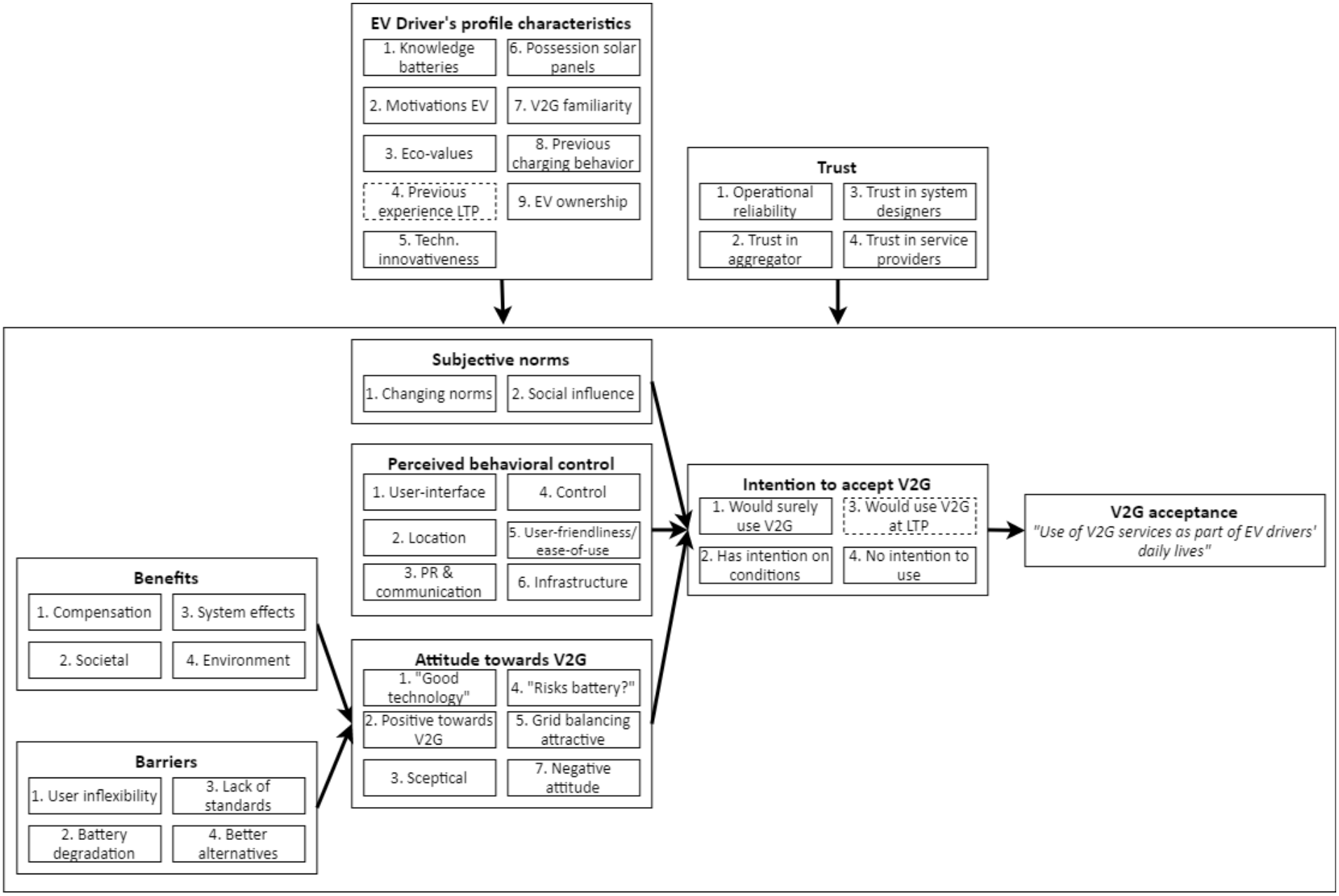

Figure 15: Resulting model based on interviews

4.4 Impressionistic representation of results

This section will more closely consider the code categories and codes within each category. The code categories and top-codes have been already demonstrated in Table 11. An impressionistic representation of the results means that, whenever possible, citations and quotations of interview reports will be provided to support the results. Each complete interview report is also attached in Appendix II. The Sections 4.4.1 and 4.4.2 present the results of the perceived benefits and perceived barriers respectively. Section 4.4.3 takes a closer look at the drivers' attitudes towards V2G which are related to the perceived benefits and barriers. Section 4.4.4 looks at the factors related to perceived behavioural control. An overview of the results regarding the subjective norm is provided in Section 4.4.5. Section 4.4.6 provides the results regarding the code category intentions to use V2G. Sections 4.4.7 and 4.4.8 demonstrate the results regarding the two added categories *trust* and *EV drivers' profile characteristics.*

4.4.1 Perceived benefits

The perceived benefits are divided into compensation, societal benefits, system effects.

Compensation

Compensation has different aspects: type of compensation, the amount, for what the EV driver is compensated. In general, the interviewees indicated that proper compensation is important to persuade them to participate in V2G. In most cases, the participants expect to be compensated for battery wear and additional advantages for participating in V2G (e.g. discount on parking tariffs).

> ***C1.*** *CED11: "Very good concept where I will participate in if my cars allow it". CED10 thinks that the financial compensation aspect and discount on charging/parking tariff is an important advantage to him. CED11: "What is in for me?". [CED11]*

> ***C2.*** *The interviewee believes that monetary compensation (e.g. cheaper energy, free parking) will stimulate and encourage him to use V2G. [CED15]*

Interviewees expressed also concerns about the feasibility of generating proper compensation. When it comes to compensation, CED12 and CED13 expressed their doubts whether it is feasible to come to reasonable compensation. The argument is that they believe that the feasible margins are too small and compensation cannot be more than a fraction of Eurocents per kW.

> ***C3.*** *Financial compensation does not influence the CED13's willingness to participate. The interviewee does not believe that financial compensation could be realized which is enough to compensate for the degradation of the battery. [CED13]*

Other interviewees expressed concerns about who will receive the compensation. More than half of the interviewees had a leased EV, so who will receive compensation for V2G usage?

> ***C4.*** *Who receives the compensation? CED14: "Suppose that I almost fully charge (95%) my EV at a fast charger, using the charging pass of the employer. And then connect the EV to the V2G system at home. What happens with the compensation and costs of charging? Then I use energy where my employer paid for." [CED14]*

Societal contribution

In general, interviewees perceived societal benefits of V2G systems. The personal opinions differed on how important this benefit is. The interviewees mentioned different aspects regarding a societal contribution by V2G participation: helping organizations in achieving goals regarding GHG reduction, contributing to solving grid balancing issues, environmental benefits that V2G can deliver (better use of RES, peak shaving), form of charity (transporting energy to a non-profit foundation or donating the received compensation to charities).

> ***C5.*** *VDP1: "Better ecological footprint. We are dreaming about gas-free households and a transition towards solar energy and wind energy". Interviewee: "If my car can contribute to that, that would be very interesting".*

Some interviewees have explicitly mentioned that the societal contribution they can make by participating in V2G services is more important than receiving compensation.

> ***C6.*** *The societal aspect is the most important benefit to her. "If the grid will be overloaded, we all experience the disadvantages from it". We have a societal problem where we all contribute to; we all want to drive electric and have financial tax advantages. CED3 mentioned: "when I can do something back for society by participating in V2G, it is a good thing". [CED3]*

> ***C7.*** *The financial compensation is less important compared to contributing and helping the airport with achieving its plans and goals. That would be one half of the motivation to participate. The other half would be, what happens with the battery? There should be clarity about that. [CED10]*

System benefits

Numerous interviewees perceived the system effects of V2G as beneficial. In other words, interviewees were appealed by the technical benefits of V2G systems. For example, peak shaving, temporarily energy storage, energy trading, frequency regulation. It was noticed that their belief in the system's benefits contributes to their attitudes towards V2G. In other words, when the interviewees perceived these benefits, they were likely to be more enthusiastic about the concept. This is demonstrated using citations of several interview reports.

> ***C8.*** *The interviewee perceives the idea of energy storage in the EV as a very good idea which should be further explored to contribute to grid balancing. [CED1]*

> ***C9.*** *CED4's perception is that V2G delivers more possibilities for himself as an end-user for energy storage capacity and various other applications (e.g. V2G at home). He admires the idea that it provides possibilities for the grid to be more balanced. [CED4]*

> ***C10.*** *"If you can add battery capacity to the grid, you can help to balance the system." [CED14]*

> ***C11.*** *There is also another advantage: if netting arrangements are not possible anymore. You can store overcapacity and use your solar-generated energy. [VDP1]*

Not all interviewees understood these technical functionalities of V2G (e.g. frequency regulation) but were still enthusiastic towards the V2G concept. In other words, knowledge of the type of grid services contributes to their attitudes; however, is not a precondition for V2G acceptance. One interviewee mentioned that it is questionable whether all EV drivers want to know (exactly) for what grid services their EV is used. They might only want to know that their EV is being used, but not exactly for what services.

Practical benefits

Interview participants perceived practical benefits of V2G. EV drivers expressed their frustrations about other EVs occupying public charging points.

> ***C12.*** *. In the current situation, people often unnecessary occupy parking spaces with chargers. The interviewee is frustrated about "charging station stickers" at public areas. [CED7]*

One interviewee perceived it as an advantage that she does not have to remove her car when the battery is fully charged since high plug-in time is part of the V2G concept (CED8). She expressed that she might sometimes feel guilty when she parked her car (and charging) and did not move it for a couple of days. CED8 that this guilty feeling is not present with the V2G concept since it is the core of the V2G concept that EV drivers achieve high plug-in times. In other words, assuming there are enough

V2G bi-directional chargers available at a public location, the interviewee believes that this is partly solved. This is called 'the charging sticking problem solved'.

> ***C13.*** *The interviewee believes that it is an advantage that she does not have to remove her car from the charger when it is fully charged since high plug-in time is part of the V2G concept. [CED8]*

> ***C14.*** *The interviewee notices that the guilty feeling of sticking to a charging station is not present. [CED17]*

4.4.2 Perceived barriers

User Inflexibility

The barrier of user inflexibility refers to anxiety that the battery is not fully charged when the EV is needed for mobility or *range anxiety.* Namely, interviewees questioned whether there is enough energy in the EV's battery when the vehicle is needed for mobility, especially in case of unexpected trips (e.g. emergencies):

> ***C15.*** *[CED3:] mentioned that: "How do I know that my car is enough charged when I want to leave?". Furthermore, CED3 sometimes makes unexpected trips and, therefore, does not want the battery state-of-charge is low when making an unexpected trip.*

This view is supported by CED5, who explicitly mentioned that this would be an important barrier to her.

> ***C16.*** *[CED5:] questioned: "What happens when I have to make an ad hoc trip?". There exists a chance that the battery is low.*

It is a common belief that driving EVs requires the need for additional planning. With V2G, planning by the EV driver should be done even more. So, the second aspect of user inflexibility is related to the experienced burden of additional planning. However, interviewees responded predominantly positive towards the requirement of additional planning of mobility:

> ***C17.*** *[VDP1] argued: "Personally, more planning does not matter so much. However, the larger public has to be convinced that this planning aspect should be part of their daily lives and routines."*

This interviewee mentioned that additional planning is not a problem because the interviewee desires to be self-sustaining and participated in a V2G pilot. However, the interviewee acknowledged that the large public most probably will perceive this as a large barrier. Different potential solutions have been proposed by interviewees. The first is related to the agreement on a minimum state-of-charge or lower limit.

> ***C18.*** *[CED6] The interviewee proposes that there may be other EV drivers who have more unpredictable behaviour. That may be a problem since the battery is not fully charged then. CED6 proposed a solution: "Everything above 60% state-of-charge can be delivered back".*

An interviewee proposed the ability to connect a personal agenda to the V2G as a potential solution.

> ***C19.*** *[CED16] believes that there is a small group of people that is very enthusiast about the concept (including himself) that is willing to provide input (e.g. agenda coupling or a smartphone app) about his personal schedule and expectations about next trips.*

Battery degradation

Battery degradation was widely discussed concept during interviews. Different attitudes and beliefs regarding battery degradation have been observed. Some interviewees expressed concerns regarding the battery degradation effects caused by V2G. Other interviewees acknowledged possible battery degradation effects, but perceive it not as a problem. The role of EV ownership (leased/purchased) played an important role in the discussion of battery degradation. In general, EV drivers with leased EV care less about battery degradation effects.

> ***C20.*** *[CED3:] mentioned that possible negative effects on the battery are acceptable as long as the effect is not larger than for instance the battery degradation caused by regular driving. Furthermore, the battery is from a leased car, so it is of minimal importance to her. As long as the battery keeps its performance for 3-4 years.*

EV drivers with a privately owned EV (purchased), on the other hand, have indicated that it is imperative to clarify actual battery degradation effects caused by V2G and to take precautionary measures. For instance, CED13 mentioned that battery technology has to be developed further first before he would participate in V2G services. With his current purchased vehicle, the interviewee would not participate in V2G operations.

> ***C21.*** *[CED13:] "If discharging for V2G-mode is done only a couple of times per year, then it would be acceptable. But if you do V2G on a daily basis (hundreds of times per year), I believe that the battery pack will be damaged". CED13: "An EV has a couple of thousand charges/discharging cycles. Suppose you charge and discharge 200 times per year for V2G-mode, then after 5 years, the vehicle's battery pack is significantly degraded due to V2G".*

However, there was one interviewee (CED4) with a purchased EV who perceived battery degradation, not as a barrier. The interviewee believes that when charging and discharging will be done between the boundaries of 20%-80% state-of-charge, it would not be detrimental for the EV's battery.

> ***C22.*** *CED4 beliefs that when charging is between 20% and 80% state-of-charge it has no negative influence on battery life. CED4 beliefs that: "fully charging the battery and a completely empty battery is bad for the battery pack".*

It can be also argued that knowledge about battery technology can contribute to V2G acceptance since. In other words, EV drivers with additional knowledge of EV technical components tend to find battery degradation as less a barrier. Over the years, CED15 has kept track of actual battery degradation of his current EV and concluded that the battery degradation effects are minimal (mentioned a difference of 0.1 kWh after 100,000 km driven). This is also the case for CED19, who indicated that she had already driven 7 years with the same EV and noticed minimal battery degradation. Therefore, both participants believe that battery degradation effects caused by V2G are minimal and negligible. Put differently, persons' believes about what is good and bad for li-ion batteries influence the extent to which battery degradation is perceived as a barrier.

Lastly, most interviewees expect to be compensated for caused battery degradation effects. However, the interviewees expressed concerns and doubts about who will receive this compensation in case of a leased EV.

> ***C23.*** *Possible battery wear caused by charging and discharging is not a barrier so that CED10 would not use the V2G service. As long as it is transparent and clear to what extent there is battery wear. And that you are somehow compensated for it. [CED10]*

Lack of standards/protocols

Interviewees worried that only limited car models do support V2G. They have doubts about whether all OEMs (cars) will engage in V2G and will make their EVs V2G capable in the near future. Furthermore, a few interviewees expressed uncertainties regarding whether their current EV supports V2G or has V2G capabilities. Moreover, a few interviewees (especially CED15 and CED17) were advocates of the integration of user-interface with existing applications (e.g. parking apps). Both interviewees expressed concerns whether there will be standardized interfaces for V2G applications on the short-term. They were advocates of the development of such standards.

Better alternative technologies

Interviewees believed there might be other technologies more suitable for solving the identified grid balancing problems. CED10 mentioned during the interview that "there may be alternative technologies (e.g. static home batteries) that can fulfil the same purpose, but better". CED13 believes "in better alternatives (e.g. home battery packs or hydrogen storage) for solving grid balancing problems". CED15 perceived challenges with the dropping prices of li-ion batteries and that if the battery packs will be affordable for the large public, that everyone will have a home battery in no-time and not necessarily participate in V2G.

4.4.3 Attitude towards V2G

From the previously defined research lens, it became apparent that perceived benefits and perceived barriers influence people's attitudes towards behaviour. In general, the interview participants were predominantly positive towards the V2G concept. The participants were appealed by the system effects (e.g. grid balancing, energy trading, frequency control, etc.) and perceived it as a "smart concept". Two interviewees believed that V2G will be a standard part of future energy systems and future charging. That it will not be a matter of if it will be realized, but when V2G systems will be realized. As mentioned in the previous paragraph, compensation and societal contribution are two dominant perceived benefits.

Interviewees also expressed concerns. CED13 recognized that V2G is a solid concept from a technical perspective. However, CED13 hopes that V2G will not be realized in the short-run because of possible accelerated battery degradation. Furthermore, concerns have been expressed about the underlying motivations of V2G to help to solve grid balancing issues. This motivation for developing V2G systems is not perceived as meaningful and attractive by all interviewees. In other words, not all interviewees are triggered by technical system benefits. CED7 explicitly mentioned the importance of defining clear goals of each V2G use case and communicating them to the end-user. CED7 expressed her doubts about whether the majority of EV drivers will be attracted by the goal of grid balancing and will persuade them to participate in V2G services. When it comes to compensation, CED12 and CED13 expressed their doubts whether it is feasible to come to reasonable compensation. The argument is that they believe that the feasible margins are too small and compensation cannot be more than a fraction of Eurocents per kW. Interviewees expressed also concerns about who will receive the compensation. More than half of the interviewees had a leased EV, so who will receive compensation for V2G usage? Lastly, interviewees expressed concerns whether alternative technologies (e.g. static batteries) are more suitable given the grid balancing issues.

4.4.4 Perceived behavioural control

User-interface

The larger part of interviewees indicated that the presence of a user-interface is of importance to achieve a user-friendly experience with V2G systems. An user-interface which provides the EV driver with the possibility to provide input for trips schedules, but also gives an overview of the V2G transactions including statistics and information about discharging. They pointed out that it does not matter on which device; in-car, on a smartphone or a display on the bi-directional charger, but that the availability of software in order to keep a degree of control over discharging will be necessary to convince most interviewees to participate in V2G.

> ***C24.*** *The interviewee proposed the idea of using the software in the car and V2G charger. The car and bi-directional charger should have to collaborate. He wants to keep control using a smartphone*

application which provides notifications about when the car is going to discharge. Wants to be able to set a limit for minimal state-of-charge. [CED1]

The majority of interviewees want the possibility to provide input about their expected next trip (e.g. required and departure time), while a few interviewees do not want additional tasks and "hassle". Some interviewees expressed that they want full control over discharging, while other interviewees just want the possibility of controlling discharging available, but doubt whether they will use it on a daily basis.

C25. *There exists a chance that the interviewee considers using V2G incidentally. In the case of the V2G home application, the interviewee wants to have full control over the energy system and discharging of the battery. So, CED13: "control is a very important aspect". [CED13]*

C26. *CED4 also mentioned that: "I want to keep control". The interviewee noticed that he does not want that you want to make a trip and that a third party just drained the battery. You want to keep it in control as an end-user. [CED4]*

C27. *CED10: "Preferably not real-time control (don't want to get notifications throughout the whole day)". The interviewee believes that weekly or monthly reports (in-car/smartphone) are enough to keep control. It should/is technically managed that you are not facing an empty battery when want to make a trip. [CED10]*

Some interviewed experienced EV drivers who are also e-mobility experts expressed concerns that there is not yet a standard or protocol for this kind of software apps. These interviewees pointed out that the V2G functionalities are preferably integrated with existing software. For instance, they prefer existing smartphone apps to be integrated with V2G system environments (over an additional new smartphone app).

C28. *The interviewee believes that it should be integrated with existing EV smartphone apps or parking apps. CED15: "you can better have 1 application than all separate smartphone apps". There is no European standard and protocol in place for this. You need other organizations and authorities to generate such standards. [CED15]*

Lastly, the V2G driver participants (VDPs) experienced the usage of a smartphone app where the driver was able to provide input about trip schedules, expected next trip. The VDPs indicated that additional trip scheduling was personally not a problem to them. They questioned whether the public would be willing to do this in the future.

PR & communication

This factor involves information transparency about benefits, costs and risks. A few interviewees (e.g. VDP1) expressed that it should be communicated what is done to mitigate the risks. Furthermore, there should be openness about the contributions that an EV driver can make through V2G participation (e.g. GHG emissions reduction), and the system's benefits should be briefly made clear to them. In other words, interviewees mentioned that it should be clear to what they are contributing to. For instance, how their V2G participation relates to the service providing the organization's goals. This also includes explanations of how the system works. VDP1 also explained that V2G project groups could foster drivers' familiarity with V2G through publicity of their projects (e.g. in magazines).

User-friendliness & ease-of-use

Interviewees indicated the importance of user-friendliness regarding V2G systems and V2G applications usage. This involves the following four dimensions. Firstly, the usage of user-friendly interfaces can be a contributor to V2G acceptance. Numerous interviewees proposed the ideas of using mobility planning software and large parts of a user-friendly experience can be achieved in the software or user-interface. This could include the provision of input about the personal time scheme. One interviewee proposed that this could be automated or connected to the personal agenda or

personal schedule. Another interviewee prosed the idea of having an "integral arrangement" (e.g. booking V2G-enabled parking lot at the airport when booking the flight). Most interviewees highlighted the importance of simplicity in V2G transactions ("ease-of-use"). However, a few interviewees (e.g. CED17) questioned whether it is possible to make it more user-friendly than traditional charging.

Control

Interviewees expressed that they would want to have the option to keep control over discharging (e.g. through a smartphone app). A few interviewees indicated that the ability to set a minimum state-of-charge must be present. In other words, the possibility to set a lower limit for battery discharging. A few interviewees (e.g. CED1) perceived control of discharging as a solution for having a user-friendly experience with V2G. Interviewees proposed different ways to control the V2G system: time of discharge, number of discharge cycles, set minimum state-of-charge, boundaries for SOC. Based on the interviews, it did not become apparent which are more preferred.

Location

Interviewees have been asked at which locations they prefer a V2G charger, in general. There was not a univocal response or location that stands out which is most appropriate. The indicated preferences are shown in Table 12, where the distinction is made between short-term parking long-term parking (columns) and private/semi-public/public parking (rows). The table includes *groundedness (g=)* which is the frequency mentioned by different interviewees. Based on Table 12, drivers' personal opinion regarding the ideal location of a V2G bi-directional charger is dependent on practical preference. The majority of interviewees pointed out that location does not play a crucial or decisive role in their acceptance of V2G, but that it is more important from a practical point of view. For instance, CED1 indicated that there is not one specific location where he will use bi-directional chargers or that there is one location where the perceived benefits are greater. However, it was noticeable that interviewees often reason from a practical perspective (e.g. where it is personally usable and easy where to have a bi-directional charger). 'Previous charging behaviour' seems to be a good indicator for determining at which location an EV driver prefers the installation of a V2G charger. For instance, EV drivers who charge their EV at home mostly indicated that it would be more useful to have a V2G bi-directional charger at home. CED4 indicated that she makes use of her EV for commuting in most cases and that a V2G at the office and at home would be most meaningful.

Table 12: Mentioned preferred V2G location interviewees

	Short-term parking	**Long-term parking**
Private	• Home (*g* = 5)	• Airport (reserved) *(g* = 2)
Semi-public	• Office (*g* = 3) • Event venues (*g* = 4) • Soccer stadiums (*g* = 3) • Non-profits (e.g. local sports club) *(g* = 1) • Amusement parks (*g* = 1)	-
Public	• Home (*g* = 2) • P+R traffic relays (*g* = 3) • Large supermarkets & shopping malls (*g = 2)*	-

A number of interviewees indicated that parking duration should be taken into account. Within this research, distinction is made between short-term and long-term parking. Within short-term parking, distinction is made between short-stay and mid-term parking, but in terms of simplicity, short-term parking was taken as an umbrella term. This assumption or simplification is not convenient because interviewees perceived mid-term and long-term parking as more meaningful for V2G application by the EV drivers. For instance, EV drivers that park their EV at the office the entire working day, perceive that as more relevant for V2G. Long-term parking is separately discussed in the next section. On the contrary, short-term parking lots (<2 hours) was often perceived as purposeless (e.g. V2G at supermarket). At such locations, the EV driver just wants the battery to be charged as soon as possible. However, CED15 and CED17 mentioned that it would be attractive to "bring energy to a location". For instance, if an EV driver visits a soccer match, a contribution can be made to the driver's favourite sports club. CED7 indicated that with foundations (e.g. amateur sports clubs) or an association where you are a member, you could help the organization by bringing energy to the venue.

4.4.5 Subjective norm

During the start of each interview, it was asked to interviewees whether their social environment influenced their decision to purchase an EV. 8 out of 20 interviewees indicated that they were not influenced at all or to a little extent. Only 2 interviewees indicated that they were influenced by their environment. Since none of the interviewees was using V2G on a daily basis, no results could be provided about the role of social environment or social pressure on their acceptance. But, another part of the subjective norm is that new norms have to be developed for V2G usage. For instance, the idea of helping the V2G service providing organization or grid operator with balancing the energy grid as an EV driver could be a new norm. A new norm would be that, in order to be allowed to drive an EV, that you contribute to grid balancing since the grid is something that we all use on a daily basis. Another new norm would be one of the trips planning or mobility planning. For V2G participation, the new norm would be that you plan your mobility in order to make use of V2G and of an EV. Lastly, some interviewees believed that there is no other option than V2G. Two interviewees believed this as part of the future of e-mobility and charging.

> ***C29.*** *"in the future, when a great part of the car fleet will be electric, there is probably no other option or choice for the consumer; It is either you cannot charge your car or have power/current issues so we cannot watch TV at night". [CED9]*

4.4.6 Intention to accept V2G

Interviewees were directly asked whether they have the intention to accept V2G when it becomes increasingly available. In general, the majority of the interviewees would have the intention to use it. Put differently, the larger part of the interviewees had positive intentions.

> ***C30.*** *[CED2:] has the intention to use V2G at several locations. He would use V2G chargers because he believes it is a good concept with societal impact. Has a very positive attitude.*

> ***C31.*** *[CED6:] The interviewee: "Would find it great to participate!".*

Nevertheless, a number of interviewees had other intentions. CED9 and CED13 determined clear restrictions or terms and conditions which must be formulated before they would intend to use V2G. CED9 argued that he would have the intention to accept V2G as long as it will not result in additional monetary costs. CED10 explicitly mentioned that the planning system should be well designed and developed. CED13 notified that he will not have the intention to accept V2G, given CED13's concerns of battery degradation caused by additional charging cycles. The interviewee first wants battery technology further developed so that V2G's impact on battery life is minimal.

C32. *[CED9:] Would use it as long as there are no additional (monetary) costs attached.*

C33. *[CED10:] If it would become increasingly available, CED10 would use it (but the planning aspect and unexpected trips aspect should be designed well).*

4.4.7 Trust

Based on the interviews, trust played an important role in individuals' acceptance. This is trust in both the technology (operational reliability) and in the service providing organization or aggregator. CED 7 mentioned that it is important to her what the goals of the aggregator are and whether she can trust this institution.

C34. *CED7: "So if there is a third party that is arranging the energy flows, what are the organization's underlying reasons to run such a company? CED7: "Are they profit-focused? Who is this organization? Would I feel attracted to the why of this aggregating party?". In other words, is the organization doing it for the greater good ("making the world a better place")? In this case, CED7 would feel more attracted (compared to a profit-focused organization) to participate in V2G.*

Also, interviewees indicated that operational reliability is an important precondition for acceptance. When an EV user plans a certain trip for the next day using a smartphone app, for instance. Then, the EV users want to be 100% sure that the battery is enough charged the next day and that the system works as intended to, without errors.

C35. *CED18: "Moreover, the uptime of the app and system is important. If there are many break downs or black-outs, then trust in the charging station and responsible organization is gone. So a high uptime and low error margins is an important aspect." In other words, "operational reliability". To illustrate, VDP1: "if you have set the app to be able to leave early in the morning (7 a.m.), then the car's battery has to be fully charged and ready 7 am the next day". In other words, you can trust the system.*

Furthermore, trust in the system developers. Often it occurred that interviewees expressed trust in system developers that the system would be designed in a way that the (technical) risks are minimized.

C36. *CED11: "The system developers know what kind of safety measures should be taken, the number of KWh they can use, how to minimize battery degradation, etc.". The interviewee: "I trust that these kind of aspects are arranged so that risks are minimized".*

Lastly, a few interviewees indicated their trust in technical battery developments and that in the short-term, batteries are well-established and developed so that battery degradation effects are minimal.

C37. *The interviewee mentioned that "there may be accelerated battery wear", however, CED9 trusts that the battery technology will be far better in the near future.*

4.4.8 EV drivers' profile

During interviews, more information was obtained about EV drivers' profiles and background. This resulted in 9 codes with a total of 26 sub-codes. These sub-codes provide a more detailed view of the different codes. For instance, the code 'main motivation driving an EV' has one sub-code 'financial' to indicate that 10 interviewees mentioned the financial benefits of EVs as the main driver of EV adoption. In general, the following 9 codes have been created: 'eco-values', 'influence social environment on decision to drive an EV', 'previous charging behaviour', 'previous experience with long-term parking', 'solar panels possession', 'technological innovativeness', 'V2G familiarity', 'high knowledge', 'main motivation driving an EV'. An overview is provided in Table 13 on page 54. The table demonstrates the codes and sub-codes in the first two columns. The third column and the fourth column indicate the groundedness and frequency of interviewees mentioned.

Based on the table, half of the interviewees had apparent (technical) knowledge of EV battery technology, keeping track of actual battery degradation of their EV's battery, or certain beliefs about what is good for batteries and whatnot. Eight interviewees mentioned that they have clear eco-values. That they highly value environmentally-awareness during their daily lives (e.g. active waste separation, eating less meat, etc.). There was an equal number of individuals that were influenced by their environment to adopt an EV as compared people that were not influenced. Looking at Table 13, two interviewees mentioned that they believe that they have influenced other people to drive electric. With regards to previous charging behaviour, the interviewees indicated that office and home charging is done mostly by the sample. Interviewees mentioned that they also charge at public places, but not as much as charging at home or at the office. Note that not all interviewees were asked about previous charging behaviour, so this resulted in missing data due to time constraints of the interviews. The majority of interviewees heard about V2G or were up-to-date about the concept of V2G. Two interviewees explicitly mentioned they never heard of V2G before. These factors are part of the code category 'EV drivers' profile characteristics' which is included in the resulting model in Figure 15.

Table 13: Codes and Sub-codes of the code category 'EV drivers' profile characteristics'

Codes	Sub-codes	# Grounded	Frequency of interviewees mentioned
Eco-values	Eco-values	8	6
High Knowledge	Battery technology	10	9
Influence social environment to drive an EV	influences others	2	2
	not at all	4	4
	to some extent	4	4
Main motivation driving EV	car design	2	2
	environmental	5	5
	financial	10	10
	new technology	5	5
Previous charging behaviour	home	5	5
	office	5	5
Previous experience long-term parking	never	8	8
	occasionally	3	3
	often business trips	1	1
	once or twice a year	5	5
Solar panels possession	no	1	1
	plans to buy	4	4
	yes	6	4
Technological innovativeness	Not at all	3	3
	Pilot participant	3	3
	Profession	2	1
	Reads articles/forums	8	8
	UTD latest developments	6	5
V2G familiarity	heard/read about it	4	4
	highly familiar	5	5
	not at all	2	2

4.5 V2G at long-term parking

During interviews, V2G at long-term parking was discussed separately with the participants because this location application of V2G is part of the main research question. Based on the interviews, several factors should be interpreted slightly different for V2G at long-term parking. In other words, for long-term parking, small nuances for several factors have been observed. By discussing V2G at long-term parking with each interviewee, it was possible to gain in-depth insights about what is important to them personally. This section will take a closer look at these nuances and small differences.

4.5.1 Attitudes towards V2G at long-term parking

In principle, the majority of interviewees were enthusiastic about the application of V2G at long-term parking. Four interviewees pointed out that they park their EV at long-term parking lots on a regular basis at airports, at home or at holiday destinations. With every interviewee, the concept of V2G at long-term parking was discussed.

Generally, the interview participants were like-minded and prevalent positive about the concept. There was one interviewee who agreed that the technology is correct from a technological perspective but still hoped that it will not be introduced. Later in the interview, CED13 changed his mind and mentioned that, under restrictions and predefined conditions (e.g. maximum number of discharge cycles and lower limit state-of-charge), he would participate in V2G services at long-term parking. However, the majority of interviewees have perceived V2G at long-term parking as a good use case. A part of the research participants admitted that they have never parked at long-term parking before because they do no travel by aeroplane on a regular basis or prefer public traffic/taxi to the airport. Two interviewees indicated that proper compensation (e.g. free parking or charging) would be a trigger to travel to the airport with their EV, instead of public traffic or taxi.

4.5.2 Compensation for V2G participation at long-term parking

Based on the interviews, compensation remains an important aspect, also for the long-term parking use case. As mentioned, interviewees perceived battery degradation as a larger barrier and, therefore, expected higher compensation. Nevertheless, the opinions have been divided when it comes to the amount and type of compensation.

During interviews, different compensation types have been proposed: discount on parking tariff, discount on charging (kW), free parking, free charging. Based on the interviews, not one compensation type or amount of compensation has been identified which maximizes drivers' acceptance. Interviewees preferred different types and amounts of compensation. Five interviewees indicated that they perceived compensation as less important. They were more appealed by the fact they are contributing to an organization and helping, for instance, an airport with their energy provider. These interviewees indicated that an organization, such as an airport, should give drivers the feeling they are contributing to the environment (e.g. help to reach goals to reduce GHG reduction).

4.5.3 Perceived barrier 'User Inflexibility' not present

The barrier of 'user inflexibility' is negligible for V2G at long-term parking. User inflexibility was identified as a number one barrier for other use case of V2G (e.g. office application). During interviews, 4 interviewees admitted that this barrier is not applicable for V2G at long-term parking. With the long-term parking use case, EV drivers expressed that they trust in the planning systems. That it can be predicted with high certainty when the driver is returning to the vehicle. They believed that planning could be done very accurately. Furthermore, they expressed that they is no need for unexpected trips

(when parked at long-term parking). Accurate estimation can be made of when the EV driver is returning to the EV based on flight information of the return flight. They saw that the V2G system could make sure that the battery is fully charged when they will return to their EV.

> ***C38.*** *[CED3] Furthermore, the disadvantage of making unexpected trips and the possibility of a low state-of-charge battery is not applicable in the long-term parking situation at an airport*

> ***C39.*** *[CED9] When comparing the V2G office and V2G airport application, the interviewee perceives the essence or core of the concepts as the same. However, with the V2G at the airport application, the EV driver can better plan when returning to their car.*

4.5.4 Battery degradation barrier of increased importance

Interviewees expressed increased concerns about battery degradation for V2G at long-term parking. EV drivers understood the EV would be parked for a long period of time. Additional concerns have been observed about the effects of V2G participation on their battery. In other words, battery degradation is a larger barrier when it comes to V2G at long-term parking because several interviewees acknowledged that a higher number of (dis)charging cycles would take place compared to other V2G applications. Interviewees proposed solutions on how should be dealt with these aspects. An interviewee indicated there should be clarity about how often the battery is being charged and discharged. The same interviewee proposed a SOC bandwidth of 20% and 80% in which the battery is being charged and discharged.

Another interviewee had admitted that transparency and information provision about the effects on the battery is crucial in case an EV driver has doubts and uncertainties. There must be a possibility for the EV driver to gather information.

> ***C40.*** *[CED16] Battery wear is still an issue, maybe a larger issue at the airport because of probably more charging/discharging cycles.*

4.5.5 Intention to accept V2G at long-term parking

Interviewees indicated that they would have the intention to use V2G at long-term parking when becoming available. An important determinant or criteria is whether the EV driver travels by aeroplane on a regular basis. Furthermore, interviewees mentioned that it should be no more difficult than regular charging.

> ***C41.*** *[CED9:] The interviewee thinks that he would use V2G chargers when becoming available at long-term parking. Assuming he would also start using long-term parking lots.*

> ***C42.*** *[CED19:] Would definitely have the intention to use V2G at long-term parking. But, the app has to work and has to be very simple. No separate membership to participate should be required.*

4.5.6 Practical solutions proposed by interviewees

Interviewees proposed ideas or creative solutions in order to deal with the perceived barriers and to improve V2G at long-term parking service offerings so that their willingness to participate and acceptance of V2G would (further) increase. CED7 proposed the usage of electric buses to bring the EV user to the flight terminal instead of using polluting diesel combustion vehicles. Furthermore, CED11 proposed the idea of creating separate parts for EVs and V2G at parking lots with clear road signs and markings to lead the way. Both CED4 and CED11 suggested the possibility to book a V2G bi-directional charger and parking lot in advance during the process of booking the flight trip or holiday (“integral arrangement”). 10 interviewees supported the idea of having a smartphone app to provide input about the trips schedules and preferences regarding charging and discharging (e.g. minimum state-of-charge or maximum amount of discharging cycles).

4.6 Differences and similarities interview groups: CEDs and VDPs

Two interview groups of EV drivers have been interviewed: current EV drivers (CEDs) and V2G pilot participants (VDPs). These two groups have similarities and differences which will be further explained. Table 14 compares the two groups of interviewees. The left column shows the CEDs. The right column includes the characteristics of the VDPs. The differences and similarities are further discussed below.

When starting this research, the intention was to measure whether an EV driver's actual usage of V2G would influence acceptance and their attitudes. The idea was to do so by creating two groups: CEDs and VDPs. During data analysis and coding, the two interview groups were eventually not treated separately because all 3 VDPs did not experience actual discharging of the EV's battery pack. This was caused because of technical failures with the software during the pilot and newness of 1 pilot. However, since none of the interview participants had experienced actual discharging, the two groups were further merged during data analysis in terms of codes. Another reason why the groups were merged during the data analysis phase was the fact that only 3 VDPs were interviewed compared to 17 CEDs. The CEDs were predominant in terms of number of interviewees. The low number of interviewees in the VDP group compared to the CEDs resulted in the second reason to decide to merge the two groups during further data analysis. What the 3 VDPs did experience, was the usage of a mobility planning system (smartphone app) where the participants had to provide input about trip schedules. This, however, provided some subtle insights and these will be further discussed in Section 5.1 (conclusions).

The general view was that there have been no major differences between the two groups in terms of attitudes and opinions regarding V2G. A part of CEDs had never heard of V2G before and the majority of CEDs had read about it in the news. A small group of CEDs had advanced (technical) knowledge of V2G. In contrast, all VDPs were highly familiar with the V2G concept The VDPs have experienced additional planning of trips in a smartphone app, but none of them had ever experienced actual discharging.

Table 14: Differences and similarities CED and VDP interview groups

Current EV drivers interviewee group (CEDs)	**V2G pilot driver participants interviewee group (VDPs)**
• 17 interviewees	• 3 interviewees
• V2G familiarity divided	• All highly familiar with V2G concept
• No experience planning with mobility	• Actual experience with planning mobility (pilot's smartphone app)
• No experience discharging battery EV	• No experience discharging battery EV
• More divided attitudes V2G concept	• All very positive about V2G concept

During the set-up phase of the research and conducting interviews, it soon became clear that finding interviewees with actual V2G experience is very difficult. Beforehand, it was assumed that the V2G pilot driver participants also experienced discharging of the battery. During interviews with VDPs, it soon became clear that in none of the pilots discharging of the system actually worked. The 3 interviewed VDPs participated in a total of 2 different pilots. In one pilot, actual discharging of the EV's batteries did not work because of software failures. For the other pilot, the V2G system was recently installed and not fully up-and-running at the time of the interview yet. Due to time constraints of the present research, it was not possible to interview VDP3 at a later moment in time.

Despite actual discharging of the battery never was done during the V2G pilots, VDP1, VDP2, and VDP3 experienced the usage of a smartphone app where they had to plan their mobility. It became apparent that all 3 VDPs were highly up-to-date about how V2G systems work in general what the system effects are (e.g. grid balancing). In other words, VDPs had a higher knowledge level of V2G systems compared to CEDs. For instance, VDPs could tell more about important barriers from an end-user perspective based on their usage of the mobility planning systems. The interviewees indicated that they were personally willing to plan their mobility more. However, all 3 VDPs had doubts whether the large public will be also willing to do this when V2G becomes available on a larger-scale in the future. They also pointed out that operational reliability is a very important factor for V2G acceptance. This means that EV drivers can trust that the system works as intended to. EV drivers could find V2G an attractive concept, but if it does not work technically, EV drivers will still not use it most probably.

In sum, one could argue that VDPs were more familiar with the V2G concept than CEDs. The VDPs were very positive about V2G in general, something that was also noticed among the CEDs. But, the CED group had more divided attitudes and opinions. Within the CED group, a few participants had never heard of the V2G concept before. A larger part had heard of the V2G concept. A few interviewees had even technical knowledge about V2G technology. The VDP group had actual experience with planning mobility. The CED group had never done this before but could imagine how that would be based on the shown animation during interviews.

4.7 Attitudes changes caused by actual V2G usage experiences

Part of this research was investigating whether V2G actual usage influenced interviewee's attitudes towards V2G usage. Since none of the interviewees had ever experienced actual discharging of the batteries, it could not be investigated during interviews whether actual usage of a fully operational V2G system influenced their attitudes. However, the VDPs had actual experience with mobility planning which is a large part of V2G participation. These interviewees were asked whether they believe this correlation does exist. Two VDPs indicated that operational reliability plays an important role in this possible relationship between those two factors. Namely, if someone uses V2G systems, but errors do occur, their attitude would be negatively influenced and the chance they will use it again will decrease.

> ***C43.*** *The interviewee honestly explained that he was (sometimes) frustrated about the fact that the charger was not working at certain moments during the pilot. In conclusion, the system has to work properly as intended and has to be reliable.*

One other interviewee (CED14) did not believe that this relationship is present in his personal case. The interviewee expressed that he considers himself as an innovator. He likes trying new innovations and be a pioneer. When he is enthusiastic about a concept (positive attitude), he wants to try and use it. On second thought, the interviewee expressed that he would find it hard to justify whether this relationship is applicable to him and does exist.

5 Conclusion & discussion

This section presents the conclusion of this study and elaborates on the results by discussing the contributions for both scientific literature and practical V2G domains. Furthermore, the limitations of the research are discussed. Lastly, it provides recommendations to various stakeholders.

5.1 Conclusion

This section presents the conclusion of this research. In 5.1.1, it provides an answer to the main research question. In Section 5.1.2 , it takes a closer look at acceptance differences for V2G at short-term and long-term parking.

5.1.1 Answering the main research question

The main objective of this thesis research was the *identification of factors influencing Dutch EV drivers' acceptance of V2G at long-term parking* by researching the perspectives of (potential) end-users. The main research question of this research was:

"To what extent do Dutch EV drivers' accept V2G at long-term parking?"

A conceptual model was created and further extended by including factors based on the conducted interviews. This resulted in the *resulting model,* which includes 25 top-factors (from 85 in total) influencing V2G acceptance at long-term parking. Based on the interviews, the main conclusion was that EV users predominantly showed high acceptance of V2G at long-term parking, but that it was dependent on a relatively high number of different factors (85) and that their individual attitudes differed with regards to several topic areas (e.g. perceived benefits and barriers). Using the identified factors and respective relations, the answer to the main research question will be now further explained.

The interviewees indicated that *compensation*, *control* (e.g. through a user-interface) and *PR & communication* are important drivers of V2G acceptance. *User-inflexibility* (the combination of *range anxiety* and *experienced discomfort*) and *battery degradation* were perceived as barriers of V2G acceptance. It was found that the relative importance of factors differed based on EV users' personal opinions and profile characteristics. The opinions of interviewees varied on specific topics. For instance, some interviewees expressed concerns about battery degradation, while others perceived no problems with it. Their attitude towards battery degradation was influenced by both EV ownership type (leased/purchased) and their knowledge of battery technology. Even though the research participants had divided opinions, the results generally showed high acceptance of V2G at long-term parking. Most interviewed EV users would have the intention to use a bi-directional charger at long-term parking on condition that they would be able to reap financial benefits (e.g. discount on parking tariff) and as long as they would not experience additional discomfort compared to the current situation of parking and charging. Most interviewees found it appealing that they would be able to contribute to grid balancing and the environment (e.g. RES integration). Furthermore, they noticed that high charger plug-in rates also had several practical benefits (e.g. charging sticking issue solved). As mentioned, a few EV users were sceptical and most interviewees perceived also disadvantages, risks and challenges. But, in general, the risks were considered acceptable as long as three conditions would be met. Firstly, the technical risks should be communicated in a transparent manner. Secondly, the possibility to receive compensation for possible battery degradation and user-inflexibility. Thirdly, the possibility to control the system (e.g. through a user interface). When comparing V2G pilot driver

participants and current Dutch EV drivers, the former had actual experience with trips planning for V2G services and were all very positive towards the V2G concept. The latter had never used V2G systems and they had more divided attitudes. The results showed that EV drivers' acceptance levels did not vary when differentiating between short-term and long-term V2G applications, except that for V2G at long-term parking, user inflexibility was less an issue (e.g. EV users less worried whether their battery is fully charged). Furthermore, for V2G at long-term parking, users expressed increased concerns for possible battery degradation (e.g. high number of discharge cycles at long-term parking). The V2G location (e.g. airport or office) hardly influenced V2G acceptance. EV users tended to prefer certain V2G locations based on previous charging behaviour but also for practical reasons.

5.1.2 Generalizing the findings to other V2G applications

There are a lot of potential applications locations of V2G at public/private locations and short-term/long-term parking. Put differently, V2G at long-term parking is just one of the potential applications. As mentioned before, this thesis intended to provide also a deeper understanding of Dutch EV drivers' acceptance of other applications of V2G. During interviews, an open-view with regards to other V2G applications was adopted. This means that, besides the focus on V2G at long-term parking application, other use cases (e.g. V2G at office buildings) have been discussed with interviewees as well. It has been observed that the location of V2G bi-directional charger hardly influenced EV drivers' acceptance of V2G. EV users do prefer certain locations based on their (previous) charging behaviour and places where they charge most often currently. Also, no major differences in EV users' acceptance of short-term and long-term applications have been observed, except that for long-term parking EV users have larger concerns regarding *battery degradation* and *user-inflexibility* is not an issue at all. These larger concerns for battery wear are possibly caused by EV drivers' beliefs that more battery charging- and discharging cycles are made with V2G at long-term parking that may cause additional battery degradation. User-inflexibility is not an issue since most drivers *trust* that their battery is fully charged when needing the vehicle for the next trips and that the moment of returning to their car can be accurately predicted (e.g. based on flight information). Also, EV drivers prefer certain locations for V2G based on practical reasons. For instance, it makes more sense to them to apply V2G at mid-term and long-term parking lots because of higher feasible plug-in time. EV users just want their battery charged as soon as possible at most short-term parking lots. A few drivers indicated that V2G at short-term parking would be appealing when they can "bring energy" to a certain location. In short, no large differences between short-term and long-term parking with regards to drivers' acceptance have been observed and V2G location hardly influenced acceptance in general. The identified factors can provide useful insights for the V2G concept in general and other potential applications of V2G.

5.2 Discussion

This section provides a discussion about research contributions, research limitations, the author's personal view on V2G systems and the long-term parking and link to the MSc program.

5.2.1 Research contributions'

The research contributions are divided into scientific and practical contributions.

Scientific contributions

In Section 1.2, three research gaps have been identified. Firstly, it was unclear which factors would contribute to EV drivers' acceptance of V2G. Secondly, previous studies provided only superficial insights regarding EV drivers' preferences and underlying motivations since these studies mainly relied on survey methodologies (stated choice experiments). Thirdly, none of the previous studies aimed at

investigating drivers' acceptance of V2G applications at long-term parking. Based on these findings, this section reflects upon the identified knowledge gaps by elaborating on how this research contributes to filling those gaps. An additional paragraph discusses how the research has attempted to challenge existing theory, the Theory of Planned Behaviour (TPB) by Ajzen (1991).

Over the past decade, researchers from the Nordic countries have developed an extensive line of V2G research adopting a sociotechnical perspective. These researchers emphasized the urge for more research in the field of consumer and social acceptance of V2G. This study adapts to their requests by focusing on EV driver acceptance of V2G but within another country (the Netherlands). Before this study was conducted, none of the previous researches provided a comprehensive overview of factors contributing to EV drivers' acceptance of V2G, neither in the Netherlands nor in the Nordic region. The model of Ajzen (1991) – the Theory of Planned Behavior (TPB) – has been extended and contextualized for the V2G domain by including the factors related to *perceived benefits*, *perceived barriers*, *trust* and *EV drivers' profile*. By conducting semi-structured interviews with EV users, the *resulting model* has been developed which included the top-25 most important factors contributing to V2G acceptance. Based on the research sample, it has become clear that EV drivers perceived certain factors as more important than others regarding the transition to make V2G as part of their daily routines. These insights facilitate the measurement of EV users' acceptance of V2G by including the complexity of user motivations and barriers, which is an area that is still under-studied (Sovacool et al., 2018). This study attempts to take a step for the Dutch EV drivers by presenting the resulting model which includes factors (and their respective relations) that drive EV drivers' acceptance of V2G.

A unique feature of this research is the use of semi-structured interviews with Dutch EV drivers. During the literature review of V2G studies (section 3.1), it has been concluded that none of the previous studies have used semi-structured interviews with EV drivers as the main research methodology. As can be deduced from Table 5, previous studies solely rely on survey methods and/or expert interviews. These studies have provided solely superficial insights regarding consumer preferences and attitudes regarding V2G and V2G contracts. The choice of semi-structured interviews ensured that an in-depth understanding of EV drivers' motivations, attitudes and perceptions could be developed during interviews. The length of each interview, approximately 45-60 minutes, facilitated in-depth discussions of the interview topic areas and detailed answers to interview questions. The insights of the 20 interviews have been processed in the interview reports and interview results chapter. To the researcher's best knowledge, it was the first time that V2G focused consumer research have used semi-structured interviews with EV drivers. Therefore, in-depth insights in the interviewed EV drivers' attitudes, opinions, motivations and barriers could be obtained. This makes the present thesis study novel within the V2G research field.

V2G at long-term parking is one of the potential use cases. Previous studies briefly touched upon V2G at long-term parking. To the researcher's best knowledge, none of these researches included V2G at long-term parking as the main focus or investigated differences in short-term and long-term parking. This study has made a contribution by choosing V2G at long-term parking as the focal application. During interviews, the use case of V2G at long-term parking has been separately discussed with each interviewee. However, short-term parking applications (e.g. V2G at office buildings) have been discussed as well with interviewees. Therefore, the differences between short-term and long-term parking could be discussed. The main research question of this study focused on drivers' acceptance of V2G at long-term parking. A separate section in the conclusion was devoted to what the findings mean for other short-term applications (Section 5.1.2). In short, interviewees' acceptance of V2G was

generally the same for short-term and long-term parking, except that user-inflexibility is less an issue and drivers expressed increased concerns regarding battery degradation in the situation of V2G at long-term parking.

An attempt was made to challenge the existing theory. TPB was used as a main theoretical framework or theoretical perspective through which the main research question was addressed. TPB is a relatively simple model that states that *attitudes towards behaviour*, *subjective norm* and *perceived behavioural control* determine a person's *intention towards certain behaviour*. *Intentions towards behaviour* directly influence *actual behaviour* (Ajzen, 1991). The model was developed by social psychologists and already has been often used by other academics. For instance, TPB was used for investigating technology acceptance of information systems – Technology Acceptance Model (TAM) – by Davis, Bagozzi, and Warshaw (1989). Moreover, Huijts et al. (2012) extended the model by including *perceived benefits* and *perceived barriers* (*costs* and *risks* merged). However, this model focused mainly on public acceptance of risky technologies (e.g. hydrogen fuel stations). TPB is straightforward, extendable and simple to apply, but different aspects are not covered by the original model, as will be discussed in the limitations section (next section 5.2.2). Although initially, the basic structure of TPB was already almost complete, we added four main factors or categories. The present study has shown that EV drivers also behave based on emotional reactions or more subjective grounds. This tackles TPB's assumption that individuals are rational actors. Based on the results, it has not been possible to include EV users' *'trust'* directly within TPB. Furthermore, it has been shown that certain personal characteristics (*EV driver's profile*) influence an individual's intention to accept V2G. *Trust* and *EV drivers profile characteristics* have been included in *the resulting model* of this research. Moreover, previous studies supposed that persons experiencing actual usage of technology may influence a person's attitude towards the behaviour. This study attempted to identify whether there is a correlation between *acceptance* and *attitudes towards behaviour*, but no concrete evidence could be found, except that *operational reliability* (part of '*trust*') is an important condition of acceptance. In short, the TPB was extended in this study by including *perceived benefits, barriers, trust* and *EV driver's profile* in order to make it more complete or to contextualize the model for consumer acceptance within the V2G domain.

Practical contributions

From a practical point of view, organizations that plan to install V2G bi-directional chargers at their parking facilities can utilize the findings to substantiate the communication strategy for the EV drivers. For the V2G marketing & communication strategy, these organizations can find out what EV drivers find important. Perhaps, further case-specific research should be conducted to reveal the real needs of the EV driver for that specific case. However, this study attempts to make the first step. Furthermore, the findings can be used to underpin the business case. Namely, for the development of the business case, an important step is to investigate potential *earnings models* and whether the EV driver would have the intention to use the V2G service given a certain compensation model or V2G contract. The interviews revealed that a part of the Dutch EV drivers perceives receiving compensation for V2G participation as a prerequisite for actual V2G participation. A part of the sample indicated that they might actually want compensation for caused battery degradation, something that can be taken into account in the business case.

Research is specifically done for the (long-term) parking lot project developers that operate for landowners who might consider installing V2G charging points to offer innovative charging services. The findings can be taken into account for the redesign of services and creating acceptable V2G system

designs. Therefore, it is expected to contribute to increasing EV driver's adoption rates. Consultancy firms (e.g. Cenex NL) may gain insights and knowledge to include in future advises to their clients. Engineers (e.g. V2G charging point designers) may get inspired with new insights to adjust the design of the V2G system components, for instance, lay-out or interface designs. In Section 5.3 (practical) recommendations have been formulated for various stakeholders based on the findings of this study.

5.2.2 Limitations

Each research comes with limitations. This section examines the limitations of the present study. The section is divided into limitations related to the choice of theory, chosen research methodology and generalizability.

Choice of theory

In Section 3.2.4, it has been already explained that Theory of Planned Behavior (TPB) has a number of known limitations. In short, TPB has the following known limitations. Firstly, the model is not complete since it excludes habits and emotions moderating variables (Sniehotta et al., 2014). Secondly, it has limited predictive validity (Sniehotta et al., 2014) and, therefore, lacks explanatory power for what happens when individuals form an intention towards behaviour and do not perform the actual behaviour. Thirdly, TPB assumes that the influence of attitude towards behaviour on actual behaviour is constant, but researchers have questioned this assumption. Before entering the interview phase, different adjustments have been made to the conceptual model in order to circumvent several known limitations of TPB. The following adjustments have been made. Firstly, the factors 'trust', 'EV drivers profile characteristics', 'perceived benefits' and 'perceived barrier' have been added. Secondly, a causal relation between 'acceptance of V2G' and 'attitudes towards V2G' have been added (two-sided arrow in Figure 11). However, in hindsight, not all of the limitations could be fully addressed or solved. Moreover, the chosen definition of 'acceptance' posed limitations. This section explains the limitations that could not be circumvented and its impact on this study. In Section 5.3.1, different ideas for future research are provided to creatively circumvent research limitations.

Emotions are still not within the resulting model's range because it (still) mainly assumes EV drivers as rational actors. Adding several factors helped to explore subjective sides or emotions during interviews. However, we argue that the rational side is predominantly present since the core of both the conceptual model and the resulting model is based on TPB. Therefore, it was hard to position a few factors within the model. For instance, 'car as a status symbol' could not be covered by the categories '*trust*' or '*EV driver's profile'* and was left out of scope. Based on the interviews, this research lacks exploring the 'car as a status symbol' mentality, which is a widely-discussed topic among academia (e.g. Noppers, Keizer, Bockarjova, & Steg, 2015). Possession of an automobile is perceived as a status object and it is often an individual's most precious possession. One can hypothesize that individuals are more protective regarding their EV. The present study attempts to explore whether *car ownership* and *car type* play a role in their acceptance of V2G, however, it is argued that it still lacks this dimension since it was not explicitly discussed with the research sample by asking interview questions about this specific topic. Furthermore, TPB assumes individuals as rational actors. This assumption is still present in the resulting model because it still assumes linear relations between the factors. For instance, 'perceived benefits' influences 'attitudes towards V2G', 'attitudes towards V2G', in turn, influences 'intentions'. Lastly, 'intentions' influences 'actual V2G acceptance'. Like TPB, the *resulting model* of this study assumes that *intention to accept V2G* directly influences *V2G acceptance*. In this study, no factors have been identified that explain what happens or has happened when EV users form intentions but do not ultimately accept V2G by using V2G and making it part of their daily

habits. Lastly, within the conceptual model, a causal relation between acceptance and attitudes towards V2G have been added. However, the results could not verify or validate whether. A few interviewees indicated that 'operational relatability' of V2G systems is a precondition for this relation (e.g. repeating software errors would decrease EV users' willingness to participate).

Another set of limitations stems originates from the adopted definition of acceptance. Within this study, EV drivers' *acceptance* of V2G was equated to an individuals' *actual usage* of V2G as part of their daily lives. This leads up to two issues. First, this definition can be tackled by suggesting that *acceptance* is a precondition of *actual use* and more an *attitude* instead of *behaviour*. In other words, using another definition of acceptance would decrease the applicability of the findings to other cases where a different definition of *acceptance* has been adopted. Second, measuring acceptance before the wide-scale implementation of new technology may lead up to biased results. During interviews, *attitude towards V2G concept* and V2G application at long-term parking have been discussed. In other words, respondents were asked about future technology or situations which do not exist yet. It may be hard to elicit perceptions of a technology that is not yet widely used, only at the pilot test stage, or in the pre-commercialization phase (Sovacool et al., 2018).

Limitations research methodology

This study is explorative in nature which means that 85 factors contributing to acceptance have been identified, based on a high volume of qualitative data. Put differently, this research resulted in a high volume of insights based on attitudes and opinions of the research participants. These research design choices resulted in the fact that it was not possible to statistically test and substantiate findings (e.g. effects and influences) and to quantitatively measure effects in order to confirm or refute hypotheses.

It is known by academics that semi-structured interviews are sensitive to biases. Potential interviewees will be invited according to the sampling design. EV drivers that are more interested, knowledgeable or enthusiastic about the topic may be more willing to accept the invitation (*self-selection bias*). Furthermore, *interviewer bias* may have occurred; the respondent may have been influenced in some way by the interviewer or not fully informed because of usage of strange/different wording. The majority of interviewees had not heard of V2G before or only read/heard about it. In order to deal with this, all participants were provided with information about V2G and the use case of V2G at long-term parking by showing them an animation (see I.9) during the interview. In this study, it was assumed that the animation provided a clear view of the concept and that it was equally understandable for each interviewee. This assumption could lead up to biases. The provision of such information could influence their perceptions, attitudes and beliefs and they could be framed to have more positive or negative attitudes. Based on the results, it has been observed that the majority of the sample was predominantly positive towards the V2G concept and V2G at long-term parking. Possible effect of showing an animation on their attitudes and opinions, together with possible framing, may have contributed to predominant positive attitudes. Furthermore, V2G pilot participants' attitudes may be biased because of their practice experiences during the pilot (e.g. negative encounters with the project managing organization or project delays).

Moreover, the interviewer can interpret answers wrongly. Therefore, each interviewee received the interview report for approval. Other aspects such as emphasizing certain words (e.g. by tone) or inappropriate suggestions may increase *interviewer bias*. Good training and practising interviews beforehand decrease interviewer bias (Sekaran & Bougie, 2016). On the other hand, respondents can interpret interview questions wrongly. They can provide socially desirable answers to interview

questions. For instance, the interviewees were asked about their *technological innovativeness*. Almost all interviewees answered that they consider themselves as up-to-date about the latest developments regarding e-mobility. An unrecorded practising interview with another MoT student was conducted before actually starting the interviews so that the interviewer could get used to the interview setting and practice the determined interview questions. Moreover, there is also a possibility of *response bias* on the respondent's side. To minimize bias in responses, the interviewer must establish rapport with the respondents and ask unbiased questions (Sekaran & Bougie, 2016). Furthermore, interviews are time expensive if a large number of subjects are involved. Lastly, the interview data was collected at one point in time (between October 2019 and December 2019) in a *cross-sectional study*. The limitation is that behaviour and attitudes, beliefs and opinions could not be investigated over time.

Generalizability

Earlier in Section 4.1.4, it was concluded that the sample is most probably not representative due to a low number (n=20) of research participants and that representativeness cannot be proven since no information or database is available with socio-demographic information of the population. However, by comparing the sample of this study with the three other samples of other studies, it was argued that certain characteristics of the sample do match. Namely, that EV users are mostly young adult males, with higher income and education levels. Furthermore, when analyzing the code saturation in Figure 14, not much new information and factors have been identified after the first 6 interviews. The 14 interviews thereafter helped to further validate the findings. For these reasons, it has been supposed that the findings do provide a proper overview of the current situation (last quarter of the year 2019) with regards to the population's attitudes and opinions related to the V2G concept and V2G acceptance at long-term parking. But still, as mentioned in Section 4.1.4, the results should be carefully considered with regards to generalizability since the sample is most probably not representative. Furthermore, in Noppers et al. (2015) indicated that the composition of Dutch EV drivers is changing over time (e.g. from *early adopters* to *early majority*) and that the current Dutch EV drivers may not be representative for future groups of EV users. It should be acknowledged that new groups of EV drivers emerge with different motivations and perspectives and who might have divergent attitudes towards V2G. In other words, the findings could become soon outdated when new groups of EV drivers emerge. Therefore, the time-aspect should be closely considered when using the findings of this research. Lastly, in the conclusion Section 5.1.2, specific attention was paid towards generalizing the findings to other situations and V2G applications (not long-term parking). We argue that these conclusions are sound and reliable because other V2G applications have been explicitly discussed with the interview participants. For instance, *parking duration* (comparing short-term and long-term parking) and *V2G location* (e.g. contrasting office and home situations with airports) have been separately discussed during interviews.

5.2.3 Personal view author on the V2G concept and long-term parking use case

This section provides a personal reflection of V2G systems in general and the use case of V2G at long-term parking. It provides answers to the questions: "What does the author think of V2G personally?" and "what is the personal view of the author?".

V2G technology has high potential to add value to the energy transition. The idea of grid support is excellent from a technical perspective since the concept makes a lot of sense since it logically follows from the grid balancing problems. However, I am not sure whether V2G is "the" solution for solving the emerging balancing issues caused by increased RES and EV charging. Static batteries or hydrogen storage, for instance, are possible alternative solutions. To make a good chance of success in terms of

wide-scale adoption, a real user-side should be found and implemented. It should be further investigated how real additional value for EV drivers can be found, compared to the current situation with traditional charging and smart charging. Preferably, it should be an additional functionality or benefit, on top of compensations and financial incentives.

The success of V2G will significantly depend on future developments of battery technology and whether OEMs will support V2G. Bi-directional chargers could be installed at various locations, but if none of the EV models will support it, V2G's chance on success will significantly decrease. Besides that, larger investments should be made in realising living proof of V2G to show the real value to various stakeholders. The last point seems quite a challenge since much pilots still do fail (e.g. software issues). Therefore, realizing working proof of V2G is still a challenge. Other critical criteria are: realisation of cost reductions of V2G systems, increased operational reliability of V2G systems and the formulation of a solid business case so that both consumers and organisations will invest in V2G systems installation. Lastly, grid operators must be willing to facilitate V2G. This willingness is closely linked to the potential benefits for them while keeping up the safety and reliability of the grid.

Two interviewed V2G pilot driver participants mentioned that they personally do not have problems with planning their mobility and energy use. However, they expressed doubts about whether the general public (especially emerging groups of new EV drivers) are willing to do that. Both emphasised the importance of reliable systems. To illustrate, if EV drivers have to work with a smartphone application, it should work smooth and adequately (not to be unreliable). VDP2: "The necessary software should be for free and without errors". Lastly, I think that the long-term parking use case is a classic example/ or paragon of V2G application. Within the Netherlands, it would be an excellent first step that an airport (e.g. Schiphol or Rotterdam The Hague airport) would invest in the realisation of a V2G pilot at their long-term parking lot. At this point, the sociotechnical barriers are whether airports will engage or can be convinced to invest in V2G bi-directional chargers, politics, standardisation (e.g. the amount of EVs on the road capable of V2G), finding an attractive business case for all involved parties and operational reliability of the systems. My view is that V2G pilots should continue and the end-user has to be more central during the development of V2G systems (e.g. strive for easy-to-use applications).

5.2.4 Link MSc Management of Technology and this thesis

The Master's program Management of Technology (MoT) at Delft University of Technology teaches students to explore and understand technology as a corporate resource. It teaches that firms can use technology to design products that maximize customer satisfaction and maximize corporate productivity, profitability and competitiveness. The multidisciplinary dimensions of this thesis research (i.e. technical, economic, institutional and social) and technical understanding of the underlying problem (i.e. vehicle-to-grid systems and electric vehicles), perfectly exemplifies the type of research a Management of Technology alumni should exhibit. The thesis work *is* a scientific study in a technological context and therefore, seamlessly fits the MoT programme. Scientific methods and techniques have been used to analyze a problem and this master thesis has specifically been inspired and facilitated by the courses (Scientific and) Social Values, Technology Dynamics, High-Tech Marketing and Research Methods for Business.

5.3 Recommendations

This paragraph includes recommendations to scientists covering suggested areas for future research. Furthermore, recommendations are provided to stakeholders from the practical V2G who are deemed to play an important role in contributing to stimulating EV drivers' acceptance of V2G: V2G system designers, Mobility Service Providers (MSPs) and policy-makers.

5.3.1 Recommendations for scientists

Building on this study: EV drivers' acceptance of V2G.

Firstly, in this study, the research participants had never used a working V2G system because of technical failures within the V2G pilots. Future research could reveal attitudes and opinions of EV drivers that have actually used a (working) V2G system. Such a type of research can provide a theoretical contribution by investigating whether the actual use of the system correlates with the individual's attitude towards V2G usage. Secondly, future research should further include emotions and subjective feelings regarding both EVs and V2G. Earlier, the "car as a status symbol" mentality or perspective has been discussed. A limitation of this study is that this perspective has been included only partly. Future research can circumvent this limitation by including what meaning drivers give to their car. And its influence on an individual's willingness to participate in V2G services and whether it relates to people's concerns regarding battery degradation.

Thirdly, the main motivation for adopting semi-structured interviews as the main data collection method was that previous studies relied on survey methodologies and stated preference experiments. To the best knowledge of the research, these previous survey-based researches mainly focused on V2G contracts and EV drivers' preferences regarding V2G contract attributes. In this study, it was not the focus to investigate the acceptance of V2G contract elements. Instead, this research aimed at V2G acceptance as a technology. It is argued that future research should take into account the explorative insights and to set-up quantitative research aiming at V2G technology acceptance (not V2G contract preferences). In other words, future research should adopt survey methodologies as a next step, based on this research. The advantage of this is that higher response can be achieved and the relative importance of factors contributing to V2G acceptance can be further explored. Statistic substantiations can help to reveal cause-and-effect relationships between the factors and to reveal quantitative insights regarding V2G acceptance (e.g. percentage of the population that has an intention to use V2G).

Fourthly, Noppers et al. (2015) concluded that current Dutch EV drivers are not representative for future groups of EV drivers. The field of e-mobility is rapidly evolving and new groups of EV drivers emerge over time. A limitation of this research is that it did not include these time aspects of driver groups, but was rather a snapshot of EV drivers' attitudes and opinions. Future research should circumvent this limitation by investigating whether there are different EV customer archetypes, how these groups evolve over time and whether their V2G acceptance levels differ. For instance, there may be a financially-driven group of EV drivers. As concluded in Section 4.1.4, part of this group may be young-adults males with high education and income levels who lease an EV for its tax advantages. But when EVs become more affordable (e.g. due to the advancements of battery technology), car drivers with other characteristics can join this group. For instance, male individuals who are part of middle-income levels and that have purchased their EV. As discussed before, these individuals may give different meanings to their car, have different profile characteristics, use their car differently (e.g. urban commuting or long-distance travelling), but have similar motivations to adopt an EV (e.g. financial reasons). It should be incorporated whether clustering of the driver groups may lead to more

heterogeneity of the results regarding V2G acceptance. Such research can contribute to the formulation of Dutch V2G customer archetypes based on EV archetypes and field research.

Other directions for further research

There is also room for other directions of research within the V2G field. First, technical research aiming at revealing the actual influence of bi-directional charging on battery degradation. From this study, it became apparent that EV drivers want clarity about the actual effects on the EV's battery (information provisioning). Second, research can be done in V2G business models and the different revenue stream of the different actors and stakeholders within V2G systems. There should be financial incentives for all stakeholders and it should be investigated which incentives trigger stakeholders to participate. Previous studies had diverging conclusions about the amount of monetary compensation for V2G participation. This study revealed that EV drivers are uncertain whether proper compensation is feasible and this uncertainty can be tackled by conducting these types of research. Future research should clarify the amount of compensation that EV drivers can receive for V2G participation. Lastly, future research should focus on the standardization of V2G hardware and protocols for IT systems. We recommend a value-sensitive design (VSD) approach for the design of new V2G user interfaces that can result in new protocols and standards for interfaces. This may help to incorporate different meanings that drivers give to their car within the design of V2G user interfaces. VSD may also solve possible value conflicts that different stakeholders have regarding V2G systems. For instance, a possible value conflict could emerge between EV drivers and the aggregator. The values of EV drivers with battery degradation concerns may conflict with the interests of aggregators who may want to maximize the amount of (dis)charging cycles for maximized profits.

5.3.2 Recommendations for V2G system designers

System designers are responsible for the design and development of parking lots that may include charging points devices and more specifically V2G bi-directional chargers. Based on the results, system designers should support the development of V2G projects at long-term parking lots since the EV users have shown high acceptance and expressed intentions to use. In general, parking lot designers will increasingly face the option to include V2G in their design since V2G technology is maturing. An increasing number of charging point manufacturers do deliver charging stations with V2G capabilities, and the costs of V2G bi-directional chargers will further drop. Based on the results of this study, it is recommended that V2G system designers adopt a consumer-centric approach by

1. **Provide clear-cut information about the installed V2G system** on-site or within the user-interface about how it works, the benefits, and risks for the end-user
2. **Choose a bi-directional charger vendor that offers a user-friendly interface** which is an easy-to-use system for EV drivers
3. **One point of contact** for the EV user to keep V2G transactions simple
4. **Focus on a steady business case** so that all stakeholders show a level of content
5. **Take into account that different groups EV drivers do exist** and not all of them are appealed by solely financial benefits

5.3.3 Recommendations for Mobility Service Providers (MSP)

The responsibility of the MSP is to provide different charging points for the end-user. The MSP ensures that payments are handled and arranges that EV users can charge at different charging points. Given the fact that MSPs are the link between the EV driver and Charging Point Operators, the MSPs will play a crucial role in fostering drivers' acceptance of V2G. In the future situation, a new role will emerge of the aggregator. MSPs will most likely have to work together with this stakeholder. From an

end-user perspective, it was found that EV users highly value simple user interfaces and software platforms for V2G operation. This results in the following recommendations:

1. **Be prepared to work together with aggregators** (e.g. organizational ready) and to, perhaps, adopt this role to make it as simple for the EV driver
2. **Integrate V2G user interfaces with existing applications**, for instance, merge V2G trip planning system with existing parking app or mobility platforms)
3. **Ensure that payments handing includes the provision of compensations** for V2G participants

5.3.4 Recommendations for policy-makers

Policy-makers are known for the development of laws and regulations and their ability to influence V2G development through different policy instruments such as subsidies. In 2019, the Dutch government already granted €5 million subsidies for "EV charging points of the future"[11] and demonstrably stimulate V2G development. Also, policy-instruments can be used to influence consumers' attitudes and opinions so that intentions controlled positively. This study revealed that most current EV drivers have never heard of V2G and that V2G familiarity is low. Mostly experts have in-depth knowledge of the system's benefits and how it works. The following recommendations have been formulated for policy-makers given their large possible contributions to stimulating consumer acceptance of V2G.

1. **Stimulate V2G information provision** through marketing and communication efforts where the societal benefits of V2G are emphasized
2. **Develop laws and regulation to avoid double taxes** and so that V2G is advantageous given the netting arrangements
3. **Stimulate the creation of V2G standards** and ICT protocols
4. **Continue with the short-term provision of subsidies** for V2G projects in case consumers show low V2G awareness or familiarity

[11] https://www.rijksoverheid.nl/actueel/nieuws/2019/09/02/5-miljoen-voor-laadpalen-van-de-toekomst

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Appendices

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Table 15: Overview structure of appendices

Interview protocol

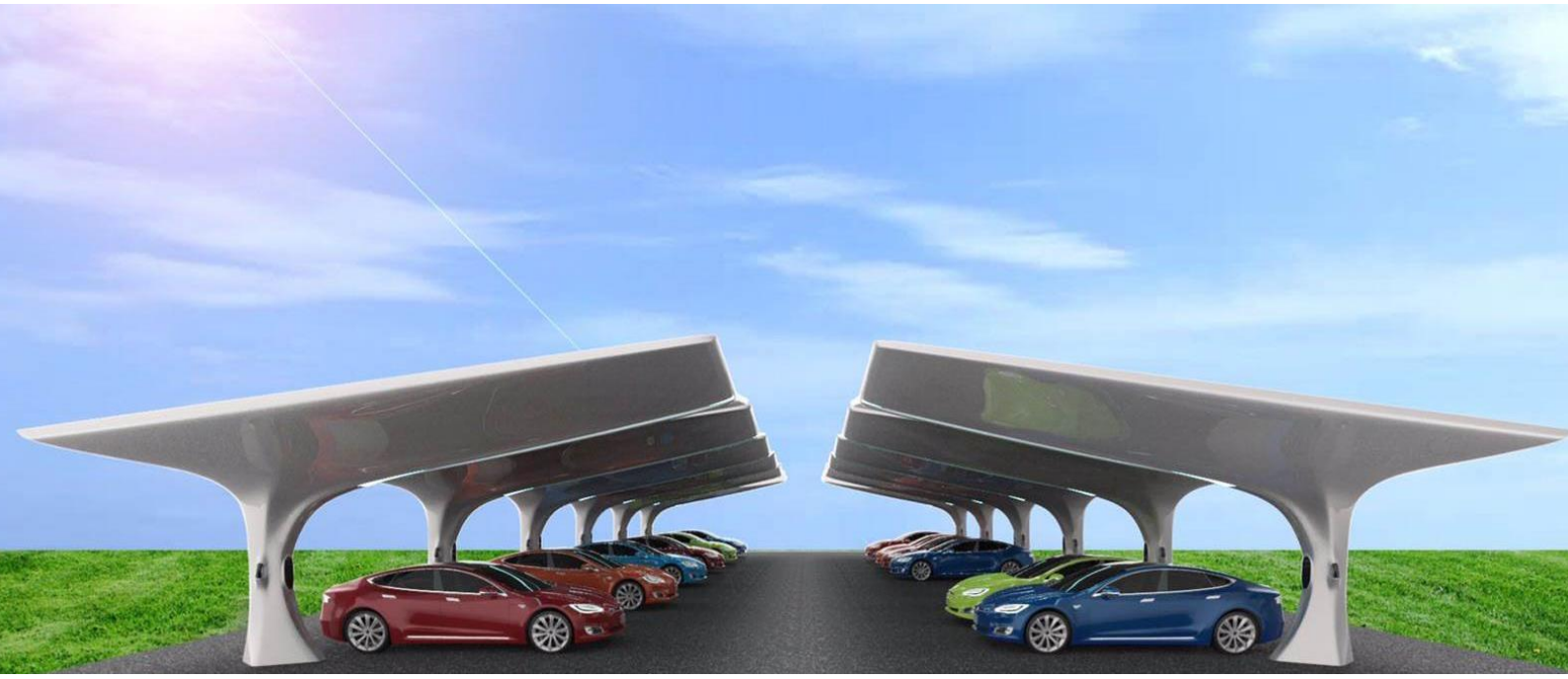
Related to MSc Thesis: Dutch EV driver's acceptance of vehicle-to-grid at long-term parking

Author

K.H.J. van Heuveln (4180860)

As part of

Management of Technology



Graduation committee

Chairperson	: Prof. dr. G.P. van Wee, Section Transport & Logistics
First supervisor	: Dr. J.A. Annema, Section Transport & Logistics
Second supervisor	: Dr. U. Pesch, Section Ethics & Philosophy of Technology
External supervisor	: R. Ghotge, PhD candidate, Section Process & Energy (3mE)
External supervisor	: E. van Bergen, General manager, Cenex Nederland

I.1 Introduction

Background of the research

Vehicle-to-grid (V2G) is an emerging form of electrical vehicle (EV) charging which allow EVs to deliver back electrical power to the grid. The goal is to create a more stable electrical grid and integrating energy from renewables. Currently, V2G development is in the test & demonstration phase and numerous V2G test pilot projects have been organized within the Netherlands. Drivers can potentially generate new revenue streams and, thereby, reduce the total cost of EV ownership. One potential application location is V2G at long-term parking (e.g. at the airport) for three reasons: high plug-in rates, predictable parking patterns and battery capacity aggregation due to a high number of simultaneously parked EVs. However, actual usage of these chargers at long-term parking will greatly depend on the acceptability of V2G to the EV drivers. Previous V2G studies have seldom incorporated user acceptance aspects and focussed mainly on short-term parking applications (e.g. vehicle-to-office). These researches typically relied on surveys and stated choice experiments which provided insufficient insights regarding driver acceptance. Subsequently, it remains unclear what explains Dutch EV driver's acceptance regarding V2G at long-stay parking: **To what extent do Dutch EV drivers accept V2G at long-term parking?** Based on a chosen theoretical lens: Theory of Planned Behaviour adapted to Technology Acceptance (Ajzen, 1991; Huijts et al., 2012), semi-structured interviews will be held with both Dutch driver participants of Dutch V2G pilot tests and regular Dutch EV drivers to gain an in-depth understanding about their perceptions and attitudes. The results are expected to provide rich insights for parking lot project developers that might include V2G in their design. Hence, the present study is expected to contribute to increased acceptability and actual V2G usage by drivers. Future research can integrate the findings in quantitative research designs in order to statistically validate the results and to reveal possible causal relationships of the identified V2G acceptance factors.

Objectives of conducting semi-structured interviews with Dutch EV drivers

Since previous researches relied on survey and stated preference experiments, a semi-structured interview approach has been chosen which provides the opportunity to gain in-depth insights of people's attitudes and motivations. Namely, the goal is to investigate **V2G acceptance** and its contributing factors which is a complex phenomenon and requires the ability to shed light on underlying motivations and reasons. Put differently, the overarching goal of the present research is *identifying factors that influence Dutch EV driver's acceptance of V2G through semi-structured interviews*. Interviews are held after the review of previous studies and literature on technology acceptance. Before actually starting the interviews with EV drivers, the interview protocol is an important document that has been created.

Purpose of the interview protocol

The interview protocol or interview guide provides an overview of the topics or questions that will be explored during a set of interviews with Dutch EV drivers. These issues or questions related to certain topic areas within which the interviewer has the freedom to explore, dive into and ask questions that will provide a clarifying explanation and illuminate that particular subject. An interview guide ensures that the same basic lines of inquiry is followed with each interviewee. The interviewer has the freedom to establish conversations within a topic, ask spontaneous questions and to adopt a conversational interview approach, but with a focus on a predetermined topic area. Moreover, the interviewer can use the interview guide as a checklist in order to ensure that all topic have been covered (Patton, 1990).

Structure interview protocol report

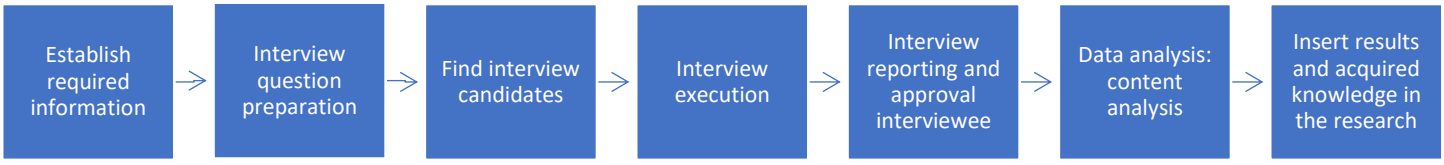
The present interview protocol includes the following components:

1. Methodology: overview of the interviewee sampling approach and determining the groups of interviewees. Furthermore, an overview of the interview process is provided
2. Theoretical framework: A literature review has been conducted. An overview of the main findings of the review is provided. The findings are translated into main topic areas for the interviews.
3. Interview question guidelines for each interviewee group including link to theory, script of what will be said before and while concluding the interview, prompts for the interviewer to collect informed consent, prompts to remind the interviewer the information that she or he is interested in collecting
4. Advertisement for finding interviewees
5. Research ethics & data management: informed consent contract, Delft university of technology ethics committee permit
6. Informed consent form (Dutch) where interviewees provide permission to use the provided information for this Master thesis research
7. Animations used during interviews to explain the concept of V2G and V2G at long-term parking

I.2 Recap of interview methodology

The following steps are taken for the interviews:

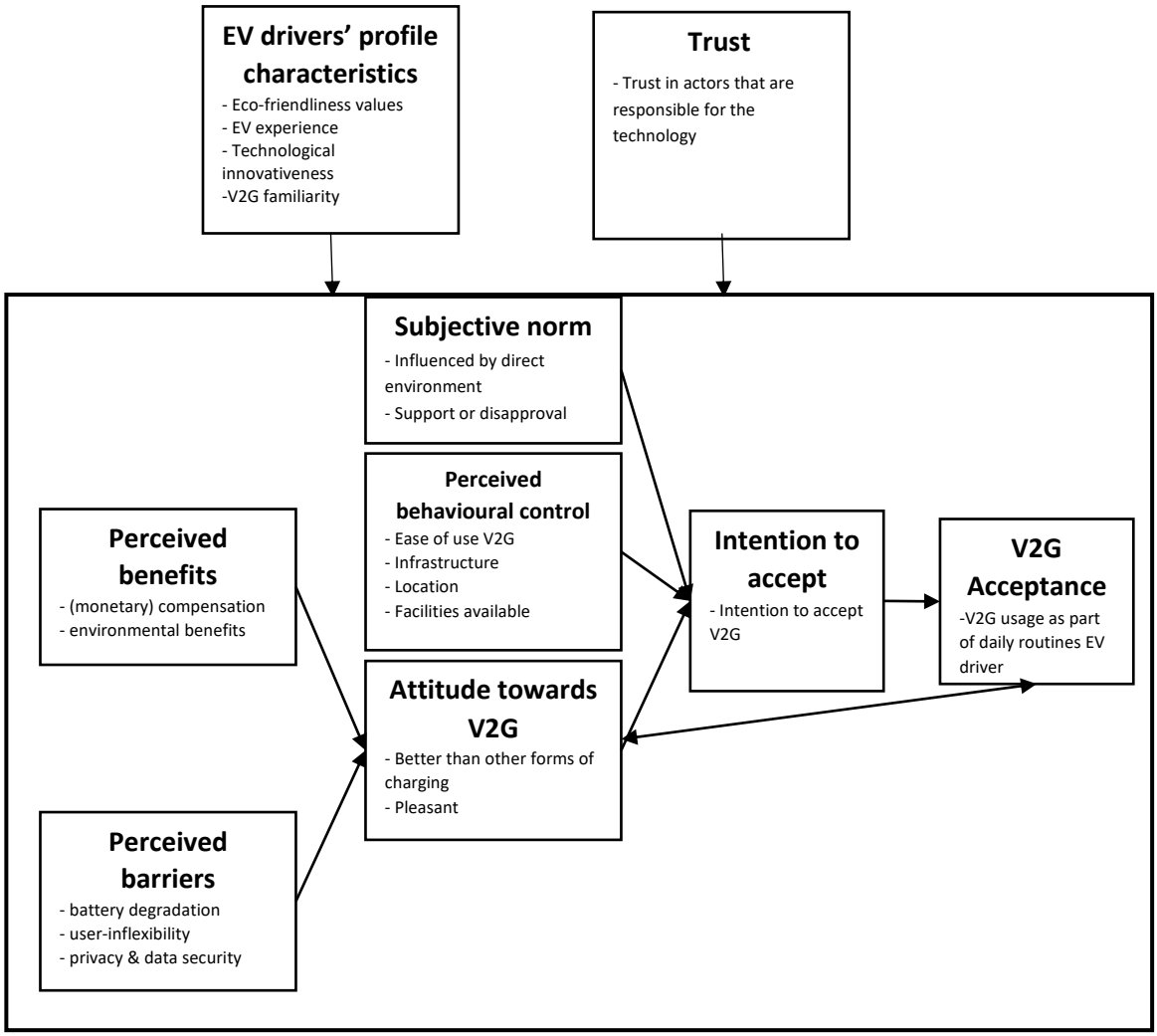
1. Establishing the required information for the interview. What do we want to know? The questions included in the protocol may change over time since new topics may emerge.
2. Preparation of the interview questions. Before each interview, the researcher assesses whether the interview protocol is still up-to-date and whether new questions can be included and existing questions in the protocol may be adjusted or even excluded.
3. Finding interview candidates based on predetermined criteria. Candidates are found via the following channels: researcher's own network, supervisors' network, online advertisement, TU Delft campus advertisement (coffee machines).
4. After candidates have been found, the interviews are planned and executed. All interviews will be done in a face-to-face setting. The researcher visits the interviewee at their work or (nearby) home
5. After each interview, the researcher reports the main findings in the interview report. The interview report is sent to the interviewee. The interviewee can give input whether certain answers should be adjusted. If the interviewee agrees upon the interview answers, he or she can respond to the e-mail. After 2 weeks of non-response, the researcher assumes that the report can be used for the thesis results.
6. Data analysis will be done using the interview reports. Both coding and counting is done and impressionistic representation of the results.
7. The new knowledge (interview results) is inserted in the thesis research. The results will be used to draw conclusions and discuss the findings.



I.3 Theoretical background: Recap of the conceptual model and topic areas

Based on the review of previous V2G researches and previous studies focussing on technology acceptance, a conceptual model (see figure below page) has been created which includes factors that contribute to the acceptance of V2G by Dutch EV drivers. The factors included in the model are used to define topic areas for the interviews. The topic areas are used to generate interview questions. Besides the existing topic areas, new topic areas or factors, that are not included in the model yet, are being explored. We refer to the actual thesis work (Chapter 2) for further information and a detailed explanation of the identified factors in literature. We will discuss them one-by-one shortly.

- EV drivers' **acceptance** is defined as "EV drivers' behavioural responses to the availability of technological innovations (e.g. vehicle-to-grid services), that is, the purchase and use of such products without any doubts". EV drivers' acceptance is dependent on the intentions.
- **Intention to accept** is based on outcome evaluation and perceived behavioural control. TPB assumes that the *intention* to perform behaviour captures the motivational factors that influence behaviour. It is an indication of how hard people are willing to try, how much effort they are planning to exert to perform the behaviour.
- **Attitude** toward the use of technology refers to the degree to which a person has a favourable or unfavourable evaluation or appraisal of the behaviour of interest.
- **Subjective norm** is a social factor. It refers to the perceived social pressure to perform or not perform the behaviour.



- **Perceived behavioural control** has to do with a person's *perceptions* regarding the resources and opportunities available to conduct the behaviour. It refers to people's perception of the ease or difficulty of performing the behaviour. E.g. perceptions regarding whether the required infrastructure is in place or whether a system is easy to use.
- **Perceived costs, benefits and risks** are assumed to influence a person's attitude toward the behaviour (acceptance).
- **EV driver's profile** include factors identified in the literature related to a person's personal characteristics or previous experiences. For instance, a person's EV experience (positive/negative) is found to influence a person's intention to accept V2G. However, cannot be placed under one of the identified factors.
- **Trust** relates to consumer (dis)trust in actors that are responsible for the V2G systems.

I.4 Interview scripts

Now that the various topic areas are clear. The interview questions have been formulated. The interview script includes interview opening, main interview questions and closing questions. The main interview questions can be divided into 1) questions for pilot participants and 2) questions for current EV drivers (not necessarily V2G experience). The interview questions are based on the earlier presented topic areas.

Interview opening

The following questions are used for opening the interview.

Table 16: Interview opening questions

English	Dutch
1. Appreciation for the cooperation and time 2. This interview will be mainly used as data for my Master thesis 3. You will be participating anonymously 4. Permission for an audio recording of the interview 5. Interview will be transcribed / notes taken for approval, e-mail within 5 days to your mailbox 6. You have the right to request access to and rectification or erase of personal data 7. Non-response on sent transcript after 2 weeks is assumed as a permission to use the data	1. Bedankt voor uw medewerking en tijd 2. Interview wordt gebruikt als onderdeel voor mijn Master thesis 3. Deelnemen is anoniem 4. Toestemming vragen om een audio recording te maken van het interview 5. Interview notities zullen worden gemaakt. U ontvant deze per e-mail binnen 5 werkdagen ter goedkeuring. 6. U heeft het recht om te vragen voor toegang tot en correcties of verwijdering van persoonlijke data 7. Als u niet reageert op de e-mail binnen 10 werkdagen wordt aangenomen dat er toestemming is om de data te gebruiken 8. Proces: informed consent, questionnaire, deel A pilot & EVs, deel B V2G, deel C voorbeeld toepassing

Main interview questions

The following questions are asked during the main body of the interview.

Questions for Pilot participants

The questions below represent the interview questions for EV driver test participants of V2G pilots.

Questions 9-12 adapted from Vogelsang, Steinhüser, and Hoppe (2013):

Table 17: Main interview questions V2G pilot participants

English	Dutch
Part A: General questions pilot & EVs	**Part A: General questions pilot & EVs**
1. Could you tell me about the pilot you have participated in? 2. For what reasons did you participate in the pilot project? How did that happen? 3. Please tell more about the technical set-up: type of car, charger, location, etc.? 4. Outside the pilot, did you had experience with driving an EV? Your opinion? 5. How involved are you with the technological developments regarding electric driving? Are you always up-to-date? *[Technological innovativeness]* 6. Have you noticed the discharging of the vehicle's battery pack? In what way have you noticed? 7. What were the positive points in the pilot? What could be improved?	1. Kunt u wat meer vertellen over de pilot waaraan u deel hebt genomen? 2. Hoe kwam het dat u deel heeft genomen? 3. Kunt u wat meer vertellen over de technische opstelling: auto type, laadpaal (brand), locatie, etc.? 4. Had u al ervaring met elektrisch rijden voordat u meedeed aan de pilot? 5. In hoeverre acht u uzelf als een pionier als het gaat om nieuwe technologische ontwikkelingen? Waarom? 6. Heeft u iets gemerkt van het ontladen van de batterij van de auto? Op welke manier? 7. Wat ging er goed in de pilot? Wat zijn de verbeterpunten?
Part B: Questions based on V2G concept	**Part B:** Questions based on V2G concept
8. What do you think of the V2G concept? 9. Can you tell me more about your experiences with V2G systems? 10. To what extent were you influenced by your environment to participate in the pilot (e.g. family/friends)? 11. Could you tell me about the benefits of using V2G? 12. Could you tell me about the disadvantages or costs of using V2G? 13. What are the risks of V2G usage? 14. Please tell me about user-friendliness of the used system? How to improve? 15. To what extent do you want to keep control of discharging? How to keep control? 16. Do you have the intention to use V2G when it becomes increasingly available at various locations?	8. Wat denkt u van het V2G concept? 9. Hoe heeft u het gebruik van het V2G system ervaren? 10. Wat dacht uw omgeving (familie/vrienden) over dat u mee ging doen aan een V2G slim laden pilot? In hoeverre beinvloed? 11. Wat zijn voor u de voordelen van het V2G systeem voor de eindgebruiker? 12. Wat zijn voor u de nadelen van het V2G systeem voor de eindgebruiker? 13. Kunt u wat vertellen over eventuele risico's verbonden aan V2G systemen voor de eind-gebruiker? 14. Kunt u wat meer vertellen over de gebruikersvriendelijkheid van het systeem? Hoe verbeteren? 15. In hoeverre wilt u controle over de ontlaadcycli en wat er technisch gebeurt? Hoe zou u die controle willen bewaren?

17. *-provide definition of Acceptance-* What are important aspects to increase your acceptance of V2G? 18. What could system designers do to increase acceptance?	16. Heeft u de intentie om V2G te gebruiken mocht het beschikbaar komen op verschillende locaties? 17. *-definitie acceptatie-* Wat denkt u dat belangrijke zaken zijn om acceptatie van V2G door de eind-gebruiker te stimuleren? 18. Wat kunnen systeemontwerpers doen om acceptatie te verhogen?
Part C: Questions based on long-term parking application 19. Have you ever parked 3 days or longer with your electric vehicle? Where? *[Current parking behaviour]* 20. What do you think of V2G at long-term parking? What is different from the system you have used? *[Attitude]* *21.* When it comes to benefits, costs, risks; tell me about what would be different? *[Perceived benefits, costs, risks]* 22. What do you think about the user-friendliness of V2G when parked long-term? What would you find important? *[Perceived behavioural control]* 23. Would you consider using V2G at long-term parking? Why? *[Intention to Use]* 24. *- definition Acceptance & Attitude-* Are there other important aspects of importance on your acceptance of V2G? Things not mentioned? *[Acceptance]* 25. To what extent does your actual experience with V2G influences your attitude? *[Relation: Acceptance & Attitude]* 26. What would be the ideal V2G charger location for you? *[Location]*	**Part C:** vragen gebaseerd op de lange-termijn parkeren toepassing 19. Staat u weleens 3 dagen of langer geparkeerd met uw elektrische auto? Waar? 20. Wat denkt u van V2G bij lange-termijn parkeerplekken (bijv. vliegveld)? Wat is er anders vergeleken met het gebruikte systeem? 21. Wat zouden voor u nadelen zijn bij deelname? 22. Wat zou voor u belangrijk zijn om een gebruikersvriendelijke ervaring te hebben? 23. Zou u de intentie hebben om V2G bij lange-termijn parkeren te gebruiken? 24. *-Definitie acceptatie-* Zijn er nog andere zaken belangrijk die van invloed zijn op uw acceptatie van V2G? Wat is belangrijk voor u als het gaat om volledige acceptatie van V2G and gebruik van V2G? 25. In hoeverre beinvloed uw ervaring met V2G uw houding/mening tegenover V2G? 26. Tot slot: Wat denkt u over geschikte locaties voor V2G laders? What is de ideale plek? Waarom?

Questions for Current EV drivers

Below the main interview questions for current EV drivers.

Table 18: Main interview questions current EV drivers

English	Dutch
Introducing: First a few introductory questions. Then discussing a new form of smart charging. Lastly, we will discuss an application of this.	*Introducerend: Eerst een aantal algemene vragen, dan gaan we het hebben over een nieuwe vorm van laden. Vervolgens gaan we een toepassing bespreken*.
1. What do you think about energy presumption/self-sustainability (e.g. with for instance solar panels)? [Eco-friendly values]	1. Hoe kijkt u aan tegen zelf energie opwekken met bijvoorbeeld zonnepalen (prosumers)?
2. What do you think of driving electric in general? Pros/cons/risks. Why do you drive electric? [EV attitude]	2. Wat denkt u over het algemeen van elektrisch rijden? Voordelen /nadelen/ risico's. Waarom rijdt u elektrisch?
3. At what locations do you often park/charge? Why? Your experience? [EV attitude]	3. Bij welke locaties parkeert/laadt u? Waarom? Hoe gaat dat?
4. To what extent are you influenced by your environment (family/friends) when it comes to electric driving? [Subjective Norm]	4. In hoeverre bent u door uw omgeving (familie/vrienden) beinvloed om elektrisch te gaan rijden?
5. How involved are you with the technological developments regarding electric driving? Are you always up-to-date? [Technological innovativeness]	5. Hoe betrokken bent u bij de technologische ontwikkelingen op het gebied van elektrisch rijden? Bent u op de hoogte?
-Show slides general explanation V2G & office explanation [3 min]-	*-Speel af slides algemene uitleg V2G & kantoor toepassing [3 min]-*
6. Have you heard before of V2G? Have you used it already? [V2G familiarity]	6. Heeft u eerder gehoord over V2G? Heeft u het misschien al eens gebruikt?
7. Based on what you have seen, what do you think about V2G? [Attitude towards tech.]	7. Gebaseerd op deze slides. Wat denkt u van V2G? (Heeft u het al eens gebruikt?)
8. What are the important benefits of this system for you? [Perceived benefits]	8. Wat zijn voor u belangrijke (mogelijke) voordelen van dit system?
9. What would be possible risks/barriers for you to use V2G? [Perceived risks]	9. Wat zouden mogelijke barrieres zijn voor u om V2G te gebruiken?
10. What costs attached to V2G systems do you perceive? [Perceived costs]	10. Welke kosten (monetair/niet-monetair) zijn er denkt u verbonden aan dit systeem?
11. Optional: Could you rate the named factors from 0 (irrelevant) - 3 (essential).	11. Optioneel: Kunt u de genoemde factoren raten van 0 (irrelevant) tot 3 (essentieel).
12. How would the ideal V2G situation look alike for you to overcome mentioned barriers?	12. Hoe ziet voor u de ideale V2G situatie eruit om barrieres te overwinnen?
13. What would be important aspects for you to achieve a user friendly experience with a V2G charger? Why? [Perceived behavioural control]	13. Wat zou belangrijk zijn voor een gebruikersvriendelijke ervaring met een V2G paal?

14. To what extend do you want to keep control of charging & discharging operations? Why? [Perceived behavioural control] 15. Optional: Which kind of action can companies take to increase V2G acceptance? 16. Optional: Are you influenced by your environment? [Subjective norm] *-show images/explanation V2G at long-term parking for case-based questions [3 min]-* 1. Do you ever park 3 days or longer with your electric vehicle? [Current parking behaviour] 2. What would you think of V2G at long-term parking? What is different to you? [Attitude] 3. When it comes to benefits, costs, risks; tell me about whether this application would be different from the office application [Perceived benefits, costs, risks] 4. What do you think about the user-friendliness of V2G when parked long-term? What would you find important? [Perceived behavioural control] 5. Would you consider using V2G at long-term parking? Why? [Intention to Use] 6. What would be important for you to fully accept V2G and use V2G? Things not mentioned yet? [Acceptance] 7. What would be the ideal V2G charger location for you?	14. Tot op welke hoogte wilt u de controle behouden over het laden en ontladen? 15. Optioneel: Welke acties kunnen bedrijven nemen om V2G acceptatie te verhogen? 16. Optioneel: Bent u beinvloed door uw omgeving? -laat zien plaatjes en uitleg V2G bij lange termijn parkeren voor case vragen [3 min]- 1. Staat u weleens 3 dagen of langer geparkeerd met uw elektrische auto? 2. Wat denk je van V2G bij lange-termijn parkeren? Wat is er anders in uw beleving? 3. Kijkend naar de voordelen, nadelen, risico's; Wat maakt deze toepassing anders voor u vergeleken met de gepresenteerde kantoor toepassing? Waarom? 4. Wat zou voor u belangrijk zijn voor een gebruikersvriendelijke ervaring met een V2G paal bij lange termijn parkeerplaatsen? 5. Overweegt u om V2G bij lange-termijn parkeren te gebruiken? 6. *-Definitie acceptatie-* Zijn er nog andere zaken belangrijk die van invloed zijn op uw acceptatie van V2G? Wat is belangrijk voor u als het gaat om volledige acceptatie van V2G and gebruik van V2G? 7. Wat zou voor u de ideale locatie zijn voor V2G palen?

Concluding and closure

Table 19: Interview closure questions

English	Dutch
1. Again gratitude for time/cooperation 2. Is there anything you would like to add to your answers? 3. Do you have any questions or remarks regarding this interview and my research? 4. Is there any information that you have shared confidential, if so, can it be used anonymously? 5. State that the notes/full transcript will be sent for approval 6. Approval within 2 weeks, otherwise, it is assumed that permission is given to use the data in for the research. 7. You have the right to request access to the provided information or to withdrawal from the study 8. Do you know other people relevant to my research? 9. Are you interested to receive the final research report? 10. Is it possible to ask follow-up questions?	1. Nogmaals bedankt voor uw tijd en medewerking 2. Wilt u nog iets toevoegen aan uw antwoorden? 3. Heeft u vragen of opmerkingen over dit interview and mijn onderzoek? 4. Is er enige informatie confidentieel, indien het geval, kan het anoniem worden opgenomen? 5. De aantekeningen / transcript worden verzonden voor goedkeuring. 6. S.v.p. goedkeuring verlenen binnen 2 weken. Indien geen reactie zal na twee weken de goedkeuring worden aagenomen. 7. U heeft het recht om toegang te vragen tot verstrekte informatie of om uw terug te trekken van het onderzoek. 8. Kent u andere mensen relevant voor dit onderzoek en wie mogelijk een interview zouden willen afleggen? 9. Bent u geinteresseerd om het eindresultaat in het onderzoek te ontvangen? 10. Mogelijk om Follow-up vragen te stellen?

I.5 Exit questionnaire

Onderstaande vragen worden gebruikt om ervoor te zorgen dat er een representatieve verdeling van interview deelnemers is en zal anoniem worden behandeld in het verdere onderzoek.

Uw interview deelnemer code: ….

Datum interview: …..-….-2019

Wat is uw geslacht?

- Man
- Vrouw

Wat is uw leeftijd?

- <25 jaar
- 25-35 jaar
- 36-45 jaar
- 46-55 jaar
- 56-65 jaar
- >65 jaar

Geef aan wat voor u van toepassing is:

- Ik lease een elektrische auto
- Ik heb een elektrische auto aangeschaft
- Anders, namelijk:_____

Geef aan wat het type elektrische auto is waarin u rijdt:

- Plug-in hybride auto, namelijk een: _____
- Batterij elektrische auto (volledig elektrisch), namelijk een: _____
- Anders, namelijk: _____

Wat is uw jaarlijks inkomen?

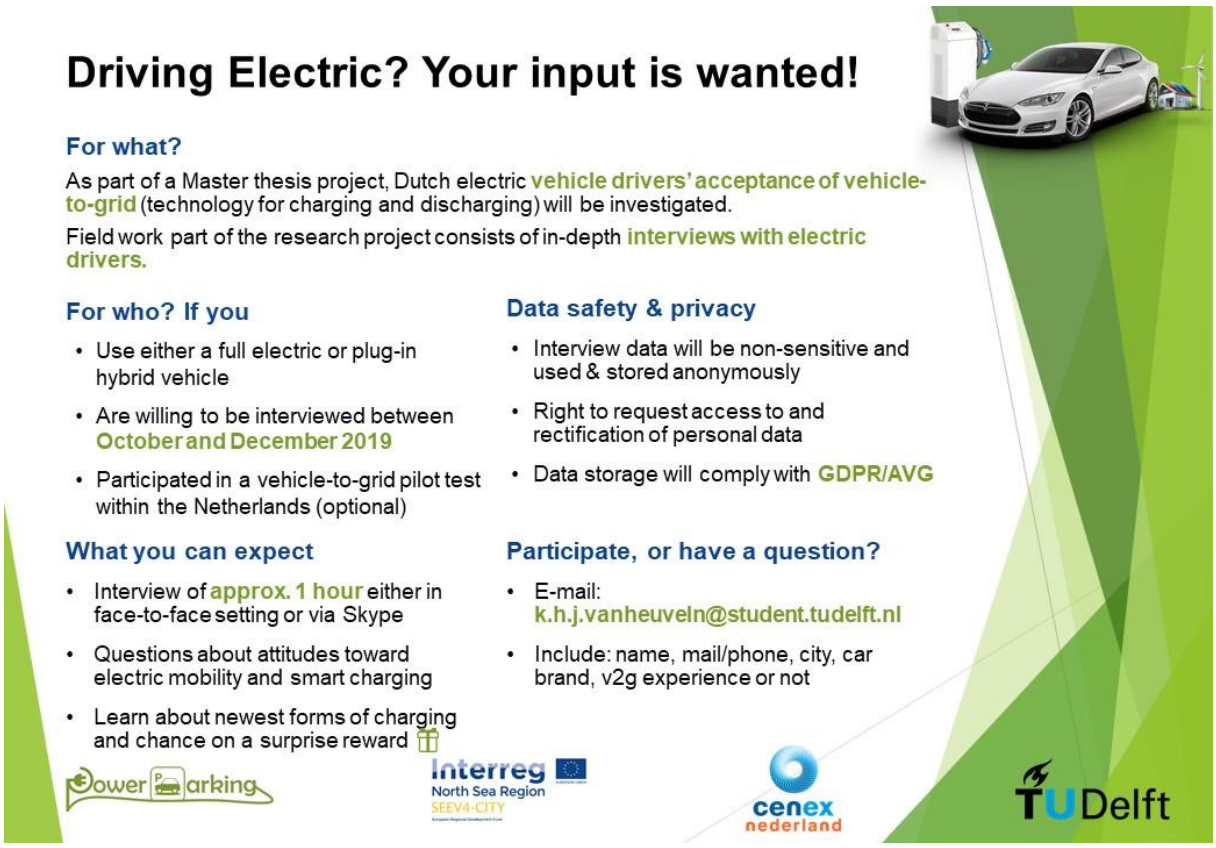
- <€20.000
- €20.000-€35.000
- €35.000-€70.000
- >€70.000

Wat is uw hoogst behaalde diploma?

- Geen/lager- of basisonderwijs
- VMBO/MAVO
- MBO
- HAVO/VWO
- HBO
- WO bachelor
- WO master
- PhD (Doctor)
- Anders, namelijk: _____

I.6 Advertisement for finding interviewees

This advertisement is used for approaching potential interviewees and as a flyer to spread the word.



I.7 Research ethics & data management

Close attention has been paid toward the anonymity of the research participants and their informed consent regarding participating in the research. Furthermore, data protection is an important topic since data has been gathered from consumers. All data is stored on TU Delft project data storages, only accessible to the research group.

Informed consent participants

All research participants have to fill in the informed consent form and read the information sheet (see paragraph 4.3/4.4, next page). The researcher provides additional information about the content of the research, purpose, risks of participating and data storage and access. The participant has to read and provide consent on a set of statements that are made explicit on the informed consent form. These statements are related to the extent to which the participant is informed about the research, that it will be used for academic purposes and data storage. This ensures that the participants been adequately informed and given free consent. The participant is also informed about what they can withdraw without any implication.

Data protection

All audio-recordings are stored on the TU Delft project data storage and will be later uploaded to the 4TU data folder. This data management strategy has been approved by the data office of 3mE faculty of TU Delft and is approved by the HREC application.

I.8 Informed consent form (Dutch)

Hierbij verleen ik toestemming aan Koen van Heuveln, student aan de TU Delft, om de informatie die ik tijdens het interview zal verstrekken, te gebruiken voor zijn Master scriptieonderzoek. Hierbij ben ik op de hoogte van het bijgevoegde informatiesheet.

De informatie en gegevens zullen vertrouwelijk worden behandeld en volgens Algemene Verordening Gegevensbescherming (AVG) en daarop gebaseerde richtlijnen van de TU Delft. Het opnemen van de verstrekte informatie en gegevens zijn volledige geanonimiseerd.

Accepteer de voorwaarden door aan te vinken

Deelnemen aan het onderzoek	**Ja**	**Nee**
Ik heb het informatie sheet gelezen en begrepen, en/of het is aan mij uitgelegd. Ik heb de mogelijkheid gehad om vragen over het onderzoek te stellen en al mijn vragen zijn beantwoord.	○	○
Ik geef toestemming om vrijwillig deel te nemen aan dit onderzoek. Ik begrijp dat ik het beantwoorden van bepaalde vragen kan weigeren en dat ik op elk moment kan stoppen met het deelnemen zonder het hebben van een (geldige) reden.	○	○
Ik begrijp dat het deelnemen aan dit onderzoek inhoudt dat ik: een interview zal afleggen met de onderzoeker, daar een audio-opname van zal worden gemaakt, een korte vragenlijst zal invullen.	○	○
Gebruik van informatie voor het onderzoek		
Ik begrijp dat de informatie die ik zal verstrekken zal worden gebruikt voor een Master scriptie onderzoek.	○	○
Ik begrijp dat de door mij verstrekte persoonlijke informatie waarmee ik kan worden geïdentificeerd (bijv. naam en adres) niet publiekelijk en buiten de onderzoeksgroep zal worden gedeeld.	○	○
Toekomstig gebruik en hergebruik door derden		
Ik geef toestemming dat de geanonimiseerde interview transcripten, ingevulde enquêtes en de daarop gebaseerde resultaten mogen worden bewaarde in de 'TU Delft repository' zodat het kan worden gebruikt voor toekomstig onderzoek en onderwijs.	○	○

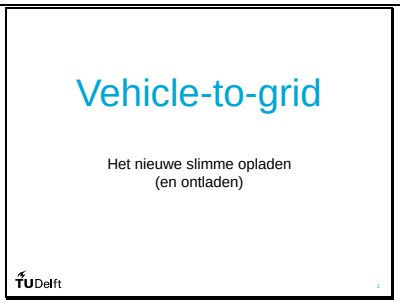
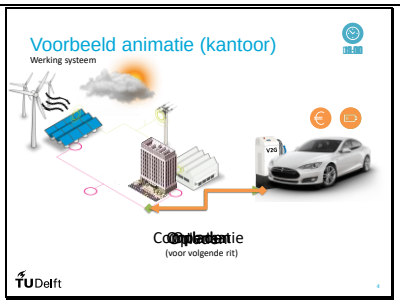
Ik verklaar hierbij op een duidelijke wijze te zijn ingelicht over het doel van het onderzoek.

Ik begrijp de bovenstaande tekst en ga akkoord met de deelname aan het onderzoek.

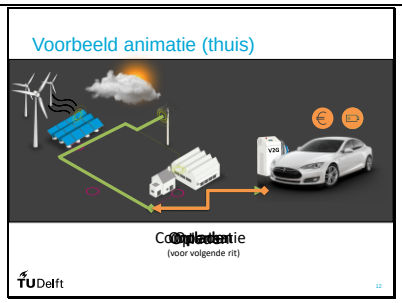
Handtekeningen

_____	_____	_____
Naam deelnemer	Signature	Date
_____	_____	_____
Naam onderzoeker	Signature	Date

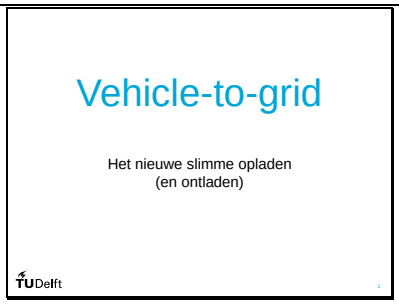
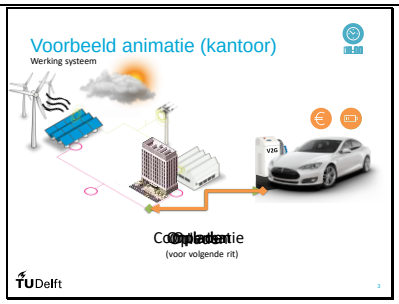
I.9 Animation for Current EV drivers

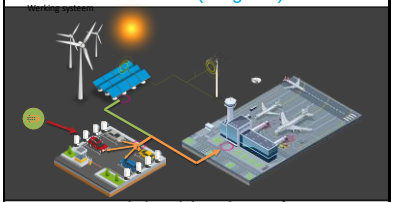
Dia 1		Deel 2 van het interview begint
Dia 2		Zie hier 3 krantenkoppen. Elektrisch rijden en toenemende mate van zonne- en windenergie heeft een impact op ons elektriciteitsnet. Mogelijk kan het elektriciteitsnet de vele vraag en hoeveelheden energie niet meer aan in de toekomst.
Dia 3		Bij vehicle-to-grid wordt de batterij van uw elektrische auto gebruikt als (tijdelijke) elektriciteitsopslag. Als er veel electriciteit beschikbaar is dan wordt uw electrische auto opgeladen. Als er veel vraag is in het electriciteitssysteem, kan de energie die nog in uw auto zit, teruggeleverd worden aan het electriciteitsnet door middel van ontladen. Dit alles kan bijdragen aan meer balans van het elektriciteitsnet.
Dia 4		Een voorbeeld is: Op een zonnige dag wordt er heel veel electriciteit opgewekt middels zonnepanelen. Ook waait het heel erg hard die dag. Er is veel duurzaam opgewekte stroom beschikbaar in het electriciteitsnet. Er is een vehicle-to-grid paal aanwezig bij het kantoor van uw werk. Rond 09:00: U heeft uw elektrische auto aan de vehicle-to-grid paal aangesloten en weet dat u de rest van de dag op kantoor bent. De zonne- en windenergie wordt opgeslagen in de batterij van uw elektrische auto. S'middags is de wind gaan liggen en het is bewolkt geworden. Ook is de vraag naar electriciteit is hoog doordat er meerdere elektrische auto's moeten worden geladen en de lift en koffiemachine draaien overuren op kantoor. De s'morgens opgeslagen wind- en zonneenergie wordt dan teruggeleverd van uw auto aan het electriciteitsnet. Voor dit terugleveren van electriciteit krijgt u een vergoeding. Vlak voordat u aan het einde van de werkdag terug naar huis rijdt, zorgt het system dat uw batterij voldoende is opgeladen. Er wordt er gezorgd dat de accu genoeg opgeladen is zodat u uw ritje naar huis kunt maken.

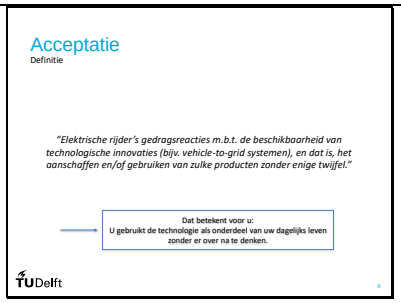
Dia 5	Kortom… Conclusie • Nieuwe vorm slim laden en ontladen • Stabieler elektriciteitsnet • Groene stroom beter benutten • Energie zelfvoorzienendheid • Mogelijkheid: monetaire compensatie  TU Delft	Kortom, vehicle-to-grid is een nieuwe vorm van slim laden en ontladen van de batterij van uw auto. Het doel is om zo een stabieler elektriciteitsnet te creëren en groene stroom beter te benutten. Ook zou het voor eigenaren op den duur mogelijk moeten worden om geld te verdienen met hun elektrische auto. Dit zou kunnen door wagens beschikbaar te stellen als er veel vraag is naar energie. De stroom wordt dan teruggeleverd aan het network.
Dia 6	Vervolg Interview vragen TU Delft	Nu het vervolg van interview vragen
Dia 7	Deel 2: voorbeeld toepassing TU Delft	(Deel 3 van het interview…)
Dia 8	Lange termijn parkeren Achtergrond • Schiphol, Lelystad airport, Rotterdam airport • Schiphol: 3+ dagen parkeren • Aantrekkelijk voor vehicle-to-grid: 1. Auto's relatief lang aangesloten 2. Parkeergedrag voorspelbaar TU Delft	Een mogelijke toepassing is vehicle-to-grid bij lange termijn parkeerplaatsen. Bijna alle vliegvelden in Nederland hebben een lange termijn parkeerplaats. Onder lange termijn parkeren wordt verstaan: 3+ dagen. Alles daaronder wordt gezien als korte termijn parkeren. Lange termijn parkeergelegenheden is een plek waar vehicle-to-grid mogelijk snel beschikbaar zal zijn (bijv. Schiphol, Lelystad (als het open is ha-ha) en Rotterdam The Hague Airport. Het is aantrekkelijk omdat auto's relatief lang staan aangesloten aan een V2G paal en het voorspelbaar is wanneer de eigenaar terug komt bij zijn/haar auto (o.b.v. vluchtinformatie). Vaak moet een lange termijnparkeerplek ook van tervoren geboekt worden.
Dia 9	Lange termijn parkeren Achtergrond  TU Delft	Zie hier een voorbeeld van P3 bij Schiphol airport. Auto's staan hier dagen geparkeerd en soms ook weken als mensen bijvoorbeeld op zakenreis op vakantie zijn. Dit om een idee te krijgen van de omvang.

Dia 10		Stel je voor.. Je gaat 5 dagen op zakenreis naar het buitenland met het vliegtuig. Je hebt een lange termijn parkeerplek gereserveerd bij het vliegveld. -Je meldt jezelf en parkeert je auto op de vooraf bepaalde parkeerplaats. Je sluit de auto aan een V2G laadpaal en gaat naar de gate. -Overdag worden de auto's op de parkeerplaats opgeladen. -S'nachts leverende de auto's energie terug aan het net en kan de vertrekhal ervan worden verlicht (o.a.) -Dit gaat het aantal dagen zo door tot het system merkt dat je bijna terugkomt. -Het system zorgt dat de batterij van je auto voldoende is opgeladen voor het ritje naar huis. Ook wordt de compensatie berekend. -Je rijdt weer veilig naar huis en hebt niks van het laden en ontladen gemerkt.
Dia 11		Vervolg interview vragen…

I.11 Animation for V2G driver participants

Dia 1		Deel 2 van het interview begint…
Dia 2		Bij vehicle-to-grid wordt de batterij van uw elektrische auto gebruikt als (tijdelijke) elektriciteitsopslag. Als er veel electriciteit beschikbaar is dan wordt uw electrische auto opgeladen. Als er veel vraag is in het electriciteitssysteem, kan de energie die nog in uw auto zit, teruggeleverd worden aan het electriciteitsnet door middel van ontladen. Dit alles kan bijdragen aan meer balans van het elektriciteitsnet.
Dia 3		Een voorbeeld is: Op een zonnige dag wordt er heel veel electriciteit opgewekt middels zonnepanelen. Ook waait het heel erg hard die dag. Er is veel duurzaam opgewekte stroom beschikbaar in het electriciteitsnet. Er is een vehicle-to-grid paal aanwezig bij het kantoor van uw werk. Rond 09:00: U heeft uw elektrische auto aan de vehicle-to-grid paal aangesloten en weet dat u de rest van de dag op kantoor bent. De zonne- en windenergie wordt opgeslagen in de batterij van uw elektrische auto. S'middags is de wind gaan liggen en het is bewolkt geworden. Ook is de vraag naar electriciteit is hoog doordat er meerdere elektrische auto's moeten worden geladen en de lift en koffiemachine draaien overuren op kantoor. De s'morgens opgeslagen wind- en zonneenergie wordt dan teruggeleverd van uw auto aan het electriciteitsnet. Voor dit terugleveren van electriciteit krijgt u een vergoeding. Vlak voordat u aan het einde van de werkdag terug naar huis rijdt, zorgt het system dat uw batterij voldoende is opgeladen. Er wordt er gezorgd dat de accu genoeg opgeladen is zodat u uw ritje naar huis kunt maken.

Dia 4	Interview vragen TUDelft 4	Interview vragen vervolgt
Dia 5	Voorbeeld toepassing TUDelft 5	Deel 3 van het interview
Dia 6	Lange termijn parkeren Achtergrond • Schiphol, Lelystad airport, Rotterdam airport • Schiphol: 3+ dagen parkeren • Aantrekkelijk voor vehicle-to-grid: 1. Auto's relatief lang aangesloten 2. Parkeergedrag voorspelbaar TUDelft 6	Een mogelijke toepassing is vehicle-to-grid bij lange termijn parkeerplaatsen. Bijna alle vliegvelden in Nederland hebben een lange termijn parkeerplaats. Onder lange termijn parkeren wordt verstaan: 3+ dagen. Alles daaronder wordt gezien als korte termijn parkeren. Lange termijn parkeergelegenheden is een plek waar vehicle-to-grid mogelijk snel beschikbaar zal zijn (bijv. Schiphol, Lelystad (als het open is ha-ha) en Rotterdam The Hague Airport. Het is aantrekkelijk omdat auto's relatief lang staan aangesloten aan een V2G paal en het voorspelbaar is wanneer de eigenaar terug komt bij zijn/haar auto (o.b.v. vluchtinformatie). Vaak moet een lange termijnparkeerplek ook van tervoren geboekt worden.
Dia 7	Voorbeeld animatie (vliegveld) Werking systeem  Opladen elektrische auto's TUDelft 7	Stel je voor.. Je gaat 5 dagen op zakenreis naar het buitenland met het vliegtuig. Je hebt een lange termijn parkeerplek gereserveerd bij het vliegveld. -Je meldt jezelf en parkeert je auto op de vooraf bepaalde parkeerplaats. Je sluit de auto aan een V2G laadpaal en gaat naar de gate. -Overdag worden de auto's op de parkeerplaats opgeladen. -S'nachts leverende de auto's energie terug aan het net en kan de vertrekhal ervan worden verlicht (o.a.) -Dit gaat het aantal dagen zo door tot het system merkt dat je bijna terugkomt. -Het system zorgt dat de batterij van je auto voldoende is opgeladen voor het ritje naar huis. Ook wordt de compensatie berekend.

		-Je rijdt weer veilig naar huis en hebt niks van het laden en ontladen gemerkt.
Dia 8		Interview vervolgt
Dia 9		Additioneel: In het onderzoek wordt acceptatie als volgt gedefinieerd. Dat betekent voor u: U gebruikt de technologie als onderdeel van uw dagelijks leven zonder er over na te denken. Discussie over definitie en wat er bijdraagt aan V2G acceptatie…

Appendix II Interview reports

II.1 Report: Current EV driver 1 (CED1) – 08-10-2019

Interview information

Interview ID	**CED1**
Date of interview	**08-10-2019**
Gender	**Male**
Age category	**25-35 years**
EV ownership	**Lease**
EV type	**Plug-in hybrid**
Income category	**20.000-34.999**
Highest education level	**HAVO/VWO**

Interview answers and findings

Part 1 – answers based on general questions

The interviewee has chosen a plug-in hybrid vehicle because of fiscal reasons. Electric driving is very relaxing, no noise, fast acceleration and parking advantages (always space at public locations, however, is decreasing a bit). Will get a Tesla Model 3 because of fiscal reasons at the end of the year. Finds the developments regarding electric driving very interesting (Tesla developments).

When asked whether his environment influenced his choice to drive electric, the interviewee answered that he thinks that he is slightly influenced by environment. His colleagues drive electric but family not. At the office several colleagues drive electric and they discuss this during private conversations.

Acknowledges some disadvantages of electric driving. Namely, range and battery capacity limitations. However, super charging network is very good. Still, you have to be more aware about planning your trips.

Has 3 solar panels at his home that covers 1/3th of energy usage on yearly basis. He acknowledges that large financial investments should be made to make his home self-sustaining (for full coverage). Has 3 panels because the house has a certain energy label. However, the sustainability aspects are important to him but not that important that he did the full investment. The interviewee is very interested in the technological developments regarding e-mobility. Not from a job perspective but based on personal interests. Likes to read about how the (fossil) energy lobby and traditional automotive industry try to block companies such as Tesla.

Currently, the interviewee is not convinced that electric vehicles are as “green” as people think/say. For example, higher tyre wear, hazardous fine particles, minerals needed for batteries. However, thinks that this is a first step which is needed to fully launch the energy transition and to break our dependencies on fossil fuels. In his opinion, environmental friendly mobility is highly important and an important contributor why he decided to drive electric (besides the fiscal reasons).

Part 2 – Questions about vehicle-to-grid

Heard about vehicle-to-grid before the researcher approached him for the interview. Interviewee was aware of a Dutch start-up that uses Nissan Leafs to deliver energy at events and festivals. For instance, people can charge their phone and power is being delivered to the stands at the events.

The interviewee thinks that vehicle-to-grid is a very good idea. Is not sure whether his own car provides V2G capabilities yet. However, the interviewee is very positive toward V2G. When asked why, the interviewee perceives the idea of energy storage in the EV as a very good idea which should be further explored to contribute to grid balancing. However, an important risk follows from charging and discharging the battery. There exists the possibility that the battery is not fully charged when want to make a trip. It disallows to make unexpected trips. At this point in the interview, perceives that as the only possible disadvantage of V2G.

When asked about overcoming this barrier and a user friendly experience, the interviewee proposed the idea of using software in the car and V2G charger. The car and charger should have to collaborate. He wants to keep control using a smartphone application which provides notifications about when the car is going to discharge. Wants to be able to set a limit for minimal state-of-charge. The charger should be not much different from the current EV chargers (using a tag/pass) and a lightweight cable.

Part 3 – Questions about V2G example use case at long-term parking (e.g. at airport)

Seldom that he parks his car 3 days or longer. And does not frequently park the car at the airport. Thinks that the airport application is an ideal application because of the clarity about parking time and behaviour (based on flight information and reservation which is often required).

Acknowledges that there is a risk is that battery degradation which may be increased due to charging and discharging. Interviewee mentioned that it is already a topic about which some drivers are concerned. Namely, sees that it is often a topic of discussion among

EV drivers on the internet. However, does not perceive the battery degradation aspect as highly important since he is leasing the vehicle. But, finds it important that, from a mobility perspective, he can drive almost as many kilometres on one battery when the car is four years old (compared to the first year). He has tested the battery degradation with his own car battery from the beginning. After the first year he noticed a degradation of 5% regarding the range of his own vehicle.

The interviewee was asked why he perceives battery degradation in the long-term parking application as a barrier and in the other application not. The topic of battery degradation is more of a discussion (for the interviewee) in the V2G at long-term parking situation (compared to the office application), because the vehicle stands still for a longer period of time. Assuming the battery will be charged and discharged more often (compared to the office application), battery degradation effects will be larger in this situation. Charging and discharging while driving is also a cycle of charging and discharging. But, then it serves a particular goal, namely the interviewee's mobility. But if the car stands still for a longer time and there is still battery wear from V2G, the interviewee would have more difficulties with that and wants to be compensated.

The interviewee does not care about whether the energy from the battery is used for lighting the airport or used for other purposes. "Energy is energy" ("stroom is stroom"). However, if the interviewee parks the vehicle at the airport, he expects a higher compensation than the office application. He expects a higher compensation because, assuming that a parking fee has to be paid and, the airport is also going to use the battery from the EV. When asked about the form of compensation, a discount on the parking tariff would be the form that the interviewee would expect. When asked about the height of the compensation, the answer was about 33% discount on the parking tariff.

Regarding user-friendliness, the interviewees hold the same view as in the office application (smartphone app, data input in the car, software in the V2G charger).

When asked about the ideal location of V2G applications and with the aim of grid balancing in mind, all chargers and electric vehicles should enable V2G capabilities. There is not one specific location where V2G is more likely to be seen. The interviewee perceives it as the new standard for the long-term vision.

Additional notes

- Would like to receive end result of research.

II.2 Report: Current EV driver 2 (CED2) – 16-10-2019

Interview information

Interview ID	**CED2**
Date of interview	**16-10-2019**
Gender	**Male**
Age category	**>65 year**
EV ownership	**Lease**
EV type	**Plug-in hybrid**
Income category	**35,000-70,000**
Highest education level	**HAVO/VWO**

Interview answers and findings

Part 1 – answers based on general questions

CED2 drives a plug-in hybrid vehicle, to be more specific: a VW Golf hybrid. The interviewee mentioned that he is driving as much as possible in the electric stance and tries to reduce using the combustion engine. He calculated himself (based on information from the dashboard computer) that he drives 75km on 1 litre of gasoline (on average) up until now with his current car.

When asked about his motivations to drive electric, the interviewee mentioned that he drives electric because he thinks that air pollution is a bad thing. Zero-emission is what required with the mobility of the future. He mentioned that he wants to "drive as clean as possible". Acknowledges that other advantages of electric driving are: no noise and that it is fast. Furthermore, CED2 mentioned that he drives electric "to make the world a better place". CED2 is a strong advocate of electric driving and also advises colleagues to drive electric (an ambassador). Despite CED2 drives a plug-in hybrid vehicle, the interviewee considers himself as an electric driver because he tries to drive on the electric stance as much as possible. He believes that charging is an important part of driving a plug-in hybrid. Believes that all people driving a plug-in hybrid must charge as much as possible. He only switches back to ICE when it is extremely necessary for making longer trips than the battery capacity allows (which is seldom the case).

Regarding the energy transition, CED2 mentioned that he was one of the first that had solar panels at his home. Thinks that we have to continue this energy transition and believes it must be done faster and should be accelerated more. Interviewee thinks that he is quite environmentally aware and adjusts his behaviour accordingly. For instance, he mentioned that he sometimes throws away the garbage of others that he finds on the street (e.g. plastic packaging). He believes that the youth is the future regarding environmental awareness and sustainability. Thinks that plastic soup is a big problem which should be solved in the coming years. However, CED2 continuously mentioned that it is an effort of all people, that it is a social thing. "We must do it together".

When zooming in on the perceived disadvantages of electric driving, CED2 mentioned that more chargers have to be installed in the Netherlands. In both urban areas (cities etc.) but also in the rural areas. Currently, the interviewee mentioned that he charges at the office and at home mostly but would charge at other places as well if chargers become more available. Other disadvantages are that the electric range of the current vehicle (the plug-in hybrid) is low.

The interviewee mentioned that he thinks that his direct environment (family, friends, colleagues) did not play a role in why he started electric driving. He was one of the first people at his company that drove electric and that he had to "fight for it" to get an EV. The interviewee tries to stay up-to-date regarding e-mobility. Beliefs that this (and hydrogen) is the future compared to fossil fuel cars. The interviewee mentioned several times that "All people have to drive electric and/or using hydrogen cars".

Part 2 – Questions about V2G

The interviewee heard before of the vehicle-to-grid concept but does not have in-depth (technical) knowledge of the concept. He heard about it in the newspaper/television. CED2 has a positive attitude toward V2G. He believes that it has the potential for large social impact. CED2: "We have to, as a collective, contribute to grid balancing since it is something that we all use". However, CED2 perceives that battery capacities of PHEVs as a barrier (must be bigger). CED2: "The question is still whether other people than myself would want it". However, CED2 believes that we have to do it together and also this with the grid balancing.

CED2 mentioned the aspect of "balancing of society". He believes that certain things are not built for peaks and that peak shaving is required. He thinks that V2G can play a big role in that. CED2 thinks that another advantage is: "charging when energy is cheap and discharging when energy is expensive". Acknowledges that smart charging is in line with his motivation to drive electric (contribute to zero-emission). And thinks that we will have a major problem when there is no current anymore/chance on black-out and we have to start anticipating now.

The interviewee did not perceive major barriers of V2G usage. CED2 mentioned that: "even when it costs me something I still would contribute". The interviewee had a small remark that when he wants to make an unexpected trip, there is a chance of low energy in the battery. However, he acknowledges that with his hybrid car, it is not a big problem since he can still drive using the combustion engine. But he tries to reduce driving using the ICE as much as possible. When asked about the risks, CED2 mentioned that he assumes that the charging cables will become better and more expensive. This results in a higher probability that the cables will be stolen. Furthermore, he already mentioned with his current charging cable that sometimes the cables become very hot/warm and should be looked into when energy is flowing in 2-ways.

When being asked about control and user-friendliness, CED2 mentioned that UX could be improved by removing the need to plug in a cable, but preferably do contactless/wireless charging. Currently, he always needs a pass/"drupel" at the charger and perceives this as a disadvantage. When asked further this has to do with bad experiences that the charger plug could not be unplugged (that CED2 needed to make a phone call to the owner of the EV charger etc.).

Part 3 – Questions about V2G example use case at long-term parking (e.g. at the airport)

In general, CED2 perceives the airport application as a good use case. He likes the idea of helping the airport with its energy supply using his own car. CED2 noticed that V2G at long-term parking (airport) applications solves the problem of occupying a charger at long-term parking. Currently, he feels a bit uncomfortable when parked for several days and occupying a charger. This problem is solved with V2G at long-term parking.

CED2 had a doubt about energy metering. So, how it works with charging/discharging with his tag/pass: "since the car is being charged and discharged several times, how does it work with my tag/pass so that I do not receive several bills?".

CED2 has experience with parking at long-term parking occasions. He parks sometimes at Schiphol Airport at the long-term. His previous experiences regarding charging were not that positive. He had to search for a charger at Schiphol Airport. But was not surprised by that fact since he has to search for chargers often, also at other public and semi-public locations.

The interviewee did not believe there were much difference when comparing the office/airport applications. CED2 did not see big differences in terms of advantages/disadvantages of V2G. The interviewee thinks that it can be installed at more places (than only these two places).

When asked about battery degradation effects and how much he cares about the battery capacity, the interviewee told that he asked the car dealer whether the battery capacity could be improved. CED2 has the knowledge that the batteries have a limit (set by the manufacturer) so that the batteries have a battery life of 5-7 years. His general perceptions are the batteries are very good already and beliefs that they will become better in the coming years.

Concluding, CED2 has the intention to use V2G at several locations. He would use V2G chargers because he believes it is a good concept with societal impact. Has a very positive attitude.

Additional notes

- Would like to receive the end result of research.

II.3 Report: Current EV driver 3 (CED3) – 16-10-2019

Interview information

Interview ID	**CED3**
Date of interview	**16-10-2019**
Gender	**Female**
Age category	**<25 year**
EV ownership	**Lease**
EV type	**Battery electric vehicle (fully electric)**
Income category	**35,000-70,000**
Highest education level	**Master's degree**

Interview answers and main findings

For each of the 3 interview parts, the most important findings are presented below.

Part 1 – answers based on general questions

What do you think of driving electric in general? [EV attitude]

The interviewee mentioned that she drives a car that has 200 km range. It is a Volkswagen e-Golf which is fully electric. Electric driving is "smooth, without noise, fast, and very nice". CED3 mentioned that, in her opinion, the charging infrastructure in the Netherlands is proper and quite well, in general. Also in her neighbourhood (where she lives). CED3 noticed a Tesla (Model 3) explosion the last months, which negatively influences the amount of available parking lots with EV chargers. Furthermore, the interviewee mentioned that the process of requesting a (public) charger (at home) is too long.

Why do you drive an EV? [EV attitude]

CED3 drives electric for financial reasons (fiscal), 4% additional tax liability in 2019 in the Netherlands. The employer has provided the opportunity for CED3 to choose between a (leased) e-Golf, VW polo (ICE) or Renault Clio (ICE). She had to decide on this 2 years ago. The VW e-Golf is bigger, cheaper, and has a better design in her opinion. In 5 years, assuming that the additional tax liability in the Netherlands will be 22% in 5 years. CED3 is not sure that she would choose for an EV again when taking into account the additional planning of trips and limited range. CED3 wanted to make a remark that she does not fully believe that EVs is really the future. CED3 had heard different stories about battery production and that it might be more polluting. However, the environmental aspects played a side-role in her decision to drive electric.

Are you aware of the disadvantages of electric driving? Could you name as much as possible disadvantages? [EV knowledge]

The availability of public chargers is satisfactory in the Netherlands but could be improved by installing more public chargers. Furthermore, the dependence on chargers is a disadvantage together with the current range of EVs. CED3 mentioned that it is allowed (at certain parts of the highway) to drive 130 km/h in the Netherlands. However, CED3 always drives slower than this with the EV, because it has a negative impact on the range. You have to adjust your driving style. The interviewee mentioned that it misses "spontaneity". You cannot make long unexpected trips if you have parked the car with only 40 km battery capacity left the night before. Therefore, it requires additional planning.

What do you think about energy presumption/self-sustainability (e.g. with for instance solar panels)? How do you value the environmental aspects of EV driving? [Eco-friendly values]

According to CED3, it is an important sub-benefit of EVs, the environmental aspect. It is also an important discussion for her, she believes it requires attention on a global scale and is an important societal issue. However, CED3 is not sure whether EVs are really environmentally friendly. Mentioned that she has heard different stories about it. Tries to do small things in daily life: no gas cooking, less meat. CED3 mentioned that she does not have solar panels at home.

How involved are you with the technological developments regarding electric driving? Are you always up-to-date? [Technological innovativeness]

2 Years ago, when CED3 could choose one of the lease car models, electric driving was quite new. People in her environment (especially one family member) already drove electric at that time and could help her with practical questions. However, colleagues did not pay that much attention to electric driving. Thinks that she is not that much influenced by the environment to drive electric. However, played a role in her decision (that a family member could help her).

How involved are you with the technological developments regarding electric driving? Are you always up-to-date?

2 years ago, when CED3 has chosen for an EV, the interviewee read much about how charging worked etc. Tries to read about new electric models in the newspaper. And follows developments about charging infrastructure etc. in the Netherlands. Based on what she reads, mentioned that she has concerns about whether the government is making electric driving less attractive by increasing the additional tax liabilities: "We are now all enthusiastic, but that may decrease over the coming years. Fewer people might choose for an EV".

Part 2 – Questions about V2G

Have you heard before of V2G? Have you used it already? [Knowledge V2G]

Was not aware of the grid balancing problems in the Netherland. Furthermore, did not hear of V2G before the researcher approached her for the interview.

Based on what you have seen, what do you think about V2G? [Attitude towards tech.]

Thinks that it is a good concept. However, has various questions: 1) Do the batteries of the current EVs support it? 2) What is the effect on the battery? That is one of the first questions that come to CED3's mind. CED3 mentioned that possible negative effects on the battery are acceptable as long as the effect is not larger than for instance the battery degradation caused by regular driving. Furthermore, the battery is from a leased car, so it is of minimal importance to her. As long as the battery keeps its performance for 3-4 years.

What are the benefits for you as an EV driver, you think?

Since CED3's car is leased, the interviewee perceives benefits for the employer. The employer has possibly less transport costs because of financial compensations. Her employer pays now for the energy for charging the EV. CED3 thinks that the employer will receive (probably) the financial advantages of V2G for delivering back energy to the grid. The social/societal aspect is the most important benefit to her. "If the grid will be overloaded, we all experience the disadvantages from it". We have a societal problem where we all contribute to; we all want to drive electric and have financial tax advantages. CED3 mentioned: "when I can do something back for society by participating in V2G, it is a good thing". CED3 believes that there are not much benefits for herself. Only that the energy grid can be sustained/maintained.

What would be possible barriers for you to use this technology? [Perceived risks]

CED3 mentioned that: "How do I know that my car is enough charged when I want to leave?". Furthermore, CED3 sometimes makes unexpected trips and, therefore, does not want the battery state-of-charge is low when making an unexpected trip. She wants to be sure that there is enough state-of-charge to make these kind of trips. Furthermore, CED3 mentioned that for her the goal of a charger is to (preferably fully) charge the battery for the next trip. So, charging is the purpose. If V2G systems for delivering back energy would ignore/overtake this goal, that would become a barrier.

Do you have an idea what could be done to overcome these barriers?

CED3 mentioned that the system has to be user-friendly: additional planning system in place where input about expected trips can be done (already has it in her current car). CED3 called it "a smart car" which knows what time to leave etc. And where she can provide input on the amount of minimal KM. Another idea CED3: not discharging under a certain state-of-charge. CED3 wants to have at least 150 km → then it would not be a barrier for unexpected trips.

Part 3 – Questions about V2G example use case at long-term parking (e.g. at the airport)

Do you ever park 3 days or longer with your electric vehicle?

Not often. CED3 mentioned that, if she does, she would not connect it to a charger. Otherwise, she would occupy a parking place including a charger which results in other EV drivers cannot use it. Does not go to Schiphol with her EV because she thinks it is antisocial behaviour to park her car for several days while the car is only charging for, let's say, 4 hours. The car is occupying a parking spot that someone else can use as well. She would experience a guilty feeling to leave her car parked like that.

What makes the long-term airport parking example different from the office example in terms of advantages and costs/risks?

With the long-term parking example, it is part of the concept to park the car for a longer period of time and plug-in the charger. In this case, CED3 mentioned that she would not leave her parked car with a guilty feeling. Furthermore, the disadvantage of making unexpected trips and the possibility of a low state-of-charge battery is not applicable in the long-term parking situation at an airport. Moreover, CED3 mentioned that suppose that the car has an error (in a smartphone application), you are not nearby to look at the car and to unplug- and plug the charger again. E.g. 'current supply is blocked' is an error that sometimes happens. Lastly, parking your car at an airport for several days/weeks is expensive in the current situation. Sees opportunities to receive discounts on parking tariffs.

What would you think of V2G at long-term parking? [Attitude]

Very good concept because of the storage for renewables and contributing to providing energy for the airport.

How to overcome the perceived barriers?

CED3 thinks of compensation. When asked about the exact amount of compensation, she suggests a 50% discount on parking tariff. The idea of: "You help us (airport). We help you." Is important to her. She finds that more important than a fixed compensation and would trigger her to participate in V2G.

Would you consider using V2G at long-term parking? [Intention to Use]

She would use it at an airport. Thinks that the office situation is maybe better since the airport is visited only 1 or 2 times per year. The office concept is then a better idea in her perception.

What would be the ideal V2G charger location for you?

The home and office application. Note: CED3 means the public charger in the neighbourhood. Does not have experience with a private charger at home. However, on second thoughts, CED3 mentioned that V2G can be applied in every parking situation. But, for commuting it would make more sense to start with because that is what you do almost every day.

Additional notes

- Would like to receive the end result of research.

II.4 Report: Current EV driver 4 (CED4) – 24-10-2019

Interview information

Interview ID	CED4
Date of interview	24-10-2019
Gender	Male
Age category	>65 year
EV ownership	Purchased
EV type	Battery electric vehicle (fully electric)
Income category	35,000-70,000
Highest education level	Master's degree

Interview answers and main findings

For each of the 3 interview parts, the most important findings are presented below.

Part 1 – answers based on general questions

The interviewee mentioned that he has started driving electric (partly) because of his career background and job at the Dutch government (Ministry of Infrastructure and Water Management). Namely, CED4 have had a job function that had to do with "energy transition thinking" and sustainable mobility at the ministry. For years already, the focus is on GHG emission reduction, air quality and (energy) transition thinking. Furthermore, one of his main interest is innovation for mobility and change management for changing the current mobility/energy systems.

CED4 finds driving an EV very comfortable. The interviewee has also experience with fuel cell driving (hydrogen). Overall, EVs require less maintenance. And you don't have to go to petrol stations anymore. However, he thinks that there are still not enough chargers. Moreover, there is in Europe not the same standard for chargers which makes travelling outside the Netherlands sometimes a challenge. Lastly, the interviewee finds the fact that you have cables sometimes a hassle. During the decision whether to drive an EV or ICE, he made up the business case for himself (what is the ROI taking into account electricity/fuel prices?).

Part 2 – Questions about V2G

CED4's perception is that V2G delivers more possibilities for himself as an end-user for energy storage capacity and various other applications. He admires the idea that it provides possibilities for the grid to be more balanced. If new business models which are attractive for him as an EV driver it would make electric driving more attractive (the emergence of new services).

However, V2G raises also uncertainty about: "Is there enough energy in the EV?". So, whether there is enough energy to do the expected trips. Generally, with EV driving, the interviewee mentioned that he continiously questions "Do I have fast enough energy when I have to do something". But with this concept, CED4 mentioned that he finds it important that the battery has enough energy for an unexpected trip. On second thoughts he mentioned that: "unexpected trips that never occur". CED4 mentioned that, furthermore, in the current situation charging is still to slow. The interviewee is wondering how that will be with V2G. Moreover, with V2G the charger cable has to be plugged-in as much as possible. But how do we deal with that from a spacial perspective? CED4: "I don't want that my car is parked in the front yard at all time". Interviewee: "It hinders my view". When the EV is charged, I prefer to park it somewhat further in my street. CED4 also mentioned that his case (with the front yard) is very specific.

CED4 also mentioned that: "I want to keep control". The interviewee noticed that he does not want that you want to make a trip and that a third party just drained the battery. You want to keep it in control as an end-user. Furthermore, CED4 "I find it a strange idea that an energy supplier is suddenly my client".

When asked about overcoming barriers, CED4 mentioned that rules have to be defined in a contract. For instance, the battery is not drained under a certain amount. Since I have to be more aware of my driving patterns, there must be a smart solution. The interviewee is not sure how that should be designed or look alike.

Part 3 – Questions based on the V2G example use case at long-term parking (e.g. at the airport)

CED4 perceives the V2G at long-term parking of an airport as a "very nice concept". The researcher noticed that it seems that CED4 is more enthusiastic about this use case compared to the home/office application. The interviewee already sometimes park (once per year) the car at the airport or go by train as an alternative with holidays. The trade-off is then: train/car to the airport. However, mostly prefers the car due to its flexibility. The interviewee mentioned that it makes parking at the airport more attractive when a discount is provided on the parking tariff (for V2G participation). The interviewee prefers the idea because existing car parking space is used for energy storage capacity.

The interviewee proposes other locations: soccer stadiums, event venues, concert halls. However, is not sure if it is interesting when parked only very short-term. CED4: “then I just want my car to be charged”. Another proposal for a location: CED4 often parks at a P+R in Amsterdam to visit his daughter. This is another interesting use case since he parks his car the whole day.
When asked about a user-friendly experience with V2G systems, CED4 expects an “integral arrangement”. That V2G is part of the holiday. Namely, that it is part of the whole chain of a holiday: the vacation is booked and includes parking the car at the long-term parking, connecting the EV to V2G and delivering energy back to the grid, the flight, the hotel. And that when returning to the car it is fully charged.
In a final question, the interviewee was asked whether battery degradation, which is caused by V2G, is important to him. CED4 beliefs that when charging is between 20% and 80% state-of-charge it has no negative influence on battery life. CED4 beliefs that: “fully charging the battery and a completely empty battery is bad for the battery pack”. However, an important note CED4 made was that he has never done research about this topic, but that he heard this rumour.

Additional notes

- Would like to receive the end result of research.

II.5 Report: Current EV driver 5 (CED5) – 26-10-2019

Interview information

Interview ID	CED5
Date of interview	26-10-2019
Gender	Female
Age category	25-35
EV ownership	Lease
EV type	Battery electric vehicle (fully electric)
Current EV	Kia e-Niro
Income category	35,000-70,000
Highest education level	Master’s degree

Interview answers and main findings

For each of the 3 interview parts, the most important findings/points of discussion are presented below.

Part 1 – answers based on general questions

Energy transition

CED5 thinks that electric vehicles (EVs) are the future of (car) mobility and can play a role in the ongoing energy transition. The interviewee is aware of sustainability/environmental issues and tries to adjust her behaviour accordingly. For instance, eating less meat.

Electric driving

The interviewee’s motivation to drive electric are largely financial reasons (lower additional tax liability). Furthermore, CED5 lives in the city centre of Amsterdam. With an internal combustion engine car, she would not receive a parking permit in Amsterdam immediately. CED5: “With EVs, you can still get a parking permit the same day”. Furthermore, she could choose a leased car with a respectively high range (380 km). CED5: “This is enough to travel in the Netherlands”.
CED5 mentioned that driving an EV is smooth, without noise and gives her a better feeling (from the environmental aspects that she is contributing). However, charging infrastructure is sometimes a hassle especially when going to a neighbouring country (e.g. France). CED5 mentioned that a trip to France had cost 40% more time caused by charging.

Charging

Currently, CED5 mostly charges her EV at home. Also, charging in the city centre of Amsterdam provides advantages with parking the car. CED5: “parking spaces with a charger are available mostly”. It was mentioned that there are around 6 public chargers in 200m radius from her home. With her current vehicle, she does not have an app right now to keep control and track of the battery status. She sometimes regrets that.

Social influence

CED5 was the first person at her company that had chosen for an EV. Furthermore, it was mentioned that her partner works at a Dutch charging infrastructure company. He provides her with information about EVs and has a strong vision regarding driving electric and charging.

Technological innovativeness

Her partner keeps her up-to-date about trends and developments. Furthermore, receives newsletters of charging companies and car manufacturers about the newest models and car (software) updates.

Part 2 – Questions about V2G

V2G

CED5 perceives vehicle-to-grid as a very cool concept. She believes that draining back energy to the grid is part of the future vision of our energy systems. Perceives storing energy when there is enough available and feeding back to the grid when there is a high demand for energy as a societal advantage (doing something back). Furthermore, another perceived advantage is charging when it

is only necessary. CED5: “if the charging system would be smart and know when I would park my car for 3 days, it could charge only if necessary”.

Barriers

CED5: “What happens when I have to make an ad hoc trip?”. There exists a chance that the battery is low. That would be a possible barrier for CED5.

Overcoming barriers

The problem regarding ad hoc trips could be (partly) solved by keeping a minimum of 30% state-of-charge. CED5: “Then I could use a fast charger to fully charge it”. Furthermore, CED5 suggested that she would like to keep control (somehow). So, to provide input and monitor what happens with the battery state-of-charge.

Possible battery degradation is not really an important issue to her because CED5 leases the car. CED5: “as long as the battery works properly during her lease contract period” and thinks she is more short-term focussed than someone that purchases the car.

Part 3 – Questions based on the V2G example use case at long-term parking (e.g. at the airport)

Long-term parking experience

CED5 does not have experience with long-term parking at the airport. However, the interviewee sometimes parks the car 3+ days at home. She also plugs in the charger and considers herself sometimes as a “charging station sticker” (NL: “laadpaalklever”).

Attitude V2G @ long-stay parking

Thinks that V2G at long-term parking at the airport is a “cool” concept and that V2G applicability is high here. CED5 immediately mentioned that there are no issues with ad hoc trips in this case. However, perceives battery degradation more of an issue here (from a general point-of-view). But is still not a big barrier because CED5 drives a leased EV.

Differences attitude toward office and airport application

Does not perceive major differences. At the airport, it does not matter so much what the aggregator is doing with the battery as long as it is not detrimental to the battery.

Intention

Would use V2G at long-term parking at the airport. However, the interviewee mentioned that she tries to reduce the amount of flights she makes. Because of environmental reasons and GHG emissions. She thinks that the probability is low that she would actually use it. When it is not necessary to make a flight, she does not do it. However, sometimes have to fly for her job. But, it is a very long time ago that she decided to make a flight in her private time.

Ideal location

(Public) home application would be the ideal location for her given her current charging behaviour.

Additional notes

- Would like to receive the end result of research.

II.6 Report: Current EV driver 6 (CED6) – 29-10-2019

Interview information

Interview ID	**CED6**
Date of interview	**29-10-2019**
Gender	**Male**
Age category	**36-45**
EV ownership	**Lease**
EV type	**Battery electric vehicle (fully electric)**
Current EV	**Tesla Model 3**
Income category	**35,000-70,000**
Highest education level	**Bachelor’s degree (applied sciences)**

Interview answers and main findings

For each of the 3 interview parts, the most important findings/points of discussion are presented below.

Part 1 – answers based on general questions

Background interviewee and attitude towards EVs

The interviewee has a very positive attitude towards driving an EV. CED6: “It drives very well, smooth, without noise and is fast”. Interviewee has received three weeks before the interview his new EV (Tesla Model 3).

His Tesla has a 500 km range (long-range model). But in practice, it is less than 500 km. CED6 called his vehicle a “Driving iPad” because of all the technological components and extensive software components. Personally, he finds this very interesting since he also has a technical IT background in his professional career.

Motivations/drivers to choose for an electric vehicle

CED6 mentioned the financial advantages (additional tax liability). So, there is an important financial driver. Furthermore, CED6 has a positive attitude towards the design of the car: “it is a very nice design etc.”. That it is quite a new technology on the mass market has played a side-role.

When asked about environmental reasons, the interviewee mentioned that it played a role in his decision but was not of main importance. It was a less important argument compared to the financial advantages. CED6 is environmentally aware, but, does not adjust his daily life to it. Does not do small things such as waste separation and does not possess solar panels, for instance.

Questions about charging

Cannot charge at home and, therefore, charges at the office. The interviewee told about a negative experience with the charger at the office (blow a fuse and bugs in software of the charger). However, CED6’s expectations were that this would be fixed in the coming weeks. Lastly, a perceived advantage that you don’t have to go to a petrol station anymore that often (only sometimes to a fast charger).

Subjective norm and influence of social environment on decision to drive an EV

CED6 mentioned that the neighbours own a Tesla. The interviewee believes that he is not so much influenced by the environment. He was the first person at his company driving a fully electric car. Thinks that he is maybe inspired by the neighbours.

Technological innovativeness

CED6 mentioned that he tries to read websites, blogs and news updates. Is quite up-to-date about the latest developments regarding Tesla and charging infrastructure.

Disadvantages EV

First, the limited range. Battery capacities should be improved in the coming years. Furthermore, the charging infrastructure in other EU countries is less mature. CED6: “It requires more planning and stops when making long trips, for instance for holidays (e.g. to south France)”. Lastly, the interviewee is frustrated by other fully electric vehicles and plug-in hybrids that occupy public parking spaces with chargers, while the battery is fully charged (e.g. in the neighbourhood where he lives).

Part 2 – Questions about V2G

CED6: “Smart concept. Good concept for the energy companies and grid operators”. The interviewee referred to the “GTST effect” (GTST=Dutch TV series), that he had to think of it. The GTST effect means that, during the break of the TV series, everyone started using the toilets, coffee machines and water cookers. This led to a massive peak demand for energy and water and was a problem for water and energy companies. Despite the fact that eco-friendliness did not play a big role during the consideration or decision to adopt an EV, CED6 has a very positive towards the V2G concept.

Barriers V2G

For him, the office application does not have barriers. But the interviewee thinks that he has quite predictable driving patterns (enters and leaves the offices at the same time, every day). The interviewee proposes that there may be other EV drivers who have more unpredictable behaviour. That may be a problem since the battery is not fully charged then. CED6 proposed a solution: “Everything above 60% state-of-charge can be delivered back”.

Regarding battery degradation, CED6 has leased the EV, so battery wear is not a very important issue for him. CED6: “The caused battery degradation may be noticed after 3-4 years, but then you can get a new car from the lease company”. Furthermore, CED6 thinks that financial compensation is an option for compensating battery degradation caused by V2G. However, the interviewee finds that less important, “as long as it is not more harmful compared to regular battery cycles from driving”.

Important aspects for a user-friendliness experience with V2G

A way to provide input about his own time scheme. The interviewee finds it important that he is able to keep in control of charging and discharging, if necessary. Moreover, he wants to be able to monitor this on a software app (in car or on smartphone). CED6 mentioned that he would find this personally interesting because of his technical background in IT.

Part 3 – Questions based on the V2G example use case at long-term parking (e.g. at the airport)

Current behaviour long-term parking

CED6 uses once or twice a year the long-term parking at airports. CED6 is aware of that there are various chargers at Schiphol. A perceived disadvantage of parking at Schiphol in the current situation: “cannot make reservations at Schiphol”.

Attitude towards technology

CED6 perceives V2G at long-stay parking at an airport as a very smart concept. The interviewee thinks that it will work because a high volume of cars are parked at the same time and also that the energy demand of an airport is high.

Perceived advantage

The interviewee: “Would find it great to participate!”. A connection could be made to the Dutch nitrogen problem. An aeroplane would not fly using electric motors in the near future. CED6 thinks that it would be an ideal situation if airports would aim for being energy-neutral and that this concept would contribute to that goal.

Intention to use and financial compensation model

No barriers experienced or perceived barriers for the V2G @ long-stay parking (Schiphol example) concept. The interviewee has the intention to use V2G at long-term parking at airports! When asked about a financial compensation model, the interviewee proposed: discount on parking and/or cheaper energy for charging.

V2G ideal location

Sees the advantage of the concept at soccer stadiums, Ahoy, large event venues. CED6: "You need a spot where a lot of people come together". Another place might be big supermarkets.
Application at home does not provide so much added value for him because he is not able to place a V2G charger on his driveway and never charges at public chargers in the street where he lives.
The location does not matter so much, communication about the (environmental) contribution he can make and help the airport with providing energy is more of an importance to CED6.

Last remark interviewee

The interviewee is frustrated about the process of requesting public chargers and thinks that government policies should change. Requesting permits for installing a charger is a very bureaucratic and a slow process. CED6 believes that the government is still lacking behind with the regulation and organizational processes for requesting a public charger, near his house.
Furthermore, the interviewee thinks that charging station occupiers or stickers (especially PHEVs) is an important disadvantage regarding the public charging infrastructure.

Additional notes

- Would like to receive the end result of research.

II.7 Report: Current EV driver 7 (CED7) – 30-10-2019

Interview information

Interview ID	**CED7**
Date of interview	**30-10-2019**
Gender	**Female**
Age category	**36-45**
EV ownership	**Lease**
EV type	**Battery electric vehicle (fully electric)**
Current EV	**Tesla Model S**
Income category	**>70,000**
Highest education level	**Bachelor's degree (applied sciences)**

Interview answers and main findings

For each of the 3 interview parts, the most important findings/points of discussion are presented below.

Part 1 – answers based on general questions

Experience EV

CED7's first response to the question of what she thinks of driving electric was: "Super!". The interviewee drives a Tesla Model S and is a leased car. CED7 mentioned that she makes short trips mostly. Therefore, the range of the car (around 400 km) is enough for her usage. According to CED7, driving an EV requires additional planning, especially with longer trips. One time the interviewee went to France with the EV which requires additional planning for charging.
In conclusion, driving electric is fast, nice, and smooth. It provides more comfort compared to internal combustion engine vehicle.

Disadvantage(s) driving an EV

Sometimes the interviewee had a black screen/error while driving which was a bug in the car's system. Then she had to reset the vehicle and do software updates. The interviewee heard that some other Tesla driver had the same error.

Motivations to choose for an EV

The main reason was: 4% Additional tax liability (2014/2015). Nowadays, these rules have been changed by the government. Her employer arranged organized and arranged everything very well (e.g. received a charger at her home and her employer pays the energy for charging).

Technological innovativeness

Was one of the first that drove an EV. Often reads mail newsletters and the news about e-mobility. CED7 perceives herself as a pioneer when it comes to electric driving. Drives an EV since 2014/2015.

Environmental reasons to drive an EV?

Not the main motivator to drive electric. But it was an important side-topic (that there are no tailpipe emissions). However, the interviewee remains critical regarding the actual extent to which EVs are better for the environment (e.g. pollution caused by battery production). For instance, the interviewee perceives li-ion battery production as a polluting process.

Environmentally-driven

CED7 wants to contribute (e.g. takes the bike instead of the car) where she can. Currently, she and her husband are looking into whether to adopt solar panels, heat pump, etc. Nevertheless, she considers herself not as an environmental activist. In other words, she explained that topics related to sustainability/the environment is not the only thing she cares about. There are important other aspects such as financial benefits, ease-of-use and accessibility. CED7's opinion is that it still remains complex for consumers to request and purchase eco-friendly products and technologies (e.g. solar panels, EVs, heat pumps). CED7: "information should be more clear and trustworthy".

Social influence and her decision to drive an EV

CED7 was one of the first that drove an EV. Therefore, she believes that she is not much influenced by other people to drive electric. The interviewee: "it was a new innovation, cool and good". After the interviewee did some test drives she noticed that it was a cool car for relatively low monthly costs.

Part 2 – Questions about V2G

The interviewee assumes that you have to keep it plugged in with the concept of V2G. In the current situation, people often unnecessary occupy parking spaces with chargers. The interviewee is frustrated about "charging station stickers" at public areas.

Attitude towards the V2G concept

Thinks that the idea of V2G is a good idea. Storing energy when there is much available in order to avoid unnecessary losses. CED7 proposed an idea about compensations: "people that drive electric for environmental reasons can donate the compensation to environmental-focused charity".

Customer segments

CED7 mentioned the existence of different customer segments. CED7 believes that these can be divided into 1) environmental-driven, 2) financial-driven, 3) followers. The interviewee would not so much be triggered by financial compensation. The interviewee believes that V2G is most suitable for people that privately purchase an EV for environmental reasons.

Barriers V2G

CED7: "An important barrier would be 'trust' in the aggregator". So if there is a third party that is arranging the energy flows, what are the organization's underlying reasons to run such a company? CED7: "Are they profit-focused? Who is this organization? Would I feel attracted to the why of this aggregating party?". In other words, is the organization doing it for the greater good ("making the world a better place")? In this case, CED7 would feel more attracted (compared to a profit-focused organization) to participate in V2G.

Regarding battery degradation, the interviewee mentioned that she has leased the Tesla for 4-5 years. After that, she could choose a new car. Battery degradation would be, therefore, not of great importance. However, the interviewee assumes that other people who privately purchased an electric vehicle would perceive battery degradation as a problem.

Part 3 – Questions based on the V2G example use case at long-term parking (e.g. at the airport)

Previous experience with long-term parking

The interviewee sometimes parks 3+ days, even 5+ days. Sometimes at home or at the airport. CED7 has noticed (one time) that the state-of-charge lowers when parked for a longer period.

Her experience with long-term parking is that there are not many chargers available and that it is not possible to make a reservation for a charger. Searching for a charging station at the long-stay parking was perceived as annoying/frustrating.

Attitude concept V2G at long-stay parking

Initial question of CED7 was: "Does the financial compensation goes to the employer?". In this case, the interviewee believes that her employer would perceive this as an advantage of V2G. Furthermore, the interviewee suggested the idea of making agreements with corporate employers/organizations (with a large vehicle fleet), so that people can charge and park with a discount/for free. It could help these companies to make connections to their corporate responsibility and relating communication strategies.

Important aspects of having a user-friendly experience with V2G at long-stay parking

Important aspects for a user-friendly experience would be the availability of parking spaces with V2G nearby the departure hall

and V2G chargers nearby the terminal. Furthermore, it should be possible to make a reservation (and to have guaranteed parking space) in advance.
In case V2G charging stations are installed further away from the terminal, the interviewee proposes the usage of electric buses to bring the EV owners to the departures hall.

Ideal location to install V2G chargers
When asked about an ideal location, the interviewee suggested the following idea: "Equip non-profit foundations (e.g. sport clubs) with V2G/smart chargers". In this case, these organizations would pay lower amounts of money for the energy bill. In other words, the (e.g.) sports clubs receive a discount on their energy bill. Non-profit foundations would benefit from it by receiving a discount on their energy bill and the members of the foundation can contribute/help their sports club (by lowering energy costs) by bringing energy with their EVs to the foundations.

Lastly, the interviewee mentioned that when seeking for ideal locations to apply V2G, the "why?" is an important aspect/question to consider when forming new business models. So, what are the underlying drivers and beliefs of this organization? This should be communicated to the end-user in a clear, transparent and simple way.

Additional notes
- Would like to receive the end result of research.
- Interviewee is a marketing expert (because of educational background and current career position) and, therefore, often provided useful input/insights about business models and marketing strategies. During the interview, CED7 provided various creative ideas on how to market V2G technology.

II.8 Report: Current EV driver 8 (CED8) – 31-10-2019

Interview information

Interview ID	**CED8**
Date of interview	**31-10-2019**
Gender	**Female**
Age category	**25-35**
EV ownership	**Purchased**
EV type	**Plug-in hybrid electric vehicle**
Current EV	**Mitsubishi Outlander**
Income category	**20,000-35,000**
Highest education level	**Bachelor's degree (applied sciences)**

Interview answers and main findings
For each of the 3 interview parts, the most important findings/points of discussion are presented below.

Part 1 – answers based on general questions
The interviewee has purchased a plug-in hybrid electric vehicle, namely a Mitsubishi Outlander PHEV. Initially, CED8 perceived the EV-stance of the hybrid as a disadvantage which was unnecessary. The reason was that she had no experience with charging and had a lot of uncertainties about charging. Furthermore, the first public charger in her residential areas was very far away.
After a while, she started to regret that she was not using the electric stance that much and she had looked into purchasing a private charger. However, that was quite expensive. Now, she has arranged that there will be installed a public charger soon. CED8 experienced this as a very time-consuming and bureaucratic process.
Currently, she is using the electric stance within the hybrid very often and tries to charge the battery as much as possible. This is mainly because she started to regret that she had this capability in her car but was not using it. And after experiencing driving electric, she became more enthusiastic.

In Dutch cities (e.g. Rotterdam) the charging infrastructure is highly mature and charges often when visiting clients. An important disadvantage is that the battery range is between 20 & 40 km.
CED8's opinion is that environmental aspects are quite important. But this was not the main reason for starting to drive electric or buying the hybrid. She was very enthusiastic about the car's design and looks. This has played an important role in purchasing it.
When asked about the ongoing energy transition and her opinion, CED8 mentioned that she would want solar panels on her next house. Her current experience with charging was that it is sometimes a hassle when being in a hurry (unplugging, rolling up cable,

etc.). She also experienced that in some cases, the charger was not working. However, the charger is user-friendly in general. An important last remark was that she often thinks: can I park the car and charge it for so long (thinking about occupying the charger).

Part 2 – Questions about V2G

The interviewee has a positive attitude toward the V2G concept as long as there are no additional monetary costs attached.
The interviewee stated that the V2G-concept could also cause parking space availability problems since it is the idea with V2G that you park somewhere and plug-in the vehicle as long as possible. Currently, in the ideal situation, you have to remove the car from parking space with a charger whenever it is fully charged. So, there is a higher chance that V2G chargers are occupied.
The interviewee does not perceive large barriers besides the risk that the battery is not fully charged when she has to make an unexpected trip. This should be solved or a way to deal with this should be found by the system developers

Part 3 – Questions based on the V2G example use case at long-term parking (e.g. at the airport)

Does not park the car for 3+ days. Goes often on holidays using the car.
The interviewee perceives the V2G at long-term parking application as a smart concept. Thinks that there are no major barriers for her to use it. The interviewee finds it an advantage that she does not have to remove her car from the charger when fully charged since high plug-in time is part of the V2G concept. Things that it is an ideal concept for business people making business trips often.
The interviewee has the intention to use the concept.
CED8 thinks that the V2G at home application is an "the ideal application". So, the combination of such a system with solar panels and electronic devices at home. An important last remark, the V2G concept (in combination with solar panels) might be less effective during winter.

Additional notes

- Would be interested to receive the end result of research.

II.9 Report: Current EV driver 9 (CED9) – 31-10-2019

Interview information

Interview ID	**CED8**
Date of interview	**31-10-2019**
Gender	**Male**
Age category	**25-35**
EV ownership	**Purchased**
EV type	**Plug-in hybrid electric vehicle**
Current EV	**Mitsubishi Outlander**
Income category	**35,000-70,000**
Highest education level	**Intermediate vocational education**

Interview answers and main findings

For each of the 3 interview parts, the most important findings/points of discussion are presented below.

Part 1 – answers based on general questions

The reason for purchasing the PHEV was that the interviewee became "In love with the looks of the vehicle". The existence of electric stance was an additional point/of secondary importance. CED9 found it a nice looking car and did not buy it because of the hybrid capabilities.
Currently, CED9 owns the vehicle for about 8 months. Does not drive often using the electric stance. It has a range of 40 km for electric driving. A remark that the interviewee made was that the process of requesting a public charger is quite a hassle and slow process.
The environmental aspects of electric driving are not of great importance.
The interviewee started to read a little bit about electric driving when they received it (how it works with charging etc.). However, does not perceives himself as concerned with the latest technological advances.

Part 2 – Questions about V2G

First response to the concept: "you have to be able to provide input about trip schedules and expectations about future trips".
The V2G concept does not influence his behaviour that much because he is driving a plug-in hybrid. In other words, CED9 mentioned that he is not dependent on electricity and can still drive also when the battery is low.
Would use it as long as there are no additional (monetary) costs attached.
The interviewee mentioned that "there may be accelerated battery wear", however, CED9 trusts that the battery technology will be far better in the near future.

CED9: “in the future, I believe that we will all drive electric and I believe that the V2G concept is part of a direction/future vision it will go to”.

Part 3 – Questions based on the V2G example use case at long-term parking (e.g. at the airport)

Never parks the car for 3+ days. Does not have experience with parking the PHEV or charging at the long-term parking of an airport. Mostly goes on holidays by car and making flight trips for his job is not needed.
The interviewee believes that most of the advantages are for the airport. Airports can generate solar panel during the day and store it so that it can be used overnight. To him, as an end-user, there must be compensation in place for possible battery wear.
CED9 does not perceive major barriers which would restrain him from participating in V2G. The interviewee believes that: “in the future, when a great part of the car fleet will be electric, there is probably no other option or choice for the consumer; It is either you cannot charge your car or have power/current issues so we cannot watch TV at night”.

When comparing the V2G office and V2G airport application, the interviewee perceives the essence or core of the concepts as the same. However, with the V2G at the airport application, the EV driver can better plan when returning to their car.
The interviewee thinks that he would use V2G chargers when becoming available at long-term parking. Assuming he would also start using long-term parking lots. At a certain point in time, you cannot get away from it. An important side note is that he would not use it for environmental reasons, but for societal reasons and that there is not another option.
The interviewee believes that the V2G home application might be the best concept, in combination with solar panels at home. Then it would be able to use solar power generated energy at night. CED9: “That would be a “cool concept” which I would find highly attractive”. However, the long-term parking application will be also high potential. However, the question is whether he will use it since he never parks his car at the airport.

Additional notes

- Would like to receive the end result of research.
- Despite the fact the interviewee did not purchase the PHEV for environmental reasons, he believes the V2G concept will be an important part of our future energy systems and energy grid. He would have the intention to use V2G as long as it does not result in additional (monetary) costs. Battery degradation is perceived as a risk, but the interviewee believes that the battery technology will be improved so that it is not an issue anymore.

II.10 Report: Current EV driver 10 (CED10) – 07-11-2019

Interview information

Interview ID	**CED10**
Date of interview	**07-11-2019**
Gender	**Male**
Age category	**46-55**
EV ownership	**Leased**
EV type	**Battery electric vehicle (fully electric)**
Current EV	**Nissan Leaf**
Income category	**>70.000**
Highest education level	**Bachelor’s degree (applied sciences)**

Interview answers and main findings

For each of the 3 interview parts, the most important findings are presented below.

Part 1 – answers based on general questions

<u>What do you think of driving electric in general? [EV attitude]</u>

The interviewee explained that driving electric was attractive mainly for financial reasons (low additional tax liability) in the beginning. Furthermore, CED10 expressed that driving electric is “lovely”. It is smooth, fast and is clean. After the first test drive, the interviewee was “sold”. Later on, the environmental aspects became more of an importance. The interviewee bought a house with a heat pump and 40 solar panels. The combination of charging EVs combined with 40 solar panels made it more a straightforward decision to drive electric.

<u>Charging and environment</u>

The environmental aspects regarding driving an EV became more important after a while. The interviewee charges the EV both during the day but also at night at his home. The interviewee finds it important that he uses “green electricity” for charging his EV but also for powering the house. However, the environmental benefits became of more importance at a later stage when the interviewee bought a house with 40 panels good for 10 MW energy on a yearly basis. The question is whether the interviewee would

install 40 panels himself. The solar panels already present, so why not use it? The main point is when it is available and it is readily available, the barriers are low and it also provides a good feeling. A feeling that you are contributing to something bigger.

What do you think about the ongoing energy transition?
The interviewee believes that the energy transition is important, however, thinks that the policy-side and how to manage it is a very complex and difficult thing. As mentioned, the interviewee has 40 solar panels (10 MW/year) and a heat pump. He likes to keeps track of the energy balance. The interviewee believes in investing sustainable technologies to stimulate it amongst the mass. The more green energy becomes available, the faster people will join the bandwagon.

Are you aware of the disadvantages of electric driving? Could you name as much as possible disadvantages? [EV knowledge]
In the beginning, the interviewee was anxious that the range was not enough of one fully charged battery. CED10: "Suppose, the battery is empty and you have to stop next to the highway". However, this feeling disappeared as soon the interviewee was using the car often and making also longer trips.
CED10 mentioned that the charging infrastructure is quite major but could be improved in the Netherlands. The existence of different energy providers and charging station brands made is sometimes complex to understand and arrange all the passes/cards. The interviewee explained that he also made some mistakes in the beginning (charging the car but forgot to pay the parking fee and received a fine for that).

Are you influenced by your environment to drive electric? To what extent?
Not at all the interviewee thinks. CED10 heard of positive stories but made the choice based on financial and practical reasons. After making a test drive, the interviewee was convinced.

How involved are you with the technological developments regarding electric driving? Are you always up-to-date? [Technological innovativeness]
Only following the news. Not actively involved. Started to read more about solar panels, e-mobility, heat pump and energy balance when he bought a new house where solar panels and a heat pump were already present and installed.

Part 2 – Questions about V2G

Concept of V2G [attitude]
CED10: "Assuming that it is technologically feasible, it is an interesting concept". The first question that emerged: "Is mobility suffering?". So the interviewee mentioned: "suppose that you have to make a trip, will there be discontinuity?".
At the other hand, the interviewee mentioned: "why should we not use an EV's battery for temporary energy storage when you are not using the car for mobility?". However, the interviewee mentioned that there may be alternative technologies (e.g. home batteries) that can fulfil the same purpose better.

Have you heard before of V2G? Have you used it already? [Knowledge V2G]
CED10 heard before of the Amsterdam ArenA that uses second-hand battery packs of Nissan Leafs for storage capacity. Was aware of the grid issues.

Idea of using the battery for grid services by companies or third party
As long as it is clear what the goals of this organization is. Preferably clarity about which organization you are helping.

Perceived behavioural control
Possible battery wear caused by charging and discharging. Is not a barrier so that he would not use the V2G service. As long as it is transparent and clear to what extent there is battery wear. And that there is someway of compensation for that. Preferably not real-time control (don't want to get notifications throughout the whole day). Thinks that weekly or monthly reports (in-car/smartphone) are enough to keep control. That it should/is technically managed that you are not facing an empty battery when want to make a trip.

Do you have an idea what could be done to overcome these barriers?
It should not be a hassle. And when I have to make an unexpected trip, I need to have enough state-of-charge. Furthermore, it should not be too different from regular charging. Generally, CED10 does not want that it is much different from regular charging. If it would become increasingly available, CED10 would use it (but the planning aspect and unexpected trips aspect should be designed well).

Part 3 – Questions about V2G example use case at long-term parking (e.g. at the airport)

Do you ever park 3 days or longer with your electric vehicle?

Yes, at Schiphol for making holiday trips or at home. The interviewee has 2 EVs (1 BEV and 1 PHEV). When going on holiday and the other EV is parked at home. Around 5 weeks per year.

What would you think of V2G at long-term parking? [Attitude]

Good idea. However, it is very important for CED10 is that it is communicated what the vision/plans of Schiphol. And that, by participating in V2G, there is a contribution to achieving the goals/plans. The financial compensation is less important compared to contributing and helping the airport with achieving its plans and goals. That would be one half of the motivation to participate. The other half would be, what happens with the battery? There should be clarity about that. Contributing to balancing the energy grid is not important to him. There are other industries that have very large energy peaks. What are these organizations doing?

Experience

The interviewee described the following process: "You drive to the long-term parking area. You park there. Plug-in the vehicle at the V2G system. You scan it with your card. Then you walk tot he departures hall. It should not be more complicated than that". According tot he interviewee, it should not contain more work or actions than with regular charging.

What would be the ideal V2G charger location for you?

The home application would be the ideal V2G application for the interviewee. Both CED10 and his family members do not commute (he often works at home). The long-term parking at the airport is also a "good concept". However, the interviewee explained that he won't use that on a daily basis. CED10: "Maybe public traffic/rail relays or train stations".

Additional notes

- Would like to receive the end result of research.
- Summary: Interviewee is quite positive towards the concept. Communication about why bi-directional charging is done should be very clear and simple. It must evoke the feeling that you are contributing to a greater good. The financial compensation part is less important and it should be no more of a hassle compared to regular charging.

II.11 Report: Current EV driver 11 (CED11) – 07-11-2019

Interview information

Interview ID	**CED11**
Date of interview	**07-11-2019**
Gender	**Male**
Age category	**25-35**
EV ownership	**Leased**
EV type	**Plug-in Hybrid Electric Vehicle**
Current EV	**VW Golf GTE**
Income category	**20,000-35,000**
Highest education level	**Bachelor's degree (applied sciences)**

Interview answers and main findings

For each of the 3 interview parts, the most important findings are presented below.

Part 1 – answers based on general questions

Driving electric

Since April 2019, the interviewee has a leased a VW Golf GTE (plug-in hybrid electric vehicle) which has around 46 km range. Before that, CED11 had a diesel car. In practice, the range is around 30-35 km. The electric stance is experienced as comfortable and pleasant. CED11: "Electric driving itself is fun: you have immediately power and torque".

Charging

The interviewee charges at the office and tries to charge as much as possible at public chargers at residential areas. But, the interviewee charges mainly at the office. The range of the vehicle is not enough to travel to and from the office, so charging should be done in-between. In the morning, he drives electric to work and then, the last 10-15 km, has to use the internal combustion engine. Nevertheless, the interviewee strives to drive electric as much as possible or using the combination (electric and ICE) stance.

Motivations driving electric (hybrid in this case)

The car was provided by the employer (the car became available in the pool). The interviewee mentioned that he drives electric because of the financial benefits (it was cheaper to lease compared to other car options). So, for the lower additional tax liability. Furthermore, the car provided more comfort and has nice looks. But it was mainly a financial consideration.

Environmental awareness

The interviewee tries to do small things in daily life regarding eco-friendliness, for instance, waste separation. The interviewee admits that he could that better. CED11 tries to reduce the use of plastics (less plastic bags).

The interviewee sometimes reads news articles about these kind of topics. However, it was not the main reason to choose for the hybrid car. The interviewee believes that "he has a nuanced point-of-view and looks at it from a global perspective".

Technological innovativeness

The interviewee believes that he is quite up-to-date about the latest technological innovations. As mentioned, the interviewee likes to read sometimes about charging, driving electric and how it is in other countries.

Part 2 – Questions about V2G

Attitude towards the V2G concept

The interviewee did not heard of V2G before. Heard of criticism about the grid and feasibility of charging the increasing number of vehicles in the coming years. Regarding vehicle-to-grid, the interviewee is quite positive. But the interviewee came up with alternative ideas. CED11's first question: why not storing energy within the electricity transmission houses in the local residential areas instead?

Perceived risks

According to CED11: people would have the same thoughts as with smartphones. If the smartphone is charged and discharged several times, the smartphone battery life reduces quite fast. The same is with cars. If my car is discharged from 100% to 50% several times, then the battery pack life is possibly shortened. I think it is important that this is communicated transparently and that people should get compensated for that.

The interviewee, however, does not perceive it as a very important barrier since the car is leased and is not fully dependent on battery (can also still drive using the internal combustion engine). But in case he will purchase an EV privately in the future, he thinks that he will care about this point much more.

Other perceived disadvantages:

- When you are not aware/up-to-date about when it is uncharged. Then you may face an empty battery. Proposed solution: fixed times for uncharging, notifications and "rules of the game".
- Additional costs for installation/fuse box adjustments at the office or at home (who pays what?). Proposed solution: Governmental subsidies or compensation for V2G installation, companies making investments in V2G (then he would participate faster),

Provided solutions

- Solution battery degradation: insurance/warranty on battery pack. When that is clear, he would faster willing to participate
- Solution unexpected trips: again, sort of "rules of the game" and fixed times when the car is discharging, agreement on not below a fixed state-of-charge

Control:

The interviewee thinks that keeping control is important. For instance, having a smartphone app or application in the car. CED11 would find it pleasant to see how fully the car is charged but does not want to have control about uncharging. CED11: "If you choose for V2G, you have to rely on that everything is arranged well by the service providing party. It is often the case that you also get other people that want all the benefits (compensation, driving electric), but giving energy back to the grid is too much or they won't participate in that. You participate or you do not participate."

User-friendliness

CED11: "The system must be user-friendly". This means no errors, always space for parking and charging/discharging, know when you can drive and when it is fully charged, good overview when it is fully charged, countdown clock for when the system starts with discharging, types of subsidy. If the provision of information and content of the information remains vague, then he would not participate as an early adopter.

Communication and PR

The interviewee believes that advertisements, YouTube movies with explanations, a pdf file with a short presentation (much visuals) are channels and ways to communicate the benefits, costs, risks and practical aspects to the end-user. CED11: "it should include: if you choose for this then this happens, what will change for the end-user, and what is in for them.

What companies could do to stimulate consumer acceptance of V2G:

CED11: "Ensure that there is enough parking lots and available chargers. Furthermore, provide clarity that it is fully charged at the next trip. Introduce "rules of the game" about discharging (e.g. fixed times for discharging) and transparency about what is happening and what will happen for the end-user".

Part 3 – Questions about V2G example use case at long-term parking (e.g. at the airport)

Previous experience long-term parking

CED11: "Yes at the airport". However, he has no experience with an EV at the long-term parking. But currently goes by train because the train connection is very well. He uses the car on a daily basis so it is never parked at home for 3+ days.

Attitude towards V2G at long-term parking

CED11: "Very good concept where I will participate in if his cars allows it". Thinks that the financial compensation aspect and discount on charging/parking tariff is an important advantage! What is in for me? This is perceived as very important by the interviewee.

Differences compared to the office application in terms of costs and benefits

The compensation aspect is more attractive in this case compared to the other presented case. It is not a hassle and you get compensated. Regarding the unexpected trips, that is not present in this long-term parking case. CED11: "Here it is not an advantage".

Risks participating V2G at long-term parking

Perceives hardly any risks regarding V2G usage at long-term parking. CED11: "The system developers know what kind of safety measures should be taken, the number of KWh they can use, how to minimize battery degradation, etc.". The interviewee: "I trust that these kind of aspects are arranged so that risks are minimized".

User-friendly Experience long-term parking, how it should be (description of the ideal process)

The interviewee described the following process: "I Arrive at the airport, follow the long-term parking signs (e.g. P3). Then I could choose: 'normal parking' and 'electric vehicle parking'. Then I drive to the V2G parking spots. I arrive at a gate and get a card there. The parking place will be assigned. I park at the assigned parking place, plug-in the connector to the car, walk to the bus (preferably electric) to go to the terminal". The interviewee mentioned that, if it is designed like this, he would have the intention to use it.

Ideal location

The interviewee proposed the following locations for V2G:

- Fixed taxi stands because taxi's are often waiting.
- Petrol stations would not be an ideal location because people are parking not long enough. The interviewee does not perceive that as a potential location.
- Event locations: concert halls or soccer stadiums. A lot of people come together and spend there a couple of hours. When people come back, there should be a rule that you are parked for a minimum of 2 hours because the possibility otherwise exists that the battery pack is not fully charged.
- CED11, last remark: "Hopes that it will be realized soon"

Additional notes

- Quite enthusiastic about the concept, very practical view on what should be in place and whatnot. However, has only experience with driving a plug-in hybrid. The interviewee mentioned that he drove a fully electric vehicle a couple of times.

II.12 Report: Current EV driver 12 (CED12) – 12-11-2019

Interview information

Interview ID	**CED12**
Date of interview	**12-11-2019**
Gender	**Male**
Age category	**46-55**
EV ownership	**Leased**
EV type	**Battery electric vehicle (fully electric)**
Current EV	**Tesla Model S**
Income category	**>70,000**
Highest education level	**Master's degree**

Interview answers and main findings

For each of the 3 interview parts, the most important findings are presented below.

Part 1 – answers based on general questions

Motivations to drive an EV

The interviewee drives a Tesla Model S. CED12's main motivation to drive electric was because of its financial advantages regarding low additional tax liability. According to the interviewee, electric driving is comfortable, noiseless and pleasant. The environmental aspects to drive electric did not play a large role when choosing for the EV. It was mainly a financial decision.

Charging experience and behaviour

The interviewee has experience with travelling to other countries with the EV and mentioned that he had no troubles with charging. The interviewee mostly charges at the office (2 locations Rotterdam and Den Bosch). To the opinion of CED12, the charging infrastructure in the Netherlands is good and he had not faced problems with charging (despite the fact that he is travelling a lot).

Technological innovativeness

The interviewee mentioned that he is not actively trying to stay informed about the latest technological developments regarding EV. He mentioned that he is currently looking into whether to install solar panels at home or not (has an interest in it). But, he just uses the car and is not involved in forums or social media channels regarding electric driving. Follows Tesla in the news.

Part 2 – Questions about V2G

Attitude towards the V2G concept

On a conceptual level (as presented), the interviewee perceives the home application as a good idea where you can temporarily store energy at your home, in combination with solar panels. CED12: "It might be an additional service provided by the energy company." However, he has doubts about whether there are actual economic benefits since it is about tens of cents per kWh. Furthermore, he has doubts whether these potential economic benefits would be appealing to him and would convince him to participate in V2G.

Comparing home and office application

To the opinion of CED12, regarding the office application, the office would not be a good use case since there are a couple of perceived barriers. The interviewee mentioned that he drives a lot during the day and has to make unexpected trips sometimes. CED12 has doubts whether that will work for him and thinks that it would be less suitable for him.

Perceived benefits

On the other hand, the interviewee perceives more benefits for the home application in combination with solar panels. The interviewee mentioned that he parks and charges his car overnight often. Then, the battery pack in the car could be used to deliver back energy (e.g. to power the dishwasher) and to charge the vehicle using cheap electricity. However, the interviewee mentioned that he is not at home often during the day (at times when the solar panels are generating electricity).

Perceived costs

Initially, battery degradation is a perceived cost by the interviewee. The interviewer: "What do you think of extra battery charging and discharging cycles?". The interviewee: "I would do a comparative assessment and then that would be a purely economic decision, so again, what's in it for me". So the interviewee thinks that the costs of battery wear should be arranged in the compensation aspect. Furthermore, it should be also technically arranged that charging and discharging has a low impact on battery life. However, the interviewee has uncertainties regarding whether the feasible financial compensation could be enough to compensate for caused battery wear. CED12: "you should make up the business case because I currently have doubts regarding that".

Last remark interviewee about target groups for V2G: Tesla drivers group

Last remark of interviewee; the interviewee thinks that a large part of the Tesla group/drivers would be less appealed to the V2G concept compared to people that drive electric for environmental reasons or being an innovator or pioneer.

Part 3 – Questions about V2G example use case at long-term parking (e.g. at the airport)

Previous experience long-term parking at airports

Has experience parking with long-term parking at the airport: both valid parking (P6) and "nearby parking". The interviewee finds it important that the parking areas are nearby the departures hall. Does not want the need to take the bus to the departures hall.

Financial compensation V2G at long-term parking

Regarding V2G and compensation: discount on parking tariff is appealing to the interviewee, however, parking and charging should not be more of a hassle compared to the current situation.

PR and communication to the EV driver

About V2G and communication: the interviewee explained that it should be communicated as simple as possible that you are contributing to something. On a second thought, the interviewee does not care much about how it should be communicated, as long as charging works and there is a fully charged battery when returning to the car. The interviewee made a remark that it would be interesting to see how much you contributed in terms of GHG emissions and to what extent you have compensated for the flight trip you have made

Control

Does not want to keep control. Just wants a quick view about what he contributed when returning to the car (when returning to vehicle after the flight trip). Furthermore, the interviewee wants his battery to be fully charged when returning to his car after a business trip or holidays. To his opinion, that is the most important aspect.

Ideal location

The interviewee believes that the ideal location for V2G would be at at the valid parking, where he usually parks his vehicle at the airport. The home application is a good location; That it is connected to the energy contract and solar panels. Lastly, the idea of storing the energy which you generated with your own solar cells is appealing. The interviewee mentioned twice that he believes that he is not the right target customer for this (see additional notes).

Additional notes

- Interviewee mentioned himself that he considers himself not as the right target group for this V2G concept. He explained that he would not participate in V2G for financial compensation (does not need it). Also, the other advantages (e.g. the environmental or grid balancing) are not that convincing enough to him. Later in the interview, the interviewee adjusted his view by explaining that the home application of V2G would be appealing if it is part of the private energy system at home (in combination with solar panels and the energy contract). However, the interviewee explained that he would expect that this concept would be more appealing to people who drive electric from an environmental point-of-view/that are highly environmentally-driven.

II.13 Report: Current EV driver 13 (CED13) – 12-11-2019

Interview information

Interview ID	**CED13**
Date of interview	**12-11-2019**
Gender	**Male**
Age category	**46-55**
EV ownership	**Purchased**
EV type	**Battery electric vehicle (fully electric)**
Current EV	**Tesla Model 3 (LR AWD)**
Income category	**>70,000**
Highest education level	**Bachelor's degree (applied sciences)**

Interview answers and main findings

For each of the 3 interview parts, the most important findings are presented below.

Part 1 – answers based on general questions

Motivations for driving an electric vehicle

The interviewee mentioned that it was a combination of reasons or arguments.

- The interviewee has a great personal interest in e-mobility and that it is "a cool and new innovation". CED13: "Tesla made some great steps regarding battery technology". The interviewee mentioned that he has chosen the Model 3 over the Model S because he does drive much(/enough) kilometres.
- For fiscal/financial reasons (additional tax liability) and it was a business consideration.
- It is part of the whole energy transition and it provides a feeling that you contribute to lower tailpipe emissions and a better living environment.

Energy transition

From the interviewee's viewpoint, a good living environment and sustainability aspects are important issues. Also, the energy transition is an important topic for the interviewee. However, the interviewee admits that these topics are not top of mind or having his main attention. The interviewee does not have solar panels at home. But, has plans to install them next year.

Technological innovativeness

The interviewee makes sure that he is up-to-date about e-mobility and the latest developments regarding Tesla. The interviewee is active in various social media channels and forums. The interview has read various publications and even scientific publications (e.g. about battery technology).

Previous charging behaviour and experiences

The interviewee mentioned the following about charging at home, at public charging stations and fast chargers:

- Home charging: does not do that yet. The interviewee has planned to install a charger on the driveway at home.
- Public chargers: charges at charging stations in the residential area (area where he lives), charges at the office, or at other public places such as at the metro station. The interviewee mentioned that he chargers most often at the office. Sometimes charges at the metro station when the interviewee takes the metro to the office.

- Fast chargers → does not use that quite often because he drives not that much KMs.
- The last remark of CED13 regarding charging infrastructure: "In the Netherland, the charging infrastructure is highly mature. Charging has been made very simple for the Dutch EV driver"

Part 2 – Questions about V2G

V2G concept familiarity

The interviewee is highly familiar with the concept. CED13 read about the concept on the internet and has developed a personal opinion about it.

Attitude towards the technology

- The interviewee thinks that it is a great concept from a technical perspective, but the interviewee hopes that it will be never realized the coming 10-15 years.
- CED13 believes that it is purely from the perspective of: "V2G is technically feasible. So, let's work that out". The interviewee believes that this motivation or this perspective is not the right perspective or reason to develop an innovation.

Perceived costs and risks

The interviewee mentioned the following reasons why he hopes that it won't be realized in the coming 10-15 years:

- Battery degradation: if discharging for V2G-mode is done only a couple of times per year, then it would be acceptable. But if you do V2G on a daily basis (hundreds of times per year), the interviewee believes that the battery pack will be damaged.
    - CED13: "An EV has a couple of thousand charge/discharging cycles. Suppose you charge and discharge 200 times per year for V2G-mode, then after 5 years, the vehicle's battery pack is significantly degraded due to V2G
- Charging/discharging-dependant on planning
    - What happens when I have to make ad-hoc trips?
    - CED13: "There exists a chance, especially with business people, that unexpected trips should be made. Then you don't want that the vehicle's battery is low".
- Suppose this is realized, mass acceptance of electric driving (among the public) will become even more difficult
    - Currently, sometimes there are quite aggressive reactions of non-EV drivers. The interviewee believes that this is a problem for mass-adoption of EVs. CED13: "The car is often part of a person's identity and it is a status symbol". The interviewee believes that when EV will be used for powering the grid as part of the energy transition, the public oppression against EVs will become even bigger and acceptance of the energy transition also negatively influenced.
    - In parallel, the interviewee believes that oppression against EVs also negatively affects how the public will react to V2G.
- Current practical problems regarding V2G and its implementation
    - Standards: hardly any car that supports it. The interviewee believes that only CHAdeMO equipped cars can support it.
    - CED13 belies in better alternatives (e.g. home battery packs or hydrogen storage) for solving grid balancing problem

V2Home

The interviewee has a more positive attitude regarding vehicle-to-home applications. CED13: "in case that an EV driver uses the battery pack for own consumption sounds more acceptable to me and is more likely that it will be a success". The interviewee: "then you can control everything yourself and you store the energy that you have generated with your own solar panels".

Financial compensation

The interviewer asked the interviewee to reflect on the effect of financial compensation on his willingness to participate in V2G.

- Financial compensation does not influence the interviewee's willingness to participate.
- The interviewee does not believe that financial compensation could be realized which is enough to compensate for the degradation of the battery
- The interviewee believes that range anxiety is increased by V2G and could not be compensated

Lease/private owned EV

CED13: "Probably, people with leased care less about degradation of the battery because they can choose a new car after 3-5 years. However, the goal of the energy transition is that these vehicles will be used on the second-hand market afterwards and that the batteries may be re-used for different purposes. After 3-5 years when the EV enters the second-hand market, it has a lower value due to battery degradation caused by V2G operations". The interviewee has planned to drive around 10 years in the current EV which is privately owned.

The interviewee has knowledge about that it is best to charge and discharge between 20% and 80% state-of-charge. CED13 tries to live up to that/take that into account while charging as much as possible.

What would play a role to drive acceptance of V2G for you

The interviewee stated that it is not very likely that he will accept V2G and make it part of his daily routines. The interviewee believes that it is the first step that most electric vehicle support V2G. Then, the interviewee wants a larger battery capacity, so that the EVs have a larger range (interviewee mentioned 900 KM). In that case, a small percentage (e.g. 10-20%) of the battery capacity can be used for discharging. Furthermore, the batteries have to be developed and produced in a way they do not suffer from battery degradation or are less vulnerable to battery degradation. Furthermore, agreements should be made about a minimum state-of-charge (do not go under 50% state-of-charge for instance, the interviewee mentioned).

Control

Assuming most of these points can be realized, there exists a chance that the interviewee considers to use V2G incidentally. In the case of the V2G home application, the interviewee wants to have full control over the energy system and discharging of the battery. So, CED13: “control is a very important aspect”. The interviewee likes the idea of when there is overcapacity of solar energy at home, then you could charge your vehicle and discharge it later during the day. An important precondition is that the energy is used for own consumption (not that other people use the energy).

Part 3 – Questions about V2G example use case at long-term parking (e.g. at the airport)

Previous experience regarding long-term parking

Uses at least 2 weeks per year long-term parking at an airport. Does not have previous experience with charging at long-term parking yet.

Attitude towards V2G at long-term parking

Long-term parking concept is valid on the conceptual level. CED13: “It is a logical concept, but only on the conceptual level”. The interviewee still perceives the disadvantages as described in part 2, especially with battery degradation and practical problems. However, the interviewee noticed that the ad-hoc trips problem is not present in this use case. However, CED13 thinks that there are better alternative energy storage technologies (e.g. hydrogen) which are more suitable for companies such as airports. But still, CED13: “if my car would support this, then I would cut a wire so that it is not able to do V2G. I just don’t want it. In the short-term, there are too many disadvantages”.

Overcoming perceived V2G barriers

At first glance, the interviewee mentioned that there are hardly things that companies could do so that CED13 would accept V2G at long-term parking. CED13: “none can come up with solutions so that my problems are solved. For instance, none can produce a battery that will provide a 900 km range or is resistant for battery degradation”.

On a second thought, there were a couple of things that would make it more acceptable for CED13. In other words, the interviewer explored various elements that could be done so that CED13 may accept V2G at long-term parking. These are discussed shortly:

- The interviewee noticed that the problem of additional planning and the chance of an unexpected trip is not a problem in the long-term parking use case anymore.
- At all times, the interviewee would want to have control over the amount of discharging cycles while it is parked at long-term parking. Setting a minimum amount of charging and discharging cycles would make it more acceptable. The interviewer asked for the amount of discharging cycles. The interviewee mentioned that, in one week, not more than 2 charging and discharging cycles would be acceptable. This will partly take away the concerns regarding battery degradation and then would be an option.
- The interviewee would expect compensation in terms of free parking.
- There should 4-5 fast-charging stations next to the V2G charging stations. This will remove the range anxiety.
- The option for opt-out should be available! This should be respected at all times
    - (of course, if you opt-out, you won’t get the benefits of V2G at all)

Last remarks interviewee

- CED13: “The initiative is fantastic and also that researchers are working on these kind of innovations. The energy transition should be pursued at all times”.
- However, the interviewee has a couple of perceived problems why he thinks that V2G will not be realized on the short-term. A couple of barriers should be solved before it can be rolled out on a large-scale
- The interviewee made the last remark that he does not want to discourage research in this field.
    - Hydrogen and other energy buffers, for instance, should be further explored, tested and investigated.
- The interviewee believes that the V2G concept, comparable with the ‘static home batteries’, thus, the V2G at home application has the most potential.

Additional notes

- Would like to receive the end result of research.
- Interviewee likes the V2G concept on a conceptual level. However, CED13 hopes that it won’t be realised.
- During the interview, it was explored what could be done so that CED13 would accept V2G, especially for the long-term parking application. The interviewee does not want to participate in V2G on the short-run because of possible battery degradation, especially does not want to participate with the current owned EV (given de range and battery capacity). Battery technology should be improved first. Certain agreements (e.g. in contracts) have been explored about the type and amount of compensation, minimum state-of-charge (lower limit) and maximum discharging cycles (e.g. in one week) and charging and discharging between the boundaries of 20% and 80% state-of-charge. These elements would influence the EV driver’s acceptance. Nevertheless, the interviewee would not use V2G at other locations, only at the long-term parking occasions.

II.14 Report: Current EV driver 14 (CED14) – 14-11-2019

Interview information

Interview ID	**CED14**
Date of interview	**14-11-2019**
Gender	**Male**
Age category	**36-45**
EV ownership	**Leased**
EV type	**Battery electric vehicle (fully electric)**
Current EV	**BMW i3S**
Income category	**>70,000**
Highest education level	**Bachelor's degree (applied sciences)**

Interview answers and main findings

For each of the 3 interview parts, the most important findings are presented below.

Part 1 – answers based on general questions

Motivation for driving an EV

Currently, the interviewee has two EVs in the household. Two aspects were important why the interviewee started to drive an EV. First, it was a new type of car on the market and the interviewee found e-mobility very interesting and wanted to contribute to the technological development of the car. Second, driving an EV was mainly also for financial reasons (additional tax liability). The interviewee mentioned that the environmental aspects played a little role, but admits that he realizes that there is a shift ongoing in mobility.

Experiencing an EV

Comparing it with a fossil fuel car, it is much more comfortable and even relaxing. Furthermore, you have to make stops more often, which results in that you are less stressed when arriving at the destination. You drive 1,5 hour and then you have a break.

Motivations for participating in the research

Wants to contribute to knowledge generation and researches where possible. A couple of things were unclear when the interviewee started driving electric. The first was how fast you charge at a certain charger. There are many uncertainties among the public regarding e-mobility and knowledge & information provision could be improved. The interviewee believes that a larger part of the public still do not know what e-mobility is, what the advantages are and the disadvantages. By contributing to researchers, the interviewee hopes that more information becomes available for the public.

Charging behaviour and experiences

- Fast charging → good experience and it is relatively simple. At certain parts, the charging infrastructure could be improved (e.g. Tilburg-Eindhoven-Roermond and German border and Koln).
- non-fast charging (AC) → the experience is that public chargers are often occupied or even do not work. Uses this only when really necessary.

Technological innovativeness

The interviewee thinks he is very much up-to-date about technological developments regarding e-mobility. Likes to read about new innovations in e-mobility, new technologies, infrastructure. Also more technical topics such as battery technology, e.g. active cooling.

Battery degradation and battery life

The interviewee's experience is that battery degradation is very small. The interviewee noticed a difference of 0,1 kWh after 100,000 kilometres driving and thinks that battery degradation effects are very small. Also used fast chargers very often. In other words, the interviewee did some experiments himself to measure battery degradation (based on information BMS).

Part 2 – Questions about V2G

Attitude towards V2G

The interviewee thinks that it is a smart concept. He is not fully sure whether it is the best solution that EV will be used for this but believes that you can use second-hand battery packs (for instance) to install at your home.

Perceived benefits

The interviewee mentioned that compensation is an advantage. However, does not perceive much more benefits from a user perspective.

Perceived risks

- Who receives the compensation? CED14: "Suppose that I fully charge (95%) my EV at a fast charger, using the charging pass of the employer. And then connect the EV to the V2G system at home. What happens with the compensation and costs of charging? Then I use energy where my employer paid for."

- Another uncertainty the interviewee had was regarding energy trading. CED14: "Suppose that you purchase energy for quite a high price and deliver it back when the energy price is quite low. Then you lose money."
- No technical risks for the vehicle (no battery degradation)

Perceived costs

The interviewee believes that it limits the end-user in certain aspects. For instance, CED14: "What happens when I want my car fully charged at a moment in time. But the system had decided to uncharge. Then my battery is not fully charged".

Control

- There must be a way to provide input when you want to charge and discharge. Input about the expected next trip.
- The interviewee suggested the possibility to opt-out; the possibility for the EV driver to say: "at this moment no discharging".

Part 3 – Questions about V2G example use case at long-term parking (e.g. at the airport)

Previous experience long-term parking

- Has one time experienced long-term parking at the airport
- No charging possibilities at that time

Attitude towards V2G at long-term parking

First of all, the interviewee perceives it as a "smart concept". However, does not think he would use it that often. First of all, the interviewee goes on holiday by car mostly (e.g. ski trips) and he has to carry much gear for winter sports. And has a holiday caravan.

Difference 2 use cases

Does not perceive differences. Would have the intention to use both situations because he perceives the advantages in both cases. Energy provision is a challenge. That is also the reason why energy overnight is cheaper than during the day. If you can add battery capacity to the grid, you can help to balance the system. Furthermore, by aggregating the battery capacities of different cars, you have huge storage capacities available. The system's benefits would trigger the interviewee to participate in V2G systems, no matter what location.

Short-term parking

Initially, the interviewee mentioned that, when the battery is fully charged, he would less likely plug a V2G charger in the EV. But later on, the interviewee mentioned that when V2G becomes also available at short-term parking lots, he would plug it also in at such places. The interviewee perceives the advantages of societal contribution and getting a good feeling, which is also an advantage of the system.

Ideal location

V2G at the office would be the best place in the interviewee's case. The interviewee does not need the full battery capacity and is almost 5 days per week there. At home, it would be less attractive because the interviewee makes more trips where he needs a fully charged battery when leaving home

Influence attitude towards technology → actual usage

The interviewee thinks that actual usage does not influence the attitude. CED14 mentioned that he likes innovations and trying new stuff. For the interviewee, he is initially enthusiastic about something and then he will try it. The other way around is less present, the interviewee thinks. The interviewee thinks he could make other people enthusiastic about new technologies.

Last remark: does not want another smartphone app for V2G. Should be integrated into existing smartphone app which is delivered with the car.

Additional notes

- Would like to receive the end result of research.
- The interviewee has a positive attitude towards V2G. However, is also critical and perceives various challenges. But CED14 believes in such systems, and that they are necessary to contribute to the ongoing energy transition.

II.15 Report: Current EV driver 15 (CED15) – 19-11-2019

Interview information

Interview ID	**CED15**
Date of interview	**19-11-2019**
Gender	**Male**
Age category	**56-65**
EV ownership	**Purchased**
EV type	**Battery electric vehicle (fully electric)**
Current EV	**Tesla Model S**
Income category	**Does not want to say**
Highest education level	**Does not want to say**

Interview answers and main findings

For each of the 3 interview parts, the most important findings are presented below.

Part 1 – answers based on general questions

Background interviewee

CED15 is an entrepreneur in e-mobility and smart mobility. The interviewee helps charging companies with finding the right locations for installing charging stations and new propositions. The interviewee also has a high personal interest in solar energy and charging infrastructure.

CED15 is currently working on a smart charging project in the Netherlands where a parking lot is going to be rebuilt into a smart charging station next to both a Shopping mall and residential area. The idea is that, during the day, people who visit the shopping mall can park and charge their car. People living in the area can park and charge there overnight.

Motivation for driving an EV

- CED15: "Technology is very cool". That is the most important motivation.
- Driving itself is very comfortable: silent, noiseless, good performance.
- Tesla concept and brand was very appealing to the interviewee
- Sustainability, eco-friendliness and the fact it is the future of mobility are side-issues

Experiencing an EV

- Noiseless, fast car
- In the very beginning: range anxiety. However, this faints away quickly. The interviewee mentioned that he immediately noticed how reliable it is to drive electric. CED15: "Charging infrastructure very reliable (also in South of Europe)".
- Interviewee tested also fast-charging in Germany and different charging providers.
- Tesla has a reliable charging infrastructure. The interviewee experienced one time that a fast charger was occupied.
- CED15: "you have to experience EV driving, how charging works. Then you quickly notice that it is very reliable".

Charging behaviour and experiences

- Charging behaviour interviewee: 80% at home, 15% super charing on the road, 15% at other places.
- Sometimes has to drive long distances (e.g. to Groningen). Then, the interviewee has to stop at a fast charger.
- At home, the interviewee has a home charger with a type-2 plug attached. In 5 years of driving electric, it occurred 2 times that he forgot to plug-in the charging cable at home.

Technological innovativeness

- The interviewee follows Tesla as a company, follows the competition of Tesla.
- Up-to-date about charging infrastructure and available products on the market.
- The interviewee considers himself as highly up-to-date and is part of his job.

Influenced by the social environment

The interviewee believes he is not at all influenced by his family, friends and relatives. The interviewee believes he is an innovator. CED15: "it was the other way around, I influenced other people to drive electric".

Part 2 – Questions about V2G

Attitude towards V2G

The concept is "okay". The interviewee finds it a pity that it starts with the perspective of the grid operator. He does not agree. For every stakeholder, there has to be something in it, especially the end-user. The end-user is most important. He will experience the technology. But the most important question: What's in for the end-user?

Alternative technologies

The interviewee perceives static fixed batteries (e.g. at parking stations) as a better solution. A big barrier according to the interviewee; CED15: "the concept is logical and is okay, but it is the question whether battery technology developments are going too rapid and that the battery price is lowering quick. Then it would not make sense to create energy storage capacity using the battery packs in vehicles. If the battery prices are lowering, then everyone will have a home batter in no-time. I believe this might be a reason why EV manufacturers and OEMs are reluctant to make their cars V2G supporting."

Perceived benefits

- The interviewee believes that monetary compensation (e.g. cheaper energy, free parking) will stimulate and encourage him to use V2G.
- The advantages for the grid operators to balance the energy grid and do peak shaving are highly present in the V2G concept.
- Interviewee believes that the benefits of V2G for other stakeholders are still neglected. CED15: "smart charging does not have a user-side yet. If there are no concrete and practical advantages are present for them, they won't use it most probably".
- Another perceived benefit would be providing the option or service to balance the battery once in a while using V2G. The interviewee believes that balancing the battery makes the battery more accurate again. CED15: "people that charge and discharge the EV always between 50% and 70% will ultimately have a battery which 1) you cannot fully charge anymore or 2) where the battery quickly drains quickly under a certain percentage (let's say 50%). Then, as an end-user, you can decide to balance the battery". This may be another proposition or service offer proposed by the interviewee using V2G.

Perceived risks / Perceived costs

The interviewee thinks there are different groups of EV drivers. CED15: "Most of them are early adaptors. But, how will it be when the large mass will drive an EV. What do they think of V2G and the underlying motivations and technical advantages and purposes?". CED15 added: "the current EV driver is an early-adopter and still a pioneer".

Furthermore, do the car manufacturers provide warranty on the battery packs when participating in V2G? I believe that V2G fosters battery degradation and the end-users should be compensated for that or receive extra guarantee/warranty or maintenance on the battery pack.

Acceptance

- In a business-setting, the interviewee thinks that V2G can be 'part-of-the-deal' of driving a leased EV. The employer makes sure that you can make your trip home. The interviewee perceives the V2G at the office application as a good proposition. So, it is part of the lease contract.
- For regular consumers, it is different he believes. For them, V2G home application or at public places (e.g. supermarket) would be more suitable or even appealing. In this case, you have to be clear about the benefits and risks to the end-user and how it works.

Control, user-friendliness, communication

- Communication about the benefits, risks and how the system works are important aspects, according to the interviewee. Furthermore, user-friendliness should be in place at all times. CED15: "Providing input about scheduled trips should be done in an app easily so that you can do it from your couch".
- The interviewee believes that it should be integrated with existing EV apps or parking apps. CED15: "you can better have 1 app than all separate smartphone apps".
- There is no European standard and protocol in place for this. You need other organizations and authorities to generate such standards.
- The interviewee has experienced a pay-as-you-go solution for charging in Italy. You can make reservations in advance. The interviewee believes that is part of the future of charging.

Part 3 – Questions about V2G example use case at long-term parking (e.g. at the airport)

Previous experience long-term parking

The interviewee has no previous experience with long-term parking at airports. CED15 lives nearby Schiphol, so would take a taxi to the airport.

Attitude towards V2G at long-term parking

Compared to the V2G at office application, the long-term parking use case makes more sense to the interviewee. The interviewee has a remarkable more positive attitude towards V2G at long-term parking. The V2G operation managing authorities could better ensure that the car is fully charged when the driver returns to the vehicle.

Furthermore, the interviewee is triggered by the compensations in terms of charging discounts and discount on parking tariffs.

Perceived risks/costs

The interviewee perceives risks regarding the impact of V2G on battery degradation. CED15: "most probably, many EV drivers don't care about battery degradation. Especially, drivers who have a leased car. Personally, I would care about this point. I just want to be careful with the battery and don't want that range of the car decreases".

The interviewee is highly up-to-date about the number of charging cycles and that charging and discharging between the boundaries of 20-80% is better for the battery.

Control

Control of the end-user is an important aspect of V2G systems. The interviewee again mentioned that a smartphone app would help to provide the possibility to control charge/discharge operations. CED15: "it would be also nice to have an overview in the end about the amount of kWh's that went into the battery and are used by the airport. You can also say something about the healthy charge rate".

Customer/EV driver profiles V2G at long-term parking

The interviewer and interviewee discussed different V2G customer (EV driver) profiles. The interviewee proposed a beginner/expert mode. He believes that different profiles should be created of potential end-users of V2G. The interviewee proposed the following customer profiles:

- Average EV driver group: People who do not care as long as their battery is charged and they can make their trips. These are mostly people with a leased EV.
- Informed & interest group or expert group. People that are highly up-to-date about the latest technological developments.
- The critical group. People in this group are really careful about their car and internal hardware and software. CED15: "don't touch my stuff!"
- Ideological group; people who are environmentally-driven and that feel attracted to things such as GHG-emission compensation, etc.

User-friendliness of V2G at long-term parking

In order to make V2G as user-friendly as possible, a smartphone app is an option, according to the interviewee. CED15 mentioned that it should be avoided that people have to download another app and have to subscribe and such things. The interviewee believes that this will raise the bar for people to actually use it.

According to the interviewee, another option would be to install a display at the charger and a smartphone app for frequent users. In the display, the end-user is presented with a couple of choices (e.g. when you expect to leave, how much KM you will need then, whether you want to participate in an energy sharing project). The interviewee believes that there should be a 'frequent-user/expert mode' and a 'beginner mode'. More information is provided to the beginners or people who try it for the first time. CED15: "the explanation of the system has to be simple and to-the-point. It is a possibility to somehow be transparent about the risks (e.g. battery degradation) and how there is dealt with these risks".

Lastly, in the ideal situation, a standard should be developed with standardized interfaces (e.g. an application standard). This could be in the form of integration with a parking application or car application with several basic steps in the process.
Lastly, an additional mode must be included which is the option for op-out. For people who don't want to participate in V2G or do not care about it. Certainly in the early stages of development.

Ideal location V2G

The interviewee perceived several locations as high potential for V2G

- Soccer stadiums because you spend a couple of hours there and that, as an EV-driver, you support your club by providing energy.
- Amusement parks where you spend around 8 hours a day. Furthermore, a lot of EVs are parked there simultaneously.
- Short-term parking places (e.g. supermarkets, theatres or shopping malls); The interviewee thinks that is more suitable if the EV driver lives nearby. The idea of bringing energy to another place would be very much a trigger for idealogical EV drivers. The interviewee wonders how the average EV driver responds to that.
- Less potential use case: V2G charging stations next to highways (e.g. at petrol stations or highway stopping places). CED15: "EV drivers want to charge their car at a fast charger as quick as possible".

Additional notes

- Would like to receive the end result of research.
- Interviewee is an expert in e-mobility and an entrepreneur in this field.
- Discussed a V2G location application matrix. The interviewee referred to different types of smart charging from Elaad: 1) standardized, 2) accelerated, 3) delayed, 4) paused, 5) delivering back. Interviewee proposes to include charging speed and power in the matrix.

II.16 Report: Current EV driver 16 (CED16) – 21-11-2019

Interview information

Interview ID	**CED16**
Date of interview	**21-11-2019**
Gender	**Male**
Age category	**36-45**
EV ownership	**Leased**
EV type	**Battery electric vehicle (fully electric)**
Current EV	**Jaguar iPace (high specification / performance model)**
Income category	**>70,000**
Highest education level	**Master's degree**

Interview answers and main findings

For each of the 3 interview parts, the most important findings are presented below.

Part 1 – answers based on general questions

(Professional) background of the interviewee

The interviewee worked at energy companies and has a technical background. Currently works at a Dutch grid operator focussing on IT and security. The interviewee drives an EV and previously a diesel car. Likes to travel a lot by car for his hobbies: hiking, camping in the Alps. Therefore, it was a big transition to drive electric.

Driving an EV

CED16: "it is a new technology which is interesting". The interviewee previously drove a diesel car and currently has a Jaguar iPace. The main reason to choose for this car was that it is able to pull a folding trailer for holidays. The second reason: it had to be able to drive a 250 km range in all (weather conditions). Currently, the interviewee has the Jaguar iPace for about one year and has a 'formal' range of 470 km.

Motivation to drive electric

The interviewee likes to look into new technologies and has a large interest in the technological developments regarding e-mobility. His main motivation was that it is new and wants to experience how it works. It is not financially more attractive compared to the previous vehicle. So that did not play a large role. Sustainability: did not play a role. CED16: "if you want to drive an EV for environmental reasons, you should not choose for a Jaguar iPace (energy consumption high)". CED16: "however, I changed my energy contract to make sure the electricity for the car comes from wind, solar and hydraulic power plants only to limit the impact of the high energy consumption on the environment".

Technological innovativeness

Considers himself as a pioneer/innovator. Compared to other people with an iPace in social media groups, the interviewee thinks that he has much knowledge about the technical aspects of EVs and charging infrastructure. Believes that you need quite much technical knowledge if you want to drive electric (e.g. choosing the right charger).

Charging experience

- 95% home charging
- 5% at public chargers (AC)
- Used a fast charger 2 times
- For at least this year, tries to avoid long trips charging outside the Netherlands
- Jaguar is not so well yet for fast charging. It takes for instance 1,5 hours at a fast charger outside the Netherlands (ionity).

Energy transition

Works at a Dutch grid operator. Has a vision about the energy transition. The interviewee believes that we have to go from non-renewable resources to the use of renewable resources (deal with raw materials differently). The interviewee thinks that electrification has a large impact on the electricity grid. The interviewee mentioned 5-10 times higher energy consumption due to electrification (compared with before having an EV). This applies to the interviewee's household. Based on the entire year, this is approximately 5 times the regular energy consumption (from 2000 to 10,000 kWh per year). CED16: "Days on which I charge after a long-distance trip, I use 10 times the amount of energy than I consume on a daily average. So it is between 5-10 times higher energy consumption".

The advantage of charging at home: you have much time to charge batteries the batteries (overnight charging). You can arrange when the EV should be charged in order to avoid large peaks. CED16: "if everyone comes home from work and starts charging at 6 PM, this results in large peaks in the energy grid". A combination of postponed charging, load balancing would be necessary. Aggravate the grid is costly.

A disadvantage with EVs with large battery capacities and high energy consumption is that you need every minute to charge your EV overnight. You cannot afford it to not charge for a couple of hours and especially not use the battery for discharging. However, the interviewee still thinks that there are many opportunities when the battery capacity is not fully needed for driving (e.g. people that drive a low amount of KMs per day, let's say 50 KM/day).

Remark of interviewee

- The Netherlands is special: Type of charging infrastructure (charger types → 3-phase chargers) is not suitable or appropriate for the type cars (1-phase) in the Netherlands.
- Within the iPace end-user group much uncertainties about charging (where to charge, which charger, technical aspects, etc.)

Part 2 – Questions about V2G

V2G attitude

The interviewee perceives V2G as a promising concept that potentially solves a number of problems. Especially when it comes to the difference between the amount of energy needed for the car and the energy needed at home (flexible charging). Increased charging of EVs, increased usage of renewables has a negative impact on the grid. The interviewee: "It is not only about energy availability, but also about transport capacity". However, perceives also challenges.

Perceived challenges V2G

- Numerous challenges perceived by the interviewee with regards to V2G:
    - Is the place where you park the car most often also the location where there is (always) high energy demand? Or is there still energy transport capacity needed? A transport capacity issue remains.
    - Not much is known about battery degradation/total amount of charging cycles. The interviewee has knowledge about that li-ion batteries, in the ideal situation, are used between 20% and 80% state-of-charge (better for the battery).
    - Ease of use for end-user → having always a fully charged vehicle is much simpler. As an EV driver, you simply want your battery charged. With V2G, you have to plan your trips much more and you are less flexible.
    - From a grid operator perspective, the grid will become dependent on this type of measuring and control systems. This means that the possible influence of grid operators on controlling the grid and robustness of the energy grid is decreasing. It also stimulates emerging vulnerabilities within the energy grid when it comes to security and hacking.
- The interviewee's advice: experiments with V2G to test these kind of aspects and to prepare for a large-scale roll-out.

End-users ease-of-use and acceptance

CED16 believes that there is a small group of people that is very enthusiast about the concept (including himself) that is willing to provide input (e.g. agenda coupling or a smartphone app) about his personal schedule and expectations about next trips.

The risk, however, remains that the battery is not fully charged when making an unexpected trip. But 10%-20% usage of the battery capacity would be acceptable from the interviewee's perspective.

There exists a possibility that there is also another group (especially people that have a high income) that would not be willing to do that, given the small financial compensations. In other words, the hassle is too large compared to 'what is in for them'. They just want their EV fully charged.

The interviewee believes that, in order to achieve broad consumer acceptance, good financial compensation is needed or other ways to motivate them (e.g. that they realize that it is quite important for society/greater-good).

CED16 thinks that proper compensation is a challenge given the fact we are talking about tens of cents per kWh (leaving out taxes). The interviewee would not expect a compensation above 1 euro per (dis)charging session. Such high compensations would not fit in the business case.

There should be sought for other ways. For instance, people must be convinced that it is a smart technology and for the greater good.

CED16 perceives that the amount of kilometres a person drives (e.g. per year) is a good indicator for the number of times the person needs to use the car. CED16: “A person that drives less is probably more willing to use V2G”. CED16: “a person that drives only 50 km per day and also has an EV with a large battery capacity would be faster willing to accept V2G”.

Customer segments, what kind of characteristics of EV drivers should be taken into account when looking for groups of EV drivers more likely to use V2G?

- Income (higher income groups are probably less triggered by financial compensation)
- Amount of KMs a person drives per day
- Type of car and battery capacity
- Lease or private ownership vehicle

Financial model for the EV drivers group with a leased EV

- The interviewee has uncertainties regarding a solid financial model for both EV drivers with a leased EV and the lease companies.
- CED16: “the lease company wants to have compensation for the battery degradation and the EV driver wants to have compensation for inflexibility caused by V2G”.
- Interviewee: “then you are suddenly dependant on two parties”.
- The point is, the interviewee believes that the model is easier with EV drivers that have privately owned EV.

Which barriers should be handled in the short-term and which ones in the long-term?

- Short-term: experimenting with the technology, pilots, experiencing the technology. You should make it accessible for people to participate and to provide input about their expected trips and personal schedule.
- Long-term: The interviewee believes that, with small-scale testing, cyber security is of less importance. But on the long-term, when having a large-scale roll-out, cyber security is an important topic because it can influence the grid’s stability and should be taken into account seriously.

Last remark interviewee

- Uncertainty of CED16: “What is the impact of different seasons (winter vs. summer)? In the summer you generate more energy compared to winter. And also, in winter your energy consumption is also higher. V2G is more suitable for inter-day balancing”.
- Other energy storage capacities might be more applicable.
- Hydrogen might be more suitable for this kind of purposes. And the question is then whether V2G still has rights to exist or is still needed. However, an important disadvantage of hydrogen: much energy losses.

Part 3 – Questions about V2G example use case at long-term parking (e.g. at the airport)

Previous experience long-term parking

- No experience with long-term parking (e.g. at the airport)
- Lives nearby Schiphol → takes public transport or taxi to the airport
- Then the EV is parked at home for the long-term

V2G – long-term parking @ airport

- The interviewee has a positive attitude toward this concept and believes it is a good location for V2G application. Perceives opportunities for airports, grid operators, end-users, energy companies.
- The interviewee believes that the compensation aspect for possible battery degradation is important.

Barriers of V2G long-term parking

- The predictability/flexibility issues are not the present here.
- Battery wear is still an issue, maybe a larger issue at the airport because probably more charging/discharging cycles.
- Leasing companies would be probably less willing to participate. Also the question: “who receives the compensation (EV driver or lease company)?” is still valid. The interviewee mentioned that there are many stakeholders involved with leasing companies who might have an interest in this.

Ideal location of V2G applications

- Concert halls → a lot of people come together and they could “bring energy” to the location
- Offices → car parked the whole day
    - Preferably your cars to be plugged-in for a longer period of time
- Hotels/holiday destinations might be less suitable because people are not parked quite long there.
- Car sharing → these cars are parked and charging often.

Advice/recommendations interviewee for system developers

The interviewee’s advice is that the system developers should start on a small-scale with people that find the concept interesting, people who do not care much about receiving compensation or whatsoever. The next step would be to slowly look for a model with which you can reach out to the larger public. For now, just experiment and then you will see what works and what does not work. The early adopters are often willing to experience disadvantages or liabilities. These people do not care much about that and stay enthusiastic.

Additional notes

- Would like to receive the end result of research.
- "Interviewee currently works at a Dutch grid operator. However, the statements above reflect his personal opinion and experience and not necessarily the opinion of the grid operator."

II.17 Report: Current EV driver 17 (CED17) – 25-11-2019

Interview information

Interview ID	**CED17**
Date of interview	**25-11-2019**
Gender	**Male**
Age category	**46-55**
EV ownership	**Leased**
EV type	**Battery electric vehicle (fully electric)**
Current EV	**Tesla Model 3**
Income category	**35.000-70.000**
Highest education level	**Bachelor's degree (applied sciences)**

Interview answers and main findings

For each of the 3 interview parts, the most important findings are presented below.

Part 1 – answers based on general questions

(Professional) background of the interviewee

The interviewee is a pioneer in e-mobility. CED17 saw already opportunities in e-mobility in 2008. Worked as an entrepreneur in the e-mobility sector since 2010 and drives electric since 2010 as well. The Think City was his first EV and he personally was also a reseller of this EV. Before that, the interviewee worked in the automotive industry (focusing on finance and assurance). Currently works as an entrepreneur in retail/retail of charging infrastructure.

His main motivation for entering the e-mobility industry and driving electric was the feeling of contributing to the environment (environmentally-driven).

With regards to social influence and influence of the direct environment, the interviewee explained that he was one of the first in his direct environment that decided to start a business in e-mobility. He, therefore, thinks that his social environment (family/friends) did not play a role in this decision.

Charging

Long-term vision of interviewee: induction (contactless) charging. Also for the highway (integrated in existing roads and highways). It might be an idea to get the energy from the nearby railroads (next to the highways). With induction charging, it would be simpler for the EV drivers.

His personal experiences with charging: in the Netherlands, the infrastructure is very good. Currently has a Tesla Model 3 that has a range of 500 km. The interviewee believes that, with other types of EVs (less range), you have to plan your trips somewhat more. For these kind of cars, you really need public charging stations.

Part 2 – Questions about V2G

Vehicle-to-grid

2014/2015 was the first time the interviewee had heard of V2G. During the introduction of a car-sharing and V2G project in Utrecht which was presented at a conference.

Thinks that the V2G concept/solution is fantastic since it can contribute to solving various energy problems (e.g. minimizing peaks) and to help for the integration of solar panels.

The interviewee perceives also barriers that consumers will have anxiety that the battery is discharged at moments so that making a long and/or unexpected trip is not possible anymore.

Overcoming these barriers could be done by introducing forms of control (e.g. switching off the uncharging). CED17 believes that making agreements about minimum state-of-charge is not the solution because "if you need a fully charged battery, you just simply need it for a long trip".

Consumer acceptance of V2G

- The interviewee: "V2G should be fast, accurate and simple". Maybe with a smartphone app that communicates with the charger and with the car. Every end-user of V2G should be able to use such an app.
- The interviewee believes that the marketing aspect of V2G and spread the word of positive experience/word-of-mouth marketing will be very important for V2G to succeed. CED17: "If people have good experiences with the system and that they share these experiences, this will be an important aspect to achieve large-scale diffusion."
- The interviewee does not think that consumers will reject/refuse the technical advantages of V2G (grid balancing, peak shaving, energy storage, etc.).

User-friendliness

- How more user-friendly can you make it compared to traditional charging?
- A smartphone app might be a good option, as explained.
- An idea: Induction technology and V2G combined, however, much energy losses

- Interviewee: “There are groups of EV drivers that are less willing to share energy despite the fact they have many resources and a large battery capacity available”.

Other barriers (sociotechnical)

Not many EVs, currently on the road, do support V2G. Traditional car manufacturers and OEMs should realize this and, ideally, make sure that new cars technically can support V2G. It would be an idea to negotiate with OEMs and to discuss/debate V2G support on more car types. Furthermore, most chargers do not support it. Only a couple of suppliers can deliver V2G system, but these are often costly.

CED17: “I cannot think of good reasons why consumers would not be interested in V2G. You can make better use of your solar panels and have storage capacity available and to do peak shaving”. However, the perceived problem lies with the OEMs and traditional car manufacturers.

Part 3 – Questions about V2G example use case at long-term parking (e.g. at the airport)

Previous experience long-term parking

- Makes often use of air travel (e.g. for holidays)
- Not much experience with long-term parking
- Currently uses public transport to go to the airport (lives nearby Schiphol). EV is parked at home then.
- In case that V2G would lead to free parking, it would be more attractive to park at the long-term parking (at the airport) since it is more comfortable.

Attitude V2G – long-term parking @ airport

It is a smart and good concept. The interviewee did not think about this concept yet. CED17 mentioned that he was mainly thinking about the home application. But, CED17: “This concept is fantastic! Because you get compensated for battery degradation and my car serves a function even when I am not around”. Furthermore, the interviewee perceived the fact that you can do something for an organization (e.g. an airport), so that they can better use renewables for instance, as an important benefit.

However, it should not be more of a hassle compared to how charging is now. It should even be made simpler if possible. Furthermore, the EV driver should receive compensation for battery degradation. When an EV is parked, the battery does not provide value. Using this concept you can extract value out of the battery when the vehicle is not used for mobility purposes. CED17 liked the idea of helping the airport for the provision of energy generated by renewable energy sources.

Perceived costs

- Battery degradation is an issue. In the end, there will be extra battery charging cycles. The interviewee has knowledge about this topic. The battery life is determined by the number of charging cycles. However, the interviewee believes that the impact of discharging is not so large. This is also with the case for fast charging where people are afraid that it is bad for the battery.
- For this battery compensation, you should receive financial compensation.

Control

- Previously mentioned that there should be a smartphone app for control. However, in this case, the interviewee would be less interested in communication about exact contribution (not so interested in seeing the exact contribution, e.g. exact numbers on GHG emission savings, when returning to the vehicle). The idea that you are contributing is more important.
- The fact that you will be contributing to the greater good is enough. The exact contribution (e.g. saved amount of GHG emission) would be less interesting to the interviewee.

Charger stickers

- Currently, it is often the case that fully charged EVs are occupying the parking space with charger. The interviewee acknowledges that an EV when plugged-into a V2G system is still functional. V2G will partly solve this discussion of charging station stickers.
- At the other hand, CED17: “other people can still not use the parking space with V2G”.
- However, the interviewee notices that the guilty feeling of sticking to a charging station is not present.

V2G ideal location

- The interviewee believes that the location of V2G charging station does not matter when it comes to consumer acceptance.
- The short-term parking use case is perceived as purposeless by the interviewee. However, he added, “it would make it more useful if you can contribute to bring energy to a certain location. That could make it attractive for a certain group of environmentally-driven EV drivers”. CED17: “I am going to a certain place and I can bring energy there and I park for free and receive a certain compensation”.
- The interviewee mentioned that it can provide advantages for the EV driver, but there are certain factors that are decisive/determining when it comes to stimulating V2G acceptance: communication about the advantages, risks, costs and word-of-mouth storytelling about positive experiences.
- One last remark of the interviewee was that it should be clear to the EV driver what the benefits, risks and disadvantages are for the end-user when participating in V2G. Communication should be simple and transparent.

Overcoming sociotechnical barriers

- Mainly the standardization of V2G and low availability of existing V2G supporting EVs and chargers (OEMs and traditional car manufacturers).
- The interviewee believes that government subsidies and a clear business case are necessary
- CED17: “We have seen this chicken and egg problem previously with the current charging infrastructure. In the past, companies did not want to invest in charging infrastructure because there were almost no EVs. Furthermore, local governments did not want to invest in charging infrastructure because there were almost no EVs on the road and would lead to tax revenue losses (from parking tariffs). Lastly, consumers did not want to purchase EVs because there was no charging infrastructure. The chicken and egg problem. At one point in time, we could get around these obstacles because of the

combination of government subsidies and stimulus and the energy companies saw opportunities in the business case of exploiting charging infrastructure."

Additional notes

- Would like to receive the end result of research.
- Interview was held because the interviewee responded to the advertisement in the 'Vereniging Elektrische Rijders' social media group.
- Currently, interviewee works as an entrepreneur in e-mobility/retail charging stations. Much knowledge and experience in the professional field of charging infrastructure and retail. Has both a business/commercial and personal interest in V2G topic.

II.18 Report: V2G pilot driver participant 1 (VDP1) – 20-11-2019

Interview information

Interview ID	**VDP1**
Date of interview	**20-11-2019**
Gender	**Male**
Age category	**55-65**
EV ownership	**Borrowed for pilot**
EV type	**BEV**
Current EV	**Mitsubishi i-Miev (from pilot)**
Income category	**>70,000**
Highest education level	**Master's degree**

Interview answers and main findings

For each of the 3 interview parts, the most important findings are presented below.

Part 1 – answers based on general questions/pilot

Please tell more about the pilot

The interviewee mentioned that there were practical problems regarding the V2G pilot. The supplier of the charger has changed (German to Spanish). Hence, the development of the charging station took very long. Despite that, the car was already delivered.

When the system was up-and-running, charging was possible. But, discharging and delivering power back to the grid was not possible due to software problems. So, the interviewee had never experienced discharging of the car.

The smartphone app did work. So, the interviewee could provide input such as: when do you need to use the car? What is de plan? How much KMs and power do you need? However, this was fictional/simulated. So actual discharging had never happened. So, the laundry machine did not work on the power of the car, unfortunately.

Why participated in pilot

There was a local organization that is focussing on the energy flows and sources in the local village. The interviewee was involved in that organization. Within that organization, the request for pilot participants was placed. Questions were asked about the family composition and transportation needs of the individuals within the household. Then he was selected (probably an interesting test case). The entire family participated (different transportation/mobility needs in the family).

Technical specifications charger/car/home

- The pilot was about a home application of V2G
- Limited range of the car: 125 km of EV used in pilot. In practice, 75 km with extreme weather conditions.
- Car was for local usage because of the limited range

Electric driving

Great to drive in an EV. Sometimes still hires an EV in a car-sharing platform. However, it is still too expensive to buy an EV privately. Currently, the interviewee uses public traffic 90% of the time.

The interviewee's experience: It is comfortable (acceleration and power) and the range of most new EVs is not a problem anymore. Because of the limited range, the interviewee experienced some range-anxiety. The interviewee beliefs that range anxiety is still a major barrier for most people: "will I arrive at my destination?". After the pilot, the interviewee owns a hybrid vehicle (currently).

Charging

Fast charging with the i-Miev was not possible. Regarding the V2G charger at home, the interviewee could provide input (in a smartphone app) about: when he wanted to use the EV and how much KMs he expects to need. Subsequently, the software determined whether there was power available for discharging or not

Why did the pilot appeal to you?

The interviewee owns solar panels and was interested in the vehicle-to-grid concept. Furthermore, the financial aspects are interesting to the opinion of the interviewee (storing overcapacity and to be self-sustaining). In the context of sustainability, it is "a

beautiful solution" together with renewables. However, the interviewee has doubts regarding the actual eco-friendliness of driving EVs and the. Thinks that a lot of things still should be arranged (e.g. improving battery technology).

Technological innovativeness

- One of the first in his village that was in possession of solar panels
- One of the first members of the local energy corporation/organization. The goal of this organization is to have energy for the inhabitants of the village which is as inexpensive as possible.
- Participated in a smart grid project.
- Likes to be an innovator in these fields. Likes to read about it and talk with experts/to visit events.
- The interviewee mentioned that he would also participate in new V2G pilots if they will be organized in his residential area

Grid services within the pilot

- Delayed charging worked
- Discharging was never done because a part of the software was not ready for the grid services and due to the delays

Pilot, what went well

- Information provision about possibilities (technical and background of experiments)
- Guidance of the managing organization was very good

Points of improvement

With such new technologies, there do exist a lot of 'childhood diseases', you know that beforehand. Furthermore, the interviewee mentioned that it was bad luck that the supplier of the bidirectional charger had to be changed. This resulted that the pilot consortium had to make a lot of new agreements and took much time. So, the majority were just setbacks (not points of improvement). It was planned to set-up a large (external) communication campaign, however, this was never realized because the project did not deliver what they expected.

Take-home messages for other V2G pilots

- Expectations management: Small steps and Feasible goals
- Incremental approach

Part 2 – Questions about V2G

What do you think of the V2G concept?

Peak shaving is an important advantage to solve the large imbalances in the grid (which will become only larger in the near future). If you can dilute it by using the cars of people that did not use it that day, this would be great. However, the interviewee proposes the following question: "Don't we need other and more storage capacity? Is there not more storage needed than with EVs?". V2G would be an option, but alternatives should be also explored.

Perceived Advantages of V2G

- Better ecological footprint. We are dreaming about gas-free households and a transition towards solar energy and wind energy. "If my car can contribute to that, that would be very interesting".
- There is also another advantage: if netting arrangements are not possible anymore. You can store overcapacity and use your solar-generated energy.
- Better use of solar energy (climate advantages also present in the office application).
- The idea of exchanging energy is also fruitful. VDP1: "that might be able to trade energy with your neighbours".
- Financial advantages → lower energy tariffs because the cars can be used for storage of overcapacity

Disadvantages/risks of V2G

The interviewee does not perceive much disadvantages/costs with V2G. VDP1: "People have to plan their trips and energy more, but is more a societal challenge". The interviewee: "these people have to start perceiving the benefits of V2G and energy planning".

The interviewee does not believe there are technical costs or risks. He does not perceive battery degradation as disadvantages/risks. The interviewee believes that you can always solve technological problems. The speed/rapidness of technological developments are promising which also provides opportunities for employment.

For VDP1 personally, inflexibility (more planning etc.) issues do not matter so much. However, the larger public has to be convinced that this planning aspect should be part of their daily lives and routines.

User-friendliness, important aspects

The way how the app is designed and how you can communicate with the app. Moreover, the uptime of the app and system is important. If there are many break downs or black-outs, than trust in the charging station and responsible organization is gone. So a high uptime and low error margins is an important aspect. In other words, "operational reliability". To illustrate, VDP1: "if you have set the app to be able to leave early in the morning (7 a.m.), then the car's battery has to be fully charged and ready 7 am the next day". In other words, you can trust the system.

Control

The interviewee was asked whether he would find it important to have real-time control over discharging of the system. The interviewee: "It should be a good thing when the end-user can request information about charging and discharging (live information)". However, he mentioned, that the question is whether the interviewee himself will use it a lot. VDP1: "it is the same as with solar panels. In the beginning, you are looking often at this kind of information on an app. However, later on, you do not look at it that often anymore".

Within the pilot, the interviewee was able to set a minimum state-of-charger. This means that the system will never discharge under 30% state-of-charge. This is an important setting for when emergencies occur (safety).

Stimulating consumer acceptance

Acceptance is defined as: "you use V2G without doubts as part of your daily routines". The interviewee mentioned that PR is very important. So, spread the word and sharing success stories. Second, sharing best practices. Third, transparency and honesty when things did not work out as intended or planned. Last, communication from the organizations and enough exposure in professional/specialist journals. The last point is very important for the development/creation of support among various stakeholders.

Part 3 – Questions about V2G example use case at long-term parking (e.g. at the airport)

Long-term parking, previous experience

- Has experience with long-term parking (valid parking).
- Has used it about 8 times in total.

Attitude towards the V2G concept at long-term parking

The concept appeals to the interviewee. VDP1 perceives a lot of opportunities. Interviewee: "If you can apply this concept at your home or for private use, why could you not apply it to public areas?". The compensation aspect is important here and will be an incentive for people. Furthermore, the idea that solar energy is better used is attractive to the interviewee.

Again, you might be able to provide input about the amount of KMs you need to drive to home. If the battery is larger than necessary. Then you can do extra discharging cycles. You can do that when you make a reservation of the parking lot. This can be done in a smartphone app (maybe with flight information). The interviewee mentioned that he experimented with this concept (by using the app in the pilot) and also thought about it. Lastly, interviewee: "PR is important to stimulate familiarity with the V2G concept".

Important in acceptance of V2G at long-term parking

- Reliable systems and technology
- Expectations management: Honesty and transparency about the development phase
- PR and sharing success stories

Imagination of experiences V2G at long-term parking

1. You book your trip and parking place (with V2G).
2. During the reservation, you can provide input about the required capacity (KMs to home), when you return to your car etc.
3. You already receive a notification about the expected financial compensation (discount, etc.).
4. When you arrive there on the reserved day, a charging station will be automatically assigned
5. You park there
6. Information is present at the charger: your car is being used for discharging etc. A simple and transparent explanation.
7. You return from your trip and your battery is charged enough to make your trip

Ideal location

Preferably locations where the car is parked for a longer period of time. Another option: P&R at train stations. Also here, you can provide data in an app about the expected next trip. The system calculates how much of the capacity can be used for charging and discharging. VDP1: "at short-term parking, discharging does not make sense or is purposeless".

Interaction between 'attitude towards technology' and 'technology acceptance'

The interviewee believes that this interaction can be present for people. However, the interviewee mentioned that positive experience with using the system is a decisive factor in this 2-sided effect. The interviewee honestly explained that he was (sometimes) frustrated about the fact that the charger was not working at certain moments during the pilot. In conclusion, the system has to work properly as intended and has to be reliable.

Additional notes

- Would like to receive the end result of research/thesis. Management/executive summary or paper.
- Interviewee participated in a V2G pilot which was aiming at application of V2G at home (the driveway). Therefore, many answers were based on V2G at home and with this concept in the mind of the interviewee.

II.19 Report: V2G pilot driver participant 2 (VDP2) – 21-11-2019

Interview information

Interview ID	**VDP2**
Date of interview	**21-11-2019**
Gender	**Female**
Age category	**55-65**
EV ownership	**Borrowed for pilot**
EV type	**PHEV**
Current EV	**Mitsubishi Outlander PHEV**
Income category	**20,000-35,000**
Highest education level	**Bachelor's degree (applied sciences)**

Interview answers and main findings

For each of the 3 interview parts, the most important findings are presented below.

Part 1 – answers based on general questions/pilot

Background interviewee

The interviewee and her husband participated in a V2G project. For the project, VDP2 received a Mitsubishi Outlander PHEV for about 2 years. The pilot has finished and currently drives a Chevrolet Volt (comparable with an Opel Ampera). Before the pilot, the interviewee drove already this hybrid electric vehicle (Chevrolet Volt).

The interviewee mentioned that they have 52 solar panels at home. The reason why they participated in the pilot was because they found discharging was very interesting. Since they have many solar panels and the idea you could power electric devices at home using the battery of the EV was interesting to them. Interviewee and her husband have a high interest in sustainability, living off-grid, self-sustaining, etc.

V2G usage in pilot

Participant was not sure whether the actual discharging of the battery pack was done. The interviewee mentioned problems regarding the installation of the software in the charger. However, the participant noticed that she had to fill in a travel diary and that she did that accurately. Within the pilot, a smartphone app was provided and up-and-running. The smartphone app could be used to fill in information about the expected next trip and amount of KMs required. The system could then calculate whether discharging could be done. But, also a lot of errors in the app.

Technological innovativeness

The first years, the interviewee felt she was a pioneer. After a couple of years, the interviewee noticed that other people started to install solar panels and drive electric. So, feeling of pioneership disappeared.

Interviewee follows the latest trends and developments regarding electric mobility. For instance, the range of EVs and battery developments.

Sustainability

Tries to make their house as sustainable as possible. Solar panels, wood-fired heating.

Currently lives in Spain, where the interviewee lives off-grid: 9 solar panels and 3 batteries (7,5 kW each). VDP2: "The more self-sustaining, the better".

Pilot evaluation

- Good points pilot: Infrastructure was installed properly, Communication with project members went very well and it was clear who to contact when there were problems.
- Points of improvement: Communication within the project group, that the system works as intended without errors
- Key take-home messages interviewee to other V2G pilots: Before starting, make sure that everything is arranged properly and works. So, that the software is installed properly, the infrastructure installed. Minimize the chance of unexpected problems.

Part 2 – Questions about V2G

Attitude towards V2G technology

The interviewee thinks that the V2G concept is very interesting. Especially the fact that solar-powered energy can be stored temporarily. However, the main question according to the interviewee is: are people willing to engage in such systems? Perceives a problem regarding whether people are willing to participate and to plan their energy usage more. When reflecting on her own motivations, the interviewee's main motivation for V2G usage: to be self-supporting. So, not being dependant on large energy companies. The financial advantages is a side-benefit.

Important aspects for acceptance V2G

- Good working software with a smartphone app.
- Make it as simple as possible for the end-user

- The interviewee thinks that different people are triggered by different motivations: self-supporting, financial advantages, contributing to greater-good.
- Software for free and should work without errors
- Point system (e.g. Airmiles, bonus points)
- In the case of private owned EVs, you compensate the EV drivers. They hand in something, so they have to get something back. VDP2: “Most often, their car is their baby”. So, make it attractive by providing battery maintenance or a new battery once in a while. Or a financial compensation.
- For lease drivers, make agreements with large companies that have a large EV fleet. They could make it compulsory to participate in V2G. However, agreements should be made with these companies, lease companies, government, and car manufacturers. Perhaps that the government can provide financial incentives for them (e.g. lower additional tax liability)

Barriers/risks/disadvantages V2G

For large-scale usage of V2G (e.g. at a large apartment complex), when the batteries are used for discharging and powering the apartments, you will get people that will have high energy consumption. Other people will experience this as a disadvantage since the batteries of the vehicles are low. In other words, you will annoy other people when you have high energy consumption.
For small-scale V2G (1 car and 1 home), the owners of the EVs are responsible for their own energy usage. In case it is cloudy for a couple of days, the owner is responsible for himself and risks to have an empty battery.

The interviewee does not perceive technical risks: so does not perceive battery degradation as a risk or cost. This is because the interviewee has a positive experience with their own EV. Currently, she owns the EV for 7 years and have not noticed any degradation of the battery.

- The interviewee has knowledge about the charging cycles of the home batteries. They allow 6000 cycles which is good for 20 years of usage.
- VDP2: “Maybe, if the batteries are 10-15 years old, then battery degradation might occur.”

The interviewee perceives the following as the biggest barrier: Not all OEMs and car manufacturers are supporting V2G and made their technically ready for V2G. For instance, the interviewee mentioned that certain car brands are reluctant to make their vehicle ready for discharge. VDP2: “Please, give me immediately an app so that I can discharge with my vehicle”.
Technical aspects: Interviewee perceives challenges regarding orchestration and coordination of various technical components in the system. Which device receives what electricity at what moments (so smart metering and smart inverters should be used). The interviewee perceives smart inverters as a possible solution.

Part 3 – Questions about V2G example use case at long-term parking (e.g. at the airport)

Attitude towards V2G at long-term parking

The interviewee finds this a “Great concept!”. She believes that it will be part of the future and important part of the energy transition. An important remark, she perceives it as a part of a larger solution (“a secondary system for balancing”).

Previous experience

- Has some experience with long-term parking.
- No experience with charging at long-term parking
- Is reluctant to charge at long-term parking. VDP2: “You have to get a membership. I don’t want that”.

Barriers

The interviewee mentioned that she cannot discharge with the current car (Chevrolet Volt). The interviewee knows that Tesla cannot discharge as well. The interviewee mentioned: “OEMs and traditional car manufacturers should enable V2G and use one protocol”. Furthermore, the number of charging stations should be enormous. Therefore, a large investment will be required.
According to the interviewee, solar and wind parks should be included in the design at long-term parking. Otherwise, it does not make sense in terms of sustainability.

Important aspects to reach end-user acceptance

- Explanation of usage of V2G should be explained simply
- Guarantee scheme for EV drivers with both private ownership and leased EVs.
  - Should be arranged with the OEMs
- Compensation and maybe bonus points or awarding credits
- Publicity and PR. The EV driver should be able to share his participation in V2G with his/her social environment. VDP2: “look at how cool I am”.
- VDP2: “Probably you get a question: Should we (as EV drivers) contribute to solve the problems regarding the grid? A problem that is not our problem?”. There should be a clear answer to that question. “What will you answer?”.

Intention to use V2G at long-term parking

- Would definitely have the intention to use V2G at long-term parking
- But, the app has to work and has to be very simple
- No separate membership to participate should be required.

Keeping control over discharging

It should be an option to keep full control over the system. If you want that as an EV driver, it should be possible. But, 9/10 EV drivers probably don’t want that. But the possibility should be there.

Furthermore, when you return from holidays, people should be made aware that their car has contributed to something. VDP2: "your energy has contributed to solving this problem. You have saved this amount of CO2". You also anticipate people's guilty feeling that they make a flight trip (CO2 emissions).

Whether there is interaction between "acceptance" & "attitude"

Depends on their experience with the technology. If it worked properly, probably yes. But if the experience is bad (errors etc.), then this can lead to a less positive and even negative attitude.

The emerging new group of EV drivers require more information provision/knowledge sharing.

Additional notes

- Would like to receive the end result of research/thesis. Management/executive summary or paper.
- Interviewee participated in a V2G pilot which was aiming at application of V2G at home (the driveway). Therefore, many answers were based on V2G at home and with this concept in the mind of the interviewee.
- Halfway the interview, the husband of the interviewee also joined the conversation/interview.

II.20 Report: V2G pilot driver participant 3 (VDP3) – 12-12-2019

Interview information

Interview ID	**VDP3**
Date of interview	**13-12-2019**
Gender	**Male**
EV ownership	**Borrowed for pilot**
EV type	**BEV**
Current EV	**Nissan Leaf**
Income category	**€35,000-€70,000**
Age category	**25-35**
Education level	**Master's degree**

Interview answers and main findings

Background interviewee & pilot

The interviewee participates in an EV pilot which is based on car-sharing. An important side-topic within the pilot is V2G, where the car is being used for various grid services in and around the venue (e.g. a neighbouring residential area in Amsterdam). The project is at a large soccer stadium in the Netherlands. The V2G part of the pilot just started one week before the interview, so the interviewee has not noticed actual discharging of the EV. In other words, the interviewee did not drive the EV just before/after discharging for V2G.

Experiences interviewee with E-mobility

One of the most important things is the operational reliability of the car. This means that you can use the vehicle whenever you want to use it. In the beginning, with EVs, you have to get used to the new technology (e.g. get used to regular charging and limited range). In other words, other driving behaviour is often necessary, especially with longer trips when driving an EV.

Ideas about V2G (in the context of the car-sharing platform)

Keeping in mind that operational reliability of an EV very important, then the point with V2G is that the end-user should not notice much of discharging for grid services, in the ideal situation. Especially with car-sharing platforms, as an end-user, you just want that the battery is fully charged when you start your reservation. For this, you need to be able to use an advanced reservation and planning system. For example, a person makes a reservation and wants to drive in 1 hour, then the system has to ensure that the battery is fully charged.

Acceptance V2G, important factors or aspects

The interviewee believes that V2G can play a role in the future vision of energy/energy transition. The interviewee believes in energy as some sort of payment method. For vehicle owners (not in the car-sharing case), there must be a type of compensation for possible caused battery degradation, but also a share of generated income from grid services or energy trading. Put differently, energy is/includes a new form of supply/demand where you, as an EV driver, are helping with grid balancing and supplying energy at moments when it is most needed. In short, there is a financial model on one side.

At the other side, there is also societal contribution. As an EV driver, you are helping a certain organization or various organizations (e.g. grid operator, service providing organization, venue where you are parked).

Discussion use case V2G at long-term parking

The interviewee believes that the idea of V2G at long-term parking at the airport is a smart concept. VDP3: "it can be an enormous energy buffer, even for back-up power for the airports in case of an emergency". The interviewee noticed that, especially in cases where there is a total black-out, it can be of great value to large organizations such as airports.

EV driver's informed consent V2G-mode

An important aspect is that the EV driver will consent that the organization is using the EV's battery energy back-up/storage. People might be triggered and persuaded by offering a "fair price". So, proper compensation, as discussed earlier.
Second, the interviewee also believes that it will be a normal habit for EV drivers to park and plug-in the charger in the car, in the long-term. The interviewee believes that V2G will be a regular part of EV charging stations. Laws and regulation will oblige drivers to participate in V2G under clear and strict agreements (energy in the battery can be used under certain conditions for societal reasons and on special occasions). These laws and regulation will ensure automated permission. This will ensure that energy demand can be fulfilled at places where a lot of people come together (mostly the places where energy demand is highest).

Most important factor V2G acceptance

As an EV driver, you want that your battery can be used for 15-20 years. If future researches will indicate and even prove that V2G participation will result in accelerated battery degradation, then there must be a compensation model for that. For now, it is very important that researches and practical tests will learn us what the actual effects on the battery are.
Second, there must be extensive and advanced planning systems in place. Currently, most chargers do not even support smart charging (automated timing charging, changing charging speed, charging amounts of kW). It will be a first step to implement smart charging and make it a standard part of the charging landscape.
Third, there must be enough V2G bi-directional chargers available to make a real impact and to make it part of the EV driver's daily life.

Additional notes

- Would like to receive the end result of research/thesis. Management/executive summary or paper.
- Currently works at the organization that a test set-up with one V2G bi-directional charger. A car-sharing platform is being used so that different people use the EV (Nissan Leaf) and that the EV's battery can be used for various grid services when the EV is not being used.

Appendix III Initial codebook

Explanation codebooks

9 code categories have been defined in the literature review section. This is based on the earlier presented conceptual model. An overview is presented below in the table. Within each category, various codes have been assigned before interviews have been coded. It was assumed that each code is part of a code category and that codes and factors are the same. In other words, a code is a factor contributing to EV drivers' acceptance of V2G. On the basis of earlier literature studies, there have been initial ideas of what codes were most likely to be found. These codes have been included in the initial codebook (see below in Table 20) With these codes in mind, different iterations of coding of the interview reports have been done. Within each category, new codes emerged and existing ones were adjusted. The resulting list of codes is presented in the definitive top-codebook which is presented in Appendix V and is further discussed in 4.2.2.

Using the code categories and further findings from the literature review, the initial codebook has been drawn up which is shown in Table 20. The literature sources are mentioned to show which insights from which specific studies have been included. The codebook shows the codes and code categories that have been used during the deductive or selective coding phase (the first iteration of coding). Labelling quotations of the interview reports has been done during the first iteration of coding. Codes have been accommodated within code categories based on their definition, meaning and content. This does not mean that this is fixed. During the second iteration of coding with an inductive or open coding approach, codes were renamed or replaced under different code categories. The initial codebook was solely used as the main guidance to make sense out of a large volume of qualitative data, to provide structure and not to get lost during the first iteration of coding. The second coding iteration resulted in the definitive codebook. For a detailed explanation of the coding strategy and codebooks, we refer to the Methodology in Chapter 2.

Initial codebook

Table 20: Initial codebook based on previous V2G studies and theoretical perspective

Code category	Code	Source
PBN		
1	**Compensation**	Brandt et al. (2013); Geske and Schumann (2018); Kester, Noel, de Rubens, et al. (2018); Will and Schuller (2016)
2	**Societal benefits**	Noel, Zarazua de Rubens, et al. (2019)
3	**Eco-friendliness**	Sioshansi and Denholm (2009)
4	**System effects**	Will and Schuller (2016)
PBR		
5	**User Inflexibility**	Broneske and Wozabal (2017)
6	**Battery degradation**	Bailey and Axsen (2015); Kester et al. (2019)
7	**Privacy & data security**	Bailey and Axsen (2015); Will and Schuller (2016)

8	**Range anxiety**	Noel, de Rubens, et al. (2019d); Sovacool et al. (2017)
SN		
	No initial codes identified based on literature	-
PBC		
9	**Control**	Noel, Zarazua de Rubens, et al. (2019)
10	**V2G contract type**	Geske and Schumann (2018); Meijssen (2019); Michaels and Parag (2016); Parsons et al. (2014); Zonneveld (2019)
11	**Information provision**	Geske and Schumann (2018); Kester, Noel, de Rubens, et al. (2018)
12	**Ease of use V2G**	Daim et al. (2016)
13	**V2G standards**	Kester, Noel, Lin, et al. (2018)
14	**Availability V2G facilities**	Noel, Zarazua de Rubens, et al. (2019)
ATV		
	No initial codes identified based on V2G literature	-
EDP		
15	**Eco-friendliness values**	Will and Schuller (2016)
16	**EV experience**	Will and Schuller (2016)
17	**Technological innovativeness**	Will and Schuller (2016)
18	**V2G familiarity**	Meijssen (2019)
TR		
19	**Consumer distrust**	(Noel, de Rubens, et al., 2019b)
I		
	No initial codes identified based on V2G literature	-
A		
	No initial codes identified based on V2G literature	-

Appendix IV Exit questionnaire results

IV.1 Overview results in one table

Table 21: Overview exit questionnaire in one table

Participant_ID	Gender	Age category	EV ownership	EV type	Current EV	Income Category	Highest Education Level
CED1	Male	25-35	Leased	PHEV	VW Golf GTE	€35,000-€70,000	Higher General Secondary Education/Pre-university education
CED2	Male	65+	Leased	PHEV	VW Golf GTE	€35,000-€70,000	Higher General Secondary Education/Pre-university education
CED3	Female	<25	Leased	BEV	VW e-Golf	€35,000-€70,000	Master's degree
CED4	Male	65+	Purchased	BEV	Hyundai Kona Electric	€35,000-€70,000	Master's degree
CED5	Female	25-35	Leased	BEV	Kia e-Niro	€35,000-€70,000	Master's degree
CED6	Male	36-45	Leased	BEV	Tesla Model 3	€35,000-€70,000	Bachelor 's degree (applied sciences)
CED7	Female	36-45	Leased	BEV	Tesla Model S	>€70,000	Bachelor 's degree (applied sciences)
CED8	Female	25-35	Purchased	PHEV	Mitsubishi Outlander	€20,000-€35,000	Bachelor 's degree (applied sciences)
CED9	Male	25-35	Purchased	PHEV	Mitsubishi Outlander	€35,000-€70,000	Secondary vocational education
CED10	Male	46-55	Leased	BEV	Nissan Leaf	>€70,000	Bachelor 's degree (applied sciences)
CED11	Male	25-35	Leased	PHEV	VW Golf GTE	€20,000-€35,000	Bachelor 's degree (applied sciences)
CED12	Male	46-55	Leased	BEV	Tesla Model S	>€70,000	Master's degree
CED13	Male	46-55	Purchased	BEV	Tesla Model 3	>€70,000	Bachelor 's degree (applied sciences)
CED14	Male	36-45	Leased	BEV	BMW i3S	>€70,000	Bachelor 's degree (applied sciences)
CED15	Male	56-65	Purchased	BEV	Tesla Model S	Prefer not to say	Prefer not to say
CED16	Male	36-45	Leased	BEV	Jaguar I-Pace	>€70,000	Master's degree
CED17	Male	46-55	Leased	BEV	Tesla Model 3	€35,000-€70,000	Bachelor 's degree (applied sciences)
VDP1	Male	56-65	Borrowed for Pilot	BEV	Mitsubishi i-MiEV	>€70,000	Master's degree
VDP2	Female	56-65	Borrowed for Pilot	PHEV	Mitsubishi Outlander	€20,000-€35,000	Bachelor 's degree (applied sciences)
VDP3	Male	25-35	Borrowed for Pilot	BEV	Nissan Leaf	€35,000-€70,000	Master's degree

IV.2 Separate tables with percentages

Table 22: Overview analysis exit questionnaire (detailed)

Gender	%	Count
Male	75%	15
Female	25%	5

Age	%	Count
<25	5%	1
25-35	30%	6
36-45	20%	4
46-55	20%	4
56-65	15%	3
65+	10%	2

EV ownership	%	Count
Lease	60%	12
Purchase	25%	5
Borrowed for Pilot	15%	3

EV type	%	Count
Plug-in hybrid electric vehicle	30%	6
Battery electric vehicle (fully electric)	70%	14

Gross Income Category	%	Count
<€20,000	0%	0
€20,000-€35,000	15%	3
€35,000-€70,000	45%	9
>€70,000	35%	7
Prefer not to say	5%	1

Highest Education Level	%	Count
No education/high school graduate	0%	0
Pre-vocational secondary educaction	0%	0
Secondary vocational education	5%	1
Higher General Secondary Eduction/Pre-university education	10%	2
Bachelor 's degree (applied sciences)	45%	9
Bachelor's degree (university education)	0%	0
Master's degree	35%	7
Doctorate degree (PhD)	0%	0
Prefer not to say	5%	1

Current EV	%	Amount
VW Golf GTE (PHEV)	15%	3
VW e-Golf (BEV)	5%	1
Hyundai Kona Electric (BEV)	5%	1
Kia e-Niro (BEV)	5%	1
Tesla Model 3 (BEV)	15%	3
Tesla Model S (BEV)	15%	3
Mitsubishi Outlander (PHEV)	15%	3
Nissan Leaf (BEV)	10%	2
BMW i3S (BEV)	5%	1
Jaguar I-Pace (BEV)	5%	1
Mitsubishi i-MiEV (BEV)	5%	1

Appendix V Detailed definitive codebook

This appendix demonstrates the definitive codebook. The code categories 'attitude towards V2G' and 'intention to accept V2G' have been included as code reports, because these code categories were codes themselves.

V.1 Perceived benefits

Table 23: Codes definitive codebook perceived benefits

Code	Grounded
V2G-PBN-Compensation	33
V2G-PBN-Societal contribution	13
V2G-PBN-storage capacity	6
V2G-PBN-environmental benefits	6
V2G-PBN-Charging station stickers solved	5
V2G-PBN-Financial advantages	5
V2G-PBN-grid balancing	3
V2G-PBN-energy trading	3
V2G-PBN-Employer receives compensation	3
V2G-SN-There is no other option	3
V2G-PBN-battery balancing	1
V2G-PBN-better use of solar energy	1

V.2 Perceived barriers

Table 24: Codes definitive codebook perceived barriers

Code	Grounded
V2G-PBR-User inflexibility	32
V2G-PBR-battery degradation	25
V2G-PBR-standardization	11
V2G-PBR-doubts & uncertainties V2G	11
V2G-PBR-better alternative technologies	5
V2G-PBR-no perceived barriers	4
V2G-PBR-safety & security	3
V2G-PBR-battery capacity	3
V2G-PBR-installation costs	2
V2G-PBR-additional monetary costs	2
V2G-PBR-no perceived benefits for end-user	1
V2G-PBR-spacial problems	1
V2G-PBR-Goes beyond goal charger	1
V2G-PBR-billing & energy metering	1
V2G-PBR-cable stolen	1
V2G-PBR-public oppression	1
V2G-PBR-negative externality	1

V.3 Perceived behavioural control

Table 25: Codes definitive codebook perceived behavioural control

Code	Grounded
V2G-PBC-User interface	23
V2G-PBC-location	22
V2G-PBC-PR and communication	15
V2G-PBC-control important	13
V2G-PBC-user-friendliness	10
V2G-PBC-Battery degradation not important (leased)	10
V2G-PBC-minimum SOC	8
V2G-PBR-trust	5
V2G-PBC-operational reliability	5
V2G-PBC-availability V2G devices	4
V2G-PBC-possibility opt-out	4
V2G-PBC-warranty	3
V2G-PBC-awareness type of grid services	2
V2G-PBC-Guiding rules	2
V2G-PBC-minimum (dis)charge cycles	2
V2G-PBC-Parking duration	1
V2G-PBC-control not neccessary	1

V.4 Subjective Norm

Table 26: Codes definitive codebook subjective norms

Code	Grounded
V2G-SN-customer segmenting	10
V2G-SN-changing norm	9
EDP-influenced by social environment-not at all	4
EDP-influenced by social environment-to some extent	4
V2G-SN-There is no other option	3
V2G-SN-Energy & mobility planning	3
EDP-influenced by social environment-influences others	2

V.5 EV driver's profile characteristics

Table 27: Codes definitive codebook EV drivers profile characteristics

Code	Grounded
EDP-motivation-financial	10
EDP-Has knowledge-Batteries	10
EDP-Techn. Innovativeness-Reads	8
EDP-Previous experience long-term parking-never	8
EDP-Eco-values	8
EDP-Techn. Innovativeness-UTD latest developments	6
EDP-Solar panels possession-yes	6
EDP-Previous charging behavior-home	5

EDP-Previous experience long-term parking-once or twice a year	5
EDP-motivation-environment	5
EDP-V2G familiarity-highly familiar	5
EDP-Previous charging behavior-office	5
EDP-motivation-new technology	5
EDP-influenced by social environment-to some extent	4
EDP-influenced by social environment-not at all	4
EDP-V2G familiarity-heard/read about it	4
EDP-Solar panels possession-plans to buy	4
EDP-Techn. Innovativeness-Pilot participant	3
EDP-Previous experience long-term parking-occasionally	3
EDP-Techn. Innovativeness-Not at all	3
EDP-V2G familiarity-not at all	2
EDP-Techn. Innovativeness-Profession	2
EDP-motivation-car design	2
EDP-influenced by social environment-influences others	2
EDP-Solar panels possession-no	1
EDP-Previous experience long-term parking-often business trips	1

V.6 Trust

Table 28: Codes definitive codebook Trust

Code	Grounded
V2G-Trust	5
V2G-Trust-operational reliability	5

V.7 Attitudes towards V2G (code report is provided)

General V2G concept

1:24 The interviewee thinks that vehicle-to-grid is a very good idea. Is no…… (9428:10072) - D 1: Interview report CED1

2:16 CED2 has a positive attitude toward V2G. He believes that it has the p…… (10440:10648) - D 2: Interview report CED2

3:12 Thinks that it is a good concept. However, has various questions: 1) D…… (5107:5648) - D 3: Interview report CED3

4:1 CED4's perception is that V2G delivers more possibilities for himself…… (1700:2076) - D 4: Interview report CED4

5:1 CED5 perceives vehicle-to-grid as a very cool concept. She believes th…… (2623:3158) - D 5: Interview report CED5

6:8 CED6: "Smart concept. Good concept for the energy companies and grid o…… (3360:3944) - D 6: Interview report CED6

7:11 Thinks that the idea of V2G is a good idea. Storing energy when there…… (3746:3870) - D 7: Interview report CED7

8:1 The interviewee has a positive attitude toward the V2G concept as long…… (2560:2682) - D 8: Interview report CED8

9:7 CED9: "in the future, I believe that we will all drive electric and I…… (1989:2140) - D 9: Interview report CED9

9:18 Despite the fact the interviewee did not purchase the PHEV for environ…… (4215:4656) - D 9: Interview report CED9

10:13 CED10: "Assuming that it is technologically feasible, it is an interes…… (3975:4521) - D 10: Interview report CED10

11:6 The interviewee did not heard of V2G before. Heard of criticism about…… (2646:3051) - D 11: Interview report CED11

12:4 On a conceptual level (as presented), the interviewee perceives the ho…… (1802:2317) - D 12: Interview report CED12

13:6 Attitude towards the technology - The interviewee thinks that…… (3030:3490) - D 13: Interview report CED13

13:14 The interviewee has a more positive attitude regarding vehicle-to-home…… (5399:5773) - D 13 Interview report CED13

13:29 The interviewee mentioned the following reasons why he hopes that it w…… (3517:3628) - D 13: Interview report CED13

14:6 The interviewee thinks that it is a smart concept. He is not fully sur…… (3132:3360) - D 14: Interview report CED14

15:5 The concept is "okay". The interviewee finds it a pity that it starts…… (3267:3607) - D 15: Interview report CED15 v2

16:6 The interviewee perceives V2G as a promising concept that potentially…… (4857:5321) - D 16: Interview report CED16 v2

17:6 Thinks that the V2G concept/solution is fantastic since it can contrib…… (2328:2695) - D 17: Interview report CED17

18:5 Peak shaving is an important advantage to solve the large imbalances i…… (5348:5802) - D 18: Interview report VDP1 v2.0

Long-term parking

1:31 Thinks that the airport application is an ideal application because of…… (10775:10960) - D 1: Interview report CED1

2:25 In general, CED2 perceives the airport application as a good use case……. (12859:13289) - D 2: Interview report CED2

3:27 Very good concept because of the storage for renewables and contributi…… (9403:9512) - D 3: Interview report CED3

4:9 CED4 perceives the V2G at long-term parking of an airport as a "very n…… (3847:4550) - D 4: Interview report CED4

5:6 Thinks that V2G at long-term parking at the airport is a "cool" concep…… (4344:4698) - D 5: Interview report CED5

6:13 CED6 perceives V2G at long-stay parking at an airport as a very smart…… (5734:5967) - D 6: Interview report CED6

8:5 The interviewee perceives the V2G at long-term parking application as…… (3485:3630) - D 8: Interview report CED8

9:11 The interviewee believes that: "in the future, when a great part of th…… (2814:3077) - D 9: Interview report CED9

10:23 Good idea. However, it is very important for CED10 is that it is commu…… (6384:7029) - D 10: Interview report CED10

11:19 CED11: "Very good concept where I will participate in if his cars all…… (6852:7118) - D 11: Interview report CED11

11:26 CED11, last remark: "Hopes that it will be realized soon" (9073:9129) - D 11: Interview report CED11

13:21 Long-term parking concept is valid on the conceptual level. CED13: "It…… (8779:9475) - D 13: Interview report CED13

14:15 First of all, the interviewee perceives it as a "smart concept". Howev…… (4962:5230) - D 14: Interview report CED14

15:37 Compared to the V2G at office application, the long-term parking use c…… (7842:8298) - D 15: Interview report CED15 v2

16:15 The interviewee has a positive attitude toward this concept and believ…… (10887:11199) - D 16: Interview report CED16 v2

17:13 It is a smart and good concept. The interviewee did not think about the…… (5447:6426) - D 17: Interview report CED17

18:19 The concept appeals to the interviewee. VDP1 perceives a lot of opport…… (9563:9933) - D 18: Interview report VDP1 v2.0

19:17 The interviewee finds this a "Great concept!". She believes that it wi…… (6819:7066) - D 19: Interview report VDP2

20:4 The interviewee believes that the idea of V2G at long-term parking at…… (2739:3101) - D 20: Interview report VDP3

V.8 Intention to accept V2G (code report is provided)

2:32 CED2 has the intention to use V2G at several locations. He would use V…… (14649:14824) - D 2: Interview report CED2

6:23 The interviewee: "Would find it great to participate!" (5988:6041) - D 6: Interview report CED6

9:5 Would use it as long as there are no additional (monetary) costs attac…… (1752:1826) - D 9: Interview report CED9

9:13 The interviewee thinks that he would use V2G chargers when becoming av…… (3323:3481) - D 9: Interview report CED9

10:21 If it would become increasingly available, CED10 would use it (but the…… (5830:5969) - D 10: Interview report CED10

14:16 Does not perceive differences. Would have the intention to use both si…… (5255:5385) - D 14: Interview report CED14

19:23 Intention to use V2G at long-term parking - Would definitely…… (8562:8814) - D 19: Interview report VDP2

3:31 She would use it at an airport. Thinks that the office situation is ma…… (9923:10121) - D 3: Interview report CED3

5:5 Would use V2G at long-term parking at the airport. However, the interv…… (4945:5407) - D 5: Interview report CED5

6:14 No barriers experienced or perceived barriers for the V2G @ long-stay…… (6373:6557) - D 6: Interview report CED6

8:6 Things that it is an ideal concept for business people making business…… (3798:3935) - D 8: Interview report CED8